Wide-Spread Implementation of Renewable Energy Projects in APEC Member Economies: Road Maps for Success

November 2000

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Asia-Pacific Economic Cooperation
Energy Working Group
Expert Group on New and Renewable Energy Technologies

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The 193 MWe Storm Lake wind power plant, courtesy Enron Wind (USA)

The Bangsue Chia Meng Rice Mill in Thailand, courtesy COGEN Programme (Thailand)

Dedication of the PV/LPG hybrid power unit at Alaminos village in the Philippines, courtesy of Shell Renewables

PV rooftop integration, courtesy of the New Energy and Industrial Technology Development Organization (Japan)

CONTENTS

TABLES

FIGURES

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ACRONYMS AND ABBREVIATIONS

AED	Alternative Energy Development, Inc.
AIT	Asian Institute of Technology
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of South-East Asian Nations
CPC	Community Power Corporation (United States)
GHG	Greenhouse Gas
IMAR	Inner Mongolian Autonomous Region
kW	Kilowatt
kWh	Kilowatt-hour
LFG	Landfill Gas
LGU	Local Government Unit
MITI	Ministry of International Trade and Industry (Japan)
MW	Megawatt
NEDO	New Energy and Industrial Technology Development Organization (Japan)
NEF	New Energy Foundation (Japan)
NGO	Non-Governmental Organization
NRE	New and Renewable Energy
NREL	National Renewable Energy Laboratory (United States)
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaics
RESCO	Rural Energy Services Company
SHS	Solar Home System
SMB	Small Modular Biopower
SPP	Small Power Producer
US	The United States of America
USEPA	Environmental Protection Agency (United States)
UNFCCC	United Nations Framework Convention on Climate Change

OVERVIEW

Introduction

Renewable energy technologies are potentially important options for power generation throughout the APEC region. Some APEC economies have had considerable success in implementing renewables, such as Thailand, Malaysia, and the United States (US) for biomass cogeneration, China, US, and Canada for wind electric power, and the US for landfill gas-to-energy projects. Indonesia, China, the Philippines, Chile, Australia, and others have had success in implementing solar PV projects for off-grid applications. Japan, Australia, and the US are leaders in building-integrated applications of photovoltaics. Virtually all of the APEC economies have experience with some of these technologies, and many are exploring the possibilities and requirements for use of renewables on a significant scale. In part this is motivated by the goals expressed in the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), by local environmental considerations, and sometimes by the need to address rural electrification objectives that are not fully within the reach of conventional grid extension. Yet, even in APEC economies with good records of accomplishment for some renewable energy technologies, there are often serious obstacles to major scaleup of renewable energy applications.

Many of the APEC energy ministers have indicated their strong interest in initiating or expanding and accelerating the use of various renewable energy technologies in their economies. They have requested that the APEC Secretariat provide them with a report that would identify the conditions for successful renewable energy project and program development and implementation, and that would provide “road maps” for such development, based on a review of successful case examples in APEC economies.

Alternative Energy Development, Inc. (AED) has prepared this report for the APEC Secretariat and for the APEC Energy Working Group / Expert Group on New and Renewable Energy Technologies. The purpose is to deepen their understanding of why specific renewable energy projects have been technically and financially successful in several APEC economies.

The Selection of APEC Economies and Renewable Energy Project Examples

In consultation with the APEC task manager for this project, AED selected five APEC member economies with six principal project examples in the areas of wind energy, photovoltaics, bioenergy, and landfill gas for on-grid and / or off-grid projects. The economies are the United States, the Philippines, Thailand, Japan, and China. The technologies and associated APEC economies that we have selected for the case studies are listed below.

- Off-grid wind energy applications (China) *program*
- Grid-connected photovoltaics (Japan) *program*
- Off-grid photovoltaics (Philippines) *project / business initiative*
- Grid-connected and free-standing biomass cogeneration (Thailand) *project*
- Grid-connected landfill gas recovery and conversion (United States) *project*
- Grid-connected wind energy development (United States) *project*

"Roadmaps" of Successful Renewable Energy Projects and Programs

AED has conducted a review and analysis of selected renewable energy projects and programs in APEC economies, to describe the "road maps" for successful project development. The principal steps in the project development and implementation process are described for the selected case examples. Our goal in conducting this work is to contribute to a greater understanding of general best practices for successful renewable energy project identification, financing, development, and operation.

Three of the projects selected are commercial single technology initiatives, and their development roadmaps are quite similar. The technologies are large-scale grid-connected wind electric power, industrial biomass cogeneration, and landfill methane recovery and conversion. Generic roadmaps can be developed for each of these, but there are important differences in the roadmaps among these technologies. There is no single roadmap that fits all commercial renewable energy projects. For the other three examples in this report, it is even more complex. The small wind turbine program in China is not a project, but a national program with regional support. While it can serve to some extent as a model for similar programs elsewhere, the roadmap for this program bears little resemblance to those for the single technology commercial projects.

The development of the Rural Energy Services Company (RESCO) project / business initiative in the Philippines is an important example of new trails being blazed. This project is one of several being developed under a new business initiative by Shell International. It has created its own unique roadmap, although the lessons learned appear to be widely applicable to initiatives designed to use clean energy technologies to bring priority energy services to off-grid communities. The Japan PV rooftop program is an example of a national initiative designed to reduce the cost of a specific set of technologies and to stimulate the market demand for these. Again, there are important lessons to be drawn from this experience that can be applied by other APEC economies with similar goals, but the roadmap is different from all the other initiatives presented in this report.

Lessons Learned

While this report focuses on describing the road maps for the selected renewable energy projects, it also identifies and characterizes the "lessons learned" from these project development efforts (including unsuccessful project development attempts), and presents a set of "best practices" for renewable energy project identification and development. Effective public- and private-sector *programs* that have facilitated multiple successful projects (e.g., grid-interactive photovoltaics or biomass cogeneration) are also discussed.

The 'Landscape" for Successful Renewable Energy Projects and Programs

It is useful to understand *how* successful projects are developed, but equally important and perhaps even more useful to policy makers is understanding *why* these projects were developed. Policy makers have the capacity to structure the national policy environment in such a way that both private sector and public sector investments are attracted (i.e., market pull) to renewable energy projects and programs. While regulatory agencies have jurisdiction in specific aspects of project design, development, and operation, government in general tends to stay out of the actual project development *process*. This is the province of the project developer, whether a public agency or a private company.

As several of the case studies demonstrate, technically and financially successful projects tend to occur in substantial numbers, gradually penetrating a potential market. It is unusual to find isolated examples of highly successful projects. Successful projects reflect attractive market environments, often shaped by deliberate policy incentives. In such environments it is natural to find many similar projects. Also, through the development of many successful projects the relevant industries and government agencies learn how to improve the process and increase the economic and technical effectiveness of such projects. Professional practices become established, together with standards and appropriate regulatory initiatives, as an industry grows. This in turn usually makes it increasingly easy to develop the next project in this environment.

This has been the case in the United States for both large-scale grid connected wind power generation and for landfill methane recovery systems for power production and cogeneration, and for Thailand and Malaysia for biomass based cogeneration projects. Deliberate policy initiatives at both the federal and state levels in the United States over the past twenty years have stimulated technical, financial, and institutional innovation that have led to the development of the modern wind electric power industry. Such incentives have produced a large and rapidly expanding market for large-scale wind electric power plant investments. The array of incentives established in the US and several non-APEC economies in Europe are presented in an Annex to the case example for large-scale wind power. Understanding how such incentives can stimulate private investment in wind electric power development is at least as important as understanding the project development process itself.

Project Summaries

Off-Grid Small-Scale Wind Electric Power in China

China has had a unique success in the very large-scale use of small wind-electric turbines in free-standing applications for unelectrified households. Several hundred thousand wind turbines, both locally produced (in some cases under licensing or joint-venture arrangements) and imported are in use, most of them (more than 140,000) in the Inner Mongolian Autonomous Region (IMAR). Most of these have rated capacities of 100 – 400 watts. This is a private sector-driven activity, and relevant to many other APEC economies with unelectrified rural communities and households. Rather than being a project, this activity has been primarily the product of a government program. Total installed small turbine capacity is estimated at over 26 MWe. There are some recent installations as large as 5 kilowatts.

China produces more small wind turbines than any other economy and has forty small wind turbine manufacturers. Seventeen of them, including the largest manufacturer, are located in the Inner Mongolia Autonomous Region (IMAR). *This is by far the most extensive use of small wind electric turbines in the world.* Until recently the market has been the result of government incentives rather than a response to market forces. This now appears to be shifting, although the central government and the IMAR provincial government are committed to providing technical support to the industry.

Small wind turbines have been especially successful as a small power source in IMAR, where one-third of the rural remote herdsmen use wind electric generators to charge batteries to power televisions, radios, and lights. This region now has an extensive distribution and marketing infrastructure for household-scale wind turbines and wind electric units. The Chinese micro-turbines have been designed to perform well at the low wind speeds found at their typical hub height of less than 10 m. Chinese turbines generate power near their rated capacity at much lower wind speeds than do small turbines from OECD manufacturers; they are designed for the specific market requirements of the rural households, many of them nomadic. This case example demonstrates the effectiveness of public/private collaboration to promote the large-scale use of small-scale renewable energy technologies. It seems especially relevant to specific APEC economies including Chile, Mexico, the Philippines, and Indonesia.

Grid-Connected Photovoltaics in Japan

The Japanese government and the PV industry are working to achieve ongoing cost reductions for PV systems. The *New Sunshine Program* is an ambitious program that has installed over 120 MWp of photovoltaic generation capacity on rooftops throughout the country. The program was initiated in 1993 and has been *heavily oversubscribed by potential customers.*

This program is expected to strengthen the market demand for PV systems and to increase the competitiveness of Japanese PV products. In April 1997, following earlier initiatives to establish a residential PV program, a larger follow-on subsidy program was launched. This is the *Program for Developing Infrastructure for Introduction of Residential PV Systems*. This program reflects a deliberate and highly focused public/private partnership in Japan to create a world class PV industry that will be highly competitive internationally. A significant by-product of this initiative is the development of PV systems well suited to integration with buildings, laying the groundwork for future large scale use of PV technologies in the built environment of many of the APEC economies.

Because the urban centers of the APEC economies have many important similarities, successful implementation of this program could catalyze similar programs elsewhere in the APEC region. Recent work in the United States has revealed that there are already urban locations in the US where the value of PV-generated electricity would justify installed building-integrated PV system at current costs of $8 - $12 per peak kilowatt. This is based on the local cost of electricity and the utility load curve, as well as sunshine patterns. In many cities in APEC economies (including in Japan) similar conditions prevail. As these installed costs decline to the expected $4 - $6 per peak watt, the potential market for this technology/application option will become very large in many, perhaps most, APEC economies. In the US the potential market at this price level would be several thousands of megawatts (compared with a total worldwide aggregate installation of 1,000 MW of PV units today).

Off-Grid Photovoltaics for Rural Energy Services in the Philippines

The Philippines is emerging as an important proving ground for photovoltaic technology-based initiatives to address the needs of unelectrified communities. A highly innovative approach (the SunStation model) has been launched by Shell International and Community Power Corporation (CPC). It combines a new business initiative with specific community-focused projects. In collaboration with the Philippines Department of Energy and local government in the Province of Aklan, Shell Renewables Philippines has established the first of many planned rural energy services companies (RESCOs). The company is providing electricity *services* via both freestanding PV units and full-time AC power with a village low-voltage minigrid. The grid is presently powered by a 12 kWe PV/propane hybrid power generation unit. CPC has developed a 12.5 kWe small modular biopower (SMB) unit that will be introduced by Shell as a replacement for the PV/hybrid unit in regions where there are substantial available biomass residues such as coconut shells that can be used as high-quality feedstock for the SMB unit. This will permit greater levels of electricity service at dramatically lower costs. Hence, while this case example involves the use of PV technologies for off-grid rural energy services, it is market- and service-driven, not technology driven, and other renewable and low-green house gas (GHG) emission technologies are also used. *This market-based energy services enterprise approach is an important emerging paradigm for addressing the energy needs of unelectrified communities.*

About 100 residential customers (ca. 85% of all households) are connected to the minigrid, and most pay a weekly fee of a few US dollars equivalent for about one kilowatt hour of AC electricity daily, sufficient for basic lighting and information/entertainment services. A few households are paying a higher weekly fee for greater electricity consumption. Technology innovations from CPC and Shell permit the customers to *prepay* for AC electricity services, based on a contract with the RESCO office. A major innovation is that the fee for service is market-driven. It is *not* a subsidized electricity tariff, and is not being regulated by the Government.

The RESCO approach removes the technical and financial risks from the end users, requiring only that they operate the equipment properly and pay the periodic service fees. Shell is publicly committed to establishing ten such operations in the Provinces of Aklan and Palawan; if these are successful they will expand the operations and initiate such services in other economies. This project can provide a useful example for similar initiatives in many of the APEC economies.

Biomass-Based Cogeneration in Thailand

There is an enormous unrealized biomass cogeneration potential in several APEC economies including Indonesia, the Philippines, and China. Biomass residues are widely available at agro-industrial sites in many APEC economies. Those residues suitable for fueling cogeneration installations include wood waste, rice hulls, bagasse, palm oil nut residue, and coconut shells. The success of commercial biomass cogeneration projects in Thailand and Malaysia provides an important model for other APEC economies, and demonstrates the importance of risk reduction through facilitated access to technical and financial assistance. An example from Thailand has been chosen to illustrate both the effectiveness of the technology and the potent process of facilitation provided by the ASEAN-based regional *COGEN Programme* described in the example.

The Bangsue Chia Meng Rice Mill is one of the largest rice mills in Thailand, with a capacity for processing 500 metric tons of rice paddy per day. As a result of the interest expressed by the mill owner, a European engineering consulting company conducted a feasibility study for a 2.5 MW cogeneration facility that would be built on site at the mill. The plant was designed and financed with the assistance of the COGEN Programme, and was commissioned in March 1997. As with the other biomass cogeneration projects facilitated by the COGEN Programme, this investment has been both technically and financially successful.

Thailand has a favorable environment for the development of biomass cogeneration projects. Important considerations include the resource abundance, government policies that enable and provide incentives for biomass based cogeneration projects, the increasing demand for power from private sources, and the ongoing success of biomass projects that provides increasing comfort for potential investors in new cogeneration projects. Key elements of the favorable environment are presented in the case example.

The COGEN Programme, based at the Asian Institute of Technology (AIT) in Bangkok, has facilitated the development of dozens of successful biomass-based cogeneration projects in the Southeast Asia region, especially in Thailand and Malaysia. This program, which could be a model for similar consortia established by APEC economies, was initiated as a cooperative program of the European Commission and the Association of South-East Asian Nations (ASEAN). Its purpose is to accelerate the use of proven commercial equipment and technology for power generation and cogeneration from wood and agro-industrial residues through partnerships between European and Southeast Asian companies.

Grid-Connected Landfill Gas Recovery and Conversion in the United States

The United States has the most extensive and successful program in the world for recovery and economic use of methane generated from landfills. There are over 300 landfill methane projects in operation, and more under development. We have selected one of the premier landfill methane recovery projects for detailed review and presentation. This is the *Brown's Station Road Sanitary Landfill Gas Recovery Project* in Prince George's County, Maryland. The project was developed to provide both electricity and fuel (gas for water and space heating) for a correctional institution owned by the local government 3 km. from the land fill. The gas is piped to a powerhouse adjacent to the correctional facility. There, three 850 kWe engine generators provide the power. The county owns the facility, and generates positive cash flow from it.

Since 1988, the LFG to energy project has performed very well. The average on-line availability of each engine generator over the last nine years is approximately 92 percent. The overall systems availability including meeting heat fuel demand and electricity demand at the Correctional Complex is approximately 99.9 percent. Due to the performance of the system, the local utility, PEPCO, agreed to a 20-year power purchase contract that provides a capacity credit during the on-peak summer demand period in addition to kWh payment for electricity delivered. This project has transformed an environmental liability into an environmental and financial asset. Canada, China, Thailand, the Philippines, and South Korea are among the APEC economies with growing interest and commitment to the recovery and use of landfill methane emissions. The US program can provide a useful model for other APEC economies; virtually all of them have growing landfill waste management challenges. The "landscape" in which such projects have developed includes a federal environmental law requiring the capture and conversion of landfill methane emissions, and (typically on a state by state basis) financial incentives for such projects. Similar policy initiatives could underpin the emergence of strong markets for landfill methane recovery projects in other APEC economies. In addition the need to mitigate greenhouse gas (GHG) emissions will lend further support for landfill gas projects.

Grid-connected Wind Electric Power in the United States

Many of the APEC economies have large commercially interesting wind energy resources. Economies with known commercially important wind resources include Chile, Peru, Mexico, the United States, Canada, China, Japan, Taiwan, the Philippines, Australia, and New Zealand. Indonesia, often characterized as not very windy, has some areas where the wind resources are of commercial potential. Of all the APEC economies, only the United States has developed its wind resources on a significant commercial scale, with over 2,500 MWe of wind power plant capacity on line in the year 2000. China is in the initial stages of such commercial development, with about 250 MWe of capacity on line, Japan is developing some small commercial wind farms, and the Philippines is starting the commercial wind farm development process. Australia, Canada, Mexico, and New Zealand also have begun commercial wind power development.

The case example chosen is the 193 megawatt wind plant at Storm Lake, Iowa (US). This is the single largest wind power project in the world, although this record will fall shortly, with new larger projects under development. The project was developed by Enron Wind (US), which also built the 257 Zond 750 kWe wind turbines used in the project. In 1983 the Iowa State legislature introduced a law requiring that 2% of utility electricity should be generated from renewable energy sources. The local electric utilities opposed this legislation. However, after losing a ten-year battle in the courts, the utilities began to explore ways to respond to this mandate. In the mid-1990s Enron initiated negotiations for power purchase agreements with two Iowa electric utilities. A twenty-year power purchase contract was signed in March 1997, and the plant construction began in October 1998. In less than a year the plant was completed, commissioned, and started up. Producing electricity at an average cost of $0.045/kWh, the project has benefited significantly from the US federal production tax credit of $0.015, which lowered the net production cost to $0.03/kWh. This project reflects the market impact of enabling legislation and financial incentives that could also be established in other APEC economies.

The six case study project examples are presented in the following sections.

CHINA: SMALL-SCALE WIND ELECTRIC POWER

Figure 1: Residential Wind Electric System in China

Program Summary[1]

Less than ten percent of China's population remains formally unelectrified, with most of the unelectrified communities in the western provinces. These are typically poorer, more remote, and smaller communities. The national policy goal is to expand electricity access to the rural population. To accomplish this goal, the national and provincial governments have implemented several programs to electrify off-grid rural areas with the use of renewable energy.

Over the past 20 years, more than 160,000 households in rural China have been electrified with small wind turbine. Almost all of the turbines are rated at 100 to 300 watts. *Rather than being a project, this activity has been primarily the product of a government program.* Total installed small turbine capacity is estimated at over 26 MWe. There are some recent installations as large as 5 kilowatts. China produces more small wind turbines than any other economy and has forty small wind turbine manufacturers. Seventeen of them, including the largest manufacturer, are located in the Inner Mongolia Autonomous Region (IMAR). This is by far the most extensive use of small wind electric turbines in the world. Until recently the market has been the result of government incentives rather than a response to market forces. This now appears to be shifting, although the government remains committed to the support of the industry.

Small wind turbines have been especially successful as a small power source in IMAR, where one-third of the rural remote herdsmen use wind electric generators to charge batteries to power televisions, radios, and lights. This region now has an extensive distribution and marketing infrastructure for household-scale wind turbines and wind electric units. The Chinese micro-turbines have been designed to perform well at the low wind speeds found at their typical hub height of less than 10 m. Chinese turbines generate power near their rated capacity at much lower wind speeds than do small turbines from OECD manufacturers; they are designed for the specific market requirements of the rural households, many of them nomadic.

Even though over 160,000 small wind turbines have been installed in China, it is estimated[2] that at least 15% of them are not in operation due to several factors; among them is inconsistent quality of the turbines. Most of the turbines produced in China today are "old" technology that has not benefited from recent advances in small turbine design and manufacture. In some cases the turbines are not operating because the grid has been extended to households

[1] We are grateful to Dr. Debra Lew of the US National Renewable Energy Laboratory (NREL) for permission to incorporate or paraphrase materials that she prepared on the small wind turbine program in China.
[2] China Center for Renewable Energy Development (CRED), Beijing. *Private communication.*

that were using wind turbines, and the turbines were simply abandoned. In other cases the units failed and were never repaired or replaced. For the older machines the lack of spare parts is an obvious problem. Under the *Program on New and Renewable Energy Development in China (1996-2010)* approved by the State Council, the government is committed to continue its support to improve the production, marketing, and technical performance of locally produced small wind turbines.

Figure 2: Contemporary Yurt with Portable Small Wind Turbine

Although there are no international joint ventures for small wind turbine systems in place in China, the central government and the IMAR government are trying to encourage such linkages. Under agreements that China has forged with several other APEC economies (Indonesia, Philippines, Viet Nam, Cambodia, Laos, and others), about 15% of the small wind turbine production is being exported with Chinese government development assistance. Similar joint ventures may be an important commercial opportunity for some APEC economy producers of advanced small turbine systems.

Program Development Roadmap

The "roadmap" for China's small wind turbine dissemination program[3] is diagrammed in Figure 4 at the end of this section. The following describes the major elements of the roadmap.

