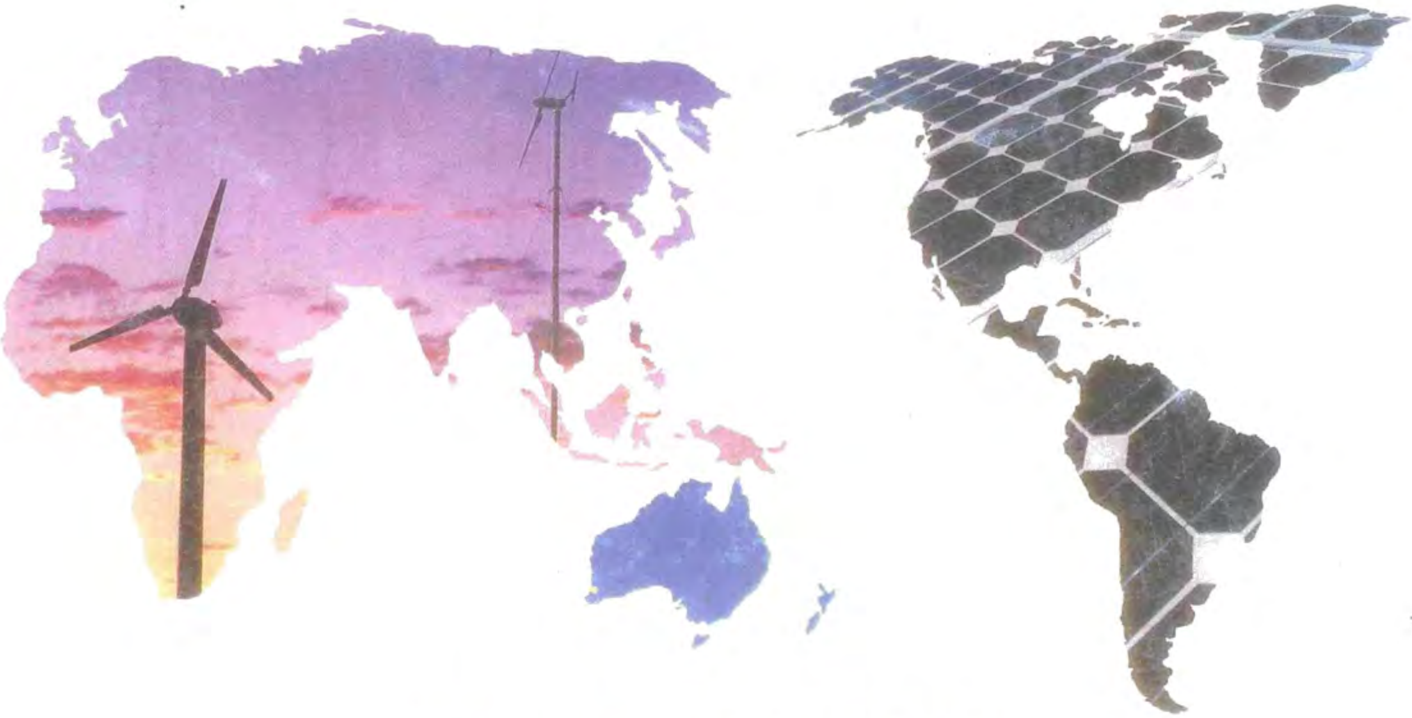
Global Seminar for Women Leaders on the Uptake of Renewable Energy Technology



27 June - 4 July 2001
Murdoch University
Perth, Western Australia

Hosted by

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Acknowledgements

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Global Seminar

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PREFACE

Over the last five years the United Nations Environment Programme (UNEP) and Murdoch University, Perth have joined hands in promoting environmentally sound technologies, particularly among prospective users in developing countries and countries with economies in transition. A number of awareness creating and training activities have been successfully implemented through the close cooperation of the two institutions. These activities have been followed by events at regional and national levels indicating we were obviously meeting the demands of our target groups. Demand also became evident in the high number of applications which were received for those training programmes, and which exceeded by far our limited possibilities. The same applies for this Seminar on Women and Uptake of Renewable Energy Technologies. Training, tailored particularly for women on utilizing alternative energy resources, belongs to one of the most needed, but least attended capacity development subjects.

Right in front of the doorstep of UNEP's headquarters in Nairobi, we can observe how close women are to using fossil fuels for cooking, heating, drying and processing agricultural produce. Every day women spend many hours collecting their main source of energy - fuel wood -which is fast becoming scarce leading to soil erosion, desertification and loss of biodiversity. To draw women's attention to RET's as an environmentally sound alternative to fossil fuels, we need to establish core teams of women leaders and trainers and provide them with knowledge and skills on renewable energy technologies, so that they can spread the message to other women and men in their neighborhoods, villages, towns, provinces and nations.

This effort becomes a burning issue at a time, when some influential politicians are making it fashionable to question the effects of climate change as threatening livelihood on earth. Consequently, this Seminar, not only has a technical value, but at the same time a political one. To look for ways and means in fully exploiting the abundant renewable energy resources in our countries is a matter of follow or leave the path of sustainable development.

Christian Holger Strohmann
Head, Environmental Education, Training and Capacity Development
United Nations Environment Programme

Empowerment for women in making energy choices will come, at least in part, from the ability of policy makers and administrators to make technologically informed decisions. This involves understanding the costs, benefits and limitations of various energy options and the influence that policy exerts on technology outcomes. It is with all this in mind that we have organised this workshop which is intended to be a catalyst for the development of over 20 Action Plans for women to be involved with the introduction of RET's into national policy, projects and communities in developing nations.

The social outcomes of implementing technology are frequently determined by the effectiveness of policy decisions. Because of this, policy must be genuinely informed by the needs of those upon whom the technology will have the greatest impact. In many developing economies the burden of a lack of adequate energy can fall disproportionately on Women. One of the keys to changing that situation is to involve women in decisions regarding the implementation of energy solutions.

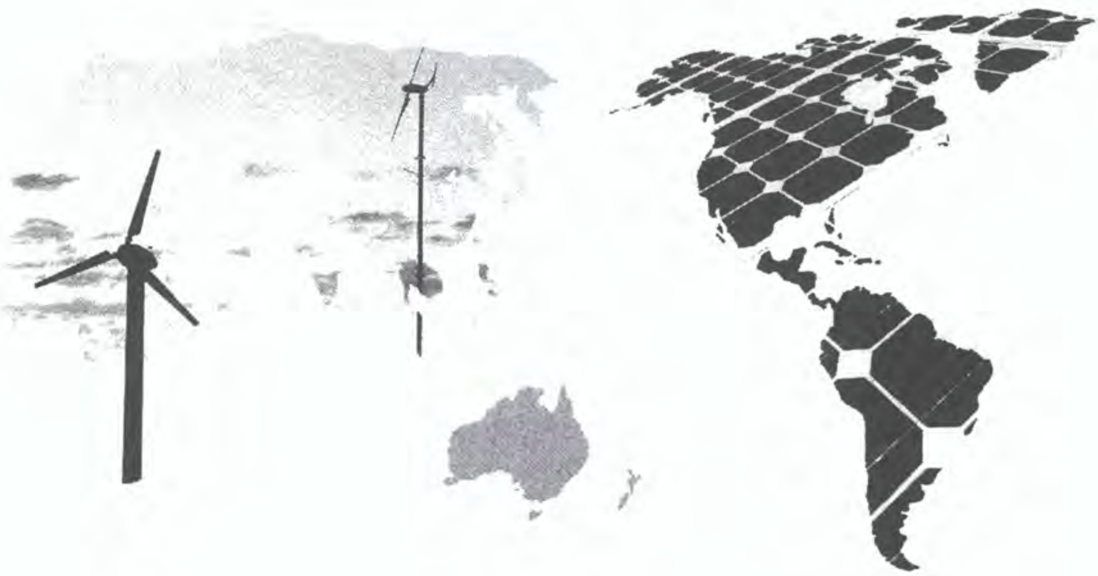
With this in mind, it is a great pleasure to welcome international delegates to this key Seminar on the Uptake of Renewable Energy Technologies.

Aimed at women leaders in energy, community and non governmental organisations, the social significance, need and value of this Seminar is evident from the level of participation of speakers and delegates from industry, government, small to medium enterprises and academic organisations based in over 23 countries.

Finally, it is my hope that this Seminar provided the insights, shared experiences and the critical exchange that will inform delegates in the areas of RETs and assist them to make a lasting contribution to the communities that we all serve.

Frank Reid
Managing Director, ACRE Ltd

Report on the Global Seminar for Women Leaders on the Uptake of Renewable Energy Technology



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Introduction

The Global Seminar for Women Leaders on the Uptake of Renewable Energy Technology was held on the Murdoch University campus, Perth, Western Australia, over six days from the 27 June to 4 July, 2001. It included five half-day seminar sessions and four field trips to renewable energy and energy efficiency demonstration projects, which provided practical examples of the technologies. Three workshop sessions were held to discuss gender issues and action plans. Planning and discussion sessions were also held, where delegates interacted and discussed technology options for their own nations and developed regional/national follow-up activities for awareness raising and training of women on the uptake of renewable energy resources and technologies.

The seminar presenters included some of Australia's leading researchers, policy analysts and trainers from the Australian Cooperative Research Centre for Renewable Energy (ACRE) and its industry associates.

Perth is recognised as an ideal Australian location to host renewable energy training events, especially those which focus on stand-alone energy supply systems for remote and rural areas. Large numbers of working and demonstration systems are located within an 80-kilometre radius of the Perth Central Business District, which is ideal for site visits. Perth's geographic location, approximately half way between Africa and South America and its proximity to South East Asia and the Indian Subcontinent, make it an excellent location for discussing development issues. Western Australia also has a diverse climate ranging from tropical regions in the north of the State, arid desert regions in the central and eastern parts and a temperate, Mediterranean climate in the south. This provides for a full range of conditions for renewable energy planning.

Aims

The primary aim of the Global Seminar was to familiarise delegates with reliable and proven renewable energy technologies for development in tropical and sub tropical regions of the developing world. It also aimed to provide an opportunity for women leaders to visit sites where renewable energy and energy efficiency are being utilised. Another major theme of the Global Seminar was to address gender issues affecting the uptake of renewable energy technologies in developing countries.

Specific Objectives

The Global Seminar was intended to:

- train participants to advocate for the political will and resources to support integrated and holistic energy policies, which take into account women's needs;
- educate participants in sustainable energy issues and concerns relevant to women's needs, so that they can share this knowledge with others;
- provide technical education to increase access to women-friendly energy technologies;
- promote women's collaboration with energy and other organizations in improving access to sustainable energy for both women and men; and,
- encourage women to participate in energy policy and planning discussions, and to play a significant role in energy service companies/co-operatives.

Background

There is growing national and international concern about the environmental impacts of current energy consumption and production patterns. At the national level this concern is reflected as an increasing focus on local pollution consequences, particularly in the rapidly expanding urban areas of most developing countries. Internationally, it is clearly expressed in connection with the on-going negotiations under the United Nations Framework Convention on Climate Change (UNFCCC), which focuses on the reduction of greenhouse gas (GHG) emissions. The United Nations Environment Programme (UNEP) Governing Council Decision number 9, adopted at the 21st Session on 9 February 2001, urges all Governments in line with their commitments and obligations under the UNFCCC to promote and cooperate in building technical and scientific capacity of developing countries in order to encourage their full partnership in the Climate Agenda. Similarly the dedication of the 9th Session of the Commission on Sustainable Development (CSD) in April 2001 to the issue of sustainable energy development reflects a concern not only with GHG emissions, but with the full range of environmental impacts.

Increased use of Renewable Energy Technologies (RETs) and enhanced energy efficiency are ways of meeting the growing demand for energy, while simultaneously providing additional economic, social and environmental benefits. Over recent decades, numerous programs have demonstrated the technical potential of many RETs, but implementation still remains limited due to the various barriers preventing their increased application, especially in developing countries. Paragraph 14 of the Malmö Ministerial Declaration stresses the potential of civil society in playing a critically important role in addressing environmental issues. With regard to uptake of RETs, this applies to major groups, particularly to women's key roles and interests in energy consumption and often production, for example women are:

- the principal consumers and users of household energy and public transport;
- purchasers of stoves, fans, and other energy-using appliances and the selectors of cooking fuels;
- the main decision-makers in determining their household's direct and indirect energy consumption through use of cooking, heating, hot water and electrical appliances; and household purchases, which may be more or less energy intensively produced;
- particularly vulnerable to environmental pollution due to their reproductive role and household responsibility for cooking;
- the victims of high energy prices and expenditures, especially as females manage households in most developing countries;
- more frequent users of public transport and pedestrian walkways than men;
- the primary educators and formers of their children's future energy conservation and consumption habits; and,
- effective activists on energy issues in health, environmental, children's and peace-related organizations, ranging from community education for recycling, to lobbying for sustainable energy and anti-nuclear protests.

In developing countries, women have an especially critical interest in improved access to sustainable energy supplies because:

- Rural women (and their children) are the primary collectors of wood and residue fuels, which account for 80% of all household energy use in many developing countries. Based on FAO estimates, the proportions of rural women affected by fuel wood scarcity range from 60% in Africa, to nearly 80% in Asia, and nearly 40% in Latin America. Time spent in fuel collection in fuel-scarce areas can range from one to five hours per household per day;

- Women work longer hours than men in providing human energy for survival activities such as fuel and water carrying, cooking, food processing, transport, agriculture, and small enterprises;

- Many income activities of women in the informal sector - often critical to family economic survival - are fuel intensive, and the viability of these activities is affected by energy prices and availability;

- Energy scarcity impinges on the provision of other basic services, such as water, health, and education. For example, the proportions of rural women affected by water scarcity are estimated to be 55% in Africa, 32% in Asia, and 45% in Latin America, with the median time for collecting water in the dry season about 1.6 hours per day;

- More than half the world's households cook daily with wood, crop residues, dung and untreated coal, as a result of which women and children have the highest exposures to indoor air pollution, linked to acute respiratory infections, chronic obstructive lung diseases, low birth weights, lung cancer and eye problems;

- Occupational health hazards for women involved in energy use and production include bone fractures, back disorders and miscarriages due to fuel wood load carrying; and exposure to burns and smoke in informal sector enterprises; and

- Physical and psychological violence against women collecting wood and residue fuels has been reported: rapes while gathering fuel wood around refugee camps in Kenya and Somalia, undergoing sniper fire to gather fuel in Sarajevo, and bride suicides related to women's inability to meet their family's wood fuel needs in India.

As a contribution to improve women's awareness of sustainable energy resources and helping them to better access and utilize those resources, UNEP's Division of Environmental Policy Implementation (DEPI) with support from the Swedish Government initiated an *"Awareness and education programme for women leaders on uptake of renewable energy technologies"* of which the Global Seminar in Perth, Australia, was intended as a kick-off event.

Participants

Twenty-eight delegates, from 23 countries attended the Global Seminar. Delegates were women leaders from the private and educational sectors as well as Government and Non Government Organizations (NGOs) in developing countries. Most were already active in the field, and had the potential to disseminate knowledge and skills acquired during the Global Seminar through follow-up activities at the sub-regional, national and local levels.

Profiles and contact details of the delegates who participated in the event are presented in Appendix 1.

Program
The key objective of the seminar was to educate participants on sustainable energy issues, through the provision of technical sessions to enhance their knowledge of the technologies and systems. In collaboration with the Environmental Education and Capacity Unit of UNEP, ACRE developed a program to address the technical, social and policy issues of renewable energy technologies.

Daily morning technical sessions were designed to provide background material for the technologies and systems discussed in the afternoon site visits.

Technical sessions were organised around five major themes:
- Overview and Scene Setting
- Stand-alone Renewable Energy Systems
- Energy Efficiency and Energy Management
- Policy and Social Issues
- Education and Training

Presenters were selected on the basis of their knowledge and expertise in these areas, and also on their experience working in or with developing nations or indigenous communities in rural and remote areas. Attention was given to providing speakers with some experience in gender aspects of renewable energy.

Thirty-one presenters representing 24 organizations or groups were involved in the technical presentations to delegates at the Global Seminar. Organizations included private companies, research and development organizations, special interest groups, NGOs and Government departments.

A copy of the final program is presented in Appendix 2. Profiles and contact details of the presenters who participated in the seminar are given in Appendix 3.

Sponsors
The Global Seminar was funded jointly by UNEP and ACRE, with additional support from 22 organisations and firms, which contributed staff time, facilities, food, refreshments and information to delegates. ACRE and UNEP gratefully acknowledge these organizations and firms, which contributed support and helped keep the costs of the Global Seminar within budget. A full list of sponsors and supporters is presented in Appendix 4.

Field Trips and Site Visits
Site visits were designed to provide delegates with direct experience of technologies and themes addressed in the presentations and discussions; thus providing practical examples of the theoretical concepts discussed in the Global Seminar.

Eleven visits were organized around four major technological themes:

- Stand alone renewable energy systems
- Energy efficient and climate sensible buildings
- Energy production from biomass waste
- Manufacturers of solar water heaters and wind turbines

Two additional themes addressed at a number of sites were:
- Water harvesting and reuse
- Sustainable agricultural and gardening strategies

The eleven site visits in four afternoons enabled the delegates to:

- see in detail a range of transferable technologies and systems
- see the practical application of the principles of climate sensible building
- make personal contacts in institutions and companies from which advice, goods and services can be obtained

The visits raised key questions relating to the application of renewable and energy efficient technologies. For example: the issue of converting knowledge into effective action was highlighted by the observation that although the principles for designing climate sensible buildings for Perth were established long ago, a plentiful supply of relatively cheap energy has enabled architects, builders and house purchasers to continue to use inefficient designs. Similarly the contrast between the mechanical windmills, produced for water pumping by W.D. Moore and Company, and successfully used for over 100 years across outback Australia; and, the experiences of Dr Pryor of the Murdoch University Energy Research Institute (MUERI), with the maintenance problems of early remote area power supply (RAPS) systems, again raised questions about how best to choose technologies that are appropriate for the areas in which they are to be used.

Details of the field trip program and site visit presenters can be found in Appendix 5.

Workshops

Dr Joy Clancy, Director of Capacity Building, ENERGIA and Dr Njeri Wamukonya, Researcher, UN Collaborating Centre for Energy and the Environment (UNCCEE) led the workshops. Ms Catrina-Luz Aniere from Millennium Kids, assisted Dr Clancy in the first workshop, by providing specialist local knowledge on Australia and working with groups in identifying regional issues of concern with regard to renewable energy.

Three workshop sessions were included in the program with two distinct aims:

- To provide delegates with an opportunity to meet one another and learn about their particular interests and their personal expectations from this event;
- To identify activities at the national and regional level which encourage women to effectively participate in all aspects of energy policy and planning as well as the delivery of energy services.

Details, including a copy of the program for these workshops can be found in Appendix 6.

The main outcomes from these sessions were regional action plans, prepared by the delegates and these are presented in Appendix 7.

Ongoing Networking and Communication

ACRE will maintain, for the short term, a website (http://www.acre.murdoch .edu.au/unep/) which was developed for the Global Seminar. Through this site, participants from this event can keep in touch with developments and actions in this area following the seminar. In addition, an email distribution list has been established, so that the participants can further develop and maintain the contacts that they have developed during the Global Seminar.

Papers and Presentations

A complete set of papers and presentations from the Global Seminar has been prepared. These papers can be found in second part of this report.

Recommendations

There was general agreement that the Global Seminar was a useful first step in addressing gender issues in relation to sustainable energy.

Detailed plans for follow up action at a regional level were prepared and will be pursued through regional offices of UNEP.

In general there was widespread support from all regions for follow up activities in the areas of:

- Policy research on women's roles in promoting and using renewable energy technologies
- Capacity building activities such as education and training at all levels to support the introduction of RETs
- Follow up interaction via regional seminars, networking and communication

These follow up activities will require additional funding in most cases.

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Appendix 3
Final Program

Day 1 - Wednesday 27 June 2001

0800	Hotel Pickup Session One Chair: *Dr Frank Reid, ACRE Ltd*
0900	ACRE Welcome *Dr Frank Reid, ACRE Ltd*
0910	Welcome to Murdoch University *Professor Tony Tate, Division of Science and Engineering, Murdoch University*
0920	Traditional Women's Nyungar Welcome *Mrs Marie Taylor, Kulbardi Centre*
0935	Welcome to Community Technology 2001 *Mrs Mara West, Mahdijungu Consultancy Services*
0945	UNEP Welcome *Dr Ludgarde Coppens, UNEP – ROAP*
0955	UNEP Activities in Renewable Energy Technologies & Implications for Women *Dr Njeri Wamukonya, UN CCEE*
1015	UNEP – ROAP Initiatives on Renewable Energy Technologies in the Asia Pacific Region *Dr Ludgarde Coppens, UNEP – ROAP*
1035	Morning Tea
	Session Two Chair: *Ms Katrina Lyon, ACRE Ltd*
1100	The Outlook for Renewable Energy *Dr Frank Reid, ACRE Ltd*
1130	World Bank Funding for Renewable Energy Projects *Dr Marc Saupin, IDT International*
1200	Energy, Poverty and Gender *Dr Joy Clancy, ENERGIA*
1230	Lunch
1330 – 1730	Workshop Session 1 Facilitated by *Dr Joy Clancy, ENERGIA & Ms Catrina-Luz Aniere, Millennium Kids*
1830	Welcome Dinner Function Centre, Murdoch University
2000	Return to Hotel

Day 2 Thursday 28 June 2001

0800	Hotel Pickup Session Three Chair: *Ms Alix Rhodes, ACRE Ltd*
0900	Climate Change Mechanisms and Renewable Energy Projects *Mr Simon Dawkins, EcoCarbon*
0930	Diesel Hybrid Systems for Village Power *Dr Trevor Pryor, Murdoch University*
1000	Renewable Energy Systems for Remote Areas *Dr Bob Lloyd, ACRE Ltd*
1030	Morning Tea
	Session Four Chair: *Dr Angelina Galang, Miriam College, Phillipines*
1100	Monitoring and Evaluation of Stand Alone Renewable Energy Power Systems *Dr Chris Lund, Murdoch University*
1130	Training Designers and Installers of Stand Alone Power Systems *Mr Trevor Berrill, Brisbane Institute of TAFE*
1200	Government Support for Stand Alone Power Systems: an example from WA *Mr Evan Gray, Office of Energy WA*
1230	Gender and Energy *Dr Njeri Wamukonya, UN CCEE*
1300	Lunch
1400	Field Trip One Stand Alone Power Supply Systems Facilitated by *Dr Bill Wheatley, ACRE Ltd*
1730	Return to Hotel

Day 3 - Friday 29 June 2001

0800	Hotel Pickup Session Five Chair: *Dr Ludgarde Coppens, UNEP-ROAP*
0900	Energy and Sustainability *Professor Philip Jennings, Murdoch University*
0930	Climate Sensible Building Design in the Tropics and Subtropics *Dr Martin Anda, Murdoch University*
1000	Energy Efficient Appliances *Dr Mary Dale, Office of Energy WA*
1030	Morning Tea
	Session Six Chair: *Ms Alix Rhodes, ACRE Ltd*
1100	Implementing Energy Efficiency in Communities *Dr Stephanie Jennings, Office of Energy WA*
1130	Renewable Energy Beyond the Village *Mr Michael Dymond, Advanced Energy Systems Ltd*
1200	Lunch
1330	Field Trip Two Climate Sensible and Energy Efficient Buildings Facilitated by *Dr Bill Wheatley, ACRE Ltd*
1730	Return to Hotel

Day 4 - Monday 2 July 2001

0800	Hotel Pickup Session Seven Chair: *Dr Mary Dale, Office of Energy WA*
0900	Solar Drying *Dr Trevor Pryor, Murdoch University*
0915	Vaccine Refrigeration *Dr Trevor Pryor, Murdoch University*
0930	Renewable Energy Pumping Systems *Mr Geoff Moore, W.D. Moore & Company*
0945	Disinfection and Desalination of Water Supplies *Dr Kuruvilla Mathew, Murdoch University*
1000	DC Lighting for Solar Appliances *Ms Susan Godfrey, 12 Volt Shop Pty Ltd*
1015	The Sun Cooks for Us *Mr Sunny Miller, Solar Cooking Interest Group*
1030	Morning Tea
	Session Eight Chair: *Dr Njeri Wamukonya UN CCEE*
1100	Developing Biomass Options *Dr Don Harrison, Western Power Corporation*
1115	Low Cost Solar Hot Water Systems *Professor Goen Ho, Murdoch University*
1130	Small Wind Turbines *Dr Jonathan Whale, ACRE Ltd*
1200	Lunch
1330	Field Trip Three Major Installations Illustrating Sustainable Energy Practices Facilitated by *Dr Bill Wheatley, ACRE Ltd*
1730	Return to Hotel

Day 5 - Tuesday 3 July 2001

0800	Hotel Pickup Session Nine Chair: *Mr Levis Kavagi, UNEP*
0900	Policies for the Promotion of Renewable Energy Technologies *Dr Mary Dale, Office of Energy WA*
0930	Cities for Climate Protection: Local Government Action to Reduce GHG Emissions *Ms Nicole Hodgson, WA Municipal Association*
1000	Climate Change and Developing Countries *Dr David Annandale, Murdoch University*
1030	Morning Tea
	Session Ten Chair: *Ms Tahira Syed, IUCN – The World Conservation Union*
1100	Energy Efficiency Training for Remote Communities *Mr Fred Spring, Relspree Ltd*
1130	Renewable Energy and Energy Efficiency from the Indigenous Woman's Perspective *Mrs Mara West, Mahdijungu Consultancy Services*
1145	Energy Efficiency and Community Empowerment *Ms Veronica Vann, Conservation Council of WA*
1215	Information and Training Needs for Government and Industry *Ms Katrina Lyon, ACRE Ltd*
1245	Lunch
1330	Field Trip Four Site Visits to Renewable Energy Industry Facilitated by *Dr Bill Wheatley, ACRE Ltd*
1730	Return to Hotel
1915	Hotel Pickup for Farewell Dinner
1930	Farewell Dinner, Hillcrest Restaurant, South Perth
2200	Return to Hotel

Day 6 - Wednesday 4 July 2001

0800	Hotel Pickup Session Eleven Workshop Facilitators: *Dr Njeri Wamukonya and Dr Joy Clancy*
0900	Workshop Session – Planning for Follow up Action
1030	Morning Tea
1100	Workshop Session – Planning for Follow up Action
1230	Lunch
1330	Workshop Session – Developing Action Plans
1530	Afternoon Tea
1550	Concluding Remarks
1700	Community Technology 2001 Welcome BBQ
2000	Return to Hotel

Appendix 4
Acknowledgements

We gratefully acknowledge the support of all organizations involved with the Global Seminar. This event would not have been possible without the generous support of:

UNEP

ACRE
Australian CRC for Renewable Energy Ltd

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

Advanced Energy Systems
Arrid Power
Conservation Council of WA
Curtin University of Technology
Ecotect Architects
ENERGIA
Environmental Solutions International
IDT International
Mahdijungu Consultancy
Melville City Council
Millennium Kids
Office of Energy WA
Perth Zoo
Piney Lakes Environmental Centre
Relspree Ltd
Solahart Pty Ltd
WA Municipals Association
Water Corporation
W.D. Moore & Company
Western Power Corporation
Westwind Turbines

Appendix 5
Site Visits

Site Visit Program

Thursday 28 June 2001

1345 Assemble at Murdoch University Chancellery Bus Terminus
1400 Murdoch University Energy Research Institute (MUERI)
1500 ACRE Lab
1545 Environmental Technology Centre (ETC), Murdoch University
1700 Return to Hotels

Friday 29 June 2001

1300 Assemble at Murdoch University Chancellery Bus Terminus
1330 Piney Lakes Environmental Centre
1430 Perth Zoo, South Perth
1630 Centre for Renewable Energy Systems Technology Australia (CRESTA), Curtin University, Bentley
1730 Return to Hotels

Monday 2 July 2001

1330 Assemble at Murdoch University Chancellery Bus Terminus
1345 W. D. Moore & Company
1500 Water Corporation, Woodman Point
1630 Water Corporation and Environmental Solutions International (ESI), Subiaco
1800 Return to Hotels

Tuesday 3 July 2001

1330 Assemble at Murdoch University Chancellery Bus Terminus
1400 Solahart, Welshpool
1530 Venco -Westwind, Kelmscott
1700 Return to Hotels
1900 Assemble South Perth to depart for farewell dinner

Occupational health, safety and welfare laws in Western Australia are very strict. Companies are liable for any accidents which result in employees and visitors not wearing appropriate clothing and footwear. For this reason, during the site visits the delegates must wear:

- Covered shoes (not sandals or high heels)
- Long trousers
- Jackets or shirts with long sleeves

Site Visit Overview

Site visits were designed to complement Global Seminar presentations and discussions and were organised around four major themes:

- Stand alone renewable energy systems
- Energy efficient and climate sensible buildings
- Energy production from biomass waste and the manufacture of water pumping systems
- Manufacturers of solar water heaters and wind turbines

Murdoch University Energy Research Institute (MUERI)

MUERI carries out research on renewable energy systems, energy conversion devices, energy storage, and energy management and efficiency. MUERI staff also teaches and advise on this range of topics.

Dr Trevor Pryor welcomed delegates to MUERI and gave an overview of the Institute's activities. Together with Dr Chris Lund, he gave delegates a tour of:

- the Remote Area Power Supply (RAPS) display that features three stand alone electricity generation systems incorporating PV panels, wind turbines, battery banks and controllers;
- a photovoltaic test facility, where PV panels are tested in both natural and controlled conditions;
- a wind turbine test facility and the Westwind-ACRE 20 kW turbine, three of which will shortly be installed at Exmouth, in the North West of Western Australia; and,
- an old solid state containerised PV-battery system (Solar Pack), examples of which had been installed in remote settlements in Western Australia to provide DC power.

The performance of the RAPS system can be monitored on the website at http://wwwphys.murdoch.edu.au/WebRAPS/. Dr Pryor explained that MUERI could advise other users on setting up similar monitoring systems which provide good insights into systems performance and design.

Discussions on the importance of long term maintenance of hybrid RAPS systems and the suitability of complex systems in remote locations arose during the visit.

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http://wwwphys.murdoch.edu.au/WebRAPS/

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ACRELab

ACRELab is a laboratory operated by ACRE on the Murdoch University campus. ACRELab tests renewable energy systems for reliability and performance. The facility includes a large environmental chamber where components and systems can be tested under a range temperature and humidity conditions. As well as testing renewable energy systems the staff at the laboratory also provide advice on renewable energy system design and training on their use.

Dr Bob Lloyd welcomed delegates to ACRELab, and gave a short presentation on the structure and activities of ACRE, a University-Industry research, development and teaching cooperative and ACRELab.

Dr Lloyd and Mr Nigel Wilmot then led delegates around the facility.

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Dr Bob Lloyd
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Environmental Technology Centre (ETC), Murdoch University
ETC is sponsored by UNEP and is dedicated to research on the integration of technologies used in:

- climate-sensible buildings,
- renewable energy systems for power supply and water pumping,
- aquaculture systems,
- organic waste management, and
- sustainable organic agricultural methods (permaculture).

The Centre's buildings are currently being extended to create a new International Environmental Technology Centre.

Dr Martin Anda greeted delegates and gave an introductory talk on the activities of the Centre and the principles of climate sensible building design. He then led the delegates around parts of the Centre, concentrating on the new buildings. Here delegates saw:

- high thermal mass walls of rammed recycled crushed brick,
- roof integrated PV systems,
- fans for venting the hot air that gathers under these roofs to either the interior of the buildings in winter or the exterior in summer,
- different approaches to sizing and positioning windows, veranda and tree shading options for buildings facing E-W rather than N-S, and
- permaculture plots.

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Dr Martin Anda
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Friday June 29 Energy Efficient and Climate Sensible Buildings

Piney Lakes Environmental Centre

This Centre is being built for the local government authority of the City of Melville as a site for environmental education. It has been designed by a firm of Perth architects (Ecotect Architects) to demonstrate the principles of climate sensible design in a building that has a low embodied energy and is self-sufficient with regard to both energy and water.

Mike Collett of Ecotect Architects demonstrated the building to the delegates, highlighting the following features:

- rammed limestone walls for high thermal mass and low embodied energy
- recycled wooden power poles as the main structural supports for the roof
- heavily insulated ceiling/roof structures
- earth berms to increase wall insulation
- solar pergolas to maximise winter solar gain and to minimise this in summer
- fan, louvre and thermostat system to vent hot air and draw in cool air during summer nights
- the positioning of doors and windows to facilitate cross ventilation
- fixed and solar tracking PV arrays
- a mast mounted Westwind wind-turbine
- a battery pack and power management system
- solar hot water systems
- water storage tank fed from the roofs, and
- sewage treatment systems to maximise the re-use of grey and black water.

Some delegates commented on the high cost (around $A 2 million) and complexity of the building.

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Perth Zoo, South Perth

The Administration Building of the Perth Zoo is an early Ecotect design that uses passive solar design features and low energy ventilation systems to minimise energy use for cooling and heating.

After Mike Lane had welcomed delegates to Perth Zoo, he demonstrated key points of the building. While many of the passive solar design and night ventilation features were similar to those seen at Piney Lakes, this building was different in that:

- it is grid connected;

- damp cool air from an evaporative air cooling system is mixed with dry warm air from roof mounted solar air heaters to give a plentiful supply of dry moderately cool air for summer comfort;
- a standard electrically driven vapour-compression air conditioning system is available for use on the hottest summer days; and
- an electronic energy management system is used to control these systems and minimise energy usage.

Delegates were then shown around the Homestead - an education centre on climate sensible housing and sustainable gardening and agricultural practices. Some of the exhibits emphasised recycling and composting techniques.

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Centre for Renewable Energy Systems Technology Australia (CRESTA), Curtin University

CRESTA is a renewable energy research, development and teaching facility at Curtin University of Technology. Curtin University is a member of ACRE and has a strong record of work in power conditioning and diesel-hybrid stand-alone power systems.

Dr Bill Lawrance welcomed delegates and briefly outlined the activities of CRESTA and the Centre for the Management of Arid Environments (CMAE).

Ms Elizabeth Carol of the Architecture Department of Curtin then talked about the CRESTA building, which had been constructed in 1982 as a demonstration passive solar building. The Centre consisted of 3 main rooms, the central one of which had been designed to house a computer system. Today computing is distributed, the use of the building has changed, so more rooms have been created, and the original design and use philosophy have been abandoned.

A discussion ensued on how a model of building use could be maintained as the occupants changed, and why, if good design principles had been known for so long they were so little applied. Ms Carol suggested that in Perth the availability of cheap energy and the apparent lack of pollution caused by its use, were at the root of this behavour.

Dr Lawrance and Mr Hooman Debonai then gave a presentation on a grid connected PV system and Ms Sally Male presented a simple model of a solar water pumping system. Ms Male had earlier talked of her work in encouraging female students to study engineering.

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Associate Professor Bill Lawrance
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Monday July 2 — Energy Production from Biomass Waste and the Manufacture of Water Pumping Systems

W. D. Moore & Company, O'Connor
W.D. Moore was established 140 years ago (only 40 years after the foundation of Perth) and has supplied generations of farmers in Western Australia with windmills for water pumping. Today the company manufactures windmills and mechanical water pumps, solar powered submersible water pumping systems and wood fired stoves.

Geoff Moore welcomed the delegates and together with Steve Warner-Jones led the delegates around the factory. As well as seeing manufacturing equipment and the foundry (the company casts its own metal parts, recycling old brake drums), the working parts of both traditional mechanical windmills and solar pumping systems were presented. For the solar pumping systems the contrast between the complexity of larger submersible pumps and smaller positive displacement pumps (Archimedean screw), was clearly demonstrated. Delegates commented on the potential to transfer the mechanical windmill technology to developing countries and the wood burning stoves intrigued many.

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Water Corporation Sewage Treatment Plant, Woodman Point
The Water Corporation of Western Australia is the State body responsible for provision of drinking water supplies and sewage and wastewater services to population centres across Western Australia.

The Woodman Point sewage treatment facility processes sewage and wastewater from the 700,000 people living in the southern part of the Perth-Fremantle urban area. The sewage sludge is separated from wastewater and is then heated in two egg shaped digesters where anaerobic bacteria break down the volatile solids in the sludge to produce biogas and a solid residue. The temperature in the digesters is a constant 33 degrees C and the residence time is 20 days. Processing is on a continuous, not batch basis. The biogas (60 % methane, 30% carbon dioxide with around 4000ppm hydrogen sulphide) is treated to remove the hydrogen sulphide, stored in a gasholder and then burnt as fuel in two V16 internal combustion engines. These engines drive alternators that produce electricity for use on the site or for sale to Western Power, the local electricity utility. Waste heat from the engines is used to heat the digesters.

Delegates were welcomed to the plant and then Margaret Domurad, the engineer in charge of all Perth treatment plants, and Mike Pokuchinski, the plant superintendent for the Woodman Point facility, led delegates on a tour of inspection.

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Water Corporation Sewage Treatment Plant Subiaco, and Environmental Solutions International (ESI), Subiaco

This Subiaco sewage treatment facility processes sewage and wastewater from surrounding parts of the metropolitan area. Sewage is utilised in a full-scale pilot plant built by ESI for the Water Corporation, which produces oil that can be burnt in a suitable diesel engine to produce electricity. ESI is a Perth based company that develops and builds water, wastewater treatment and disposal systems designed to minimise the use of chemicals and energy, and to maximise the production of useful by-products.

Some of the sewage entering the plant is subjected to aerobic decomposition and then mixed with raw sewage. The combined sewage stream then passes through dewatering centrifuges, in which the solids content of the swage stream increases from 4% to 28% and then passes to the sludge drier. Here the sludge is mixed with pellets that have previously been through the drier and the mix is then heated and dried to form pellets with a solids content of 68%. The hot gases used in the drier come from the Hot Gas Generator (HGG).

The pellets are then pyrolised in a reactor vessel at 450°C for 40 minutes. This process drives off the volatiles and produces a coke like residue called char. The volatiles are then condensed, and fed to a second reactor with the char where they are heated to 450°C in the presence of alumino-silicate catalysts. This produces a complex mix of hydrocarbons that are then condensed and cleaned to form the oil.

Char from the reactors is fed to the HGG where it is burnt in a fluidised bed to produce hot gases for use in the sludge drier. An ash residue is left. Currently, the oil is utilised off site and it is planned to use the ash to make paving bricks.

Jane Oliver, the Water Corporation Plant Superintendent, gave an introductory talk and then Tim Casey of ESI gave a presentation on the conversion process.
Delegates were then escorted around the facility by Water Corporation and ESI staff.

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Tuesday July 3 **The Manufacture of Solar Water Heaters and Wind Turbines**

Solahart Pty Ltd, Welshpool

Solahart is an engineering company that manufactures a wide range of solar water heaters sold in Australia and internationally. Solahart water heaters have been installed in 100 countries worldwide. Both heat exchange and open circuit flat plate solar water heaters are made. In the former a heat transfer fluid circulates across the flat plate, where it is heated by the Sun. The heat from this fluid is then transferred through a heat exchanger to the water that is to be used. In the open circuit system the water itself circulates in copper tubes across the flat plate and is warmed directly. Both types of system can be boosted by the use of electricity or gas and can be used with or without a mains pressure water supply.

Solahart also produces an evacuated tube collector capable of heating water to higher temperatures than flat plate models. Solahart is also cooperating with ACRE and the Australian National University on the development of a photovoltaic concentrator system for electricity generation.

Brian Morris, Solahart's International Manager, welcomed the delegates. After watching a short CD presentation the delegates split into three groups and toured the factory and the outside test facility. Mr Morris confirmed the suggestion made earlier in the day that if the Israeli and Greek examples of mandating the fitting of solar hot water heaters to new homes were to be followed in Australia, the cost of the systems would fall significantly due to efficiencies associated with the additional production and savings in advertising spending.

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Venco-Westwind, Kelmscott

Venco -Westwind is an engineering company that manufactures the range of Westwind three bladed-wind turbines, with capacities from 2.5 to 20 kW. Westwind also manufacture standard and light wind turbines, which operate in average and low temperature environments. These rugged turbines are in use across Australia and internationally and feature directly driven sealed generators (there is no gearbox) with permanent magnets in the rotor. All models are self-furling in high winds and can be mounted on guyed towers so they can be lowered for yearly maintenance. The 3-phase electricity produced by the turbine-generator is normally rectified in a controller and used to charge a battery bank. The larger models can be grid connected and three of the 20 kW models will shortly be joined to a diesel based mini-grid at Exmouth, in the north of Western Australia.

Delegates saw the manufacture of turbine and generator components.

Venco - Westwind is working with ACRE on the development of advanced wind turbine designs and has started the construction of a 30kW model.

Geoff Hill, the co-owner of the company, greeted the delegates and gave an introductory presentation. Delegates were then shown through manufacturing facilities and the systems in the turbine and controller.

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Appendix 6
Workshop Details

Workshop Program

Day 1: 27th June 2001 Workshop Session 1 Program

Purpose: To provide delegates with the opportunity to meet one another and learn about their particular interests and what they want to get from the workshop. Delegates will interact with organisers and raise issues for consideration during the Global Seminar such as program content, how to get more information about a particular topic or administrative issues. In this session, delegates will work in small groups and report back to the whole group.

Facilitators: Dr Joy Clancy – ENERGIA
Catrina-Luz Aniere – Millenium Kids

Support staff: Workshop scribe (ACRE)
Project Development Officer (ACRE)

Tasks:

1330 – 1530hrs

1. Introduction:
   Delegates meet the facilitators.
2. Getting to know each other:
   Randomly selected groups prepare posters containing photographs of each delegate and profile information including job, organization, and personal details.
3. Poster presentations:
   Each group presents poster information.
4. What we would like to know about Australia:
   Each delegate asked to list 3 things they'd like to learn about Australia.
5. The Australian Experience:
   Facilitator answers delegates' questions about Australia.
6. Outcomes: *Workshop Report Day 1, Session 1*
   Each delegate asked to list 3 workshop expectations.

1530 to1630hrs

Identification of regional and national issues and activities: *(Workshop Report Day 1, Session 2 and (Workshop Report Day 6, Session 1)*

1630 to 1730

Development of procedures for logging key ideas or issues during the Seminar in preparation for Day 6: *(Workshop Report Day 6, Session 2)*

Day 6: 4th July 2001 Workshop Session – Developing Action Plans

Facilitator: Dr Njeri Wamukonya

Support staff: Two workshop scribes (ACRE)
Project Leader (ACRE)
Project Development Officer (ACRE)

Workshop objective: To identify activities at the national and regional level which will encourage women to effectively participate in all aspects of energy policy and planning and delivery of energy services.

Questions for panel discussion

a) Should women promote RETs? If yes why? If no why not?
b) Which RETs should women promote?
c) How can women promote the selected RETs?
d) How can women's involvement make a difference?
e) What are the barriers to promotion of RETs by women?

Working group question

What activities can be undertaken to remove the barriers to the promotion of RETs by women?

08:30	Delegates Regional Presentations
09:30	Setting the Stage – What Are the Issues?

Panel led discussion – addressing the issues
Fatma Denton
Marlene Kalmet
Frederick Spring
Bob Lloyd

1100 to 1115	Tea/Coffee
1130 to 1230	Working Groups to identify national/regional activities that address the issues. *(Workshop Report Day 6, Session 3)*
1230 to 1330	Lunch
1330 to 1500	Working groups continued
1500: 1630	Presentations by Groups with closing remarks by Levis Kavagi

Workshop Report – Day 1
Session 1

What outcomes would you like to achieve from the workshop?

INFORMATION

General

- RAPS systems
- Knowledge and skills in RETs
- Biomass
- RE project applications and real world examples
- Proven RETs
- Accessibility for rural people to RETs
- Links between RE uptake and the stopping of deforestation
- Approaches to clean versus Renewable Energies

Technologies

- Shared experiences with women delegates who have undertaken RE projects
- Understanding of how to ensure women benefit from RE projects
- Learn about RE initiatives involving women from around the world
- Identify areas in RE programs where women can participate effectively
- Collect ideas on where and how to gain funding for RE activities

Project Implementation

- Processes for improving RE project design. Results based on local experiences and how these experiences can be related to home countries.
- Information to encourage NGO's towards RE.

POLICY

How can we improve/ influence policy decision-making?
How do we include gender perspectives in energy policy?

- Identification of policy initiatives.
- Understanding of RE initiatives in Australia.
- Ability to relate RE lessons learned to regional locations.
- Strategies for co-operation regionally and globally.
- Understanding of NGO's influence in policy formulation.
- Identification of ways to participate in the decision-making process.

NETWORKING

Participation

- Participatory/ collaborative projects.
- Initiate regional activities with agenda and a time frame.
- Strategies for co-operation.
- Formation of an educational network for women in RE with a global perspective.
- Learn from the cultural/ technical issues faced in other countries.
- Strong leaders globally with a gender perspective.

- To know each other professionally and personally.

Women in RE

- Identify how to integrate women RE issues into mainstream energy agendas
- Decide if a gender perspective is appropriate in RE promotion and if so how to action this?

CAPACITY BUILDING

- Strategies for community capacity building.
- How to train women in RE issues?
- Increased awareness of RETs and their broad applications.

GENDER ISSUES

We are looking for a means to empower men and women for gender mainstreaming issues relating to energy and specifically RE.

EXPECTED OUTPUTS FROM WORKSHOP

1. Dissemination of proceedings and outcome of the workshop.
2. To improve the roles and perceptions of the roles which women do and can play in the energy sector.
3. To establish an action plan which is realistic and includes a gender perspective, which is practical for implementation.
4. Emergence of a Global Forum for further cooperation to achieve our individual, regional and global desired outcomes.

Workshop Report – Day 1
Session 2

Regional Issues

AFRICA
- Women and energy for development
- Shifting from energy for household use to energy for commercial enterprises (energy for development)
- Establish secretariat at national level
- Access to resources / modern energy
- Implementation of existing policies
- Training for implementers and end-users (women)
- Definition of appropriate technologies for development
- Raising income levels for women

LATIN AMERICA
- Education and training for small and medium size enterprises in biomass projects
- Financial support for equipment and technology (biomass)
- Training: operation, maintenance and small repairs for equipment

PACIFIC ISLANDS
- Small islands
- Need for energy dependence
- Remote locations and stand-alone energy systems
- Locations are vulnerable to climate change systems
- Role of Renewable Energy in sustainable energy supply
- Sustainable tourism, agriculture, forestry etc
- Sources of funding
- Market promotion of Renewable Energy
- Foreign investment
- Information sharing and access
- Encouragement of women in Renewable Energy programs and promotion

ASIA
- Promotion of sustainable energy technologies and know how transfer
- Ensuring transferred technology adapted to women's / local need
- Educating policy makers about the importance of energy and women's participation in energy related matters
- Promotion of rural women's participation (India, Pakistan and Indonesia)
- Spending of Multinational Development Banking and aid agencies toward promoting renewable energy projects

Workshop Report – Day 6
Session 1

Identification of regional and national activities

Addressing issues at a regional level has legitimacy and there is increasingly in international fora the tendency to take this approach, for example, around issues related to Climate Change.

