Asia-Pacific
Economic Cooperation

TECHNICAL WORKSHOP TO SUPPORT VILLAGE POWER APPLICATIONS

Canterbury, New Zealand
7–9 November 2004

APEC 21st Century Renewable Energy Development Initiative (Collaborative I): (EWG 04/2003)

APEC ENERGY WORKING GROUP
DECEMBER 2004

Workshop organization led by

US Department of Energy
National Renewable Energy Laboratory
www.nrel.gov

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Workshop Participants

Acronyms and Abbreviations

ADB	www.adb.org	Asian Development Bank
ANL	www.anl.gov	Argonne National Laboratory (US)
APEC	www.apec.org	Asia-Pacific Economic Cooperation
APERC		Asia-Pacific Energy Research Center
CONAE	www.conae.gov.mx	National Commission for Energy Conservation (CONAE), Mexico
EGNRET	www.apec.org	Expert Group on New and Renewable Energy Technologies
EWG	www.apecenergy.org.au	Energy Working Group (APEC)
FIRR		Financial Internal Rate of Return
GEF	www.gefweb.org	Global Environment Facility
GVEP	www.gvep.org	Global Village Energy Partnership
IRG	www.irgltd.com	International Resources Group, Ltd. US)
NGO		Non-governmental organization
NPC	www.napocor.gov.ph	National Power Corporation (Philippines)
NREL	www.nrel.gov	US National Renewable Energy Laboratory
PREGA		Promotion of Renewable Energy, Energy Efficiency, and Green-house Gas Abatement (Asian Development Bank)
REEEP	www.reeep.org	Renewable Energy and Energy Efficiency Partnership
RESCO		Rural *(or Renewable)* Energy Services Company
SPUG	www.napocor.gov.ph	Small Power Utilities Group (Philippines)
USDOE	www.doe.gov	US Department of Energy
VP		Village Power

Contents

Workshop Overview

The APEC Village Power Workshop

The APEC Village Power Workshop was held November 7 – 9, 2004 at the Heritage Hanmer Springs Hotel in Canterbury, New Zealand. This workshop was convened under the auspices of the APEC EGNRET (Expert Group on New and Renewable Energy Technologies). The workshop was undertaken as an APEC sponsored project, *APEC 21st Century Renewable Energy Development Initiative (Collaborative I): Technical Workshop to Support Village Power Applications (EWG-04/2003).*

Workshop Purpose: The purpose of the workshop was (1) to explore renewable energy technology options and solutions for village power applications; (2) to share lessons learned, best practices, and experiences in the use of renewable energy for village power applications; and (3) to explore establishment of an APEC regional network of village power champions and proponents. This workshop was held prior to the Expert Group Meeting on New and Renewable Energy Technologies on Wednesday, November 10, 2004.

Workshop Hosting, Organization, and Management: New Zealand hosted the workshop, and Ms. Dominique Dowding and Mr. Barrie Leay coordinated and managed all logistical and many substantive aspects of the workshop, resulting in a smoothly running and very productive meeting in an outstanding facility and a beautiful setting. Barrie is past Chairman of APEC's Energy Business Network and is the current New Zealand Representative on the Expert Group on New and Renewable Energy Technologies. Dominique is Managing Director of Evolution Technologies Ltd. the company trading as APEC-CPI©. She is the inventor of the PCT protected system/business model

The US Department of Energy (DOE) provided essential substantive, technical, and financial support. Mr. Harvey Major (US Department of Energy headquarters) is the US Government DOE representative and the chair of EGNRET.

Mr. Cary Bloyd (Argonne National Laboratory – ANL) is the Secretariat of the Expert Group on New and Renewable Energy Technologies. He is an Energy & Environmental Policy Scientist with the Environmental Assessment and Information Sciences Division of Argonne National Laboratory (ANL). He is currently on assignment to the International Center for Sustainable Development in Gaithersburg, Maryland. For the past twelve years he has also been supporting the USDOE in implementing its Asia Pacific Economic Cooperation (APEC) program in the areas of energy efficiency and renewable energy.

Ms. Jean Ku is Project Leader with the Energy and Environmental Applications Office, US National Renewable Energy Laboratory (NREL). Jean engages in activities to support the U.S./China bilateral protocol, including the areas of renewable energy business development, geothermal heat pumps, policy and planning, wind power, and rural electrification. She was the chair of the Workshop, and headed the workshop organizing team Mr. Cary Bloyd, Ms. Judy Siegel, and Mr. Jerome Weingart.

Background: Many APEC economies support renewable energy-based rural electrification, though more than 1.7 billion people in the world continue to lack access to electricity. Together, agriculture, fishing, and aquaculture together constitute the dominant economic activity in the rural areas of the developing world, including the developing regions of APEC economies. Lack of access to reliable and affordable electricity and non-electric energy services (e.g., clean fuels) in rural areas significantly diminishes the opportunities for the development of many economically productive activities, including agro-enterprises and fishing. Electricity, shaft energy, and heat are essential inputs to many agricultural production and post-harvest processes. Providing modern energy services to agricultural production and processing, often the largest employer in rural areas, is an important way to grow beyond subsistence farming and out of poverty. Development of "non-farm" income generating activities is also an important element of moving out

of poverty and building wealth in rural areas, and the availability of modern energy services is one essential ingredient in development of non-farm income generating activities. "Village Power" refers to the combined technical / financial / institutional systems that provide modern energy services to rural communities that lack significant access to such services. In a broader sense it refers to the empowerment of rural communities through provision of energy and other vital infrastructure services (e.g., clean water, health services, schools, telecommunications, good roads, etc.) that are essential for local social and economic development to proceed and be sustainable.

Renewable energy has the potential to make a significant contribution to increasing access to modern energy services (especially electricity and clean fuels) for those unserved and to do so in a way that enhances economic and social development. This recognition underlies the NREL Village Power Program and NREL/World Bank global village power conferences[1] in 1998 and 2000 (Village Power 98 and Village Power 2000). For some of the APEC economies including Indonesia, Korea, and the Philippines, there are thousands of inhabited islands in each. In Indonesia and the Philippines decentralized use of renewable energy systems is expected to be an important source of clean fuels and electricity; in Korea the hybridization of solar, wind, and biomass energy electric power systems with existing diesel generators can reduce the long-run costs of diesel minigrids and reduce their unit greenhouse gas (GHG) emissions.

In Australia, Chile, China, and Mexico, where most of the populations have grid electricity, there are significant programs for bringing modern energy services to the remaining off-grid communities, using a mix of renewable and fossil fuel-based technologies. Vietnam is developing a national renewable energy program, including a component for off-grid rural communities. In small Pacific Island nations, the opportunity to use renewables on a sustainable basis for providing basic electricity services to small communities is illustrated by the example of the rural energy services company (RESCO) *Solar Energy Company* in Kiribati.

The *APEC Village Power Workshop* provided an excellent opportunity to obtain up-to-date information on renewable energy technologies, including a range of issues crucial to the selection, deployment, operation, maintenance, financing and scale up of these options. It also extended and deepened the APEC network of village power practitioners and related organizations and programs.

Participants: The workshop involved over two dozen people from both the public, private, NGO, and multilateral development finance sectors. They included policy and decision makers, energy service providers, and financiers, among others. Participants included those involved in energy and/or related sectors such as rural development, agriculture, water, small and medium enterprises, etc. Participants were from economies including Australia, Chile, China, Indonesia, Kiribati, Mexico, New Zealand, the Philippines, United States, and Vietnam. Also represented were the Asian Development Bank (ADB), the Global Village Energy Partnership (GVEP), and the Renewable Energy and Energy Efficiency Partnership (REEEP).

Workshop Topics: The workshop agenda focused on technical, financial, and institutional aspects of expanding rural access to modern energy services, especially electricity and clean fuels. It included:

- Lessons learned and best practices developed from village power programs and market opportunities in APEC economies;
- Renewable energy technology updates;
- Models and tools for evaluating village power options; and
- Financing village power projects and programs in APEC economies, including the role of micro-finance institutions
- Discussion of next steps for Asia Regional Cooperation on Village Power, including possible development of an APEC village power network.

[1] http://www.rsvp.nrel.gov/vpconference/vp2000/vp2000_proceedings.html Full proceedings of Village Power 2000 plus the NREL guidebooks on renewable energy for schools, for health clinics, and for microenterprise.

Principal Outcomes of the Workshop

All of the planned objectives of the workshop were realized. The principal objectives and related outcomes were:

1. To explore renewable energy technology options and solutions for village power applications;

   The presentations (see summary of presentations in Annex 3, below) provided a quick overview of a range of renewable energy options suitable for household, community, and commercial scales. They also provided many examples of how provision of modern energy services in rural environments could be coupled with income generating activities as well as enhanced community services (e.g., reliable potable water supply, better schools and health clinics, affordable and effective rural telecommunications, etc.).

2. To share lessons learned, best practices, and experiences in the use of renewable energy options for village power applications; and

   Many specific lessons learned and the resulting "best practices" for renewable energy and village power were presented. There were useful examples of learning from previous failures in early rural renewable energy initiatives. Useful new associations among village power experts were made, and the workshop provided updates on important VP initiatives.