Program Setting

Less than ten percent of China's population remains unelectrified, with most of the unelectrified communities in the western provinces. These are often poorer, more remote, and smaller communities. The national policy goal is to expand electricity access to the rural population. To do this, the national and provincial governments have implemented several programs to electrify rural areas with renewable energy.

The development of the small wind turbine industry and market has been largely within Inner Mongolia. Most of the IMAR is grassland, and many of the rural people are herdsmen and farmers. The average per capita annual income is about 2,000 Yuan ($240). This is relatively wealthy for a rural, unelectrified population in an underdeveloped Chinese province.

The IMAR government has promoted the deployment of the small wind turbines to provide electricity services to the rural residents of IMAR and to support and promote its small wind turbine manufacturing industry. To achieve these objectives, IMAR has provided a financial

[3] For detailed background information, see Debra Lew, Alternatives to Coal and Candles: Wind Power in China. *Energy Policy*, 28 (2000), 271-286; Debra J. Lew, C. Dennis Barley, and Lawrence T. Flowers (5 March 1997). *Hybrid Wind / Photovoltaic Systems for Households in Inner Mongolia*. International Conference on Village Electrification through Renewable Energy, New Delhi, 3-5 March 1997. The authors are with the US National Renewable Energy Laboratory.

Figure 3: 500-watt PV/wind Hybrid System

incentive to households who installed the wind turbines. The subsidy was made available in the form of a coupon to households. The coupon was redeemed at the time of purchase of a small wind turbine. A subsidy of about 200 – 300 yuan[4] is available only in Inner Mongolia.

Although the Chinese central government provided research and development support for small wind turbine technology, the government has had a minor role in the commercial success of small-scale wind turbine dissemination. The local governments in some rural windy provinces such as Xinjiang and Qinghai have only been mildly successful in disseminating small-scale wind turbines. The government of IMAR has the most aggressive policy of wind power utilization. More than 90% of the small-scale turbines in China are located in IMAR.

Program History

In the early 1980s, small wind turbines were imported from abroad, especially from the Netherlands and Denmark. The unit sizes ranged from 50 to 1,000 watts. Most were in the range of 50 – 100 watts, and were used for battery charging, to power lights and radios. A government program was initiated to develop a small wind turbine industry, and a 20% end-user subsidy was instituted (and still remains).

The Inner Mongolian government has long viewed wind power as an exploitable energy source, a boost to the local economy and solution to rural electrification. In 1980, the Science and Technology Commission of IMAR declared renewable energy development and utilization a priority program. They emphasized local development and implementation with the following guidelines:

- To develop stand-alone wind, PV and balance of systems components for remote areas;
- To develop systems that were reliable and convenient to operate and maintain and affordable for rural people;
- To integrate needs for production and daily life of the herdsmen; and
- To ensure that local people were in charge of the program, with the State providing appropriate support

The local government integrated the research, production and outreach components of their program into a single continuous system. In 1984, the New Energy Office was established to manage the renewable energy program. This agency set policies for renewable energy development, conducted near- and long-term planning for renewable energy, and coordinated activities in research, production and dissemination.

[4] US$1.00 = 8.3 yuan (October 2000)

During this same time, the central government was establishing an extensive network of rural energy offices to disseminate information and provide technical training and service at the county level. These offices have been instrumental in deployment of the small-scale renewable energy technologies. During the Seventh Five-Year Plan (1986-90), low-interest loans were given to local industries to build up manufacturing capabilities.

In addition to the central government's rural energy offices, the IMAR regional government had established new energy service stations in over 60 of the region's 88 counties by the early 1990s. These stations provide information and subsidies specifically for renewable energy systems. Their technical and training sites provide additional technical support. The Chinese realized that to accelerate development of wind power, they needed to introduce advanced wind turbine technologies from abroad. Technology was acquired from foreign research institutions and industries. By 1987, 38 types of wind turbines had been imported for technology transfer and cooperation - nearly all of which were micro-turbines and small turbines.

With the dissemination and management infrastructure and local production of wind turbines established the local government developed the market for the turbines by reducing a critical barrier: affordability. In 1986, the Inner Mongolian government began offering a financial incentive of 200 Yuan per turbine (or PV panel) and 50 Yuan per battery for components manufactured in IMAR (Lin, 1988). This is the first subsidy that the government has offered for development of renewable energy. The process for obtaining the subsidy was quite simple: the herdsmen went to their local new energy office and obtained a coupon that they brought to the Inner Mongolian turbine manufacturer of their choice. This helped to build up the local industry. The local government and utility each provided 5 million Yuan annually for these programs. Currently, subsidies are about 100 Yuan per 100 W rated capacity for the wind turbine and they do not apply for batteries. This program was completely driven by the local government until 1990, when the central government began contributing about one-third of the wind power subsidies.

These programs have helped stimulate the establishment of a domestic small wind turbine industry. With forty manufacturers, China now produces more turbines than any other economy. Most of the turbines are 100-watt units used in single households, although 300-watt units have recently become very popular. Shangdu Livestock Machinery Works reports production growth of 58% per year to about 10,000 units in 1996. In 1996 the total annual production in China was estimated at 20,000 units. China also exports these turbines to various Asian economies including Mongolia, Malaysia, Viet Nam, Pakistan, Sri Lanka, and Japan. In addition to creating a manufacturing industry, by 1989, over 10,000 people were trained for construction, installation, and/or maintenance of wind turbines.

While the IMAR programs have been successful from a deployment perspective, the sustainability of these systems has not been established. Estimates from the early 1990s indicated that of all wind turbines in IMAR, 85% were in good condition. This is remarkable in light of the fact that these wind turbines have reported lifetimes of 10-12 years, and that parts of the turbines are reportedly of questionable quality, especially the blades, which must be replaced more often. *Recent anecdotal evidence*[5] *suggests that these figures have overestimated the real situation and that many turbines are no longer operational. There is a need to*

[5] Personal communications from program managers at the Chinese Academy of Sciences, with the US DOE/China collaboration and with the GTZ/China collaboration.

formally survey these systems to ascertain the performance of these turbines and the sustainability of the systems.

Program Financing

Nearly all sales of household wind systems have been for cash. A relatively wealthy rural population, low-cost locally manufactured equipment, and the government financial incentive have made the systems affordable. In order for the dissemination program to reach less affluent households, mechanisms including credit sales, equipment leasing, and fee-for-service energy service companies may need to be developed.

Recent studies indicate that wind generators are the least-cost option for household electricity in the four counties of the IMAR. Small wind generators in the 100-, 200-, and 300-W size range are manufactured locally in IMAR for the household market. The levelized cost of energy for small PV/wind hybrid and PV systems is higher than the cost of electricity generated by wind systems, but all of these renewable systems options result in a significantly lower cost of electricity compared to gasoline engine generator sets.

Table 1: Levelized Cost of Energy for Rural Electrification Options in Inner Mongolia

System	Output range (kWh/yr)	Levelized cost based on Mfr. Quoted battery lifetime ($/kWh)	Levelized cost based on battery lifetime from field analysis ($/kWh)
Wind only	200-640	0.24-0.37	0.50-0.63
PV only	120-240	0.67-0.73	0.77-0.83
Small hybrids	400-750	0.31-0.46	0.57-0.72
Large hybrids	560-870	0.32-0.46	0.43-0.57
Diesel gensets (not serving continuous duty cycle applications)	660-730	0.76-0.80	0.76-0.80
Diesel gensets (serving continuous duty cycle applications)	480-560	1.09-1.19	1.16-1.27

Source: John Byrne et al. (March 1996). Levelized Cost Analyses of Small-Scale, Off-Grid Photovoltaic, Wind, and PV-Wind Hybrid Systems for Inner Mongolia, China, Center for Energy and Environmental Policy, University of Delaware, Newark, Delaware.

Program "landscape" / environment

The environment of the program is dominated by several interwoven elements. These are the national and provincial government policies and programs, the nature of the market in Inner Mongolia, the growing presence of wind turbine manufacturers, and the emergence of small PV/wind hybrid units as a commercial technology. The government is planning to have 23 million people in remote areas electrified by wind and PV technologies by 2010. The Chinese government initiated the *Brightness Program* to stimulate further the market demand for renewable energy technologies and electrification of rural areas. China has regions that are quite windy, including Xinjiang Autonomous Region, Gansu Province, Inner Mongolia, and along the southeast coastline. In Inner Mongolia alone there are more than 300,000 households, 1,100 villages, and 198 townships that are unelectrified. The use of subsidies for rural systems is being phased out and commercialization based on market forces is being encouraged. Thus the "landscape" includes supportive central and regional government policies, international technology cooperation, a large potential market with sufficient interest and the payment ability to realize a large real market. It also includes the climate conditions that make small wind turbines an economically as well as logistically attractive option for unelectrified households and for small installations for community facilities and economically productive uses.

Wind power brightens prairie (from the China Daily, 09 May 2000)

The sparsely-populated Inner Mongolia Autonomous Region is particularly rich in wind power. The Inner Mongolia Wind Power General Company estimates that the total wind power in the region is greater than 1,000 GW. Starting in 1996, the government of IMAR stepped up efforts to provide electricity to remote grasslands through using wind-driven generators.

Wind-driven electricity generators are the key to bringing light to remote Inner Mongolia, Xinjiang Uygur and Tibet autonomous regions, Qinghai and Gansu provinces and some coastal islands. To help the 23 million people in these remote areas use electricity, the State Development Planning Commission launched the China Brightness Project in 1999 to popularize the utilization of wind-power technology in these areas.

The project was first tried in Inner Mongolia, Tibet and Gansu early this year. A recent survey conducted among the 27,000 households in Inner Mongolia indicated that most residents are willing to buy wind-driven generators if finance permitted. "It is impossible for local government to help all residents buy wind-driven generators. Regional governments should help farmers to obtain loans to buy wind-driven generators," said Ma Shenghong, deputy-director and senior engineer of Beijing Jikedian Renewable Energy Development Centre, which conducted the survey.

Entrusted by the State Development Planning Commission, the centre undertakes the implementation of the China Brightness Project, including technological service, quality inspection and assessment of wind-driven electricity generators that are installed in Inner Mongolia and other piloted areas.

The First Phase Plan of the Chinese Brightness Program (CBP)

The objective of the First Phase of the Chinese Brightness Program is to supply about 8 million people (1.78 million home systems), 2,000 villages, and 200 boarder and microwave stations with off-grid electricity. The goals of the program are summarized in Table 2. The total investment for the first phase is estimated at 10 billion Yuan ($1.2 billion). The users are expected to pay 86 percent while local governments in grants and loans will provide 6.7 percent, the central government in grants will contribute 2 percent and international foreign assistance is expected to provide the remaining 5 percent of the initial capital cost. The market pull from the Brightness Program is expected to reduce the production, distribution, and service cost of the wind and solar energy systems by more than 20 percent.

Table 2: System Installation Goals of the Chinese Brightness Program

System	Approximate Peak Power per System (W)	Electricity Consumed (Wh/day)	Number of Systems	Installed Capacity (MW)	Total Investment (million Yuan)
Home Systems					
- High consumer	526	1,830	356,000 (20%)	187	4,545
- Mid consumer	62	260	801,000 (45%)	50	3,520
- Small consumer	24	100	623,000 (35%)	15	894
Village Systems	17,000	62,200	2,000	34	890
Total				286	9,849

There is still no effective quality assurance system for either wind or PV systems in China. To address the need for quality control, all equipment procured under the Brightness Program will be certified. Suppliers will be selected on a competitive bidding basis to ensure the most favorable prices.

Under the current program end users may select from various systems options in accordance with their energy requirements. The cost of electricity is in the range of 2 to 6.5 Yuan per kWh depending on local wind and solar resources. Small Chinese wind turbine systems cost about 15 Yuan per watt, PV home systems are about 80 Yuan ($10) per watt, and hybrid systems (40 watt PV, 300 watt wind, plus battery and inverter) cost about 30 Yuan per watt. If the mean wind speed is more than 4.5 m/s, the wind home system is normally the least-cost option. However, in some regions, such as Inner Mongolia, it tends to be windy in the cloudy winter, but with little wind during the sunny summer. PV/wind hybrid power unit are well-suited to providing basic electricity services all year under these conditions. This recognition has led to the development of commercial small wind/PV/battery/inverter systems. These typically combine a 50-watt PV panel with a 300 – 400 watt wind turbine, plus battery and small DC/AC inverter. The development of this important new option is described below.

Program Lessons Learned

China's small wind program is now evolving rapidly, and lessons continue to be learned. However, some observations from the program to date are the following:

- Government-driven programs can stimulate the emergence of a renewable energy technology market, but by themselves they are rarely able to facilitate the transition to a commercial market-driven activity.

- Without the discipline of market-based competition, there is little incentive for quality control, after-sales service, and development of new technology. Until recently the locally made small wind turbines were using what is now twenty year old technology, and China's best small wind turbines are considered seriously inferior to their counterparts from several other economies, including APEC economies. Quality control and equipment reliability remain major problems, and are disincentives for potential customers.

- Higher value markets (e.g., Inner Mongolia households, with relatively high rural incomes and the need for portable power) are the appropriate market entry point for small wind and solar power units.

- Hybrids appear to have special commercial and market appeal in China. Technical assessment by the US National Renewable Energy Laboratory and the University of Delaware shows that small PV/wind hybrid systems with battery storage are an attractive option for household systems in Inner Mongolia. These systems are more reliable electricity sources than PV or wind systems alone because of the complementary seasonal wind and solar resources. It is windy but not sunny in the winter, and sunny but not very windy in the summer.

- PV, wind, and PV/wind hybrid systems are all lower-cost options for small rural energy systems than fossil-fueled generators in rural China.

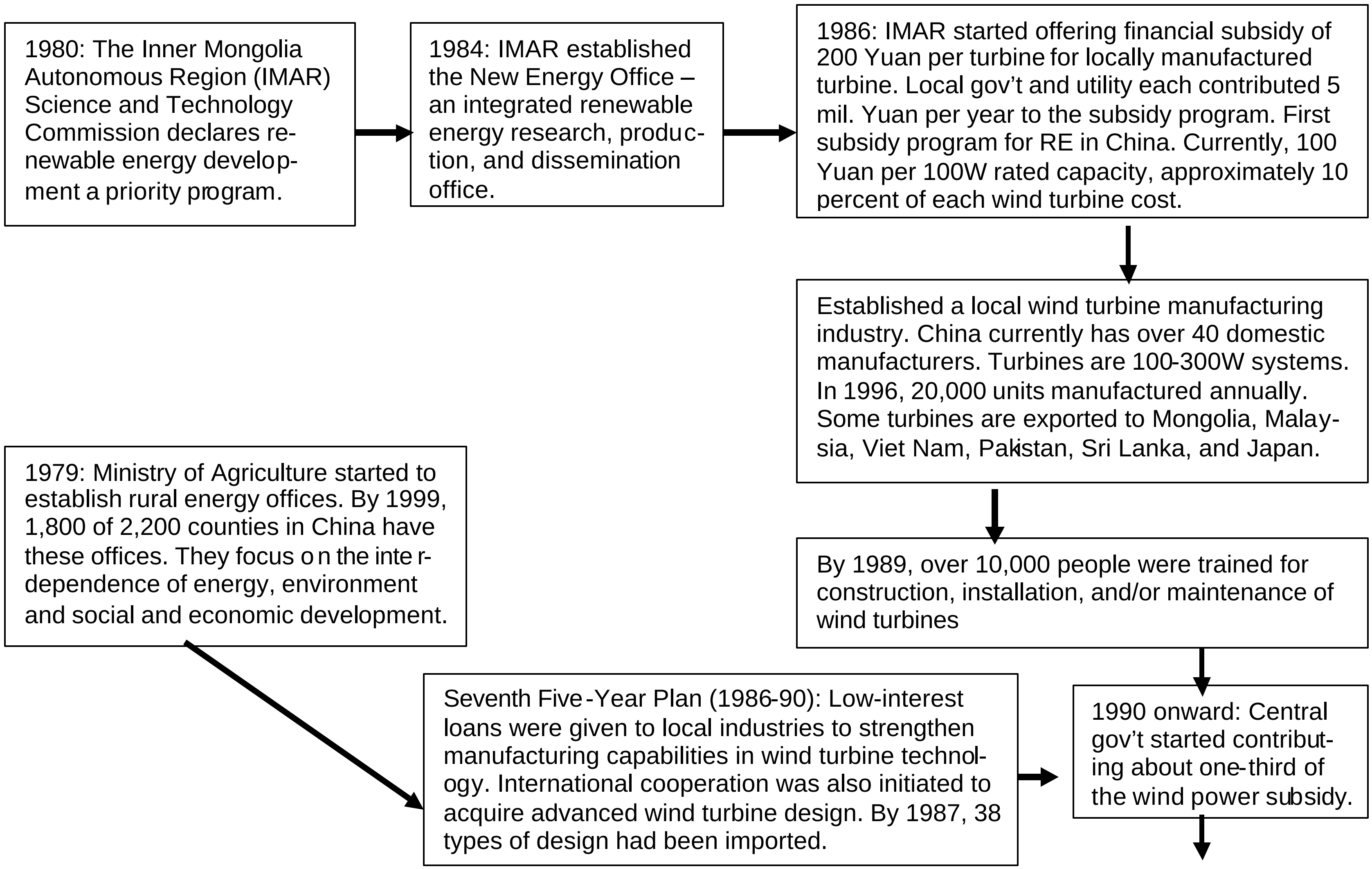
Future Developments

We increasingly expect to see small wind/PV hybrid units used in place of wind or PV installations alone, especially in regions where there is a seasonal strong complementarity between the availability of solar energy and wind energy. The recently launched program for commercial development and subsequent diffusion of over 40,000 small hybrid units will test this potential market. For unelectrified rural communities in other APEC economies, small hybrid systems may be of interest if there are good wind resources available. This would apply to some regions of the Philippines, Indonesia, Viet Nam, Mexico, and Chile, for example.

The living standards and quality of life of some unelectrified rural households and communities are improving with the growing commercial diffusion of PV, wind, and small hybrid power units for household-scale applications. The potential market for these units is very large, and extends well beyond Inner Mongolia. Other regions in China with significant market potential include northern and western China, and unelectrified inhabited coastal islands.

The World Bank has estimated that in the five northern and western provinces and in the autonomous regions of Qinghai, Tibet, Inner Mongolia, Xinjiang, and Gansu alone, there are at least 2.2 million unelectrified households that are located in regions where the grid is not present. For more than 300 inhabited islands and potentially several thousand uninhabited coastal islands that might eventually be populated, the development of grid power in the near term is also not considered feasible by the Chinese government. Renewable energy technologies can be used for sequenced pre-grid electrification and minigrid electrification to meet some or all of the energy required for community and economically important activities.

Figure 4: Schematic Roadmap of the China Small Wind Electric Program



Starting in 1996, the government of Inner Mongolia Autonomous Region stepped up efforts to provide electricity to remote grasslands through using wind-driven generators.

By 1999, over 160,000 stand-alone wind turbines (100W-5kW) with a total capacity of 26.3MW had been installed in China. (UNDP/GEF China RE Commercialization Project). Nearly all installations to date of household wind systems have been cash sales. A combination of a relatively wealthy rural population, relatively low-cost locally manufactured equipment, and the government financial incentive has made the systems affordable for the users. The use of subsidies for rural systems is being phased out and commercialization based on market forces is being encouraged. One-third of the rural, remote herdsmen use wind electric generators to charge batteries, and power televisions, radios and lights.

WWF's China Programme Office will launch training programmes to help residents in Inner Mongolia and other remote areas learn how to use clean energy-powered electricity generators. The office will also initiate a series of training and publicity programmes to enhance the public's awareness.

In 1999, the State Development Planning Commission launched the China Brightness Project to provide 23 million people in the remote areas with electricity. The Brightness project will utilize wind-and solar PV technologies to provide power to the rural population. A recent survey conducted among the 27,000 households in Inner Mongolia indicated that most residents are willing to buy wind-driven generators if financing is available.

Wind-driven electricity generators are the key to bringing light to remote Inner Mongolia, Xinjiang Uygur and Tibet autonomous regions, Qinghai and Gansu provinces and some coastal islands (China Daily, 5/9/2000).

Support from SDPC in the areas of technological service, quality inspection and assessment of wind-driven electricity generators.

Annex: Inner Mongolia Household PV/Wind Hybrid Systems Pilot Project

A Collaborative Program[6] between the
US Department of Energy and the US National Renewable Energy Laboratory,
and the People's Republic of China

Pilot Projects for Home Based Solar/Wind Systems

The US Department of Energy and the China Ministry of Agriculture (MOA) signed an agreement for *Developing Cooperation in Rural Electrification* on June 27, 1995. This was the first initiative for cooperation and project development under the US/China *Energy Efficiency and Renewable Energy Protocol.* The objectives of the rural electrification collaboration include (1) to promote sustainable development in rural areas of China by accelerating the deployment of renewable energy systems, (2) to demonstrate the technical and economic feasibility of these technologies for rural inhabitants, and (3) to the facilitate development of links between the Chinese and U.S. renewable energy industries. The scope of this collaboration includes work on PV systems, small wind turbines, and hybrid power systems. Major projects include provincial household surveys for market characterization and rural electrification options analyses in Inner Mongolia, Xinjiang, Qinghai, and Gansu, and a remote household wind/solar hybrid system project in Inner Mongolia.