This meeting is for the generation of ideas and is not part of a formal process.

Objective of Day 6

To identify activities at the national and regional level which will encourage women to participate in all aspects of energy policy and planning and delivery of energy services.

The Task

- What activities can be done at a national level to encourage women's participation in all aspects of energy policy and planning and delivery of energy services?
- What activities can be done to encourage women's participation in energy policy and planning and delivery of energy services at the regional level?
- What can be done at a regional level that can facilitate these activities at the national level?

Formulating a project activity[1]

1. What issues would you like to address and why?
2. Where is the issue located?
3. Who is involved?
4. What are the causes of this issue?
5. What do you want to achieve?
6. How are you going to achieve this?
7. What needs to be done?
8. Who needs to be involved (nationally/ regionally)?
9. What are your assumptions?
10. What financial resources are required?
11. What human resources are required?
12. How will you monitor and evaluate the project activity?

Some tips on good proposal / activity development

Steps 1 to 4 form the background and justification to what you want to do. The "why" part of question 1 is asking, "what" is your vision? For example: Empower women to promote renewables. Clarity here is important – otherwise it leads to incorrect formulation of your next steps.

[1] The Green Teams 10-point strategy developed by the Youth Board of Millennium Kids Inc. is acknowledged for inspiring the inclusion of this item.

Step 5 gives you your objectives. Keep them simple and not too many! A project / activity should not have more than 3 or 4 objectives – any more and it becomes too unwieldy and more like a program, which then needs breaking down into a number of projects/ activities.

Step 6 gives you the components to your project / activity – these should be linked to the objectives. Each objective should be achieved through one, two or possibly three components.

Steps 7 and 8 are the details of 6. The "who" in steps 3 and 8 can be different. For example, if you think the issue is poor quality solar panels then in step 3 "who" might be the user and supplier and you think the solution is the introduction of standards the "who" in step 8 might be the National Bureau of Standards as well as the user and supplier.

Step 9 is what you expect at the end of the project. An output is what you expect immediately the project/ activity has finished and which is easy to identify (eg 25 women trained in renewable energy technologies). An outcome is usually longer term and sometimes more difficult to demonstrate that it is a direct result of your activity (eg trained women reach more influential decision making positions in the energy sector).

Step 10 is important to think about. For example, you are assuming that women want to be trained.

Step 11 – these can be your greatest assets!!

Step 12 – these are often forgotten when you design the project or activity. They should be an integral part from the beginning.

Workshop Report – Day 6
Session 2

Emerging Issues

Over the duration of the workshop, delegates were asked to collate any issues that emerged from the presentations for discussion on day 6. This report contains those responses. Dr Njeri Wamukonya also asked delegates to identify barriers, which resulted in women not being engaged in the energy sector.

Day 2

- Community projects funded by donors at times create a risk of cultivating a culture of depending on aid, which at times works against the concept of community ownership and responsibility.

Day 3

- What are the challenges faced trying to bring different institutions together? (Implementing energy efficiency in communities)
- Is it possible to practice permaculture and have climate sensible building designs in the tropics and subtropics without investing so much capital? Are there alternative means of reaching the same goal at a lesser cost? (Climate sensible building design in the tropics and Subtropics)
- "Information" and "Education" are not the same thing but are often used interchangeably.

Day 4

- DC lighting products for gardens/footpaths?
- Native forests for electricity has implications for climate change effects
- Women involvement with technology applications is possible in terms of managing community electricity and influencing policy makers
- How do you define "success"?
- Beware of solar salesmen! Solar technology is not as simple as it is made out to be.
- Where does the electric light go in the house? Who decides?
- Is it my imagination or do only men advocate solar cookers?
- What is women's involvement in designing solar technologies?
- Importance of co-operation of Ministry of Finance to get funding for the Minister of Energy to develop projects
- Donor technology (imported) versus local technology (cost-maintenance/service)
- Capacity of the government to integrate projects within national energy plan
- We often talk of "distance from the grid" without looking at the capacity to supply sufficient quantities (kW) for potential demand (if connected)
- Talking about electricity: a) how much of it is used for cooking, heating, lighting? b) Are the villagers able to pay for the actual cost? (Sustainability)
- DC Lighting: Can the in-built inverters of the halogen lights be easily fixed should there be a problem? Should the whole halogen light be discarded with the inverter after no longer operating?
- Vaccine Refrigeration: Where is the closest test lab (certified by WHO) to the Southwest Pacific region? WHO requires that the PV fridge/freezer for vaccine and

the system be in compliance with the WHO standard. How much would it cost to send equipment to the closest test lab from the Southwest Pacific (specifically Vanuatu)?

Day 5

- In addition to presentations on RETs there could be presentations by gender experts.
- Need for women focused research could be an area for follow-up to this seminar, which UNEP/ ACRE can look into.
- Gender issues in energy policies should be taken with an integrated framework of social, economic and technological aspects taking into account the traditional and cultural characteristics.
- It is important to discuss how women, particularly in rural communities, can benefit from RETs.
- Women involvement in promoting RETs is to be discussed from the point of view of gender, education and training programmes.

Why are women not involved in the energy sector?

- Because energy has not been directly linked with rural development the rural community as a whole has not been involved with energy planning or technology choices.
- In rural communities cooking is a woman's job and thus the problems associated with fuel wood collection have been ignored since they do not affect men. Making a transition to modern fuels influences the budget which is handled by the man and thus women still do not participate in the transition.
- Few trained or skilled women available. Limited knowledge and capacity.
- No engineering training
- Initially the sector was technology orientated and mainly men had skills to participate. Even though there are changes towards more institutional issues, inclusion of women is limited by nature of the fact that there is a male dominance which wants to maintain the status quo.
- New area
- Few incentives (eg. policy)
- Energy is not a priority
- Cultural and traditional sensitivities. Women do not make decisions and they are also not heard.
- Women are not interested at all.
- Career choice
- Lack of awareness of the role women can play
- Had not realised that it is important
- Fear of not being acknowledged since a male dominated world
- No chance to be there

Education systems should be seen as a tool for addressing limited participation by women.

Working Group Chart

	Intervention Issues	Participation of Women	
International Trade Agreements: Donors, Export credit mechanisms, Finance Development Initiatives, Multilateral Development Bank, Government	Energy Policy Planning E Service delivery Manufacturing Education and Training Standards	Advocacy Acceptance Adoption Promotion of RETs	**Sustainable Development**
Providers: Industry			
Stakeholders: NGOs			
Other stakeholders: Communities, Universities, agents			

Appendix 7
Regional Action Plans

African Region Action Plan

Regional participants:

Fatma Denton – Senegal
Levis Kavagi – Kenya
Fatiha Lemmini – Morocco
Sabina Mensah – Ghana
Lydia Muchiri – Kenya
Tieho Theoha – South Africa
Duggan Tugume – Uganda
Njeri Wamukonya - Denmark

Barriers

Gender Perspective – 70% of the 1.3 billion people in the developing world living below poverty threshold are women

Energy Dimension – 2 billion people without access to modern forms of energy use biomass as the most common source of energy in developing countries

Other barriers include:

1. Education
2. Accessibility
3. Socio – cultural belief systems
4. Poverty
5. Policy

In response, the participants sought to:

1. develop and promote education awareness and training programs in renewable energy systems
2. provide access for women to education and renewable energy systems at the same time as men
3. undertake research to assess what affects cultural change in relation to sustainable and economic development
4. access funds to install renewable energy systems and create income generation
5. engage in capacity building and policy development.

Scope

A working group needs to be established to identify key areas of focus for participants from the region. Projects seem to need to be grouped into education and training programs, hardware installation projects and capacity building activities and policy development.

To avoid integrating this particular initiative with existing gender and energy processes and strategies MEPC will take stake in the African regional action plan and feed its share into the whole plan as a different activity to the SAGEN/ENERGIA initiative.

Education programs for remote communities will require use of mobile audiovisuals, technical demonstrations and provision of more radios to remote communities which will involve an audit of transmission signals in remote areas and identification of a renewable power source. Renewable energy programs need to be piloted which will require training for whole families, villages and training of trainers. Workshops are needed to enhance women's understanding of RETs.

Technology transfer issues will include the need for an awareness campaign on renewable energy systems, creation of a desire for renewables, product trials and follow-up action within communities.

Communities cannot afford capital costs and overcoming poverty will involve identification of financing mechanisms, funding, effective subsidies and revolving funds. Communities will still need to contribute to projects financially so they can have some ownership. Policy makers will need to allocate set budgets for RETs and gender sensitive programs.

Capacity building will involve advocating funding for RETs projects and training, lobbying to improve services (energy and water), gender sensitive training for policy makers, technical training, and needs assessment surveys.

The working group needs to encourage more interactions between NGOs and governments to work towards coordinated and effective policies. Governments need to allocate budgets for RETs and gender sensitive programs and there needs to be a mechanism to facilitate entry and encourage women to apply for positions within high powered ministries of decision making

Implementation Steps

Each country to develop case studies: a scoping exercise identifying what has been happening with respect to the promotion of renewable energy technologies, assessment of successes and failures, identification of ways of cleaning up the mistakes and measuring how the concept of renewable energy has been beneficial to women.

Each country to work out strategies for women to 'use' versus 'promote' renewable energy technologies, having identified which technologies are appropriate for which region for what specific purposes.

Elect a coordinator/contact point/ organization which countries will report to and which is not MEPC, ENDA or ITDG because of the coordination of other regional initiatives.

Develop country case studies with specific terms of reference. These case studies could then be analysed, to identify areas of commonalities and differences and how to influence

Asian Region Action Plan

Regional participants:

Yanee Chantajitra – Thailand
Akanksha Chaurey – India
Ophelia Cowell – Indonesia
Angelina Galang – Phillipines
Qiying Hu – China
Mayurapan Sajjakulnukit – Thailand
Tahira Syed – Pakistan
Ris Wahyuti Soemardi Indonesia
Sarantuyaa Zandaryaa - Mongolia

Barriers

Women in both rural and urban areas have a role to play in making a transition to modern fuels or new energy technologies. Hence, the challenge is how to involve them in the use and uptake of renewable energy technologies and services.

In response, the participants sought to:

- develop a network or forum where workshop participant countries share learning about interventions related to the uptake of renewable energy amongst women in their respective countries
- engage in a common activity and formally report outcomes based on the situation in each country and respective policy/strategy agendas
- develop a common resource base for the region with information on women and renewable energy technologies in participating countries
- use resource material as a tool to inform and influence policy decisions within participating countries
- undertake initiatives that lead to networking and lobbying at the regional level
- contribute to the future alleviation of poverty in the home country.

Scope

A regional report on the present situation of women in renewable energy technologies will be developed to establish a baseline of information on present status, and ongoing and potential work in the participating countries. A voluntary Working Group will be formed to develop this report. The group will also lead to the establishment of a formal network on women's role in the use and uptake of renewable energy in the region. The Working Group will be a voluntary initiative by the participating countries in the Global Seminar and will be formalised by a written invitation to participants' organizations by UNEP.

The initial working group would consist of a core group of those people / organizations / governments who participated in the UNEP/ACRE Global seminar who could commit to it. The working group can define the boundaries of the region and could grow over time as deemed necessary. A coordinator/leader would be appointed from within the group on a rotational basis. In addition, each participating country will have the country coordinator (person who attended the Global Seminar).

The working Group will engage in a common activity and formally report outcomes based on each country's agenda through development of a regional report.

The report is to be a baseline on the participation of women in the use and uptake of renewable energy at all levels in the countries in the Asian region and would contain case studies of interventions.

It is intended that the report will be presented at the World Summit in 2002 to give it authority and profile for influencing policy and decision makers in the respective countries.

The report would not only be an end in itself but would also:

- be the next step to funding and implementation
- highlight areas and projects in the region for funding, especially for women, and
- lead to individual proposals for funding and projects

Target Audience

- Policy makers and implementers, NGO's, academia and civil society
- Individuals and organizations and funding bodies who can influence policy, people planning and the implementing of projects
- Working Group participants who will use and share the resource and experiences embodied by the report and the network.

Objectives

To assess the role of women in the uptake of renewable energy technologies in the individual countries and to:

1) produce resource material that will be useful for policy, planning, service provision and manufacturing
2) formulate policy recommendations at the national level for industry, government and other stakeholders, and
3) identify gaps and make recommendations where specific interventions are required at the national and international level.

Implementation Steps

Step 1. Select a coordinator/writer of concept paper
Step 2. Send draft of concept paper to all representative
Step 3. Submit concept paper to UNEP
Step 4. Work with UNEP to fund and implement working group and report

The concept paper should contain the background (as arrived at in the Global Seminar and this workshop session) what they seek to achieve, and how.

Timeline

Final report document should be printed one year from now, in time for the 2002 World Summit.

Outline of final report

1) Secondary data on the 4 levels/sectors consisting of policy, planning, service delivery and manufacturing
2) Empirical research: surveys and consultations with stakeholders
3) Case studies.

Content of report

Qualitative and quantitative information, analysis and identification of the status and gaps, in the role of women in the uptake of renewable energy technologies in the region represented by the members of this group in the context of the following:

1) Policy
2) Planning
3) Energy service delivery
4) Manufacturing
5) Education and training needs

Funding

Total duration of the project is 9 -10 months with the following budget lines.

1) One Regional Coordinator and one National Coordinator in each country

$US5000 per month for 6 months intensive
= $US30,000 x7
= $US210,000

2) Research operations and supplies
$US4000 x 7
= $US28,000

3) One meeting face-to-face to finalise the report.
= $US20,000

Total $US250,000 to $US300,000

Latin American Region Action Plan

Regional participants:

Irene Canas Diaz - Costa Rica
Lenia Ribeiro de Souza Vieira – Brazil

Barriers

- Lack of education
- Lack of policies
- High introduction costs of technologies
  - PV
  - Biomass

In response participants sought to:

1. develop contact with regional UNEP/ UNDP offices
2. open government doors through the legitimising of delegates positions
3. establish what resources are available from NGO's and existing organisations e.g. Pan American Health Organization/World Health Organization (PAHO) – Division of Health and Environment / Washington, DC.
4. create a support network through encouraging each of the Latin American Countries to nominate a representative for a collaborative forum on the further development of a regional program
5. identify areas of financial support

Scope

Work towards education and training program in RETs for the region which is:

- Formal (elementary schools, high schools and universities)
- Informal (NGO's, Industry and SMEs enterprises)

Target Audience

- National and local governments
- National and local education institutions and universities
- Industry
- International funding bodies

General Objective

- Provide education and training programs

Specific Objectives

- Promote the use of biomass plant residues of sugarcane bagasse in sugar and alcohol plants, and coffee mills.(waste-to-energy projects)
- Develop training and educational sustainable models on RETs to attend Latin American: cities, city halls, and community associations
- Train local agents in operating, maintenance and small repairs in renewable energy systems

Funding

1) Education programs
2) Face to face meetings
3) Folders, books, video tapes, CDs, etc to be used in specifics training programs

Pacific Island Region Action Plan

Regional participants: Marlene Kalmet – Vanuatu
Sili'a Kilepoa – Ualesi – Samoa
Tea Kovacevic – Croatia
Anare Matakaviti – Fiji
Makereta Sauturaga – Fiji
'Apisake Soakai – Tonga

Barriers

1. Policy and planning

- lack of regional capacity to plan and national/regional energy policy
- lack of strategy for integrating energy and economic development (Croatia)
- low priority within government (energy)
- limited involvement by community in policy formulation and energy planning
- no equal opportunity policy

2. Capacity building

- limited resources
- size of market – too big or too small
- limited education and skills

3. Technology development

- donors / investors dictate technology
- appropriateness of technology
- no local industry to provide support
- high risk area that does not attract private investment
- small industry

4. Project development and implementation

Donors / investors:

- drive own marketing strategy
- appoint aid project team
- transfer own nation's technology and knowledge.

Vision

Women in the Pacific region will participate actively in the sustainable management of the limited energy resources in the region.

Scope (Priority programs)

Participants identified the following programs, which are listed below in priority order:

1. Networking and Awareness Raising

Convening a Pacific Regional Conference on Women in Renewable Energy (PRCWRE) which is not limited to renewable energy. The aim of the Conference will be to raise awareness amongst women in the Pacific of the importance/ relevance of energy in their social and economic enrichment. The Conference program will *promote women at the production and distribution end of the energy chain as well as include traditional information focused on the end use of energy.*

It is intended that the outcome of the PRCWRE will be the establishment of a regional network titled Women in Renewable Energy Development (Women in RED)

Target audience

- Professional women
- International/regional/national organizations such as UNEP, SOPAC, SPC, AusAID
- Women NGO's (ENERGIA etc)

2. User Evaluation / Monitoring and Maintenance

Undertake a Pacific Regional Energy Assessment as an awareness exercise on the end use pattern of energy and energy supply and demand situations in Pacific countries.

3. Policy Reviews and Energy Planning

Review existing policies to reflect women's role in regional/national energy initiatives, in terms of community involvement and priority etc. Draft a regional/ national plan to account for recruiting, training, and promoting women's participation.

4. Capacity building

Increase the number of women involved in energy activities and enhance their roles in energy planning, projects, and technology application. This may be achieved through training (formal/ informal) and increase appropriate resources.

Target audience

- academic and formal training institutions
- Donor communities

5. Technology application

Ensure that technology application (i) enhances women's role in the community (ii) is manageable to women.

Target audience

- Manufacturers, suppliers & distributors
- Trainers
- Funding agencies

6. Project development and implementation

Develop projects that provide opportunities for women to participate and ensure they are involved throughout the process.

Target audience

- Communities
- NGO's
- Funding agencies
- National governments
- Business community

Actions

1. **Policy and planning**

Role of women

Encouraging the involvement of women at all levels by:

- Advocating governments to include energy education in policy
- Encouraging education institutions and universities to encourage women through Women's scholarships
- Capacity building for women through Women facilitators; identification of Women role models in business, mentoring programs and government support schemes.

2. Capacity building

Education and training

Identifying funding to provide community awareness and education programs in renewable energy technologies that encourage information sharing and encompass social/ cultural influences among participants. This will include:

1. Creating awareness among:
   - communities
   - policy makers
   - service providers
   - rural and regional areas.

2. Training the local community to continue user evaluations and undertake monitoring and maintenance of projects after international teams go home which will involve:
   - training local designers
   - conducting long term user evaluations
   - establishing local monitoring and maintenance services, and
   - training local project managers.

3. Technology development

- identify and establish standards
- promote appropriate technology application

4. Project design and implementation

Ensure financial sustainability by:

- Identifying income generating projects as well as projects that provide social or remote access solutions
- Establishing income generating projects for women initiated by government, businesses or the community.

Implementation Steps

Step 1. Establish a working committee to coordinate projects for women and energy

Step 2. Working committee coordinate with Donors for regional/national projects funding assistance with donors

Step 3. Working Committee regularly monitors & evaluates initiatives

Step 4. Report to member countries and donors.

Timeline **2001 – 2004**

Funding

To be determined upon consultation with multinational and international funding agencies.

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Edited By
Katrina Lyon & Philip Jennings

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UNEP

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Australian CRC for Renewable Energy Ltd

DISCLAIMER
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Overview and Scene Setting

Energy(,) Poverty and Gender

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ABSTRACT

This paper explores the energy-poverty-gender nexus. In particular it looks at how women are affected by the poor quality fuels that they have to collect and use. Approaches to delivering better quality energy services to households and micro-enterprises are discussed and the active role that women can play in breaking free from the poverty trap.

INTRODUCTION

Energy is a basic input into all human activities. At the most simplistic level: without energy from food we would die! Producing food requires energy inputs to prepare the land, for harvesting the crops, transporting, processing and cooking the food. The more complex the activities become, the more complex the energy inputs. In the South, the energy input, at least for poor people, is in the form of human and animal energy, whereas in the North fossil fuels are the main input. One major difference between energy use in the North and South is that, in the North, energy reduces physical effort and drudgery. One of the reasons behind this difference is that poor people do not have the money to buy improved energy services to make their lives better. The first part of the paper, explores the implications of being poor on the type of energy used and, in particular, the gender dimensions of energy and poverty. The second part of the paper, examines the assumption that if income generation is the answer to poverty, then what do women want to enable them to generate income, and what is the role of energy in this process?

ENERGY (AND) POVERTY

Poverty is regarded as one of the world's most fundamental issues, which needs to be addressed through development. *Poverty* is conceptualised in material terms as not having access to adequate levels of food, water, clothing, shelter, sanitation, health care and education. This can be translated into people having insufficient income to pay for these goods and services. Estimates of the number of people living in poverty[1] put the figure at around 1.3 billion in 1993. However, poverty can be conceptualised in much broader terms, not only in relation to the level of basic needs listed earlier but also in terms of a more general sense of well-being. "Well-being" is more difficult to define and measure, particularly because it contains a subjective element. However, many people living in poverty are often not treated with respect and dignity by other members of society, and they often lack a personal sense of worth. I would argue that true development has to address both faces of poverty.

Energy is one of the most essential inputs into sustaining people's livelihoods, at the most basic level it provides cooked food, boiled water and warmth. Lack of access to clean and affordable energy is considered a core dimension of poverty. It has been well known for a long time that poor people tend to use biomass as their energy carrier. In many areas there are increasing biomass supply shortages, which adds to women's burden whose responsibility it is to collect fuel. However, despite the fact that around 2 billion people use biomass fuels, there has been little attempt to analyse the energy-*poverty* nexus in depth. Partly this can be explained by the fact that the biomass[2] in rural areas is collected at zero monetary cost mainly by women and children, and so it falls outside of national energy accounts. As a consequence decision makers are not aware of the full significance of biomass energy and policies and strategies fail to address fully the issues.

The use of biomass by poor people has a number of repercussions. The fuel quality is low, combusting with quantities of smoke and particulates that are recognised as having negative effects on health. Several hours a day spent in collecting fuel means that this time cannot be used for other livelihood activities. Although nearly every household in rural areas will use some biomass as an energy carrier, poor households will spend more time searching than households in higher income groups. Wealthier households can also afford to purchase other higher quality fuels, which will be used for a greater variety of end-uses than in poor households. In urban areas, poor people have to purchase cooking fuel, and they spend a larger share of their income than higher income households on fuels. In rural areas, poor households will generally only purchase fuel to provide lighting (candles and kerosene).

Poor households use less energy per household than wealthier ones. This means that less water is boiled for drinking and hygiene purposes. This increases the likelihood of water borne diseases, which in turn reduces the ability of poor people to improve their livelihoods, not only preventing adults from working effectively but also negatively effecting children's learning.

Wealthier people are able to exercise some choice in their energy carrier and many opt for the cleaner and more efficient "modern" energy carriers of electricity or gas (LPG or biogas[3]). These modern energy carriers do not have the associated negative health and time effects linked to biomass. Wealthier people are also able to afford the appliances that make use of these modern energy carriers. In cases where they are reliant on biomass fuels, they are also able to purchase more fuel-efficient stoves. Poor people adopt higher discount rates when deciding on energy services, opting for lower first cost options, rather than those that are based on life-cycle costs[4]. The consequences for the poor are that precious cash resources are used on low quality fuels, which are then used at low efficiency and this reduces their ability to accumulate the financial resources they need to invest in strategies for improving their livelihoods.

ENERGY POVERTY AND GENDER

Gender can be defined as the socially determined roles undertaken by men and women. The energy-poverty nexus outlined above has distinct gender characteristics. Of the approximately 1.3 billion people living in poverty, it is estimated that 70% are women, many of whom live in female-headed households in rural areas. It is important to take note of this fact, not only because men and women have different energy needs and may have different ideas about sustainable livelihoods, but also because women and men have different access to resources and decision making. Women's access to decision-making within the household and community is restricted, reducing their ability to influence processes and resource allocation.

In households where there are adult men and women, the gendered division of labour generally allocates to women the responsibility for household energy provision related to their spheres of influence in the household, in particular activities centred around the kitchen. However, when energy has to be purchased, men enter the decision making process, for example, in the purchase of batteries for radios.

In poor households, women carry a physical and metaphorical burden in household energy provision. In rural areas, it can mean spending several hours a day collecting fuelwood loads of 20kg or more. In urban areas, it can mean juggling with tight household incomes to buy charcoal or kerosene. Many of these tasks are demanding on both human energy and time and they affect disproportionately women's health. For example, the higher levels of lung and eye diseases due to the longer hours of exposure to smoke and particulates in smoky kitchens experienced by women compared to men. Fuel collection also reduces the time women have available for contributing to other aspects of livelihood strategies. For example, up to six hours a day can be spent on fuel collection.

The full consequences of women continuing to rely on their own energy inputs and biomass fuels are not known. While there is some excellent research being carried out, much with the support of the World Health Organisation, into the effect of smoky kitchens on women's and children's health (see for example, Smith (1999)), other health linkages are not so well researched. For example, although it is frequently stated that the amount of time women spend in collecting fuel and carrying heavy loads, the damage these loads cause to women's spines is not documented. Energy interventions are available which could do much to reduce the drudgery involved in these daily household activities. For example, the preparation of many staple root crops takes an hour of vigorous pounding, which could be simply substituted by milling.

The whole issue of women's time and effort saving (reduction of drudgery) seems not to receive the attention it deserves. This might be attributed to the fact that decision makers and planners are not fully aware of the situation of women's physical labour. Women's survival tasks, based on their own metabolic energy inputs, are invisible in energy statistics (Cecelski, 1999)[5]. As a consequence, the development of labour saving devices seems not to be high on the agenda.

The question is: how to move forward? A number of things need to happen. Firstly, women have to be empowered to make choices about energy. This is linked to issues around sustainable livelihoods and poverty alleviation, including having access to income generating activities. However, it is more than financial improvements since women should be able to act upon energy choices open to them and this is linked to decision-making within households. This requires social and political changes.

Secondly, the types of energy that women would like to use need to be made available at affordable prices as well as the equipment that uses modern energy forms and reduces the drudgery of much of their labour.

Energy for households

If we look at the current trend with energy policies and planning, the focus is very much on electricity. What are the implications for women? Although this energy form has many benefits, it does not help address the major energy problem most women in rural areas face, meeting their daily cooking needs. Cooking with electricity is not cheap in terms of both energy costs and the stove. Also stand-alone photovoltaic home systems are not capable of delivering sufficient power to cook family meals. Solar cookers seem to be undergoing a period of renewed interest with donors[6] but their long-term popularity with cooks has to be evaluated. A serious objection to solar cookers, which has to be overcome, is that cooking at midday does not coincide in many cultures with the time of eating the main family meal[7]. (Mandhlazi, 1999)

If we look at the market in the energy sector the emphasis is on deregulation and opening it up to outside investment. Do these changes benefit women? The major changes have been most noticeable in the electricity supply industry. However, as has already been pointed out above, this is only an energy option for wealthy households and for most women it is not an option for cooking (and also in some places space heating). Petroleum supply is in both public and private ownership, although generally governments still control kerosene prices. Women are able to buy this lighting fuel in small quantities, to match their cash flows, at reasonable prices. There have been reductions in subsidies on transport fuels, which has increased the cost of getting to work for women in urban areas and pushed up prices in general. The supply of traditional fuels such as wood (in rural areas and urban areas of Latin America) and charcoal (in urban areas of Africa and Asia) for the local market is at present not of interest to companies involved in international markets. Rural fuels are still gathered informally at no direct monetary cost[8] and local suppliers control urban markets. In the commercial woodfuel sector women's role and benefits are variable. For example, in West Africa they play a key role and can earn good incomes, while in sub-Saharan Africa they play only a small role in charcoal production but carry the burden of environmental damage caused by unregulated charcoal making. However, what do women, as end-users, want in terms of their fuel type and its acquisition? Do women want to continue to use wood/charcoal, only with more efficient stoves, because it fits with their traditions? Or would they prefer to use gas (biogas or LPG) or electricity because they value the convenience? Would rural women pay for wood (good quality, regular supply, in quantities that matched cash flow) if it relieved them of the burden of collection and freed them to participate in income generation, community activities, or to devote more time to their families? The answers to these types of questions are important for the formulation of energy policy.

Energy for micro-enterprises

Women already have income generating activities. In most countries, the majority of small and medium scale enterprises are owned and operated by women, with women making up the largest proportion of the work force. The enterprises tend to concentrate on a relatively narrow range of activities (beer brewing, knitting, dress making, crocheting, cane work and retail trading) with disproportionately low rates of return, compared to typical make employment. Despite the low financial returns, women's enterprises provide critical sources of household income, even in male-headed households. Women-headed enterprises tend to work from home. This can result in them being overlooked by agencies since they are in the informal sector which is diffuse and difficult to reach and regulate.

The role of energy in the sustainability of women's enterprises is not well understood. However, in food processing it has been estimated that energy costs are 20 to 25% of the total inputs, which would indicate that technological interventions might be possible. The types of enterprises women are traditionally involved in are energy intensive and rely on biomass fuels. Even in rural areas women may have to buy fuelwood to run their enterprises. An important question is: what mechanisms can assist women in gaining access to improved energy services? Despite efforts in the past to develop equipment (eg grain mills) to improve product quality as well as reducing human energy input, these have had limited impact. If these extra tasks are to be taken up without simultaneously reducing the labour in other household tasks then no mater how beneficial the technology it is likely to have low acceptance. Also if women do not control decision making on household purchases or have access to credit, there will be limited take up. However, women do take up technologies which can increase their incomes. For example, women's groups in Ghana use LPG for fish preservation which gives them a better quality product than when using wood and enable them to reache export standards, considerably improving their income (Mensah, 2001). Another example is the Multi-Functional Platform (Burn and Coche, 2001). The platform consists of a diesel engine mounted on a chassis to which a variety of end-use equipment can be attached, for example, grain mills, battery chargers, oil presses, welding machines and carpentry tools. In addition the engine can be used to generate electricity which opens up the prospect of women becoming energy entrepreneurs setting up their own energy service companies. Women are ideal candidates to do the job, as has been argued by Batliwala and Reddy (1996). Women who live in rural areas know and understand local circumstances and needs. A woman maybe able to sell more effectively to other women, and access to female clients is not hindered by social constraints.

However, the extent to which electricity can contribute significantly to poverty alleviation is still not clear. Many women's income generating activities are based around process heat, for which electricity is not the cheapest option. Electricity in rural areas is mainly used for lighting, which can extend evening working hours. More research needs to be done into what use is actually made of the lighting and electricity. Does access to electricity add to the burden of a woman's working day? An interesting study in Namibia showed that women did stay up later than men, not working but socialising (Wamukonya and Davis, 1999).

Although there is attention paid to women, energy and poverty in rural areas, is this the same for the urban poor? Renewable energy systems are generally not a viable option for urban women who are more dependent on commercial energy than their rural counterparts. They also pay a high price for their fuels. Barnes (1995) has shown that the poorest 20% of households spend a higher proportion of their incomes for fuels than wealthier households. Different mechanisms are required in urban areas to those in rural areas since the fuel markets are monetarised. Since cash incomes are low and not always reliable innovative credit schemes are needed which allow access to electricity and LPG (both the service and the appliances).

Income generation and poverty alleviation

Certainly providing women with access to cash resources can be viewed positively if it allows them to determine their own priorities and make choices about the energy forms for particular end-uses. When asked about priorities, women generally set a high priority on being able to earn some cash income. However, what is not clear is if the levels of income envisaged by those proposing income generating projects are the same as those of the women who are expected to undertake them. Women, particularly those in rural areas, undertake income generating activities simultaneously, and often strongly linked, with household and agricultural duties. These may be seasonal activities based on household tasks, such as food preparation and basket making, and they tend to be small-scale, labour intensive and predominantly in the informal sector. Women in male headed households may not wish to increase their workload by becoming full scale entrepreneurs[9], which can lead to project "failure" (if measured in terms of total numbers of take up). There are undoubtedly a significant number of female-headed households who would welcome the opportunity to earn levels of income that would move them out of poverty. However, this level of entrepreneurial activity needs more than a good idea to succeed. The energy inputs are often overlooked even though the availability of affordable sources is an important ingredient. A market for products and their transport (also with an energy component) are important aspects that may be overlooked. Women themselves are aware of these barriers and may be reluctant to take up proposals to expand their businesses. Income generation needs a basket of entrepreneurial skills and assistance with gaining access to markets. Lack of consultation with women about their needs leads to low levels of participation in projects, especially if they feel that they do not have the required skills or inputs.

Access to micro-credit

Starting up a business or expanding/modernising an old one needs capital. For women, there are additional problems of access to capital not faced by men. Families are often the source of the type of capital needed for business ventures. There maybe cultural barriers which deny women access to this source of family funds. The lack of women's property rights prevents loans from the commercial banks. Informal micro-credit systems lend only small amounts, certainly insufficient to fund purchasing equipment, of the type needed for setting up a solar home system supply and maintenance business. There have been a number of projects to set up micro-credit banks which attempt to emulate these informal systems and provide women with access to funding that they would otherwise be denied from the commercial banks. Women have been lauded for their excellent repayment record, for example, figures from the Grameen Bank show that women, who make up 94% of the Bank's borrowers, have a 98% repayment record.

However, it might be a good point to pause and ask at what personal cost? If the money is used only for consumptive purposes, and there is only a fixed sum coming into the household, something has to be given up to enable the loan to be repaid. The fear is that this might be at a significant personal sacrifice by the woman, for example, lower food intake or increased domestic violence due to non-purchase of particular products.

On the surface at least, micro-credit systems do appear to be welcomed by women. However, another relevant question is, do they really provide sufficient levels of funding to move women out of poverty? Do they enable women to develop as entrepreneurs? In general, project-based micro-credit systems lend small amounts over short terms. Therefore, they would probably be unable to assist women in, for example, becoming energy entrepreneurs or purchasing renewable energy systems or appropriate appliances for their home or enterprise. This would need different levels of finance. There are moves to ensure access to these levels of finance for solar PV home lighting systems and solar lamps (for example, the ESMAP supported project in Bangladesh (Khan, 2001)). There is a need therefore to extend women's access to the levels of financing which will allow them to choose the energy systems that they consider appropriate.

CONCLUSIONS

Poor people's lack of options over energy forms lead them to rely on poor quality fuels. In part this is due to insufficient income to buy more efficient conversion equipment and modern fuels. Women are particularly affected by this energy poverty. Their health suffers and they work long hours daily both in providing energy for their household and in compensating for their lack of access to drudgery reducing technologies. Women could break out of this vicious cycle if they are given the opportunity, for example through the provision of affordable technologies which reduce their time and physical effort in routine household chores such as biomass and water collection and food preparation. There is concern that current developments in the energy sector are neglecting this important development dimension. There is a tendency to focus on electricity supply which is not the least cost option for cooking. Women have the opportunity to make their own contribution to breaking the energy poverty barrier through income generation projects, including establishing energy services companies. However, they need a number of institutional constraints removing before these activities can take off. On the other hand, women often have good reasons not to become full-time entrepreneurs and so other ways of reducing poverty have to also be considered.

ENDNOTES

1 Poverty here is defined in economic terms of consumption of goods and services. People were considered to be living in poverty if they consumed less than US$1/day of goods and services. (UNDP, 2000)

2 Biomass is any organic material of plant or animal origin and includes wood, agricultural residues and dung.

3 Biogas is a combustible gas formed by the natural process of anaerobic digestion, in which micro-organisms convert organic material into a gas with a composition similar to natural gas.

4 Energy services which have low costs per unit of received energy on a life cycle costs basis may have high investment costs.

5 This also means that the energy inputs (with a large biomass contribution) are also missing from the national energy statistics.

6 For example, Solar Cooking workshop organised in 1999 under the auspices of UNESCO and the European Union.

7 Despite the enthusiasm in some circles for solar cookers, there is little evidence of wide spread commercial uptake of the technology. It seems to be a niche technology, for example, in refugee camps. There are impressive figures for the number in use in China. However, closer inspection reveals that these are mainly used for boiling water for tea making.

8 There is of course an opportunity cost.

9 There is interesting work by Jackson (1999) in the water sector which shows that some women deliberately adopt a non-participation strategy in projects to avoid increasing their work loads.

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Appendix 1
List of Participants

Renewable Energy Beyond the Village

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ABSTRACT

Historically the implementation of rural electrification systems has required financial subsidies from utility groups and government agencies. Renewable energy systems, over the last two decades, have typically been demonstrated on larger, higher profile project models, which are not yet commercialised on a high volume basis. This paper outlines an approach for rural electrification success on a higher volume basis, oriented particularly towards delivering the needs of the end consumer. Such an approach is primarily constrained within the consumer's actual financial capacity. The four guiding principles for success are that:

a) the needs of all stakeholders are met
b) the systems are least-cost from the cradle to the grave
c) O&M services are built in
d) local commercial activity is incorporated in the project

This paper reports on actual projects undertaken in various countries over the last decade.

INTRODUCTION

For several decades the use of rural renewable power systems has been promoted through demonstration projects and the investment of many millions of dollars. Yet today it is difficult to find many examples of *successful* rural electrification projects. Most of the existing utility based rural programs as implemented over the last 70 years may also be seen as a failure to the extent that they are loss making for the utility and hence require a financial cross subsidy from the broader community.

So what has been going wrong in this business for so long and more particularly in the recent application of renewable energy technology? For a start the consumer is often accused of expecting too much for too little. Suppliers of equipment are suspected of pushing immature products into the field and then not backing them up professionally. The owner and planner are blamed for focusing on cost, not value; on capacity, not services; and generally ignoring the requirements for *sustainability*. The financier is considered to be intransigent and demanding of excessive terms with little or no risk.

Unless this cycle is broken the future of large scale rural electrification using renewable energy is problematic at best. Millions of people, therefore, living away from electrified urban centres will remain cut off from opportunities to improve the quality of their lives through electricity generated primarily from their own local energy resources such as sun, wind, water and biomass.

The solution lies in a proper understanding of the key elements of any business and in this case *successful* rural or remote area electrification projects. When the focus and criteria for success are singularly placed on technology, or first costs, or economic rates of returns, then projects typically have failed. When the focus is placed on meeting the totality of consumer *needs*, of real cost of services, of cost recovery and sustainability, then there is a very high chance that projects will succeed.

With over 10 years of designing, supplying and maintaining renewable energy-based rural power projects on small remote islands, mountains, jungles and desert plateaux, we at Advanced Energy Systems Ltd have found that there are generally four key characteristics of *successful* projects, as detailed below.

CHARACTERISTICS OF SUCCESSFUL PROJECTS

Requirement One: The Project Meets the Needs of All Stakeholders

Firstly, the short and long term requirements of all stakeholders (consumers, owners, planners, financiers and suppliers) are defined, understood and accommodated from the start. Success and *sustainability* are designed in at the start - not added on at the end. Successful projects must have a built-in process of analysis, dialogue, learning and compromise as well as mechanisms for recourse.

We are currently implementing a rural electrification project for villages in Eastern Indonesia. A key aspect of developing a sustainable project has been to address the needs of the villagers and the capability of the project to be financial sustainable. The following points have been addressed as part of the project development:

a) The electricity will contribute to non farm income growth and specifically to fishing, crafts and tourism. Particularly significant will be the implications for the village recipients in terms of training and skill development in both commercial and technical areas.

b) A major benefit will accrue in terms of health and education development in the villages. Schools will be able to use better equipment and health clinics will have access to refrigeration. Households with electric lighting offer a far superior home environment.

c) Major beneficiaries at the village level will be women and children who will not be required to purchase lighting batteries or kerosene.

d) Renewable hybrid technology is a vastly better option for power generation in small to medium term applications. It demonstrates a real and sustainable application of technologies that can abate greenhouse gas emissions from power generation and reduce local pollution including noise, fumes and oil/fuel spillages.

e) The provision of electricity for recreational purposes could have a significant benefit in rural villages. The electricity can be used for television, radio, stereo systems and communications technology. This will have a benefit for young people and assist in retaining them in the family/village environment.

Requirement Two: Power System is Least-Cost and Financially Sustainable

Secondly, the choice of power generation technology and delivery infrastructure must be the best mix of least-cost, preferred and sustainable as determined by the owner and consumer. The least-cost alternative has the lowest overall life cycle cost to the owner. The preferred choice of system will best meet the operational, service, financial, economic, developmental and political requirements of all stakeholders. The sustainable choice will deliver the planned level of service to consumers with a minimum need for external services or capital.

When the power system is least-cost, preferred and sustainable, it best meets the needs of all stakeholders over the life of the project. These needs will typically include the following:

- Type of electricity (DC, AC, single or three phase)
- Minimum level of service in daily kilowatt-hours and peak watts
- Cost of service commensurate with the value of the benefits
- Acceptable performance of the power systems in terms of reliability, availability, maintainability, economy and environmental impact
- Acceptable economic and financial rates of returns
- Acceleration and achievement of technology transfer, commercialisation and employment creation
- Substitution of fossil fuels with renewable energy and reduction of inbuilt subsidies

Placing inordinate importance on only one or a very limited number of needs or conditions for acceptability such as capital costs, economic rates of return or technology virtually guarantees that the project will fail. For instance, the old paradigm that one technology (such as diesel generation) fits all is no longer sustainable.

Requirement Three: O&M Services are Funded and Tied to Performance
Thirdly, competent operation and maintenance services on a local basis are included in the project design and budget and are tied to specific performance standards of electricity service delivered to each consumer. All successful projects will always provide for a *local O&M infrastructure* where the provider of the O&M services has a close economic link to the consumer and/or owner. Successful projects also require that suppliers are accountable for meeting the performance and operational standards of their power systems, while owners are required by financing institutions to see that the investments are maintained and operated at peak efficiency. Projects without a locally supplied, adequately funded and sustained program for operation, maintenance and repair services *will* fail.

Requirement Four: The Project Creates Commercial Opportunities
Fourthly, the project is part of and supports the creation of expanding near-term commercial opportunities for suppliers. Projects that offer suppliers clear opportunities to expand their business (through successful products and services) attract the best suppliers and have a strong inherent driver for success. Once under an appropriate contract and with the prospect of expanding business opportunities, suppliers will do whatever it takes to ensure that their products work reliably and keep customers and consumers satisfied. Where the supplier sees no future benefit or has no commercial risk, then at best only the strength of the contract will determine the performance of the project.

DESIGNING SUCCESSFUL PROJECTS

Successful projects should be designed, implemented and evaluated on the same basis as all commercial enterprises; ie, the degree to which they provide consumers and owners with services and outcomes that meet their requirements. To achieve this objective the following steps are necessary:

Define Key Requirements, Objectives and Roles of All Stakeholders
All stakeholders have distinct and, in many cases, conflicting priorities and understandings that must be defined and resolved before the project is implemented. Clearly all of the stakeholders must win from the project in order that sustainability be achieved. For example, incorrect assumptions about what level of electricity services consumers actually need and are willing and

able to pay for, or the requirements for and costs of O&M services, or economic rates of return, or cost recovery estimates, can easily produce wrong investment decisions regarding power generation technology and delivery models.

Bringing suppliers and operators into the project design process and providing commercial opportunities for success or penalties for failure will add much needed realism and efficiencies in renewable energy-based rural electrification projects.

Define Requirements for Sustainability

Even poorly conceived projects can be made 'sustainable' for a given period of time with enough inputs of money and effort. Clearly the objective must be to create projects with up-front success that are not only sustainable but can be replicable with flexibility in the future. With these constraints in mind the relatively narrow focus and particular priorities of each stakeholder must be accommodated in the following four categories. These categories ultimately determine a rural electrification project's potential for sustainability using renewable energy:

a) Technical/Operational Sustainability
- Reliable components and systems
- Sound design of system configuration
- Warranties and performance guarantees
- Local capability O&M services
- Long intervals (months) between service visits
- O&M services linked to consumer satisfaction

b) Economic and Financial Sustainability
- Least-cost preferred power systems
- Flexible pricing policy for electricity services
- Service that matches consumer ability to pay
- Integral revenue collection and control system

c) Social/Institutional Sustainability
- Equity participation by stakeholders
- Financial support of O&M by consumers
- Training of consumers in electricity use and safety
- High level of safety precautions
- Cultural acceptance by end user

d) Environmental Sustainability
- Minimal use of diesel fuel
- No ecological impacts (installation and operation)
- Removal/recycling of batteries, lubricants
- Supplier requirement for environmental protection
- Determining of consumer & community needs

The success and cost of a rural power project, to a very large extent, are governed by the requirements for power (kW) and energy (kWh) at the consumer and community level. Often incorrect assumptions about the type, quantity and level of service for which consumers are willing to pay are made on the basis of convention or existing practices rather than realistic standards for the target area. Overestimating the consumption requirements (which is practically universal in all rural electrification projects) guarantees high levels of inefficiencies and poor economic performance of the investment. For instance, in Indonesia a decision to provide all homes in a community with access to a minimum of 2.0kWh/day of energy instead of 0.5kWh/day which will easily meet most of their electricity service requirements, can more than triple the cost of the renewable energy based power system while actually degrading the project's outcomes. In this all too common situation the planner and financier quickly turn to diesel power.

On the other hand underestimation of needs and desire for electricity services can lead to severe consumer dissatisfaction as is often seen in the small (12V DC) solar home power systems. Successful projects are invariably designed to match what the consumer is willing and able to pay towards the cost of generating the electricity and then delivering this reliably and at an acceptable quality of service. Rigorous community level household studies must be conducted to determine the balance between the need, desire and actual market price for electricity services.

To date most grid and diesel-based rural electrification projects have been designed according to long established 'standards' for electricity service that invariably over-estimate rates of connection and consumption. This approach is the result of the lower capital cost of diesel power generation technology combined with the traditional utility philosophy of 'grow and build'. Under these conditions utilities tend to provide a few consumers with restricted access to large amounts of (often unused) capacity. Successful renewable energy projects must focus not on installed capacity but on primarily meeting the minimal level of priority electricity services (lighting, information, entertainment and industry) needed by consumers.