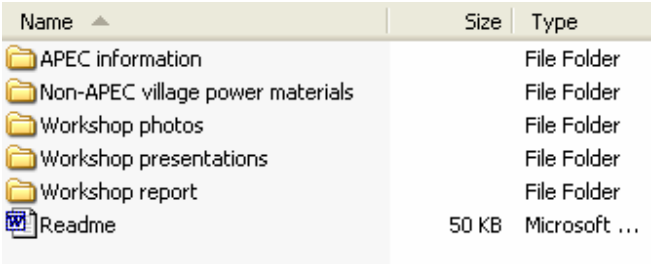
3. To explore establishment of an APEC regional network of village power champions and proponents.

There were discussions on both days of the workshop on the potential uses, operation, and focus of an APEC VP network. These discussions are summarized below. A plan of action to design, develop, and pilot such a network through the facilities of APEC- CPI will be developed in 2005 through consultations with workshop participants and other key stakeholders. The activity and progress will be posted on the APEC website.

Documentation

The workshop is documented in a set of proceedings on CD ROM. The documentation includes copies of the PowerPoint presentations, associated written documents, a summary of the presentations and discussions, and a set of photographs taken at the workshop. Also included is a set of non-APEC public domain documents related to renewable energy and village power. These documents are from NREL, GVEP, the World Bank, and the United Nations; all are freely available on the web sites of these organizations. These were included as part of the commitment of EGNRET to facilitate access to renewable energy information relevant to APEC economies.

The materials on the CD-ROM are organized as shown below. More information is available in the file *readme.doc.*



We will also provide these materials to others interested in renewable energy for village power applications. This will be done via limited distribution of the CDs as well as through access to these materials on the APEC web site, and via links from other web sites (e.g., GVEP, NREL) to the village power sections on the APEC web site.

Expert Group on New & Renewable Energy Technologies (EGNRET)

The Expert Group on New and Renewable Energy Technologies (EGNRET) is responsible for progressing work under the Energy Research, Development and Technology Transfer Theme. The work of the Expert Group has focused on maximizing the degree of new and renewable technology assimilation by member economies by increasing their ability to assess, operate, maintain, and adapt both existing and new technologies. The EGNRET meets twice a year to share information and develop projects that support directions given to them by APEC Leaders and Energy Ministers. The EGNRET has had twenty-three meetings to date.

The EGNRET operates as one of five technical expert groups under the APEC Energy Working Group (EWG). Members of the EWG usually meet twice a year to share information[2] on notable energy sector developments, and to consider progress on current projects and initiatives designed to achieve the Group's objectives and future directions.
EWG meetings are attended by representatives from each of the 21 member economies; observers from the PECC Energy Forum and the South Pacific Forum; the Asia Pacific Energy Research Centre (APERC) and current guest participants (Colombia, India, Mongolia, Pakistan and Venezuela). The Chair of the EWG Business Network has also participated in certain agenda items of meetings.

The EWG has met twenty-eight times to date, and the next meeting is scheduled for the first half of 2005. The Summary Records of the meetings held since 1998 can be downloaded from the website www.apecenergy.org.au. (Note: the underline topics above are clickable links to relevant sections of the APEC energy website.)

[2] http://www.apecenergy.org.au/welcome/activities/projects/current.html

List of Workshop Presentations and Discussions

The individual workshop presentations and discussions are summarized in Annex 3. Below are the titles and presenters of the various presentations, as well as the thematic discussions. All of the individual presentations appear in the folder "Workshop Presentations".

Workshop Introduction and Expected Outcomes
Cary Bloyd, Argonne National Laboratory (US)

Village Power Programs: Lessons Learned and Best Practices
Jerome Weingart, Chair

China's Township Electrification Program and Other Government Rural Energy Initiatives
Song Yanqin, Center for Renewable Energy Development Center, China

Renewable Energy-Based Rural Electrification in Vietnam
Pham Thuy Dung, Energy & Petroleum Department, Ministry of Industry, Vietnam

Intelligent Energy Use: Renewable Energy Markets
Diego Arjona, National Commission for Energy Conservation (CONAE), Mexico

Prospects for and Barriers to Renewable Energy-based Rural Electrification in Developing Countries: Experience and Lessons learned from the Field in China
Charlie Dou, Bergey Windpower, US/China

The Australian Bushlight Program
Geoff Stapleton, Global Sustainable Energy Solutions Pty Ltd, Australia

Wireless Energy - A Small Business Perspective in Rural Electrification
Nelson (Woody) Stevens, Wireless Energy Chile, Ltda

Renewable Energy for Off-Grid Applications in the Philippines
Rene Barruela, National Power Corporation Small Power Utilities Group (NPC-SPUG), Philippines

Combining Solar Water Heater and Ice Storage
Arthur Williamson, Thermocell, Ltd., New Zealand

Battery-Based Energy Storage Systems for Stationary Applications
Hans Desilvestro, enerSTORE Consulting Limited, New Zealand

APEC Village Power Network

Group Discussion: Building a Regional Network for Village Power?
Jorge Huacuz, Moderator

Global Village Energy Partnership

GVEP Overview and Accomplishments to Date
Judy Siegel, GVEP Technical Secretariat

APEC-CPI

The Global Renewable Energy Marketplace from Concept to Commercialization
Dominique Dowding, Director, APEC-CPI (New Zealand)

Productive Uses of Renewable Energy
Grace Yeneza, Chair

Case Studies and Lessons Learned in Productive Uses: Mexico's Experiences
Jorge Huacuz, Instituto de Investigaciones Electricas

Using Renewable Energy as a Catalyst to Address Social and Economic Issues: Lessons from Alliance for Mindanao Off-Grid Renewable Energy (AMORE) Project
Ellen Bomasang, Winrock International. Presented by Jerome Weingart, IRG, Ltd.

Community-based Development and Productive Uses
Ann McLean and Tony Woods, Empower Consultants, New Zealand

Lessons Learned from Field Project Implementation: Biomass Energy and Rural Economic Productivity
Jerome Weingart, IRG, Ltd.

Technology Update and Tools for Evaluating Village Power Options
Song Yanqin, Chair

Using Wind in Village Power Applications
Andy Kruse, Southwest Windpower

Renewable Energy Option for Sustainable Rural Electrification in Indonesia
Chayun Budiono, PT Gerbang Multindo Nusantara, Indonesia

Review of RESCO-based Kiribati Stand-alone PV Program
Terubentau Akura, Kiribati Solar Energy

Software Tools Supporting Village Power System Design
Jean Ku, NREL

Financing Village Power Projects and Programs in APEC countries, Including Micro-Finance Institutions and Productive Uses
Judy Siegel, Chair

Investing in Renewable Energy
Frank Pool, Sustainable Energy Development Specialist, Asian Development Bank

Financing Renewable Energy for Village Power Applications
Grace Yeneza, Preferred Energy, Inc., Philippines

Renewable Energy Financing in the Asia Region
Mike Allen, Renewable Energy & Energy Efficiency Partnership (REEEP)

Scaling Up Renewable Energy Applications in APEC Economies

Group Discussion: Scaling Up Renewable Energy in APEC Economies, Next Steps
Nelson (Woody) Stevens, Moderator

Session Summaries

Village Power Programs Lessons Learned
Jerome Weingart

Productive Uses of Renewable Energy
Grace Yeneza

Special Presentation

The Windflow 500 kWe Turbine Development
Barry Leay, Chairman, Windflow Technology, Ltd., Christchurch, New Zealand

Next Steps

Wrap Up and Next Steps
Harvey Major, US Department of Energy

Annex 1: Workshop Agenda

Sunday, November 7

6:00-8:00 Opening Reception

Monday, November 8

8:30 Registration

9:00-9:10 Welcome from New Zealand hosts
Barrie Leay, Dominic Dowding

9:10-9:30 Workshop Introduction and Expected Outcomes
Cary Bloyd, Argonne National Laboratory (US)

Village Power Programs: Lessons Learned and Best Practices
Jerome Weingart, Chair

9:30-10:00 China's Township Electrification Program and Other Government Rural Energy Initiatives
Song Yanqin, Center for Renewable Energy Development Center, China

10:00-10:20 Renewable Energy-Based Rural Electrification in Vietnam
Pham Thuy Dung, Energy & Petroleum Department, Ministry of Industry, Vietnam

10:20-10:40 Break

10:40 – 11:00 Intelligent Energy Use: Renewable Energy Markets
Diego Arjona, National Commission for Energy Conservation (CONAE), Mexico

11:00-12:00 Q&A and Discussion

12:00-1:30 Lunch

Village Power Programs: Lessons Learned and Best Practices (Part 2)

1:30-1:50 Prospects for and Barriers to Renewable Energy-based Rural Electrification in Developing Countries: Experience and Lessons learned from the Field in China
Charlie Dou, Bergey Windpower, US/China

1:50-2:10 The Australian Bushlight Program
Geoff Stapleton, Global Sustainable Energy Solutions Pty Ltd, Australia

2:10-2:30 Wireless Energy - A Small Business Perspective in Rural Electrification
Nelson (Woody) Stevens, Wireless Energy Chile, Ltda

2:30-2:50 Renewable Energy for Off-Grid Applications in the Philippines
Rene Barruela, National Power Corporation Small Power Utilities Group (NPC-SPUG), Philippines

2:50-3:10 Combining Solar Water Heater and Ice Storage
Arthur Williamson, Thermocell, Ltd., New Zealand

3:10-3:30 Battery-Based Energy Storage Systems for Stationary Applications
Hans Desilvestro, enerSTORE Consulting Limited, New Zealand

3:30-4:00 Q&A and Discussion

4:00-4:15 Break

4:15-5:15 Group Discussion: Building a Regional Network for Village Power?
Jorge Huacuz, Moderator

5:15 Wrap Up and Plans for Tomorrow
Jean Ku, NREL

Tuesday, November 9

Global Village Energy Partnership

9:00-9:20 GVEP Overview and Accomplishments to Date
Judy Siegel, GVEP Technical Secretariat

9:20-9:30 Q&A and Discussion

Productive Uses for Renewable Energy
Grace Yeneza, Chair

9:30-9:50 Case Studies and Lessons Learned in Productive Uses: Mexico's Experiences
Jorge Huacuz, Instituto de Investigaciones Electricas

9:50-10:10 Using Renewable Energy as a Catalyst to Address Social and Economic Issues: Lessons from Alliance for Mindanao Off-Grid Renewable Energy (AMORE) Project
Ellen Bomasang, Winrock International. Presented by Jerome Weingart, IRG, Ltd.