Current cooperation with Inner Mongolia is focused on completing the installation of 240 PV/wind home based systems during 1999. The typical demonstration system consists of: (1) a 100-watt wind turbine combined with 50-70 watts of PV or (2) a 300-watt wind turbine combined with 150-200 watts of PV, with battery storage. These systems are capable of delivering 0.6 kWh/day and 1.6 kWh/day, respectively, with high reliability. The systems provide energy for lighting, color television, consumer electronics, and some discretionary load. Systems of 450-500 Watts can also maintain a refrigeration load. Food storage by freezing is a major driving force for larger system development, even in colder climates. Summer is very hot in Inner Mongolia, which borders on the southern edge of the Gobi desert.

The Inner Mongolia Autonomous Region's (IMAR) government has been aggressive in developing renewable energy resources for both grid-connected and off-grid applications. Over the past 10 years, more than 120,000 households have been electrified with small wind generators in the range of 100 to 300 W. In addition, more than 7,000 small PV systems (total of 120 kWp) have been installed in remote households. However, there are still more than 300,000 remote households, 1100 villages, and 198 townships that are unelectrified in remote rural regions of IMAR. By the year 2000, the New Energy Office of IMAR plans to install 25,000 remote household systems using wind, PV, and wind/PV hybrid systems and in the longer term a total of 80,000 systems throughout IMAR. The use of subsidies for rural systems is being phased out and commercialization based on market forces is being encouraged. The rural population of Inner Mongolia, consisting of herdsmen and farmers, has among the highest annual income levels of the rural populations in China.

An attractive option for household systems resulting from the analysis and prior research in Inner Mongolia is the use of PV/wind hybrid systems with battery storage and (optional) a small DC/AC inverter. These systems are more reliable than PV or wind systems alone because of the seasonal wind and solar resources, with wind relatively more available in winter

[6] This summary draws directly on materials provided by Dr. Debra Lew, US National Renewable Energy Laboratory (NREL). We are grateful for her considerable assistance to the authors.

months and solar relatively more available in summer months. Analyses show that wind, PV, and PV/wind hybrid systems are lower-cost options for rural energy systems than fossil-fueled generators.

The New Energy Office of the Science and Technology Commission in Hohhot is participating in the development and deployment of PV/wind hybrid household systems in Inner Mongolia. Other partners include the Inner Mongolia Polytechnic Institute, the University of Inner Mongolia, the Chinese Academy of Sciences in Beijing, the Shangdu Machinery Company in Inner Mongolia, and the JiKe Company in Beijing.

Renewable Energy Options Analysis

In the first phase of cooperation, the University of Delaware (US), NREL, and the Inner Mongolia team completed a levelized cost analysis of rural electrification options for several counties. The analysis compared renewable energy options with conventional gasoline engine-driven generator sets based on local renewable resources and costs. In1995 NREL, the Center for Energy and Environmental Policy at the University of Delaware, and the Chinese Academy of Sciences in Beijing initiated an analysis of rural electrification options in IMAR. The project was conducted in cooperation with the Planning Commission and the New Energy Office of IMAR, which are the two key agencies responsible for renewable energy planning. Other participating organizations included the University of Inner Mongolia, the Inner Mongolia Polytechnic University, and several local companies.

The case study project involved levelized cost analyses of existing systems in four counties in the central and northern regions of IMAR. Solar and wind resource data were collected from the four counties and performance/load data were obtained for 10 PV systems, 22 wind systems, and 6 PV/wind hybrid systems ranging from 22 watts to 600 watts rated capacity. Two gasoline engine-driven generator sets (ca. 500 watts), commonly used by households and ranches, were evaluated for comparison with the renewable energy options.

The results of this first phase of the case study, the levelized cost-of-energy analyses, are shown above in Table 1. For the types of systems currently being deployed for stand-alone electrical generation in rural areas of IMAR, wind generators are the least-cost option for household electricity in the four counties. The levelized cost of energy for small PV/wind hybrid and PV systems is higher than the cost of electricity generated by wind systems, but all of these renewable systems options have a significantly lower cost of electricity than that of gasoline engine generator sets. Moreover the energy from the renewable energy systems is available full time, provided the batteries are sufficiently charged. Generators tend to be run only a few hours daily.

Analysis and field trials demonstrate that hybrid systems appear to be more reliable and economical than wind or PV systems alone. The use of small wind/PV/battery hybrid systems for remote-household electricity is attractive because of the complementary seasonal solar and wind resources.

The New Energy Office of IMAR and the Inner Mongolia Planning Commission are planning to expand the use of wind/PV hybrid systems by remote herdsmen's families for household electrification. NREL and the Center for Energy and Environmental Policy at the University of Delaware are providing technical assistance to these agencies in optimizing the design of such systems. Based on annual income levels, two types of systems are receiving attention. Hybrid systems with capacities of 400 to 500 watts are being developed to serve household loads that include lighting, a color television set and radio, a small washing machine, and a small freezer, requiring approximately 1.6 kWh per day of energy. Smaller systems in the 150 to 200 watt range are being developed for intermediate-income-level households to supply 0.6-0.7 kWh per day for household loads that do not include a freezer or washing machine. *This suggests additional opportunities for international joint venture opportunities for qualified firms in APEC economies.*

Japan: Grid-Connected Residential Photovoltaics Program

Program Background

In 1993 the Japanese government combined its Sunshine Project, Moonlight Project, and the Research and Development Project for Environment Technology into the New Sunshine Program. The goal was to intensify the development and promotion of environment friendly energy technologies including photovoltaic (PV) applications. The program has installed over 120 MWp of PV capacity on residential rooftops throughout the economy. The broader goals were to help ensure economic development, environmental protection, and energy security.

Figure 5: Grid Integrated PV Rooftop System

Diversification of energy resources is an important concern for Japan. In 1996, only 18 percent of energy consumption in Japan was supplied by domestic sources. Due to this very high dependence on energy imports, the Japanese government has placed a high priority on research and development of new and alternative energy resources.

The government has also made the commitment to protecting the global environment by signing the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). This commitment required that Japan reduce it emissions of greenhouse gases by 6 percent below 1990 level by 2010 (technically the average of emissions in 2008 to 2012 will be used as the benchmark).

The revised "Long-term Energy Supply/Demand Outlook" projections produced by the government in June 1998 predicts that in the Business-as-usual (BAU) scenario, the consumption of energy in 2010 will be 456 million kiloliters of crude oil equivalent. This is 16 percent above the 1996 consumption level. The emissions of carbon dioxide are predicted to be 21 percent above the 1990 level.

In implementing policies to meet the Kyoto Protocol commitments, the Japanese government at the Cabinet Meeting in October 1998 adopted the "Law concerning Promotion Measures to Arrest Global Warming" and plans to increase the contribution of New Energy (primarily solar and wind, hydropower and geothermal are accounted for separately) in the energy supply from 1.3 percent in 1990 to 3.1 percent in 2010. The promotion of measures against global warming is the *first law in the world to obligate local and national governments to make efforts to reduce emissions of greenhouse gases.*

Figure 6: Prototype PV Roof "Shingles"

New Energy Policies and Goal

Under national policies for promoting the use of new energy, the Ministry of International Trade and Industry (MITI), the key authority in charge of energy policy, in collaboration with local and national government agencies, private enterprises, and individuals develops programs that promote the use of new energy. MITI-supported new energy programs in 1998 and 1999 include:

- Promotion of technological research and development of PV power systems;
- Assistance in establishing residential and industrial markets for PV application;
- Promotion of development and increased use of clean energy vehicles; and
- Support to enterprises that use wind power, cogeneration, fuel cells, and power generation from waste incineration.

The primary objective of the new energy program is to stimulate demand for new and renewable energy technologies and to develop a sustainable market. In promoting the increased utilization of solar energy through PV applications, the government policy focuses on two primary approaches in achieving this goal. The first approach aims at reducing the cost of PV systems by raising the efficiency of PV cells and reducing the manufacturing, balance of system, and installation costs of the systems. A second approach calls on accelerating the application of PV systems by increasing the market demand especially from residential customers. The higher demand is also expected to lower the manufacturing cost of PV modules through mass production.

In supporting the large-scale application of PV systems, MITI has a target of cumulative installed capacity of 5,000 MW of PV applications by 2010. This undertaking will be administered by the New Energy Foundation (NEF), responsible for promoting residential applications, and the New Energy and Industrial Technology Development Organization (NEDO), responsible for industrial and other applications, in partnership with municipal corporations and utilities. In addition to the installed capacity goal, the PV program under the New Sunshine Program aims to reduce the total installed cost of PV systems to Y300 ($2.7[7]) per peak

[7] US$ 1 = 110 Japanese Yen (November 2000)

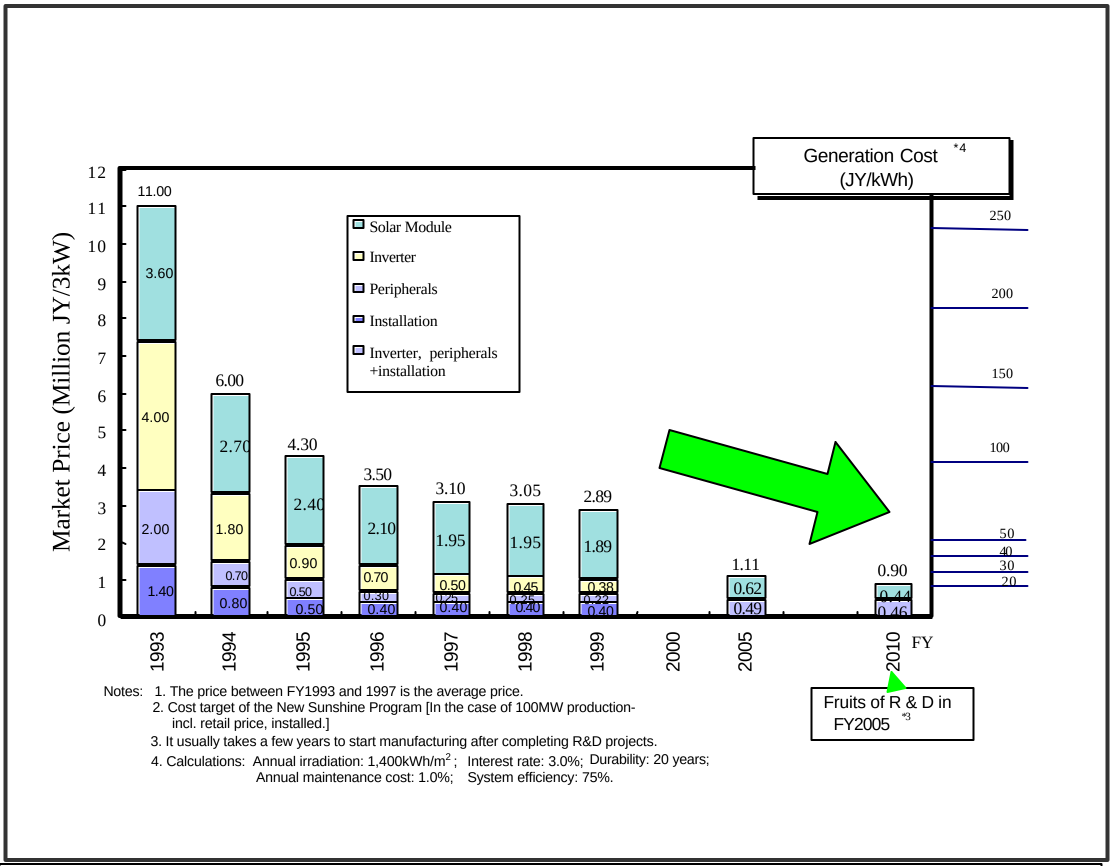


Figure 7: Trends and Targets of Residential PV Systems Costs
Source: Takekawa, T., New Energy and Industrial Technology Development Organization (NEDO), Japan. Presented at 17th APEC New and Renewable Energy Technologies Expert Group Meeting, 2-3 November 2000, Cuernavaca, Mexico.

watt by 2010 from the current cost of Y950 ($8.6) per peak watt. Figure 7 shows the trend in decline of market price of residential PV system and target installed costs for 2005 and 2010.

Program Roadmap

Since the 1970s Japan has investigated and applied new energy technologies, including photovoltaics, as alternatives to the use of conventional energy resources. However, significant policy initiatives for large-scale implementation of new energy technologies did not take hold until the early 1990s. Some key legislative and policy measures that preceded the current large program to promote residential PV systems are outlined below.

In 1992, the electric power companies agreed to buy the surplus power from PV and wind power systems from distributed sources at the selling price of electricity. This triggered a leap in the application of new energy in Japan. NEDO also began field-testing of PV applications at public and industrial facilities.

In 1993, the technical guidelines for interconnection of new energy power including residential PV systems to the utility grid were disseminated. The guidelines facilitated installation of grid integrated rooftop PV systems. The New Sunshine Program aimed at accelerating commercialization of PV power and fuel cell technologies, among others, was also launched by MITI in the same year.

In 1994, the "Basic Guidelines for New Energy Introduction" was approved at a Cabinet Meeting. The Guidelines set PV installation targets of 400 MW by 2000 and 4,600 MW by 2010. To meet the objective of the target, the *Monitoring Program for Residential PV System* was initiated to induce market demand for residential PV and reduce cost through mass production. Since the cost of electricity from PV systems was much higher than from both conventional power generation and some other renewable energy sources, the program provided a 50 percent subsidy to the installed cost of residential PV system in return for system performance and use data monitoring for 3 years.

In 1996, the Advisory Committee for Energy made a recommendation to the Energy Policy for developing a self-sustaining PV market. In the same year, the Economic Structure Plan of MITI identified the PV industry as the target for new industry creation in the new energy field. In the following year, the *Law concerning Promotion of the Use of New Energy* was passed to further promote the utilization of new energy including PV power generation. Also, the *Monitoring Program for Residential PV System* was expanded to the *Program for Developing Infrastructure for Introduction of Residential PV System* to further develop the PV market that can be sustainable after 2000 and to strengthen the Japanese PV industry.

Incentive Programs to Develop the Market for Residential PV Systems

Under mandates to increase the utilization of new energy in Japan, MITI through the New Energy Foundation (NEF) and in partnership with private enterprises launched a residential PV program, *Monitoring Program for Residential PV System*, to create demand in the residential sector for PV power systems, to reduce the cost of production and installation through greater demand, and to collect grid connected PV operation data and consumer use patterns. The program provided a 50 percent subsidy on the installed cost of a new residential PV system. The grants were given on a lot basis to applicants and approximately 50 percent of the applicants received subsidies.

The grant recipients are required to sell excess power from installed PV systems to the grid. The price received by the household is equivalent to the price charged by the utility. The grant recipients are also required to report monitored data for 3 years after the installation.

Under the three-year *Monitoring Program*, 3,590 systems were installed with a total capacity of 13 MW, an average of 3.7 kW per system. Table 1 shows the number of systems installed and the total capacity per year. During the implementation of this program, the installed cost of rooftop PV systems reduced by approximately 50 percent from Y2,000 ($18) per peak W to Y1,000 ($9) per peak W.

Table 3: Results of "Monitoring Program for Residential PV System"

	1994	1995	1996	Total
Number of grant recipients	539	1,065	1,986	3,590
Total Installed Capacity of PV systems (MW)	1.9	3.9	7.5	13.3
Average Capacity per system (kW)	3.5	3.7	3.7	3.7

Source: New Energy Foundation, May 2000. *Incentive Program for Residential PV System in Japan*.

To further accelerate the market demand for rooftop PV systems, MITI initiated a second larger PV incentive program, *Program for Developing Infrastructure for Introduction of Residential PV System*, in April 1997 to provide grants to a significantly larger number of applicants than in the first program. To achieve this, the selection of grant recipients was changed from a lot-based selection to a first-come-first-served basis. Also, since a significant reduction in the installed cost of PV systems was achieved during the first program, the grant for each system in the second subsidy program was reduced from 50 percent to approximately one-third of the installed cost.

The primary objective of the second PV incentive program is the establishment of a sustainable market for PV power systems by further reducing system cost through increased production. The program also aims to develop the infrastructure for the PV market. During the first year of this program, 5,654 grants were given to homeowners who installed PV systems on their roofs. The number of grant recipients in 1997 was larger than the total number that received grants in the three years of the first subsidy program, *Monitoring Program for Residential PV System*. For 1998, the number of applicants rose to 12 percent above 1997 (see Table 2). Due to the popularity of the program and the initiation of subsidies and loan programs by local governments (see Table 3 for a list of local government financial incentive programs), the number of recipients of the national grants rose dramatically to over 17,000 in 1999. This resulted in the installation of 65 MW of PV power in Japan.

Prior to the two PV incentive programs, the installed capacity of PV systems in 1990 was 9 MW. Due to the success of these market stimulation programs, the total installed capacity of residential PV systems in early 2000 was at 120 MW. In terms of capacity, more MW of PV systems were installed on residential rooftops in 1999 than the combined first five years of the two programs.

> *This achievement has convinced the government that PV is a real business, and it will, therefore, drop the subsidy in the 2002 financial year. [However,] the PV companies feel that three years is not long enough to drastically reduce the price of PV-generated electricity, which still costs three to seven times more than conventional energy.*
>
> *Renewable Energy World, September/October 2000*

Table 4: "Program for Developing Infrastructure for Introduction of Residential PV System"

	1997	1998	1999	Total
Number of grant recipients	5,654	6,352	17,396	29,402
Total Installed Capacity of PV systems (MW)	19.5	24.1	64.8	107.9
Average Capacity per system (kW)	3.5	3.8	3.7	3.7

Source: New Energy Foundation, May 2000. *Incentive Program for Residential PV System in Japan.*

Summary and Conclusions

The Incentive Programs to develop the market for residential PV systems reflect a deliberate and highly focused public/private partnership in Japan to create a world class PV industry that will be highly competitive internationally. A significant byproduct of this initiative is the development of PV systems well suited to integration with buildings, laying the groundwork for future large-scale use of PV technologies in the built environment of many of the APEC economies.

Because the urban centers of the APEC economies have many important similarities, successful implementation of this program could catalyze similar programs elsewhere in the APEC region. Recent work[8] in the United States has revealed that there are already urban locations in the US where the value of PV-generated electricity would justify installing building-integrated PV systems at current costs of $8 - $12 per peak kilowatt. This is based on the local cost of electricity and the utility load curve, as well as sunshine patterns. In many cities in APEC economies (including in Japan) similar conditions prevail. As these installed costs decline to the expected $3 - $6 per peak watt, the potential market for this technology/application option will become very large in many, perhaps most, APEC economies. In the US the potential market at this price level would be several thousands of megawatts (compared with a total worldwide aggregate installation of 1,000 MW of PV units today).

[8] Private communication. Dr. Richard Perez (2000), State University of New York, Albany (US). Also, see *Photovoltaics and Commercial Buildings: A Natural Match.* US Dept. of Energy, Report DOE/GO10098-657..

Table 5: Financial Incentive Programs of Local Governments for Installations of Residential PV Systems

Subsidies

Local Governments	Amount	Conditions
Fujinomiya, Shizuoka	Lower of the two: 1/12 of cost or Y85,000	Combined with national subsidy, up to Y340,000 and 4 kW, started in FY95. First subsidy program in Japan.
Kure, Hiroshima Kawagoe. Saitama	1/6 of the cost 1/9 of the cost	Combined with national subsidy. Started in 1997. Unsubsidized persons accepted, up to 4 kW, Y400,000. Started in 1997.
Seto, Aichi	1/3 of the cost	Unsubsidized persons only, up to Y 1,000,000. Started in 1997.
Higashi Hiroshima, Hiroshima	Y100,000/kW	Combined with national subsidy, up to 4 kW, Y400,000. Started in 1998.
Kasugai, Aichi	Y150,000/kW	Combined with national subsidy, up to 4 kW. Started in 1998.
Kokubu, Kagoshima	1/12 of the cost	Combined with national subsidy, up to Y400,000. Started in 1998.
Mattou, Ishikawa	Y119,000/kW	Combined with national subsidy, up to 4 kW, Started in 1998.
Shiojiri, Nagano	1/12 of the cost	Combined with national subsidy, up to Y300,000. Started in 1998.
Nagoya, Aichi	1/2 of the cost	Unsubsidized persons only, up to Y2,600,000. Started in 1998.
Nagahama, Shiga	Y100,000/unit	Combined with national subsidy. Started in 1998.
Joetsu, Niigata	Y170,000/kW	Unsubsidized persons accepted, up to Y680,000. Started in 1998.
Kanai, Sado, Niigata		Combined with national subsidy, up to Y200,000 for 3 kW or less, up to Y250,000 for 3 kW or more. Started in 1998.
Yasu, Shiga	1/12 of the cost	Combined with national subsidy, up to Y300,000. Started in 1998.
Mikata, Fukui	Y50,000 kW	Combined with national subsidy, up to 3 kW. Started in 1998.

Financing

Shimonoseki, Yamaguchi	Annual interest: 2 percent	Combined with national subsidy, up to Y3,000,000, to be repaid within 10 years. Started in 1997.
Iida, Nagano	No interest.	Combined with national subsidy, up to Y2,000,000 to be repaid within 10 years. Started in 1997.
Kitami, Hokkaido	Annual interest: 2.1 percent	Unsubsidized persons accepted, up to Y3,000,000 to be repaid within 10 years. Started in 1997.