Availability of Energy Resources
The availability of energy resources in a community dramatically impacts the choice of technology and cost of meeting the electricity service requirements. Selection of sites and alternative power generation technologies must be based on an optimal match between needs for electricity and the availability of suitable energy resources. This is an engineering challenge that includes all the factors of cost, performance, operation and maintenance of the equipment. Clearly, for communities that have an abundance of an energy resource that is inexpensive to convert to electricity (hydro, wind) the choice is more straightforward. However for most communities there are large variations in available energy due to changes in seasons, weather patterns and local topography. These variations substantially complicate the choice and invariably dictate that a combination of power conversion technologies be employed to optimise electricity service and meet least-cost objectives.

Environmental Considerations and Requirements
With the increasing concern for reducing environmental impact and the growing availability of special financing mechanisms, renewable energy based rural electrification programs are receiving new levels of interest. Feasibility studies to predict environmental impact and benefits for a range of alternative power generation technologies for target communities and regions should be part of the design process. Projects that can demonstrate environmental benefits will be easier to finance, implement and replicate.

Power System and Supply Alternatives
The choice of power generation technologies should be based on the premise of 'least-cost, preferred and sustainable', where 'least-cost' refers to financial and economic performance over the life of the project, 'preferred' relates to the satisfaction of consumers and owners, and 'sustainable' means that the power system will do what it is designed and warranted to do under acceptable conditions. When these three conditions are used as hurdles all stakeholders must participate in the design and selection process.

Design Effective O&M Services
Successful projects always provide for competent O&M services from local operations. In these projects costs for these services are included in all budgets and financial and economic analyses. Countless attempts to demonstrate how electricity can be made out of liquid fuels, gas, wind, sunlight, water, plants, hot rocks or whatever have proven time and again that notwithstanding the actual generation of electricity, entropy will always rule the day. In other words, all systems

of any type will fail sooner or later. Continuous inputs of expertise and effort backed by appropriate funding, mixed with common sense from local operations must be available and applied as needed.

Design Revenue Collection and Cost Recovery Mechanisms

Without effective cost recovery systems all stakeholders will lose and, not surprisingly, especially consumers. Most conventional or utility based rural electrification programs which operate with excess capacity tend to implement two policies:

a) under-charge consumers (become loss making)
b) avoid opportunities for increasing connections (reduce consumption and lose further revenues)

The greatest fallacy that normally arises is the question "what price per kWh will the proposed system deliver"? The real question is "what electricity service best fits the consumers' budget and needs whilst being sustainable over time"? In this context the cost per unit disappears as an issue. The utility business is now probably the only business where a social context of uniform pricing for a service applies regardless of the real cost.

With tariffs established on the basis of the market value of service and not the cost of generation, renewable energy based rural electrification programs can meet the financial performance requirements of the financiers and in developing countries this is normally the development banks. Successful projects require new paradigms for distribution, allocation, pricing and payment methods for electricity. With a strong focus on conservation and 'enoughness', coupled with market driven fees for access, new technologies for regulation of energy consumption and 'out-of-pocket' payment systems, these projects can overcome and eradicate the firmly held (but incorrect) belief that electricity from renewable energy is too expensive.

In conjunction with the Centre for Application of Solar Energy Australia (CASE) we have implemented a pilot phase of hybrid renewable energy systems in Thailand. This program was undertaken with the Provincial Electricity Authority (PEA) and the main purpose of the cooperation was to realise a model for the larger scale implementation of the hybrid technology in Thailand.

Four systems were installed over the course of 1997 and currently supply reliable electricity to the sites, with an evaluation phase currently underway. A continuing difficulty lies in the area of cost recovery where rural villagers have relatively low disposable income, thus limiting their ability to pay. Also, there is a cultural anticipation that electricity will be provided free of cost by the relevant government agencies such as the PEA.

Implement User Training Programs

In most countries where opportunities exist for large-scale renewable energy based rural electrification, importing power systems is the same as importing diesel fuel. Successful projects are designed to reduce, not increase, the dependence on foreign supplied equipment (and fuel). To achieve this goal and create commercial drivers for serious suppliers, a technology transfer component must be built into all projects. This component may range from the requirement to establish a full-scale in-country manufacturing operation to delivery of effective training programs for locally supplied O&M services. In all cases, project budgets and incentives must accommodate these components to build and strengthen local capability and reduce dependence on external sources. Projects that fail to do this are, at best, short-term and are wasteful of resources. They also reinforce the prevalent negative image concerning the sustainability of renewable energy power systems for rural electrification and by implication the integrity of the suppliers.

SUMMARY

Opportunities to create successful rural electrification projects for off-grid communities using renewable energy are rapidly emerging due to the growing commercialisation of power generation technologies and an increasing awareness of the requirements for sustainability. Successful projects are created through a rigorous process of analysis and design that focuses on meeting the priority needs of consumers ("enoughness") while satisfying the requirements of all stakeholders over the life of the project.

Traditional paradigms that dictate that rural electrification projects should use small, isolated diesel generators do not take advantage of benefits available through large-scale commercial applications of proven renewable energy based power generation technologies. Newly developed hybrid systems technology offers numerous immediate benefits while retaining high promise of an ongoing potential for accelerated progress to much higher levels of efficiency, functionality and environmental sustainability.

Ultimately the historical background of electricity at a certain cost per unit is the mental stumbling block that the stakeholders need to overcome. Once this is achieved it will be possible to build a new and sustainable model of fitness of purpose, enoughness, cost recovery and project financial viability.

The Future for Renewable Energy

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ABSTRACT

This paper gives an overview of the inter-relationship between policy and technology, and points towards a future technological convergence that could possibly drive significant social outcomes. Renewable energy (RE) can provide parts of large-scale social outcomes for governments such as slowing urban drift by leap-frogging the necessity for "hard" infrastructure, by encouraging local component manufacture, which conserves foreign exchange, and by having a positive environmental outcome. There is a feedback cycle between the development policies in many countries and the technological choices that are the outcomes of those policies It is argued that without significant government commitment RE will fail.

From the users point-of-view it usually does not matter whether energy is from a renewable resource or not. Reliable, affordable power provides a means to achieve developmental outcomes ranging from better health to education to increased economic activity, and this is their over-riding concern. In this perspective, cost and performance are important and unless renewable energy is reliable and cost competitive with other alternatives it will not be readily accepted. Trends and expectations in these areas show that although past experience has been unsatisfactory changes are occurring that indicate significant improvement is to be expected. There are characteristic of renewable energy that require technology implementation to be accompanied by a focussed capacity building program in order to optimise performance and user satisfaction.

INTRODUCTION: WHAT ARE THE ISSUES?

This workshop has been put together to consider issues surrounding renewable energy (RE) implementation in the developing economies of the world. It is not a co-incidence that the organisers and sponsors targeted the workshop at women bureaucrats in the developing world. Women suffer most of the consequences of inadequate power in their communities, and the long hours spent acquiring the necessities of existence fall largely upon their shoulders. The daily provision of potable water and fuel is largely their responsibility, while decisions regarding developmental priorities are usually made in a centralised fashion, frequently indifferent to women and other stakeholders.

The disconnection between those who should be the major beneficiaries of energy services and implementation decisions is severe. The type of energy used, the location of generators, and the priorities for supply, as well as a myriad of other issues need to intimately involve women if RE is to deliver its full potential as a development tool. This lack of engagement and empowerment of women is, however, only one of the many issues regarding energy and development.

The number of people worldwide who are without power is increasing in both relative and absolute terms. This means that the provision of electrical power is not keeping pace with population growth. The extent to which power is a developmental issue for the poorest among us is shown in Figure 1.

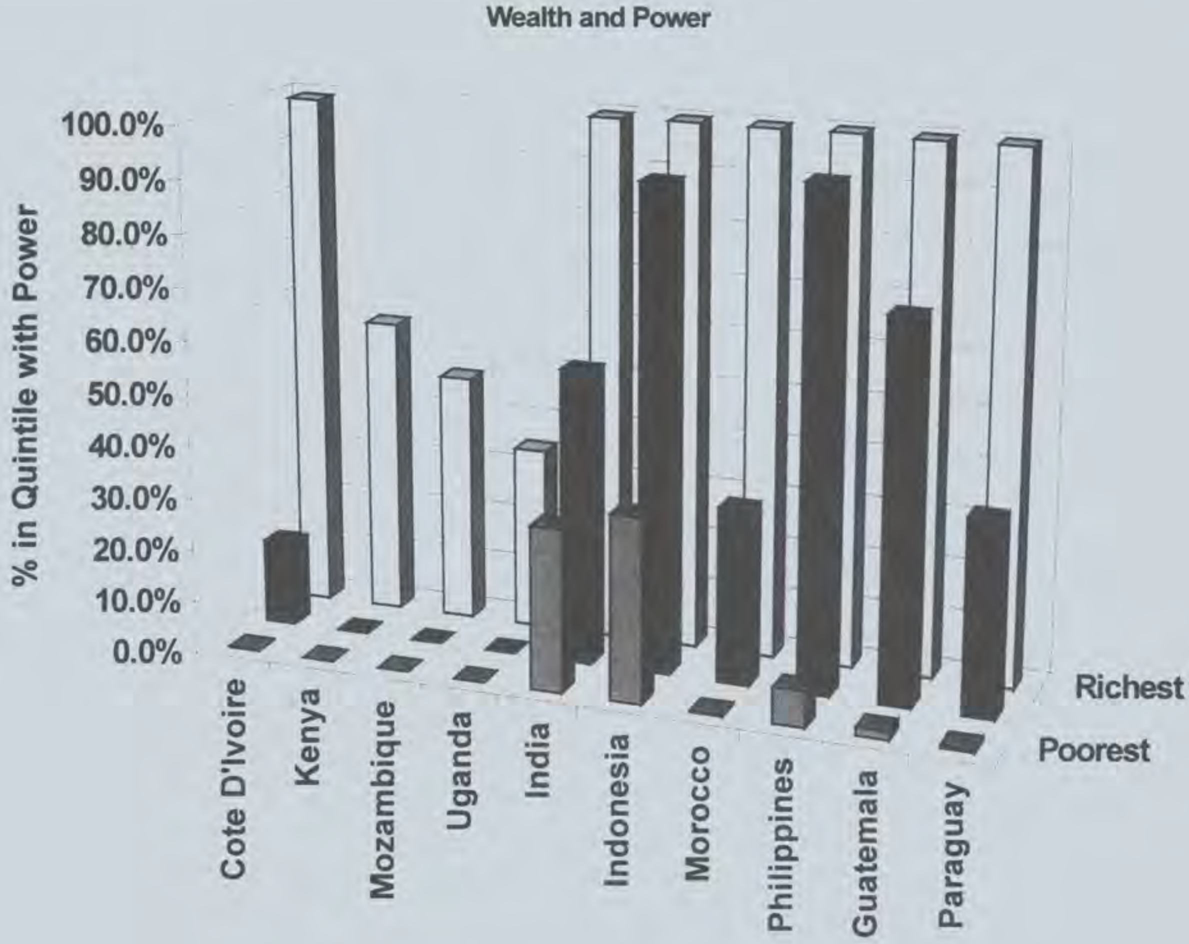

Figure1. Distribution of access to electric power in society for selected countries

The approach of this paper

In this paper I will briefly summarise some of the characteristics of renewable energy technologies and their costs in order to set the context for the rest of the workshop. I will then look at some of the policy issues that need to be taken into consideration, whether the policy is to be in the context of developed or developing economies.

Finally I will summarise how the policy and technology considerations intersect to give a picture of the future of RE.

THE FEATURES OF RENEWABLE ENERGY

Renewable energy is fuelled by a resource that is sustainable in economic social and environmental terms. It is usually defined by the fuel source, for example, solar, wind, biomass, tidal, etc., but it has other relevant characteristics that are important. For example, renewables can be economic at a number of scales from single-family units to medium scale power supply in the MW range. (In all of what follows, I have excluded large-scale hydropower as significant doubts have been raised about its environmental and social sustainability). RE has the capacity to provide cost-effective energy to remote communities without the added investment of providing grid extensions. Future cost improvement is likely to be significantly greater for RE than for fossil generation. However, RE is not generally dispatch-able in the normal sense, and capital and operating cost profiles differ for renewable and fossil generation.

Current Status of RE technologies

Technology	Status	Indicative cost (c/kW-hr)	Currently installed MW
PV	Relatively mature	25-50	2000
Wind	Large –mature Small -developing	5-8	9600
Micro-hydro	Mature		15000
Solar Thermal	Developing	30-50	700 (2003)
Biomass	Developing to mature	4-10	n.a.
Tidal	Mature	n.a.	
Wave	Developing	n.a.	0

Table 1 Cost and capacity for some RE technologies

Renewable energy is becoming more affordable

IEA studies have shown that the price of renewable generation has reduced by 50% in the last decade, and it is anticipated that there will be a further 50% drop in the next decade. The two graphs below show cost expectations for renewable energy with time. For most technologies we can anticipate a significant cost decrease with time, which is a reflection of the relative immaturity of the technology and the generally low volumes of renewables in the market today. Generally the greatest cost reduction will be in solar PV and RAPS systems (which are usually powered by PV's), but significant cost reductions can also be expected from other technologies.

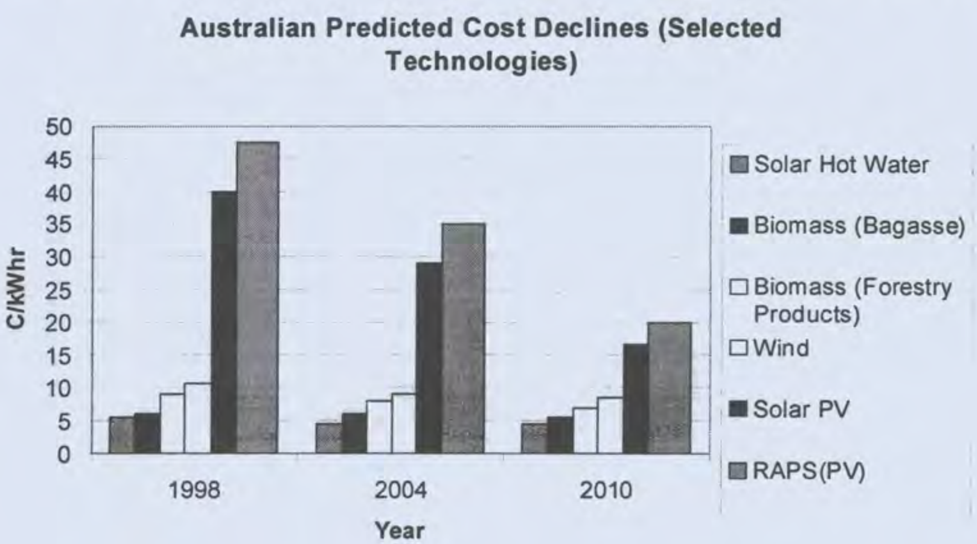

Figure 2. Expected cost of selected RE technologies to 2010

As expected, the greatest cost falls are anticipated in the technologies where volumes are increasing most rapidly, and where technology products or systems are least mature in a commercial sense.

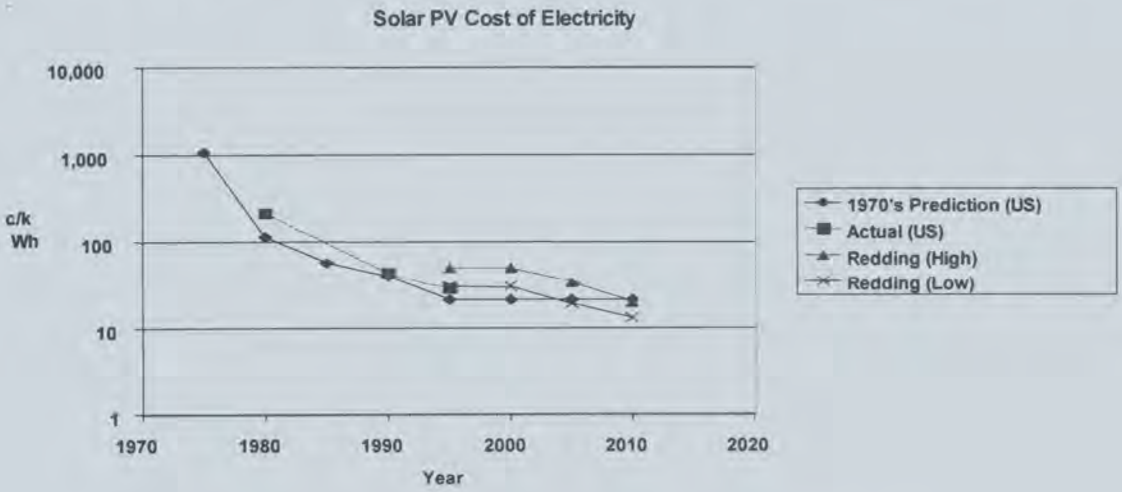

Figure 3. Actual declines of cost for PV with time and projected to 2010

This relationship between cost and volume is clearly shown for PV in figure 3. Results are similar for many other technologies. PV shipments are now growing at 35% compound per annum, and simple calculation will show that by 2048 the entire surface of the globe will be covered by PV.

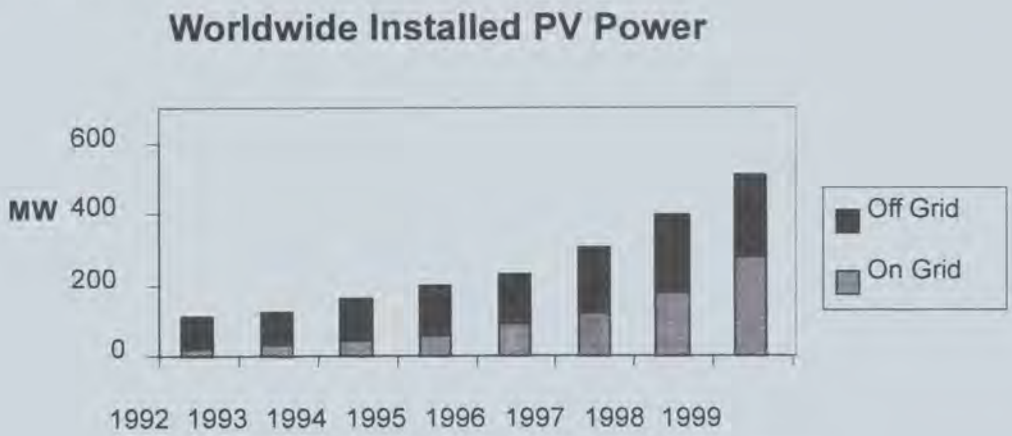

Figure 3. Worldwide installed PV power in Megawatts (Data from ITS)

Importantly, cost declines in RAPS, to a point where they compete effectively with wind and of course present fossil-fuel based power options provides a sustainable energy generation option for area-based applications as opposed one-off projects at the village level which lack the scale and intensity to improve financial viability.

Having established that costs are decreasing and volumes are increasing, why does RE sometimes appear to have difficulty in gaining a toehold in the market?

The answer lies in the three P's: perception, policy and performance. These three P's are at the heart of this workshop and we will be visiting each of them in depth over the next few days. Perception and performance are closely linked and will be covered by other speakers at the conference, but clearly if poor performance is sustained over period of time then public perceptions will become negative.

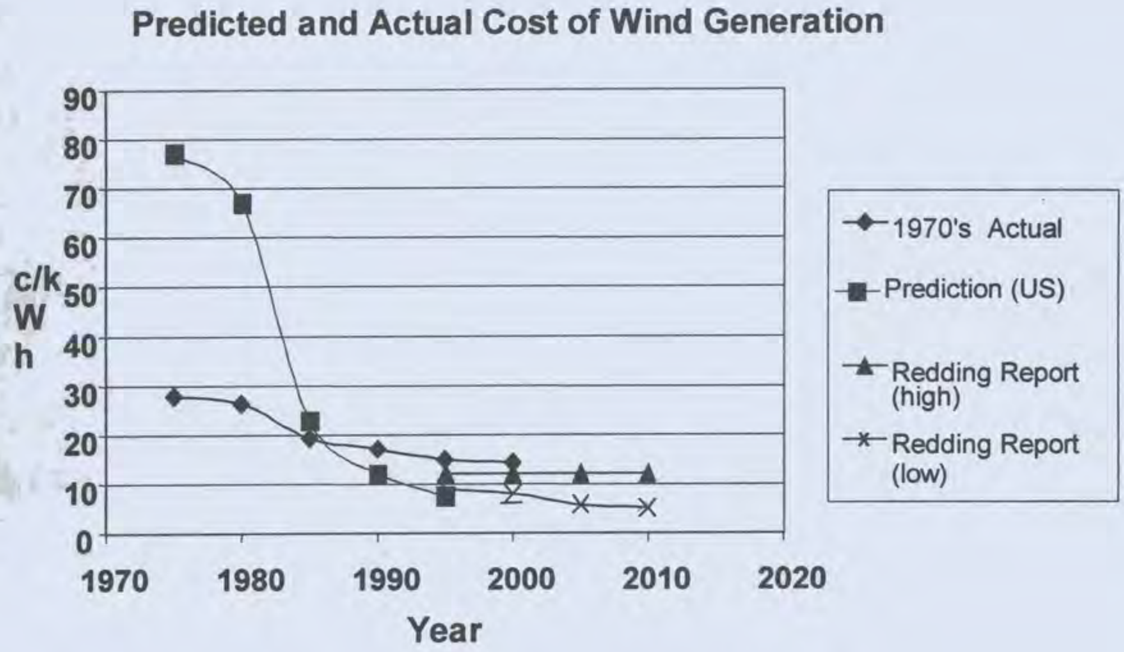

Figure 4 Historical and predicted costs of wind power

Political Will, Policy and Renewables

First of all let me say that in the absence of strong political will policies will remain without substance and invariably fail to produce the desired outcomes. Policy implementation will simply be ineffective. I will now consider some aspects of policy that can aid or retard renewable energy adoption. Sometimes policy unintentionally works against RE, as in the provision of cross-subsidies. In other cases policy is *intended* to work against RE, as in the recent US decision on the Kyoto Protocol. Policy considerations can differ between the developed and developing world but there is a large degree of commonality. The developed world has embraced RE to various degrees largely because of environmental factors while the developing world is far more driven by developmental outcomes than environmental ones. These two drivers are largely complementary and can provide an incentive for the application of RE in developed economies.

It should be remembered that developmental outcomes can potentially be delivered by energy sources other than renewables, and that these are frequently cheap and reliable. Nevertheless, there are compelling reasons for considering RE.

THE CHALLENGE FOR RE

The challenge for renewables is great. In the last 25 years 1.3 billion people living in developing countries have gained access to electricity, but population has increased by 2 billion in the same period so there are now 700 million more people without electricity than was the case 25 years ago. Because of remoteness, cost and demographics the grid will never reach most of them, and this suggests that remote area power systems (RAPS) are likely to be the only way of supplying power to them.

The degree to which such efforts will be successful will be driven in part by the existence of renewable resources and reliable cost-effective technology. Success will also depend on good policy decisions being made.

THE ROLE OF POLICY

There is a bewildering array of complexly connected issues that need to inform policy if the desired outcome of increased RE deployment is to be achieved. In many cases compromises are required, since options are mutually exclusive. In other cases, carefully considered policy can minimise the conflict between renewable and non-renewable energy.

Below I point out some of the drivers that policy-makers and implementers need to consider when RE can potentially deliver cost-effective power to communities. I have illustrated the drivers diagrammatically. Not all the drivers apply to every situation, and in some economies some drivers will take precedence whilst others will be less important.

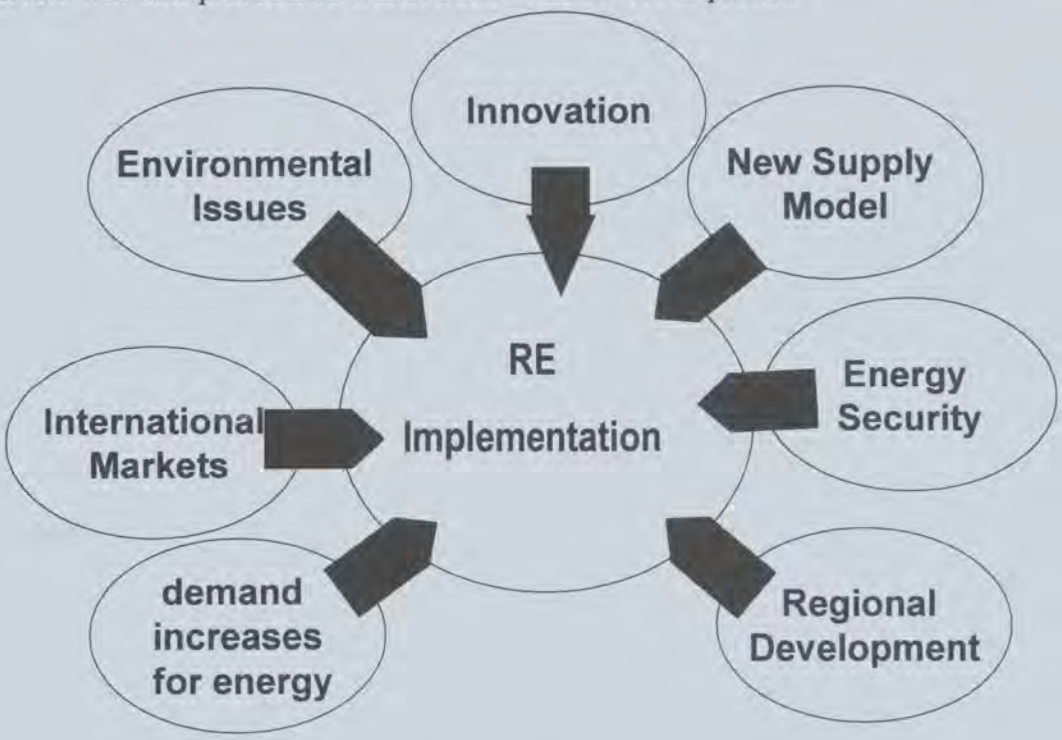

Figure 5. Key drivers for RE in developing economies

Many of the drivers are similar for developed economies

Important Policy Issues

In creating policy that recognises these drivers there are some very important aspects of energy delivery that need to be considered. I have summarised some of the most important of these in the next sections.

Access to grid

If RE generation is to be connected to an electricity grid, then the rules for connection are critical. There are technical issues associated with embedded generation, particularly on weak grids, but these are frequently used by utilities to unreasonably deny access to the grid.

Nevertheless, in former monopolistic models of electricity supply it was at least clear who had responsibility for reliability and quality of power on the grid. In a de-regulated market driven model of electricity supply, these issues are much less clear, particularly with regard to the distribution system. Some of the questions that need to be addressed are:

- Who has access and under what conditions?
- Who has responsibility for the reliability and quality of supply to customers?
- How do you deal with technical issues of connection, such as islanding?
- How does an open access regime affect energy security?

Subsidies, Positive and Negative

In most countries the price of electric power, particularly from the grid is as much a political question as an economic one. Examples abound of various forms of subsidy used to encourage the application of RE. Examples can be found throughout Europe, in India, and doubtless in many other countries. The fact is that subsidies distort market forces, and therefore need to be considered as a part of a well thought out energy strategy. If they are not, they are a drain on the public purse and deliver benefits usually to only a few companies.

There is a fairly clear correlation between subsidies for RE and installed capacity, and it is fair to say that the countries with the most aggressive subsidies have achieved a leadership position in RE. In these cases subsidies may have distorted the market, but they have delivered wealth creation because they are linked to a development vision.

There are however, numerous examples where subsidies have had the opposite effect. Cross-subsides can have a perverse effect on RE because they distort the market against RE. In Australia a good example is the effect of urban/regional electricity power pricing parity policies.

It is very clear that it is expensive to supply power to remote users. Nevertheless, equity considerations have compelled the Australian government to charge the same tariff for urban and rural users. There is thus no incentive for users in remote regions not to push for expensive grid extensions, as the cost of the extension bears no direct relationship to the price they pay for power. Where the costs of remote area generation, particularly marginal costs, are not taken into account, RE will be disadvantaged.

Cross subsidies take many other forms from government financing of fossil fuel exploration to price support for fossil generators

Developmental priorities

All countries face restrictions when it comes to the allocation of financial resources for development, and these restrictions can be particularly severe in developing countries. The choice is often between supporting urban social infrastructure, thereby increasing incentives for urban drift or supporting regional and rural development through spending choices that stimulate rural economic activity.

RE is particularly effective at promoting regional development when it is delivered as a coherent and integrated package of services. In nearly all cases, the derived nature of energy demand means the customer is not buying electric energy. Rather the consumer is interested in the service that energy enables, whether that is access to markets, education or telemedicine services. This has to be taken into consideration by RE advocates since there is little necessity, from the users point-of-view, that the enabling power comes from renewable resources.

Monopoly vs. competitive markets

In the developed world there has been a sharp shift away from the vertically integrated utility model for the provision of power. Deregulation has resulted in different entities owning the various assets necessary for power delivery. Thus generators have been separated from transmission and distribution that is in turn separated from retailing.

Experience is starting to show that this market-based approach is having some fairly significant problems as it begins to be implemented. The power supply situation in the US is a dramatic example of these bedding down problems. Whether a deregulated market will foster allocative efficiency and competitive behaviours a direct function of market structure and capacity The structure of the electricity market can have a profound effect on the implementation of RE.

Where utilities, or their political masters, are well disposed toward renewables, a monopoly can deliver results as speedily as any system. Unfortunately this is frequently not the case.

Availability of training and information

Building human capacity is fundamental to effective RE implementation. There is a great need to inform government officials, policy-makers, energy industry officials, potential investors as well as consumers. In addition an adequate supply of skilled installers and maintainers needs to be planned for.

Availability of financing

Partly related to the issue above is the continuing difficulty with financing of RE systems. This is a problem at all levels; from solar home systems to substantial embedded RE systems. Even in the current favourable climate for "sustainable investments", poor perception and performance have an impact on the cost of funds for RE projects. With improvements in reliability, improvements in the perceptions of performance will reduce the risk associated with large-scale rural electrification projects. This is not only a technical issue, but is closely related to the chosen business model of the supplier. Refinements in rural ESCO's will contribute to issues such as maintenance and reliability. Financial sustainability for rural projects is a difficult issue but will certainly be addressed when the focus of financial returns is calculated from the commercial and other services allowable following electrification and the general boost to the rural economy.

To some extent this is a problem of risk management and risk perception. The problem is frequently compounded by a lack of adequate information to providers of capital. These factors combine to make project financing on reasonable terms very challenging. Project economics always have to take into account country, commercial and technical risks but RE has the added problem of the remoteness of many of the systems, and the fact that many RE manufacturers and RESCOs are small companies. The impact on the economics of RE systems is manifested through higher costs of capital, compared to established fossil generation technologies. Pro-active government involvement in risk management strategies can be effective at lessening the problem. This calls for coherent policy and program measures that take into account the costs and other considerations across the range of generation options and invariably adopt sensible programs that take into account the energy needs for people in developing communities.

IMPLICATION FOR THE FUTURE OF RE

We can summarize the foregoing as follows:

- RE has some unique characteristics that differentiate it from fossil power generation, and many of these aspects lend themselves to applications in remote areas, or where grid electricity is of poor quality and unreliable or where populations are highly dispersed.
- RE is becoming cheaper and will continue to do so. Some technologies are already cost competitive with fossil fuel generation. In this regard it is essential that due care is given to using technology appropriate to local resources. The economics of RE are highly resource dependent.
- This cost reduction is largely a function of increased production volumes brought about by policies in individual countries. The benefits of continuing cost reduction will flow to developing economies.
- The advent of greater reliability and lower cost for the technologies has meant the realization of the distributed generation and effective RAPS. This is of particular significance to very remote communities and those serviced by poor and unreliable grid power.

- There are a number of drivers towards greater implementation of renewable energy and good policy will smooth the way for implementation. Without a pro-active approach to RE policy it is unlikely that implementation will be maximised.
- Developing economies will be interested in RE only to the extent that it delivers national development outcomes. Developed economies are driven largely by environmental concerns. These are also of concern to developing economies but development is usually their major concern.
- RE appears to be the only realistic way that a very large number of people will gain access to electric power.
- People are prepared to pay for the lifestyle benefits that access to energy provides. The energy is only a means to an end, not an end in itself. Effective integration of energy with service delivery is essential to the success of RE systems in a development context.

WHAT DOES THIS MEAN FOR RE?

It is possible to discern some trends in the developing world from the summary above. In many cases the trends for developed and developing economies are similar

Renewable Energy and Sustainability

The impact for RE in the developing world can best be summarised as follows:

- There is a convergence between the desires of the developing economies to provide sustainable economic development for their populations, and the desire on the part of the developed world for better environmental and social outcomes. RE is well placed to accommodate this convergence.
- Most increases in installed capacity have occurred in the developed world. Although parts of the developing world already have substantial RE capacity, this will grow as technology transfer occurs as part of market development in the developed economies. This means that the economics of renewables, that in many instances already makes it the favoured option, will continue to improve. This will be reinforced even further as models for costing the externalities of power generation allow these costs to be factored in.
- There will be a growing trend to service delivery in remote areas, and this will take the form of bundled services. Because RE is only a means to an end, and because of the market realities of providing infrastructure to remote and disadvantaged communities, RE will only be truly successful if RE brings about meaningful and sustainable economic opportunities by using RE to power education, medicine and commercial applications for these communities. There are already several examples of this happening in Latin America.
- In many instances RE will provide the only means of power to the worlds most disadvantaged communities. Remote villages will never be reached by the grid and as populations increase RE will enable at least rudimentary energy services to reach these communities

World Bank – GEF Funding For Renewable Energy Projects

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ABSTRACT

The momentum behind renewable energy applications is gathering pace around the world. Where gird extension is cost prohibitive decentralised systems using conventional diesel in combination with hybrid renewable energy inputs from solar and wind, for example are proving cost-effective. With the environmental benefits of reduced carbon emissions coupled with a growing recognition that energy is fundamental to rural development renewables are slowly becoming the choice of rural development planners.

Nonetheless, in spite of their qualities, the up-front capital costs associated with renewable energy projects are high and in countries where they are most needed, government budgets are constrained. With markets poorly developed and hence, investment returns vague, there is little interest from the private sector. These factors underpin some of the reasons why bilateral and multilateral donor organisation intervention is needed. Events in the recent past have created several important institutional developments around the World for renewable energy funding.

This paper examines World Bank funding for renewable energy projects. It sets out some of the goals and objectives of key World Bank programs to provide an insight into the kinds of financial modalities adopted and outcomes desired.

INTRODUCTION

Once considered the idle tinkering of those on the fringe of society, renewable energy technologies are gaining momentum among mainstream society. Reaching remote and isolated communities by extending the electricity grid is a costly undertaking. Instead, decentralised systems using conventional diesel in combination with hybrid renewable energy inputs from solar and wind, for example, are in some circumstances, proving cost-effective. With the environmental benefits of reduced carbon emissions coupled with a growing recognition that energy is fundamental to rural development, renewable energy technologies are slowly becoming the preferred choice among rural development planners (Rijal, 1998).

However, capital costs associated with renewable energy projects are high and in countries where they are most needed, government budgets are constrained. With markets poorly developed and hence, investment returns vague, the private sector shows little interest. This has caused bilateral and multilateral donor organisation to sit up and take notice creating a network of programs among the international donor agencies to fund renewable energy activities[1].

At the same time, global concern for reducing greenhouse gas (GHG) emissions has provoked governments around the world to reconsider their development options. Country-level requests for assistance has driven international donor agencies to respond. Determining the sources of energy and the choice of enabling technology are central to policy decisions. Governments of developing countries are also especially concerned for remote communities without access to

[1] See Appendix I for a snapshot of a selection of European donor efforts.

energy and therefore, the basic services that energy can provide. The lack of energy acts to constrain equitable growth and serves to compromise general principles of sustainability (Goldemberg and Johansson, 1995) and is increasingly being seen as *sine quo non* in the development equation (Farinelli, 1997).

The challenge of bringing energy, in whatever form, to poverty stricken communities is a daunting task. The poor level of geographic penetration through grid extension is mainly a cost issue. Low loads associated with rural activities widely dispersed communities of hard to reach sites means that the vast proportion of villages in developing countries are poor candidates for grid extension. In Indonesia for example, has some 13,500 remote island communities of which only about 30 per cent are electrified while in Thailand there are some 63,000 villages scattered throughout various parts of the country of which only about 40 per cent have electricity. Notwithstanding these difficulties there are a host of stylised barriers standing in the way of progress (Ramani, Reddy and Islam, 1995)

Setting aside rural electrification for the moment, the required level of investment needed in energy supply and demand in developing countries is in the order of US$100 - US$200 billion per year. Most of this comes from capital markets and government funding of nationally owned energy institutions (McCarthy and Martin, 1997). Development assistance financing for energy is less than US$11 billion (net of debt financing) per year with most of this coming from the World Bank and other multilateral development banks. The proportion actually going towards rural electrification is considerably less, around US$1.5 billion and of this a mere US$950 million directly on boosting the scale and intensity of renewable energy markets (Saupin, 1999).

Despite a slow start, renewable energy is increasingly becoming accepted amongst the international development community as a possible solution to climate change and possibly a valuable tool in the fight against poverty (Reddy, Williams and Johannsson, 1997). Events that appear to have provoked this surge in interest can be found in recent history.

RECENT HISTORICAL SNAPSHOT

The commitment by the international community to support renewable energy and energy efficiency projects has been shaped by several events in recent history. Sustainable development was first defined in the 1987 Bruntland Commission's Our Common Future. It refers to *development that meets the needs of the present without compromising the ability of further generations.*

In 1992, the Rio Summit (the United Nations Conference on Environment and Development), CoP 1 resulted in the Framework Convention on Climate Change (UNFCC), signed by over 150 member countries. In 1995 CoP 3 was held in Berlin where agreement was reached on Activities Implemented Jointly. CoP 3 was held in Kyoto in 1997 culminating in the establishment of the Kyoto Protocol. In 1998, CoP 4 was held in Bonn resulting in the development of Flexible Mechanisms. And in 1999, CoP 5 in Bonn set the deadlines for compliance.

Parties included in Annex 1 to the Convention (developed countries) committed to legally binding targets to limit or reduce emissions of six major GHGs, with an aggregate goal of a five-percent reduction from 1990 levels by 2008-2012. The major intent of the UNFCCC is to *stabilise greenhouse gas concentrations at levels that would prevent dangerous anthropogenic interference with global climate.*

POVERTY-ENVIRONMENT-ENERGY NEXUS

It can be argued that the major impact of the Bruntland Commission and the establishment of the UNFCCC is the drawing together of sustainable energy as part of a broad set tools for sustainable development. In other words, technology, environment and people under a broader pro-poor framework.

Despite the growing momentum behind the advocacy for renewable technologies in a sustainable development there is limited evidence to show that projects are accomplishing their development impact objectives. By way of reason, there is a multitude of stylised reasons put forward under the rubric "barriers to renewable energy". However, there are grounds to argue that the institutional support behind renewable energy technology, environment and poverty alleviation has historically remained disjointed. Put simply, a lack of effective institutional coordination may be a factor behind the poor results to date. This comes in spite of the claims attached to program objectives and guide-lines of the various national and international organisations for development and environment (climate change) respectively.

Until recently, the efforts of multilateral institutions resonated duplication claiming that project objectives will produce drastic reductions in greenhouse gas and as a corollary, that poverty in all its manifestations will be overcome. Bold objectives of such kinds are utter nonsense, since the empirical evidence of such multi-dimensional achievements is limited to say the least.

Nonetheless, some faith can be found in the Global Environment Facility Council Meeting in May 1999 where it was announced that the GEF will forge strategic partnerships with the United Nations Development Program and the UN Environment Program.

A closer bond between these organisations not only in deed but as part of a tripartite operational agreement makes a lot of sense. This is purely from the stand-point that the UNDP and UNEP have played a large role in spending GEF and World Bank money as well as that of the various donor countries on behalf of national governments. More convincingly however, are the prospects to develop a common set of operating principles for poverty alleviation, preserved biodiversity and greenhouse gas mitigation under a commonly defined sustainable development framework that accords across these major bodies.

The benefits of the combined financial clout of these organisations needs no further elaboration. Rather the blending of intellectual capital stands out as the most compelling reason for the strategic partnering. Multidisciplinary representation is likely to result in more sober claims on project outputs than those announced in the past. And, with more intense and diverse peer review early in the project development life-cycle, project objectives might be better articulated in ways that attach some meaning to the ways in which project development, implementation, monitoring and evaluation proceed.

THE WORLD BANK

Successful or otherwise, the World (Bank) has devoted volumes of financial capital to the fight against poverty and environmental degradation. Examining their policies and modalities for donor assistance, lending instruments and associated programs provides an insight into the Bank's approach to renewable energy[2].

[2] See Appendix II for information on Bank Programs for renewable energy

POLICIES AND MODALITIES

The Bank considers that rural energy should be a key part of its work in country assistance strategies, energy sector reform, and new investments. In specific terms, the Bank has a renewed commitment to:

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

New technologies are to be introduced by:

- Promoting commercial pricing and private involvement in distribution;
- Supporting agroforestry and biofuels programs;
- Encouraging local initiatives and open markets.

In their lending operations to India and Indonesia for example, the focus is on developing the ability of retailers and other intermediaries to reach rural markets. Technical assistance co-funded by bilateral donors helps in identifying policies and projects in many countries of sub-Saharan Africa, Asia, and Latin America that pave the way for using new decentralised technologies to provide affordable energy.

ACTION PLAN

The emerging strategies that promise to make a real difference for rural populations require a new and powerful commitment by the Bank and its partners. In this vein, the Bank's Action Plan calls for a strong effort to accelerate the opening of rural energy markets, help consumers to have a choice, and put in place better systems to deliver and finance rural energy. The Bank intends to base its efforts to provide better access to energy for rural people on five main principles:

- **Provide for consumer choice.** A better choice of affordable energy sources should be provided to rural consumers. Informed consumers will choose the most cost-effective solution, according to their preferences
- **Ensure cost-reflective pricing.** Distortions in prices that are created by subsidies and taxes should be eliminated. They create a disincentive for entrepreneurial solutions to rural energy supply, and give consumers the wrong signals.
- **Overcome the high-first-cost barrier.** The obstacle of the high initial cost of obtaining energy needs to be removed. Credit mechanisms, lower-cost equipment, and lower service standards can all contribute to achieve this.
- **Encourage local participation.** Participation of local communities, investors, and consumers in the design and delivery of energy services is essential. Decentralized approaches need to be part of the solution, including systematic local capacity building.
- **Implement good sector policies.** These are the basis for bringing better energy access to rural populations. Energy sector reform should include the opening up of the rural energy market. Macroeconomic policies should not discriminate against rural energy. The role of the government should change from central planning to supporting markets.

RURAL AND RENEWABLE ENERGY THEMATIC GROUP

The Rural and Renewable Energy Thematic Group advocates for rural and renewable energy programs in World Bank operations and country dialogue. The Thematic Group is responsible for promoting a better understanding of the Bank's agenda and strategy and seeks to widen cooperation with external partners to better implement the Bank's programs. Issues in the work of the Thematic Group concern:

- Accelerating rural electrification in a sustainable manner;
- Expanding the share of renewable energy where it is already cost effective, or where it is least cost taking externalities into consideration;
- Promoting the sustainable supply and efficient use of biofuels and the transition to modern fuels in rural areas, and;
- Promoting commercial models for delivering rural energy services.

In terms of spending the World (Bank) is arguably the most active in developing opportunities for energy efficiency and renewable energy technologies. Behind this commitment, their shared concern is for poverty alleviation, stable government political reform, infrastructure development/upgrade, education, health, agriculture and energy. Several types of lending instruments helps the Bank achieve its goals – Table 1.

Investment Lending	➢ Specific Investment Loan (SIL)
	➢ Finance Intermediary Loan (FIL)
	➢ Technical Assistance Loan (TIL)
	➢ Sector Investment and Maintenance Loan (SIM)
Adjustment Lending	➢ Emergency Recovery Loan (ERL)
	➢ Sector Adjustment Loan (SAD)
	➢ Rehabilitation Loan (RIL)
	➢ Structural Adjustment Loan (SAL)
New Products	➢ Adaptable Lending (AL)
	➢ Global Carbon Initiative (CGI)
	➢ Learning & Innovation Loan (LIL)
	➢ Partnership for Renewable Energy
Guarantee Operations	➢ Expanded Co-financing Loan (ECO)
Debt Service Reduction	➢ Debt and Debt Service Reduction Loan

Table 1. World Bank Lending Instruments (online: http://www.worldbank.org)

The Bank has several lending arms that support renewable energy and energy efficient initiatives. These include the International Bank for Reconstruction and Development (IBRD), IDA and the Global Environment Facility in association with UNEP and the GEF. The Bank adopts a programatic approach to energy, environment and sustainable development. These programs can be seen in Table 2

Entity	Implementing Agency	Geographic Focus
IBRD/IDA Lending	WB	Global
GEF	WB UNDP UNEP	Global
ESMAP	WB UNDP	Global
ASTAE	WB	Asia
AFFREI/RPTES	WB	Africa
SDC	WB IFC Foundations	Global
IFC – REEF PVMTI RE Financing SME	WB Commercial banks Foundations	Fund/Project Dependant
Prototype Carbon Fund	WB	Global

Table 2. World Bank Programs for Alternative Energy[3]

[3] See Appendix III for a list of Bank Pipeline Projects

THE GLOBAL ENVIRONMENTAL FACILITY

The Global Environment Facility is a financial mechanism providing grant and concessional funds to developing countries for projects and activities to protect the world's environment. Only the incremental costs of climate-friendly projects are funded. Responsibility for implementing the GEF is shared by UNDP, the United Nations Environment Programme (UNEP) and the World Bank. UNDP is broadly responsible for capacity building and technical assistance activities, and for managing the Small Grants Programme (SGP) on behalf of the GEF. (http://www.gefweb.org/)

On the heels of restructuring, the GEF has a strengthened mandate to link its projects with national sustainable development efforts and to complement, not replace, the implementing agencies' regular development assistance financing. There is thus a strong pressure to ensure complementarity between UNDP and GEF programme objectives. Great importance is placed on national government policy initiatives and financing to ensure that all GEF-supported national programmes are sustainable in the medium term.

By enhancing their partnership, UNDP and GEF can simultaneously meet their own priorities and advance the goals of national and global sustainable development, building a portfolio of projects based on country priorities and global benefits. GEF projects may be designed not only to support the global environment, but also to meet such UNDP objectives as job creation and capacity building.