10:10-10:30 Community-based Development and Productive Uses
Ann McLean and Tony Woods, Empower Consultants, New Zealand

10:30-10:50 Lessons Learned from Field Project Implementation: Biomass Energy and Rural Economic Productivity
Jerome Weingart, IRG, Ltd.

10:50-11:10 Q&A and Discussion

11:10-11:30 Break

Technology Update and Tools for Evaluating Village Power Options
Song Yanqin, Chair

11:30-11:50	Using Wind in Village Power Applications *Andy Kruse, Southwest Windpower*
11:50-12:10	Renewable Energy Option for Sustainable Rural Electrification in Indonesia *Chayun Budiono, PT Gerbang Multindo Nusantara, Indonesia*
12:10-12:30	Review of RESCO-based Kiribati Stand-alone PV Program *Terubentau Akura, Kiribati Solar Energy*
12:30-12:50	Software Tools Supporting Village Power System Design *Jean Ku, NREL*
12:50-1:15	Q&A and Discussion
1:15-2:30	Lunch

Financing Village Power Projects and Programs in APEC countries, Including Micro-Finance Institutions and Productive Uses
Judy Siegel, Chair

2:30-2:50	Investing in Renewable Energy *Frank Pool, Sustainable Energy Development Specialist, Asian Development Bank*
2:50-3:20	Financing Renewable Energy for Village Power Applications *Grace Yeneza, Preferred Energy, Inc., Philippines*
3:20-3:40	Renewable Energy Financing in the Asia Region *Mike Allen, Renewable Energy & Energy Efficiency Partnership (REEEP)*
3:40-4:00	Q&A and Discussion
4:00-4:30	Break
4:30-5:30	Group Discussion: Scaling Up Renewable Energy in APEC Economies, Next Steps *Nelson (Woody) Stevens, Moderator*
5:30	Wrap Up and Next Steps *Harvey Major, US Department of Energy*

Wednesday, November 10

11:00-12:00	Roundtable discussion of the results of the Village Power Technical Workshop to EGNRET 23

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Annex 3:
Summary of Workshop Presentations and Discussions

This section provides brief summaries of the presentations, and focuses on principal themes, especially on lessons learned and the best practices that result from these lessons. There are many themes that are common to many or most of the presentations, and these have been underscored in the following summaries.

Opening

Workshop Introduction and Expected Outcomes
Cary Bloyd, Argonne National Laboratory (US)

Cary Bloyd added his welcome to those of the New Zealand hosts, and provided a brief overview presentation *APEC Village Power Workshop.* He described APEC and the Energy Working Group (EWG) and its five Expert Groups, which include the Expert Group on New and Renewable Energy Technologies (EGNRET). The 21 APEC Member Economies span the Pacific Rim, and include many countries that still have a significant number of communities that lack reliable access to modern energy services, especially electricity and modern fuels. He noted that the present Village Power workshop follows the EGNRET 20 meeting held in November 2002 in Korea, in which the theme was Village Power.

Village Power Programs: Lessons Learned and Best Practices

Jerome Weingart, Chair

Jerome Weingart chaired the first day of the workshop, with the presentations focused on the lessons learned and resulting best practices that have emerged from village power programs in APEC economies. He presented highlights of the session on the second day of the workshop. Some of the observations and recommendations that emerged from the discussions among the participants on the first day were:

- The focus of village power initiatives must be social and economic development, and not just on energy *per se.*
- Modern energy services are an essential element of a suite of infrastructure services needed for development.
- We have extensive experience world-wide with many failures and a few successes in establishing sustainable models for renewable energy applications for supporting social and economic development.
- We need to design and implement *programs*, not just individual projects, and focus on *markets* and not on equipment.
- Some subsidies are necessary for village power programs, to assure affordability and equity in modern energy services access.
- Strong support from governments and the international development finance community is needed for private sector and program infrastructure development and sustainability.
- Each APEC economy with the need for and interest in accelerating and expanding the use of renewable energy options for village power must have in place an appropriate *enabling environment.* This means that there must be clear, transparent, and enforceable rules, regulations, and standards supporting renewables, and suitable financial mechanisms (with patient financing) to support such expansion.

China's Township Electrification Program and Other Government Rural Energy Initiatives
Song Yanqin, Center for Renewable Energy Development Center, China

China, with a population of ca. 1.1 billion people, has achieved almost 97% electrification. However, at the end of 2001 some 6.8 million households (about 30 million people or 3% of the population) still had no access to electricity. Most of these households are in rural areas, with many of them in western provinces that are difficult to reach with extension from backbone power grids.

The national Government views renewable energy technologies as options for both large-scale grid-connected applications and for village power use. The draft Renewable Energy Law is designed to establish an enabling framework to attract public and private sector investment in renewables, and could be introduced into law in 2005 / 2006.

China has had major rural electrification initiatives supported in part by bilateral and multilateral organizations, in cooperation with the public and private sectors. Already there are over 18 MWp of photovoltaic (PV) installations in seven provinces under the national Township Program, with individual PV systems up to 150 kWp in size. PV/wind/diesel hybrid power systems are being used for pilot projects for community electrification. These initiatives are providing a basis for substantial scaleup in the use of renewables for both grid-connected and off-grid applications. In addition, China is the world's largest market for solar heating systems for water and space heating, and also the largest producer of such systems.

Key challenges faced for the sustainable use of renewable energy and hybrid village power systems in China include the following:

- Solar and wind resource surveys are needed to permit optimal system sizing and design
- Renewable energy system ownership is an issue, primarily for village-scale systems
- System acceptance is an issue in some places
- Tariff design
- Collection of payments for energy services
- End user agreements (for rural energy services)
- Training of owners and operators of renewable energy systems must be expanded
- Operation and maintenance mechanisms are inadequate
- Sustainability remains a problem given the upfront capital costs of the RE-based systems, the need for high-quality batteries and mechanisms for ensuring their replacement (e.g., sinking fund), retention of trained staff (who may find more attractive jobs after they received RE system operations training), and the need for effective business models for sustainable operations.

Finally, there is an ongoing need to expand the menu of practical productive uses of renewable energy systems, to increase livelihoods and to facilitate social development. *These lessons and resulting practices for village power were repeated in the other APEC economies that are using renewable energy systems to provide off-grid power as well as fuels and heat.*

Renewable Energy-Based Rural Electrification in Vietnam
Pham Thuy Dung, Energy & Petroleum Department, Ministry of Industry, Vietnam

Vietnam has achieved almost 99% electrification of Districts via grid connection, 90% commune electrification, and electrification of about 82% of households. The national rural electrification goal includes electrifying 90% of households by the year 2010 with good quality electricity services.

Ms. Pham presented an overview of Vietnam's primary energy resources, including coal, oil, and gas, as well hydropower and other renewable resources (e.g., wind, solar, biomass, geothermal). The practical potential of the various renewable energy sources is not yet well understood or characterized. She also noted that there are significant barriers to the development of Vietnam's renewable energy resources. These barriers include (1) inadequate policy and regulatory framework to encourage renewable energy-derived electricity, (2) inadequate awareness of renewable energy technologies, costs, and performance, (3) lack of commercial businesses in Vietnam to provide renewable electricity equipment and services, and (4) lack of financing sources.

To address these issues and to expand the use of renewables, Vietnam prepared a Renewable Energy Action Plan in 2001, with assistance from the World Bank. This is a ten-year plan to use renewables for energy applications ranging from household systems (PV, picohydro), minihydro power systems for community grids, and grid connected minihydro and biomass power systems. The Vietnam Renewable Energy Action Plan is one of the featured national renewable energy initiatives presented in the World Bank Group's June 2004 publication *Renewable Energy for Development: the Role of the World Bank Group.*

The experience of other APEC economies in using renewable energy options to provide modern energy services to rural community should be directly useful for Vietnam, and, in turn, the experience of Vietnam over the ten-year Plan period will be highly valuable to other APEC economies. (This is one of many examples of where an APEC Village Power Network can support APEC economies in the development and application of their renewable energy resources for off-grid development.

The World Bank Group's support to Vietnam in renewable energy planning illustrates its role in helping countries develop a strategy for benefiting from renewable resources. At the request of the Government of Vietnam, the World Bank/ESMAP supported efforts to develop a 10-year Renewable Energy Action Plan. The Action Plan will give priority to providing energy services in poorer isolated communities and villages. The plan is built on six strategic principles that can be applied in other countries:

1. Renewable electricity will be used when it is the economically least expensive option and economically viable.

2. Renewable electricity will be supplied on a commercial basis, by all types of businesses, including by a variety of private and public sector companies, cooperatives, and NGOs.