Interest Grants

Katsushika, Tokyo	2/3 of interest	Unsubsidized persons accepted, up to Y5,000,000. Started in 1998.

Source: New Energy Foundation, August 1999. New Energy in Japan: Efforts for Accelerated Switching to New Energy.

PHILIPPINES: RURAL ENERGY SERVICE ENTERPRISES - THE SHELL/CPC RESCO PROJECT

Figure 8: The Shell SunStation Office in the Village of Alaminos (Philippines)

Introduction: The Shell International/Community Power Corporation Initiative

In 1999, a novel collaboration of the private sector, government (national, provincial, and community levels), and non-governmental organizations (NGOs) introduced an important new rural energy services initiative in the Philippines. This approach is of special relevance to those APEC economies that have unelectrified rural communities.

Shell Renewables Philippines Corporation and Community Power Corporation (CPC) of the US, in collaboration with local government in Aklan Province, have established the first of ten planned Rural Energy Services Companies (RESCOs) in the Philippines. The first RESCO is providing electricity services to the *barangay* (community) of Alaminos, using both freestanding PV units and full-time AC power supplied through a local low-voltage minigrid. A 12-kWe PV/propane hybrid power generation unit currently powers the grid. About 100 residential customers (ca. 85% of all households) are connected to the minigrid, and most are paying a weekly fee of about US$2 equivalent for about 0.1 kWh of AC electricity daily. A few households are paying a higher weekly fee for greater electricity consumption.

Key Stakeholders/Sources of Funds

The key stakeholders in this project include Shell Renewables, Community Power Corporation, the Aklan local government unit (LGU), and the residents of Alaminos. As the RESCO owner, Shell Renewables is providing financing and servicing of the systems. Shell owns the power system, and the localvillage minigrid was provided by the provincial government. *This project has been developed within the framework of a new business initiative by Shell Renewables.*

Shell's specific roles as service provider include:

1) Installation of equipment at each customer, including installation of an energy dispenser (supplied by CPC).
2) Financing and installation of a house-wiring package as specified by each customer
3) conduct of regular visits to the enlisted household to keep the installed equipment in good working order
4) Correction of service problems within two days upon receipt of a written service request.

Community Power Corporation, which developed the business plan, conducted pre-feasibility/detailed feasibility studies, and prepared the engineering design, is acting as technology provider/consultant to the project during the implementation phase. The provincial government provided the project's distribution network.

The main project beneficiaries are the residents of Alaminos, Madalag. Their main responsibilities in the service contract include:

1) Payment at the Shell Sun Store for the installation and weekly service fees
2) Payment for the house-wiring package (each registered household will retain ownership of this package)
3) non-abuse of/non-tampering with the installed equipment and reporting of any problems with the installed electricity dispenser
4) Provision/purchase of all appliances/equipment other than those provided by the RESCO provided they are approved by the RESCO.

Significant Innovations

There are several aspects of this project, which, taken together, constitute a significant innovation in provision of reliable renewable energy technology-based energy services to off-grid communities.

Removing Technical and Financial Risks from the End Users

By owning, operating, and maintaining all of the power equipment, the RESCO removes the technical and financial risks from the end users. Customers are only required to use the equipment properly and to pay the weekly service fee. Shell has established a *competent local infrastructure* for installation, maintenance, repair, replacement, and support of the power systems, and guarantees a reliable electricity service. Experience from PV pilot projects world wide over the past three decades has demonstrated the absolute necessity of having a local, competent, and responsive infrastructure to assure continuity in the PV system operations. Most of the very large percentage of PV project failures in developing economies has been due to the lack of such an infrastructure, and the dependence on local residents for maintenance and repair of the PV systems.

Fees and Revenue Collection

The fee for service is market-driven and is not being regulated by the Government. On a per kilowatt-hour basis the electricity services are far more costly than the subsidized rural electricity tariff, but for many communities these services are affordable and considered essential. Customers are being charged essentially the same that they previously paid for kerosene, dry cell batteries, used automobile batteries, and battery charging services in order to light a few lamps and run a radio, audio cassette player, and perhaps a small TV set. Now they receive the same *services*, with far greater quality and convenience. A related innovative aspect of this service is that the customer may decrease or increase their level of energy services by making a request and agreeing to pay the associated service fee. A small connection fee is required to hook up a customer.

Revenue collection is assured through *advance payment* of weekly energy services. To make a prepayment a customer goes to a RESCO store in Alaminos (the Shell SunStation store). The store, operated by a franchise owner, has a list of all customers and how much they need to pay. After collecting the weekly prepayments, he brings the money to Kalibo where it is deposited in a Shell Renewables bank account.

Customers pre-purchase the electricity service. Each week they pay for a specified maximum amount of electrical energy (e.g., 1 kWh). Customers may select higher or lower levels of service based on their needs and capability to pay. For a few dollars weekly, a customer can have access to about 1 kWh per week. A 50-watt solar home system operating under very sunny conditions will provide a net electricity service of ca. 150 watt hours daily, or about 1 kWh per week under optimum conditions. However, the very high reliability and availability (ca. 98% to date) of the hybrid power system, and the provision of AC power, make the subscription to the AC service much more desirable than having a solar home system. Customers may subscribe for up to 3.5 kWh per week, although almost all households are presently purchasing about 1 kWh per week.

After about six months of operation, more than 80% of the initial household subscribers were enrolled for the lowest service level, with only one household enrolled for about 3 kWh per week. The remaining households (mainly those that derive their incomes from salaried jobs, e.g. teachers, government employees) fall under the categories in between, i.e. 105 and 140 service units per week. Most of the residents use the power for lighting (usually one 10-watt or two 5-watt fluorescent lamps) and/or for their TVs, VCRs. and karaoke sets. The system has a maximum capacity of 100 kWh per day, but maximum community demand has reached only 30 kWh to date.

Institutional Innovation

The Shell/CPC partnership has brought a combination of very significant institutional and technological innovations to the use of rural renewable energy systems for community power. Full-time AC power at 220 volts is provided to all customers connected to the minigrid. Customers on the minigrid have AC power of a quality and reliability that exceeds that of almost all grid-based rural electricity supply in the developing world. Moreover it is available continuously, permitting investment in commercial enterprises that require daytime power, and facilitating important social development through electrification of schools, health centers, and *barangay* halls. This is in contrast to the usual practice in which diesel generators provide power only at night, severely limiting meaningful development opportunities.

Shell negotiated with the national government (Secretary of Energy) in order to provide power to local communities, something not presently contemplated in Philippine regulations. The local rural electric cooperative also agreed to permit Shell to serve customers in its local service territory. These institutional initiatives are very significant pioneering innovations in the Philippines, and are being considered as the basis for new policy initiatives that would permit and encourage economy-wide operation of RESCOs, whether by Shell or other parties.

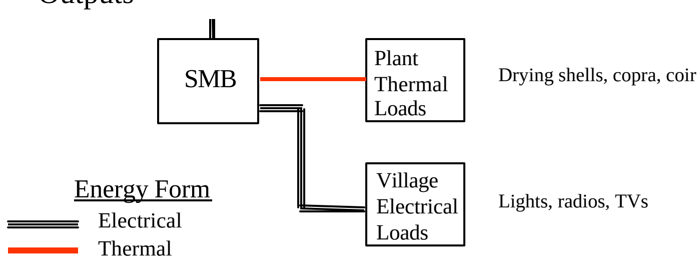
Technical Innovation

Several technical innovations are incorporated in the RESCO system and operations. The newest, to be introduced early in year 2001, is a new prepayment meter to permit greater flexibility in customer choice, and bypassing fixed weekly energy allotment subscriptions.

The PV/propane hybrid unit integrates 3.6 kWp PV (48 75-watt Shell modules), a 9 kWe LPG-fired *Koehler* genset a 4 kWe *Trace* bidirectional (AC to DC and DC to AC) inverter, a microprocessor-based system controller, and a battery bank with 50 kWh of capacity.

A small percentage (less than 20%) of the households in Alaminos are or will be serviced by PV home systems, due to the expense or difficulty of connecting them to the minigrid. The solar home systems are to be operated using the same prepayment card system that Shell is currently using in their rural solar home system fee for service project in South Africa. Another technological innovation is the development and use by CPC of a special meter/controller (EnergySwitch™) that limits the amount of electricity that the customer can use per week. This "energy dispenser" provides a maximum service consistent with the customer's chosen electricity service fee. Another innovation is the electronic disabling of the PV array, battery, and controller if these are removed from their original location. This actively discourages theft.

Figure 9: Small Modular Biopower Units have Multiple Outputs



Further commercial innovation is also occurring on the power supply side. Shell/CPC is planning to install a small modular biopower (SMB) system (developed by CPC) that will generate power from waste coconut shells. With support from the US Department of Energy and from the US National Renewable Energy Laboratory (NREL), CPC has developed a commercial prototype of a 12.5 kWe biomass power unit. Shell and CPC are planning to commercialize this technology, and apply it in village power systems. This will permit a substantial reduction in the cost of renewable energy-based electricity supply in areas where suitable agricultural residues are available. This significant technical / commercial innovation may well change the economic landscape of village power in such regions over the coming decade. The initial installation is scheduled for early in 2001. The development of the Small Modular Biopower (SMB) technology is a project within the larger Shell/CPC initiative. The presentation of this technology development process is available in the Proceedings of the conference *Village Power 2000*, and can be accessed on the website[9] of the National Renewable Energy Laboratory.

Shell/CPC has selected Alaminos as the first site for the pilot SMB, based on a comprehensive site screening and selection process. Once the SMB system is installed and commissioned, the hybrid power systems will be used as a complementary / back-up system during the SMB "shakedown cruise", and later transferred to a neighboring barangay under the Shell RESCO service program.

The Shell/CPC team used GPS/GIS (Global Positioning System / Geographic Information System) technology to survey and map the initial target communities, producing the first accurate and correct maps of these communities and their surroundings. Powerful new PC-based software[10] developed by the US National Renewable Energy Laboratory (NREL) was used to identify the technical / economic optimum low-voltage minigrid layout and configuration. CPC has pioneered in the use of GPS/GIS technologies as an integral component of village power enterprise design and development. This is shown in Figure 10.

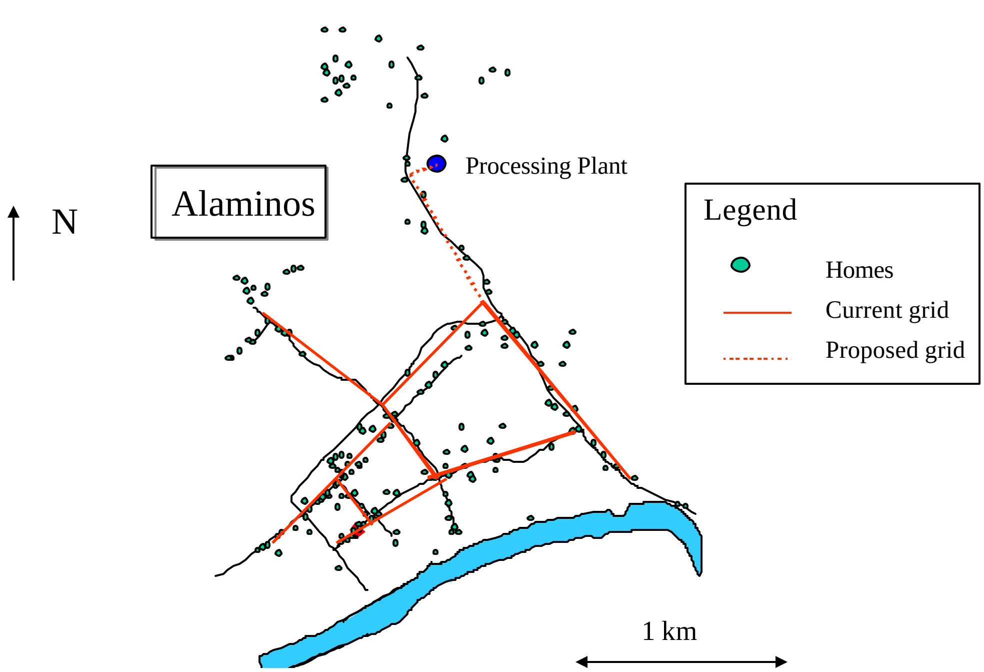


Figure 10: Alaminos and Approved Location for a Small Modular Biopower Unit

[9] Go to www.nrel.gov and select the international program / village power site. Village Power 2000 conference proceedings will appear there in early year 2001. See the presentation by Art Lilley entitled *Biomass Based RESCO for Village Industry*

[10] A detailed presentation of this software (VIPOR) is available at the NREL website (www.nrel.gov); the software is available from NREL for a modest fee, and in some instances NREL will provide technical services to organizations seeking to apply VIPOR to the identification of village power solutions. The principal author of the software can be reached at NREL for further information. (peter_lilienthal@nrel.gov)

Global Commitment and Innovation

Shell International is the first major international corporation to make a serious investment in the RESCO approach to rural energy services using clean energy technologies, and one of the few corporations to do so anywhere. The RESCO (SunStation) approach is one of four Shell business models for providing RE-based energy to rural communities. (The Shell business models, especially the SunStation model, are discussed in a section below). Moreover, Shell is partially subsidizing the initial RESCOs in order to gain the necessary experience to plan for and implement a much larger and more extensive rural electricity services project in the Philippines. Shell is publicly committed to establishing ten such operations in the Provinces of Aklan and Palawan; if these are successful they will expand the operations in the Philippines and initiate such services in other economies. This project can provide a useful example for similar initiatives in many of the APEC economies. The Alaminos installation is providing the experience and data to permit Shell/CPC to develop an appropriate business plan for this expansion.

Fostering Economic Development While Building Markets for Energy Services

Shell is planning to take an unusual proactive role in fostering local economically productive activities that will increase local incomes and expand employment while increasing the demand for electricity services (and hence the profitability of the RESCO). This is a significant departure from traditional rural energy service operations, and one that may become a widely replicated and imitated model to spur rural economic development while expanding the markets for RESCO electricity services and related products and services. Shell Renewables Philippines Corporation is working with the Alaminos Coconut Development Cooperative to expand and diversify coconut farmers' incomes while assuring a supply of coconut shells to run the small modular biopower units that can provide heat and power to the Cooperative and electricity to the local community. Initial products will include geotextiles (mats used for soil stabilization), plant growing media, dried copra, and soap. This process will integrate the village electricity loads (dominated by evening lighting) and productive use loads during the day.

Fostering Development of Community Services

For social development investments, Shell is looking to others for the funds to pay for the local infrastructure for the SunStations, such as the local AC minigrid, which the community would retain as an asset in the event that a larger power grid was extended to the community. National, provincial, and local government agencies need to invest in the end use equipment for potable water supply, schools, health centers, etc. Shell would procure and install related equipment in this public/private partnership arrangement. This synergism can help make the availability of reliable electricity and thermal energy services a potent force for social development.

The Project Roadmap

The Pre-Project History

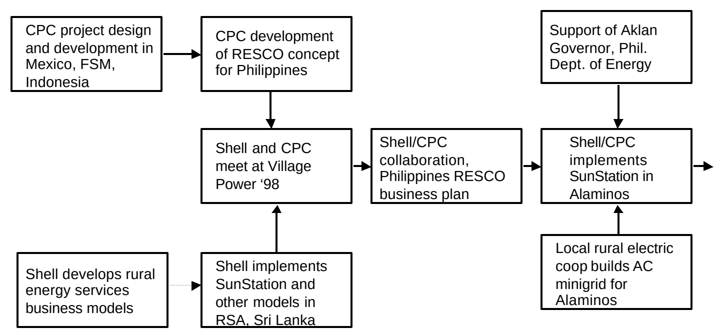


Figure 11: Shell/CPC RESCO Project Roadmap

This project did not "just happen". It is the remarkable result of two complementary and organizations coming together in a common commitment to bring environmentally sustainable energy services to rural communities. These two organizations are Shell International Renewables (SIR) and Community Power Corporation of the US. Shell International Renewables (now "Shell Renewables") is one of the five core business units of the parent company, based in the United Kingdom (UK) and the Netherlands (NL). Community Power Corporation (CPC) is a small company led by two people who each have over two decades of experience in developing and applying renewable energy systems for rural applications.

The CPC principals (Messrs. Art Lilley and Robb Walt) have been engaged in pioneering development of RE projects in Mexico, the Federated States of Micronesia, Indonesia, and most recently in the Philippines. They have experienced technical, institutional, and other challenges, some extremely severe (e.g., the collapse of the Indonesian currency during the Asian financial crisis, and the suspension of their RESCO business activities there). Their experience and vision of possibilities for sustainable large-scale use of renewables in the rural milieu was recognized by Shell Renewables managers when all of them met at the October 1998 Village Power Conference in Washington, DC. Equally committed and visionary leadership has characterized the Shell Renewables business development activities in Asia. Over a period of a year or so, the two organizations explored various ways to partner to pursue their common business objectives.

One consequence of their joint pioneering activities has been the development of business models for rural energy and related services that can be adapted and applied widely, without the same level of personal and business risks being required.

Overview

In collaboration with the local government unit (LGU) of Aklan Province in the Philippines, Shell International Renewables (SIR) and Community Power Corporation (CPC) began operating the first of ten planned rural Philippine energy services companies (RESCOs) late in 1999. This first RESCO is established in the *barangay* (town) of Alaminos in Aklan Province.

The project was inaugurated with the lighting of the town church two days before Christmas 1999. Three months later, electricity services were provided to the initial 81 service subscriber households (about 58% of the total household population of 140). In October 2000 there were over 100 subscribers. Electricity is provided via a full-time 240-volt (low-voltage) AC mini-grid. A PV/propane hybrid power unit, with 3.5 kWp PV capacity and an 8 kW LPG generator currently powers the minigrid. Individual solar home systems (SHS) have been installed to provide DC power to several houses more than 500 meters from the community center.

The idea for this project was first brought forward by CPC to SIR in late 1998, after the latter made a presentation on its efforts in NRE-based rural electrification using a RESCO approach at an international conference. By March 1999, CPC began project preparation work, starting with site identification and then market and resource assessment.

Site Selection

The community of Alaminos, Madalag was selected as the site of Shell's first RESCO operation in the Philippines for several reasons. One is the ease of access from Kalibo, the capital city of Aklan. It takes roughly one hour from Kalibo to the project site via a part-dirt, part-concrete road that can generally be traversed in any kind of weather. The local economy is fairly strong and has good growth potential, the main crops being coconuts, palay (rice), abaca, and other vegetables. Alaminos has a well-established central community, with about 70 households clustered around the community center, making it ideal for a minigrid system. There are also large numbers of dispersed homes outside the community center suitable for solar home systems and battery charging services. Another reason why Alaminos was selected as the first site of this Shell-CPC project was the strong interest indicated by the community when the idea was first broached to them. Finally, strong support for the project was and is being provided by the municipal and provincial local government units (LGUs). AKELCO (Aklan Electric Cooperative), the rural electric cooperative, *agreed to waive its franchise rights for the proposed Shell RESCO service area*, to allow the project to proceed[11].

Aklan is one of five provinces on the island of Panay in the Western Visayas. The province is a lush coconut and rice growing area with a population of over 400,000 people living in 17 municipalities and 383 communities. The Aklan Electric Cooperative (Akelco) distributes electricity to 296 communities in the province. At present there are 87 communities with over 12,000 households that do not have access to electricity. Discussions with the provincial governor, Florencia Miraflores, the chairman of Akelco, mayors of the municipalities, the head of the Philippine Coconut Authority and representatives of the local coconut farmers cooperative and other key government officials identified three regions of the province that had the highest number of unelectrified communities. These areas are the municipalities of Madalag, Libacao, and Ibajay.

[11] In the Philippines, the mandate for rural electrification falls under the rural electric cooperatives (RECs), which report to the National Electrification Administration

Identification of Alaminos and Bacyang as Ideal Communities for Introduction of the SunStation Enterprise

With 284 homes, the communities of Alaminos and Bacyang are typical of rural communities throughout most of the Philippines. Both communities have "centers" where there are groups of 50 to 80 homes suitable for distribution of low voltage (220V AC) electricity from a small modular hybrid or biopower system. Located in the central area of the community are public facilities such as a church, health center, schools, and small variety stores and, always, a basketball court. Within a radius of between 300 and 500 meters are a few much smaller groups of five to ten homes that can be served by a low voltage distribution line or solar home systems. Beyond 500 meters from the community center there are single homes scattered along the rice fields and coconut groves typically at the base of hills or on ridges. These dispersed homes can be served by solar homes systems or battery charging services – depending on income levels and the degree of shading around the house.