The challenge is to find ways to direct UNDP's resources into baseline costs and to access GEF financing for the incremental costs of energy projects that are consistent with both UNISE and GEF's operational programmes. In this way, UNDP core resources can be used strategically to leverage additional GEF financing for projects which address energy's relation with, or impact on, the global environment. There are six interrelated GEF funding categories, summarised below:

The combined funding of these entities for renewable energy projects amounts to some 32 projects of which the Bank has committed US$623 million and the GEF US$323 million. With leveraged co-financing the total investment for renewables presently stands at $3.4 billion Table 3.

Region	Fund/Amount (million)	Total Investment (million)
Global (4 projects)	GEF/$116	$364
Latin America (5 projects)	GEF/$23	
	WB/$40	$184
Europe (4 projects)	GEF/$4	$20
Africa (7 projects)	GEF/$13	
	WB/$44	$276
Middle East (1 project)	GEF/$4	$20
South Asia (3 projects)	GEF/$31	
	WB/$44	$276
East Asia Pacific (8 projects)	GEF/$116	
	WB/$237	$1,800

Table 3. World Bank/GEF Investment in Renewable Energy (http://www.worldbank.org)

At COP 5 approval of expenditure for 2000 was US$14,365,900 and for 2001 US$13,522,200. (http://www.unfcc.int/text/issues/fmaa.html)

GEF - Operational Programmes

This category consists of major, long-term GEF projects which are divided into focal areas. In the area of climate change, GEF will work to expand, facilitate, and aggregate the markets for the needed technologies to reduce greenhouse gas emissions and promote non-carbon alternatives, as well as to improve these technologies' management and utilisation. The emphasis is two-pronged:

(i) To remove barriers to implementation of climate friendly, commercially viable technologies, and
(ii) To reduce the cost of prospective technologies that are not yet commercially viable.

The three focal areas relevant to climate change are summarised below:

1) Removal of barriers to energy conservation and RE
   - Enhancing demand-side management, particularly in basic materials industries, transport, and housing;
   - Establishing and strengthening integrated resource planning and administration capabilities;
   - Encouraging supportive legal, regulatory, and policy changes;
   - Demonstrating cost recovery and facilitating mainstream financial support;
   - Facilitate learning required for widespread application of energy conservation and efficiency projects.
2) Promotion of the adoption of renewable energy by minimising implementation costs specifically for:
   - Photovoltaics (both on-grid and off-grid applications);
   - Combustion of agricultural residues to generate heat and power;
   - Other technologies using biofuels;
   - Methane-control technologies for waste disposal;
   - Wind power.
3) Reducing the long-term costs of low greenhouse gas emitting energy technologies including:
   - Solar-thermal power generation for high insolation regions;
   - Grid-connected and household solar applications;
   - Advanced biomass power and fuel technologies;
   - Fuel cells;
   - Advanced fossil fuel technologies.

Project Development Facility

Assists in the development of GEF projects from concepts into fully approved documents. PDFs are divided into Block A up to a maximum of US$25,000; Block B up to a maximum of US$200,000; and Block C up to a maximum of US$1 million.

Small Grants Programme

Provides grants up to US$50,000 to local community groups (in 5 core areas: planning grants; pilot projects[4]; capacity building; monitoring and analysis; dissemination, networking and policy dialogue).

Enabling Activities

Assists countries in preparing strategies, action plans, and reports that fulfil their obligations.

[4] Largest component

Short-term Response Measures
Urgent, high priority activities required to meet immediate needs, even if not part of the overall operational program and are not enabling activities.

These measures are very cost-effective and have dramatic short-term impacts.

Medium-size Projects
For projects with budgets of under US$1 million.

- Successful Implementation – on-going alternative energy projects successfully implemented
- New Investments: New lending programs developed for power and other end-use sectors
- Strengthen Capacity: Improved institutional capacities and policies for client countries
- Knowledge: Improved access to knowledge on alternative applications and projects among Bank staff and borrowers

KEY FACTORS FOR SUCCESSFUL PROPOSALS
A synthesis of the foregoing operational objectives, modalities and desired outcomes of the Bank, GEF and partner organisations especially UNEP and UNDP highlight several critical factors that need to be addressed when preparing project funding proposals. It is true to say that poverty alleviation in sustainable ways remains the highest priority.

The strategic alliance between the chief funding bodies of the Bank and GEF with the main development and environmental arms of the UN, UNDP and UNEP respectively lends support to this perspective. The and in the process provide for a sustainable future, In preparing for GEF Block PDF for example, these factors can be grouped along the following lines: Host Country Environment and Project Impacts - Sustainable Outcomes and generally reflect the stylised barriers to renewable energy (see Appendix IV).

HOST COUNTRY ENVIRONMENT
- Country Eligibility (Signatory to UNFCCC)
- Alignment with GEF Focal Area
- Strong Political Will
- Robust National Policy for Sustainable Development and the Environment
- Appropriate Institutional Framework
- Enabling Legislative and Regulatory Frameworks
- Provision of Market-Based Incentives
- Strong Civil Society and Community Organisations
- Committed Financial Sector
- Prospective Private Sector Involvement

Project Impacts - Sustainable Outcomes

Indicators of improved agricultural productivity

1. Irrigation systems utilising electric system equipment, tube wells, etc. allowing for multiple cropping.
2. Properly formulated livestock and poultry feeds prepared in small mills.
3. Automated poultry processing/breeding systems.
4. Refrigeration of perishable farm agricultural products and utilisation of milk coolers.
5. Electrically powered grain drying, processing, storage systems and fumigation.

6. Conservation of export quality timber (electrically replaces wood for cooking and heating).
7. Fish farms in areas where pumps required.
8. Working through cooperatives provides farmers with a degree of leverage in the marketplace.
9. Agriculture employment opportunities generated.

Indicators of improved economic productivity

1. *Electrically powered handicraft industries allowing for varied and increased production (Cottage or home produced items can be made during off-peak agricultural seasons).*
2. Employment opportunities, especially for women, in commercial non-agricultural industries. (Due to electricity, women with reduced home-making chores are able to earn much needed extra income either on full-time or part-time basis).
3. Market/stores utilising refrigeration. Decrease in spoilage of perishables, especially in tropical areas.
4. Development of small industries to meet created demand for simple electric appliances.
5. Development of industries supplying poles, cross arms, insulators, hardware, meters and transformers for electric distribution systems.
6. Employment opportunities created by co-operatives, contractors, National Electrification Administration, auditing and accounting firms.
7. Limited school facilities such as libraries opened in evenings.
8. Community facilities such as libraries opened in evenings.
9. Wider use of audio-visual equipment and materials in schools and adult education programmes.
10. Allows for home economics training for utilising sewing machines and home appliances.
11. Women's routine home chores eased, which allows for daughters to be freer to attend school.
12. Lighted outdoor athletic facilities such as basketball courts allows for community recreation. (Too hot in tropical countries to participate during daytime).
13. Teachers more productive and better prepared due to home lighting.
14. Students academically improve. Homework better prepared.

Social impacts related to health

1. Refrigeration of medical supplies by clinics and hospitals.
2. Use of sterilisers and electrical detection equipment in rural clinics.
3. Reliable source of power for hospitals and operating rooms.
4. Home electrical appliances allow for sanitary preparation of food and water. Electric pumps provide potable water.
5. Home refrigeration prevents spoilage of perishable foods and reduces health hazards.
6. Restaurants utilising electrical appliances and refrigeration reduces health hazards.
7. Correlation of home lighting and decrease in population growth rate.

Other impacts on rural population

1. *Increased security due to night lighting. Crime rate decreases.*
2. Lighted games provide social benefits.
3. Utilisation of radio and television for education, entertainment and leisure.
4. Appliances such as irons, hot-plates, simple washing machines reduce work burden for women.
5. New home construction and improvement results from electrification.
6. Co-operatives provide outlet for community and national participation by rural population. Provides experience in management and democratic decision-making.
7. Improved and increased craft production in addition to economic benefits, enhances the cultural aesthetic values that craftsmen and crafts tradition mean to a nation (national pride).
8. Co-operative institution, organisation and facilities utilised for member's services (Better Family

Living) such as family planning, craft, home economics.

9. Change in social well-being. Index of satisfaction with one's current situation improves. New confidence.
10. Keeps the economic proceeds of a region invested locally.
11. Accelerates the monetisation of the rural society.

Impacts on host country government

1. Stems rural migration to cities and improves rural-urban balance. Increased rural economic activity absorbs expanding rural labour force.
2. Decentralises economic activity.
3. Rural population participating in 'self-problem solving' climate rather than a 'depending on the government' climate.
4. Increased net tax revenues to government.
5. Levelling of ethnic differences.
6. Improved citizens-government relationship.
7. Reduced socio-economic imbalance in the population.
8. Expanded communication system to entire population. Government able to communicate with its citizens.
9. Reduced foreign exchange expenditures for kerosene and oil used for lighting, cooking and heating. (A central generator is a much more efficient method for supplying energy, rather than each household purchasing fuel).

CONCLUSIONS

Global Climate change and poverty alleviation have combined to drive the international donor assistance organisations towards mainstreaming renewable energy technologies. The funding accompanying these efforts is large but on a wider scale insufficient to address the problem. The Bank and the GEF in partners with the UNDP and UNEP are key organisations in the institutional framework for multilateral assistance. The recent strategic alliance struck between these organisations adds the finishing touch to the series of multilateral talks on sustainable development, environment and climate change dotting the landscape during the late 80's and throughout the 90s.

The programatic approach by these organisations as opposed to the outmoded project approach underscores the desire for wider-scale sustainable outcomes while recognising the multi-access nature of sustainable development. Barrier identification and removal are key activities.

The key to project success lies in being able to effectively link project inputs and outputs with national plans and priorities for sustainable development. Build or strengthen the institutional framework for renewables in the host country and ensure that the regulatory and legal frameworks support the process. Involvement of multi-sectoral interests including the private sector and most importantly adopting and end-user approach with strong involvement of grass roots organisations helps to ensure that comprehensive measures are being taken.
Finally, the support from all levels of government, wider stakeholder community and strong community participation are fundamental to achieving sustainable outcomes.

APPENDICES

Appendix I – Selected European Bilateral Support for Renewables[5]

Percentage of energy R&D budget spent on renewables for selected European countries (Source: UNFCCC Working Paper No. 15, 1998)

Most European nations have extensive R&D programs for renewable energy technologies. The table shows the percentage of the energy research and development budget devoted to renewables for selected countries.

Country	% of Energy R&D Budget Devoted to Renewables
Austria	28
Denmark	44
Finland	25
Germany	32
Italy	9 (Government only)
Portugal	50
Switzerland	25

Austria has a strong infrastructure of regional energy agencies offing support for renewable energy projects. Research projects are considering, in particular, biomass projects such as the cultivation of energy plants and further improvements in biomass combustion technologies. Further development of hydro-power and solar technologies are also objectives.

Denmark instigated a renewables support program following the oil price shock during 1973. Since then, the country has had a strong track record in research, development and commercialisation of renewable energy technologies, with significant government support provided for biomass and wind research. The Energy Action Plan "Energy 21" has been elaborated, and includes medium and long term scenarios to 2005, 2020, and 2030 for the country's use and development of renewable energy

The French government is currently supporting research and development in wood energy, solar PV, solar thermal, waste energy and bio-fuels.

In Germany, most research and development is carried out by the private sector with significant government support. Research into solar energy technology accounts for almost half of the renewables R&D budget.

The Netherlands has a strong research, development and demonstration program primarily focussing on solar PV, waste and biomass. Their Action Programme 1997-2000 for renewable energy and has elaborated scenarios for 2007 and 2020 which include: development of wind energy (750 MW in 2000, 2000 MW in 2007); solar PV (119 MW 2007); biomass (residual

[5] See also Piscitello and Bogach (1997)

flows 30-80PJ/year and energy crops (12-70 PJ/year); solar thermal (5 PJ in 2007 or 250.000 water heaters); and heat pumps (50 PJ in 2007).

Norway's "efficient and RE technology" research and development program, introduced in 1995, allocates 70% of funding to product and technology development with industry contributing an equal amount. The remaining 30% of funding is used for long term research projects.

Legislative commitment by the Swedish Government (Bill 1996/97:84Sustainable Energy Supply) to the exploitation renewable energy resources includes measures aimed at increasing the supply of electricity and heating from renewables.

Switzerland's R&D program is mainly concerned with solar, woody biomass and heat pump technologies.

The United Kingdom approaches renewable energy technologies according to their expectations of the technologies' market prospects. Funding is allocated to different technologies on the basis of their prospects. For example, funding into solar PV is supported, however wave, geothermal, and tidal power are expected to be unlikely to contribute significantly by the year 2025 will be monitored.

Appendix II – World Bank Programs for Renewable Energy

Energy Sector Management Assistance Program

The Energy Sector Management Assistance Program (ESMAP) is a global technical assistance program jointly sponsored by UNDP, the World Bank and bilateral donors. ESMAP programs focuses on pre-investment activities to complement the work of other development and private institutions. Of the average US$8m per year expenditure, some 80% is public donor funded and the remainder from the Bank. ESMAP Program goals are orientated towards:

- Facilitating access to energy services by the unserved or underserved
- Promotion of efficient energy markets
- Ensuring environmentally sustainable energy services

ESMAP activities have substantially expanded the range of renewable energy investment operations entering the World Bank's project pipeline. They have succeeded in introducing innovations in renewable energy lending such as the solar PV concession systems for Argentina.

A market-building concession in Cape Verde, through a combination of public and private sector interests is proving successful. ESMAP-financed micro-PV lantern demonstration projects in Africa are successfully attracting private sector provision of energy services to the very poorest consumers. Their program in Bangladesh – "Women in renewable Energy" is designed to mobilise women in the design and delivery of creating a valuable source of employment for women. (http://www.worldbank.org/esmap/).

The Asia Alternative Energy Program

Located in EASEG (East Asia & Pacific Energy & Mining sector), The Asia Alternative Energy Program (ASTAE) was established in 1992 to promote renewable energy and energy efficiency in the World Bank's power sector lending operations in Asia. Emphasis is placed on project support, economic/policy work, capacity building, training, resource mobilisation targeting Bank staff and client countries. Program goal: To mainstream alternative energy – Bank staff and borrowers routinely consider and adopt the use of alternative energy in meeting rural and urban energy needs

Since its inception, ASTAE has supported a broad portfolio of alternative energy projects and activities throughout Asia. The cumulative pipeline of ongoing and prospective alternative energy projects (FY93-00) is about US$1.2 billion in 31 Bank/GEF loans and grants in 10 countries. Renewable energy projects will involve the installation of over 0.7 GW of environmentally sustainable electricity generation capacity, while ongoing and proposed energy efficiency projects will offset more than 0.8 GW of capacity. (http://www.worldbank.org/astae/)

Prototype Carbon Fund

A post-Kyoto financing option, the Prototype Carbon Fund (PCF), is also under preparation by the World Bank. The PCF will be similar to a closed-end mutual fund. Its objectives are to supply high quality carbon offsets at a competitive price, and to ensure that buyers and sellers of offsets receive a fair share of the value added. The negotiated price of the carbon offsets would cover the cost of additional emissions reductions measures over the baseline technology as well as a margin representing equitable benefit sharing between the investor and host, of the gains from the offset. Final approval of the Fund will depend on the pace of the post-Kyoto discussions. (http://www.prototypecarbonfund.org/)

Renewable Energy and Energy Efficiency Fund
The IFC's Renewable Energy and Energy Efficiency Fund (REEF) is expected to be the first global fund dedicated to investing in private sector renewable energy and energy efficiency in developing countries. Now in fund-raising mode, the fund will provide $150-210 million of private and IFC capital for financing on/off-grid projects of less than 50MW. (http://www.ifc.org/russianleasing/test/enviro/How/Structure/EPU/Renewable/REEF/reef.htm)

The Photovoltaic Market Transformation Initiative
The Photovoltaic Market Transformation Initiative (PVMTI) is now in its final stages of preparation by IFC. This $30 million GEF fund will be used to accelerate the growth of PV markets in India, Kenya, and Morocco by providing leverage to private companies on a competitive basis.

The IFC has been very active in the promoting the use of photovoltaics through the five key projects and funds: Photovoltaic Market Transformation Initiative (PVMTI), SME Program, Solar Development Group (SDG), CEPALCO PV Project, and Renewable Energy and Energy Efficiency Fund (REEF). Each of the projects and/or funds is summarized below.

The IFC/GEF Photovoltaic Market Transformation Initiative

The goal of PVMTI is to accelerate the commercialization and financial viability of PVbased energy services in three countries: India, Kenya and Morocco. It has been operational since July 1998, although the concept was in formation for 34 years beginning with a meeting with key PV market players in 1993. PVMTI is utilizing US$25 million in GEF funds to provide concessional financing to local PV businesses on a competitive basis. Entrepreneurs also receive assistance with business plan development as needed, following which they could become solid candidates for concessional financing. The initiative can provide debt, equity or guarantee to project sponsors, which are likely to be companies that target sales and/or leasing, distribution, installation, and service of PV equipment in a variety of different applications. IFC may choose to coinvest with PVMTI in selected commercially viable projects.

The total project investment expected to result from PVMII is estimated at US$90120m. PVMTI approved its first investment in October 1999 in Shri Shakff Alternative Energy Technologies Ltd. (SSAET). SSAET will establish a network of over 300 Energy Stores in South India, Orissa and major towns in northern India to sell consumer products based on PV and other alternative technologies PVMTI will invest US$2.2 m in SSAET as a loan, equity and a grant. For more information on PVMTI click here or on the PVMTI button on the left.

The IFC/GEF SME Program

In addition to PVMTI, IFC's Environmental Projects Unit has been using GEF funding to support offgrid PV enterprises through the IFC/GEF Small and Medium Scale Enterprise Program (SME Program). The SME Program funding, totaling US$20.8 million, has been provided by the GEF with IFC acting as the executing agent to provide concessional loans and technical assistance as needed. One of the objectives of the SME Program is to stimulate greater involvement of private sector small and medium enterprises in investment activities in GEFeligible countries with the potential to costeffectively reduce emissions of greenhouse gases. To that end, EPU has earmarked roughly US$5 million in funds for possible PV projects and to date the SME Program has invested a total of US$1.6 million through financial intermediaries in three rural PV electrification projects: Soluz Dominicana, Grameen Shakti in Bangladesh and SELCO-Vietnam. For more information on the SME Program click here or on the SME Program button on the left.

The Small and Medium Scale Enterprise Program

The Small and Medium Scale Enterprise Program (SME) is a $21 million activity of IFC supported by GEF. It finances biodiversity and/or climate change projects carried out by small and medium scale enterprises in GEF-eligible countries. Contingent, concessional loans are provided to financial intermediaries (FIs). These FIs then finance the SMEs. Two PV projects and one efficiency project have been approved to date.

Solar Development Corporation

The Solar Development Corporation (SDC) is an initiative of the World Bank, IFC and various Foundations. The primary objective of the SDC is to accelerate the development of viable, private-sector business activity in the distribution, retail and financing of off-grid PV applications in developing countries. Up to $50 million in capital is targeted for SDC which, in addition to financing, will also make business advisory, training and market development services available to solar entrepreneurs.

The primary objective of SDC is to accelerate the development of viable, private-sector business activity in the distribution, retail and financing of off-grid PV applications in developing countries. SDC would focus on PV activities for household and productive purposes, seeking to make investments in new or existing private-sector firms with sound business plans operating in markets with growth potential.

The strategy has five main features:

- Investments would be made in PV-related businesses throughout the developing world. Early investment would mainly focus on existing companies and deals. In time, the approach would incorporate generating a robust pipeline of projects.
- SDC would provide investment funds and technical assistance in the form of business advisory services (BAS). Equity and concessional financing would be used to fund the investment fund while grant funding would be required for BAS. Returns on the investment fund's overall portfolio are expected to be below commercial levels, with a projected pre-tax IRR of 11percent. However, it is envisioned that concessional funding will be used to leverage private sector returns in the investment fund.
- SDC would minimise costs and risks by ensuring that best practice gained from earlier investments was adopted. Through experience and specialisation it would seek to reduce transaction costs and help manage risk.
- SDC would be an independent commercial entity. Its start-up or pilot phase would be for five to eight years, during which SDC's prospects for long-term sustainability could be assessed.

The ability of SDC to nurture businesses would be enhanced by creating non-preferential links between SDC and the World Bank. The World Bank would undertake to assist in developing a donor consultative group on PV market development with a view to establishing a 'Code of Conduct' for donor-supported PV operations. SDC would also have a tie in to the Bank so that policy issues relating to PV market development could be highlighted and raised in the course of Bank dialog with its clients.

Appendix III - World Bank Pipeline Project

Region	Country	Project
Latin America	Brazil	Biomass Power
	Mexico	Hybrid Solar Thermal Power
	Mexico	Methane Gas Capture
	Mexico	Off-Grid RE
	Nicaragua	Off-Grid LIL
	Peru	Rural Electrification
Europe	Armenia	Geothermal Development
	Croatia	Renewable Energy Resources
	Hungary	Szombathely Biomass Energy
	Hungary	Szekesfeherver Biomass Energy
	Kazakhstan	Wind
	Slovak Rep	Geothermal for Kosice DH
	Slovenia	Carbon-Based Loan Expansion
Africa	Benin	Decentralised Rural Energy
	Cameroon	Rural Energy
	Cameroon	Household Energy
	Ethiopia	Rural Energy
	Guinea	Rural Energy
	Kenya	Low-cost Electrification Alternatives
	Mali	Household Energy and Universal Access II
	Mozambique	Rural and Renewable Energy
	Mozambique	Rural Energy Development
	Nigeria	Rural Energy
	Senegal	Rural Electrification
	Togo	Decentralised Rural Energy
	Uganda	Energy for Rural Transformation
	Uganda	Rural Energy
	Zimbabwe	Rural Energy
South Asia	Bangladesh	Power Reform
	India	UP Water Sector Restructuring
	India	Solar Thermal
	India	Renewable Energy III
	Nepal	Power Development
East Asia Pacific	Cambodia	Rural Electrification and Transmission
	China	WB/GEF Renewable Energy Scale-Up

	China	Passive Solar Rural Health Clinics
	Philippines	Rural Electrification
	Philippines	Grid PV Distributed Utility Pilot Plant
	Thailand	Kamphangsaen Landfill Gas Utilisation
	Vietnam	System Efficiency Improvement
	Vietnam	Rural Energy II
	Vietnam	Geothermal Power Plant

Appendix IV Barriers to Renewable Energy and Possible Solutions

Market BARRIERS	POSSIBLE SOLUTIONS
Inadequate/Lack of Pre project Planning	• Establish a project planning framework • Identify development/electrification priorities for communities • Assess renewable energy resources/limitations • Understand socioeconomic circumstances/factors • PREPARE PROJECT CONCEPT PAPER - AND REVISE • Assess local skills and community resources • Assess local institutional support (eg NGO's) • Derive sustainable growth path • Design renewable energy system • Undertake economic and financial feasibility analysis • Generate project proposal
Lack of suitable financing mechanisms	• Encourage the development of more appropriate financing systems • Assist in training bank/NGO staff • Reduce transaction costs • Charge commercial rates of interest • Establish deposit facilities • Provide poorer sectors of communities with financing mechanisms • Make more funding available to small lending institutions • Undertake studies into methods of financing, also learning from other sectors
Policy and price distortions	• Encourage governments and utilities to act to reduce subsidies on fuel • Encourage the reduction of import tariffs (as applicable), reduction of subsidies, and the inclusion of life-cycle and environmental costings for all energy generation technologies
Incorrect project costing	• Allow adequately for recurrent costs in PV projects
Lack of knowledge about PV	• Major information dissemination, promotion and demonstration activities, closely targeted to particular types of decision-makers from government agencies and NGO's. Conduct public awareness campaigns on PV.
Disregard of the PV option or preference for large scale centralised projects	• Raise profile through information dissemination, promotion and demonstration • Information exchange with other organisations who have implemented PV options
Lack of integrated resource planning	• Facilitate inter-sector discussions through workshops, seminars and informal meetings
Short time horizons	• Realistic/longer project and time scales for development of the market, support industry, R&D activities and economic pay-backs
Structure of donor programmes	• Untie project lending • Decentralise country activities
Inadequate programme structures	• Clearly define in project document what organisational responsibilities will be, especially with regard to training, installation, maintenance and repairs. This includes financial responsibility as well as organisational details
Lack of electric utility involvement	• Encourage information, promotion and demonstration campaigns tailored for utility applications of PV • Exchange of information between utilities with PV programmes and those without
Regulations	• Information activities closely tied to the implementation of regulations in other countries and areas
Donor and NGO involvement	• Facilitate the transfer of up-to-date information to and from these organisations, through workshops, seminars, publications and training sessions
R&D versus marketing	• Assist governments and other institutions (as well as private organisations and NGO's) to compile and undertake well-rounded programmes which include adequate provision for marketing activities
Quality control of products and services	• Set up methods of product assessments programmes • Specify product performance in programme document/tender specifications
Lack of service infrastructure	• Specific programme structure component to set up local infrastructure
Operation and maintenance issues	• Ensure adequate provision for operation and maintenance costs, including appropriate infrastructure set-up to act for installation, maintenance, repairs, supply of equipment and training of local technicians and users

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Stand Alone Renewable Energy Systems

Government Support for Stand Alone Power Systems in Western Australia

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ABSTRACT

This paper provides an overview of Government support for stand-alone power systems in WA. It begins with a background to electricity supplies in remote areas of the State and the demand for stand-alone power systems. A range of Commonwealth and State programs providing financial assistance for the development and installation of renewable energy based stand alone power systems are described, including the Renewable Energy Remote Area Power Supply Rebate scheme, the Alternative Energy Development Board, the Photovoltaic Rebate Program, the Renewable Remote Power Generation Program and the Renewable Energy Commercialisation Program. The objectives and operation of these programs are summarised, along with the outcomes of programs that have been in operation for some time.

ELECTRICITY SUPPLY IN REMOTE AREAS OF WA

Western Australia is a relatively large State for a population of nearly two million and as such there are widely dispersed demands for electricity supply. Electricity generated from coal and gas fired power stations is provided to consumers in the southwest region of the State via the South West grid. In the Pilbara region gas fired power stations provide electricity to a number of towns and mining operations via a local grid. Outside of the areas covered by the South West and Pilbara grids there are numerous towns, communities, homesteads and businesses that rely on stand-alone power systems for electricity supplies.

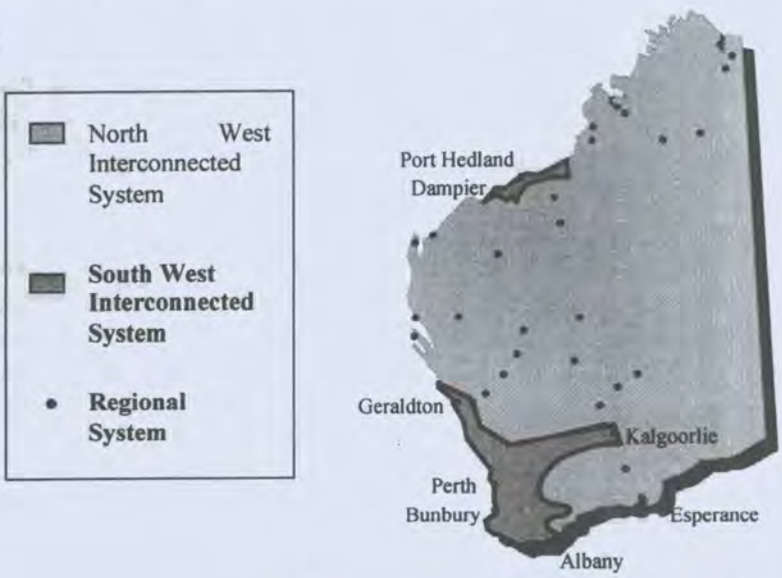

Figure 1. Major electricity supply infrastructure in WA

Western Power, the State owned electricity utility, currently provides power to 27 towns in remote areas. Diesel based power stations are generally used and the cost of generation is much higher than on the South West and Pilbara grids. However, the State Government's uniform tariff policy means that most consumers in these towns pay the same amount for their electricity as do consumers on the two main grids and so the second group effectively subsidises the first. The State is currently conducting a Regional Power Procurement Process, through which private power producers can bid to supply electricity to these remote towns, with the aim of reducing the cross subsidy.

There is a substantial amount of mining activity in WA and many mine-sites and associated facilities and communities are too far from the two main grids to make connection viable. However, unlike generators to the public, primary producers receive rebates for excise paid on diesel used for electricity generation and so fuel costs are effectively around 40% lower.

Approximately 230 indigenous communities, mostly located in the Goldfields, Pilbara and Kimberley regions of the State, do not currently have access to a public electricity supply. In the 50 or so larger communities (with populations in excess of 50), community operated diesel power stations are generally used. In the smaller communities diesel or petrol generators are commonly used to supply individual households. At present less than 10% of smaller communities use renewable energy systems and around 5% have no electricity supply.

Outside of the groups listed above there are 512 pastoral stations, numerous small business operations, other small communities and around 1500 individual households that rely on stand-alone power systems. Diesel or petrol generators are typically used and the cost of generation is high to very high. Furthermore, generators are often run for only a limited time each day, outside of which no electricity is available. While the use of inverters, batteries and renewable generation sources such as photovoltaic (PV) modules and wind turbines can provide a more cost-effective and higher quality supply, in 1991 a survey revealed that less than 10% of pastoralists utilised these components in their power systems.

FUNDING PROGRAMS FOR RENEWABLE ENERGY POWER SYSTEMS

Three main barriers to the use of renewable energy systems in remote areas were identified in a 1991 report, being high initial capital cost, lack of confidence in their performance and lack of service for maintenance. Further to this, up to 1996 subsidies were still available for primary producers in WA to purchase diesel generators. In 1993 the Commonwealth introduced the Renewable Energy Promotion Program with the aim of increasing the acceptance of renewable energy systems. This program provided subsidies for demonstration systems serving households, but only 16 systems in WA received funding and the overall impact of the program was limited.

Renewable Energy Remote Area Power Supply Rebate Scheme

The State Government introduced the Renewable Energy Remote Area Power Supply (RERAPS) Rebate scheme in September 1996 to assist people living in remote areas to obtain renewable energy based power supplies and to provide a boost to the local industry. Rebates of up to $8,000 per household were made available for renewable energy systems serving households where the cost to connect to a public electricity supply was greater then $50,000. Rebates were based on 75% of the cost of renewable generating and control components and 25% of the cost of batteries.

Since the introduction of the scheme up to the present 233 rebates with a total value of $2.3m have been paid for 184 systems serving 301 households. This has resulted in the installation of 182kW of PV capacity, 24kW of wind turbine capacity, 590kW of inverter capacity and 4810kWh of battery capacity. Over 70% of systems have been installed on pastoral stations, with remaining systems installed to serve individual households near remote towns and households in the southwest region.

A survey of rebate recipients was conducted in December 1998 and this revealed a high degree of satisfaction with renewable energy systems installed. Benefits identified by recipients included the availability of electricity 24 hours a day, the ability of to run fridges, freezers and other electric appliances and reduced maintenance and running costs. Comments included the following:
"Quite amazed, had been skeptical"
"The ability to get up in the night to a sick child and turn the light on without turning on the diesel generator is a great luxury"
"24 hour power has completely changed our life"

However, the survey also revealed some shortcomings of renewable energy systems, including problems with some components (mainly inverters and batteries), renewable generation components not supplying as much as expected, insufficient understanding amongst users of systems prior to purchase and claims made by some suppliers which users later found to be misleading. Many recipients said that potential users should gain a thorough understanding of renewable energy technologies and investigate claims made by suppliers prior to purchasing a system.

Photovoltaic Rebate Program

The Commonwealth's Photovoltaic Rebate Program (PVRP) commenced in January 2000 with the aim of encouraging the long-term use of PV technology and increasing the use of renewable energy in Australia. Other objectives are to reduce greenhouse emissions, assist in the development of the local PV industry and increase awareness of renewable energy.

Through the PVRP rebates of $5 per rated Watt of PV capacity installed are available for PV systems serving households and community buildings such as schools. Rebates are available for both grid-connect and stand-alone systems, but while PV systems are cost-effective for remote households, grid-connect systems typically have a simple payback period of around 20-30 years (even with a rebate and a favourable net-billing arrangement in place).

So far 84 rebates with an average value of $7,300 have been paid for 52 stand-alone and 33 grid-connect PV systems in WA. However, while PV systems are much more cost-effective in stand-alone applications than in grid-connect applications, it is the grid-connect PV systems and in particular some systems serving schools and other community organisations that have generated the greatest increase in awareness of solar energy amongst the general public.

Renewable Remote Power Generation Program

In 1999 the Commonwealth Government announced a new initiative, the Renewable Remote Power Generation Program (RRPGP), which would provide rebates of 50% of the cost of renewable energy systems replacing diesel generation off-grid. The objectives of this program are to help provide an effective electricity supply to remote users, assist in the development of the local renewable energy industry, help meet the energy needs of indigenous communities and lead to long-term greenhouse gas emissions.

Three programs were recently introduced in WA under the RRPGP providing rebates for renewable energy systems serving indigenous communities, businesses and households in remote areas. These programs will build on the success of the RERAPS scheme and some of the lessons learnt through its operation. New requirements have been introduced to help ensure that appropriate and good quality systems are installed, that suppliers are adequately qualified and can provide ongoing back up service, and that potential buyers have a greater understanding of renewable energy systems and their own electricity needs.

RRPGP funding programs are also available for industry support programs, such as training and education, which increase the capabilities of the local renewable energy industry and increase understanding amongst users and potential buyers of systems. These programs are seen as being important in ensuring that systems installed with RRPGP rebates remain operational in the long term and that renewable energy systems are continued to be used beyond the program.

SUPPORTING THE DEVELOPMENT OF RENEWABLE ENERGY SYSTEMS

While providing funding for renewable energy power systems is an effective way of supporting people in remote areas and developing the local renewable energy industry, the research, development and demonstration of technologies are also important means by which a wider acceptance can ultimately be gained. Through research and development new technologies may become available which can increase the viability of renewable generation. Demonstration of renewable energy systems allows potential users to gain a greater understanding of their benefits compared to established, usually fossil-fuel based, power systems.

Alternative Energy Development Board

The objectives of the State's Alternative Energy Development Board (AEDB) are to promote the use of renewable energy, encourage more efficient use of energy, assist projects providing benefits to the State's economy and improve understanding of renewable energy and energy management. These objectives are mainly achieved through the provision of grants for research, development and demonstration projects. Projects that have received funding include a renewable energy display and advisory service, an internet based information service with real time monitored data from an operating system, a mobile demonstration and training facility, a computer based simulation model for stand alone power systems, performance monitoring of three systems in remote areas of the State, an energy management training package for indigenous communities and numerous demonstration systems targeting a variety of groups.

Renewable Energy Commercialisation Program

The Commonwealth's Renewable Energy Commercialisation Program (RECP) provides funding for projects leading to the commercialisation of innovative renewable energy equipment, technologies and processes. One WA project that received RECP funding involved the installation of three wind turbines and an associated short-term energy storage and control system serving a remote town. This system allows the existing diesel power station to be turned off when sufficient wind energy is available, thus maximising fuel savings. This type of high penetration renewable system could be applied on a wide scale both within Australia and overseas, and Government support has resulted in the technology being developed and commercialized much sooner than would have occurred otherwise.

CONCLUSIONS

Electricity supply systems incorporating renewable energy components have the potential to provide economic, social and environmental benefits to people living in remote areas of WA. However, initial capital costs are high and understanding amongst users is less than for diesel and other fossil fuel based generators. Government support provides a means to address both of these barriers. Funding to help meet the capital cost of systems is an effective, though perhaps costly, way of increasing uptake and subsequently understanding. Programs to improve the viability of renewable energy systems and to educate potential users are also valuable in ensuring their long-term sustainability.

Renewable Energy Systems for Remote Areas in Australia

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OVERVIEW

This paper presents the results of an extensive field market survey detailing the use of renewable energy (RE) systems in remote area power supplies (RAPS) in Australia. 134 separate remote sites were visited encompassing over 350 separate power and water pumping systems. Remote sites involved in the study was limited to Indigenous communities, pastoral properties and tourist ventures Householders were questioned to ascertain their attitudes to renewable energy and the views of installation and maintenance people sought. Mail-out survey forms were sent to 1270 pastoral properties with 260 replies received.

A major conclusion from the data collected is that renewable energy systems, used as RAPS, are not maintenance-free. Any advertising to suggest the contrary is destined to harm the RE industry's credibility. Maintenance is mainly needed for the balance of system components and includes regular servicing and replacement of storage batteries. Costs for such maintenance are strongly related to the distance of the system from the nearest service centre. Lack of maintenance support for RE systems was one of the main complaints heard during the survey and is thought to be one of the major issues to be tackled to obtain a viable RE product in remote areas.

Overall the survey produced a wide variety of views on many topics related to renewable energy. Pastoralists viewed the high capital cost of RE systems as the main disadvantage, with the lack of reliable operation next in importance. Indigenous communities placed more stress on reliability. Education and training were perceived to be vital to the success of RE systems in remote areas. However, good on-the-ground examples of successful training packages were not apparent. Existing warranties for RE systems were not found to be consistently honoured. Demonstration systems were generally not thought to be the best way of transferring technology, and people resented being used as guinea pigs by having technology, that was in the process of development, lumped on them.

In general the smaller (less than 5 kW) renewable energy systems tended to be both more reliable and better received by the market than larger systems. RE powered water supply systems (solar bores and windmills) fared much better in terms of reliability than RE electricity supply systems.

The survey found that the range in market perceptions towards RE was considerable. There was, however, more opposition to RE than expected, and significantly, the consumer's attitude was often opposed to the industry view.

BACKGROUND

While over 85% of Australia's population reside in its major coastal centres, the remote regions of Australia are used for agriculture, mining and tourism, and are home to many of its Indigenous people. The provision of electrical energy over such vast areas is difficult and usually falls back to small individual systems for communities, homesteads and mine sites. Renewable energy has traditionally been seen as an economic option in such areas. To examine this view, a market survey of renewable energy applications in remote Australia was undertaken by the Centre for Appropriate Technology (CAT) as an Australian Cooperative Research Centre for Renewable Energy (ACRE) project.

The project began in early 1997 with a one-year paper study of electricity provision in Indigenous communities. By mid 1998 the project changed pace and moved on to intensive fieldwork and mail-out surveys. Three target sectors were identified: Indigenous communities, pastoral properties and tourist ventures. The fieldwork involved travelling many thousands of kilometres visiting remote communities representative of these three sectors in three states (WA, SA, and QLD) and the NT. The fieldwork, which included looking at individual case studies, lasted a little over one year and was completed by August 1999.

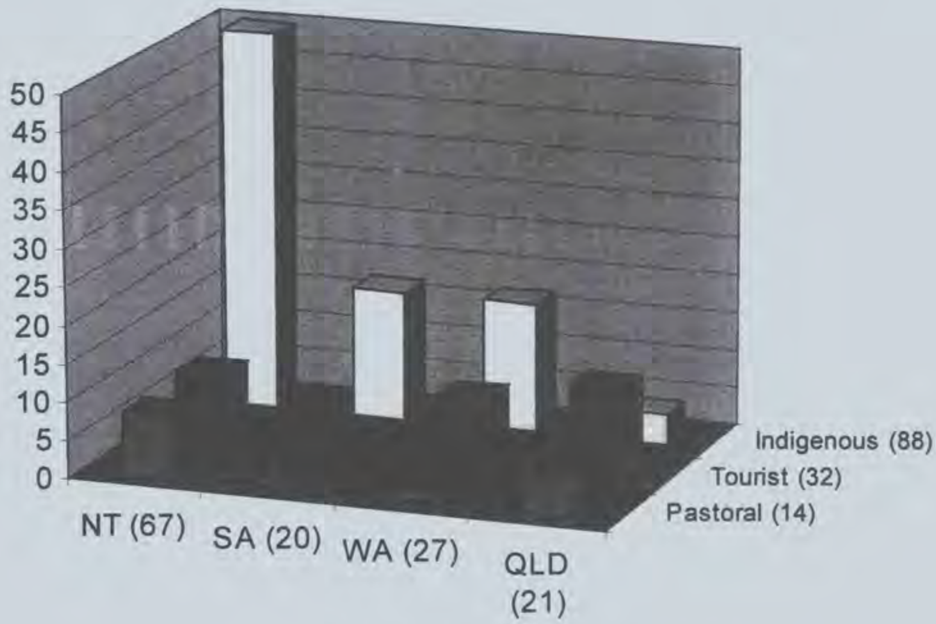

Figure 1 Site visits per sector and state/territory

For Indigenous communities the survey was centred on a database of around 1350 remote Indigenous communities which had previously been identified from existing studies completed mainly for ATSIC. Over 1270 pastoral properties were targeted for a mail-out questionnaire. This was from a total of approximately 1500 remote pastoral properties registered as pastoral leases Australia-wide. There was no existing database for the tourist sector, which consisted of roadside inns, tourist destinations and parks sites. This sector was thus surveyed using a wide variety of original sources of information.

The survey methodology used a selection of techniques including formal questionnaires, a mail-out survey, case studies, detailed physical examination, telephone interviews and journalistic style "ferreting out" of information. Individual field visits included a physical examination of the installed systems, photographs and interviews with the users. Roofs were climbed and the number of solar photovoltaic (PV) panels were counted and identified, batteries were checked and where possible voltages measured. In some cases logbooks provided a wealth of information. Operations of systems were checked by visual indication usually by making sure a load (such as a light or a refrigerator) was working. Solar bores were checked by overriding the storage tank float switches to ascertain a positive pumping action. This level of detail was necessary as in some cases we were assured that the system was working but on examining the system this was not the case.

People interviewed ranged from individual householders to community resource personnel. As a separate exercise, if the system suppliers could be found, they were queried on the details of the installation. The response from suppliers was erratic with some very cooperative and some wary both of owning up to failed systems and to giving away trade secrets on successful systems. In all cases considerable effort was given to ensuring that the surveyors were not seen to be biased either towards or against renewable energy. The survey sought unbiased opinions and thus any hint that we were for (or against) such systems would have influenced the responses. Obtaining unbiased opinions was in some cases very difficult, as a polarisation of interests was obvious.

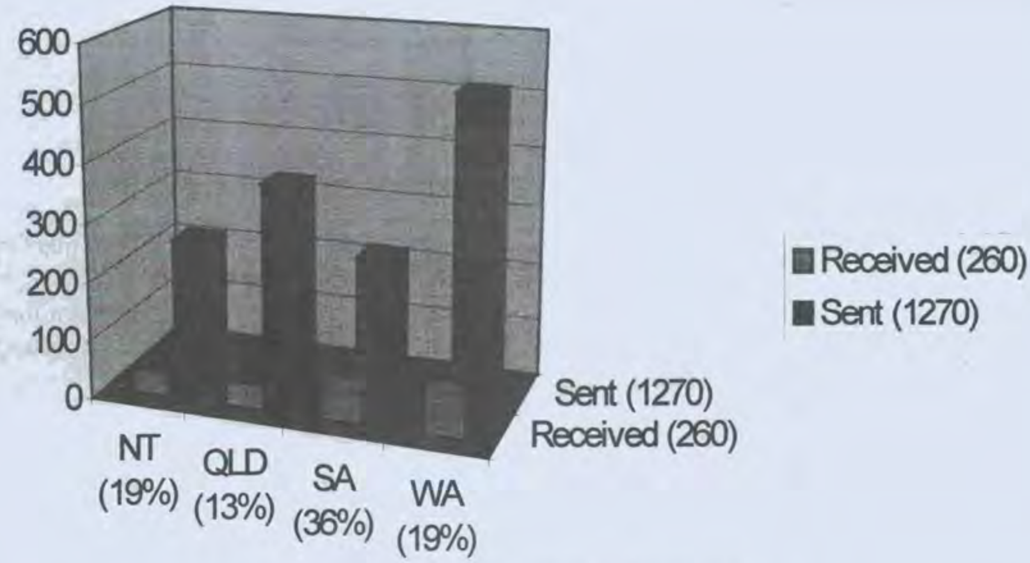

Figure 2 Pastoral properties mail out survey

By mid 1999 the project had visited some 134 remote sites, which included 195 separate power supply systems and 170 water supply systems. The sites for case studies were selected from the field survey sites that emphasised one or a range of significant issues relating to the project objectives. The mail-out survey produced some 260 replies from the pastoral sector (20% of those sent out). During the course of the project some 21 formal case studies were assembled.

RESULTS

Indigenous communities:

A total of some 88 Indigenous communities were field surveyed in northern WA, northern QLD, NT and northern SA. Typically the sites surveyed were small outstations consisting of between one and five houses; perhaps with a workshop and almost always with a bore water supply. The average number of inhabitants was 14 within a range from 3 to around 50. The sites were remote: the average distance to a regional centre was 280 km (ranging from 70 km to nearly 1000 km).

The total installed PV capacity on systems surveyed was over 243 kW coming from nearly 3400 panels. The average number of panels per house (for PV powered houses) was 8 giving around 0.63 kWp per house. A total of 2201 batteries were examined. In terms of battery types it was found that 67% of systems used flooded cells and 33% sealed, valve-regulated cells. Nine communities surveyed had a wind component as part of the renewable energy system and two communities had a battery system with no renewables.

The age of the renewable energy systems surveyed ranged from around 10 years to brand new. In many cases, however, it was not possible to accurately date the age of the systems. The survey showed that a little under two thirds (64%) of the RE systems were operational at the time of the visit. The percentage was about the same as that for small petrol gensets (67%) and somewhat worse than for small diesel gensets (79%). The situation for solar powered bores was much better with nearly 90% of systems operational at the time of the survey.

Analysis of the system faults at the time of the visit revealed that 28% of the sites experienced battery problems, 16% had inverter problems, 15% had control systems difficulties and 22% of systems had other (determined) failures. No discernible difference was found between wet cell batteries and the sealed, valve-regulated cell batteries in terms of reliability. In some cases no access could be had to control boxes or battery packs making determination of failures difficult or impossible. In addition it was found that some 61% of sites (including sites which had RE systems operating at the time of the visit) had experienced recent problems with the renewable component of the system. Only 9% of sites had experienced problems due to either vandalism or theft.

Respondents at 40% of Indigenous sites were happy with their renewable energy system. Complaints were heard that insufficient power was available at 36% of sites and there were suggestions of recurrent problems at 43% of sites. At 35% of sites respondents suggested that the maintenance situation was not satisfactory. It was noted on this latter point that only 26% of the systems were under some form of maintenance contract. Local persons were trained in the care of the systems in only 8% of cases.