3. Communities, individual consumers, and investors will actively contribute to and participate in the program. All stakeholders will participate in program design and implementation and invest their own funds in the activities and installations.

4. The government will help create the enabling market environment by issuing policies and establishing the legislation and regulation to support commercial development.

5. Access to long-term credit will be increased to improve financial viability of businesses and affordability of services. The program facilitates access to credit for individual households to purchase systems or for communities or developers to finance larger-scale plants.

6. Limited grant assistance will be provided in recognition of the social and environmental benefits, but will be used carefully. Grant funding is needed to build the capacity for large-scale, renewable electricity development and to defray the costs of preinvestment activities. For off-grid facilities targeted at poorer communities, capital cost subsidies will be considered.

Source: World Bank (June 2004). *Renewable Energy for Development: the Role of the World Bank Group.* www.worldbank.org/vn and www.worldbank.org/energy

Intelligent Energy Use: Renewable Energy Markets
Diego Arjona, National Commission for Energy Conservation (CONAE), Mexico

Diego's presentation emphasized two aspects of energy supply and use in Mexico: increased efficiency in all steps of the energy supply and end use chain, and increased use of renewable energy. It is estimated that ca. 20% of energy now used can be saved over the long term through implementation of efficiency measures, and the goal of 5% savings in energy consumption is proposed for the end of year 2006.

Mexico has been developing its renewable energy resources for several decades, with 838 MWe of geothermal capacity on line (10% of world capacity), 14 MWp of PV installations, 40 MWe of minihydro, 17 MW of biogas, and 2 MWe of wind electric power. The potential for wind electric power just in the state of Oaxaca is about 3,000 MWe, and wind farm development is proceeding with a 100 MWe wind farm in the bidding stage. Minihydro resources are easily 400 MWe, and solar installations for thermal and electricity applications are limited only by markets and economic, since most of Mexico has excellent solar radiation much of the year.

As with many of the other presentations at the Workshop, the issues include (1) the need to focus on market development rather than on hardware per se, (2) the need to have a clear and specific legal framework to promote and attract investment in energy efficiency and renewables, (3) establishment of a mechanism to cover differential costs for those renewable energy and efficiency measures that are coming down the cost learning curve but which still need some cost underwriting, (4) incentives that reward performance, and (5) clear land rights and ownership status for renewable energy facilities.

Prospects for and Barriers to Renewable Energy-based Rural Electrification in Developing Countries: Experience and Lessons learned from the Field in China
Charlie Dou, Bergey Windpower, US/China

Charlie's presentation provided an overview of China's rural electrification program and the challenges for electrifying the remaining unelectrified communities. While over 95% of China's population of 1.1 billion people has access to electricity services, there remain over 29,000 villages with some 60 million people without electric service. Most of these communities are in regions where extension of the grid is technically and financially challenging.

China's "National Township Electrification Program" was initiated in 2002, and is focused on the use of renewable energy system to electrify 1,000+ villages where township governments are located. Systems being used include PV, wind/PV, wind/PV/diesel, and wind/diesel hybrid power systems, and micro and minihydro plants. The use of renewables for village power applications presents special challenges, including the following:

- Village system ownership is often unclear, where there are government investments and donor subsidies, as well as local village participation,
- Government-assigned contracts to rural energy service companies for system management has not been particularly successful,
- It is very difficult to collect revenues for electricity sales, given the expectation in some rural communities that electricity should be provided at no charge, and
- Maintenance can be complicated, and qualified technicians are often not available.

The financial issues are complicated by the Government funding projects that often concentrate on social welfare objectives, without explicitly supporting enterprise and income development. Increasingly, the

focus of renewable energy-based village power systems should be on economic productivity as well as on social development, if the systems are to be sustainable.

The Australian Bushlight Program

Geoff Stapleton, Global Sustainable Energy Solutions Pty Ltd, Australia

Bushlight is a program established to provide improved livelihood options for Northern Australia's indigenous peoples, by increasing access to sustainable renewable energy services. This began a joint venture between the Centre for Appropriate Technology (CAT) and the Australian Cooperative Research Centre for Renewable Energy (ACRE), and is not operated by CAT. The project period is July 2002 through June 2006. The project supports improved renewable energy (RE) system design, increased community capacity to manage the energy services, and improvements in the support network. RE systems are used at the household and community level, and employ wind/PV/diesel power systems that can provide full-time AC power.

The Bushlight approach is "hands-on", with extensive ongoing interaction with local communities, including training in the proper use of the systems and in their maintenance and operations. The program responds to some serious challenges. In a field visit-based survey of 88 indigenous communities with renewable energy installations, a third of the systems were not fully operational. Satisfaction with the RE systems was only 40%, due to problems with system reliability and difficulties in maintaining the systems in an operational state. Specific issues uncovered by the surveys included the following:

- Lack of regular maintenance
- Complex, non-standard equipment
- Lack of electricity demand management
- Lack of trained community members and staff
- Insufficient technical support

The Bushlight program is working to address all of these issues. The experience, which will be shared within the APEC Village Power Network, and beyond (e.g., via the GVEP network) will be valuable to other APEC economies with village power programs.

Wireless Energy - A Small Business Perspective in Rural Electrification

Nelson (Woody) Stevens, Wireless Energy Chile, Ltda

Wireless Energy was one of the private sector companies represented at the Workshop. Woody Stevens founded the company in Chile in 1996, and the entire staff is Chilean. More than 1,500 remote power systems have been installed in Chile, using a mix of renewable and fossil fuel power options. Wireless Energy is now embarking on a new business concept for renewable energy in Chile. They are developing new capacities to operate as an energy services company in which they will own and operate the renewable energy technology, provide expert operations and maintenance support with their technical staff, and deliver a reliable energy service from clean energy sources. They work with a wide range of RE applications, from individual free-standing systems for remote site telecommunications to medium-scale industrial hybrid power systems to larger and more complex hybrid power generation systems for villages and large industrial applications.

Chile's rural electrification coverage has grown from 55% in 1992 to 79.5% in 2001. 20% of the rural population still lacks access to electricity services. The national goal is to reach 90% rural electrification across all regions of the country by 2005. Chile's national energy commission (CNE), the United Nations Development Program (UNDP) and the Global Environment Facility (GEF) launched a project in 2001 aimed at removing the barriers to rural electrification throughout Chile. The five-year, US$32.4mn project

aims to strengthen and better direct existing policies so that the present 78% rural electrification rate increases to 90% by 2005.
Projects already identified are the expansion of a diesel/wind hybrid system from Tac island in Region X to a further 32 islands in the Chiloe archipelago, the implementation of solar solutions to benefit up to 5,000 families in the north and center-south of the country, and other more disperse projects such as small-scale hydro projects in the northern desert, wind projects on Robinson Crusoe island and biomass and geothermal projects at other locations. The GEF will provide US$6mn financing, Chile's government US$17.2mn in funds and services, the private sector US$7.6mn and users US$1.5mn.

The project will also address issues learned from the Isla Tac project. These include the following:

- Electricity demand estimates were low by 50%
- Local minigrid losses were > 20%
- The technology was not amenable to modular expansion and growth in capacity
- The tariff was inappropriately low
- The operator is a utility company that lacks suitable experience in operating small minigrids

The experience with Wireless Energy has demonstrated that the combination of commercially productive applications, high-quality equipment, a skilled and experienced technical staff, and provision of energy services rather than just equipment, is an appropriate direction for provision of reliable energy services to communities and commercial/industrial facilities beyond the reach of the power grid.

Renewable Energy for Off-Grid Applications in the Philippines
Rene Barruela, National Power Corporation Small Power Utilities Group (NPC-SPUG), Philippines

The Philippines has a large and complex topography, with thousands of small islands, mountainous regions, and regions with difficult access to rural communities. The Government has been able to provide varying degrees of electricity services to 91% of the almost 42,000 communities (*barangays*). The Philippine Rural Electrification Program, implemented through the national Department of Energy, has an on-grid electrification program (power distribution development) and an off-grid "Missionary" Electrification Development Plan (MEDP). The Small Power Utilities Group has been providing power to island communities and some non-island off-grid communities through the use of diesel minigrids. At present they support 74 island power grids, supplying 767,000 households with electricity via this approach. They also use PV battery charging stations (BCS) to provide basic household electricity services for lighting and entertainment as a prelude to minigrid power. 5,400 households in 259 villages have access to this service.

SPUG has been exploring and piloting the use of wind/diesel hybrid power systems to reduce the amount of diesel fuel required per kWh generated, without reducing the reliability of the supplied power. These are for less poor rural communities, where there are economic activities and an income base for purchase of AC electricity services. The poorest communities are provided with the BCS stations as a start in electrifying such communities.

New Zealand Advanced Technology Presentations

The Workshop hosts arranged for presentations and related facilities tours as a bonus for the workshop participants. The three presentations summarized below were made at the workshop.