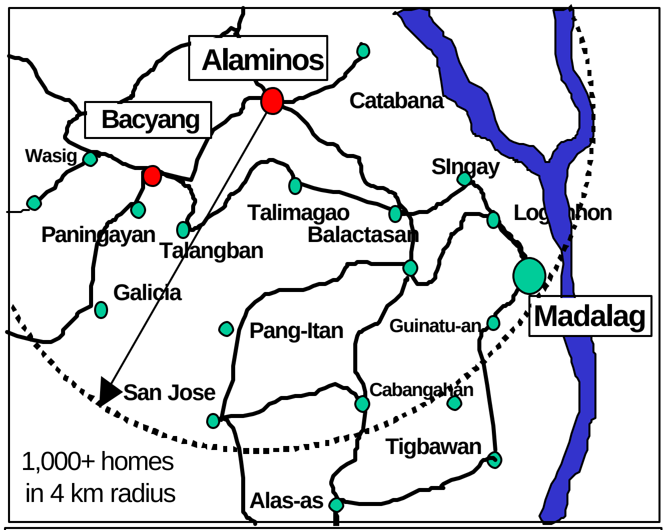
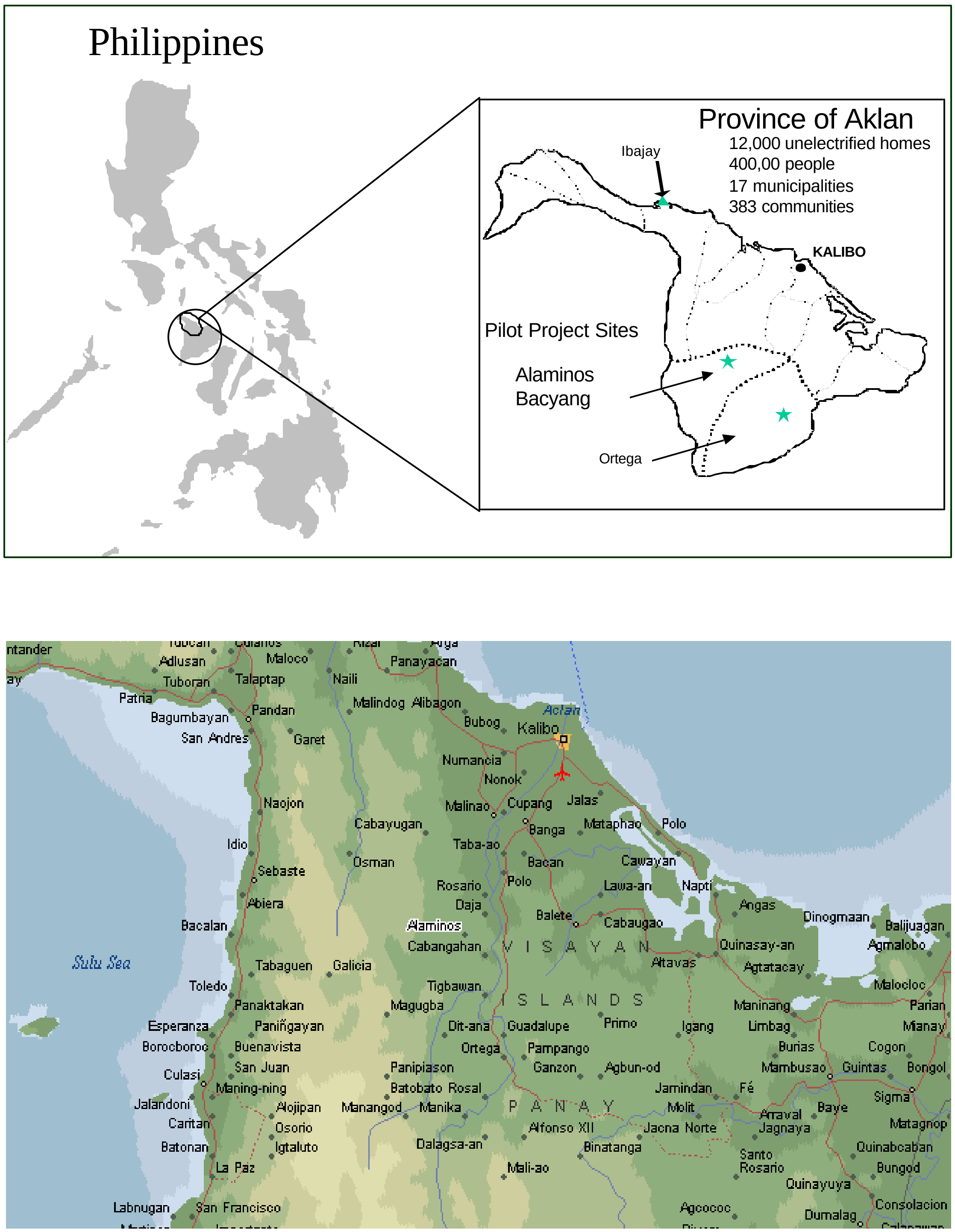


Figure 12: Communities of Alaminos and Bacyang

CPC conducted reconnaissance surveys in the Philippines to identify initial market entry regions. Their criteria for market entry regions, all found on Panay, included the following:

- Regions with large numbers of unserved households
- Potential service territories with 1,000 or more off grid households
- Clusters of households in potential service territories
- High demand from customers for "hassle free" electricity services
- Current monthly household expenditures of $5 - $10 for basic household energy services
- Good local economy and stable social and political environment
- Enthusiastic support for the RESCO from provincial and local government leaders, and from the local rural electric cooperative
- Strong potential for economic uses of (renewable energy based) energy services
- Local commercial market unspoiled by grand aid projects



Figures 13a and 13b: Aklan Province and the Shell RESCO Initial Project Site

Market Assessment

CPC's energy demand and expenditure surveys in June 1999 revealed that the residents' principal energy sources were kerosene lamps (wick) consuming an average of 320 milliliters for 2 days, car batteries (charged with 220 V AC chargers), and small dry cell batteries to power radios. Six residents also owned small diesel generator sets. These energy expenditures were consistent with the originally targeted fee of 8-10 dollars[12] a month (or about 10% of average household income). This was the basis for the fee structure. Interested households were asked to sign up in July 99 to give Shell information on the level of public acceptance and the required system size. Over 80 households signed up initially, and now there are just over 100 subscribers. Residents were generally enthusiastic about the idea of having their area electrified, and support from LGU officials was very strong.

Approvals Process

The Philippine government has no established guidelines to regulate or monitor RESCO operations. For this project, the first of its kind in the economy, it was necessary for Shell to secure an official endorsement from the Philippine Department of Energy. The rural electric cooperative Aklan Electric Cooperative (AKELCO) waived its franchise rights for the project's service area. It also forged an agreement with Shell stating that if there are plans to extend the existing grid to the project site, it will inform Shell well in advance so that Shell has sufficient time to move the RESCO operation to another site.

Project Construction/Implementation

It took Shell less than 6 months between the time the project's business development plan was launched (mid-1999) and the first bulb was lit at the Alaminos town church in December of the same year. Power became available to the households a few months later in March 2000[13].

System installation was carried out by a US systems integrator subcontracted by Shell to carry out the task, and the supplier of the PV/propane power generation unit. Also involved in this stage were the project manager and an Alaminos-based technician, who has been trained to monitor and record the performance of the hybrid system. He also performs basic maintenance and troubleshooting tasks, including replacement of bulbs or their relocation from one area of a household to another. More challenging technical problems are referred directly to the Aklan-based project manager. Replacements for bulbs can be bought at the Shell SunStore, located near the town school, where people go to pay their installation/weekly fees, file complaints, request repair service, and apply for additional service units or downgrade their existing capacity. Those located in the more remote areas can have their batteries charged at the SunStation store.

Project Performance

Technical performance has been excellent, with availability at close to 99%. Shorting of wires by some residents happens on occasion, but this has never resulted in a major supply disruption. The main system was designed in such a way that tampering in one household will lead to an automatic shut-off of the entire system.

[12] Fees are collected in Philippine pesos. US dollars are used here for ease in conversion to other currencies.
[13] The 3-month lag is attributed by Shell to bad weather and some delays in establishing the minigrid.

Long term financial feasibility has not been established due to the high startup costs for this innovative venture. A modified financial scheme will be tested in the RESCOs to be established in the province of Palawan.

In April 2000, CPC conducted a customer satisfaction survey. Results indicated that people generally perceived a major improvement in their quality of life, i.e. extended sales hours of local stores, increased inflow of information via TVs, VCRs and radios, etc. The high cost of electricity remained the common complaint, but the customers continue to pay for the service, although they are not obligated to do so under the terms of their contract with the RESCO.

Figure 14: Technical Manager with Power System and Cellphone

One unexpected service that Shell CPC has also been able to provide to residents is the use of a cellphone for making long distance and overseas calls to relatives/friends. The cellphone was installed in the hybrid system for data-downloading purposes, but is now serving a dual purpose by giving residents phone access. Existing telephone rates at the provincial capital city of Kalibo were used as the basis for determining the fee structure, e.g. an overseas call to the US costs 50 pesos, or a little over one US dollar, per minute.

Replicability/Sustainability

Shell is subsidizing the initial RESCOs in order to develop the operating and cost experience to determine how (and if) a large scale and profitable RESCO business can be established in the Philippines and elsewhere. If the RESCO approach is to benefit all unelectrified communities, some subsidies will be required from the government to permit poorer communities to participate. Coinvestments in both community service and economically productive activities will be required in order to assure a developmental benefit of the energy services supplied, and to establish a growing market for these services. As the market expands domestically, it is expected that an increasing percentage of the equipment will be produced locally, in some cases via international joint venture partnerships.

Table 6: Shell/CPC Approaches to Energy Service Delivery in Aklan and Palawan Provinces

	AKLAN	PALAWAN (scheme still under discussion)
Financing	• 100% of costs borne by Shell • Provincial LGU's equity in kind (distribution network)	• Shell to pre-finance project cost • Provincial LGU to repay fully after three-five years (soft terms) using internal revenue allotment (IRA)
Technology	• Hybrid solar PV/LPG used for first year • Small Modular Biopower (SMB) Unit to be used beginning late 2000 • Combination of centralized (minigrid) and decentralized (solar home systems and battery charging) approaches	• Combination of SMB and PV/LPG hybrid, depending on what resources are available in each location • Improved version of energy dispensers to be tried out • Combination of centralized (mini-grid) and de-centralized (solar home systems and battery charging) approaches
Livelihood component Operation and maintenance	• None at the moment • Coconut processing facility to be set up in collaboration with local coconut farmers • Shell carrying out operation and maintenance • O&M set-up: 1 project manager, 1 community-based technician, 1 administrative asst.	• Local NGO Center for Renewable Resources and Energy Efficiency (CRREE) will be involved in project for livelihood component • Scheme still being worked out, but Shell likely to carry out O&M activities to ensure optimal technical performance of installed systems • O&M set-up: 1 project manager for the whole of Palawan, 1 community-based technician for each village, 1 administrative assistant
Scope	• 1 already in operation; 3 more villages being targeted • Uses both centralized (for clustered households) and de-centralized schemes	• 5 villages (out of 17 surveyed) covering approximately 1,000 households

The fact that financing for the Palawan RESCOs will be fully supported by the Palawan LGU will provide a better indicator as to the financial sustainability of this approach. The incorporation of a livelihood component (with an established NGO tasked specifically to focus on this area) will also help ensure sustainability of the project. This NGO is supported in this work by the United Nations Development Programme / Global Environment Facility.

The Project Landscape

The "landscape" for the roadmap is one involving government commitment at all levels, the practical interest and willingness of the Department of Energy to grant special concessions to Shell in order for the RESCO approach to be tested, and local government participation and cost sharing. It also includes an environment of over 12,000 unelectrified rural communities, of which roughly half are considered by the Dept. of Energy to be unsuitable for grid extension. Convertible currency, modest but real national economic growth, and reasonably stable business conditions, coupled with an intense desire for electricity by virtually all rural communities, also combine to make the Philippines a potentially attractive environment for the RESCO innovation.

The Secretary of Energy and the local rural electric cooperative in Aklan have both supported Shell's request to operate a RESCO in Aklan Province. This is consistent with the national administration's expressed commitment to significant and rapid expansion of basic infrastructure services in the countryside, and energy is a key element of that commitment. Specific goals of the Government's program include building the framework for economic growth and the delivery of essential social services. Many of those services require high quality reliable electricity services, both DC and AC. One of the ten points of the Agenda deals with infrastructure, with special emphasis on the role of the private sector. *It is expected that this agenda will persist under future national administrations.*

Figure 15: Shell/CPC Hybrid Power System Dedication at Alaminos

The Philippines has more than 2,000 populated islands. There are more than 11,000 *barangays* (communities) and four million households are without meaningful electricity supply. Roughly half of the unelectrified communities are considered by the Philippines Department of Energy (PDOE) to be outside the practical reach of grid extension, for either or both technical and economic reasons. Yet there *is* energy in these communities. In most communities there are typically several and sometimes many small gensets that operate a few hours at night and can provide electricity to one or a few houses. In some cases a business may have its own larger genset, for its own needs. Households use kerosene for lighting and dry cell batteries for radios and cassette players. Used auto batteries, charged by local entrepreneurs with small gensets, provide electricity for lights, radio, and sometimes a television set. Typical household expenditures for kerosene, dry cell batteries, used auto batteries, and battery charging services, range between US$ 5.00 to $10.00 monthly.

The potential market for reliable high quality energy services is ca. four million rural households that presently spend about $300 million annually for inferior, inconvenient, and sometimes dangerous energy supplies. Although virtually every part of the countryside is served by rural electric cooperatives (RECs), most of these coops have been unable or unwilling to service the majority of the unelectrified population.

A new approach, capable of reaching the majority of unelectrified barangays within a decade or less, is needed in the Philippines and in other developing APEC economies that have substantial numbers of unelectrified communities. It is increasingly recognized by the government, and underscored by the Philippines Department of Energy, that public/private cooperation and collaboration will be needed if the private sector is to play a major role in off grid energy services delivery. Government cannot by itself provide the needed infrastructure services effectively and efficiently, and the private sector will not assume the full risks of entering an unproven and challenging market in which few companies anywhere in the world have demonstrated any profitability.

The Shell/CPC Market and Business Approach

Shell Renewables has four business models for providing renewable energy-based services in developing economies. These are the following:

- SunStations: low voltage AC minigrids, 24-hour power, renewables and hybrids, weekly fee for services, local government cofinancing (minigrid) *Philippines (1 operating, 9 more planned)*
- Financed sales: 5 solar centers each in *Sri Lanka and India*.
- PV solar home system fee for service: *South Africa*
- PV system sales to distributors: *Indonesia*

The Shell SunStation Model has the following elements:

- Provides AC minigrid and DC electricity services, and thermal energy services (cooking)
- Retail service on a "fee for service" basis
- Serve maximum number of people, to permit affordable energy services
- Target markets: areas with high concentration of accessible population with no electricity, but good economic development potential

CPC's Rural Integrated Energy Services Model for Renewable Energy Service Companies includes the following:

- Serve all of the customers in a geographic area and build a *service territory*. Customers include households, community services (e.g., potable water supply, schools, health clinics, government offices, churches, etc.), and rural enterprises,
- Supply a mix of AC and DC–electricity services, and thermal energy services, using a menu of environmentally friendly energy technologies.
- Use modular, transportable power systems
- Establish a local service infrastructure
- Meet each customer's priority energy needs
- Charge customers the same or less than they now pay for inferior energy services (e.g., intermittent poor quality electricity from small gensets, kerosene lighting, battery charging, etc.)
- Provide energy *services*, not power
- Charge fees for services
- Share capital costs with government and communities

Conclusions

The Shell/CPC RESCO initiative in the Philippines is in an initial commercialization stage. It has demonstrated the potential for providing reliable high quality energy services, has spawned several significant technical, operational, and policy innovations, and reflects an emerging service based paradigm for the use of low greenhouse gas emission technologies for rural energy supply. It has the potential for providing full time AC power for thousands of offgrid communities, provided the necessary public/private partnerships can be forged to assure financial viability of the RESCOs no matter the level of economic development of the served communities.

Thailand: Biomass Cogeneration[14]

Introduction

There is an enormous unrealized biomass cogeneration potential in several APEC economies including Indonesia, the Philippines, and China. Biomass residues are widely available at agroindustrial sites in many APEC economies. Those residues suitable for fueling cogeneration installations include wood waste, rice hulls, bagasse, palm oil nut residue, and coconut shells. The success of commercial biomass cogeneration projects in Thailand and Malaysia provides an important model for other APEC economies, and demonstrates the importance of risk reduction through facilitated access to technical and financial assistance.

Biomass cogeneration, although inefficient, has been implemented in almost all sugar and palm oil mills in the ASEAN economies. As an example, in the Thai sugar industry there are about 600 - 700 MWe of installed cogeneration capacity. Most systems work at a relatively low pressure of ca. 20 bar. Within the ASEAN economies, ca. 500 palm oil mills and 150 sugar mills already are using low-efficiency biomass cogeneration. *Almost all of them are potential candidates for new and more efficient systems.* In the rice and wood sectors only a few facilities are using cogeneration; they represent a significant potential market. An example of the introduction of a modern high-efficiency cogeneration facility at a rice mill in Thailand has been chosen to illustrate both the effectiveness of the technology and the process of facilitation provided by the COGEN Programme described below.

Thailand Cogeneration

- Bangsue Chia Meng Rice Mill one of largest in Thailand (500 tonnes rice paddy per day)
- 17 tonne/hour steam boiler + 2.5 MW generator
- $3.9 million investment cost
- Annual revenues = $1.7 million (>30% IRR before taxes)
  - $840,000 electricity savings
  - $128,000 oil savings (for paddy drying)
  - $152,000 rice hull disposal savings
  - $160,000 sales of electricity to the grid
  - $440,000 sales of rice hull ash
- Project development in concert with EC COGEN program

23

The large agriculture sector in Thailand produces a significant quantity of biomass residue that can be used for cogeneration of thermal and electrical energy. An economically and technically feasible potential has been estimated at more than 1,500 MWe. One of the primary agriculture products in Thailand is rice. The economy has the largest rice milling industry in Southeast Asia. Over 50 rice mills in the economy have daily process capacities greater than 100 metric tons of paddy.

Recently, biomass project developers have joined with Thai mill owners through joint venture partnerships to implement biomass energy projects. For these types of projects, project financing is being utilized through various lending agencies such as export credit agencies (ECAs), soft loans from bilateral/multilateral funding agencies, export-import banks, as well as local banks. Some developers are investigating other implementation schemes such as Build-Own-Operate-Transfer (BOOT) and Build-Own-Operate (BOO).

[14] The principal source of information for this section is from Dr. Ludo Lacrosse at the COGEN Programme based at the Asian Institute of Technology (AIT) in Bangkok. Contact: cogen@ait.ac.th See the web site at http://www.cogen.ait.ac.th/profile

Project Summary

The Bangsue Chia Meng Rice Mill is one of the largest rice mills in Thailand, with a capacity for processing 500 metric tons of rice paddy per day. The mill is located in Chakkaraj, Nakorn Ratchasima, Thailand. In processing the paddy, the mill produces over 100 metric tons of rice husk per day. The storage, handling, and disposal of the husk residue are a substantial cost for the mill owner. In 1987, the managers of the Chia Meng rice mill and professional staff from Angewandte Physik Consulting GmbH (APC or *Applied Physics Corporation*) of Germany discussed the possibility of using the rice husk as fuel in a boiler coupled with a fully condensing steam turbine for power generation. As a result of the interest expressed by the mill owner, APC conducted a feasibility study for a 2.5 MW cogeneration facility that would be built on site at the mill. The plant was commissioned in March 1997, and has proven both technically and financially successful.

Figure 16: Bangsue Chia Meng Rice Mill (Thailand)

At the mill, rice husks are stored in 8 silos with a total capacity of 2,400 m^3. A bucket elevator conveys the husk to the boiler. The cogeneration facilities include a 17 metric ton per hour superheated steam capacity boiler that operates at 35 bar with an automatic ash removal system and a 2.5 MW multi-stage fully condensing turbogenerator with a condenser. The exhaust steam pressure from the generator is 0.2 bar. The plant also includes flue gas waste heat recovery heat exchangers to generate hot air for use in drying the rice paddy. The cold water from the condenser is used to maintain the cool white rice storage cells. Approximately 120 metric tons of rice husk with 12.5 MJ/kg calorific value is used per day by the cogeneration facility.

> "Previously, the daily disposal of more than 100 tonnes of rice husk was causing us a lot of headaches. Now, we have no disposal problems and are self-sufficient in power, which gives us additional security in terms of power supply. We also export power to the grid."
>
> Taval Manathanya, Director of Bangsue Chai Meng Rice Mill.

Project Participants

The project participants include the mill owners, the architectural / engineering consultants, the equipment suppliers, the system designers, the constructors, and the COGEN Programme.

On behalf of the mill owners, *Angewandte Physik Consulting GmbH (APC)* of Germany carried out the feasibility study, including the detailed engineering design, and supervised the construction of the cogeneration facility. APC is an engineering company specializing in energy technologies. APC provides advice to energy producers in the selection of equipment that meets technical and environmental standards.

Bertrams-KONUS GmbH (a new entity resulting from the 1995 merger of Swiss company Bertrams AG and German company Konus Kessel) of Germany was the primary equipment supplier and plant contractor in collaboration with Hansa Engineering Co. Ltd. of Thailand as the local joint venture partner. The Bertrams-Konus company specializes in the design and manufacture of thermal equipment and is a world leader in high temperature heat supply technologies. The company's main products are thermal fluid heaters, electric heaters, molten salt heat transfer systems, incinerators, hot gas generators, heat exchangers and high-pressure steam boilers. The company has extensive experience in converting wood, sander dust, peanut shells, palm fiber, bagasse, and risk husk to energy.