It was clear that Indigenous communities generally placed a higher priority on function than on the use of renewable energy. Overloading of systems was found to be common due to frequent population changes within households and a high expectation of systems once installed. In general, awareness of energy conservation as a reason for having a renewable energy system was low in Indigenous communities with only 2% of householders or resource people suggesting that energy conservation was important. Similar numbers (2%) thought that environmental issues were important in choosing the type of system.

Figure 3 Map showing the main site visits

Pastoral properties:

The bulk of the information on pastoral properties came from the mail-out survey (260 replies from 1270 questionnaires), additional detail came from the individual site visits (14 visits) and follow up phone interviews (49 with RE systems and 12 with diesel-only systems). The mail-out survey suggested that on average each pastoral property incorporated 2-3 houses, providing accommodation for an average population of 5-6 people. Not surprisingly, the population of a pastoral property was found to vary significantly throughout the course of the year. The vast majority of properties for which responses were received were solely engaged in pastoral activities, specifically grazing. Some properties indicated that tourism activities and mining complemented their pastoral activities.

Diesel generators were given as the main source of electricity production on remote pastoral properties, with 85% of properties using diesel generators to produce at least a portion of their electricity. Diesel generators (ranging in size from a few kVA to over 500 kVA) were the sole source of electricity for 64% of respondents. The average diesel use for these properties for electricity generation was found to be 12,230 litres per annum for electricity generation. Diesel systems were perceived to be fairly reliable, though 30% of properties reported some form of power outage during the previous twelve months.

Systems incorporating RE technologies for electricity production were installed on approximately 21% of the pastoral properties that responded to the survey. The systems were generally a combination of solar-diesel, wind-diesel or solar-wind-diesel hybrid systems. Solar and wind in combination with diesel were the most commonly used RE systems on remote pastoral properties found during the survey. Two remote properties used small micro-hydro generators based on an artesian water flow. These figures show a considerable increase in usage of RE compared with similar a mail-out survey undertaken in WA in 1991.

Of the 49 pastoralists with RE who were interviewed by telephone, 67% were generally satisfied with the technology. Just over 12% expressed dissatisfaction with their systems while the remainder (21%) were ambivalent. With regard to outages the survey results tended to suggest that RE systems or hybrid systems were about as reliable as diesel-only systems. Of the pastoralists with RE (either stand-alone or hybrid) some 27% reported a power outage in the previous twelve months. The outage rate for diesel-only pastoralists was effectively the same, at 28%. The number of systems operational at the time of the telephone survey was quite high at 92% (only 4 systems non-operational according to the respondents).

Where there were problems, the most common reason for faults lay equally with batteries and inverters (23% of faults each). Battery problems included lifting terminals, overheated cells, cracked casings and other forms of physical deterioration. Wind turbine faults (19%) were also common. Problems with switching and regulators were also reported as well as individual pastoralists who reported problems with PV panels and solar-trackers. Batteries were regularly cited as the major source of unreliability, and the cost of replacing batteries was seen as an additional financial loading atop the initial capital outlay. The telephone interviews indicated that the average battery life was of the order of 4.5 years.

The pastoral property sector considered energy conservation to be a priority in the management of properties with most pastoralists seeing energy conservation as a necessary aspect of life in remote areas.

Tourist sector:

Overall data for this category was somewhat sparser than that from the other two categories because of a dispersed and not easily contacted set of establishments. Some data was collected from Parks and Wildlife organisations and from miscellaneous sources. No mail-out survey, however, was possible for this sector, as no central database of organisations was located.

Figure 4 Contrasting views in the Daintree. In the more remote areas surveyed, pragmatism and utility were more prevalent than slogans.

A total of 32 tourist and other sites were visited as part of the project. Of these 19 had renewable energy systems of which 16 were working at the time of the visits. The failure rate for RE systems within tourist and other operations was lower than that found for Indigenous communities and comparable to that for pastoral properties, however, 50% of the sites reported recent problems with the RE component. 19% of systems had experienced recent battery problems, 34% problems with inverters and 22% with control systems. Energy conservation and environmental issues were much to the forefront (as might be expected within the tourism industry) with 66% suggesting that such issues were important. 72% of the establishments considered that they had an effective maintenance regime in place and 50% of the sites had staff that were trained in the care of the systems. The types of systems included youth camps, holiday cottages and ranger stations. The sector also included some of the largest RE systems examined including the 150 kW wind turbine at Coober Pedy and the 100kW peak solar PV array at Wilpena Pound.

SUMMARY

The penetration of RE into both pastoral properties and Indigenous communities was found to be similar at 21% and 20 % respectively. The penetration of RE systems in the tourist sector was not ascertained. The number of systems operational in Indigenous communities at 64% was found to be quite a bit lower than for pastoral properties (between 83% and 92%) and tourist operations (82%). As might be expected the satisfaction with the RE systems for Indigenous communities was lower at 40% compared to pastoral properties at 67%. The incidence of recent problems with the systems was, however, remarkably similar with 43% of Indigenous communities and 39% of pastoral properties complaining of recent difficulties. The causes of failures too were similar with between 20% and 30% of problems attributable to batteries, and between 23% and 56% to electronic problems. A large difference was obvious in attitudes to energy conservation with only 2% of Indigenous communities thinking that energy conservation was important compared to around two thirds of the respondents from the pastoral and tourist sectors.

Demand patterns with regards to end use technologies in remote areas were similar to urban environments. This was true of Indigenous communities, pastoral properties and most tourist establishments. The demand for energy efficient appliances was not significant, probably because in most cases the subsidised cost of electrical power in remote Australia meant that the real cost of generation is not reflected in the consumer's electricity bill.

Ascertaining the real perceptions of the market towards RE was obviously tricky as it involved interpreting highly subjective comments and views from a relatively small sample of users. Nevertheless it is one of the key outputs of any market research and so it is presented in the report in some detail. As a further complication, once the data showing some of the problems associated with RE in remote areas accumulated (and extracts of it published), an industry reaction occurred which suggested, at one point, that the ACRE/CAT survey was biased against the industry. A distinct contrast was found with attitudinal information gathered from coastal fringe areas (particularly the east coast of Australia), peri-urban areas and areas that are often close to a major centre. In such areas energy conservation priorities are often seen as more important and users of RE systems often do so for ethical reasons as well as necessity.

Overall the survey produced a wide variety of views on many topics related to RE. Pastoralists thought that the high capital cost of RE systems was the main disadvantage, with the lack of reliable operation next in importance. Indigenous communities placed more stress on reliability. Education and training were perceived to be vital to the success of RE systems in remote areas, however, good on-the-ground examples of successful training packages were not apparent. Existing warranties for RE systems were not found to be consistently honoured. Some method of implementing a system of warranties that would be both fair to the consumer and to the supplier was thought highly desirable. Demonstration systems were generally not thought to be the best way of transferring technology with people resenting being used as guinea pigs by having technology that was often in the process of development, lumped on them. Lack of maintenance support for RE systems was one of the main complaints heard during the survey.

While the survey found that the range in market perceptions towards RE was considerable, there was, however, more opposition to RE than expected, and significantly, the consumer's attitude was often opposed to the industry view.

Failures in the electronic control systems and inverters tended to dominate recurrent maintenance problems while battery failures were found to be the most common final reason for system failure. Although around two thirds of systems had wet cell batteries, the failure rate for wet and sealed, valve-regulated cells were approximately equal. The observed electronic control/inverter systems tended to have high component counts, often in several discrete boxes from different original manufacturers. The great number of different systems that were observed during the field studies was found to lead to a low level of both operator and maintenance technician familiarity. For the larger systems, maintenance and problem solving had to be referred to the original manufacturer or a regional supplier. The conclusion from this plethora of electronic options is that there is a need for the renewable energy industry to produce standardised, reliable, user-friendly designs.

WHERE TO FROM HERE?

The survey information was analysed in terms of the outputs expected by the originally envisaged project. The main area not covered was that of a formal examination of the economics of RE in remote locations. While some information was gathered on actual system costs, particularly as part of the case studies, it was felt that this area should be looked at in more detail. The one point that was obvious from the study was that transport costs tended to dominate overall system economics in remote areas.

The analysis of relevant information points to several directions that the industry should take to both gain better penetration of, and better serve the interests of, the Australian remote area power market. A successful resolution of the problems identified will better position the Australian RE industry to gain greater access to the international RAPS market. The challenges are identified below together with some future tentative directions that need to be developed into a strategic plan.

***High capital cost of RE**: Innovative schemes are needed to finance capital costs (some such financing schemes now exist or are in the pipeline e.g. Australian Greenhouse Office subsidies). This challenge for RE is well known and mostly covered elsewhere. Some cost reduction in balance of system (BOS) components might be realised by tackling the second challenge below.*

***Poor reliability of RE in remote locations:** There is a need for product innovation focussed on reducing component count, developing "standard" systems, increased use of third party, accredited testing laboratories and improved quality control during manufacture. Feedback to industry is also needed to highlight product deficiencies. The development of standard systems should lead to increased production volumes and hence decreased production costs.*

***Lack of effective trained personnel to maintain and service RE systems:** There is a need for improved education programs and improved accreditation of installers for remote areas: Some programs are being developed in this important area eg. ACRE training program, CAT program and TAFE programs.*

***Lack of back up for RE systems in remote areas (especially Indigenous communities:** There is a need to establish a dedicated service for Indigenous communities. Flow on could be expected to other sectors.*

***Lack of information regarding RE capabilities and availability:** There is a need to establish a national clearinghouse and database. Particular emphasis should be given to distributing information on reliability.*

***Demand management problems:** There is a need for consumer education on demand management, development and manufacture of high efficiency end use devices, electronic control solutions for managing demand and looking at demand management and household energy use as a whole.*

***On the mismatch in perceptions between the industry and the market:** There is a need to continue objective market research and to keep a close watch on consumer attitudes, in particular to emphasise reliable first hand information.*

ACKNOWLEDGMENTS

The market survey covered a large area and visited many communities throughout remote Australia. The assistance of the communities, organizations, and individual homesteads is gratefully acknowledged. It is hoped that the results of the survey will lead to improved supply of energy services to these important remote area locations. The Australian Cooperative Research Centre for Renewable Energy (ACRE) funded the project work. Additional support in terms of provision of databases, information and logistics was received from the Aboriginal and Torres Strait Islander Commission (ATSIC), the Centre for Appropriate Technology (CAT) and many others. Michelle Guelden worked on the project in the initial stages and was responsible for the early database formulation.

Monitoring and Evaluation of Stand-alone Renewable Energy Power Supply Systems

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ABSTRACT

A large number of renewable energy projects have now been undertaken around the world, and many individual systems have been installed, but the reliable, ongoing monitoring and evaluation of these systems has been much more rarely undertaken. In most cases the results and data that are collected are not readily available to the wider renewable energy community. The widespread availability of good quality data and information about the performance and reliability of a large number of renewable energy systems, and the long-term success of renewable energy projects is, however, vitally important to the development of renewable energy as a reliable and sustainable power supply source.

Ongoing monitoring and evaluation are very important components that should be considered in the design, funding and implementation of any renewable energy project. The valuable information gained from good, ongoing monitoring and evaluation can lead to both improved system, or project performance, and increased long-term confidence in renewable energy as a reliable power source. This talk will look at some aspects of the monitoring and evaluation of small to medium sized renewable energy power supply systems and projects. This will range from the sophisticated computer based performance monitoring of a large number of performance parameters on a medium sized system to the monitoring of basic data on small solar home systems in a remote village.

Three examples of the monitoring and evaluation of renewable energy systems or projects will be briefly discussed. One of these is the computer based WebRAPS system that collects real-time and historical performance data from a demonstration household sized system in Perth and displays it to anyone in the world via the Internet. The other example is a data logger based system that collects data according to the Photovoltaic System Performance Monitoring International Standard IEC 61724 from a small community sized system in a remote area.

The third example will look at the monitoring and evaluation of renewable energy projects in developing countries using a case study of solar home and street lighting systems in the remote village of Sukatani in Indonesia. This will include a discussion of the methods used for the data collection and analysis of the performance of the systems, the success of the project and some of the lessons that can be learnt from this.

INTRODUCTION

A large number of renewable energy projects have now been undertaken around the world but reliable long-term monitoring and evaluation of systems is still rare and performance data collected is usually not readily available to wider renewable energy community. Easy access to performance data from good, reliable renewable energy systems can greatly build confidence in the technology amongst potential users. Good ongoing monitoring and evaluation can lead to improved system or project performance on the individual system, and increased long-term reliability in the renewable industry as a whole. Good, shared, data is needed for research and simulation purposes. Quantifiable mitigation will become necessary for GHG protocols, including Clean Development Mechanism (CDM) and Action Initiated Jointly (AIJ) projects. One recent example of an AIJ project developed between Australia and Mauritius required monitoring of the system performance as an integral part of the project. Further details about this project can be found at http://www.solarsales.com.au/monitor_main.html.

Most funding bodies are very willing to fund hardware and installation, but are rarely willing to fund the monitoring and evaluation needed to assess the ongoing, long-term performance and effectiveness of the system. Ongoing monitoring and evaluation are important components that need to be considered from the beginning when designing and funding any project. Monitoring ranges from sophisticated computer based monitoring of medium to large systems to basic data collection from small solar home systems in remote villages.

This seminar paper looks at 3 examples of the monitoring and evaluation of renewable energy systems and lessons that can be learnt from them. They are:

1. A sophisticated computer and internet based system collecting data from a demonstration household system in a major city in a developed country
2. A data logger based system collecting data according to the IEC international standard from a small community sized remote area system in a developed country
3. Monitoring and evaluation of solar home and street lighting systems in a remote village in a developing country (Indonesia)

WEBRAPS INTERNET BASED SYSTEM AT MURDOCH UNIVERSITY

Murdoch University's Energy Research Institutes remote area power supply (RAPS) display aims to inform the community, particularly people in remote areas about the cost, performance and reliability of renewable energy systems. It allows access to an operating RAPS system and a technical advisory service. The display demonstrates available renewable energy technologies and various system options. Visitors interested in solar and wind power can both view and interact with the systems. It consists of two rooms powered completely by the sun and wind.

The "Typical modern home system" is a 48 V stand alone system representative of systems used in modern remote country homes, or households with modest energy needs. A 1.2 kW solar array and a 1.8 kW wind turbine provide power. It has 240 V AC appliances such as a refrigerator, microwave and computer. More information about the physical system can be found at the website: **http://wwwphys.murdoch.edu.au/WebRAPS/** .

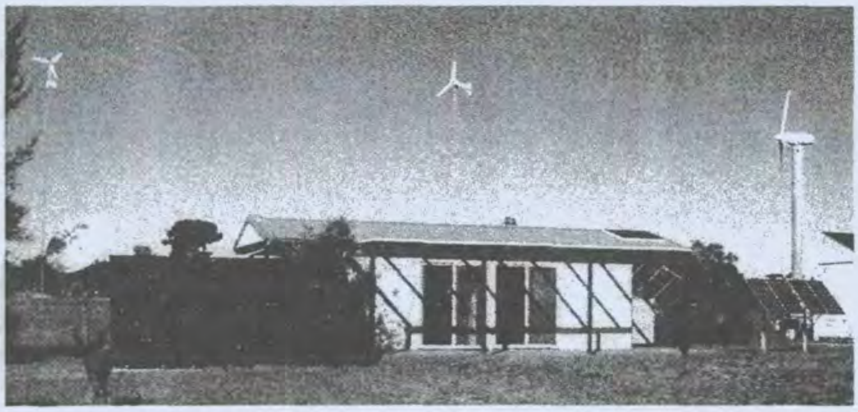

Figure 1: Picture of MUERI's renewable energy remote area power supply display.

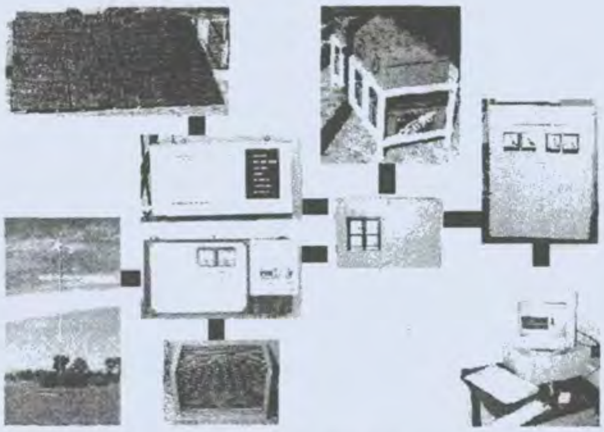

Figure 2: Schematic diagram of the 48-volt system in MUERI's renewable energy remote area power supply display.

Due to resource considerations, the physical RAPS demonstration site is only accessible by a limited number of people, and for limited amounts of time. As there is only one demonstration site in the metropolitan area it is not easily accessible to those in country areas. The increased accessibility available through the internet led the Australian CRC for Renewable Energy (ACRE) and MUERI to develop an internet based version of the physical site. WebRAPS, found at **http://wwwphys.murdoch.edu.au/WebRAPS/** makes the physical RAPS demonstration site available to a much larger audience, especially those in rural and remote areas, who are the most likely users.

A data acquisition system monitors the system performance automatically allowing analysis at a later date, or display in graphical or tabular form on the internet. The monitoring system uses an IBM compatible computer with a data acquisition card. Specially developed software collects the meteorological and system performance data, processes it and then passes the data, via an optic fiber network onto a web server that displays it. The full monitoring system with instruments cost about $AUS14,000 ($US7,800) for the hardware alone, not including the network or development of the software.

Figure 3: Schematic diagram of the interaction between the various components of the WebRAPS data monitoring and display system.

The monitoring and display system displays the major meteorological and system performance parameters in close to real time (each second), as well as historical data for each day and monthly averages. This enables visitors to the site from anywhere in the world to easily access the monitored data and view the performance of the system at any time, and to analyse its long-term performance.

Figure 4 shows typical output from the historical data section showing the 10-minute average PV array power output values from the monitoring system for a 24-hour period, in graphical form. From this data it is possible to gain valuable information about the day-to-day operation of the system. For example, the figure shows a sharp rise in the leading edge of the PV power curve, at some time after the smooth rise of the solar insolation curve. This effect, which is only, observed in the winter months, on further investigation is found to be due to self shading of the solar array due to the lower angle of the sun in the winter months. It can also be seen that the power curve does not follow the smooth, relatively symmetric, shape of the insolation curve, but is rather, jagged and more flattened. This can be traced to the batteries reaching a state of full charge, in which case the maximum power point tracker derates the solar array, meaning a loss in power generation.

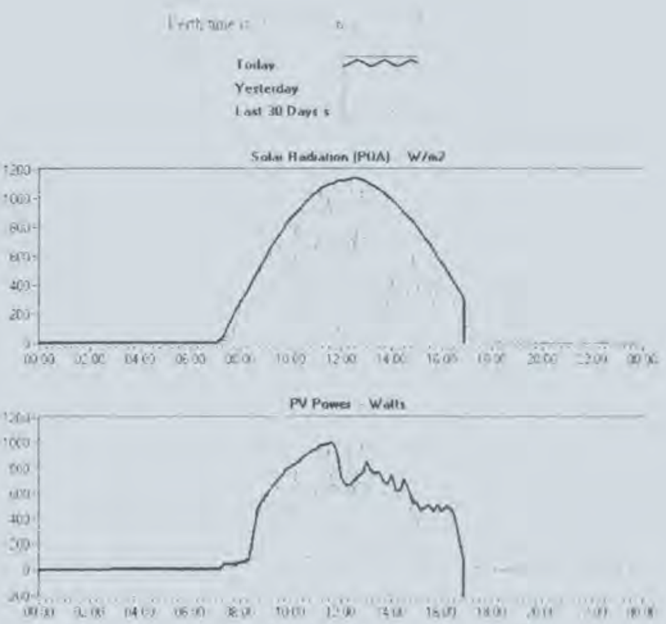

Figure 4: Typical output from the historical data section showing the 10-minute average PV array power output values from the monitoring system for a 24 hour period, in graphical form.

Figure 5 shows a plot of monthly average PV power, wind power and dumped power outputs from the system for an average year. This shows firstly that the solar resource for this site is better, and more reliable than the wind resource. More importantly it shows that, particularly in the winter months, when it is most needed, the system is dumping nearly half its wind power due to inadequate storage capacity in the battery bank. The usefulness of good monitoring for optimising system performance and learning more about the operation and effective design of stand alone renewable energy systems is clearly seen in these examples.

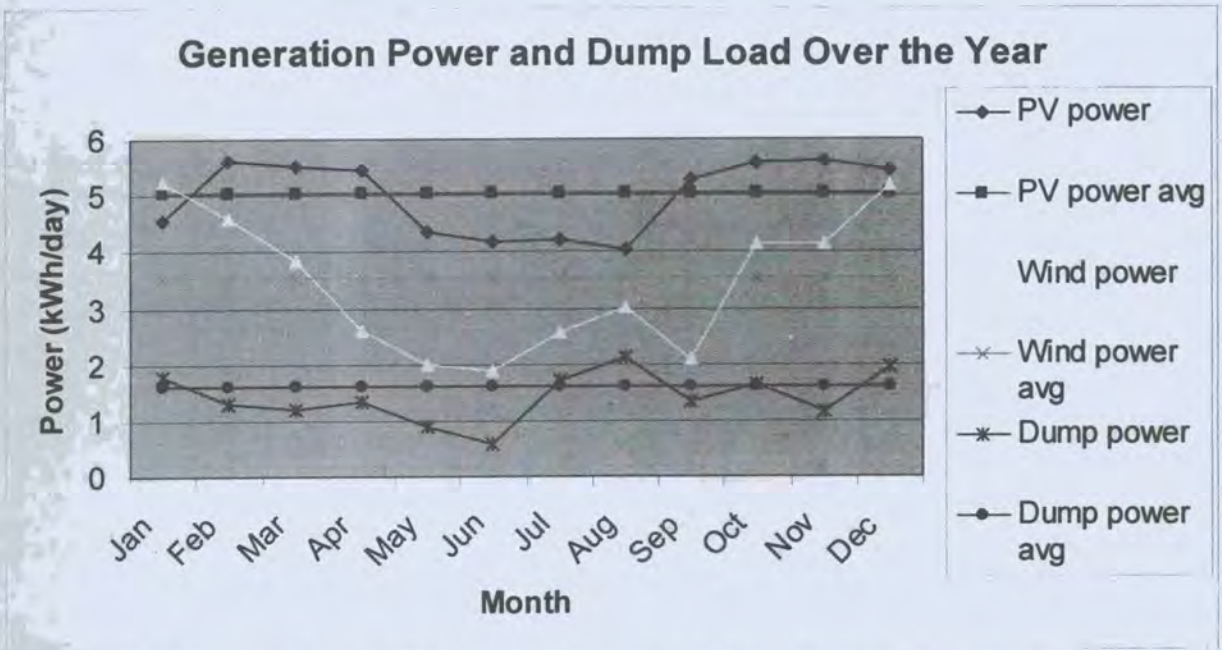

Figure 5: Plot of monthly average PV power, wind power and dumped power outputs from the system for an average year using the historical data from the WebRAPS site.

The WebRAPS system is an example of a relatively expensive monitoring system that is unlikely to be affordable in a developing country, where many of the potential users would also not have access to the internet to make use of the website. However as the use of the internet grows, sites such as WebRAPS in other more developed countries, or a similar site in the developing country, has the potential to greatly enhance the confidence of potential users who would not be able to visit a physical demonstration site. Many of these systems worldwide would also be a great benefit to researchers in both developed and developing countries for improving the performance of renewable energy systems. This potential has been shown in some of the comments left by visitors to the WebRAPs website, who have been from developed and developing countries.

> "A fine addition to on-line Wind Energy information. Good to see real data!"

> "'Real World' data can keep us from making the same mistakes many times over. Nice site mates."

> "Congratulations for the wonderful piece of work. The site provides vital information to most sustainable energy researchers especially for our developing African countries."

DATALOGGER BASED SYSTEM IN A REMOTE REGION OF WESTERN AUSTRALIA

The next example of a monitoring site is a remote pastoral station located in the Pilbara region in the north-west of Western Australia. The station supports about 12,000 head of cattle. The number of people living on the station varies seasonally and ranges from 3 to 20. The RAPS system (shown in figure 6) meets the energy demands of the homestead, the workshop and the surrounding buildings, and has a switched configuration.

Figure 6: Picture of a hybrid RAPS system on a remote pastoral station in Western Australia.

Figure 7: Pictures of monitoring system on the RAPS system on the remote pastoral station in Western Australia

A monitoring system, designed according to the International Standard IEC 61724 (IEC, 1998), was installed to assess the performance of the system in 1999. The international standard is designed to allow realistic standardised comparison with other systems throughout the world. A Datataker DT50 data logger is used to log ten-minute records of the maximum, minimum, and average values of various system parameters. The user exchanges the existing card with an empty new one every month returning the logged card to MUERI via post. This manual system has proven very reliable.

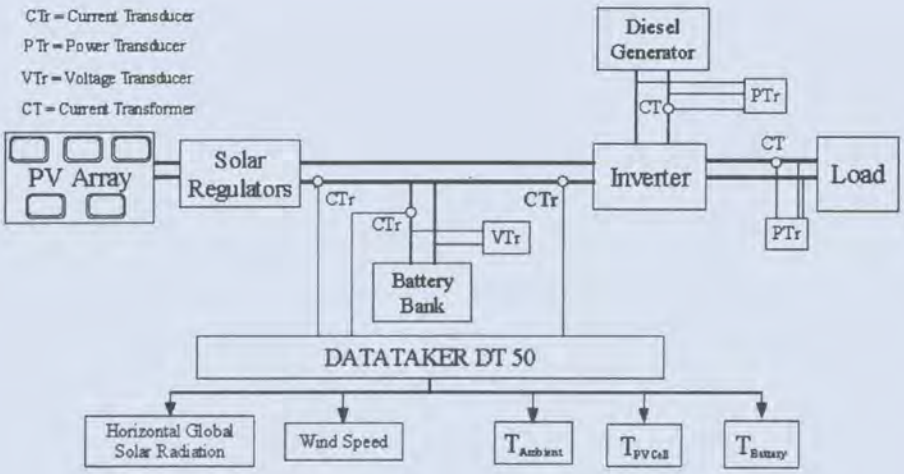

Figure 8: Block diagram of hybrid RAPS system showing the monitoring points for the electrical parameters.

The monitored data indicates that the hybrid system has performed extremely well over the 20 month period for which data is available. In this period, the system was shutdown for only 13 days and analysis of the data and comments from the site can be used to ascertain the reasons for any system shutdowns. Inverter faults caused the loss of a few days of data and a cyclone caused the loss of a few more days of data. Over the twenty-month monitoring period, 97.6% of the collected data was valid. The renewable energy contribution to the system output is 34.5%, which indicates the renewable component covers a good proportion of load. This monitoring has shown that:

- a well-designed hybrid power system can be a reliable and satisfactory power supply for remote area applications.
- it is possible to implement an international standard monitoring system on a remote hybrid power system.

A monitoring system such as this could be satisfactorily used to reliably monitor larger renewable energy systems to the international standard in developing countries, both grid connected and in remote areas.

MONITORING IN A DEVELOPING COUNTRY REMOTE VILLAGE - SUKATANI

In rural areas where no electricity grid is available, electricity can be supplied by small photovoltaic PV systems such as solar home systems (SHS) and street lighting systems (SLS). Despite the large number of SHS installed world wide, roughly 500,000 in 1996 [Lorenzo, E, 1997], only a few attempts have been made to investigate and evaluate the performance of this type of PV system in the field, for example [Aguilera and Lorenzo, 1996; Huacuz *et al.*, 1995; Schweizer-Ries and Preiser, 1997; Plas and Hankins, 1998].

Sukatani is a small village located 110 km southeast of Jakarta in Indonesia selected in 1987 for a pilot project with small PV systems. In November 1988, 86 solar house systems (SHS) and 15 street lighting systems (SLS) were installed. The Sukatani project stimulated the widespread use of SHS in Indonesia with an estimated 50,000 SHS installed in Indonesia from 1988 to 1996 [Reinders *et al.*, 1999].

Figure 9: Street lighting and solar home systems in the village of Sukatani, Indonesia.

The systems SHS systems initially consisted of 2 PV panels (40 Wp), 1 battery (100 Ah), 1 battery charge regulator and cables. The initial appliances (nominal power) were 1 strip light (10 W), 2 strip lights (6 W), 1 black and white TV (14 W), 1 radio (7 W) and 1 socket. The SLS initially consisted of 2 PV panels (40 Wp), 2 batteries (100 Ah/bat), 1 time control unit and cables. The load was 1 low-pressure sodium light (18 W).

When a household acquired the SHS users received training and an instruction sheet about usage and maintenance of their SHS.

The SHS are owned by the Agency for the Assessment and Implementation of Technology (LSDE-BPPT), who oversaw the project, and used by the villagers. The user had to pay a down payment and a monthly payment. This amounted to collective savings for new batteries and the payment of the KUD, the Village Cooperative Unit, for the management of the PV project. The user also pays for the replacement of fused or defective strip lights.

One year after the introduction of the PV systems the management of the project in the village became the responsibility of the KUD. A chairman, a secretary and a technician attend to the operation and maintenance of the PV units, the collection of the monthly fees ad the collective purchase of spare parts like strip lights, lamp-inverters and batteries. During the first 5 years of the project the KUD was supported by researchers from BPPT who during their monthly visits assisted with the maintenance of the PV systems.

The project was accompanied by a monitoring programme executed by the BPPT and PT R&S Renewable Energy Systems (Jakarta). The monitoring program had two parts. For the initial 5 years (1998 to 1993) it comprised measurements with data loggers and the establishment of periodic site surveys of technical and social aspects of the project. In 1997/1998 a later monitoring programme was conducted by Reinders *et al.* [1999]. It gathered reports and monitoring data recorded earlier and collected new data in the field by performing technical measurements on the PV systems and analysing questionnaires completed by SHS users.

Some of the major findings of the Sukatani monitoring and evaluation program as reported by Reinders *et al* [1999] were:

- In 1997, all of the PV arrays of the 62 SHS visited were in good order, agreeing with the general finding that PV generators rarely fail [Lorenzo, 1997].
- In 1997, 94% of the SHS had used up two batteries (replacement due to failure).
- After the initial 100 Ah batteries broke down they were replaced by locally produced car batteries with the majority (86%) of these having a capacity of 70 Ah. This adaptation in the system design was recommended by BPPT on the basis of the investigations of the monitoring data.
- The replacement of the original batteries by a smaller type, which is more strongly discharged, resulted in an improvement of the ratio of lifetime and costs.
- Mainly due to cost, villagers made their own incandescent lights with low power (1-5W), which have low luminous efficacy compared with the standard installed strip lights.
- In 1992 56% of villagers used extra wiring in their SHS, even though prohibited on the instruction sheet. In 51% of cases extra wiring was to add appliances and in 5% of cases to provided electricity to a second household. In 43% of these cases the extension had been executed in an amateurish manner that could cause the system to fail.
- The combination of the villagers own needs and financial capacity leads to a set of appliances other than those installed as standard, thus a broad range of system sizes and appliances may be more successful in meeting the users needs.
- Most of the 22 people interviewed in 1997 appeared to be pleased with the SLS in the village. About half the people interviewed were unreservedly positive about the SHS, whilst the other half reacted with conditional approval.
- Monitoring was done using modest equipment and the monitored data was useful for analysis of irradiation and current on a daily or longer-term basis. Easy and cheap monitoring in remote rural areas is however difficult.
- Due to deviations between real and narrated experiences a field survey that comprises only interviews may not be sufficient to assess a SHS project.
- If an accurate and reliable registration of appliance use is required then the power to each appliance should be monitored with a data logger.

SUMMARY

Easy access to performance data from good renewable energy systems can greatly build confidence in the technology amongst potential users. The widespread availability of good quality shared data on system performance and reliability is vitally important to the development of the renewable energy industry.

Ongoing monitoring and evaluation are important components to be considered from the beginning in designing and funding any renewable energy project.

Monitoring can range from sophisticated computer based monitoring of medium sized systems, to basic data collection from small solar home systems in remote villages using data loggers and surveys. Easy and cheap monitoring in remote rural areas is however difficult. Some monitoring is however better than no monitoring, but it should be well planned and implemented.

Valuable information about the operation of an individual system can be obtained to improve its performance. Information obtained and freely disseminated about the long-term reliability and performance of a large number of different renewable energy systems and technologies in many different counties and environments will ultimately strengthen the industry.

ACKNOWLEDGMENTS

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Energy Efficiency and Energy Management

Climate Sensible Building Design in the Tropics and Sub-Tropics

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ABSTRACT

The criteria commonly used in the purchase of a new house rarely includes considerations of thermal efficiency, and yet this is the single most important component of the home's comfort. Buyers are often left with unbearably hot homes in summer and cold, damp homes in winter, necessitating extra shading, skylights, air conditioners and heaters. It is common to find that 40-60% of the home's heating and cooling costs could be saved with proper but simple planning. Perhaps more importantly, planning results in a more comfortable home for little extra cost. Similarly, office buildings are constructed with little thought to running costs, as the builders are rarely the occupiers. Workers who occupy the offices often suffer from draughts, reflections on computer screens and the glare of morning and afternoon sunshine entering their work spaces. In the case of non-air conditioned offices, extremes of hot and cold are common due to inadequate attention to passive solar design and insulation. In this session workshop participants will be given an introduction to the daily and seasonal passage of the sun across the sky and the implications this holds for building design. The style and construction of houses.

INTRODUCTION

It is the basic concepts of light transmission, reflection, absorption and emission and heat transfer by convection, conduction and radiation and how these are taken into consideration in design that determines the thermal performance of buildings.

Understanding the concept of a home energy budget combined with knowledge of the efficiency of electrical appliances will demonstrate where most of the money goes to pay for the energy in running a house.

The style and construction of houses for different climatic zones will need to vary to achieve optimal thermal performance and energy efficiency.

The design of housing and buildings in general needs to focus on the following key elements to achieve energy efficiency:

- Orientation on the block;
- Zoning of living and sleeping areas;
- Window design and location;
- Trombe Walls;
- The importance of eaves design;
- Thermal mass;
- Insulation;
- Designing for wind;
- Passive or Active?

Careful attention to design in retrofitting can also correct weaknesses in thermal performance of existing houses.

Office design is too large a topic to be discussed in detail here, but the impact of the sun in creating distressing working environments through incorrect sizing and placement of windows and choice of glazing cannot be underestimated.

SUSTAINABLE DESIGN GUIDELINES

The Royal Australian Institute of Architects (RAIA 1995) has defined ecologically sustainable design as the 'use of design principles and strategies which help reduce the ecological impact of buildings by reducing the consumption of energy and resources, or by minimising disturbances to existing vegetation'.

When designing in the natural environment, it is important to direct energy into preserving the site, to look at the natural forms of the land and the way nature has shaped it through movement of water and erosion, and to allow the design to follow and respond to these influences. A detailed survey of the site and surrounding areas, including its topography, geology, hydrology, wildlife, vegetation, carrying capacity, local culture, tradition and knowledge, is needed. Buildings, pathways and services should be carefully and thoughtfully placed.

The design of the building should also take into account the cost and ecological impact of the building over its entire life - from extraction and processing of the building materials to construction, occupation and the eventual demolition of the building at the end of its useful life. In this context, important factors are running costs, energy efficiency, maintenance and durability of materials, pollution minimisation, the energy embodied in the materials during their manufacture, and the building's potential for refurbishment or adaptive reuse.

In summary, building design should:

- Take full account of the climate;
- Be subordinate to and aesthetically sympathetic with the natural environment and cultural context;
- Reinforce and exemplify environmental responsiveness;
- Enhance appreciation and awareness of the environment;
- Maintain or, where it has been disturbed, restore biodiversity;
- Minimise pollution of soil, air and water;
- Use renewable indigenous building materials wherever possible;
- Increase efficiency in the use of materials, energy and other resources;
- Use life-cycle analysis in decision making about materials and construction techniques;
- Minimise the consumption of resources, especially non-renewable ones;
- Maximise the use of materials with low embodied energy;
- Identify opportunities for re-use and recycling;
- Identify opportunities for water conservation and re-use;
- Minimise potential safety hazards; and
- Provide full access to people with physical or sensory impairment.

A building should be thought of as a complete system with specific features and performance requirements, not as a collection of industrial engineering disciplines (electrical, mechanical, structural, and so on). Climate has a crucial influence on all design decisions and passive solar design can help to set other design parameters such as orientation, glazing, thermal mass, insulation, ventilation and zoning. Careful consideration of the above issues at the earliest stages of a design can have an enormous impact on reducing subsequent operating costs. (Marsh)

PASSIVE DESIGN PRINCIPLES

Passive solar design is: 'a design technique that can, and does, increase human comfort and reduce the demands on existing forms of energy production' (Cole 1997). This includes the effective management of solar radiation and natural heating/cooling sources impacting on the building envelope to minimise heating, cooling and lighting energy requirements for occupant comfort. It is achieved through the use of strategies such as: appropriate orientation; managing direct heat gain and lighting through windows; shading; managing indirect gains (thermal control in opaque systems); ventilation; thermal mass as a heat sink or source and other more novel techniques for manipulating these to provide indoor comfort (Prasad 1996).

A passive solar design building works as an integrated system that includes solar energy collection, distribution and storage. This means that the sun's daily and seasonal cycles are considered when the building is designed, which aids natural heating, cooling, lighting and ventilation without the larger costs of undertaking these activities mechanically.

As low-energy buildings seek to regulate heating and cooling by natural means, the design principles are simply concerned with admitting and storing the sun's energy when it is needed and excluding and removing heat from the building when it is not needed.

Passive solar design has a number of environmental advantages as every opportunity to capitalise on natural radiation and daylight will minimise reliance on fossil-fuel generated electricity, which in turn reduces carbon-dioxide emissions. There is also has the added advantage of significant savings in energy costs.

Good design for thermal comfort in the various climatic conditions described above are based on the following six principles:

- Orientation of frequently used areas towards the equator (north in the southern hemisphere, south in the northern hemisphere), to allow maximum sunshine when it is needed for warmth, and to more easily exclude the sun's heat when it is not.

- Glazing used to trap the sun's warmth inside a space when it is needed, with adequate shading and protection of the building from unwanted heat gain or heat loss.

- Thermal mass to store the heat from the sun when required, and provide a heat sink when we need to be cooler.

- Insulation to reduce unwanted heat loss or heat gain through the roof, walls, and floors.

- Ventilation to provide fresh air and capture cooling breezes; and

- Zoning to allow different thermal requirements to be compartmentalised in winter.

Orientation

Buildings should be planned in such a way that benefit is obtained from shaded indoor and outdoor living areas when the weather is hot and protected, sunny indoor and outdoor areas when the weather is cold.

Well designed buildings in the Southern Hemisphere should be oriented, and the spaces arranged in such a way, that the majority of rooms face towards true north. (The opposite for the Northern Hemisphere) In this way the eastern and western sides are exposed to the low-angle summer sun in the morning and afternoon. The high angle of the sun in the northern sky in summer makes it easy to shade windows using only a generous roof overhang. The longer northern side of the building benefits from the low sun in winter. The roof overhang on the north should allow the sun to shine into the building when its warmth is required in winter and provide shade from high-angle sunlight in summer.

If the majority of windows are designed into the north wall sun penetration into the building will be maximised. Living areas should be sited to gain maximum benefit from cooling breezes in hot weather and shelter from undesirable winds. This does not mean that the orientation of the building should be varied from north towards prevailing breezes as it does not have to face directly into the breeze to achieve good cross-ventilation.

Within the internal planning, rooms such as dining and recreation rooms that require more heat during the winter months should be placed on the northern side of the building. Rooms that are used for short periods of time during the day can be placed in southern areas (for example bathrooms, laundry, ensuite, entry corridors, stairs, bedrooms, bars).

Landscape and orientation

Plant types and planting locations also have important effects on perceived comfort. Any trees to the immediate north should allow the sun into the building in winter and provide shade in summer. Deciduous trees are useful for this purpose as they can provide shade to the eastern and western facades. Shading of the surrounding land is important to reduce glare caused by reflection from dry, exposed ground cover. However, there are few native deciduous trees in Australia so a decision needs to be made between planting deciduous trees for the benefits of passive solar design, or planting native trees which may contribute to the biodiversity of the site.

Glazing

Windows, glass doors and panels and skylights play a crucial role in admitting heat and light, and can have a significant impact on energy consumption. They are also the most difficult parts of the building envelope to adequately insulate. Care needs to be taken to ensure that windows are positioned, sized and protected so as to get the most benefit from winter sun while avoiding overheating in summer and heat loss in winter.

Thermal Mass

Thermal mass is the ability of a material to store heat and may be incorporated in walls and floors.

Thermal mass affects the temperature within a building by:

- Stabilising internal temperatures by providing heat source and heat sink surfaces for radiative, conductive and convective heat exchange processes;
- Providing a time-lag in the equalisation of external and internal temperatures; and
- Providing a temperature reduction across an external wall.

Material selection to capitalise on thermal mass is an important design consideration. For instance, heavyweight internal construction (high thermal mass) such as brick, solid concrete, stone, or earth can store the sun's heat during winter days, releasing the warmth to the rooms in the night. Light weight materials such as plasterboard are not 'high mass' materials and will act as insulators to the thermal mass, reducing its effectiveness. Lightweight construction responds to temperature changes more rapidly. It is therefore suitable for rooms that need to cool quickly in the evening.

For maximum energy efficiency thermal mass should be maximised in the north facing rooms of a building. Any heat gained through the day can be lost through ventilation at night. In using this technique, the thermal mass is often referred to as a 'heat bank' and acts as a heat distributor, delaying the flow of heat out of the building by as much as 10-12 hours.

Thermal mass design considerations:

- Where mass is used for warmth, it should be exposed to incident solar radiation;
- Where mass is required for cooling, it may be better placed in a shaded zone;
- Buildings may be pre-heated using electric or hot water tubing embedded in the mass (mostly concrete floors);
- Buildings may be pre-cooled by using night time cool outside air, although this requires significant amounts of exposed mass, and may be necessary only at certain times of the year in most Australian locations where little thermal mass is used. This method removes warm indoor air and replaces it with cool air from outside); and
- It is important to note that in buildings with extended hours of use, thermal mass heated during the day can cause discomfort during the night when the heat is released.

Insulation

Insulation specifications are another important design feature. A building envelope provides a barrier between the indoor and outdoor environments allowing the thermal comfort levels indoors to be adjusted to suit the occupants. This might require heating or cooling depending on the season and location of the building. The energy required for heating or cooling will be greatly reduced if the building envelope is adequately insulated. This means insulating the ceiling, walls and floor of the building, an easy task during construction, but often more difficult for existing buildings.

Insulation reduces the rate that heat can flow through the building elements in which it is installed. It limits warmed air escaping from a building in winter, and unwanted heat coming into a building in summer. In temperature controlled buildings, this will result in significant energy savings and thermal comfort. The amount of heat loss in winter and heat gain in summer should be reduced by installing the correct level of insulation. Insulation has a second benefit - it reduces noise transfer through walls and ceilings.

There are two main types of insulation available - bulk insulation and reflective insulation. Bulk insulation refers to fibreglass, rockwool, or polyester batts or blankets; cellulose loose fill or sheep wool products (also mainly sold as loose-fill). Bulk insulation relies on small pockets of air trapped by fibres or fluff to reduce heat transfer.

Reflective insulation is made from reflective foil laminates and includes products such as 'sisalation'. The shiny surface reflects most radiant heat away. Reflective materials installed in a ceiling are more efficient at reducing heat gain in summer than preventing heat loss in winter. A technique known as 'sarking' uses reflective foil laid under the roof itself to reduce airflow and prevent water entry.

Insulation performance is measured in 'R-values' - thermal resistance values, or the ability of the insulation to slow down heat transfer. The higher the R-value, the more effective the insulation at reducing the flow of heat. The R-value required depends on the prevailing climate.

Standards Australia has recommended R-values for ceilings and walls for each region of Australia, which aim to be the best compromise between energy savings and installation cost. In most coastal areas, a suburban home ceiling requires R=2.5 to R=3.0, while inland, R=3.5 to R=4.0 is more appropriate. The other main factors to consider when choosing insulation are its resistance to both fire and insects.

Proper installation is essential to maximise the performance of insulation, and there is an Australian standard covering fire safety and health aspects of installation.

Ventilation
Ventilation of a building is critical during summer as the building must provide for sufficient ventilation and breeze paths to assist with cooling. For warmer climates doors and windows should be positioned to facilitate prevailing cooling breezes. For instance, in Sydney cooling breezes are generally from the north-east, hence windows and openings through the building should be in a relatively straight line and orientated to the NE. Casement windows may be used to act as 'wind
catches'.

Zoning
Substantial savings can be made through proper zoning. Rooms requiring heating such as dining areas can be heated without having to include less frequently used rooms such as bathrooms and bedrooms.

The following strategies could be incorporated into the design to allow for zoning in winter:

- Air locks to the main entries to the building (for example, entry, laundry).
- Similar activity rooms grouped together (for example, bedroom zone, living zone, wet or bathroom zone).
- Grouped areas need to be sealed with tight fitting seals to all four sides of the door.

To maintain indoor air quality the opportunity to provide clear breeze paths through should be maximised to encourage air flow for night time cooling in summer and 'flush out' the accommodation, by removing stale air that contains CO2, water vapour, and mould.

THE TROPICS AND SUB-TROPICS

Baverstock & Paolino (1986) recommend the following climate sensible house design features for the Sub Tropical Zone:
Framed construction and brick veneer is the prevalent form of construction in this region and is generally appropriate provided insulation, glazing and shading is properly designed. A concrete slab on ground is generally recommended and a certain amount of thermal mass in the form of masonry internal walls can be beneficial provided not overdone (mainly to achieve sound privacy). Double glazing is recommended for this region to reduce air-conditioning costs and to increase comfort in non-air-conditioned buildings. There are benefits from under slab insulation and earth berming to control heat gain from ground. Landscaping and verandah shading is essential in this area. All building material colours should be light. Refrigerative air-conditioning is generally the most appropriate system for cooling in this area, although evaporative coolers and ceiling fans can still be effective. Simple plan forms with min. perimeter wall are recommended. Cool landscaped courtyards protected from cyclone-generated dust are advisable.