The Windflow 500 kWe Turbine Development
Barry Leay, Chairman, Windflow Technology, Ltd.., Christchurch, New Zealand

A DVD presentation on the development of a new wind turbine technology for utility-scale applications was made by Barrie Leay, the chairman of Windflow Technology, Ltd., which is pioneering technology advances in wind electric power. The 500 kWe prototype's size and performance are well suited to wind/diesel hybrid power systems applications for isolated grids on the several MWe scale, as well as for larger-scale wind farm applications for large power grids. This wind turbine is being developed with the New Zealand market in mind, with 100 MWe/year increase in installed capacity demand. The technology for producing the blades draws directly from technical innovations in boat building; Christchurch is a world leader in advanced boat building technology, using composite materials. Workshop participants toured the Windflow facilities after the VP workshop.
(http://www.windflow.co.nz/)

Combining Solar Water Heater and Ice Storage (no written or PPT presentation available)
Arthur Williamson, Thermocell, Ltd., Christchurch, New Zealand

Professor (emeritus) Arthur Williamson is one of New Zealand's experts in solar energy and thermodynamics. He established a company to develop several products, including a high-efficiency light-weight solar (thermal) collector for water heating applications. Other products relevant to off-grid and village power applications include passive cooling systems that are used by telecommunication companies in the Pacific region, and remote area power supplies. He made a presentation at the workshop in which potential village power applications of his technologies were outlined. Our New Zealand hosts also arranged for workshop participants to visit his factory in Christchurch after the conclusion of the village power workshop, and the special design features of the Thermocell equipment were explained. Additional information is available at http://www.thermocell.co.nz/.

Battery-Based Energy Storage Systems for Stationary Applications
Hans Desilvestro, enerSTORE Consulting Limited, New Zealand

Hans has developed a detailed screening and evaluation methodology to evaluate various types of battery systems for stationary energy storage applications. Considering such issues as availability and cost of essential raw materials, safety to the manufacturers and users, suitability for recycling or environmentally acceptable disposal, longevity, resistance to deterioration resulting from battery cycling, and other characteristics, a safe Li-ion type of battery (LiOX) was identified as having large-scale applications potential. These characteristics are very important if renewable energy systems for small-scale electric power are going to be used on a far larger scale than at present. This presentation highlighted the importance of looking at the potential for various types of renewable energy and hybrid power systems in terms of their potential for significant (100-fold to thousand-fold) scale-up over the coming several decades.

APEC Village Power Network

Group Discussion: Building a Regional Network for Village Power?
Jorge Huacuz, Moderator

Jorge led a two-part discussion of the proposed (conceptual) village power APEC regional network. While time was limited to perhaps two hours of total discussion, several key considerations and recommendations resulted.
Starting with the assumption that such a network would be useful, three areas were discussed: (1) the network focus (technical, non-technical, or both), (2) the aim and objective of the network, and (3) the operational structure of the network. Technical issues could include such things as R&D needs and opportunities, product/system development, technical specifications and guidelines, and site selection criteria. Non-technical issues include social, organizational, financial, institutional, and policy considerations.

Network Focus
It was agreed that a lot of technical information is available and accessible. At the village level, technical *and* non-technical information are needed and technical and management issues should be addressed together. However, focusing the network and its information and knowledge products just on the village power practitioners would miss an important opportunity. The high-level audience for the products of the network is the energy ministers of the 21 APEC economies.

The Network Aim / Objectives
There were several objectives discussed. These included such possibilities as capacity building, project identification and development, promotion and awareness creation, knowledge management and knowledge creation. These and other issues will be discussed as the concept for the network is further developed through dialogue among stakeholders, starting with the workshop participants.

Network Operational Structure
Options include information sharing, visits of experts, meetings, and the use of an APEC-related web site to facilitate the network. Issues include how the network would be set up and managed, who would fund its operations, who would participate, and what products, if any, it would produce. These discussions were just the beginning of a dialogue on the possible establishment and operation of an APEC Regional VP Network. It is proposed that moderated conversations" be conducted among stakeholders throughout the APEC economies. The proposed mechanism for such Web-based dialogue and information dissemination is the APEC-CPI network based in New Zealand. This would be a forum for discussions among the public and private sectors, NGOs, international development finance organizations, and key political stakeholders in the APEC economies.

Issues Discussed – an Informal List

Some of the issues that were mentioned briefly by the participants include the following:

- It would be very useful to bring private sector RE and VP leaders together. They rarely get together. Many levels of networking would be valuable, from the practitioners "on the ground" to those determining policy and funding for village power initiatives. APEC should bring together the private sector leaders to help determine what really works and why, in the process of scaling up access to modern energy services and related investments in economic productivity and community services.

- Can such a network help facilitate technical and non-technical innovation in APEC economies for village power and sustainable rural development?

- The APEC-CPI is a powerful networking and knowledge exchange tool that is available to the Expert Group on New and Renewable Energy Technologies.

- This network should be proactive, much more than just a web site.

- Renewable energy equipment manufacturers need this. They want to know what the customers really want. For example, a 2kW wind turbine is being developed for the minigrid market now, as a result of the manufacturer talking with people in the market prior to designing the turbine. The APEC VP network can help bring suppliers of equipment and services much closer to customers and those who represent them. Future village power workshops should have many more private sector representatives; there are only two at this workshop (both suppliers of small wind and wind/fossil hybrid systems).

- A specific and powerful advantage of APEC is its audience of 21 energy ministers. The Energy Working Group has the ability and the information on how to get the private sector involved, what infrastructure is needed, and what proven products and services are available within the APEC economies. We can bring up the right questions and issues, such as how to user modern energy services to help address poverty alleviation or enhanced education, for instance.

- A caveat: The proposed network should not complete with but should complement other networks and partnerships. We need to focus and build on the access to ministers. Government ministers and their staffs often wonder what choices they should make, and what their real options are in areas such as rural poverty alleviation and provision of crucial infrastructure services.

- We must focus on what APEC is good at. APEC has immense convening power, and brings energy ministers (and ministers with other portfolios) together. There is an opportunity to bring together leaders in several areas, such as health, community water supply, education, telecommunication, and rural energy services, to provide examples of and a roadmap for *integrated rural development.* This catchphrase from the 1950s and 1960s can and should be a hallmark of development initiatives, incorporating energy services directly into economic and social development investments and activities.

- We need to hear more from the APEC economies what the [village power / energy and development] problems actually are.

- In Indonesia (and several other APEC economies), sustainability is a key challenge. Projects only work if the government is involved and seriously committed. Three key issues are (1) technology must be proven in the field (provide what is expected), (2) villagers need to contribute to operation and management of the rural energy systems, and pay for services, and (3) institutional issues should be addressed (who is responsible to manage operation of system). Oil production is constrained, and the Government is concerned about how to provide sustainable electricity to villages. Only about 60% of villages are electrified. With population growth, it will be difficult to provide universal electrification.

- We should include both technical and non-technical information and experience. Developers and managers are interested in best practices. Others in the audience are policymakers. They are mainly interested in barriers in distributing RE technologies. The proposed network can help RE promoters reach high level decision makers.

- It is often difficult to find useful detailed village power-related information on the Internet. The APEC network would help make this easier, and provide resources that can be targeted to senior decision markers as well as practitioners.

- We need to help decision makers understand that the village power approach is different from grid-connected electrification. Village power initiatives should be demand-driven, not technology driven. Rural people need to define their own needs. Large government programs should make it attractive (profitable) to get private sector with experience into the developing economies.

- Government agencies need to help create the conditions in which the private sector can profitably provide sustainable modern energy services as an integral element in rural development. Simply having private companies act as subcontractors for Government agencies is not sufficient in many cases.

- Most problems are not technical, but standards are very important, and the network should be concerned with dissemination of information on effective standards from experience various APEC economies.

Next Steps
The chair of the Expert Group on New and Renewable Energy Technologies (EGNRET) will propose a plan of action and communicate this to the workshop participants and other relevant stakeholders.

APEC-CPI

The Global Renewable Energy Marketplace from Concept to Commercialization
Dominique Dowding, Director, APEC-CPI (New Zealand)

APEC and its Energy Working Group (www.apecenergy.org.au) has developed APEC-CPI (Collaborative Projects Integrator) to bring the Private and Public Sector together through a Collaborative Trade Platform in order to accelerate development and take up of New and Renewable Energy Technologies. This industry is currently $2 trillion and estimated to grow to $30 trillion by 2020.

This platform will not only be the Asia Pacific hub for project collaboration, trade, finance, tenders, up to date information for more informed policy/decision making and research; it will be THE global New and Renewable Energy Technologies Forum for ALL global players and participants in this rapidly growing market. Both Public and Private sectors can participate in more effective partnerships devoid of geographic, economic, or social barriers. All participants will help shape the market, with the system providing a fantastic opportunity for:

- ***Governments:*** Federal, State, City, Ministries

- ***The Energy Industry:*** Product, Equipment, Technology, Utilities, Retailers and Service Suppliers.

- ***Investment:*** Investors, funds, grants, institutions, venture capitalists, Philanthropists.

- ***Education/Research:*** Academics, researchers, scientists and inventors.

The APEC-CPI has been offered as the initial platform for the APEC Regional Village Power Network pilot. A plan for the development of the pilot network will be distributed in the first quarter of 2005.

Global Village Energy Partnership (www.gvep.org)

GVEP Overview and Accomplishments to Date
Judy Siegel, GVEP Technical Secretariat

Judy is a staff member of the GVEP Secretariat, and was instrumental in the creation and launch of GVEP. She provided an overview of GVEP and presented examples of GVEP country activities in Brazil, Guatemala, and Tanzania.