The COGEN programme (originally the European Commission and Association of South East Asian Nations sponsored EC-ASEAN COGEN Programme) has facilitated the development of dozens of successful biomass-based cogeneration projects in the Southeast Asia region, especially in Thailand and Malaysia. The EC-ASEAN COGEN Programme is an economic cooperation programme between the European Commission (EC) and ASEAN. The Programme is coordinated by Asian Institute of Technology (AIT), Bangkok, Thailand. Its aim is to accelerate the implementation of proven cogeneration technologies within the industrial sectors of the ASEAN region through partnerships between European and ASEAN companies. In doing so, it is opening major markets in Southeast Asia to European cogeneration technologies and services.

The purpose of the COGEN Programme is to accelerate the use of proven commercial equipment and technology for power generation and cogeneration from wood and agro-industrial residues through partnerships between European and Southeast Asian companies. This program, which could be a model for similar consortia established by APEC economies, was initiated as a cooperative program of the European Commission (now the European Union) and the Association of South-East Asian Nations (ASEAN), and is coordinated by the Asian Institute of Technology (AIT) in Bangkok.

The Programme has provided ongoing technical and financial assistance in the effective implementation of full scale commercial demonstration projects that use wood and agro-industrial residues as the primary fuel inputs for production of electricity and thermal energy. By "demonstration", it is meant that the projects demonstrate full commercial technical and financial feasibility, and high levels of technical and financial performance. These are not "pilot" projects, but are fully commercial installations. The COGEN Programme also conducted sectoral market studies, information dissemination, industrial study tours, training workshops, seminars, and conferences. The COGEN Programme has facilitated the implementation of over $100 million in clean and efficient cogeneration projects in the ASEAN economies.

The EC-ASEAN COGEN Programme facilitated collaborative investigations of feasible cogeneration technologies at the Bangsue Rice Mill. The COGEN Programme provided technical assistance through workshops that provided information on the reliability of the technology and the success of commercial applications in other economies. The COGEN Programme also provided a grant to the project in exchange for monitoring of the project, dissemination of project results, and hosting visitors to the project.

The Energy Conservation Centre of Thailand (ECCT) under the Department of Energy Development and Promotion of the Ministry of Science, Technology and Environment approved the project under the EC-Thailand Biomass Energy Demonstration Program.

Project Financial Considerations

The total investment cost for equipment, erection and commissioning was approximately $3.9 million excluding civil works and building structures. The annual revenues are from sale of electricity and ash. The project also accrues cost savings from not having to purchase fuel oil used for paddy drying and electricity for the mill, and disposal of rise husks. The financing of the project was with corporate equity and debt through balance sheet financing. The project payback period is less than four years, and the before tax internal rate of return (IRR) for the project is greater than thirty percent. Table 1 presents the annual cost savings and revenues associated with the cogeneration facility. Some important features of the savings and revenue streams emerged from the plant financial analysis:

- The revenues from the sale of electricity to the grid account for less than ten percent of the total combined savings and revenues. This means that an Independent Power Contract with EGAT (the state electricity company), while desirable, is not necessary for the project to be financially attractive.

- The savings of electricity are the largest component of the overall revenue stream.

- The second largest component of the revenue stream is from the sales of rice hull ash. This is a highly valuable byproduct. The high quality ash is exported to Europe and Japan for steel, metallurgical, tire, concrete, and other industries.

Table 7: Annual Cogeneration Project Savings and Revenues

Revenue/Savings Category	**Amount (US$ equivalent)**
Electricity cost savings	840,000
Gas-oil cost savings for paddy drying	128,000
Rice husk disposal cost savings	152,000
Revenue from sale of power to the grid	160,000
Sale of rice husk ash	440,000
Total	**1,720,000**

Project Development Roadmap

The project took a decade from the inception of preliminary studies in 1987 to the online commissioning in 1997. Initially the mill owners were unsure if they wished to proceed with the investment in the cogeneration facility. Most of the decade was spent in technical and financial discussions and review. After completion of a full feasibility study, the mill owners contracted Angewandte Physik Consulting GmbH (APC) of Germany in May 1993 to undertake a detailed engineering design, preparation and evaluation of bidding documents, and supervision of the installation of the plant. Using APC's recommendation on the most appropriate system, equipment supplier Bertrams-Konus together with the Thai engineering counterpart, Hansa Engineering Co., Ltd., were chosen in July 1993 to provide the boiler and generator equipment and construction of the plant.

Thailand Cogeneration Timetable

- 1987: Rice mill contract with German firm for prefeasibility study for 2.5 MWe cogeneration facility
- Subsequently, the EC COGEN program provided technical assistance and encouragement to rice mill; some grant financing was also provided
- March 1997: the plant was commissioned

26

In December 1993, the project was accepted by the EC-ASEAN COGEN Programme as an EC-Thailand Biomass Energy Demonstration Project. The Programme gave technical and financial assistance to the project. The contract for equipment purchase and construction was signed in January 1994 and the plant was commissioned in March 1997. The project was designed and constructed as a turnkey project. The equipment supplier Bertrams-Konus and technical consultant APC also provided training of technical personnel in the operation and maintenance of the plant.

Project "Landscape" / Environment

Thailand has established an attractive environment for the development of biomass cogeneration projects. Important considerations include the resource abundance, government policies that enable and provide incentives for biomass-based cogeneration projects, the increasing demand for power from private sources, and the ongoing success of biomass projects that provides increasing comfort for potential investors in new cogeneration projects. Key elements of this "landscape" include the following:

Thailand Biomass Cogeneration "Landscape"

- National Electric Policy Council of Thailand permits small power producers (SPPs) to supply electricity to the grid
- SPPs must use nonconventional energy, waste, or residual fuels (e.g., agricultural residues)
- Cofiring by fossil fuels permitted if annual thermal energy input is < 25% of total thermal input.
- Up to 60 MW capacity is allowed
- Firm and non firm capacity contracts are allowed with EGAT (Thailand national electricity company)
- The Bangsue Chia Meng Rice Mill cogen project qualifies for both energy and capacity payments

25

- The peak months of the EGAT electricity system when the cogeneration plant is required to supply electricity are compatible with the paddy harvest season when the rice mill operates at high capacity.

- A large technical potential for biomass cogeneration exists in Thailand. An economically and technically feasible potential has been estimated at more than 1,500 MWe.

- Above 10 percent per annum rise in power demand from the late 1980s and to the mid 1990s. The skyrocketing demand for power resulted in national government policy initiatives that permitted private power producers to sell electricity to the grid.

- The National Energy Policy Council of Thailand has a policy that allows Small Power Producers (SPPs) to supply electricity to the regional and national grid. The fuel used by SPPs must be non-conventional energy, waste or residual fuels (i.e., agricultural residues). However, the Electricity Generating Authority of Thailand (EGAT), the national utility, allows the use commercial fuels such as petroleum, natural gas and coal as supplementary fuels. The thermal energy produced by such supplementary fuels each year must not exceed 25% of the total thermal energy used in electricity generation in that particular year. Power generation from cogeneration processes is also eligible under the SPP policy.

The Government of Thailand Announcement on Potential Government Subsidy for SPPs using Rene wable Energy (7 June 2000)

The National Energy Policy Office (NEPO) intends to solicit bids for approximately 300 MW of power produced non-conventional energy, waste and/or renewable energy co-generation by SPPs. This is part of the Thai Government's Energy Conservation Programme (ENCON Programme) that aims to promote grid-connected non-conventional power schemes. NEPO plans to issue the Request for Proposal tenders in late September 2000 and will select technically and commercially sound projects for support in the form of incentive payments from the Energy Conservation Promotion Fund (ENCON Fund). The projects selected for support will be announced at the end of March 2001.

The financial subsidy will be given on per kWh of electricity sold to the Electricity Generating Authority of Thailand (EGAT) on top of the published SPP purchase price given by EGAT. The subsidy will be offered for an approximate period of 5 years. Eligible technologies include renewable energy technologies that are in compliance with established SPP regulations, namely: (1) non-conventional energy, (2) waste or residues from agricultural activities or waste from production of agricultural products, (3) products derived from waste or residues from agricultural products and industrial production processes, (4) garbage (e.g. municipal waste), and (5) dendrothermal fuels (e.g. tree plantations). Renewable technologies that operate in a co-generation mode are also eligible for support.

Due to this announcement by NEPO, there is currently a flurry of activities by project developers, agricultural residue owners, and other IPPs in developing projects for submission to NEPO.

Policy and Contractual Details of Biomass Cogeneration Projects in Thailand

The maximum capacity allowed for SPPs to supply to the grid is 60 MW (up to 90 MW on a case by case basis). There are two types of contract - "Firm" and "Non-Firm" - that an SPP can enter with EGAT.

Firm Contract

Duration: The duration for this type of contract must be longer than 5 years but cannot exceed 25 years.

Payment: The project is eligible for energy payment and capacity payment. The energy payment is the amount paid in Baht for every unit (kWh) of electricity purchased by EGAT. The capacity payment is the amount paid in relation to the capacity of the plant in Baht/kW/month. The tariffs for the purchase of electricity from SPPs are listed in the announcement for each purchasing period.

Conditions for operation: The project must generate and supply electricity to EGAT for not less than 4,672 hours and the generation and sales must include the months of March, April, May, and June (including September and October for non-biomass SPPs). The monthly capacity factor must not be less than 0.51 of the contracted capacity, but no more than 1.0, except when otherwise requested by EGAT.

EGAT's off-take liability: EGAT divides the system's daily cycle into three periods, namely, partial peak (8:00-18:30 hours), peak (18:30-21:30 hours) and off-peak (21:30-8:00 hours). During the partial peak and peak periods, EGAT is liable to take the electricity generated by the project of up to 100% of the contracted capacity. However, during the off-peak period, EGAT could demand the project to reduce its power supply to no less than 65% of the contracted capacity. If the project supplies electricity more than what is demanded by EGAT, the energy payment for the excess electricity will be reduced to 50% of the regular tariff.

On a yearly basis, EGAT is liable to purchase power from the project in the amount of no less than 80% of the project's contracted availability. If EGAT is unable to purchase up to the amount specified in a particular year, EGAT shall purchase the remaining amount in the subsequent year. In the event that the amount specified cannot be completely absorbed in the second year, EGAT shall pay the project the remaining energy payment using the average rate of energy payment in the second year.

Penalties:
There are penalties associated with failure on the part of the project to perform according to the terms of the contract. The penalties will be mainly in the form of reduction in the capacity payment. The project may also be requested to rectify the facility, or reduce the contracted capacity, depending on the type of failure in its performance.

Non-Firm Contract

Duration: Non-firm contracts have duration that are shorter than 5 years.

Payment: The project is eligible only for energy payment which is the amount paid in Baht for every unit kWh of electricity purchased by EGAT. No capacity payment will be paid for this type of contract. The tariffs for the purchase of electricity from SPPs are listed in the announcement for each purchasing period.

Conditions for operation: The operation of a project having a non-firm contract is very flexible, and does not require any minimum hours of operation, nor does it require the project to operate during any month in a year.

EGAT's off-take liability: EGAT is liable to purchase any amount of electricity generated by the project up to a maximum of the contracted capacity.

Penalties: There is no explicit penalty associated with non-firm contracts.

Project Lessons Learned

- Highly successful *commercial* demonstration projects are essential to develop a sense of confidence among local bioindustry managers and owners regarding cogeneration project investments. Demonstration projects can be encouraged with a combination of several mechanisms, including financial incentives and expert technical and marketing assistance.

- Assured technical success of projects is crucial for small mills that rely on only one or two boilers. The consequence of failure for the mill owner is very large when the milling equipment is not diversified (e.g., only one boiler).

- The condition for the sales of electricity to the power utility is important for enhancing financial recovery of the cogeneration facility investment.

- The technical facilitating roles of independent institutions and architectural / engineering consultant firms are very important in providing impartial information and confidence in the technology.

Replicability/Sustainability Potential in Thailand and Other APEC Economies

The benefits of biomass cogeneration include the following:

- Energy cost savings – savings gained from dramatic reductions in the need to purchase fuel for boiler firing and process heat production, and electricity from the local electric power utility
- Biomass residue disposal cost savings – cost savings from transportation cost and/or landfill tipping fee
- Revenues from sale of electricity to the grid
- Revenues from sale of combustion by-product (e.g., risk husk ash)
- Environmental benefits – reduced emissions of greenhouse gases (CO_2, CH_4) and other pollutants (SOx, CO, and particulates)

Important issues related to biomass cogeneration projects include the following:

- The possible need for long–term fuel supply guarantees if the cogeneration facility operator is separate from the mill owner.
- Availability of proven equipment with a successful operating record in an environment similar to the one in which the equipment will be installed.
- The need for highly reliable technology and after–sales services from the equipment suppliers.

- The implementation schedule should be short, to minimize interest during construction and any potential down time for mill operations.
- Operation and maintenance services must be reliably available if they are not part of the mill staff.
- An energy or power purchase agreement may be necessary to ensure financial viability.

Barriers to the implementation of biomass cogeneration projects include the following:

- *Technology barrier* – there may be an inadequate local proven track record, and the equipment may be perceived as complex and difficult to operate and maintain.

- *Information barrier* – lack of understanding and knowledge by biomass residue owners of the potential of biomass cogeneration projects and lack of knowledge regarding government incentives for project implementation can be significant barriers to exploration of and commitment to investments in biomass cogeneration.

- *Institutional barriers* – the size of some mills may be too small for economically feasible cogeneration and there may be a lack of skilled technical staff on site.

- *Financial barriers* – it may be more profitable to invest in other commercial and industrial ventures than in cogeneration, even if the return on investment for cogeneration is attractive (more than 20 to 30% after–tax return on investment).

UNITED STATES: GRID-CONNECTED LANDFILL GAS RECOVERY AND CONVERSION

Figure 17: Prince George's County Landfill Site

Introduction

The United States has the most extensive and successful program in the world for recovery, beneficial and economic use of methane generated from landfills. There are over 300 landfill methane projects in operation, and more under development. The US Environmental Protection Agency (EPA) estimates that there are as many as 500 additional landfill sites suitable for development of methane recovery and conversion. The US EPA Landfill Methane Outreach Program (LMOP) encourages the use of landfill gas as an energy resource. The LMOP assists utilities, municipal and private landfill owners and operators, community groups, and state agencies in reducing methane emissions from landfills through the development of profitable landfill energy recovery projects[15]. Methane captured from landfills can be transformed into a cost-effective fuel source for electricity, heat, boiler and vehicular fuel, or sold to a pipeline. The ongoing success of this program reflects a combination of factors. These include environmental policy governing landfill methane emissions, the emergence of effective and economically attractive technologies, the opportunity for full cost recovery for landfill methane recovery installations, and the emergence of a body of experience and network of experts in the field.

In May 1991, the U.S. Environmental Protection Agency (USEPA) proposed *Rules and Guidelines for Air Emissions from Municipal Solid Waste Landfills.* These standards and guidelines required that landfill gas collection and combustion systems be installed to achieve a 98 percent emissions reduction by weight. While the standards were developed to protect *local* air quality, they also have an obvious global environmental benefit. Methane is a powerful greenhouse gas (GHG), in fact it is 20 times more potent than carbon dioxide, and mitigation of methane emissions globally is now viewed as one of the important components of an overall GHG mitigation strategy.

Landfill gas collection and destruction systems (described below) are required to meet the emission reduction standards in the US. *Energy recovery and power generation systems can*

[15] Additional information on the USEPA Landfill Methane Outreach Program can be obtained from the LMOP web site (www.epa.gov/lmop).

be added to the gas recovery and destruction systems without significant additional cost. Further, the revenues generated from the power sale (either in the form of electricity or medium or high quality natural gas) generally more than offset the additional costs associated with the power generation systems. The methods of collecting LFG are the same whether the gas is flared, used to generate electricity, or feed either directly into a steam boiler or into the natural gas network after meeting network standards.

Landfill gas (LFG) is most widely used in internal combustion engine and to a lesser extent in gas turbine driven electrical generator sets. Manufacturers of landfill gas-fired power generating equipment have acquired substantial operating experience, which has contributed to the evolution of mechanical systems that are capable of operating with high reliability and acceptable maintenance programs. The LFG can also be used to generate steam and/or hot water. The combustion of landfill gas, either in a flare or power generation system, is the most practical and economical way of reducing the methane emissions into the atmosphere.

Figure 18: Landfill Gas Intake Pipe

Project Overview

We have selected one of the premier landfill methane recovery projects in the United States for detailed review and presentation. This is the *Brown's Station Road Sanitary Landfill Gas Recovery Project* in Prince George's County, Maryland, about 25 kilometers from Washington, DC. The project was developed to provide both electricity and fuel (gas for water and space heating) for a correctional institution (prison) owned by the local government and located 3 km. from the landfill.

The landfill gas is piped to a powerhouse adjacent to the correctional facility. There, three 850 kWe engine generators provide power for the facility and the excess power is sold to the local utility. The county owns the facility, and generates positive cash flow from it. The project was constructed in 1986 with 100 percent equity financing from Prince George's County.

This project has transformed an environmental liability into an environmental and financial asset. Environmental benefits derived from the project include greenhouse gas (GHG) emissions reductions, reductions of volatile organic compounds (VOCs), non-methane organic compounds (NMOCs), and toxic emissions, odor control, and methane migration control. Excess gas not used by the correctional facility is flared.

Project Development Roadmap

In 1982, the Prince George's County's Department of Public Works recognized the need to control the emissions of LFG for health and safety reasons and the value of the LFG as an energy resource. County officials decided to investigate the potential of using landfill gas from the Brown Station Road Landfill as an energy source for the new County Correctional Complex (prison) to be built 2 miles from the landfill site.

The department, in collaboration with the Johns Hopkins University (Baltimore, MD) conducted a comprehensive field test of the gas composition and yield rates. That year (1982) the university's Applied Physics Laboratory conducted a pre-feasibility study for the Prince Georges county government, and identified some uses for the methane gas. The study indicated the technical and economic feasibility of recovering the gas for production of electricity and heat. At that time the landfill gas recovery and conversion technology and its applications were in their infancy.

In 1983 the Maguire Group Inc. (consulting engineers and architects) was commissioned to conduct a feasibility study on the extraction, treatment, and possible use of landfill gas from the Brown Station Road Landfill.

After the initial assessment, the Maguire Group Inc. was retained to investigate further possible applications of the LFG. The firm designed the landfill gas recovery and beneficial use system that provide both electricity and fuel (gas for water and space heating) for the County's correctional institution located two miles from the landfill.

In 1987 the LFG recovery and power generation system went into operation. Soon after start-up, modifications had to be performed to the gas treatment and energy generation systems due to high levels of chlorinated organic compounds. The resulting project reengineering produced some important technology innovations that have benefited similar projects in the US and elsewhere, and that are directly relevant to future LFG recovery projects in APEC economies.

In 1988 the modifications were completed. Since that time the overall project performance has been very high with, 99.9 percent availability to meet fuel and electricity requirements of the correctional facility. The average availability of each engine generator has been about 92% over more than a decade.

In 1990, due to the project's outstanding performance, PEPCO (the local utility) signed a 20-year contract with the County for on-peak summer period purchase of excess electricity from the project by paying a capacity credit in addition to the price of electricity.

In addition to the EPA's proposed *Rules and Guidelines for Air Emissions from Municipal Solid Waste Landfill* (mentioned above) the EPA, in 1996, enacted *the New Source Performance Standards and Emission Guidelines (NSPS/EG) under the Clean Air Act*. The NSPS/EG required that landfills with capacity greater than 2.75 million tons of waste and emit more than 55 tons of non-methane organic compounds (NMOCs) collect and combust the generated LFG. This created an additional impetus for long-term operation of the facility.

Landfill Methane Recovery and Conversion at the Project Site

In 1997 there were over 8.5 million tons of waste in the landfill, with annual receipts of ca. 375,000 tons. This landfill is expected to remain active through the year 2015. Gas genera-

Figure 19: Landfill Gas Processing Facility

tion is about 6 million cubic feet per day, and about 70% of the gas is recoverable. A well field covering 150 acres recovers the gas.

Initially, the gas collection system consisted of 29 vertical wells spaced approximately 70 meters apart and arrayed in a triangular grid. The wells were fabricated from PVC (polyvinyl chloride) pipes. The power generation equipment consists of 3 Waukesha 5970GL, lean-burn turbocharged engines rated at 850 kW each. There are two Cleaver-Brooks 350 HP firetube steam boilers located in the correctional facility that provide hot water for heating and washing. Even though the LFG from the landfill can provide all the electricity and heating needs of the Correctional Complex, the center is also connected to the local grid to ensure 100% back-up service to the facility. In addition, No.2 fuel oil is stored on site as a backup fuel.

Landfill gas (LFG) contains approximately 50 percent methane, thus the heating value of LFG is approximately 18.8 GJ per 1000 cubic meter. Engine modifications and development of specialized lubricant oil were performed when an engine failed soon after start-up. The failure from metal corrosion and scale deposit buildup was attributed to the high halogenated organics in the LFG. *No failures have been experienced since engine modifications were made.*

Technology Considerations and Innovation

At the time of the initial design, the effect of landfill gas on the internal combustion engines was not known. The principal effect is corrosion from various contaminants in the gas. Early failure of the internal combustion engines precipitated a detailed study and investigation of the failure, which resulted in standards that are commonly used today. These standards are (1) special materials for construction of certain engine components, (2) strict operating parameters and procedures, in particular operating temperatures of the engines, (3) the development of a special oil for use with landfill gas engines, developed in cooperation with Mobil Oil and Walker Shaw Corporation.