Baverstock & Paolino (1986) recommend the following climate sensible house design features for the Tropical Zone:
Humidity, ventilation and high ground temperatures are the major problems in this region. Solar radiation adds to these factors, and therefore total shading is necessary. It is hot all year round with the wet season being in the summer. Framed structures with little thermal mass are desirable. However, for sound privacy a small amount of masonry walling would be acceptable internally. Also this would add a certain amount of inertia to cope with abnormally cold days which are sometimes experienced. Brick veneer houses with wall and roof insulation are also appropriate for this area. Refrigerative air-conditioning systems are needed to cope with the large latent heat load. Circulation fans are also extremely effective. Because of fierce radiation

and high ground temperatures, simple plan forms with minimal perimeter wall are recommended, ideally the simple rectangular form (1:1.5). Also, cool landscaped courtyards protected from wind-generated dust are advisable.

(See also *Housing Design for the Kimberley* or in Western Australia people can ring the *Home Energy Line* 1300 658 158).

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Energy Efficient Appliances

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ABSTRACT

Consumers want the service that energy provides: heat for cooking, washing or comfort; 'coolth' for comfort or safely storing food; light for reading at night; motive power for mixers, pumps and transport; or any of the other multitude of services modern society demands. Appliances and equipment which supply these services with the least energy are cheaper to run and result in less investment in electricity generation.

Designers have made some enormous advances in energy efficiency of appliances, but these are not always getting to the market place. Some of these advances will be described. Finding out which appliances are energy efficient is not always easy. In this paper an Australian national program for promoting efficient appliances will be described. The program includes minimum energy performance standards and a star-rating scheme.

INTRODUCTION

Energy is a valuable resource. This is particularly the case when we use renewable energy which can be limited in its availability and for which the capital cost can be very large. A valuable resource should not be wasted, but every day we are using appliances and equipment which are not very energy efficient. When we purchase an appliance we are primarily looking for the service it delivers. This may be a comfortable air temperature and humidity or a light to see at night. It could be cooking, washing or safe food storage. It could be communication, education and entertainment as delivered through radio, TV and the internet.

The quality of this service is important, but is not necessarily proportional to the energy needed to run the appliance. It doesn't necessarily cost more to make an energy efficient appliance. Manufacturers will respond to the market, so it is important for customers to ask for energy efficiency. Governments can play a role in making it easier for consumers to ask the right questions.

DISCUSSION

Importance of Appliances

In Australia the use of equipment and appliances is estimated to be responsible for more than a quarter of net greenhouse gas emissions (AGO Web page – www.grenhouse.gov.au/ energyefficiency/appliances). The importance of appliances in the overall energy consumption of a nation will depend on the type of economy. For those developing countries where appliance ownership is limited, the existing impact may be small. However, most of these countries have an expectation of increased electricity and appliance use, and because they do not have such a large existing investment in appliances which can last for many years, there is an opportunity to exclude the most inefficient models.

Appliances are many and varied. Those which use the most energy have the most scope for savings and it is sensible to focus on those appliances first. In Western Australia more energy is used to heat water than for any other domestic purpose. In cold climates home heating uses the most energy, while in the hot north-west of this State it is energy used for air-conditioning and refrigeration which dominates. Energy used for lighting is generally small per unit, but if there are many lights and they are left on for a long time then the energy needed can be substantial.

To reduce national greenhouse emissions it is also necessary to look at the whole cycle of energy. It is generally more efficient, cheaper and less greenhouse emissions are produced if there are fewer transformations of energy from one type to another. As an example consider heating water. If you can heat the water directly by burning gas or wood, it is more efficient than using the gas or wood to generate electricity to send down wires to heat the water. It may not always be as convenient but it will be more efficient. So if gas or solar energy is available it is sensible to use it directly for heating purposes and save the more expensive electricity for light, electronics and motive power.

Recent technical advances in energy efficiency

Advances in appliance technology can be demonstrated by considering the changes in lighting. A century ago, and more recently in some countries, light was provided by candles and kerosene or gas lamps. The first electric incandescent lamp was very inefficient and did not last long. Technology has improved and incandescent lamps are now relatively cheap and reliable. Low voltage halogen lamps are the most technically advanced and efficient type of incandescent lamps but they still waste most of the energy as heat.

Fluorescent lamps are four to five times more efficient than incandescent lamps because less energy is wasted as heat. Fluorescent lamps can also be purchased as compact types which will fit into ordinary light sockets. The technology for fluorescent lamps continues to improve, with electronic ballasts and better tubes and colour rendering. Much of the energy wastage comes from lights which are left on when not needed. Another technical advance is to provide electronic controls with sensors to detect when light is needed and otherwise switch off to avoid waste.

Similar advances have occurred with refrigerators, by including more efficient motors, controllers and better insulation. Heat pumps and solar water heaters use free energy to heat water or rooms. Optimisation of heat transfer in gas water heaters has improved the efficiency without adding to the cost.

How does the average person tell if an appliance is energy efficient?

The average person cannot easily tell which appliances are the most efficient. For any appliance the amount of energy used can be calculated by multiplying the power rating, either in Watts or gigajoules per hour, by the time that the appliance runs for. However, it is not always easy to work out how much time an appliance is running, especially for appliances like refrigerators that are switched on all the time although the motor for cooling only runs when needed.

A standard test is needed to work out the energy used by appliances so that their energy efficiencies can be compared.

THE AUSTRALIAN APPLIANCE PROGRAM

All Australian States and the Commonwealth Government have cooperated to develop a national appliance and equipment energy efficiency program. Three main strategies have been adopted:

- Appliance labelling;
- Minimum Energy Performance Standards (MEPS); and
- Market transformation programs.

Appliance labelling

Appliance labelling is a method of providing information to the consumer so that she can exert her market power. In Australia the label has been designed to show the efficiency as a simple star rating as well as the average energy consumption as a number in kilowatt hours. This makes the label easy to understand for the lay person. A similar label is used for all appliances. An example of the label is shown below.

Certain appliances are required nation-wide by law to be labelled. These include refrigerators and freezers, dishwashers, air conditioners, clothes washers and clothes dryers. Before an appliance can be offered for sale manufacturers or importers must have each model tested according to an agreed standard. They register their appliance together with the test results and a rating is allocated according to the agreed algorithm. The government runs a check testing program to ensure that the manufacturers' test results are valid. Some appliances are selected and tested in an independent laboratory. If the independent test shows that the supplier is making invalid claims then they may be required to withdraw all models from the marketplace.

State based legislation regulates this labelling. However all States cooperate so that if an appliance can be sold in one State in can be sold anywhere in Australia. Similarly, if a model is withdrawn because of non-compliance it would be withdrawn nationally.

A review of the labelling program indicated that it had been effective, in that the public were buying more of the energy efficient models than they were before this information was made available. It is the responsibility of the retailer to display the labels, although they are generally affixed by the manufacture. Although at the start of the program some retailers would illegally hide labels with poor ratings inside cabinets, labels are now universally displayed in a prominent position.

The labelling was first introduced a decade ago. Because of advances in technology it became too easy to get a high star rating, the maximum. Last year a new label was introduced, basically the same as the old familiar label but with a green bar underneath showing what the rating would have been on the old scale. The old labels must all be phased out within one year.

Minimum Energy Performance Standards

In some situations it is not sufficient for consumers to just be given information. For example when the person responsible for purchasing the appliance is different to the person who actually pays the bill for energy. This often occurs in rental properties. Minimum Energy Performance Standards (MEPS) prevent the sale of the least efficient appliances.

In Australia MEPS have been adopted for refrigerators, freezers and small electric water heaters. They are soon to be introduced for electric motors, fluorescent lamp ballasts and packaged air conditioners.

Before MEPS can be introduced in Australia for an appliance, it is necessary to do a Regulatory Impact Statement. This exercise identifies the costs and benefits of the regulation and helps to set the level of efficiency required. In the case of MEPS the savings to society from the use of energy efficient equipment outweighed the costs of both acquiring the more efficient appliance and regulation.

The case of lamp ballasts illustrates the benefits of appropriate use of MEPS. This equipment is installed by an electrician as part of a building fit-out by the owner or developer. The difference in cost between the standard and energy efficient ballast is so small compared with the energy saving that in most cases the investment is paid back by savings in less than a year, for equipment which lasts on average more than ten years. But because the owner or developer usually passes the energy costs on to tenants he has no interest in these savings. There is a net gain to society if MEPS are introduced.

Market transformation programs

These are a set of voluntary programs which will help change the market so that more efficient appliances will be sold. Included in these is the Energy Star program, by which consumers may identify computers, printers, faxes and photocopiers by looking for the blue and green Energy Star logo. As part of the best practice program for motors some software has been developed to assist engineers decide the benefits and costs of various motors. A series of seminars have been arranged throughout Australia to provide more information on motors and motor controllers.

Many appliances, like modern televisions, stereos, clocks and microwaves, use a small amount of electricity all the time because they are on standby to be automatically switched on when necessary. If there are a lot of appliances this standby charge can add up to a significant load. It has been estimated (Harrington (2001)).that in Australia standby losses account for 11.6% of Australia's household electricity usage, costing Australian households more than $500 million and generating more than 5 million tonnes of carbon dioxide per annum. Australia is working with the International Energy Agency to put pressure on manufacturers to limit the standby requirement.

CONCLUSION

The appliance program in Australia uses both mandatory and voluntary measures and has proved to be effective in driving up the efficiency of appliances. There is a significant administration cost to the program. Other countries, like Japan and the USA, also have appliance schemes although the culture is to use voluntary measures.. The Japanese 'Top Runner' program establishes voluntary performance levels that are generally followed without exception. In the USA, the voluntary program operated by the US Environment Protection Agency results in 'de facto' standards for certain products. More information can be obtained at http://www.energystar.gov.

Products in the Australian Appliance and Equipment Energy Efficiency Program
The following table lists the products that are already included to the program and remain high priorities (National Appliance and Equipment Energy Efficiency Committee (2001)):

End Use Group	Appliance or equipment type	Energy Type	Current Status
Household refrigeration	Refrigerator, refrigerator-freezer	Electric	Mandatory labelling in place, MEPS implemented in 1999, revised MEPS scheduled for 2004 (equivalent to US 2001)
	Freezer	Electric	Mandatory labelling in place, MEPS implemented in 1999, revised MEPS scheduled for 2004 (equivalent to US 2001)
Commercial refrigeration	Remote refrigeration (compressor not located with cabinet)	Electric	Public profile due to be released in 2001
	Self-contained refrigeration	Electric	Public plan due for release 2001
Household cleaning appliances	Dishwasher	Electric	Mandatory labelling in place MEPS review due for release in 2001
	Clothes washer	Electric	Mandatory labelling in place MEPS review due for release in 2001
	Clothes dryer	Electric	Mandatory labelling in place MEPS review due for release in 2001
Household cooking appliances	Stoves and cook tops	Electric	Public plan due for release in 2001
Other consumer products	Swimming pool motors	Electric	Public plan due for release in 2001
Heating and cooling	Air conditioner (single phase)	Electric	Mandatory labelling in place. Heat pumps (no cooling) covered from 2001
	Air conditioner (three phase to 65kW cooling)	Electric	Voluntary labelling and mandatory MEPS scheduled for implementation in 2001
	Air conditioner (evaporative)	Electric	Public plan due for release in 2001
Domestic water heating	Storage water heater (80 litre, mains pressure)	Electric	MEPS implemented in 1999. Revised MEPS currently under consideration
	Small water heaters (<80 litre, mains pressure)	Electric	Revised MEPS scheduled for 2004
	Non-mains pressure water heaters (eg gravity fed and coil)	Electric	MEPS plan due for release in 2001

End Use Group	Appliance or equipment type	Energy Type	Current Status
Commercial water heating	Commercial water heating	Electric	MEPS plan due for release in 2001
	Gas boilers	Gas	Public plan due for release in 2001
Lighting	Fluorescent lamp ballast	Electric	MEPS and efficiency marking under development for 2002-3
	Lamps – all types	Electric	MEPS plan due for release in 2001
Office equipment	Personal computer	Electric	Voluntary endorsement label
	Visual display unit	Electric	Voluntary endorsement label
	Printer	Electric	Voluntary endorsement label
	Fax machine (plain paper)	Electric	Voluntary endorsement label
	Photocopier	Electric	Voluntary endorsement label
Home Entertainment	Televisions	Electric	Voluntary endorsement label
	Video Cassette Recorders	Electric	Voluntary endorsement label
Standby power	Consumer products	Electric	Range of product specific measures within the umbrella concept of the "One Watt Initiative"
Industrial and commercial equipment	Distribution transformers	Electric	MEPS plan due for release in 2001
	Air compressors	Electric	MEPS plan due for release in 2001
	Motors	Electric	MEPS and voluntary high efficiency marking scheduled for implementation in 2001

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Implementing Energy Efficiency in Communities

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ABSTRACT

In our homes and businesses there are numerous opportunities for reducing energy consumption and greenhouse gas emissions. They may be achieved through technological changes in the energy consuming processes or through behavioural changes so that we use our devices more efficiently and effectively. Energy audits by suitably qualified personnel are essential step to identifying opportunities in the buildings for energy reduction.

This paper looks at key elements of a energy efficiency project with a selected sector of the community. A critical element is good communication of these energy efficiency opportunities and information. It is critical to the success of an energy efficiency project within a community and with individual participants. The ideas need to be delivered through a variety of paths including existing local networks in the community. Identifying opportunities is often the easy step, while getting energy efficiency measures implemented requires considerable time and good communication flow. Women are essential in such projects working in a variety of roles.

INTRODUCTION

Energy efficiency projects within sectors of the community, have enormous greenhouse gas reduction potential. Their success however is critically dependent on communication of the ideas within the community and the organisation. Afterall energy efficiency is a much misunderstood term and the wide scope for energy efficiency opportunities is generally not known. Communication is needed that both informs and encourages participants from when they take the first step to consider energy efficiency to well past when they have implemented some of the recommended measures. This paper explores some features of community energy efficiency projects and looks at some examples of such projects and the importance of women working in these projects.

EMBARKING ON COMMUNITY ENERGY EFFICIENCY

There are an endless number of energy efficiency projects that can be run in the community. They can

- work with different sectors within the community, for example the small business community or domestic energy consumption,
- focus on a particular industry or association for example dairies or schools, or
- focus on one particular aspect of energy efficiency such as energy efficient building design.

The choice of location however may dictate the approach the energy efficiency project should take. The size, nature and isolation of a town will impact on the functioning of such a project and this should be carefully considered when embarking on a project. For example a small isolated holiday community with a highly seasonal population is likely to be a difficult choice of community for such a project, as local networks and communication channels are likely to be weak or few.

IDENTIFYING LOCAL NETWORKS

When embarking on an energy efficiency project, the first stage is to identify local support networks that could be tied into the project. They may be include the local council, small business association, resident's progress association, environment network, electrical contractors and a specific industry association. Ideally it is good to involve more than one such network to open up more opportunities. These networks can later prove to be invaluable in communicating energy efficiency experiences to other sectors of society through their members.

It is recommended to establish a project reference group made up of local people giving ideas and regular feedback on the project direction and successes to the project manager. Its members could include representatives from these networks or associations and perhaps some people from the participating businesses or households.

THE LOCAL COORDINATOR

It is critically important that a local person be found to take on a coordinating role, particularly if the project is being running by an organisation outside the community. This local coordinator role needs to be filled by a person (or persons) who lives and/or works in the specific community. They will be a key communication link for the project to local networks that are operating in related fields or with similar sectors of society. Where there is an external project manager and or fundee, the local coordinator will also provide a communication bridge to community participants in the project.

The local coordinator may need to take on the role of energy efficiency champion if community interest is initially lack-lustre or motivation to change is slow. So a person with an understanding of and passion for energy efficiency would be most suitable. In addition a technical background in energy management is ideal, though this expertise can be sourced from elsewhere.

As the principal local person on the project, the local coordinator has an essential role in the day-to-day functioning of the project, organising meetings with community participants, with reference group members and with energy auditors, and providing a local contact point for further information and queries from interested or participating community members. The time and energy demanded by this position means that this role should be offered as a waged position.

SEEKING PARTICIPANTS

In many community energy efficiency projects a group of community members, such as schools, households or businesses, are asked to participate in a series of energy efficiency activities associated with their facilities. For example they may be offered a free or subsidised energy audit of their premises or a brief walkthrough and followup handyman service to carry out simple recommended tasks.

The selection process for the potential participants should be undertaken with care and local input. Selection of participants who are supportive of new ideas and ready to take on new operating practices will feed the successful implementation of the project and inspire other more hesitant participants to follow suit.

The potential participants should be interested or at least curious about the subject. This interest could be for a number of reasons, afterall energy efficiency brings a range of benefits in addition to a reduction in greenhouse gas emissions and energy costs. For example an energy efficiency measure like sealing draughts improves retention of warmth and hence comfort levels. The different benefits appeal to different businesses, organisations and people. For example, for a small business trying to stay afloat, the potential for energy savings are attractive far beyond any other benefits. For some businesses trying to achieve a positive environmental reputation, the good publicity from being greenhouse-friendly through energy efficiency, and perhaps the use of a logo, is an attraction.

THE ENERGY AUDIT

At some stage in a community energy efficiency project, a series of energy audits are usually undertaken. An energy audit typically involves the following:

- a study of energy bills for the facility over the last year or two,
- investigation of energy tariffs for the facility,
- discussions with staff to establish an understanding of the facility's operation , history and energy management practices,
- inspection of the facility over 1-2 days, including a survey of energy consuming processes and observation of energy usage patterns,
- checks on metering equipment,
- analysis of energy consumption, including calculations of estimated annual energy use for different types of end use and comparisons of these figures with comparable energy efficient facilities,
- presentation, in report format, of results of energy use and costed recommendations for energy efficiency improvements in the facility with an emphasis on measures with a quick payback, and
- a debrief meeting to present findings face-to-face.

The value of a good energy audit cannot be undervalued as a means of identifying energy efficiency opportunities, both through changed practices and technology. An energy audit brings a person with a pair of independent eyes and specific energy expertise into a facility solely to focus on its review energy use. Though there may be skilled technical staff working at the premises with an eye out for energy wastage, they are unlikely to pick up all that an independent auditor can.

In some cases the value of the audit may be simply from the presentation of costed recommendations that support long-recognised changes to technology. This then enables or persuades management to take the next step to implement the measure.

Getting a high quality energy audit depends on the standard demanded and auditor availability. Australia has had various Australian Standards developed for energy auditing and energy management plans. They require a high standard of auditing which is essential to produce a detailed, reliable set of results that can be confidently implemented. The pool of experienced energy auditors is not large in Australia, and almost non-existent in regional areas, which is problematic for regional energy efficiency projects. Qualifications for recognised energy auditors also tend to be quite varied and this means one auditor may be less suited to a particular building type than others.

COMMUNICATING ENERGY EFFICIENCY

An energy audit may have identified some excellent energy efficiency measures but if they are not well communicated then they are liable to lost or misunderstood and subsequently dismissed.

The project participants will benefit from regular meetings throughout the audit stages with the local coordinator and, where relevant, energy auditor. These meetings may occur:

- at pre-audit stage, to gather information including bill history and allay any concerns about the audit inspection

- during the audit inspection, to ensure there is minimal disruption and that staff/householders are kept informed and their ideas and concerns are heard
- at the end of the audit inspection when feedback from staff on potential energy efficiency measures is valuable.
- at a debrief meeting. It is important that the audit recommendations not only be presented in a detailed report, but also face-to-face after the audit is complete and the owner of the building has had a chance to read the report.
- a number of times during the implementation phase to identify concerns that may be delaying implementation and provide a link to see this concern responded to with further information.

The communication flow out to the rest of the community should also be addressed. This may utilise stories of local experiences with energy efficiency from the project. They could be written up in newsletters, or for local newspapers to inform and inspire others in the community.

EXAMPLES OF COMMUNITY ENERGY EFFICIENCY

Much of the approach discussed in this paper was taken in an energy efficiency project, Albany Greenhouse Allies. The project's objective was to reduce greenhouse emissions in the small business sector in the regional town of Albany. It was jointly funded by the Australian Greenhouse Office (who manage the national Greenhouse Allies program) and Western Power, the state-owned electricity utility who also proposed and managed the project in Albany. Through the project 15 businesses from a diverse range of industries received a free energy audit and followup advice-based support. Audits identified savings between 5 and 20% from measures with relatively fast paybacks. For the businesses in the hospitality industry, measures with considerable savings were focussed on cooking, refrigeration and hot water. In the food processing industries there were many attractive opportunities identified in heat recovery and refrigeration (Western Power, 2001).

After 12 months the majority of the participants in the Albany project had implemented or were implementing some energy efficiency measures, that amounted to an overall saving of 950 tonnes/year of greenhouse gas emissions. Critical elements in the success of this project were some high quality audits, enthusiastic participants, a very supportive local business association and good communication flow via a dedicated local coordinator to the business community.

Community energy audits were undertaken in two remote aboriginal communities by Healey Engineering Pty Ltd in 1997 and updated in 1998-9 for the Western Australia's Aboriginal Affairs Department. There were some gains in energy efficiency achieved, though there was a need for a local champion and followup support and encouragement. It also highlighted the lack of energy awareness amongst community members and the need for energy education to occur within the community and the school as a first step to energy efficiency. The study also identified the importance of metering and billing occupants according to their use to generate awareness of their energy consumption and encourage implementation of energy efficiency measures. Though this is not straightforward where many people occupy a house, some pensioners, some not. A set of social issues then need to be resolved with community before such an option can be successfully implemented (Healey Engineering, 1998).

IMPORTANCE OF WOMEN IN ENERGY EFFICIENCY– A PERSONAL PERSPECTIVE

As a woman working in the male-dominated field of energy in roles of Project Manager and energy auditor, I have found my gender to be a strength and an element in the success of projects I've been involved in. In both indigenous communities and regional towns I found my reception with business people and community members was, on the whole, very positive. This is probably because of the perceived cultural differences between the business role models and women in Australian society. Women are viewed as less intimidating and more open and approachable than the Australian male.

In many small businesses and most households, I found females played the key role in energy management. Dealing with a woman like myself was comfortable and an almost instant rapport could be established that greatly assisted communication of energy efficiency ideas and enthusiasm.

However there are still some men in Australian society who undervalue the work and expertise of women. I found this frustrating in my work both in energy efficiency and renewable energy as phone calls would not be returned and technical discussion was stifled. Thankfully these experiences were few and these attitudes are gradually disappearing. However I found as a consequence that it was important to have a male on the team as a contact person to enable communication to occur in these situations.

CONCLUSIONS

Community energy efficiency projects have potential for significant reductions in greenhouse gas emissions, but attention needs to be given to the communication of the energy efficiency opportunities and information. The ideas need to be delivered through a variety of paths including existing local networks in the community. Identifying opportunities via energy audits is often the easy step, while getting energy efficiency measures implemented requires good communication flow and awareness of social and technical issues. Women have a critical role to play in these projects and their eventual success.

ACKNOWLEDGEMENTS

I acknowledge Western Power's Sustainable Energy Branch where I spent a year (2000-01) managing the community energy efficiency project Albany Greenhouse Allies. Many of the ideas presented in this paper were developed during the course of this project and from experiences with earlier energy efficiency projects around the state.

I also acknowledge Healey Engineering in reference to the ideas expressed on energy efficiency in indigenous communities.

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Applications of Renewable Energy

DC Lighting for Solar Applications

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ABSTRACT

Some of the most exciting recent advances in energy efficiency have been in lighting. Where possible these developments have also been applied to DC lighting powered by solar systems. The xelogen globes, the compact fluorescent tubes and the new LED lights are some examples of these Xelogen globes are now available and are similar to halogen globes in output and power use. Xelogen globes have many advantages over halogen globes as they will last longer, can be handled, produce less heat and do not produce UV rays. The compact fluorescent technologies have greatly reduced power consumption while being versatile enough to fit into many standard fittings. The compact fluorescent tubes are now widely used in remote areas for both DC and AC lighting. The new LED lighting technologies will be even more flexible and will have a large number of applications including low voltage lights for buildings and solar powered warning beacons. LED lighting is more compact, requires less maintenance and is not affected by rapid switching. Costs of LED lighting may be reduced by advances in manufacturing technologies.

THE NEED FOR DC LIGHTING

It is estimated that there are 2 billion people in the world without access to electricity (Van Der Plas, 1997). In developing countries light may be provided by either candles or kerosene lighting. The quality of light provided by these sources is very poor (10-15 lumens (L) for wick lanterns 7 and 40-50 L for hurricane lanterns) and the cost of fuel can be a continuing drain on the finances of the household. Good quality domestic lighting provided by solar power could greatly increase the quality of life by providing light for education, handicrafts, and to extend the working day.

LIGHTING OPTIONS FOR DC SYSTEMS

When choosing the type of light to be run on a DC application it it necessary to consider a number of factors including the cost of the lighting components, the situation where the light is installed and the efficiency of the lighting (or efficacy). The efficacy of the light is very important as a system with more efficient lights will require a smaller solar system. Efficacy is the ratio of light output (in lumens) to electrical input (in watts). Each type of light is considered in terms of light output and efficacy.

Incandescent bulbs

Incandescent bulbs use current to heat a tungsten filament to incandescence. During this process a lot of heat is produced and a small amount of light. These lights are very cheap to purchase but have a low efficiency of approximately 8-15 lumens of light per watt of power used (Roberts, 1991).

Halogen globes

Halogen bulbs are a type of incandescent bulb, but are approximately twice as efficient. The efficacy of a halogen globe is approximately 30 lumens per watt of power input (Roberts, 1991).

The higher efficacy of the halogen bulb is achieved because the lights operate at higher temperature. This has a number of disadvantages. The globes become much hotter than the incandescent bulbs and cannot be touched with bare fingers. Grease left on the globes from handling will cause a hot spot on the glass and can lead to the breakage. The halogen globes also operate at higher pressure than incandescent globes and halogen bulbs tend to explode if damaged.

Halogen globes are more expensive (approximately 10 times the cost) than the ordinary incandescent type but if managed properly will give approximately 2000 hours of operation. Problems can occur with high system voltage in 24 V DC systems causing halogen globes to prematurely burn out. Halogen bulbs are available in 5 W, 10 W or 20 W sizes in 12, 24 or 28 V DC.

Xelogen globes

Xelogen globes are also an incandescent globe, but they overcome the associated with halogen globes. Xelogen g,lobes have an equivalent level of light output to halogen globes, but the light tends to be more yellow in colour. The xelogen globes however can be touched with bare hands, do not emit UV light, and operate at low pressure. A xelogen globe should last from 5,000 to 10,000 hours and are available in similar sizes and voltages as the halogen globes. Xelogen globes are also available in a frosted globe to give a light that is not as "glarey" as the normal halogen or xelogen.

The incandescent globes are best used in areas where they will be on for short periods of time such as bathrooms.

Fluorescent tubes

Fluorescent tubes are far more efficient than the incandescent globes providing a luminous efficiency of approximately 50-100 lumen/W of power input (Roberts, 1991). These lights are used in areas where the lights are to be left on for long periods.

Fluorescent lights are now available in tubular or compact fluorescent types. The compact fluorescent lights are able to fit into a more compact light fitting than the older type of tubular fluorescents. The compact fluorescent tubes are available in sizes up to 38W with an output of equivalent to a standard 4 foot fluorescent, producing a luminous flux of 3300 lumens (85 lumens/W).

A common problem that can occur with fluorescent light tubes is failure of the tube as a result of low voltage in the battery, especially with the compact fluorescent tubes. To avoid problems with tubes it would be preferable to include a low voltage cut out in the system or to install lights that include a low voltage cut out in the inverter. High levels of radio interference caused by the fluorescent light inverter may also be a problem with the lower cost fittings. More expensive light inverters usually have improved radio suppression.

Light Emitting Diodes (LED)

Lights emitting diodes or LEDs have been used extensively as indicator lights in electronic appliances. The LEDs are generally used to show that the appliance is turned on, or can be used to indicate a problem. They are available in a range of colours, (ie red, green, yellow, amber and blue) and it is when they are used to replace coloured lights that the greatest energy savings occur. For example, when existing lighting technologies are used to create colour, the full spectrum of light is produced, but the light is filtered to allow only the desired colour to be seen. An LED that can produce the same output will use only 12% of the power required to produce the same light from an incandescent bulb (Zandvlief, W.P. and Van Geldermalsen, L.A., 2000). LEDs are currently used in the manufacture of traffic lights, marine beacons, emergency beacons, truck taillights and garden lights. Maintenance at such installation is reduced as the life of an LED is approximately 100,000 hours. Other advantages of the LED lights are that they are shock and vibration resistant and can withstand frequent switching without damage.

The white coloured LED is a more recent development and is used to provide lighting for solar powered systems. The light output is between 20 and 25 L/W. The LED lights are more efficient than incandescent globes and only produce minimal heat. The long life of the LEDs, is also an advantage in remote applications, although the life of the white LED may be less than for the coloured LED. The cost of LEDs for DC lighting systems is still high but should decrease as the technology develops further.

GENERAL NOTES

The initial outlay for a solar lighting system with good quality equipment is too great for many people in developing countries. If products were locally available, it may be possible to purchase individual parts of the system and to gradually increase the number of lights. Unfortunately, this type of equipment is usually available only in the major ciities.

Another option is the purchase of solar lanterns incorporating the solar panel, battery and light. Surveys have shown that the light output of 200-300 lumens from a 5 W compact fluorescent tube mounted in a solar lantern is considered to be an adequate option (Van Der Plas 1998). Information from these surveys carried out in Kenya, have lead to the development of a new solar lantern for the developing countries. The lantern, called the "glowstar" should be marketed prior to the end of 2001.

It is important that the type of light provided should suit the proposed use. Where light is required for tasks such as sewing or reading, the light should be located close to the area to be illuminated. General room lighting can be provided at a much lower level than is required for completion of such tasks. Attention should also be given to the wall and ceiling colour of the area to be lit, light coloured areas will reflect light, and will require fewer light fixtures than darker coloured areas.

The most efficient type of light should be purchased for any solar powered lighting system. Efficient lighting can greatly decrease the costs of a solar system, including the storage or battery capacity that is required.

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Narrogin Bioenergy Plant: Demonstration of Integrated Wood Processing

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ABSTRACT

Western Australia's wheatbelt town of Narrogin is home to an innovative project - the Integrated Wood Processing (IWP) demonstration plant - that addresses global warming and farmland salinity; two of Australia's most pressing environmental concerns.

INTRODUCTION

Western Power is building an Integrated Wood Processing (IWP) demonstration plant that will generate renewable electricity and produce activated carbon and eucalyptus oil from locally planted mallees. It is unlikely that either oil or electricity could be produced in isolation on a commercial basis. Producing three products at the one plant will ensure commercially competitive operation. The plant will generate enough renewable energy for 1,000 homes.

Mallee eucalypts have been the bane of farmers since colonisation because of their stubborn habit of re-sprouting after attempted removal. Mallees store food and energy in their underground lignotuber, the well-known mallee-root, which allows them to re-grow when the above-ground branches are removed, a natural adaptation to frequent fires.

This re-sprouting ability will be exploited to harvest branches every second year indefinitely without replanting. This is known as "coppicing". All the while, the deep mallees roots are soaking up the ground-water to keep the rising salt at bay. Mallees are now the farmers' ally in combating salinity that threatens 30% of the wheatbelt. The mallee trees are being planted in hedges which maximises their growth rates while minimising interference with normal cropping operations (figure 1).

Two million planted mallee trees are needed to support the IWP demonstration plant.

Figure 1. Mallees are planted in hedges to maximise growth

THE INTEGRATED WOOD PROCESS

The plant uses modern fluidised bed technology developed by CSIRO, to convert the wood into charcoal and then to "activate" the charcoal to convert it to activated carbon. Activated Carbon is used in air and liquid purification. Oil will be distilled from the leaves and the spent leaves will be "gasified" to produce fuel for the boiler. Heat from both processes will be used to generate electricity. The process is shown schematically in figure 2.

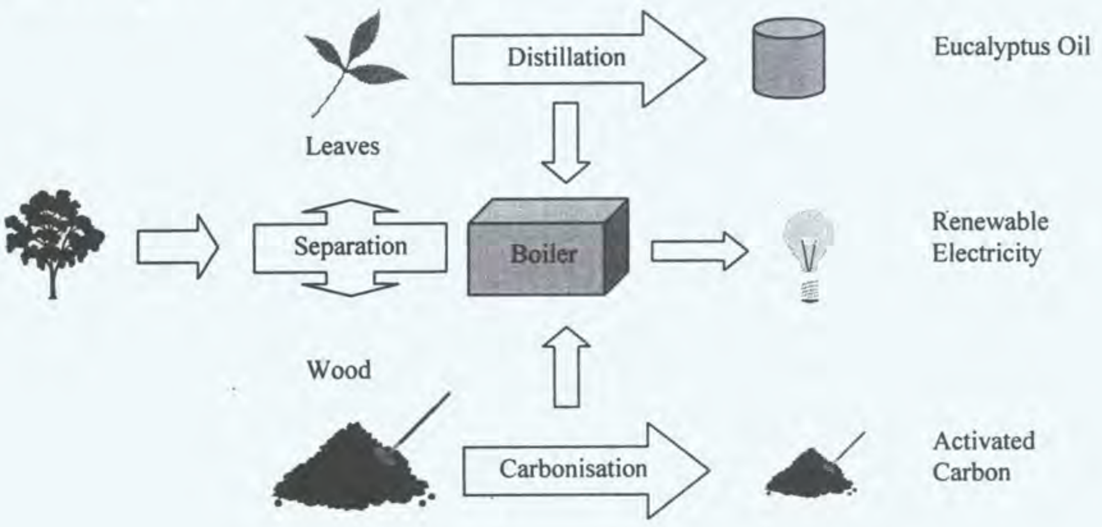

Figure 2. Schematic of the IWP process

Initially the oil will be used in the pharmaceutical market, currently dominated by imports, but will also be used to pioneer its use as a safe, environmentally friendly industrial solvent. Enecon Pty Ltd, which holds the rights to commercialise the CSIRO developed technology, will be working with Western Power on the design, construction and operation of the plant. Mallee biomass and new eucalyptus oil distillation technology will be supplied by the Oil Mallee Company of Australia Pty Ltd.

FUTURE IWP ACTIVITY

Full-scale, fully economic plants will be five times the size of the demonstration plant, requiring the planting of 20 million trees each. There is potential for many IWP plants throughout the wheatbelt of Western Australia and many more possible in other States and overseas. Future expansion is dependant on the success of the demonstration plant.

Figure 3. Artist impression of an IWP plant

IMPACT ON GREENHOUSE GAS

The electricity produced will displace fossil-fuelled generation plant and is carbon dioxide neutral. Because trees are planted specifically for the project, carbon dioxide is first fixed from the atmosphere as carbon, before being later released in the generation of electricity as carbon dioxide again. The carbon dioxide is essentially borrowed, not generated. Much of the fixed carbon stays with the activated carbon. Additionally, there is a carbon store created when the land-use is changed initially from monoculture to agroforestry, and a continuing store in the roots, which continue to grow indefinitely. The greenhouse gas savings are summarised in the following table.

Greenhouse Gas Abatement		
	Renewable Energy Generation	7,300 tonnes/annum
	Rootmass Fixation	4,300 tonnes/annum
	Standing Biomass Fixation	54,000 tonnes

FUNDING

This project has received funding support through the Renewable Energy Commercialisation Program of the Australian Greenhouse Office and through the Technology Diffusion Program of AusIndustry, Department of Industry Science and Resources.

The following organisations have contributed to the development of the IWP Demonstration project:
Western Power, Enecon Pty Ltd, the Australian Greenhouse Office, the Department of Industry Science and Resources, CSIRO, the Department of Conservation and Land Management (CALM), the Oil Mallee Co, the Oil Mallee Association, Murdoch University, Curtin University, the Rural Industries Research and Development Corporation.

CONCLUSION

Mallee eucalypts are an ideal short-rotation-coppice crop for salinity abatement in the wheatbelt. However, for plantings to expand to a significant number, a commercial market is required for their products. Neither bioenergy nor eucalyptus oil in isolation would be viable commercially, and only the integration of the three products, renewable energy, eucalyptus oil and activated carbon, offers the prospect of being truly commercial. The demonstration plant at Narrogin will aim to prove the viability of the technology, the harvest and delivery systems and the potential markets for the products. If successful, the demonstration plant will foster the development of a truly sustainable agroforestry industry that can make significant contributions to salinity abatement.

Technical Details	
Biomass Feed	20,000 tonnes/annum
Output	
Electricity	7.5 GWh/annum
Activated Carbon	690 tonnes/annum
Eucalyptus Oil	210 tonnes/annum
Plant Design	
Generation Plant	1 MW Steam Turbine
Carbonising Plant	Fluidised Bed
Distillation Plant	Steam Distillation
Spent Leaf Combustor	Thermal Gasification

Innovative Solar-Powered Village Potable Water Supply

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ABSTRACT

The Remote Area Developments Group (RADG) at Murdoch University in collaboration with local manufacturers Venco Products Pty Ltd and Solar Energy Systems Pty Ltd have developed a self-contained water supply and treatment system which is entirely solar-powered. The system is currently undergoing on-site trials at RADG's *Environmental Technology Centre* and is proposed for field trials in a remote Aboriginal community in Western Australia. RADG has been involved in the research and development of appropriate water supply and treatment systems units suitable for remote areas for over ten years. Research carried out by the group while working in remote Aboriginal communities in the late 1980's resulted in development of production prototype with industry partner Venco Products of the *Solarflow* – a solar-powered reverse osmosis desalination unit. The most recent work has seen the *Solarflow* become integrated with a locally designed and manufactured water pumping system, which is also solar-powered. Most remote Aboriginal communities rely on groundwater for their potable water supplies, however, this is a source which is often highly mineralised and in excess of the recommended drinking water quality guidelines for long term human consumption. The proposed installation at a community in the central lands is able to demonstrate a self-contained, solar powered water supply system which provides 400 litres/day of high quality, desalinated drinking water, an amount of water sufficient for up to 40 people. A system capable of meeting the requirements of larger communities of up to 150 people which can provide 1500 litre/day is currently in the prototype stage and under going performance monitoring before entering commercial production. The project can be linked to training programs in the area and will also be accessible by surrounding communities. This paper will describe the findings to date and the areas where further research is indicated.

BACKGROUND

The need for potable water in remote areas of Western Australia is widely known with many communities in rural areas suffering from scarce and often marginal quality drinking water resources. This is particularly evident in arid areas of Western Australia where rainfall and surface waters are limited and groundwater often contains high levels of salinity (3000 - 6000 ppm) and other contaminants (biological, chemical and aesthetic) (8). The deleterious health effects associated with prolonged consumption of highly mineralised drinking water are well documented and include kidney and gastric disorders (13). In particular such health problems due to inadequate quality drinking water in remote Aboriginal communities are prevalent (15). Significantly over 60% of Aboriginal communities rely on groundwater for their water supply with over an estimated 25% of these bores exceeding the salinity guidelines (14). Water for human consumption is required to meet the National Health and Medical Research Council Guidelines for Drinking Water Quality (13) and yet this is often not achieved in many remote communities.

This situation led to the investigation of appropriate technologies suitable for small-scale desalination in such communities. In cooperation with G.P. and G.F. Hill Pty Ltd as the industrial partner, the reverse osmosis *Solarflow* unit was developed by the Remote Area Developments Group (RADG). Due to portability, low maintenance and an output which matches demand, solar power was selected. This unit is capable of producing up to 400 l/day from brackish water of up to 5000 ppm total salinity from a 120 watt photovoltaic array. A larger 1500 l/day unit is currently undergoing pre-production trials.

The 400 litre/day version has two fixed recovery ratio options of 16% or 25% (Solarflow 40016 and Solarflow 40025). It has been designed to operate from a two panel photovoltaic array with built in maximiser to keep the solar panels at their optimum voltage of 30 volts. Efficacy can be improved by as much as 60 percent with the use of a solar tracker (7). The solar panels power a DC motor coupled to a high quality industrial gearbox which is capable of providing sufficient torque to run the unit even at very low power inputs. The efficiency of the unit is also greatly enhanced by the innovative energy-recovery system which allows the unit to operate with the minimum number of solar panels: the high pressure reject water is returned to the back of the piston to reduce the load on motor and gearbox, before being exhausted to waste.

The unit has recently been commercialised with twenty units presently in operation through Australia and South East Asia. The unit has won the Innovation category of the Western Australian Energy Efficiency Awards. The Alternative Energy Development Board (AEDB) of Western Australia has also provided funding for the current research and development of this project.

To date, the performance of the units placed in the field has been satisfactory, maintaining production rates and product quality often with irregular maintenance. This paper will present the findings of data from field situations, discuss the proposed central lands installation, and describe the areas where further research is indicated.

RESEARCH INTO A SOLAR-POWERED RO DESALINATION UNIT

Research on the *Solarflow* unit has focussed on photovoltaics as the most appropriate power supply and reverse osmosis as the desalination technique (7). Specifically it was necessary that the unit be simple, easy to service, robust, compatible with energy recovery and of low cost. Indeed many of the approaches taken were concessions to the range of appropriate technology parameters which were paramount for remote community application (1, 18). For example, the initial choice of low-speed double-acting simplex pumps were ultimately substituted with an integrated single acting pump to further reduce complexity (7). Similarly there are economies to be had in maximising recovery ratios, however, this in turn was not deemed to be of greater significance than the need to avoid pretreatment systems. It was reasoned that the energy recovery system would make this economical. Throughout the research and development to date, many such compromises were made to achieve a balance in the final product.

Typical energy consumption figures for reverse osmosis of brackish water with energy recovery vary from 0.5 to 2.5 kWh/m^3 although this data has been determined predominantly from large-scale systems (3, 6, 7).

Solar power is generally considered to be the best energy source for powering desalination plants in remote and arid regions (3). There are numerous ways however by which the energy can be harnessed and redistributed, such as battery storage, inverters and grid connection all of which may add to the complexity and losses of the overall system (17). With robustness and simplicity paramount, the Solarflow was ultimately configured to run directly from photovoltaic panels with the load thereby being matched to the variable solar supply (7). It was necessary however to incorporate an effective energy recovery system so as to reduce the energy required and hence reduce both the size and cost of the photovoltaic arrays. This led to the incorporation of a 'flow-regulated' approach to energy recovery as this maintains the set recovery ratio regardless of insolation levels (power input) and starts and stops automatically at sunrise and sunset.

DEVELOPMENT OF THE *SOLARFLOW* UNITS

Development of the complete unit took place over six years and resulted in four prototypes being built during this time (Mark I - Mark IV). It was at the end of development of the Mark II prototype that industry partner G.P. and G.F. Hill Pty Ltd became involved in the project and which led to several engineering and manufacturing improvements to the unit. Most significantly was the re-configuration from a two-cylinder to a one-cylinder system. From a manufacturing point of view this simplifies construction, improves modularity and reduces the cost of the unit. The single cylinder configuration was also favoured because of the ability to minimise parts since all valves are incorporated into the pump assembly. This makes field servicing by untrained personnel straightforward (10). A single cylinder is not ideal, however, for extracting maximum power from photovoltaic arrays as it gives large flow and pressure fluctuations and corresponding peaks and troughs in power demand. It was also considered likely that a single cylinder configuration would increase concentration polarisation and the risk of membrane scaling due to the period where flow is stalled. Membrane fouling and scaling are widely reported as being the main drawback as well as the least understood phenomena of reverse osmosis systems (4, 11). As described in the following section it appears that such concerns are unfounded.

SUMMARY OF FIELD TRIALS

Four sites of differing nature where field data on the *Solarflow* unit has been obtained are presented below. They represent two local sites - where one is a surface water source, a remote but monitored location in Central Australia and a site in Indonesia.

Table 1. Summary of Field Trials

Location	Duration	Activities	Outcomes	Recommendation
Environmental Technology Centre and Venco factory, Perth, WA	1995 ongoing	24 h/d bench testing at factory before ETC; 1500 unit with 6 and 8 panel PV array on 16% recovery ratio.	Main pump cylinder cracking and seal failure on piston rod gland detected in bench trials; 1069 and 1235 l/d achieved with new power maximiser.	Use solar tracker to gain additional 40% and 20% output req'd; 25% recovery ratio will then exceed 1,500 l/d.
Gidgegannup, WA	Several months	Feed from creek at 2,000 – 3,000 ppm salinity.	Fouling of 20 and 5 micron pre-filters by algae reqd use of sand filter pre-treatment.	Use sand filter as pretreatment on feed waters with bio-contamination.

Centre for Appropriate Technology, Alice Springs, NT	1997 4 weeks	Feed water from both AS at 860 uS/cm and Fregon at 2180 uS/cm to 400 unit.	350 l/d with no cloud from AS feed; 300 l/d or 20 l/amp hr (1.2 kWh/1000 l of product water) from Fregon feed; seal and piston faults since eliminated.	A sensible balance needs to be achieved between long-term trials and commercialisation.
Java, Indonesia		4 units using surface water feed.	Biological fouling of pre-filters.	Regular replacement of prefilters necessary or additional sand filter.

To date, the 21 in-field models have performed for over 12 months with only irregular maintenance, and have maintained production rates and quality. No problems have been reported with the power source (photovoltaic panels) either in terms of maintenance, performance, service or vandalism. The period between membrane replacement was estimated at the design stage to be in the order of two to four years depending upon the feedwater quality and while further time needs to elapse before this can be confirmed, such a period appears to be achievable.

The *Solarflow* operating on creek water at the Gidgeeganup site is the first unit to be run with a surface water feed source and has demonstrated the increased complexity of treating surface water as compared to ground water via reverse osmosis. The Indonesian feedback also indicates algae and biological buildup on the pre-filters from a groundwater source. Further trialing of sandfilters as an effective low-cost pretreatment system is required. A small-scale sand filter system, the *Environ 30* supplied by QED Australia Pty Ltd, is used to treat bore water prior to drinking at the *Environmental Technology Centre* and could be used as the pretreatment unit.

The units being monitored at the ETC have also performed according to specification although further trials on the 1500 l/day unit incorporating a solar tracker for the eight panel array will continue. See Figure 1. The ETC site has demonstrated the need for simulated long-term testing of units in a field situation as it enables unit modifications to be made to the model prior to full-scale marketing. The problems encountered whilst under trial at the ETC described previously were able to be remedied through relatively inexpensive material and design changes. Whereas, the cost penalty associated with 'discovery' of these problems whilst in operation in remote and overseas locations would have been significant. The situation described at the Alice Springs site highlights the need for actual field testing prior to full-scale production and provides an insight into what could have occurred had there been premature placement of units in the field. Consequently, the RO unit can now be confidently integrated into the new Village Potable Water Supply system and commercialised with the industry partners.