The Global Village Energy Partnership (GVEP), created in September, 2002, is an international network open to all individuals and various organizations—national government institutions, bilateral and multilateral development banks, professional associations, research institutions, non-governmental organizations, foundations, and private businesses—concerned with delivering modern energy services to the world's unserved and underserved. GVEP promotes the role of energy in poverty reduction while working to reach the millions in developing countries without sustainable energy access. Over 428 partner organizations from around the world have joined GVEP as of September 2004. **Judy invited the workshop participants, either through their institutions or individually, to become GVEP partners.**

Through its network of partners, GVEP offers five core services—facilitating national action planning and investments in energy-poverty reduction, harnessing and sharing best practices and lessons learned in the energy field, developing the capacity of energy providers and consumers, linking energy providers to sources of financing, and monitoring the impact of energy on poverty reduction. GVEP offers a new approach for reaching the 2-3 billion people without energy services. GVEP moves *beyond electricity* to address the broader range of heating, cooling and cooking needs. GVEP is *technology neutral*, advocating those options that best meet the local needs, requirements and resources.

GVEP recognizes *energy as an input not output*, linking to the agriculture, business education, health, and water communities to improve quality of life and contribute to economic development. GVEP *commits to a 10- year program* to reach over 300 million people and thousands of communities in addressing energy poverty. And, GVEP acknowledges that meeting the global energy demand is beyond the capability and capacity of any one organization, requiring a pooling of resources, skills and organizations to address the need.

Consequently, GVEP convenes regional workshops for senior decision makers to show how energy is a central consideration in facilitating social and economic development. To date there have been four regional energy/poverty workshops in Africa and Latin America / Caribbean, with 500 participants from 30 countries. *Over half of the countries participating in the regional workshops have begun incorporating lessons learned in their energy / poverty alleviation initiatives and programs.*

Some of the key lessons learned include (1) the need for financing support across the spectrum, from prefeasibility studies to project finance, (2) microfinance institutions are effective credit delivery mechanisms in rural areas, (3) markets need to grow on their own strengths, not on subsidies (although some early financial support intervention is often needed to help launch these markets), (4) there is a substantial knowledge gap for all partners in areas relevant to village power, and (5) public-private partnerships are essential for building sustainable village power programs and markets.

The proposed APEC regional Village Power Network, if launched, will have strong links with the GVEP village power network, broadening the international village power network and increasing access to crucial technical, financial, market, and institutional experience.

Productive Uses of Renewable Energy

Grace Yeneza, Chair
Summary: Productive Uses of Renewable Energy

The workshop participants had a very interesting sharing session on Productive Uses for Renewable Energy. The session demonstrated the recognition that renewable energy is an input, not an output or an end in itself. Renewable energy can be a tool for poverty alleviation and for promoting economic development, especially in off-grid areas. By linking and integrating renewable energy with productive uses, it is possible to go beyond the provision of basic electricity for household lighting, and support activities that improve productivity, increase incomes, enhance economic opportunities, uplift living conditions, provide better health services, as well as promote peace and security.

The presentations focused on experiences in Mexico, the Philippines, Vietnam, Nepal, and other parts of the world. Various examples of productive use applications were shown to be most beneficial to end-users. These included micro-hydro installations for small-scale industrial applications, PV for water pumping, crop and fish drying, biogas for cooking and electricity generation, and biomass for co-generation including production of coco coir material used in control and prevention of soil erosion. From the experiences presented, lessons learned emphasized the need to use only proven technologies in order to prevent frustration and disappointment among the beneficiaries. It is also crucial to have a good match between technology and local conditions so as to maintain technical integrity and reliability. The involvement of stakeholders, whether from government or local communities, is likewise essential to ensure acceptance and avoid institutional problems in implementation.

One of the major concerns identified by almost all presenters is the lack of sustainability of rural energy projects. This issue can be mitigated by giving special emphasis on the development of energy projects to generate power for productive uses. Productive use applications will increase income generation and enhance the capacity to pay of end-users. To do this, renewable energy development should not be confined within the energy sector alone but should be integrated with other sectors such as agriculture, health, education, and social services.

Case Studies and Lessons Learned in Productive Uses: Mexico's Experiences
Jorge Huacuz, Instituto de Investigaciones Electricas

Although most of the population of Mexico (103 million) has access to electricity, there are still 80,000 small and often remote communities, with 5 million inhabitants, still without electricity. The challenges to universal electrification are immense, given the low incomes of these people, the dispersed population, and difficult terrain.

Mexico has been using renewable energy systems for productive activities since the early 1970s. Many of the systems installed in that period are no longer working, but some are. Since that time there have been many lessons learned and incorporated in the Government's programs to apply renewables for off-grid development purposes. The recent history of renewable energy applications can be considered to have started around 1989. The first stage (1989 – 1991) was one of trial and error. It was characterized by high enthusiasm but poor understanding of the technologies, no vision for large-scale deployment, a technology "push" approach, with small "hit and run" companies, and no technical standards.

The second stage, from 1991 – 1997, was one of infrastructure building. Here the focus was on sustainability, human capacity building, technical standards, testing laboratories, definition of institutional roles, and development of project implementation methodologies.

The third stage, which began around 1997 and which is continuing now, can be considered as a period of transition to market. Here the projects are led by local government, and there is market pull (instead of technology "push"), careful review of past experience, and growth of local industry. The emphasis is on productive activities, and new private applications are emerging. Regional planning is proceeding using Geographic Information Systems (GIS) techniques.

Mexico now has some 90,000 PV solar home systems, and PV installations for 3,500 health centers, schools, and community centers. There are over 13,000 PV-powered telephones, hundreds of PV water pumps (especially for small farms in unelectrified regions), a dozen PV/wind/diesel powered minigrids.

The focus has been increasingly on economically and socially productive activities. Many aspects of the renewable energy programs have worked well, such as information, training, and user involvement, quality assurance mechanisms, establishment of a strong regulatory body, and a communal fund for PV projects. However, some things are not working well. These include after-sales service, reinforcement of user training, the transition from federal to local government ownership and control, and PV/diesel minigrid hybrids.

Principal barriers to achieving large0scale market-oriented productive applications of renewables include (1) perceived technological risks, lack of sufficient energy resource information, and the lack of a supportive infrastructure for the installed systems. There is an important opportunity for other APEC economies to learn from the Mexican experience, and for Mexico to make use of successful applications in other APEC economies, to the extent those applications are truly transferable to Mexican conditions.

Using Renewable Energy as a Catalyst to Address Social and Economic Issues: Lessons from Alliance for Mindanao Off-Grid Renewable Energy (AMORE) Project

Ellen Bomasang, Winrock International. Presented by Jerome Weingart, IRG, Ltd.

(Due to illness, Ms. Bomasang was unable to travel to New Zealand. Mr. Weingart, who is a consultant to Winrock International working on the AMORE project, gave the presentation on her behalf.)

Winrock International, with support from the US Agency for International Development (USAID), has been actively engaged in a project in the southern Philippines to use renewable energy to facilitate social and economic development. This is the *Alliance for Mindanao Off-Grid Renewable Energy (AMORE) Program.* The goal is to help local communities make the transition from socio-political instability to economic growth and social development (especially in health and education). The AMORE sites are in one of the poorest regions in the country, with the lowest level of public services. It has long been a conflict area with severe peace and order problems. Yet there have been good examples of communities becoming relatively peaceful when employment with meaningful incomes has been developed.

The project is supporting electrification of more than 160 rural communities in Mindanao using renewable energy systems for lighting, productive uses, and social infrastructure (e.g., health posts, schools, telecommunications). The project is supporting the peace process by working with former rebel communities to create social and economic development. Integration of renewable energy systems and economic productivity include the use of a 12 kW microhydro facility that supports corn and coffee milling and provides added income to 300 households; PV water pumping for production of high-value vegetables, biomass-fired driers for drying of grains, and use of LED lights in Lapu Lapu fish cages to attract small marine animals for feed, saving money and reducing mortality of the fish. Other investments include drying and preprocessing of seaweed (for industrial-scale use in the food industry), as well as use of PV power for local payphones (both cellular and fixed satellite technologies) and distance education. Japan is cofinancing development of potable water supplies.

This project is a bold experiment. It is difficult enough to introduce and support decentralized renewable energy systems under conditions of political stability and peace. This project has evolved into an almost decade-long program (with the project renewal beginning in 2005). It *m*ay serve as an effective model for achieving peaceful development through investments in infrastructure and economic productivity.

Community-based Development and Productive Uses
Ann McLean and Tony Woods, Empower Consultants, New Zealand

Empower Consultants is a small development consultancy, specializing in community infrastructure and livelihood development. With a staff that is half engineers and half social scientists, they have supported development projects in China, India, the Philippines, Chinese Taipei, Vietnam, and a dozen other Pacific and Asian countries.

Their presentation illustrates applications of renewable energy that have resulted in significant increases in household incomes as well as social innovations such as the Sherpa of Nepal using PV and microhydro electricity for culture preservation, including production of a CD of their songs. In rural Pakistan, the availability of full-time electricity has made possible a new level of health services, education, communication, and other vital services.

Lessons learned include:

- Power availability matters – 24 hours, continuously available
- Power quality matters, and reliable three-phase power is needed for large productive loads
- Power meters are essential to avoid overloading the generators
- Equipment quality is more important than price in remote areas, and
- Technical and management support is essential.

Some of the obstacles to using renewables effectively in off-grid rural environments include first costs of renewable energy and hybrid power systems, incoherent policy and regulatory frameworks, limited access to finance, poor investment climates, week technical and managerial capacity, lack of practical support networks, and the remote locations of many of the communities.

Lessons Learned from Field Project Implementation: Biomass Energy and Rural Economic Productivity
Jerome Weingart, IRG, Ltd.