Because the LFG would be transmitted through a two-mile steel pipeline to the detention center, it was necessary to dry the gas so that condensation did not occur in the pipeline, which would have caused corrosion. Although not anticipated at the time, this also had benefits to the operation of the engine. In many other projects in the USA where there was no transmission requirement for the gas (direct use at the landfill) drying was not included in the gas treatment which resulted in engine failures due to the gas moisture content.

One of the project's successes has been the fact that the original engine supplier has also been under contract to PG County to operate and maintain the facility. Today, much more is understood about landfill gas than was known at the project inception. There is now a solid understanding of the required technical specifications of engines suitable for the use of the landfill gas, and the operations requirements for them. Consequently it is not necessary to have the same level of skill in current projects as was required in the early projects. Today there is good understanding of potential problems and the technology can be operated in a more simple way. However, *a well-trained operations and maintenance crew is essential.*

Industrial engine operation and maintenance experience *is* needed, plus some training specific to the use of landfill gas. In the event that LFG facilities are developed in other APEC economies, it would be very useful to bring designers, managers, and operators to US and European facilities and to train them on site. This would greatly facilitate technology transfer.

Project Financing and Financial Performance

The Prince Georges County owns the facility, and generates positive cash flow from it. This project has transformed an environmental liability into an environmental and financial asset. The facility was financed by a project-specific 10-year bond issue. The bond was repaid in 7 years. Excess power is sold to the local utility (Potomac Electric Power Company – PEPCO), and initially the rates were extremely favorable, as they were subject to the provisions of PURPA (the Public Utility Regulatory Policy Act).

The benefits of the project are the avoided costs for electricity and heat at the Prince George's County Correctional Facility and revenues from the sale of excess electricity to PEPCO. In 1992, the annual gross benefits were over $1.3 million. The project's financial performance has been very good as well with approximate annual net benefits of $0.35 million per year during the period of the debt service and $0.87 million per year since debt retirement.

Table 8: Landfill Gas Recovery Project Economics

	US$ (1992)
Capital Costs	
Gas Collection System	287,000
Gas Treatment – Compressor Facility	1,725,000
Gas Transmission Line	485,000
Power Generation Facility	2,500,000
Total System Capital Cost	4,997,000
Environmental Credit	287,000
Federal & Maryland Dept of Corrections Funding	802,500
Net Incremental Capital Cost	**3,907,500**
Recurring Costs (yearly)	
Debt Service (5.5% interest, first 10 yrs.)	520,000
Operation and maintenance	400,000
Total Recurring Cost	**920,000**
Annual Energy Revenues	
Avoided costs of electricity (7.88 mil. kWh * $0.065/kWh) Avoided costs of heating fuel (29,956 MMBtu * $6.79/MMBtu)	512,500 203,400
Revenue from sale of electricity (13.14 mil. kWh * $0.042(1)/kWh)	551,900
Total Annual Revenue	**1,267,800**
Annual Net Revenue	**347,800**

(1) Includes $0.01187/kWh capacity credit

Project "Landscape" / Environment

The development of landfill gas to energy projects is induced by the need to comply with regulation of landfill gas, strong economic attractiveness of project financials and local community benefits, and local and global environmental benefits.

Federal Laws and Regulations

In the United States, landfill gas is regulated under the New Source Performance Standards and Emissions Guidelines (NSPS/EG) of the Clean Air Act. The target of the regulation is the emissions of volatile organic compounds (VOCs), non-methane organic compounds (NMOC's) contained in the LFG. To comply with the regulation, landfill owner/operators need to collect and combust their landfill gas. The collected gas can be flared or used as an energy resource.

Economic Attractiveness

Since investments will be committed to collect the gas for flaring under the NSPS/EG regulation, the incremental cost of adding an engine generator for power production or selling the captured LFG for use as heat or fuel is minimal. The sale and use of generated power and/or LFG as an energy resource also generate revenue and/or savings for the landfill owner. The construction and operation of a landfill gas energy project will also create employment opportunities for the local economy.

Local and Global Environmental Benefits

Using LFG as a renewable energy resource provides enhanced local environmental benefits such as reduction of local ozone levels, smog formation, unpleasant odor, migration of the gas to surrounding buildings and structures, and diminished threats of explosion from spontaneous methane combustion. Converting landfill gas to energy also offsets the need to use conventional energy resources such as coal and oil, and thus reducing the emissions of air pollutants (e.g., carbon dioxide, methane, and sulfur oxides) that contribute to acid rain and global climate change.

Financial Incentives

Local financial incentives are also available in the US to stimulate the development of landfill methane recovery and conversion projects. These include the following:

<u>Low interest Loans</u>

- Iowa: Low-Interest Rate Loans
- New Jersey: Sustainable Development Low-Interest Loan Fund
- North Carolina: Business and Energy Development support
- New York: Clean Water State Revolving Loan Fund
- Missouri: Financing Support for Direct Use of Landfill Methane in Public Buildings

<u>Tax Incentives</u>

- Washington State: Sales and Use Tax Exemptions for landfill gas-to-energy (LFGTE) Projects
- Iowa: Property Tax Exemption for Methane Gas Conversion Property
- Ohio: Air Pollution Control Project Tax Exemptions

<u>Grants</u>

- Wisconsin: Renewable Energy Project Development
- California: Opportunities Created by Electricity Deregulation

<u>State Procurement policy</u>

- Colorado: State Purchasing of Renewable Energy

<u>Regulations</u>

- Wisconsin: Requiring Renewable Energy Utilization

Summary and Conclusions

Landfill gas-to-energy projects can turn an environmental problem into an asset. By developing landfill gas-to-energy projects, landfill owners/operators can capture the gas and convert it to an energy source. This reduces odors and other hazards associated with landfill gas emissions and helps lessen the reliance on fossil fuel-based energy. It also will help prevent methane from migrating into the atmosphere and contributing to local smog and global climate change.

The Brown Station Road Project that has been illustrated is an excellent example of how a liability was turned into an asset and how local and federal standards were the driving force behind such a project. The project also demonstrates the innovative and beneficial use of this resource. Landfill gas can be used in many ways such as electric generation, direct firing in boilers, upgrading (purification) to medium and high quality pipeline gas, or as an alternate vehicular fuel. This project is one of many in the US that has been the catalyst for the development of equipment specially designed or adapted for use in the landfill gas industry. As other technologies are developed and perfected there will be more opportunities for the beneficial use of landfill gas.

Key issues associated with developing successful landfill gas-to-energy projects are:

- Careful investigation and selection of a suitable landfill for energy project development
- Conservative estimate of the amount of landfill gas that can be captured
- Analysis of all possible beneficial uses of the landfill gas
- Project design firm should be experienced landfill gas-to-energy project design firm
- Use of equipment designed or developed specifically for the landfill gas-to-energy industry
- Hiring of an experienced construction firm for installation of the project
- Selection of an operation and maintenance firm that has a track record with the equipment and is familiar with problems associated with landfill gas.

The above guidelines were used by the Prince George's County in the development of their project and modified from experience gained during the early days of project operation.

US: GRID-CONNECTED LARGE-SCALE WIND ELECTRIC POWER

The Enron Wind Power Plant at Storm Lake, Iowa (US)

Relevance to APEC Economies

Large-scale, grid-connected wind energy installations are fully commercial options today, with major suppliers in Europe (e.g., Denmark, the UK, the Netherlands, Germany), Japan, India, and the U.S. The largest national source of wind turbines is Denmark. By fall 2000 there were over 15,000 MWe of installed wind generation capacity worldwide. By the end of year 2002 this is expected to grow to more than 20,000 MWe, with 3,000 MWe in Asia alone (primarily India and China).

Figure 20: The Enron 193 MWe Wind Plant at Storm Lake, Iowa.

Many of the APEC economies have large commercially interesting wind energy resources. Economies with known commercially important wind resources include Chile, Peru, Mexico, the United States, Canada, China, Japan, Taiwan, the Philippines, Australia, and New Zealand. Even Indonesia, often thought to be not windy, has some areas where the wind resources have been demonstrated to be of potential commercial use.

In order for an APEC economy lacking experience in wind power development to explore and exploit possibilities for wind electric power development, it is essential to understand several things. These include the *process* (road map) for wind power project development, and the *enabling environment* (landscape) for large scale deployment of wind power plants. Understanding the project development process is important in order that APEC governments know what they must do to facilitate rather than impede renewable energy project development. Of course this is subject to environmental, land use, and other constraints, but often the reluctance of government planning agencies to freely share data on existing land use and land use planning can be a major hindrance to renewable energy project development, especially for wind. The development process is presented both generically and with the example of the 193 MWe Storm Lake (Iowa) plant commissioned late in 1999 by Enron Corporation.

APEC economies acting in concert with the private sector and the financial community, can stimulate commercial wind electric power development through a variety of policy initiatives and associated financial incentives. The array of possible incentives is very large, and no single initiative is likely to be sufficient to attract the scale of private investment needed for wind electric power to become a significant source of electricity in an economy over the coming ten to twenty years. Fortunately, there are many examples of successful initiatives elsewhere (and some startling examples of failures as well!). A broad menu of policy instruments that are in place and responsible for facilitating the very large scale commercial investments in wind electric power in the United States and several European economies is presented later in this section.

The Contemporary Wind Electric Power Industry

Large-scale, grid-connected wind energy installations are fully commercial options[16] today, with major suppliers in Europe (Denmark, Netherlands, Germany), Japan, India, and the U.S. The largest national source of wind turbines is Denmark. By fall 2000 there were over 15,000 MWe of installed wind generation capacity worldwide. By the end of year 2002 this is expected[17] to grow to over 20,000 MWe, with 3,000 MWe in Asia alone (primarily India and China).

"Medium sized" wind turbines with rated capacities around 600 kWe are now a mature technology, with units as large as 1.5 MWe now being installed. A third of all installed wind capacity worldwide is with turbines in the range of 500 – 700 kWe. The wholesale price per kWe of wind turbines in the range of 300 kWe to 1.5 MWe is roughly $700 - $1,000. The cost of electricity produced by a wind plant depends on the capital and operating costs of the plant, the plant financing structure, and the annual average wind speed (which determines the net annual energy output). The present levelized busbar costs of electricity from modern wind power plants are in the range of $0.03 to $0.06, and these costs are expected to decline by 30 to 50% over the coming decade of commercial wind electric power expansion.

Table 9: Current and Year 2002 Expected Global Wind Electric Power

Region	Cumulative capacity beginning 1998 (MWe)	Cumulative capacity beginning 1999 (MWe)	Expected capacity end of 2002 (MWe)
European Union	4,739	6,379	12,450
United States	1,584	1,819	2,900
Asia*	1,116	1,158	3,050
Rest of the world	309	449	1,900
TOTAL	**7,784**	**9,805**	**20,300**

* 1998 and 1999 data are for China and India; 2002 data for all of Asia

[16] See, for example Louise Guey-Lee (1998), *Wind Energy Development: Incentives in Selected Countries*, Energy Information Administration / Renewable Energy Annual 1998; Jamie Chapman, Steven Wise, et. al. (November 1998), *A Few Dollars Per Family: The Cost of Large-Scale Wind Power Development*, Renewable Energy Policy Project Research Report No. 6; European Commission – Directorate General for Energy (1998), *Wind Energy – The Facts. 5 volumes.*

[17] European renewable energy institutions, as quoted in *Renewable Energy World, May 1999, page 135.*

Table 10: Wind Electric Power in Europe, the United States, and Asia in 1998, 1999, and 2000 (APEC Economies shown in boldface)

Economy	Cumulative capacity beginning 1998 (MWe)	Cumulative capacity beginning 1999 (MWe)	Cumulative capacity beginning 2000 (MWe)
Germany	2,080	2,874	4,445
Denmark	1,116	1,450	1,742
India	950	968	1,095
Spain	512	834	1,530
Netherlands	325	363	410
United Kingdom	320	334	355
Italy	100	180	211
Sweden	117	150	220
United States	**1,584**	**1,927**	**2,492**
Australia		**17**	**11**
China	**166**	**224**	**182**
Canada		**83**	**127**
Japan	**17**	**31**	**70**
Mexico		**3**	**3**
South Korea		**2**	**7**
New Zealand		**5**	**37**

Source: *Renewable Energy World* (November 2000)

Business Requirements for Wind Power Plant Development

As a prelude to wind electric power plant development, there are specific preconditions necessary to attract investment capital. The initial stage of the project development "road map" is the determination of these factors. Of course it is necessary that for the APEC economy and region of interest, independent energy production is permitted, generation with alternative renewable energy technologies is permitted, and there are clear procedures for obtaining approvals and permits. National or provincial policies and laws promoting the use of renewable energy power systems are an attractive element of the policy environment.

The environment conducive to the development of wind power plants includes the following:

- Clear potential for a technically sound project
- Clear potential for a financially feasible project
- Clear and enforceable energy sale commitments
- Clear and appropriate investment and environmental regulations applying to wind power
- Well-defined and guaranteed access to and use of the land (power plant site)

The project must be technically feasible: Technical feasibility requires the availability of potential project sites with good wind resources that have been accurately measured for a period of one to several years. "Good" means annual average wind speeds in excess of 7 meters/second, with the potential for generating power with a capacity factor (CF) of 25% or more. The CF is the percentage of time that the plant would operate at its rated capacity to produce the annual energy production. In reality the energy generated by the wind farm varies with the wind speed; the CF collapses the annual average electricity production into a single parameter. The possibility of extreme wind events (e.g. typhoons) may limit the suitability of an otherwise attractive wind farm site.

Other requirements for acceptable wind power plant sites include the following:

- The presence of suitable all weather roads to carry the heavy equipment and wind turbine components to the site,
- Suitable soil conditions,
- Proximity to transmission corridors,
- Long-term availability (20 years or more) of the site via lease, sale, or other assignment for *at least* the life of the project, and
- A stable electric power grid that supports interconnection of wind farms.

The implications for host economy government support are generally clear.

The project must be financially feasible: Financial feasibility requires that the project provide adequate revenues to assure scheduled debt repayment and an adequate return on investor equity. This in turn requires a clear and transparent, enforceable contract between the owner of the wind farm and the customer (usually the electric utility) for the generation capacity and energy. In order for the developer to achieve sufficient returns and debt coverage, especially for the initial wind plants in an APEC economy, there may be a need for specific incentives. These may include tax holidays, exemptions from import duties, no payment of VAT, below-market financing, and an acceptable contractual energy sales commitment.

The elements of an acceptable energy sales commitment, such as *a power purchase agreement (PPA)*, typically include the following:

- Guarantees for the sale of the energy and in some cases the generation capacity as well
- Energy and power purchase price established for the term of the contract
- Ability to assign the project and project assets to lenders in order to secure financing
- Specific procedures and penalties for early termination of the project
- The right of the lender to cure defaults before the contract termination
- Well-defined arrangements in the event of *force majeure* and natural disasters (sometimes referred to as "Acts of God") such as floods, hurricanes, and earthquakes.
- Enforceable international rules of arbitration for the resolution of dispute, without recourse to formal appeals by any court.

Risks facing wind power developers in some of the APEC economies include the following:

- Currency risk
- Regulatory risk in restructured power sectors.
- Unknown treatment of Independent Power Producer (IPP) contracts with the national electric utility if there is privatization, deregulation, or restructuring.
- Typhoons (in some regions of some APEC economies), which raise equipment risks
- Any requirements that the majority of the equity be held by host country firms may deter foreign firms interested in owning and operating wind power plants.

A recent consultant study for one APEC economy (Philippines) suggests that the private sector will request the following actions by government in order to proceed with investment and development of wind power projects, no matter which APEC economy:

1) Provide long-term power purchase contracts (ca. 20 years) to encourage private sector investment.
2) Denominate wind energy contract payments (power tariffs) in hard currency.
3) Formalize treatment of wind energy as a "must-run," must-take" form of energy.
4) Create front-loaded power tariff structures for wind projects (higher prices in the early years).
5) Provide waiver of import duties, VAT and other taxes on imported wind equipment on an ongoing basis (for all wind projects regardless on whether "first-of-a-kind."
6) Eliminate or reduce the requirement limiting foreign ownership to 40%, or provide other contractual mechanisms to encourage foreign investment (e.g., service contracts).
7) Guaranteed repatriation of profits.
8) Establish production and/or investment tax credits to accelerate wind project development
9) Establish accelerated depreciation schemes
10) Government to build a transmission line to handle substantial wind capacity in key resource areas.
11) Examine the potential for matching wind projects with pumped storage hydro projects. Wind projects can increase the productivity of some hydro projects.
12) Perform "load flow" analysis to explore impact of adding different levels of wind energy into the grid system at various points. This analysis is relevant for Luzon and for islands where system stability may be more of an issue.
13) Assess the potential for smaller, distributed wind projects on the grid throughout the economy.
14) Continue the analysis of the wind resource to reduce wind project development risks.

If these conditions (or a sufficient subset) are present, the developer typically will proceed along the following steps ("road map" for project development).

Steps in Wind Farm Development

At each of these steps there may be the need for obtaining information and data from government agencies, and there will be requirements for permits, easements, etc. APEC economies committed to attracting both domestic and international investment in wind power project development will need to streamline the processes for information access and permitting. Time is money in project development, and extended development times due to unnecessary roadblocks will result in developers going to more wind power "friendly" regions.

Prefeasibility Assessment

- Market assessment (identify the elements of as acceptable or attractive market environment, including government policies, financial incentives and requirements, constraints, etc. Also the quality of the grid, including interconnection opportunities and requirements, rules and costs of wheeling, etc.)
- Preliminary wind resource and site identification, assessment, and screening
- Estimation (from wind resource estimates) of the annual energy production potential for the site, for specified wind turbines
- Preliminary project *pro forma* financial analysis and assessment
- Determine requirements to secure long-term rights to the site and access to the site

Full Engineering and Financial Feasibility Assessment

- Identify reliable power purchaser or market
- Assess all relevant site characteristics
- Determine proximity to transmission lines and corridors
- Secure access to the land
- Conduct detailed measurement and assessment of the wind resource
- Establish access to capital
- Determine the plant financial feasibility
- Obtain the necessary permits
- Conduct dialogue with local communities and potential stakeholders
- Establish dialogue with turbine suppliers
- Secure agreement to meet O&M needs

Wind Energy Resource Assessment

The assessment of wind energy resources is a crucial element of wind power development. It is a multi-step process. Initially, a high resolution wind map of a large region, perhaps even an entire economy, will determine where the likely high value wind resources are located. By overlaying graphic information displaying roads, transmission corridors, location of load centers, land use patterns (e.g., parks, other protected areas, restricted areas, airports, farmland, forests, etc.), the locations of possible good wind power plant sites can be identified. The wind data and other relevant siting data should be in a Geographic Information System (GIS) format to facilitate wind power plant site assessment. *For such activities to proceed efficiently, an APEC economy government must provide efficient access to this information. Without adequate information available in a timely manner, developers will not be able to proceed.*

This desk study work is followed by on site inspection by an experienced wind resource expert (usually a meteorologist), and a subset of sites that meet the general criteria for wind power plant development can be characterized in term of the local wind resource. Multiple anemometers that take measurements at two or three heights (including the projected hub height for the selected wind turbines) will gather data for a period of a year or more. Highly detailed data are stored on a microchip, and data are either collected by hand (swapping out the chips monthly) or, if cellular phone service is available, via telemetry.

Project Example: the Enron Wind Power Plant at Storm Lake, Iowa

Enron Wind Corporation has developed, constructed, and now operates the 193 megawatt Storm Lake project, the largest wind plant in the world. The plant is in northwestern Iowa, in Buena Vista and Cherokee counties. This plant is presented as a case example of technically and financially successful large scale wind power development. It is also socially successful, due to early discussions with local communities in which both the benefits and potential liabilities of the project were presented. Local communities have supported the project, which has brought 30 operation and maintenance positions to the area.

Enron Wind Corporation is considered a pioneer and leader in the wind industry. Since the mid-1990s, with the acquisition of Zond (wind turbine manufacturer and project developer), the company has developed and constructed over 4,300 wind turbines, comprising more than 1,400 MW. Enron Wind is based in North America and Europe, and produces advanced wind turbines ranging from 750 kWe to 2.0 MWe.

Technology

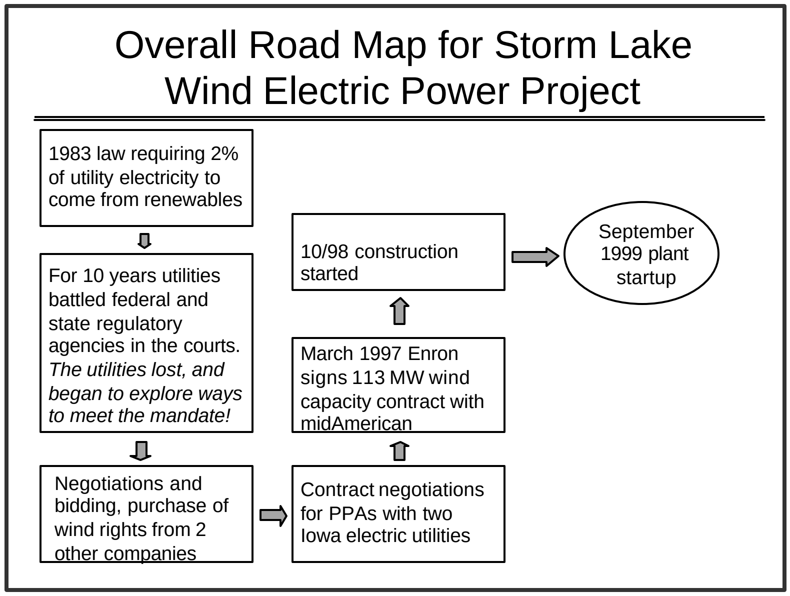
The plant contains 257 Zond Z-750 kWe wind turbines. These machines have a variable speed, constant frequency configuration. The design leads to improved power quality and increases the aerodynamic efficiency of the turbines while reducing mechanical loads. At the time the Storm Lake project was developed, the Z-750 was the largest wind turbine manufactured in the United States. Enron Wind's 1.5 MWe wind turbine began manufacture in the US in year 2000.