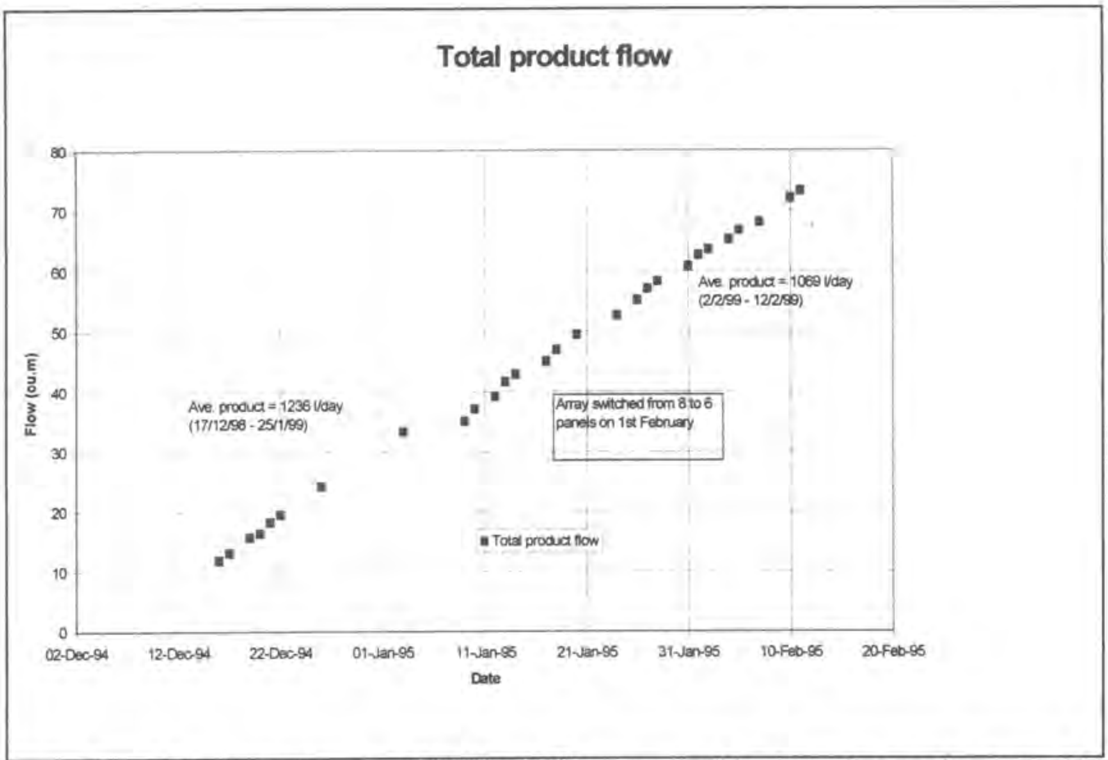

Figure 1. Product volumes on 1500 l/day (16% recovery ratio) unit running on solar power at ETC

COMMERCIALISATION OF THE SOLARFLOW UNITS

The partnership between Murdoch University and GP & GF Hill Pty Ltd (Venco Products – manufacturer of the Solarflow units) has been expended to include Solar Energy Systems (SES). SES are a commercial manufacturer & distributor of solar powered water pumping and power systems incorporating unique components including (amongst other things) the Sun Tracer tracker, Poly Piston Pump and Power Maximiser (maximum power point tracker). This expanded partnership has allowed the development and commercialisation of a complete integrated village water supply system that treats water to potable quality, which includes all the latter components from SES. The system can also be configured as a stock water supply and treatment system. The total 1,500 litres/day system was installed at the Environmental Technology Centre for commercial demonstration purposes as well as ongoing trials. The system was inaugurated by the WA Minister for Water Resources on October 3, 1999.

Component costs of the "Total Village Potable Water Supply" system are listed in Table 2.

Table 2. Component costs of total village potable water supply system

Component	Sub component	Cost ($)
250 W Solar Stock Water Pump	4 x 64 W Canon Unisolar PV panels; F2 sun tracer; Custom-built power maximiser; Tall pump drive with 540 W motor; Poly Piston Pump.	$6,460
Solarflow 400 l/d reverse osmosis unit		$6,188
Water tanks and tank frame		$3,300
Spare parts – pump & sun tracer	Stuffing box, nylon rod, foot valve,, seals and piston for Poly Piston Pump ($220); Spare DC motor & brushes $685); Gearbox oil, grease and grease gun ($100); Battery, electronics andsensor for sun tracer ($375); Power maximiser ($400); 2 x Canon Unisolar panels ($1,280).	$3,060
Spare parts – Solarflow	RO membrane ($639); 10 x 5 micron 10" filters (non-wash) ($100); 5 x 30 micron 10" filters (washable) ($85); Pump assembly ($1,930); Conductivity meter ($150); Pressure gauges ($32).	$2,936
Total		**$21,944**

PROPOSED DEMONSTRATION UNIT IN CENTRAL RESERVES

It is proposed to install a 400 litres/day complete system at a major Aboriginal community in the central lands region of Western Australia to enable community managers and residents from there and surrounding communities to evaluate the quality of system performance and the water for drinking purposes. Groundwater supplies to all of these communities are typically highly mineralised. Table 3 compares the chemical water quality from Perth mains supply (at Murdoch), ETC groundwater, and Warburton groundwater from 1999 samples.

Table 3: Physical - Chemical Analyses of Perth Mains, ETC Bore, Warburton Bore.

Loc'n	Al mg/l	Ca mg/l	Cl mg/l	E. Con mS/m	Fe mg/l	Hardness mg/l	Mg mg/l	Mn mg/l	TDS Calc mg/l	pH
Perth	0.13	3	53	23.5	0.20	24	4	0.02	130	6.8
ETC	0.16	4	78	38.8	0.36	55	11	<0.02	210	7.2
Warb.	<0.008		190		0.007	430		<0.002	970 TFS	7.73
NHMRC guide	0.1		250		0.3	60-200		0.5	500-1000	6.5-8.5
Max. for plant growth									1000	

As can be seen from Table 3, the drinking water supply at Warburton, like that of many communities in remote areas, is highly mineralised. While this level of calcium carbonate or TDS is not directly deleterious to human health, indirectly it can be. For a start, water with bad taste does not encourage drinking of the volumes of water ideal for better health. Ideally, one should drink around 2 litres/day but when involved with physical work in the hot outdoors this should be more like 5 litres/day. Moreover, the tendency for many people in remote indigenous communities is to add cordial to water with poor taste or to consume soft drinks instead [19]. This excessive consumption of sugar contributes to poor health and may lead to diabetes – a common problem in indigenous communities. Furthermore, highly mineralised water supply causes scaling in kettles, hot water systems, and the seals of toilet cisterns.

The provision of a second reticulated water supply from the *Solarflow* unit and dedicated for drinking purposes has the potential to make a major contribution to improved health in indigenous communities if this can encourage drinking greater volumes of fresh water. While it may not be feasible to service all households with one unit in a community as big as Warburton a unit could be installed at each key community facility, such as the school, clinic, store, office, college, where large numbers of people congregate and where a high quality drinking water supply would be appreciated and well-patronised. Alternatively, one unit could service each cluster of dwellings. Initially, one unit could be established at one community facility as a demonstration.

CONCLUSIONS

Performance of the *Solarflow* (400 l/day unit) to date has been in line with expectations in terms of low maintenance, minimal servicing requirements and treated water volumes. It is likely that this is a result of the many design and engineering concessions to appropriate technology parameters for remote area application. In order that more sites may have access to the unit, investigations into pretreatment and prefilter systems suitable for the *Solarflow* are underway (16). This will allow those sites which have feedwater that according to current knowledge should induce fouling, to be serviced. Any additional equipment required, however, to enhance the performance of the *Solarflow* unit will need to be developed according to the same guidelines that were paramount in the construction of the unit itself: simplicity, low cost, low maintenance and robustness.

The *Solarflow* is ready for application in most situations. The recent partnership with Solar Energy Systems Pty Ltd will allow the final stage of commercialisation to occur. This partnership has resulted in the integration of the Solarflow with the other components necessary for a total village potable water supply. It is now necessary to establish a series of demonstration sites for key market sectors such as remote indigenous communities, stock watering systems, remote homesteads, small island communities, and villages in developing countries.

ACKNOWLEDGEMENTS

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Performance Testing of Cardboard Solar Box Cookers

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ABSTRACT

Solar cookers are simple. But they are real, functioning appliances that can be made of many different things. Solar cookers are perfect example of appropriate technology.
There are many NGO's and other groups worldwide now designing, constructing and using these simple, elegant and effective devices. One such group is based in Western Australia. We conducted solar box cooker tests using two different test methods. Various design changes were examined. Results show the advantages of double glazing and black absorption plates in the base of the cooker. The optimum combination of these changes resulted in an increase of 175% in cooking power compared to the basic design. Cooking temperatures of 70°C were reached in one hour and water boiled within two hours. These temperatures and heating rates allow practical cooking of many foods. Solar cookers easily reach 120°C and so can also, dye cloth and sterilise medical supplies, stored food and even soil.

INTRODUCTION

Solar box cookers represent a simple, low cost and effective application of solar energy. In many developing countries they can play vital roles in improving health by lowering exposure to wood-smoke and reducing pressure on firewood resources. They can be used to sterilize drinking water. They can also be locally manufactured. It is not surprising that many papers (e.g. Lenssen 1989; SunWorld 1988) and books (e.g. Kerr 1991) have been written on the subject, extolling the virtues of solar cookers.

We suggest solar cookers do have a valuable role to play. They are excellent educational tools. They illustrate how the sun's energy can substitute for conventional fuels in the simplest possible way – an insulated box with a glass lid. Principles of passive solar design can be demonstrated and understood. Children can build their own cookers. It is also very instructive for adults to see and operate such appliances.

It is unlikely that solar cookers will substitute for conventional gas or electric cooking in developed countries. In Australia the cost of cooking a meal with gas or electricity is only a few tenths of a dollar, so financial savings attributable to solar cooking are almost trivial. A solar cooked meal will reduce Greenhouse gas emissions by 0.5 to 1.5 kg of CO_2. Small compared to average per capita emissions of 15 t CO_2, but there is a market where electricity is unavailable and carrying gas containers is inconvenient. Examples of this include for campers and remote areas such as prospecting in the outback. Here recreation and education rather than economics or ecological gain, are likely to be the main reasons to promote solar cookers in Australia and New Zealand. The principles of solar box cookers are so simple and elegant. If they were more widely promoted people would gain a greater appreciation of solar energy. Also, some of the benefits of this technology might be carried with field workers and tourists as they travel or work in regions of the world where solar cookers could play a role in saving lives and protecting the environment.

With these principles in mind, this paper sets out to illustrate some basic design features of solar cookers. We hope that this will stimulate your interest. The paper also illustrates the importance of a standard method for comparing the performance of solar cookers.

TEST METHODS

Two different test methods were used here. The first is comparative testing. In this case two 'identical' solar cookers were constructed, checked to see if they had similar performance and then one was modified. The effect of the modification was measure by comparing performance with the unmodified cooker. The second method is 'absolute' performance assessment using a test procedure. The standard test method allows comparisons of cookers' performance anywhere on Earth.

Cooker performance

What makes a better cooker? To help find out a physical indicator was chosen – the rate at which heat is transferred to water in a cooking pot. The advantage of this indicator is that it can be objectively and accurately measured. It is a surrogate for cooking 'speed' and indicates how quickly useful cooking temperatures can be reached. It is a combination of the cooker's ability to capture and transfer solar energy to the pot, and the rate at which heat si lost from the cooker (i.e. its insulation properties). It also allows calculation of the cooker's efficiency (i.e. what proportion of the intercepted solar radiation is captured for the cooking task).

It is acknowledged that many other performance indicators might be used. Some examples include maximum temperature reached by the cooker (stagnation temperature), ease of use (obviously subjective), temperature control, or cost per kW of cooking power. All these indicators have merit.

Comparative testing

Comparative testing is relatively simple and provides a way of checking design changes to see how these effect performance. Two simple cardboard solar cookers were constructed so they were as similar as possible. Both were fitted with identical pots and identical amounts of water. They were placed side-by-side and about 200 mm apart. This meant they were under nearly identical conditions. The advantages of comparative testing are that relatively small changes in performance can be seen and weather conditions need not restrict testing.

Testing to a standard method

Our tests were based on a method outlined by Funk (1998). The method yields a wattage statement as a measure of cooker performance. This number is then 'standardised' by adjusting it as if there had been 700 W/m^2 of sunshine. The power is determined by fitting a linear curve to the curve of the power absorbed by the pot over a temperature range from 40 to 90□C. Some minor problems with the method were encountered, but overall it seemed very good.

Other methods for comparing solar cookers have been proposed. The Indian Standard method a 'figure of merit' approach (e.g. Garg 1994) has been adopted (IS 13429: 1992)

TESTING A SIMPLE, CARDBOARD COOKER

Two cardboard box cookers were built to a Kerr-Cole design (Solar Cookers International n.d., Miller 1997). The basic cooker is constructed from two cardboard boxes, one inside the other, with loosely crumpled newspaper and reflective foil insulation in the cavity (Figures 1 and 2). All inner surfaces are covered with aluminium foil. The basic cooker is single glazed. It has a cardboard and aluminium foil reflector. The materials cost $21 plus $16 if cardboard boxes are purchased rather than 'found'. Construction takes about 10 hours (including glue drying time). With experience this can be cut to about 4 hours.

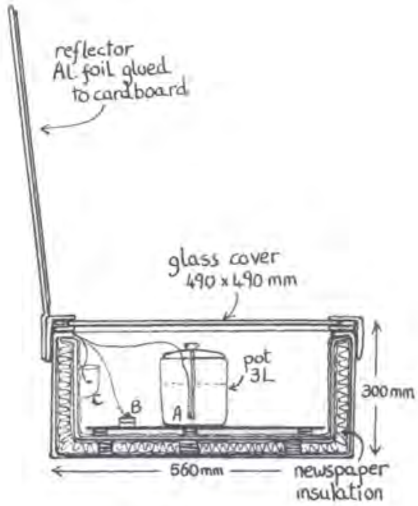

Figure 1 Sketch of the cardboard solar cooker used for performance testing.
All internal cardboard surfaces are covered with aluminium foil. A black painted metal sheet, raised about 15mm above the base, was used in some tests (as shown in sketch).

Testing was limited to a two-month period between 15 January and 17 March 1999. We carried out 24 tests, including 7 preliminary tests used to check equipment and refine the method. Identical 3 L pots with close fitting lids were painted matt-black. They were filled with exactly 1500 g of deionised water. Water was checked every three or four tests and topped up as required. If the pots boiled, the water was refilled before the next test. The pots were carefully positioned in each cooker using a cardboard template (in front of right cooker fig. 2).

Water temperature was measured 10 mm from the bottom of the pot using t-type thermocouples linked to an impartial, automatic data recorder. Temperatures were sampled every second. Every ten minutes the recorder averaged and stored the temperature value. Open-air temperature was measured in the shade behind one of the cookers. Solar radiation was measured using a whole-sky radiometer. Wind speed was not measured.

Preliminary tests showed the two 'identical' cookers had performances within 2% of one another One cooker performing consistently better.

The following designs were assessed in the testing: (1) cookers with/without the reflector; (2) with/without black absorber plate in base of cooker; (3) with/without a raising the base plate from the base of the cooker; (4) with/without double-glazing; and (5) with polystyrene insulation replacing crumpled newspaper. At least two tests were carried out for each configuration.

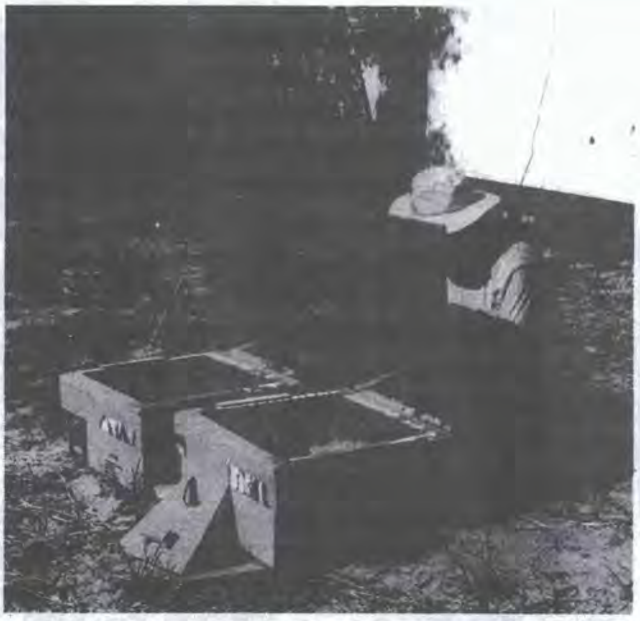

Figure 2: Photograph of the two solar cookers during testing. Note the cardboard template in front of the right-hand cooker. This was used to position the pot the same in both cookers.

TEST RESULTS

Examples of results are shown in Figures 3 to 5. Figure 3 shows the change of water temperature in the pots over time. In this test cooker-B was fitted with a black absorber plate across the entire base of the cooker and raised about 15 mm above the reflective foil of the normal cooker base. Cooker-A had no black absorber. The cookers were exposed to the sun about 20 minutes after recording began at which point the water in both pots started to heat. After three hours the water in pot-B was near boiling, the water in pot-A was about 20□C cooler. Near end of the test, the windy conditions on this day caused the lid of cooker-A to blow closed and the water started to cool. The final 40 minutes of the test were, therefore, not valid.

3 March 1999 solar cooker tests showing:

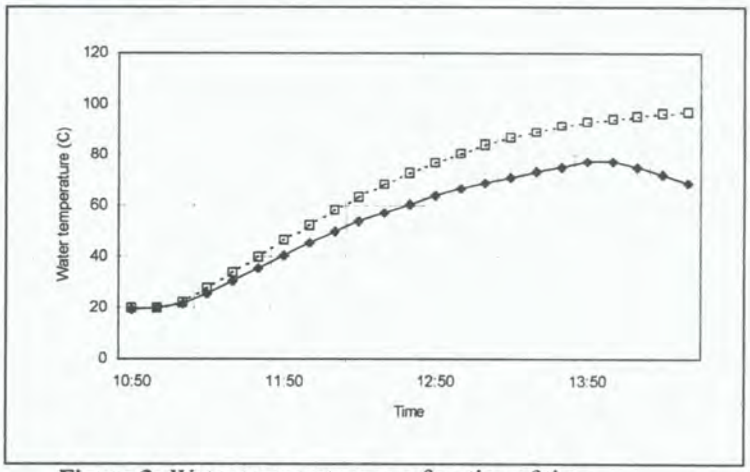

Figure 3: Water temperature as a function of time.
Cooker-A (lower curve) is the 'standard' configuration; cooker-B (upper curve) has a raised black absorber plate inside. The temperature drop in cooker-A from 14.00 was due to the reflector blowing closed.

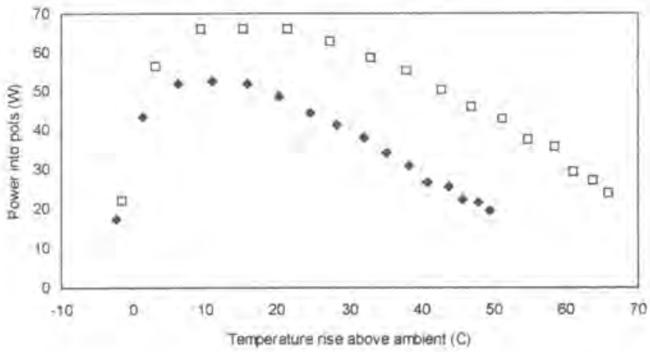

Figure 4: Power curves. Power is plotted as a function of the difference between open air temperature and water temperature. Cooker-A (lower curve) and cooker-B (upper curve).

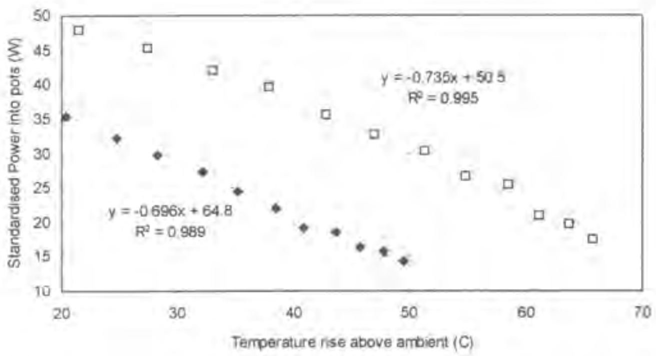

Figure 5: Standardised power. Power is standardised to equal solar radiation of 700W/m^2.
Only the linear section from Figure 4 is plotted. Equations show straight line of best fit and R^2 values.

Figure 4 shows the power absorbed by the pots as a function of the water temperature compared to open air temperature. Power is not shown for the period after the lid blew closed. The shape of the power curve is determined by two factors. The rapid rise over the first 30 to 40 minutes is an artefact of the thermocouple location. If water temperature is measured near the top of the water rather than 10mm from the bottom, the maximum power is observed almost immediately. As the pot warms, the rate of heat-loss through the cooker envelope (walls, base and glass) increases in direct proportion to the temperature difference between inside and outside the cooker. Hence the linear decrease in power. To obtain a standardised figure for cooker performance, the near linear part of the power curve is first adjusted to a solar insolation of 700 W/m^2. This adjustment to insolation is made for each 10 minute interval before a straight-line curve is fitted (Figure 5). As can be seen in this example, a good fit is achieved. This proved typical for clear sky days. Intermittent thick cloud made testing inconclusive.

Analysis of the results from 15 tests allows an estimate of the change in performance when changes were made to the cooker (Table 1). The results show large differences in performance because of changes in the cooker configuration. A combination of double-glazing (significant reduction in heat loss) and a raised black base plate (improved solar absorption) resulted in an average power (at ΔT=50°C) of 44W compared to 16 W for the base-case design.

Replacing the crumpled newspaper in the sides and base of one cooker with polystyrene did not produce a significant improvement in performance. This is consistent with the observations of

Pejack (1990) who found crumpled newspaper had a similar thermal resistance to broken polystyrene pieces in solar cooker walls.

	Percent change in standardised power relative to base case
Basic cooker (reflector + sides and base foil covered)	0
Basic cooker without reflector	- 48%
Basic cooker with black absorber plate on base	+ 75%
Basic cooker with black base raised 15mm	+ 85%
Basic cooker with double glazing	+ 28%
Raised black base plus double glazing	+ 175%
Replace crumpled newspaper with polystyrene	Inconclusive (small change)

Table 1: Results from 15 tests of two solar cookers (i.e. 30 results available for comparison).

The cookers intercepted approximately 0.29 m^2 of the solar beam (glass area plus reflector). This figure is based on the average value for a two-hour period around solar noon. The average 'efficiency' for the basic cooker (i.e. the proportion of intercepted solar energy contributing to heating the water in the pot) was 8% (at □T=50□C) and 22% for the best cooker design tested. The maximum efficiency observed, over all tests, for any 10-minute period was 33%.

DISCUSSION

The aim of this research project was not to develop 'the perfect solar cooker'. Instead we looked critically at the test method. Some interesting design features were highlighted. Comparative testing led to some interesting qualitative observations, but we found it best to use quantitative description (i.e. based on a standard method) to report the relative performance of different designs. An example of a qualitative observation was that double-glazing meant a slower rate of temperature rise for about the first hour. Then the reduced heat loss led to higher temperatures in the double-glazed cooker. Small differences such as this initial lower power in the double glazed cooker cannot be measured on separate days. Another lesson we learnt was that the two cookers were probably too close to one another during our tests. Some interference (e.g. input from the other cooker's reflector) may have occurred in earlier tests. In later tests, better efficiencies meant shorter test periods. Sun reflecting into the adjacent cooker would have been less of a problem then.

The standard method (Funk 1998) proved robust. It meant that appropriate levels of care in procedure and measurement were required. There was a temptation to be much more *ad hoc* during comparative testing. This leads to less useful results. We found it impossible to meet the wind speed requirements of the standard method (i.e. wind speed less than 1 m/s). The maximum ambient temperature (35□C) was exceeded during 10 of the 24 tests. Attempts at using existing buildings as windbreaks proved unsuccessful. A custom built windbreak was beyond the resources of this project. Temperature stratification in the water in the pot meant true power was not measured. Two or three thermocouples at different depths would cure this problem. A systematic approach to setting the angle of the reflector and aligning the cookers (possibly turning them at, say, one hour intervals) would have improved the accuracy of our results. Finally, whole sky radiation, rather than direct beam as specified in Funk's method, was measured and used as the basis for standardisation.

The testing is relatively time consuming (even with data loggers). This is particularly so where the weather is unreliable. Testing several designs at one time seems desirable (e.g. see Funk and Larson 1994).

In this research program, one issue has become apparent that we have not uncovered relevant information on. That relates to the cooking process itself. Solar cookers operate at lower power than most other cooking systems. Solar box cookers range from 20 to 100W. Typical gas, electric, kerosene and biomass cooking all deliver much more power to the cooking pot. Thus, solar cooking is slower. The food spends more time at lower temperatures. Is this a good or bad thing? Anecdotal evidence suggests that this might be advantageous from a nutritional viewpoint. Is this true? If food cooked in solar cookers is to be eaten in the evening, then it might remain in a gradually cooling cooker for several hours. Does this create a health risk? These, and related questions, suggest that there are still opportunities for valuable interdisciplinary research in the field of solar cooking. The authors acknowledge work done on cooking aspects at Avinashilingham Deemed University, Tamil Nadu, India.

CONCLUSION

The design and testing of these simple solar cookers proved interesting and instructive. It reinforced our views that these devices can play a useful role in Australia and New Zealand. If testing is done systematically, the cookers become more than just a novelty demonstration of solar energy. They teach some very important basic principles relevant to many other solar energy applications. There are many interesting and fine designs of solar cookers throughout the world from basic to highly sophisticated. Many Indigenous models have been developed using locally available, inexpensive materials. There is no point in reinventing such designs. The Sun smiles when it looks to Earth and sees a shiny solar cooker. As a reward it sends warming, loving radiation down which cooks quietly, and without air pollution. There remains more to be discovered in the actual cooking with solar cookers. What time/temperature conditions are necessary to cook different foodstuffs? What are the health implications of slow, lower temperature cooking of foods (nutrition, bacteria, etc.)?

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Solar Cooking Interest Group, 23 Morley St, Maddington, WA 6109, Australia. The group publish a small newsletter three times per year (subscription $6.75 in Australia).

Solar Cookers International, http://www.solarcooking.org
An excellent web page with lots of practical information and links to other sites, discussion groups, etc.

Renewable Energy Pumping Systems

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ABSTRACT

Solar water pumping is really renewable water pumping; it involves both photovoltaic (PV) and wind. Over the past 10 to 15 years the evolution of the former has seen some highs and some lows while the later (with only a few exceptions) has remained unchanged.

Renewable water pumping can be classified as low, medium, or high volume. Photovoltaic systems are good in the low range and wind is good in the high range. The two share the medium area. There can be dangers with each as there can be with any pumping system. The important factor to consider is the cost of maintenance.

INTRODUCTION

The evolution of solar water pumping in Australia has been driven by a desire in the market for an inexpensive, safe, reliable, and long lasting alternative to the water-pumping (mechanical) windmill. The market is exclusively the remote rural market where the cost of Grid power and diesel fuel is prohibitive. For most of Australia this is often only a few kilometres from towns and cities.

The key questions are "Have the desires of the market been met?" and "Is Solar water –pumping successful?"

The Answer to both these questions is Yes … (But with some reservations)

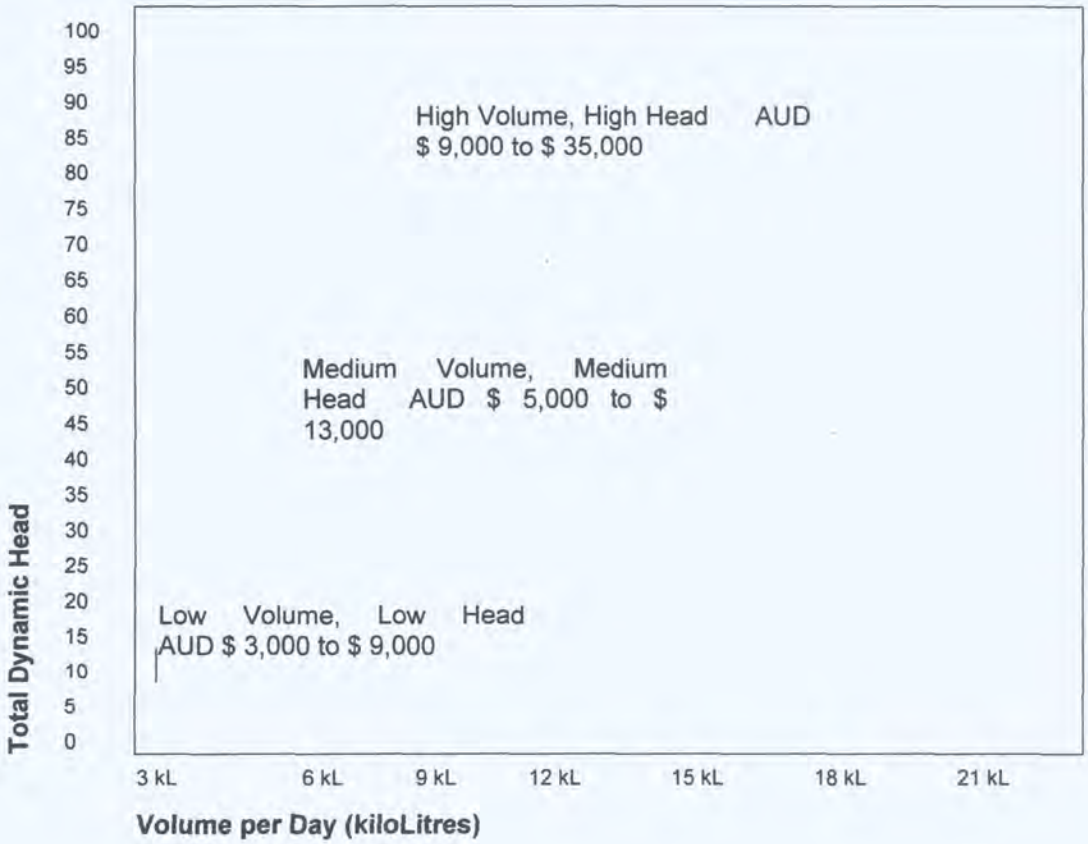
The technology that solar seeks to replace is the old fashioned windmill – the multi-bladed farm type water pumper. These machines were first developed for general use over 150 years ago, perfected around the 1880's, and have remained largely unchanged since about 1920. There have been some recent innovations that have been better marketing exercises than real technology advances, and I am sceptical of the claims made about their longevity. Without longevity the windmill is not economic. These machines should have a design life of better than 30 years and a probable life in excess of 50 years.

Windmills can be made to pump between 5000 litres up to 200,000 litres per day. That is with Windwheel sizes from 1.8 metres to 10 metres in diameter. The most economical sizes however are 1.8, 2.4, 3.0, 3.6 and 4.2 Metres. Sizes over this diameter pose problems in installation and require special equipment that is not always available. In practice then water-pumping windmills are made in sizes from 1.8 to 4.2 metres in diameter to pump between 5000 to 30,000 litres per day from depths up to 100 metres.
The main reason for using a windmill is its low running cost, its low maintenance cost, and its reliability (longevity). There is no other pumping system that can produce water for the same cost over such an extended life. Why then do customers consider solar pumping systems?

- Fuel savings
- Clean technology
- Simple to install (most systems are supplied pre-assembled)
- Safe (usually solar pumps use sub-lethal voltages)
- Modern (not like old windmills)
- Control systems (to regulate the flow, no water is wasted).

Water pumping systems can be divided in either low or high volume, pumping depths can also be considered as either low or high head. In Solar pumping systems high volume is around 21,000 litres per day, and high head is 100 metres. This is not to say that higher heads and higher volumes are not possible, but it suggests that there are some practical limits to where solar energy should be used for pumping water. There are a variety of pumps used in solar pumping systems.

Solar Pumping Matrix



The pumps used in the low volume, low head systems are usually positive displacement pumps with brushed DC motors – a low level of technology. These systems are user serviceable and the cost of maintenance is minimal. This is bread and butter solar; the system cost is competitive with windmills and the level of technology is low – only basic training is required to make a mechanical tradesperson competent at fixing and maintaining these systems.

The pumps used in the larger systems begin to use some very high technology – usually brushless DC motors. The reason for using such high technology is because of the need to chase very high efficiency. Not only do these pumps use the latest electronic technology, but they also use sophisticated machining and production methods. All this adds up to a system that is no longer user serviceable that must be installed in a pristine bore. These high technology pumps are used exclusively in the area of the high volume, high head. However they can also be used in the medium volume, medium head range as well.

Experience has shown that the cost of maintenance for high technology systems can be quite high. In a system costing around $ 13,000 (Australian Dollars) the pump will cost around $ 5,000. It is possible that this pump will last only five years. If this is the case then the cost of maintenance will be $ 1,000 per year. It is the cost of maintenance rather than the cost of the system that is the important issue to focus upon – the cost of the system will be forgotten, but the maintenance cost never goes away.

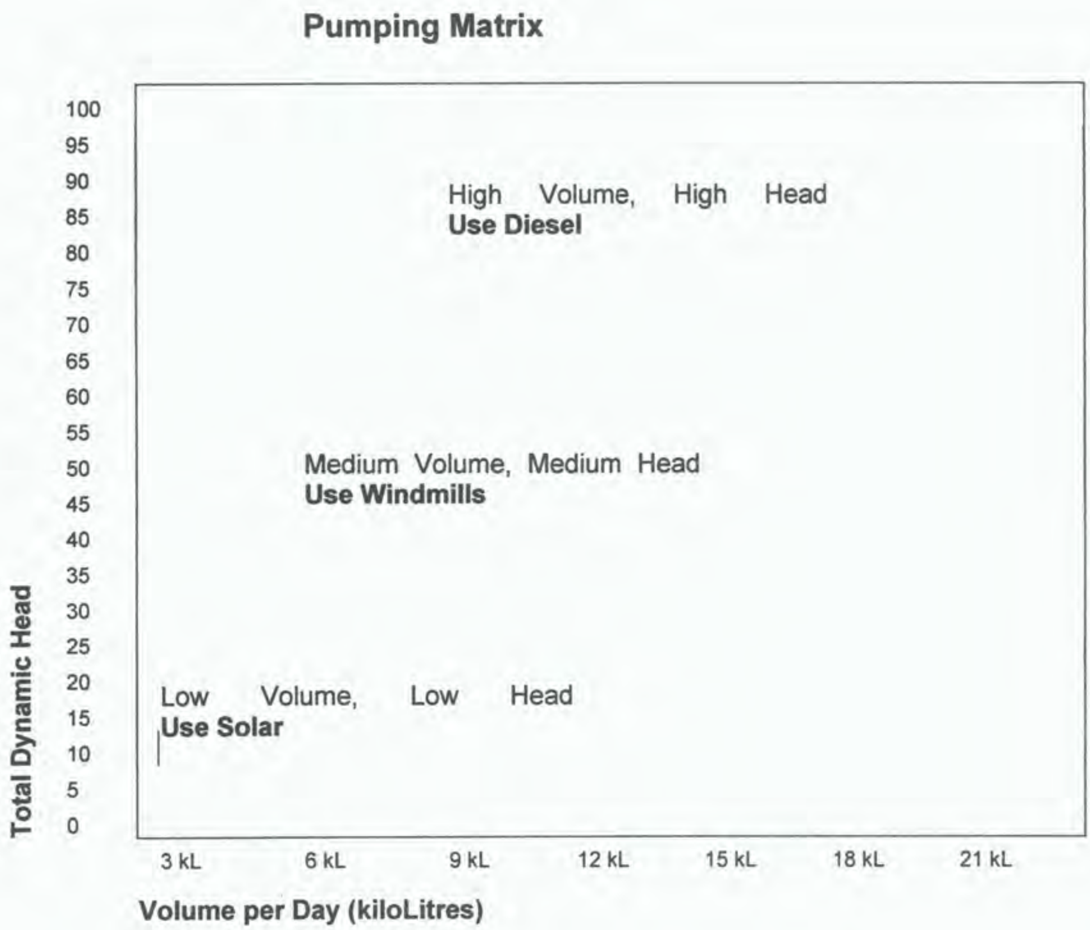
The question today is will solar technology develop to overcome this maintenance cost impediment? My belief is that the technology will continue to evolve and it is inconceivable that answers will not be found. Unfortunately the current trend is towards greater dependence on electronics and high efficiency. The breakthrough will probably come if the cost of solar panels does come down, and low technology pumps can be used. The key to the successful use of solar energy is found in the small systems. In the range of small systems we find pumps that are simple, reliable, and long lasting.

It needs to be stressed that pumping water is one of the biggest users of energy. And it doesn't matter wether the pumping system uses renewable energy or fossil fuel, there is always a cost. In the case of renewable energy systems the cost is mainly up-front, whereas with fossil fuel systems the cost is in their running costs. Whereas, it is possible to do a cost comparison, to determine the cost of pumping water on a per litre basis, over an extended period of time, such comparisons are easily manipulated to achieve a desired result. There are also many non-financial factors that should be taken into account such as the level of technology, available skills, and economic conditions like the availability of foreign exchange. All this leads to the conclusion that direct comparisons are meaningless.

So how do remote users decide which system to use?

It is clear that remote users throughout Australia are using all available systems wether that is windmills, solar, or fossil fuel based systems. Sales in Australia are divided equally among all options. It is usually personal preference that makes the final decision.

With all factors included, my advice is to use each system where it is most appropriate. If we use capital cost, running cost, and maintenance cost as the only parameters then the decision becomes easier. Solar is great in the low end, Windmills dominate the middle ground, and diesel is the domain of the big systems.


Pumping Matrix
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Total Dynamic Head
High Volume, High Head
Use Diesel
Medium Volume, Medium Head
Use Windmills
Low Volume, Low Head
Use Solar
3 kL
6 kL
9 kL
12 kL
15 kL
18 kL
21 kL
Volume per Day (kiloLitres)

Solar Drying

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ABSTRACT

Solar drying is one method of preserving food in remote areas. Many approaches have been proposed and developed for the solar drying of crops and other produce. This paper will describe the basic concepts behind solar drying and then provide examples which illustrate how this technology can often utilize locally available materials in the construction of the drying units.

INTRODUCTION

The use of the sun for drying is one application of solar energy with a long history. It has traditionally involved spreading out the produce to be dried on the ground and allowing the solar radiation to be absorbed by this material. Sun drying is the term that will be applied to this method of utilizing the sun's energy.

It is sometimes useful to distinguish between the above method of drying and those methods in which water vapour is removed by heated air flowing through, or over, the material. The term dehydration will be used to describe this active method of drying produce. The heat required for such dehydration processes can be supplied with fossil fuels, such as natural gas, coal, or oil, biomass fuels or solar heating systems. In this paper the term solar drying will be applied to the deliberate use of solar energy to heat the air and/or produce in the drier and so achieve dehydration, or drying, of the produce.

APPLICATIONS OF SOLAR DRYING

Many types of horticultural products are suitable for drying in solar driers. Fuller (1993) lists twelve types of fruit (including apples, bananas, grapes, mangoes and papaya), twelve types of vegetables (including beans, carrots, cassava, taro, tomatoes and yams), three beverage crops(cocoa, tea, coffee) and peanuts as examples of produce that have been dried in solar driers. He also states that, in addition to these food crops, flowers, herbs and medicinal plants have also been used in solar driers.

SOLAR DRYING TECHNOLOGIES

Solar drying systems can generally be classified into one of two types:

- Direct driers in which the solar radiation is absorbed directly by the produce and its immediate surroundings. The simplest form of such a drier would be a box containing the produce with a sloping transparent cover, and vents to allow the moist air to escape and fresh air to enter. The solar radiation entering the box heats up the produce, or dark surfaces in the drying chamber, and causes water vapour to be driven off from the material being dried. Such systems can be much more elaborate and take the form of a greenhouse where plastic glazing covers a framed structure.

- Indirect driers in which solar radiation is used to heat air which then flows through the volume containing the produce. This involves the use of a separate solar air collector that generally consists of a dark metal plate enclosed in a box with a glass cover. The air flow in such systems can be driven by a fan (a forced flow system) or it may use the principle that hot air rises to produce the air movement in the system (a natural convection system).

In some situations a combination of these two approaches can be used to create a hybrid system. Local materials such as bamboo, wood, scrap metal and plastic can often be used to form the drying chamber and key parts of any solar collector. In this way the various designs can be customized to local situations.

When choosing a particular type of solar drier the following criteria should be considered:
- The use of locally available construction materials and skills
- The cost to set up and maintain the drier
- The drying capacity and the holding capacity
- The adaptability to different products
- The drying times required
- The quality of the end product

THE POTENTIAL FOR SOLAR DRYING

The question arises that, given all the different types of produce that have been used in solar driers, and all the different types of solar drying systems that have been developed, why are solar drying systems not used more? The reasons for this have been addressed by several authors and are summarized in Fuller (1993).

Solar drying is a possible replacement for sun drying or for standard dehydration processes. In terms of sun drying, solar drying is competing with an approach that is deeply entrenched in the way of life for most potential users. Sun drying is by no means a perfect process with problems arising due to potential contamination of the produce, variability in drying times, rain damage and so on. However some of the reasons proposed for the lack of success in adoption of solar drying are as follows:
- Solar driers have often been too expensive
- Solar driers have often been too complicated
- Solar driers have often required too great a change from traditional methods
- Solar driers have not been built for long term use
- There is a lack of incentive to improve the quality of the product (poor quality produce is never wasted; rather it is simply consumed at home)
- Many people appear to prefer the taste of the sun-dried produce in preference to the solar dried produce
- The price differential between different grades of produce is not large enough to encourage the introduction of newer, more costly, methods
- Generally an alternative strategy is needed for poor weather conditions (eg wood fires) and so the need for an additional heating system, such as the solar system, becomes more difficult to justify
- Risk-taking is very difficult when one's very survival may be at stake

- When comparing solar drying to the conventional dehydration processes a new range of issues arises. These include:

- Solar driers must provide the equivalent performance to that of the conventional processes in terms of capacity, labour input, quality of final product, total drying costs and reliability
- Large collector areas are required to provide substantial amounts of heat because the solar resource is very diffuse
- A full-sized backup system must also be installed to ensure drying during the critical periods even if the weather is bad
- The high capital cost due to the previous two items is difficult to recover from fuel saving because the drying season is often short and the alternative fuels are, in many places, not very expensive

Despite these difficulties Fuller (1993) states that there have been some successful instances where solar drying has been introduced, in both industrialized and developing countries, and that "These successes illustrate not only that solar drying can be competitive with alternative drying methods but may also point the way to strategies for future success."

Some of the wisdom that Fuller suggests can be distilled from past successes and failures in the area of solar drying, and which therefore could encourage the greater use of solar driers, includes the following:

- In designing a solar drying system, one should start with the specific requirements for drying and the methods that have traditionally been used. It is better to try and build on this base rather than introduce something completely alien, even though this foreign solution may be based on very sound science and engineering.
- A focus on high-value/low volume commodities is more likely to generate a successful solar drying project in developing countries. This takes into account the fact that many of the products currently sun-dried in these countries are low value, large volume crops which would be difficult to provide with solar drying.
- Transfer of technology is critical to the success of any solar drying application.
- A holistic approach that includes such factors as the availability of credit facilities, the training of personnel and the marketing of the final product will always greatly enhance the chances of success of any such project.

CONCLUSIONS

There are documented cases of the successful implementation of solar drying systems. However, there are many cases where solar drying systems have not realized their full potential. In seeking ways to further promote solar drying it would be wise to accept the challenge of Fuller (1993) when he wrote: "The challenge for researchers is to develop a technology which meets the needs of the users at the technical, economic and social levels".

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Vaccine Refrigeration

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ABSTRACT

Vaccine refrigerators are important links in the cold chain process which seeks to deliver viable vaccines to all people, even those in very remote locations. This paper will outline the basic requirements for a vaccine refrigerator and how such units are tested to ensure adequate performance. The types of units that are currently approved by the World Health Organisation will also be described.

THE COLD CHAIN

The cold chain seeks to deliver potent vaccines from the manufacturing facility to the remotest parts of the world. It does this by providing controlled temperature conditions for the vaccines from the factory to the health worker administering the vaccine in the field. Along the way this could involve centralized cold rooms and freezers, large regional fridges and freezes, local refrigerators and freezers, and cold boxes and vaccine carriers for the transport of the vaccines.

Some vaccines can be safely frozen (eg oral polio, yellow fever). However, the majority need to be stored in a narrow range of temperatures, namely from 0□C to 8□C. During any transportation phase of the cold chain this temperature range must also be maintained. Maintaining these conditions is essential because once potency has been lost through exposure to heat or cold it cannot be regained by returning the vaccine to the correct storage temperature. Also "if potency is lost through heat exposure, vaccines do not change their appearance so it is not possible to see whether a vaccine in a vial has lot its potency without a complete laboratory test" (WHO, 2000).

The World Health Organization has developed a series of test requirements for the various elements of the cold chain. These test programs seek to determine whether the component can maintain the vaccines within the appropriate temperature range during a range of external conditions.

VACCINE REFRIGERATORS

A vaccine refrigerator needs to maintain the vaccines contained inside at temperatures within the range of 0°C to 8°C. It needs to do this no matter what the outside conditions are. Therefore whether the outside temperatures are 10□C or 40□C, the refrigerator needs to maintain the required temperatures within the refrigerator chamber.

Many vaccine refrigerators also have the capability to freeze icepacks. These are used in cold boxes and vaccine carriers to transport the vaccines to the final clinic or location where the vaccine is to be administered.

Numerous energy sources can be utilized to operate vaccine refrigerator units. These include electricity, kerosene, gas and solar energy.

Vaccine refrigerators can operate on a number of refrigeration principles. The units available include:

- Absorption refrigerators
  Absorption refrigerators use heat as the main energy input. This heat can be provided by electricity, gas or kerosene. Generally "Absorption refrigerators and icepack freezers do not perform as well as their compressor-driven equivalents. They require constant attention to ensure adequate performance for the vaccine cold chain." (WHO, 2000)
- Compression refrigerators
  Compressor refrigerators use a refrigeration cycle that includes a compressor driven by electricity. These refrigerators require a standard electricity supply and cannot operate on gas or kerosene. For the same amount of electricity consumed the compression refrigerator produces about four time as much cooling as the absorption refrigerator. Most domestic refrigerators are of this type. However, these standard domestic refrigerators have not been designed to meet the stringent requirements of vaccine refrigerators and so generally cannot be used for storing vaccines safely. Some work has been undertaken to develop kits that can transform standard domestic refrigerators into vaccine refrigerators. This is achieved by the use of additional insulation and water storage to create smaller areas within the unit where the conditions required by the vaccines are maintained.
- Solar refrigerators
  Solar vaccine refrigerators use an array of photovoltaic (PV) modules to charge a battery bank. The refrigeration units generally have compressors that operate on dc power, in contrast to those in standard domestic refrigerators that use ac power. The WHO has developed standard performance specifications for such units. These specifications cover areas such as the system design, the temperature control required, the energy consumption, the performance of the battery set and the battery charge controller, and the requirement for spare parts and instruction manuals. The batteries should be sized so that the system can operate successfully for a five day period if the batteries start fully charged and the PV array is disconnected.