An advanced bioenergy-based multi-function platform has been developed by US-based Community Power Corporation (CPC) for markets worldwide. The *Community Productive Use Platform* (C-PUP), produces thermal energy, shaft power, and electricity. One of the commercial prototypes is operating in the Philippines at a coconut cooperative, providing energy and power for production of commercial products from coconuts. CPC's Gas Production Module (GPM) converts coconut shells and other dry woody biomass to a product gas for delivery to a spark-ignited engine mounted on a power distribution platform. The platform can allocate shaft power as needed to various mechanical and electrical loads. The peak electrical output of the C-PUP is 15 kWe from the conversion of about 23 kg of coconut shells per hour. In addition, about 20 kW of thermal energy is available in the form of clean, hot air for drying crops and fish. Newer models generate up to 50 kWe.

This type of biopower system is well suited for many rural enterprises. Sustainable supplies of biomass residues are available in many of the APEC economies (e.g., Philippines, Indonesia, Thailand, Malaysia, etc., and they can be converted to high-quality power to drive complex electrical and mechanical loads. Unlike renewable energy equipment such as photovoltaic systems and wind turbines, biomass energy systems also produce thermal energy, which can be used for drying and processing food and fiber, for driving refrigeration units, and for institutional cooking (e.g., at schools).

A new enterprise model was developed by Sustainable Rural Enterprise (SRE) in the Philippines (a rural NGO) and Community Power Corporation (CPC) in the US. Sustainably available biomass is used to support economically productive activities, through use of the C-PUP. The pilot initiative was established in Aklan Province that produces large quantities of coconuts, and generates small mountains of coconut shells that are burned in the field. The SMB technology makes it possible to *transform an environmental liability into an economic and social asset.*

Productive Rural Enterprise (PRE) is a for-profit joint venture company that was formed in 2002 by CPC and local Philippine partners to employ rural people to operate and maintain the C-PUP, and to make geo-textiles and other high-value products from coconut byproducts, for sale to domestic and export customers. PRE is also offering manufactured systems. The PRE business model, using the C-PUP to support sustainable enterprise development and growth, appears replicable in rural areas of many developing countries if there is sustainable availability of suitable biomass residues. As of October 2003 several large orders have been placed with PRE for geo-textile soil stabilization / erosion control mats.

Empowering Rural Women and Children

At the Ibajay Coconut Cooperative in Aklan Province (Philippines), women who previously were unemployed now earn money on a regular basis by weaving geo-textile mats from coconut coir. These soil stabilization mats are very valuable and in great demand for enhancing soil stability, especially for sloping areas where there have been fires and where the soil has to be stabilized and fast-growing vegetation can be planted and take root. One of the social consequences of this work, which is done only by local women, is that these women have gained new social power through their new regular source of income. Their children, many of whom had inadequate clothes for school and lacked the money even for simple notebooks, now have the clothes, notebooks, and umbrellas that their wealthier rural classmates have.

Children like to work with their mothers in preparing the coconut coir ropes that are then woven into the geo-textile mats. Children are able to earn a bit of money and participate in the family income generation. However, they are allowed to do this *only during non-school periods.* There is anecdotal evidence that this after-school opportunity has resulted in decreased after-school vandalism and other problems by school children.

Other products created from coconuts at the SRE facility in Aklan include premium cooking oil and high-quality soaps, as well as potting media for houseplants. Coconut coir dust can hold ten times its weight in water, and is well suited for transport and storage of premium houseplants.

This is an example of how sustainable renewable energy resources can be used to support rural livelihood and social development, and appears to be a widely replicable model for regions that have substantial quantities of suitable biomass and biomass byproducts available.

Technology Update and Tools for Evaluating Village Power Options

Song Yanqin, Chair

Using Wind in Village Power Applications

Andy Kruse, Southwest Windpower

Southwest Windpower is a leading producer and supplier of small wind turbines in the 400 – 3,000 watt range. They have produced over 70,000 turbines, and production 2004 has reached 8 MWe total capacity (10,000 turbines). These turbines are used in over 130 countries, with distributors in 60 countries. Applications include street lighting (in combination with PV panels), water pumping, remote monitoring, offshore navigation, and onboard power for sailboats. In Indonesia Winrock International has used thirty-five 600 watt turbines with batteries and hardware for battery charging (lights, television, and refrigeration applications) on Java and five outer islands.

Andy explained that through their experience, they have learned what the major contributors to systems failure are in the village power environment. These include

- Full (100%) subsidization
- No network of qualified installers
- No follow-up maintenance and repair
- No end user training programs
- Use of unqualified equipment
- Too many "hands' that the equipment must pass through

What works is making technology affordable through a combination of subsidies and payment programs, good training and education of technicians and end users, establishment of qualified distributors, and laws and regulations that encourage the use of renewables.

Small wind turbine systems and combination systems (e.g., with PV, backup gensets) are now available in much of the world. The best of these products are rugged and reliable, and will operate for many years (now several decades!) provided there is sound basic maintenance support available.

Renewable Energy Option for Sustainable Rural Electrification in Indonesia
Chayun Budiono, PT Gerbang Multindo Nusantara, Indonesia

Indonesia is one of the most populous countries, with over 210 million inhabitants, 70,000 villages, and several thousand populated islands. Some 20 million rural households remain unelectrified. Indonesia is increasingly using pico and microhydro power, PV systems, small wind systems, and PV/wind/diesel hybrids (small island village power systems). In communities where AC power is needed and full-time power would support daytime social and economic activities, PV/diesel systems are increasingly attractive, as oil prices continue to rise. There is a potential for some 45 MWp of PV systems in combination with diesel gensets in 1,000 potential installations.

Biomass potential is enormous on many islands, including Sumatra and Kalimantan. Wood, palm oil residues, rice hulls, and coconuts are abundant. Some small rural rice mills generate electricity (ca. 5 kWe) and heat. The more than 700 smallholder sawmills have a demand for 60 kWe for ten hours daily; twice this can be produced from the typical wood waste stream.

A microhydro facility at Kalimaron has an output of 30kWe, and is grid connected. Both the electric utility and the community pay for electricity services, and the system is profitable. Some of the key lessons are the importance of community participation, reliable community organization, and the establishment of a fund to support sustainable operations. Because the hydro resource depends on maintenance of the catchment area, local communities also become aware of the need for environmental management.

Note added by proceedings editor: The potential for linking renewable energy options with productive uses is enormous in Indonesia. However, potential investors will have to see a secure enabling environment in order for private sector-driven scaleup of renewables. Public/private partnerships may be the preferred route to such scaleup in the near future.

Review of RESCO-based Kiribati Stand-alone PV Program
Terubentau Akura, Kiribati Solar Energy

Note: In the presentations folder there is a paper by Mr. Akura and colleagues on the Kiribati experience. Some brief excerpts follow.

The experience of Kiribati with PV-based rural electrification is unusual and important in that Kiribati originally failed in its attempt to use PV for rural electrification through promotion of the purchase of systems by rural households. Recognizing that the problem was institutional, not technical, Kiribati then changed the institutional structure of the solar implementation agency from sales based to a service based institution and turned failure into success.

Kiribati is one of the world's least-developed countries. Because almost all manufactured commodities must be imported, the government is trying to develop small-scale import substitution industries, handicrafts, tourism, and commercial fishing. Recently, seaweed farming for the European market has grown to a significant export level. The capital island, South Tarawa, is electrified by a grid with power from Diesel engines. A short extension of that grid into rural Tarawa (North Tarawa) was completed in 1992. Small Diesel or petrol generators power outer island government offices and larger secondary schools but there is no grid based electricity provided outside of Tarawa other than a small local grid developed on Christmas Island.

The first national involvement with PV for general rural electrification began in 1984 with the formation of the Solar Energy Company of Kiribati (SEC). The SEC was established as a private enterprise by the Foundation for the Peoples of the South Pacific (FSP), a US-based NGO. The SEC was established using USAID funding and was organized as a private corporation with the purpose of promoting and selling PV to rural households. The initial private shareholders were FSP and the Bank of Kiribati with shares also held by the Ministry of Public Works and Utilities (MPWU).

Note from editor: After many years of technical, financial, and managerial failure, a new approach was developed with the assistance of Mr. Herb Wade, a well-known authority on the practical uses of renewable energy for Pacific Island communities. This process is described in some detail in the paper.

Of the more than 8,000 rural households in Kiribati, nearly 50% have specifically requested systems as they become available and another 30% are considered very likely to accept systems under the affordable solar utility fee structure. A 50% connection rate is quite comparable to the connection rate found with grid based rural electrification systems. The cost of the PV systems for reaching 50% of rural households is less than the cost for creation and operation of a diesel based grid for the same customer base and service provision.

Existing users have been polled for satisfaction and a large majority considered their solar PV systems to be superior to a grid connection. Satisfaction has been high and reliability of service very high. Users report a significantly better quality of life particularly for women and children. Women report less pressure for completion of household chores due to the availability of good lighting. They also report greater social interaction at night and better ease of care of babies after dark. Children have been reported to have improved school grades due to improved lighting for homework and study.

Men report less pressure to complete work during the day as good light is available at night, something particularly valuable for the common activity of fishing net preparation and repair. Fishermen also find the good lighting valuable for their pre-dawn preparations and all members of the household have expressed pleasure at being able to have radio and cassette players available for entertainment at any time. Improvements in health services have also been reported due to the availability of emergency radio com-

munications, good lighting and vaccine refrigeration at island health centers. With a lessened need to ship and store kerosene and dry batteries, there is lowered environmental impact. When compared to the environmental impact of a diesel based grid, the PV electrification is substantially lower though there remains the need to recycle the lead acid batteries every 5-7 years.