Figure 21. Construction Activities at the Storm Lake Site

The project's turbines are certified for a 30 year fatigue life. They are designed to withstand hurricane loads of up to 131.1 mph (59.5 meters per second) as a once in 50-year occurrence and 99.8 mph (44.6 meters per second) as a yearly occurrence. This is an important consideration for APEC economies subject to extreme storms (especially the Philippines, with typhoons affecting the northern regions of the economy). The towers are as high as a 20-story building (63 meters) and the turbines are spaced over 600 meters apart. The rotor diameter is 50 meters, about the same size as the wingspan of a jumbo jet.

Project Schedule and Road Map

Although the plant was constructed in less than a year, the project development began in the mid 1990s, and the genesis of wind power in Iowa began a decade before. Policy and institutional issues rather than technical or financial obstacles delayed this project. The principal events and dates in the development of wind electric power in Iowa and the subsequent development of the Enron project are as follows:



- In 1983 the Iowa State legislature introduced a law requiring that 2% of utility electricity should be generated from renewable energy sources.
- For the next decade the local electric utilities opposed this legislation. However, after losing a ten-year battle in the courts, the utilities began to explore ways to respond to this mandate.
- In the mid-1990s Enron initiated negotiations for power purchase agreements with two Iowa electric utilities.
- Enron initiated discussions with local communities early in the project development process. Their approach to community involvement in and understanding of the project was crucial in being able to develop the project rapidly once the power purchase agreements were signed.
- In March 1997 Enron Wind entered into a long-term agreement with MidAmerican (Des Moines, Iowa) to provide 113 MWe of wind generated capacity to the MidAmerican grid.
- In July 1997, Enron Wind also entered into an agreement with IES Utilities (Iowa) to provide IES with 80 MWe of wind generated capacity.
- Ground breaking was in June 1998.
- September 1998 - Grading of roads, turbine pads, and foundations was initiated. Collection system lines were placed underground in the farm fields and overhead on poles near roads. The substation was constructed. Turbines and towers began arriving at the site.
- Plant construction began in October 1998.

- January 1999 – the substation was completed and turbines began to be placed on line while other turbines were being erected.

- In September 1999 the plant was completed, commissioned, and started up.

Policy and Financial Incentives in Stimulating Wind Power Development

This section summarizes many of the incentives established in Europe, Asia, and the United States in the 1980s and 1990s to facilitate and encourage the commercialization of wind electric power generation as a main-stream utility power systems technology. Within the U.S. there have been many incentives at the individual state level as well, in addition to Federal incentives and policies. There are discussed in detail in a recent report [18] from the Energy Information Administration. The summary below includes material drawn directly from that report, and illustrates the myriad of policy and other options available in principle to APEC economies that are seriously interested in developing their wind energy resources.

U.S. Incentives for Wind Electric Power

The passage in 1978 in the U.S. of the *Public Utility Regulatory Policies Act (PURPA)* created the first market for wind-generated electric power. The specific implementation of PURPA in California resulted in highly attractive long-term power purchase contracts for wind power plant developers. The new attractive market environment in California led to major investments in the development of commercial wind electric power systems, by companies within and outside of the United States. The emergence of the international wind electric power industry is a direct result of policy incentives created in the U.S. two decades ago.

The following is a representative though incomplete summary of the broad menu of incentives available in the United States for wind electric power development.

Investment Tax Credits. Only a few states retain these credits. These include Hawaii, Massachusetts, Montana, North Carolina, Oregon and Utah.

Production Tax Credits. This type of credit provides the investor or owner of qualifying property with an annual tax credit based on the amount of electricity generated by that facility. By focusing on production, improved project performance is encouraged. Section 1914 of the Energy Policy Act of 1992 (EPACT) created a 10-year, 1.5 cents per kilowatt hour credit adjusted for inflation for new plants entering service before June 30, 1999. It has been estimated that this production tax credit can lower life-cycle levelized costs of wind power by about 25 percent. Much of new and planned capacity depends on this credit, which has been extended beyond the end of 2001.

Property Tax Reductions. Reductions in property taxes can be used to promote wind development by decreasing the tax burden associated with owning a wind power facility. The tax burden is relatively high compared to that for the use of fossil energy because of the greater land requirements per kWh of output. This policy is an effective incentive in several states. In Minnesota, where property taxes are high, property tax exemptions could reduce levelized costs by 1.0 cent per kWh in some cases. The disadvantage of this mechanism is that it produces an incentive for development, not a market *per se.*

[18] Louise Guey-Lee (1998), *Wind Energy Developments: Incentives in Selected Countries.* US Energy Information Administration (EIA), Renewable Energy Annual 1998 (available on the World Wide Web).

Accelerated Depreciation. Tax depreciation is a non-cash expense meant to approximate the loss of asset value over time. It defined as the portion of an investment that can be deducted from taxable income in any given year. The federal Tax Reform Act of 1986, which established the modified accelerated cost recovery system (MACRS), set the current rules for federal tax depreciation. Under MACRS, wind property is currently provided a depreciation life of 5 years, substantially shorter than the 15 to 20 year depreciation lives of non-renewable power supply investments. Accelerated depreciation results in tax benefits early in a project's life, and is preferred by investors because an after-tax dollar is worth more today than in later years.

Direct Production Incentives. Although similar to a production tax credit, direct production incentives provide cash income directly. At the Federal level, Section 1212 of Energy Policy Act of 1992 (EPACT) provides a "Renewable Energy Production Incentive" (REPI) of 1.5 cents per kWh to non-profit organizations that own wind facilities.

Direct Investment Incentives (Grants). These include programs such as the Department of Energy's Turbine Verification Program, in which cost sharing with utilities permits early development of wind systems preceding full-scale deployment of turbines. It also includes State funds used for seed grants to conduct resource assessments and feasibility studies.

Government Subsidized Loans. Utility-scale wind system debt interest rates typically are 1 to 2 percent higher than rates for gas-fired projects. Subsidized loans can be provided at below market interest rates, thus reducing loan payments and levelized costs. Although there is no federally subsidized loan program, several States including Minnesota have established them. This type of program promotes wind energy, but the effect by itself is insufficient to make wind electric power competitive.

"Long-term Avoided Cost Standard Offer Contracts" for Small and Distributed Projects. During the 1980s, long-term standard offer contracts (the so-called "Standard Offer 4 Contracts") that guaranteed energy and capacity payments 10 years into the future (and saved on transaction costs), were pivotal in the development of the wind electric and solar thermal electric industries. These contracts were developed to support the implementation of PURPA, and the most significant impact of these was in California, where over 1,000 MWe of wind generation capacity and over 400 MWe of solar thermal electric power generation capacity was developed commercially in the 1980s. The guaranteed prices were based on each utility's "full avoided cost" of marginal generation assuming continuously escalating energy prices (which did not materialize). As these contracts have been renewed, the new prices have been much lower and threaten the viability of operating wind plants.

Net Metering or Net Billing. Under this system, utility customers are guaranteed a market for their power by being permitted to operate a "reversible meter." When customers use more electricity than they generate, they pay for the additional electricity at retail prices as usual. Conversely, when customers generate more electricity than they use, the electric utility is obliged to purchase the additional electricity. The prices customers receive for their excess electricity varies widely by State and region and between wholesale and retail levels. So far, experience for wind and net metering is limited. Although California has a provision for net metering, it excludes wind as a source. Other States limit the size of eligible projects, so larger wind projects (greater than 50 or 100 kW) cannot participate.

Site Prospecting, Review and Permitting. Programs in California and at the Federal level have been developed to conduct site resource assessments, evaluate transmission issues, conduct bird population studies, settle zoning issues, and streamline permitting processes. This helped to promote the early development of wind energy projects in California. The U.S. Department of Energy Utility Wind Resource Assessment Program performed a similar function in later years.

Renewable Portfolio Standard (RPS). The terms of renewable portfolio standards vary among States, but an RPS generally requires every retail power supplier to provide a certain minimum percentage (or floor) of electricity from specified renewable sources for a given time period. A RPS can operate in tandem with a credit trading system, so suppliers sell credits for extra renewable power they generated or vice versa. If they are short of renewable power they can purchase credits to make up the difference to settle their account. Legislation establishing some sort of renewable portfolio standard has passed in a number of states including Arizona, Maine, Massachusetts, and Nevada.

Renewable Energy Set-asides. In California, a recent ruling provides for a 0.7-percent surcharge on electric bills to support renewables during the four-year transition to a competitive market. Wind energy is earmarked to receive $70 million of an estimated $540 million total budgeted. Already, some 300 megawatts of new wind energy projects have won the opportunity to receive California Energy Commission financial incentive funds.

Auctioned Contracts. Increasingly, electric utilities have acquired renewable energy competitively by issuing requests for proposals (RFPs), which generator owners can bid on. In effect, the bidder guarantees to provide a given amount of electricity under specified terms for a given price. To date, most of these RFPs were issued as renewable only or technology specific only.

Green Marketing/Pricing. These are voluntary programs in which customers agree to pay a premium to purchase "environmentally friendly" or "green" electricity. This encourages development of a market for renewable power, wind included. So far, public response has been limited. It is estimated that only 1 to 4 percent of residential consumers will participate in the near future in California's green pricing program. Green pricing appears to be increasingly popular in both the US and some European economies, and may be of interest in some of the APEC economies as well.

State Mandates. These provisions differ for each State. In Minnesota, the State legislature has required Northern States Power to phase in construction of 425 megawatts of new wind capacity by 2002 as compensation for being allowed to store nuclear waste on site. In Iowa, the Alternative Energy Law (AEL) requires investor-owned utilities to purchase a combined total of 105 megawatts of their generation from renewable and small hydropower sources. The majority of needed capacity will be from wind power and biomass applications.

Research and Development. The United States government has long supported development of wind technology that will be economically competitive as an energy source.

The Wind Energy Program, administered by the Department of Energy, supports applied research, turbine research, and cooperative research and testing.

Denmark Incentives for Wind Energy[19]

In addition to incentives for in-country generation of electricity from wind electric power plants, Denmark has supported its wind electric power industry (the world's largest) with research and development funds and concessional financing for international projects. The principal in-country incentives are the following:

Windmill Law. This law requires electric utilities to purchase output from private wind turbine owners at 85 percent of the consumer price of electricity plus ecotax relief of about Kroner 0.62, or 9 cents per kilowatt hour. Electric utilities receive Kroner .10 or 1.5 cents per kilowatt hour production subsidy for power generated by wind.

Energy 21. In earlier years, Denmark undertook development of wind energy to lessen dependence on imported oil. Now development is tied to its Energy 21 goal of reducing CO_2 emissions by 20 percent by 2005. This translates into an initial 1,500 megawatts of wind capacity on land and later by 2030, 4,000 megawatts offshore. This plan also encourages support at the grass roots level as local planning boards have been asked to include wind in their energy plans.

Germany Incentives for Wind Energy

Germany has made impressive gains in installed wind capacity since 1991 and is now setting the trend for Europe's future. German wind electric power capacity is nearly 2,000 megawatts, up from less than 100 megawatts in 1990. In mid-1997, Germany surpassed the United States as the economy with the greatest wind capacity. German incentives include the following (see footnote 19 for source):

Electricity Feed Law (EFL). Since 1991, the EFL has obliged electric utilities to purchase renewable energy at guaranteed prices equal to 90 percent of retail price. For wind, this amounts to Deutsche Mark (DM) .1715, or 10.5 cents per kilowatt hour in 1997 for the life of the plant--a significant stimulus to development. In the future, as prices come down in Europe's more competitive, liberalized electricity market, the guaranteed price is expected to be lower--about 2 percent less in 1998 for example. This type of decrease is expected to gradually put economic pressure on developers. In addition, the electric utilities are opposed to the EFL because of the burden it places on them. Efforts to declare the law unconstitutional failed, but the amendment to the EFL recently passed in Germany's Parliament is more favorable for utilities. It provides a cap (some 5 percent) on electric power taken from renewable sources. This is good and bad news for the wind industry--the EFL is still in force, but there is a limit on benefits.

Investment Assistance. The Deutsche Ausgleichsbank grants to wind turbine operators soft loans with average interest rates of 1 to 2 percent below the rates in the capital mar-

[19] Louise Guey-Lee (1998), *Wind Energy Developments: Incentives in Selected Countries.* US Energy Information Administration (EIA), Renewable Energy Annual 1998 (available on the World Wide Web). Also the source for the German and Indian Incentives information.

ket. Rates are fixed for the duration of the loan and thus provide easy financing for German wind farms, when compared with the rest of Europe.

Planning Privileges. The German Building Statute Book prohibits erection of buildings and similar structures on open countryside with some exceptions. Facilities for public electricity supply, including wind turbines, are permitted. This facilitates the development of wind power, which has significant land requirements, but which leaves 90 – 95% of the land available for other purposes such as agriculture and grazing.

250 Megawatt Program. The goal of the *250 Megawatt Program* is to carry out a broad test over several years of the application of wind energy on a commercial scale. As an incentive for their participation in the program, operators of the wind turbine/wind farm receive grants for the successful operation of their facilities. The current benefit is either DM .06 or .08 (about $.03 or $.04) per kilowatt hour depending on whether the energy is fed into the grid or used by the owner of the turbine, respectively.

India Incentives for Wind Energy

Guaranteed Prices. The Tamil Nadu State Electricity Board (SEB) and several other SEBs have agreed to purchase wind power at the equivalent of $ 0.064 per kilowatt hour.

Tax Benefits. These include:

- Five-year tax holidays on income from sales of electricity
- First year 100 percent depreciation on investments in capital equipment for wind electric power generation and other renewable energy investments.
- Excise duty and sales tax exemptions for wind turbines
- Waiver of import duties on a variety of components
- Moving toward a production tax incentive to encourage performance.

Project Financing. India Renewable Energy Development Agency (IREDA) was formed in 1987 to provide assistance in obtaining loans from the World Bank, the Asian Development Bank, and the Danish International Development Agency (DANIDA). This included acting as a conduit for World Bank Loans totaling $78 million specifically for wind. There are World Bank/GEF and UNDP/GEF programs for China that are supporting expanded use of wind electric power and other renewables.

Planning and Resource Assessment. India has a large wind assessment program with over 600 stations in 25 States to provide information about the best sites for development.

Grants/Demonstration Projects. By the end of 1996, some 50 megawatts of demonstration capacity had become operational. This capacity was concentrated in the States of Tamil Nadu and Gujarat.

Conclusions Regarding the Role of Policy in Stimulating Wind Electric Power Development

These examples demonstrate the wide variety of incentives being used to stimulate increased use of wind electric power worldwide. The APEC economies with suitable wind resources and the interest in developing them have a broad menu of policy instruments to consider, in order to assure that private sector investments in wind electric power development will be attracted to them.

CONCLUSIONS AND RECOMMENDATIONS

This study reviewed six distinct renewable energy initiatives in five APEC economies. Three of the initiatives are commercial single-technology projects. Two are national technology and market development programs, and one is an innovative path-finding commercial enterprise and associated renewable energy-based rural energy services projects developed and funded by the enterprise. They provide important lessons for APEC economies (and others) regarding stimulation and facilitation of commercial renewable energy projects (Thailand, United States), support for indigenous technology and market development (China, Japan), and support for innovative private sector approaches for environmentally friendly off-grid rural energy services (Philippines). These are summarized in Table 11.

Table 11. Overview and Comparison of the Case Examples

APEC Economy	Case Example	Type	Technologies	Objectives
United States	Storm Lake 193 MWe Wind Power Plant	Commercial Project	Large Wind Turbines	Enron (supplier and developer): profitability. State of Iowa: Increased use of renewables.
United States	Brown's Station Landfill Gas Recovery and Conversion	Commercial Project	Landfill Gas Recovery and Cogeneration	County government: Solution of environmental problem and solid return on investment.
Thailand	Bangsue Chia Meng Rice Mill Cogeneration	Commercial Project	Biomass Cogeneration	Mill Owner: Fast return on investment. Technology Suppliers: profitability.
China	Small Wind Turbines for Residential Use	National Technology and Market Development Program	Small (sub-kilowatt) Wind Turbines	Government: Stimulate market and support private sector in technology development. Private Sector: profitability.
Japan	Residential Photovoltaic Program	National Technology and Market Development Program	Building-Integrated Photovoltaic Systems	Government: Stimulate market and support private sector in technology development and PV cost reductions Private Sector: profitability.
Philippines	Shell Renewables Rural Energy Service Company initiative	New business enterprise, with associated community-based projects	PV solar home systems, PV/LPG hybrid power, small modular biopower	Shell: Assessment of new business models for rural energy services, long-term profitability. National government: Test potential for private sector to supply off-grid rural communities with energy services. Local communities: Reliable high-quality energy services.

Generic Renewable Energy Project Roadmaps

A simplified generic roadmap for renewable energy *project development* is shown in Figure 22. This roadmap applies generally to the three commercial renewable energy projects considered in this study. Areas where government agencies of APEC economies can facilitate such commercial project development include the following: (1) Establishment of policies and pricing signals that make it attractive in principle for the private sector to invest in renewable energy projects (or for parastatals and government agencies to do the same), (2) provision of project developers with access to meteorological, land use, and other relevant data, and (3) facilitation of the permitting process. The latter includes eliminating or limiting any "special fees or considerations" or "informal charges" that officials and others may request as a condition of permitting the project development to proceed. All three commercial projects are operating in environments in which it is possible to develop the projects quickly and for the project developers and owners to make an attractive return on investment, while contributing to an enhanced local and global environment. The rules of the game are clear and explicit, and subject to the rule of law.

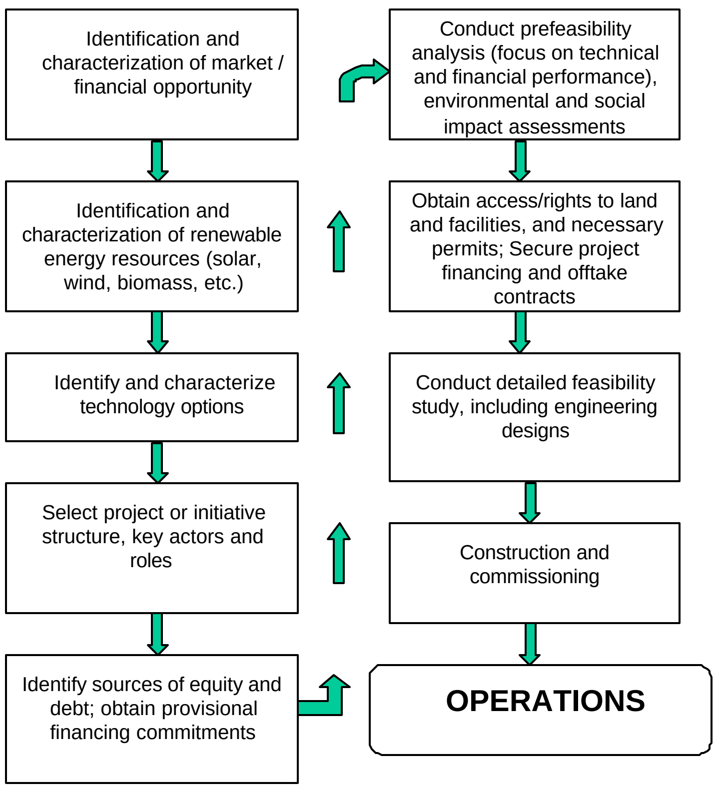


Figure 22: Generic Roadmap for Commercial Renewable Energy Project Development

Stimulating Development of Indigenous Renewable Energy Technologies and Markets

The examples from China and Japan are very different in terms of the types of technologies, their levels of sophistication, and the markets that they address. However, they share several important characteristics. They demonstrate that government alliances with the private sector can stimulate the development of indigenous renewable energy products, with associated price reductions and quality improvement, and that such public/private partnerships can also stimulate the markets for such technologies. There are many such models available, especially from the more industrialized APEC countries, and these are applicable throughout the APEC economies, especially through intergovernmental cooperation.

Building New Roads for Innovative Renewable Energy Initiatives

The example from the Philippines is an example of a business initiative and series of projects that occurred in spite of the lack of precedent. By focusing on the objective of establishing a viable rural energy services enterprise, Shell Renewables and Community Power Corporation were able to create a *new roadmap* that can inform other similar initiatives in the Philippines and in other APEC economies. A combination of vision, persistence, capital, and commitment contributed to the success in developing this enterprise and the first of several rural energy service companies in the Philippines. Also essential to the success of this enterprise has been the explicit enthusiastic cooperation and support of senior government officials at both the national and provincial levels.

Implications for APEC Economies

These six examples illustrate a variety of ways in which renewable energy initiatives can be successfully developed. The examples are replicable in other APEC economies providing the conditions that allowed them to take place are also present.