During its 10 years of operation as a solar utility, the Solar Energy Company has continuously provided electrical service to its customers with no operating subsidy. All solar utility operating and maintenance costs have been covered by the SEC through its operational income. However, no excess income for further capitalization of new systems has been possible with the small installed base of 300 systems and some financial shortfall in the utility operation has been covered by SEC income from other projects not connected with the utility operations. Therefore, the Government of Kiribati has petitioned the EU for funding to increase the installed customer base of the SEC to over 1500 systems so that (a) the strong demand for additional systems on outer islands is at least partially met and (b) the customer base would become large enough for the SEC to maintain acceptably low fees yet have sufficient income to cover all costs and have a moderate surplus to accumulate capital funds for additional installations. This EU project was launched in August in 2001 and will be completed in March 2005.

Barriers to replication, and lessons learned

Two primary barriers exist to the creation of a successful solar utility in a developing country.

1. An installed base of from 500-1,000 systems is necessary to break even on O&M costs with a fee structure that is affordable for most rural developing country households. An initial capital investment of about A$1 million is needed, a sum that is unlikely to be available though commercial sources at an affordable rate.

2. Good quality, continuing management training is required since long term planning, good accounting and careful cost control is necessary in the management of a solar utility and such skills need development in most countries that can benefit from solar based rural electrification.

Software Tools Supporting Village Power System Design
Jean Ku, NREL

Software tools that run easily and quickly on laptop and desktop personal computers are essential for optimizing the technical designs and costs of renewable energy systems. This applies both to free-standing applications, such as small wind, PV, or PV/wind hybrids, as well as to large hybrid power systems that support local minigrids and microenterprise zones. NREL has developed a suite of three computer models that provide system designers, operators, and investors with the tools for cost and performance optimization of renewable energy systems under a wide range of renewable energy resource conditions, capital costs, fuel costs, and other parameters.

These models are available from NREL at www.nrel.gov. They are

- **ViPOR**: An optimization model that determines the best mix of centralized (micro/minigrid) and isolated power generation systems for a particular community. www.nrel.gov/vipor
- **HOMER**: An optimization model that determines the least-cost system configuration for a wide variety of renewable and hybrid power systems. www.nrel.gov/homer
- **Hybrid2:** A simulation model to determine the cost and performance of a variety of power systems under specified energy loads and available solar and wind resources.

These models are available either free of charge or a nominal cost from NREL, and some support is provided to users. NREL also has an ongoing program of training for users around the world.

Financing Village Power Projects and Programs in APEC Economies, including Micro-Finance Institutions and Productive Uses

Judy Siegel, Chair

Note from editor: Limited access to suitable financing remains one of the major obstacles to many village power programs. Several new and emerging initiatives and programs are aimed at expanding the available financial instruments and providing long-term "patient" financing for village power initiatives.

Investing in Renewable Energy

Frank Pool, Sustainable Energy Development Specialist, Asian Development Bank

The full costs of traditional energy resource surveying verification, extraction, transformation, distribution, and retailing are rarely reflected in energy prices. Environmental and social costs associated with the full chain of energy resource mobilization and use are typically not fully internalized and often not internalized at all in the prices to end users. Such internalization of costs is essential to "level the playing field" for renewables and energy efficiency systems.

There are many barriers to expanding the use of renewables for small-scale (village power) applications. These include

- Energy services expectations often exceeds reality
- Costs often exceed ability to pay
- No local ownership for systems that are "parachuted' in
- Unrealistically low tariffs (heavy subsidies) undermine the economics of sustainable energy supply
- Necessary resource assessments often poor or non-existent
- Policy implementation work often started much too late
- Single technology focused advocates can hinder a more evenhanded approach to energy system choice
- Unrealistic and incomplete prefeasibility studies

However, there is good news. This includes

- Tariff reform and utility unbundling
- Recognition that fossil fuels subsidies are becoming or are unaffordable
- Growing donor and development funding interest in sustainable commercial approaches
- The Clean Development Mechanism (CDM) can double the financial internal rate of return (FIRR) with payments of $4 per ton of avoided CO2.

The Asian Development Bank is providing support in the Asia/Pacific region for energy policy studies, development initiatives, energy infrastructure and rehabilitation lending, capacity building, development of innovative financing schemes, resource assessment studies, and leveraging of GEF project funding. Special funds for clean energy are available to the ADB from Canada, Denmark, and the Netherlands.

The PREGA Project (Promotion of Renewable Energy, Energy Efficiency, and Greenhouse Gas Abatement) is a major initiative funded by the Netherlands, and is supporting renewable energy prefeasibility and feasibility studies, workshops, and some targeted demonstrations. Through this, the ADB is increasingly a major force in facilitating renewable energy applications in the Asia-Pacific region.

Financing Renewable Energy for Village Power Applications
Grace Yeneza, Preferred Energy, Inc., Philippines

PEI is a Filipino non-profit organization committed to promotion and development of renewable energy systems for power and other applications. They work closely with communities and other stakeholders to develop project approaches that emphasize economic productivity and social benefits. Establishing "bankable" renewable energy projects in the Philippines faces serious obstacles, including a long history of dependence on grants and "dole outs", remote dispersed sites, and the informal nature of community organizations. Yet PEI has been able to work with rural communities to develop successful renewable energy projects, especially microhydro projects tied to productive uses.

PEI is now developing a Village Power Fund that will be a pilot revolving fund for development and financing of commercially viable and sustainable energy / productivity investments in rural areas. Such a fund can reduce significantly the time required to generate financing for these small but highly useful projects. The approach, which is replicable in other developing countries as well, is that (1) it focuses on the integration of energy supply with economically and socially productive activities, (2) is highly participatory, and (3) uses flexible financing mechanisms.

Editor's note: PEI projects and financing approaches are presented on their web site www.pei.net.ph

Renewable Energy Financing in the Asia Region
Mike Allen, Renewable Energy & Energy Efficiency Partnership (REEEP)

The Renewable Energy and Energy Efficiency Partnership (REEEP) is a coalition of governments, businesses, and other organizations. Their approach is to support renewable energy and energy efficiency services, and by doing so reduce the negative environmental effects of energy production and use, and contribute towards energy security through diversification of energy supply and increased use of indigenous renewable energy resources. They have regional secretariats around the world, including in China, Latin America, and the US, with headquarters in Vienna, Austria.

Because many renewable energy projects require patient finance, but projects that offer below 10% return have little support, there is a need to encourage public private participation. REEEP financing support includes the establishment of an ASEAN/Pacific regional facility for renewable energy and energy efficiency support and financing, and support for feasibility studies in China.

REEEP will be the catalyst for the Foundation for Sustainable Energy. This is a Singapore-based foundation that looks to ASEAN and Pacific markets. It provides early stage support and finance, and can offer limited project finance and terms and conditions appropriate to the market.

E+Co (Energy Through Enterprise) has made 116 investments over the past decade, and fields teams in Africa, Latin America, and Asia. They have supported some high-risk high-potential renewable energy projects. Their efforts have resulted in modern energy services being provided to 1.65 million people. Their projected weighted average IRR on the total portfolio, after write-offs, is 7.4%. This underscores the need to bring a mix of financing from multilaterals, governments, foundations, and the private sector.

Editor note: The approach and toolkits development by E+Co are available on the Internet and are very useful in screening small-scale renewable energy enterprise investments as well as providing business training support.

Scaling Up Renewable Energy Applications in APEC Economies

Group Discussion: Scaling Up Renewable Energy in APEC Economies, Next Steps
Nelson (Woody) Stevens, Moderator

Woody led a workshop discussion on the needs for and requirements for scaling up renewable energy in APEC economies, specifically for village power applications. Scaling up will require resources, including experienced experts, money and financial vehicles, the demand for renewable energy-based services, and the political will for the country to pursue renewables as an ingredient of sustainable development.

Woody proposed that the approach to village power should be very businesslike, with the development of a business plan as a starting point. Such a plan would identify and characterize the markets for RE-based services, would identify the processes and best practices for servicing the markets, define product and service needs, identify the risk factors, and identify the capital investment and cash flow requirements. APEC / EGNRET could play a vital role in supporting the development and dissemination of quality standards, monitoring and evaluation methods, and training of communities and ESCOs.

Wrap Up and Next Steps

Harvey Major, US Department of Energy
Chair, APEC Expert Group on New and Renewable Energy Technologies

The workshop has provided an excellent opportunity for representatives of APEC member economies to obtain information and learn about the current status of various renewable energy technologies. We have been able to review a range of issues crucial to the selection, deployment, operation, maintenance, financing, and scale up of these options. Many of the APEC economies support energy-based rural electrification, though more than 1.5 billion people continue to lack access to electricity. Renewable energy has the potential to make a significant contribution to providing and increasing access to modern energy services for those unserved and underserved, and to do so in a way that enhances economic and social development. These activities would also provide a market for renewable to hydrogen technologies when they become available as proven commercial options.

The workshop provided an opportunity for the APEC representatives to learn from the experiences and lessons learned by experts in the field. The experts represented government, public and private sector energy service providers, non-governmental organizations, and financiers who have been involved in energy sectors related to rural development, agriculture, water and small and medium enterprises. The informal discussions between the government representatives and the practitioners were lively and often extended well into the evening.