TESTING VACCINE REFRIGERATORS

The WHO has developed a series of tests that provide an indication of how well any particular unit will maintain the required temperature range during a series of different conditions (WHO, 1997). These conditions include continuous operation at elevated temperatures, the normal day/night cycling of temperatures, the situation where the energy source is only available for a certain fraction of the day, and the situation where the energy source fails. The tests themselves include the following:

- Measuring the energy consumption and internal temperatures during continuous operation at ambient temperatures of 32°C and 43°C
- Measuring the energy consumption and internal temperatures during day/night cycling operation between 15°C and 43°C
- Measuring the performance of the unit if energy is only available for 8 hours per 24 hour period
- A holdover test where the energy source is removed from the unit and the time until the internal temperatures exceed the required conditions is measured
- Measuring the quantity of ice packs that can be frozen at a number of conditions and checking that the freezing of the ice packs does not adversely affect the temperatures in the refrigerator section of the unit

The WHO has recently introduced a further refinement in the classification and testing of vaccine refrigerator units. This is in recognition of the fact that vaccine refrigerators will operate in very different climates in different parts of the world. Therefore a series of temperature zones have been introduced and the refrigerators and freezers are now classified in terms of the temperature zone in which they can operate. The testing regimes for the day/night tests have been adjusted to allow for the different temperatures expected in these different regions. The three temperature zones identified are a hot zone (0°C to 43°C), a temperate zone (0°C to 32°C) and a cold zone(-5°C to 32°C).

The tests are generally conducted in temperature-controlled rooms. An array of temperature sensors is placed inside the refrigerator and the internal temperatures together with the energy consumption of the unit are measured during the various tests. The WHO publishes a book with the test results for all the equipment that has been tested and found to satisfy the requirements for use in the cold chain (WHO, 2000).

SELECTING A VACCINE REFRIGERATOR

The WHO suggest that the following points should be considered when choosing a vaccine refrigerator or freezer:

- Which temperature zone is most appropriate for the proposed site?
  This will depend on the climate of the location (what are the average temperatures during the hottest and coldest months?) and the environment in which the refrigerator is to be situated (is the unit in an air-conditioned space?)
- What vaccine storage capacity is required?
  This will depend on the location of the unit within the cold chain. While most vaccines require a temperature range of 0°C to 8°C, some long term storage situations require storage at -20°C.
- What icepack freezing capacity is required?
  This is expressed in terms of how many icepacks the unit can freeze in a 24 hour period.
- Does the proposed unit have satisfactory performance in terms of maintaining internal temperatures?
  Select a unit that remains in the 0°C to 8°C range both in the steady ambient test conditions and in the day/night cycling test conditions
- What is the most appropriate energy source?
  If grid electricity or electricity from a diesel generator is available for more than 8 hours per day then this would probably be the cheapest option. The reliability of the supply is a key issue. If power will only be available for part of the day then a unit that can operate in such an environment will be required. Units such as ice-lined units use power when available to freeze an internal lining of water filled tubes that surrounds the vaccine storage area. These tubes can then provide cooling during periods when no power is available. If kerosene or gas units are proposed then the reliability of the supply of these fuels should be carefully determined. In areas with a good solar resource a solar unit can be considered. Interestingly the WHO guidelines indicate that such an option is best considered if grid power is not available for more than 8 hours per day and if kerosene and bottled gas is too expensive. However, it is also stated "Solar refrigeration systems are now widely used in many developing countries for the vaccine cold chain." (WHO, 2000, p61).
- What holdover time is needed in case of power failure?
  The holdover time is the time before the internal temperatures in the refrigerator unit rise above 10°C after the power supply has been removed from the system. As the quality of the power supply becomes poorer, the importance of this factor increases.

- What maintenance and repair facilities exist for the proposed unit?
  The reliability of any unit will depend critically on the maintenance and service facilities that exist to support the long-term operation of the unit. Local knowledge will be critically important in determining this factor. Many of the units listed in the WHO Product Information Sheets provide an "essential spare parts" list. This is a list of equipment that would normally be required in the first seven years of operation of the system. It is recommended that these parts be purchased at the same time as the unit itself.
- Which refrigerator system meets the above requirements with the lowest cost?
  In such an analysis items such as freight costs, installation costs and any ongoing fuel costs should be included. In other words the analysis should consider the life cycle costs of the alternatives.
- Are the users and those in charge of maintenance of the equipment properly trained? This follows on from an earlier point but reinforces the importance of the training of users and technicians if such systems are to operate successfully in the field.
- Do the units comply with Montreal Protocol on CFCs?
  The use of units that are CFC free is strongly recommended, as those using CFCs will eventually not be available. However, this can only be implemented if the CFC-free equipment has been tested and found to have satisfactory performance, and if the local infrastructure is in place to service and maintain the equipment.

CONCLUSIONS

Vaccine refrigerators play a major role in implementing the cold chain for vaccine distribution and use. The different types of units available have been described and the methods used for testing them have been introduced. The most appropriate unit for a particular location will depend on the climate of the location, the availability of fuels, the level of the renewable resources and the local infrastructure in place for maintaining and servicing the units.

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Small Wind Turbines

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ABSTRACT

Small wind turbine systems are typically classified as machines rated from a few Watts to 10-20kW. They are used in a variety of off-grid applications from supplying power for sailboats and recreational vehicles to e.g. providing lighting and refrigeration for remote area communities. In many cases they are used in combination with small diesel generators or as hybrid wind and solar systems. This paper gives an overview of the small wind turbine market and details the features of small wind turbine systems that distinguish them from large wind turbines. In addition, the 20kW Westwind turbine is selected as a case study of a small wind turbine system under development.

INTRODUCTION

According to Gipe (1999), the phrase 'small wind turbines' describes machines that are rated anywhere from a few Watts (W) to around 10 – 20 kiloWatts (kW). The definition of a small wind system, however, varies from source to source and is also constantly changing as the small wind turbine market expands. Manufacturers are pushing the upper bound of the classification, testing the economics of making slightly larger machines while keeping in mind the need for high reliability and low-maintenance for off-grid turbines in remote areas. There are currently a small number of 30kW machines on the market including machines manufactured by DEBA Systemtechnik GmbH in Germany and Pitchwind AB in Sweden (Johnsen (ed.), 2001). In the USA, Bergey Windpower Co. Inc. are currently developing a 50kW machine while the Atlantic Orient Corp. already produce a 50kW machine that is being promoted with the aid of the National Renewable Energy Laboratory (NREL) for 'village power' systems and small wind power plants.

Small wind turbines can be further classified into micro systems, mini systems and household-size systems. Classification depends on rotor diameter and generating capacity but once again there is flexibility in the definitions of these classes. Extending the conventions of Gipe (1999) to incorporate 50kW machines, approximate limits on rotor size can be used to classify small wind turbine systems. Micro systems describe machines that have a rotor diameter between 0.5 metres (m) and 1.25m. This includes the 90W Rutland Windcharger manufactured by Marlec Engineering Co. Ltd. of the UK as well as the 400W AIR-403 produced by Southwest Windpower in the USA. Mini systems are machines with rotor diameters within the range 1.25m – 2.75m and examples include the 600W machine from Proven Wind Turbines Ltd. in the UK as well as the German company Aerocraft's 'turbo' series of machines ranging from 500W to 1kW. Finally, household-size machines have a rotor diameter in the range 2.75m – 15m including the 5kW turbine by French company Vergnet, the 10kW machine by Dutch company LMW Renewables B.V. and the 20kW turbine by Australia's Westwind Wind Turbines.

Currently the number of manufacturers of small wind turbines in the world ranks above fifty and small wind systems have revolutionised the way that wind energy is used as well as bringing more people in contact with wind technology. This paper gives an overview of the background to the small wind turbine market and explores the variety of off-grid applications of small wind systems. In addition, the common configuration of small wind turbines is examined and a case study is presented of the 20kW Westwind turbine currently under development at the Australian Cooperative Research Centre for Renewable Energy (ACRE).

THE SMALL WIND TURBINE MARKET

Background

Early wind turbines were mechanical devices used for pumping water or grinding grain. The turbines spread into Western Europe from the Middle East and by the 19^{th} Century were so prevalent in Europe that in the Netherlands, 90% of the power used in industry was based on wind power (Ackermann and Söder, 2000). With the advent of industrialisation, the number of wind turbines in Europe went into gradual decline but they were introduced by settlers to North America and used for pumping water for livestock.

In the 1930's several Midwest manufacturers built 'wind chargers', small battery-charging machines that were often the only source of electricity for many homesteads in remote areas in the Great Plains. This industry collapsed after rural electrification in the 1950's but interest in wind energy was renewed in the early 1970's after the oil crisis. A new series of small wind turbines were manufactured in which the direct-current (DC) generators of the wind chargers were replaced by permanent-magnet alternators. In the 1980's some wind turbines with induction generators were manufactured for the purpose of direct connection to a utility's electricity grid. Although this proved a commercial failure in the USA, small turbines with induction generators were readily accepted in parts of Europe, particularly Denmark, Germany and the Netherlands.

The small wind systems with induction generators gradually grew in size and formed the beginning of a wind energy industry in which a 1.5MW machine is becoming a standard product and which achieved annual sales of $4 billion US dollars last year (AWEA, 2001). As well as their role as a catalyst for the large wind turbine industry, the small wind turbine systems with permanent magnet alternators have formed a separate market that has grown in parallel with the large wind turbine industry and has focused on off-grid applications. This has brought more people and communities into contact with wind energy and has increased the variety of uses of wind power.

Currently there are more than 50 manufacturers of small wind systems worldwide and over 100 different models (Gipe, 1999). In China 150,000 turbines have been installed (Bergey 2000) and, in the last 20 years, 60,000 turbines have been manufactured in Western countries. The small wind turbine market is a niche market as it is dependent on the wind regime at the site. In many applications it is used in conjunction with small diesel generators or photovoltaic modules as 'hybrid' systems.

Applications

The applications for small wind systems can again be categorised according to class of wind system but this paper by no means provides a rigid categorisation or a complete study of small wind turbine applications. Micro systems have been used traditionally by the marine and recreational vehicle (RV) industries to provide power in e.g. sailboats and motor homes. It is possible that in the future wind energy will be used to charge electric cars for homeowners. Micro systems are also used for small dwellings such as the tents that nomad's use in Mongolia. Tens of thousands of machines are manufactured in China for this purpose. Mini systems are used to power slightly larger buildings such as cabins and holiday homes.

Household-size systems can be used in hybrid systems to provide 'village power' i.e. electricity for homes, schools, clinics and small industries. Gipe (1999) states that providing 100kWh per month at a site with mean annual wind speed of 5.5m/s is enough to power a village with lighting, refrigeration and a radio or TV for entertainment. Household-size systems also provide a crucial role as either mechanical windpumps or wind-electric pumps to provide water for people and livestock. Two Bergey Windpower 10kW machines are providing a community of 4,000 people in Niama, Morocco with 220% more water than the original diesel pumps and have been instrumental in reversing population decline (Bergey, 2000).

FEATURES OF SMALL WIND TURBINES

The blades of small wind turbines are made of composite materials such as fibreglass and each rotor is usually composed of two or three blades. Three blades on a rotor are most common since, despite the decrease in manufacturing costs, a rotor with two blades produces greater cyclic stresses on the hub and tower of the turbine. The rotor is mounted upwind of the tower on a horizontal-axis. Up to this point the discussion of the features of small wind turbines are similar to large wind turbines but here the similarity ends. Since the rotor blades are shorter on small turbines, the blades must rotate at a faster frequency to capture a reasonable energy yield from the wind. Thus, the aerodynamic profiles of the blades differ from large wind turbines. The wind industry has placed less emphasis on research into aerodynamic efficiency for small wind turbines than it has on developing aerodynamic profiles for large wind turbines. As a result the aerodynamic efficiency of a small wind turbine is significantly lower than that of large wind turbines.

In the design of the transmission-generation system, there are also substantial differences. Most small turbines are direct-driven, variable-speed systems with permanent magnet alternators. Such a system requires no gearbox, which is good for overall reliability and low-maintenance of the machine. Due to their size, small turbines have no room for the yaw motors and mechanical drives of the larger machines and rely on a tail vane to orientate the machine into the wind. The power and speed regulation of small machines varies significantly from large machines by using mechanically controlled pitch and yaw systems instead of electronically controlled systems. Small systems often use furling as a method of overspeed control. This is either performed horizontally where the rotor swings toward the tail e.g. Bergey and Westwind machines, or vertically where the rotor tilts into the air and resembles a helicopter e.g. Southwest Windpower turbines.

Although over the years a common configuration has evolved in the design of small turbines, there are always exceptions – for example Vergnet machines employ induction generators and use pitch control mechanisms to prevent over speeding.

WESTWIND WIND TURBINES – A CASE STUDY

Westwind Wind Turbines started manufacturing wind turbines in 1984 when they designed, manufactured and installed a grid-connect, induction generator, 60kW wind turbine for the State Energy Commission of Western Australia (SECWA). Subsequently they supplied a further eight 60kW wind turbines and three 30kW wind turbines to government or semi-government customers. Westwind turbines were chosen for Australia's first wind farm in Esperance, Western Australia.

In subsequent years the market for grid-connected wind turbines in Australia continued to be very uncertain and intermittent. Thus the focus was shifted to smaller machines specifically designed for installation in remote areas where reliability and minimal maintenance are the prime requirements. Wind turbines rated at 2.5kW, 5kW, 10 kW and 20kW are currently produced. All Westwind wind turbines consist of three blades, upwind of the tower on a horizontal axis and attached directly to a sealed permanent magnet generator. Rotor overspeed protection is achieved via pitch weights on the blades and auto furling. Westwind wind turbines have been sold and installed all over the world in countries including India, China, Vietnam, Germany and Fiji.

The 20kW is in the final stages of prototyping under the co-ordination of ACRE. Testing of the 20kW turbine has been conducted at the Murdoch University Energy Research Institute (MUERI) since August 1999. Researchers from the University of Newcastle, Australia, are addressing the problem of aerodynamic efficiency for small wind turbines by developing sophisticated aerodynamic profiles for the 20kW machine. With the increase in machine size to 20kW, Westwind are entering the domain of grid-connected machines once more and three of these machines are planned for a mini-grid system at Exmouth, Western Australia.

CONCLUSIONS

Historically, small wind turbines have played a role in the development of a billion dollar large wind turbine industry while maintaining and expanding a market of their own. At present small wind systems are not economically viable for grid-connected systems and the market has focused on off-grid applications. The small wind turbine market is a niche market, dependant on wind regime, and has infiltrated the traditional domain of photovoltaic modules, where the two technologies are often used in combination as a hybrid system. The effect has been a widespread use of wind energy both in terms of the variety of applications as well as the number of people who have been brought into contact with wind technology.

The emphasis of small wind turbine design has been on high reliability and low maintenance. The 20kW Westwind turbine is being developed under the co-ordination of ACRE to incorporate these factors as well as improved aerodynamic performance. The University of Newcastle, Australia have set up research into developing sophisticated aerodynamic profiles for the 20kW Westwind turbine.

In terms of future off-grid projects, the potential market for 'village power' is significant since there are currently two billion people in the world without power. The political support shown in Denmark in the mid-1970's allowed the Danish turbine manufacturing industry (and turbine size) to grow. Given appropriate electricity feed-in laws more countries could follow this example, paving the way for more grid-connected wind systems throughout the world.

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Policy and Social Issues

Climate Change and Developing Countries: Options in International Environmental Law for Combating Greenhouse Gas Emissions

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ABSTRACT

Climate change is likely to affect all of us, but in a number of respects developing countries may well be hit hardest. This paper looks briefly at impact scenarios for developing countries, and then turns to the possible remedies that these countries might have in international law. In particular, the paper examines the position of small island states. It discusses the significant impact that they have had in the development of the climate change treaties, and then examines the options that these states might have in international environmental law to halt the potential rise of global sea levels. It is argued that the most fruitful course for developing country states in international law may be to force compliance with the procedural norms of environmental impact assessment, information provision, and consultation that are contained in recent multilateral treaties.

INTRODUCTION

It is not surprising that many developing countries look to the issue of climate change and think that the level of predicted impact places an unfair burden on them.

IPCC predictions have it that sea levels will rise between 15 and 95 cms by the year 2100, with a best estimate of 50 cms. The UK's Hadley Centre for Climate Prediction and Research (part of the Government's Meteorological Office), predicts that this kind of sea level rise will increase the number of people flooded from 13 million to 94 million. Sixty percent of this increase will occur in South Asia, and 20% will occur in South East Asia.

Coastal zones and small islands contain some of the world's most diverse and productive resources, and their global importance in terms of both ecological and socio-economic values is widely recognized.

Predicted sea level rises may well completely obliterate some developing countries, particularly small island states. The Republic of Maldives, for example, includes over 1000 islands, none of which is higher than 1.5 metres above sea level. At the same time, this country accounts for only 0.00013% of global CO_2 emissions, and as a consequence, provides little opportunity for developed countries to obtain certified emission reductions under the Clean Development Mechanism (if, indeed, this comes to pass).

The global community is effectively preparing to destroy countries such as this. Clearly this situation cannot be considered "fair" in any sense. It is tempting to think that small low-lying countries have no options for dealing with the potential catastrophe presented by sea level rise.

This paper looks at whether this assumption is justifiable, and focuses on what remedies there may be in international law for developing countries in the situation faced by the Republic of Maldives.

The structure of the paper takes the form of preliminary advice to the States in question. It focuses on the issue of whether or not it is possible for small island States to use international law to halt the potential rise of global sea level by requiring countries emitting GHGs to substantially reduce this type of pollution.

USING INTERNATIONAL LAW TO HALT SEA LEVEL RISE

There are two issues that need to be discussed in relation to attempts that small island States might make to halt sea level rise. First, small island States need to have GHG emissions reduced so as to alleviate the threat of global warming. This means that they must find a way to influence or compel States that emit GHGs to substantially reduce their output of these gases. The search for relevant instruments that may be used by small island States in this manner occurs in the context of current international environmental law. This law is found in treaties and customary law.

The second aspect of the small island States' situation that will be considered might be broadly titled "available remedies". It is an examination of how these States might seek to have current law enforced or, in the alternate, how they might seek damages for harm projected or inflicted.

Relevance of Environmental Treaties

On the face of it, the most relevant treaty for small island states to turn to is the United Nations Framework Convention on Climate Change ("the Climate Change Convention").[1] The objective of the treaty, as outlined in Article 2, is to achieve stabilisation of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The Convention is significant for a number of reasons. "It was the first environmental agreement to be negotiated by virtually the whole of the international community, with 143 countries" [2] being involved in final preparatory sessions. It is also considered to be unique in the scope of its consequences, with few human activities falling outside of its scope. [3]

Sands considers it to be one of a selection of "law-making" treaties, which have greater authority than others because they "lay down general rules of conduct among a large number of states". [4] As will be outlined later, the Convention also has potentially innovative implementation and dispute settlement mechanisms. In relation to the issue of sea level rise and its impact, Article 4 makes specific mention of the needs of small island States.

Since the Climate Change Convention came into force in 1994, there have been five Conferences of the Parties. The most significant was undoubtedly the 1997 Kyoto meeting, where a new Protocol was agreed upon. [5] The Kyoto Protocol makes binding emission targets for developed countries, and offers methods for developed countries to "trade" carbon emissions with developed country partners ("joint implementation"), and develop projects in developing countries to offset emissions ("clean development mechanism").

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[1] 1992 United Nations Framework Convention on Climate Change (1992) 31 ILM 848 (Climate Change Convention); in force 21 March 1994.

[2] P. Sands, Principles of International Environmental Law Volume 1: Frameworks, Standards and Implementation (Manchester: Manchester University Press, 1995).

[3] Ibid at 273.

[4] Ibid at 105.

[5] 1997 Kyoto Protocol to the Framework Convention on Climate Change (1998) 37 ILM 22 (1998) (Kyoto Protocol); not yet in force.

While the Climate Change Convention is undoubtedly the most important treaty for small island States to turn to, there are others that may also be relevant. These include the:

- 1992 Convention on Biological Diversity; [6]
- 1982 United Nations Convention on the Law of the Sea (UNCLOS); [7]
- 1979 Convention On Long-Range Transboundary Air Pollution; and [8]
- 1991 Convention on EIA in a Transboundary Context. [9]

One of the basic objectives of the Convention on Biological Diversity is inter alia to conserve biological diversity. [10] While this Convention focuses primarily on the activities required of Parties to conserve biodiversity within their own jurisdictions, there are specific sections of the convention where mention is made of the responsibilities that parties have to other States. For example, Article 14 requires that activities undertaken by a Party that might endanger the biodiversity of another State should be reported on, and action taken to prevent or minimise danger or damage. Clearly, inundation by sea level rise would fundamentally affect terrestrial biodiversity in small island States, and would undoubtedly affect marine biodiversity, although not necessarily to the same extent.

Another treaty that may have relevance is the United Nations Convention on the Law of the Sea (UNCLOS). The "general obligation" of Parties to UNCLOS, Article 192 is "to protect and preserve the marine environment". Article 194 presents a set of measures to prevent, reduce and control pollution of the marine environment, including a requirement that States ensure that activities undertaken within their jurisdiction do not cause pollution that might affect other States. Article 194 (3) indicates that measures should be designed to minimise the release of harmful substances from land-bases sources. As has already been mentioned, global warming leads to a change in the chemical composition of sea water, as higher rates of carbon dioxide are absorbed by the ocean and as thermal expansion leads to sea level rise. This is quite clearly pollution of the ocean, and is contrary to the requirements of UNCLOS, Article 194 (3).

Finally, there are two regional conventions that specifically relate to the control of transboundary environmental impacts. The Convention on Environmental Impact Assessment in a Transboundary Context makes it clear that parties are responsible for undertaking investigations of proposed activities that might have transboundary environmental impacts, before the activity is implemented. Article 2 requires Parties to produce environmental impact assessments of GHG-emitting activities, and to inform potentially affected States of the outcomes of these studies. Environmental impact assessments should be undertaken with public participation, and for policies, plans and programs, as well as for projects.

The Convention On Long-Range Transboundary Air Pollution has as its aim the control of air pollution originating in one State, but where the effects are felt in another State at such a distance that it is not generally possible to distinguish the contribution of individual emission sources or groups of sources. [11] The Convention clearly includes greenhouse gases as "air pollutants" (Article 1(a)), and focuses primarily on consultation and exchange of information.

[6] (1992) 31 ILM 818.
[7] (1982) 21 ILM 1261.
[8] (1979) 18 ILM 1442.
[9] (1991) 30 ILM 802.
[10] Convention on Biodiversity, Art. 1.
[11] Convention on Long-Range Transboundary Air Pollution, Art. 1 (b).

While these latter treaties seem especially specific and relevant to the case of small island States, they are regional agreements open only to members of the Economic Commission for Europe (ECE). The issue as to whether they could be used by small island states in international law is dealt with in a later section.

In conclusion, there appear to be avenues within a selection of environmental treaties for small island states to call for implementation to bring about a reduction in GHG emissions. The possibilities for implementation and enforcement of these agreements will be discussed in an upcoming section.

Relevance of Customary International Law

Customary international laws are the unwritten rules that develop over time in relation to a specific issue. Although it plays a vital part as a source of international law, there is significant disagreement as to the relevance of custom in modern international environmental law. Shaw points out that this argument is strongly influenced by the fast pace of development of environmental law. [12] Custom is also difficult to prove, requiring evidence of consistent State practice, and the subjective belief that such practice "is" law.[13]

Despite these reservations, there is an important interplay between treaties and custom in the area of environmental law and a brief discussion will allow the relevance of customary law to the situation of small island States to be explained.

Some of the most important principles of contemporary environmental treaties originate in customary law. For example, Sands makes the point that general principles of international environmental law, as reflected in State practice and other international instruments, "provide strong support for the view that customary international law prohibits states from causing significant environmental damage from transboundary air pollution". [14] This concept actually originated in the 1941 decision of the International Arbitral Tribunal in the Trail Smelter Case [15] where the USA was awarded damages to compensate it for destruction of crops from sulphur dioxide pollution emanating from a Canadian smelter.

This concept has found its way into many contemporary treaties, primarily from its inclusion in the influential Principle 21 of the 1972 UN Conference on the Human Environment (Stockholm Conference) which declares that:

> "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction".

The interplay between treaties and custom means that it is possible for customary law to be formed by treaties, through the recognised test of state practice and opinio juris. Treaty provisions that might be considered as rules of customary law can be substantive, as well as procedural guides for decision-making. Examples of substantive obligations reflected in many treaties include:

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[12] MN, Shaw, *International Law*, 4th ed (Cambridge: Cambridge University Press, 1997) at 600.

[13] The two elements of customary law. consistent State practice and subjective belief, or *opinio juris* are discussed by Sands, note 2 at 118 and Shaw, note 12 at 58.

[14] Sands, note 2 at 247.

[15] *Trail Smelter Case* (United States v. Canada) (1941) 3 RIAA 1907.

- Principle 21 of the Stockholm Conference;
- cooperation to address environmental problems with shared natural resources;
- adoption of general measures to protect the marine environment;
- conservation of endangered species; and,
- limitation of emissions of gases, such as sulphur dioxide.

Examples of norm-creating procedural guides to decision-making include: [16]

- the polluter-pays principle;
- the principle of precautionary action;
- environmental impact assessment (EIA);
- the provision of information;
- consultation; and,
- the principle of common but differentiated responsibilities of developed and developing countries.

Shaw [17] and Sands [18] discuss these "emerging" customary laws, pointing out that they are at differing stages of maturation, depending on the degree to which they have been accepted as uniform state practice. Nonetheless, they each occur in at east one of the cited environmental treaties to which small island States could turn for assistance.

Enforcement and Compliance
Both treaties and customary law seem to indicate that small island States might have a case to take against one or more countries in international law. Whether or not they are legally able to bring a case under specific provisions is a matter that will be dealt with later.

Small island States therefore have a two-pronged approach open to them. They could argue that GHG-emitting States have not complied with the requirements of treaties, or of customary law. Alternatively, they could argue that they have, or are likely to, suffer environmental damage as a result of the actions of other offending States. Non-compliance could be claimed in relation to either substantive obligations as required by treaty or custom, or procedural requirements.

It may well be easier to argue that procedural requirements have not been met, because these do not involve questions of damage or liability. The most obvious line of attack here would be in relation to environmental impact assessment, the provision of information, and consultation. All of the treaties discussed earlier require EIA work to be undertaken before pollution-emitting activities are implemented. [19] The common requirement is for environmental assessment of polluting projects to be undertaken before construction.

While there is strong evidence of consistent State practice of EIA, jurisdictions vary as to which projects must be assessed. Some only require large-scale activities to go through the EIA process, meaning that many smaller GHG-emitting proposals might not be environmentally

[16] Shaw, note 12 at 601-606; Sands, note 2 at 121.
[17] Ibid.
[18] Ibid.
[19] See UNCLOS, Art 206; Convention on Biodiversity, Art. 14(1)(a); Climate Change Convention, Art. 4(1)(f); Convention on Long-Range Transboundary Air Pollution, Art. 7(e)); and the Convention on Environmental Impact Assessment in a Transboundary Context.

assessed. [20] The treaties also call for assessment of things-other-than-projects, such as policies and programmes. This means that a State would be required to produce regular EIAs of energy policies, for example. EIA of policy is notoriously difficult, as the well defined project-based EIA techniques are not easily transferable to policy assessment. There is therefore very little evidence of policy EIA having been undertaken by States. [21]

Clearly EIA works to provide information to both emitting States, and those potentially affected by transboundary impacts. It would therefore meet the "information provision" requirements of treaties and customary law, when it is undertaken. There is, however, a separate procedural requirement in treaties to consult prior to the approval of a GHG-emitting activity. Given that it is difficult enough to encourage GHG-emitting project developers to undertake public consultation in their own jurisdictions[22], it would be reasonable to assume that northern hemisphere energy utilities and their regulators do not consult Governments of small island states before commissioning new power plants.
The final procedural norm that is worth discussing here is the common requirement for States to observe the "precautionary principle".

The precautionary principle has been defined as a guiding principle which:

> "ensures that a substance or activity posing a threat to the environment is prevented from adversely affecting the environment, even if there is no conclusive scientific proof linking that particular substance or activity to environmental damage". [23]

Sands [24] claims that there is a "good argument to be made that it reflects a principle of customary law". It is contained within a number of recent treaties, in particular the Convention on Biodiversity [25] and the Climate Change Convention. [26] The significance of the precautionary principle in the case of small island States is that there is uncertainty within the scientific community about the timing and severity of global warming. The existence of the precautionary principle in international law allows small island States to call for compliance with the "no harm" rule of Trail Smelter/Stockholm Principle 21 contained in the Climate Change Convention, despite the uncertainty surrounding anthropogenic climate change predictions.

Having dealt with non-compliance with procedural norms, a few words are needed on the issue of compliance with substantive norms. It could be argued that the Trail Smelter/Stockholm Principle 21 obligation has not been met because GHG-emitting activities of other States will cause damage to small island States. This obligation is demonstrated in the Article 3 of the Convention on Biological Diversity, the Preambles of both the Climate Change Convention and the Convention on Long-Range Transboundary Air Pollution, and UNCLOS, Article 194 (2). If States do not meet emission targets specified in the Kyoto Protocol to the Climate Change Convention [27] then this, too would be a failure to give effect to a substantive norm, although

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[20] G Glasson, R Therivel, and A Chadwick *Introduction to Environmental Impact Assessment* (UCL Press Ltd, London: 1994) 34.

[21] Ibid at 301-302.

[22] Ibid at 141.

[23] J Cameron and J Abouchar "The status of the precautionary principle in international law" in D Freestone and E Hey (eds) *The Precautionary Principle and International Law: The Challenge of Implementation* (Kluwer Law International, The Hague: 1996) 30.

[24] Sands, note 2 at 213.

[25] Convention on Biodiversity, 9th Preambular para.

[26] Climate Change Convention, Art. 3.

[27] See the quantified emissions limitations listed in Kyoto Protocol, Annex B.

small island States would have to wait until after the end of the "reduction commitment period" in 2012 to claim non-compliance with this provision. [28]

The possibility of non-compliance with substantive norms of international environmental law raises an especially problematic issue for small island States. Claims that substantive norms have not been complied with requires engaging with the issue of damage and liability. Most definitions of pollution rely upon damage or harm having been caused before liability is engaged. [29] This is a problem for the small island States' case where the focus of concern is almost entirely on future conditions rather than current damage. Shaw points out that international law does not yet generally recognize liability for risk of damage, although UNCLOS, Article 1(4) defines pollution of the marine environment as the "introduction by man, directly or indirectly, of substances or energy into the marine environment … which results or is likely to result in … deleterious effects". [30] In the case of UNCLOS, this means that it is not necessary to prove that actual damage has occurred. It should also be noted that damage may already have occurred, as it has been argued that storms that severely affected at least one small island State in 1987 could have been linked to sea level rise. [31]

Another problem presents itself in relation to dealing with substantive non-compliance. In traditional international environmental law, the notion of "state responsibility" can be invoked when it can be proven that particular damage has been caused to one State by another. This is one of the outcomes of the Trail Smelter Case. However, with regard to climate change, every country is a polluter and therefore the bilateral focus of traditional State responsibility approaches are not relevant. This is an important issue, as a number of commentators quote it as a reason for the recent trend toward cooperative, multilateral treaty making. [32] If the State responsibility approach is not relevant in this case then the traditional remedy of reparation that is predicated on this bilateral structure may be affected to some extent.

The question then arises as to how small island States could seek remedies if they did attempt to force compliance with substantive or procedural norms. The most obvious answer appears to be in the dispute resolution sections of the treaties themselves. For example, the Climate Change Convention offers three options for States wishing to resolve a question or settle a dispute. Article 13 allows for the Conference of the Parties to establish a "multilateral consultative process" for the resolution of implementation questions. Article 14 allows for compulsory recourse to arbitration or the International Court of Justice, although the latter option clearly requires the consent of the relevant parties. [33] The most interesting option for small island States could be that offered by Article 14(5) and 14 (6) of the Climate Change Convention. Here the Convention states that if the parties cannot resolve a dispute between them within 12 months, then the dispute can be sent to a special conciliation commission at the request of any of the concerned parties.

A final point needs to be made about the ability of other States to bring cases on behalf of small island States, in which the provisions of the Convention on Long-Range Transboundary Air Pollution and the Convention on Environmental Impact Assessment in a Transboundary Context

[28] Climate Change Convention, Art. 3(7).
[29] Guruswamy, Palmer and Weston, note 4 at 344.
[30] Shaw, note 12 at 594.
[31] Ministry of Planning, Human Affairs and Environment (Republic of Maldives) *Second National Environment Action Plan* (Ministry of Planning, Human Affairs and Environment, Male: 1998) 15.
[32] Shaw, note 12 at 586; Boyle, note 10 at 229.
[33] Shaw, note 12 at 756.

are of direct relevance. Participation in both, however, is restricted to Economic Commission for Europe (ECE) members. There arises a question as to whether this situation precludes an action on behalf of non-ECE small island States. While small island States are not parties to either convention, it is possible to conceive of a "friendly" third State pursuing a case in aid of one or more small island States. This would be an example of a case being pursued by one State on behalf of the international community as a whole. [34]

This so-called actio popularis concept is considered to be only a trend in international law, although some commentators have suggested that it might be possible to pursue this in the case of customary laws that have overwhelmingly acceptance (erga omnes). The International Law Commission supports the view that an obligation or duty not to cause "massive pollution" may be an obligation owed erga omnes. [35]

It is, however, most unlikely that small island States could pursue actio popularis in relation to the Convention on Transboundary Environmental Impact Assessment, because Article 22 precludes parties from requesting an EIA with respect to impact on the global commons.

CONCLUSION

Low-lying small island States in the South Pacific and South Asia are under threat of complete inundation if predictions about the degree of sea level rise as a result of human-induced climate change come to pass.

Climate change is a global issue and small island States only produce relatively small quantities of the polluting gases that give rise to the problem. A question therefore remains as to what small island States can do to bring a halt to this threat to their survival. Clearly they can lobby in international forums, and in the media. The President of the Republic of Maldives has provided a good example in this regard. [36] Another option open to small island States is to use the instruments provided by international environmental law to influence the international community.

It appears that the most fruitful course of action for small island States in international environmental law may well be to force compliance with the procedural norms of environmental impact assessment, information provision and consultation that are contained within the Climate Change Convention and the Convention on Biodiversity. [37] Enforcement would involve invoking the innovative, and relatively binding dispute settlement provisions of Article 14 of the Climate Change Convention.

This is the most fruitful course because it would not involve having to prove damage and assign liability, which would be a major hurdle if small island States attempted to ensure compliance with substantive norms of treaty or customary law. Proving that damage has already occurred as a result of GHG emissions may be difficult to prove in fact. Basing a case on potential impact is problematic, the only possibilities being reliance on Article 1(4) of UNCLOS, or making a new

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[34] Sands, note 2 at 151 points out that both the 1987 Montreal Protocol on Substances the Deplete the Ozone Layer (1987) 26 ILM 1048, and the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) 28 ILM 657 both allow for "third parties" to enforce obligations under the treaties.

[35] Shaw, note 12 at 544.

[36] See R Ellis *A Man for all Islands* (Times Editions, Singapore: 1998).

[37] Some of these provisions are also contained, in lesser degree, in UNCLOS.

argument that the prevention of "massive pollution" expected from GHG emissions is a customary law obligation erga omnes.

Given the situation faced by small island States, attempting to halt sea level rise by enforcing substantive and procedural obligations in the cited international treaties appears to be by far the most proactive use of international law.

Policies for the Promotion of Energy Efficiency and Renewable Energy

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ABSTRACT

A range of policies will be discussed grouped under legislative actions, administrative measures, information and promotion programs and incentives.
To choose the appropriate policy it is useful to consider the objective or outcome required and the existing barriers to achieving that objective. Some examples will be given of policies that have been applied for the promotion of energy efficiency and renewable energy both in Australia and other countries. The reasons why some policies are more successful than others will be examined because it is not always the case that a policy which works at one time in one place will be universally applicable.

INTRODUCTION

There are a range of policies and programs available for promoting renewable energy and energy efficiency which have been used at various times throughout the world. Some have been more successful than others. Proper analysis of a policy before it is adopted will help to ensure that resources are not wasted.

A policy is a course of action designed to achieve some effect. A new policy only needs to be developed if the required result will not happen by itself or not happen quickly enough. So the first step in developing a policy is to clearly define the objective or particular outcome desired. It is useful if the outcome is measurable and some base measurements are taken so that the effectiveness of the policy can be ascertained. All policies and programs have an associated cost. A preliminary analysis of the costs and benefits to society as a whole of a policy will help justify these costs.

TYPES OF POLICY

Legislation and Regulation

Mandatory measures require legislation to be enacted and regulations enforced. Australian examples of such measures are the Mandatory Renewables Target (MRT), imposed by the Renewable Energy (Electricity) Act 2000, and Minimum Energy Performance Standards for appliances. In a number of European countries and US States there is a minimum buy-back rate legally imposed for renewables-based electricity feeding into the grid from small generators. Taxes on emissions is another type of policy which needs legislation.

The Commonwealth's Renewable Energy (Electricity) Act 2000 requires electricity retailers and other large purchasers of electricity to gradually increase the amount of electricity they acquire from renewables-based sources until 2010 when an additional amount of 9500 GWh will need to have been acquired. This measure, referred to as the MRT, will be used to demonstrate some of the strengths and weaknesses of legislative policies.

Legislative measures can ensure that the burden is spread across society and that a predictable result is produced. For the MRT the requirement is imposed on all retailers except those in remote areas and the result is more than predicted, it is mandated. However, there are a number of disadvantages to this type of policy. Firstly legislation has to be drafted and passed through Parliament. This is usually difficult and time consuming. The Prime Minister announced the intention of imposing this measure in 1997 and it was enacted in 2000 after an enormous amount of background work including government committees, specialist studies of likely effects and political lobbying.

Once legislation is enacted and any regulations allowed there is also the cost of enforcement as well as the cost to society of doing what it would not voluntarily do. For the MRT an office of the Renewable Energy Regulator had to be set up with a not insignificant budget. As renewable energy is more expensive the cost of electricity will as a consequence rise and this cost, to be borne by the customers, may be unpopular.

The biggest disadvantage of legislative measures is that they usually only provide for a base level of action. A number of people consider that the target of 9500 GWh is too small, but unless the cost of electricity from renewable energy reduces drastically over the decade we need another policy to get above this level. Similarly Minimum Energy Performance Standards (MEPS) only eliminate the worst performers and do not provide encouragement for state of the art technology.

Legislative measures are most applicable when there is a split incentive, like in a tenant landlord situation, where economically efficient outcomes will not result from the market. They are also effective when a government wants to go further than is economically cost effective. This is the case for renewable energy targets until the environmental cost of fossil fuels is incorporated into the market.

Administrative measures - government purchase or action

Government can make a difference by having a policy to purchase Green Power or by effectively managing its own energy use. Government owned enterprises can invest in renewable energy when it may not be commercially advantageous but there is a clear benefit to the State. These policies can provide a significant boost for industry.

It is difficult to justify Western Power's 20 kW PV demonstration plant at Kalbarri in the mid West Region on commercial grounds alone. However Western Power considered that by building this system there was an opportunity to test local technology in a situation which in the future could be commercial. The system uses a locally manufactured inverter and trackers.

All Australian Governments have been asked to manage, measure and report publicly on their own energy use and publicise the savings achieved. Some Governments have decided on a policy to purchase only office equipment which meets the Energy Star standard. These actions have a financial cost but they also have a financial benefit which outweighs this cost. They provide the opportunity for Governments to lead by example, although they are often difficult to implement because Governments are generally not as responsive to commercial pressures as private enterprise.

When the measure is not cost effective it may be justified if it generates enough additional market demand to make a significant difference to local industry. Government actions are most effective when there is an attitudinal barrier and where the market demand of government is likely to make a difference.

Information and marketing

Marketing programs or policies to provide information are applicable when lack of information or public attitudes are barriers to sensible decisions. Examples include Star Rating of appliances, voluntary standards, Green Power programs, information services and award programs.

The Western Australian Office of Energy runs a Home Energy Line telephone information service. For the cost of a local call a person can telephone from anywhere in the State and ask for information about house design, renewable energy, efficiency of appliances or other issues associated with renewable energy or energy efficiency. A suite of information brochures has been developed and the relevant publication is posted out to the caller if desired. The information is also available on the Home Energy web-site.

Another example of an information program is the Green Power program. Retailers of electricity offer to sell electricity from a renewable source and the government supports this with marketing and by providing accreditation, thus ensuring the public that the electricity indeed does come from a renewable source.

Training programs are included with this set. Renewable energy is a new technology and assistance with developing training for designers, installers, and maintenance workers is needed if there are to be sufficient trained technicians to ensure reliable systems. The Western Australian government provides the Australian Cooperative Research Centre for Renewable Energy (ACRE) with some support for developing training courses. Community and user training may also be required to optimise the effectiveness of these systems.

There is a not insignificant cost to obtaining and then providing up to date information but nevertheless information programs usually cost less than mandated requirements. They also provide an incentive to go beyond base level to latest developments. One disadvantage is that it is very difficult to predict the outcome of an information program.

The Australian Appliance Star Rating program is a combination of a regulatory and information program. Legislation requires that the information on the energy efficiency of an appliance is displayed to purchasers and ensures that the information on the energy efficiency of an appliance is accurate.

Incentives

Incentives are probably the most popular of all policies. After all everyone wants the government to give them something! Incentives include grants and other capital cost subsidies as well as accelerated depreciation and tax rebates. In Western Australia we offer a rebate on the purchase of renewable energy equipment in isolated locations. Loans which are easier to get or which have lower interest are another form of incentive. Emissions caps and trading could be called a financial incentive to reduce emissions, although it would also require legislation.

Incentives have a direct and often large capital and recurrent cost as well as the cost of administration. They should be used when the capital cost is a barrier to technology being adopted and when there is a likelihood that an increased market will bring down prices and increase the market confidence in a product. Subsidies are rarely appropriate when there is already significant market penetration, because the people who would purchase the technology even if the grant was not in place get what is known as a 'free ride'. The problem with 'free riders' can be well illustrated by considering the subsidy for solar hot water systems provided in several Australian States but not yet in Western Australia.

In Western Australia some 10% of hot water system purchases or 6000 systems per year are solar powered. In other Australian States the number is much less. If the Western Australian government were to provide a subsidy of $500 per system, comparable to that offered in the Eastern States, it would cost $3 million just to subsidise those people who were already going to purchase a solar system. If as a result of the subsidy an extra 1000 systems were sold per year, the total cost would be $3.5 million and each extra system would have effectively cost the government not $500 but $3500.

Rebates are considered appropriate for renewable energy systems in isolated locations. The subsidy is considered acceptable because, although some of the recipients may be 'free riders', they are considered disadvantaged because of their isolated location and lack of grid access. The objectives in this case include an equity objective as well as an objective to increase the use of renewable energy.

Although it is not always possible to measure the 'free riders' it is usually easy to measure the outcome of a subsidy program because it is directly associated with the amount of money provided.

Support for Research and development

Research and development is needed for new technology development and it generally benefits from government support or incentives. It is necessary to go beyond research and through to commercialisation if the money spent is going to be effective. Research can be very expensive. One way to provide support is by tax rebates.

CONCLUSION

There are a great variety of available policies. A policy that works in one place will not necessarily work in another so it is risky to just copy policies. Objectives should be clearly identified and a preliminary assessment of cost effectiveness in meeting those objectives completed. Any policy or program will have a cost, associated with its implementation, and this cost will have to be justified. Base-line measurements before implementation and follow up studies will ensure that the program can be justified if it is worthwhile.

Policies that stop before they have a chance to have a significant effect can be detrimental. For example, industry gears up to meet the demand of a subsidy policy and the demand suddenly ceases because the money for the program has run out. Policy should be maintained for long enough to support, not damage the industry. Stop-start effects can also arise from incentive policies which are announced long before they are implemented. Most customers stop buying until the incentive starts and the suppliers business is damaged rather than supported.

Cities For Climate Protection: Local Government Action To Reduce Greenhouse Gas Emissions

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ABSTRACT

Local Governments don't have an immediately obvious role to play in reducing greenhouse gas emissions in comparison with international, national and regional governments.

However, it has been estimated that Local Government can potentially influence activities contributing up to 50% of our national greenhouse gas emissions, through both their legislative and decision-making responsibilities, and their connections with their communities.

The Cities for Climate Protection ™ program builds on the recognition of the role that Local Government *can* play in addressing climate change, in such areas as the facilities and operations owned and operated by a Council, the land use planning system, transportation planning and so on.

Most Councils are also finding that action to reduce greenhouse gas emissions have numerous additional benefits, such as financial saving through energy and fuel efficiency, local economic development and job creation through sustainable industries, air pollution reduction, community livability. One Environment Officer in WA has termed these 'no-regrets' actions. Another obvious imperative for action by Local Government on reducing greenhouse gas emissions is of course the potential impact of climate change on Local Governments and their jurisdictions.

THE ROLE OF LOCAL GOVERNMENT

Local Governments throughout the world are recognising the role that they can play in the reduction of greenhouse gas emissions. While they may not have a prime responsibility in comparison to national, state and regional governments, there is an obvious imperative for action by Local Governments with the potential impacts of climate change on Local Governments and their jurisdictions.

The other obvious imperative for action relates to Local Government's responsibilities and potential sphere of impact. In Australia it has been estimated that Local Governments can potentially influence activities contributing up to 50% of our national greenhouse gas emissions, through their legislative and decision-making responsibilities, and their connections with their communities (Commonwealth of Australia, 2000).

For example, Local Governments own, operate or influence:

- facilities and operations such as municipal buildings, street lighting, recreation facilities, wastewater treatment plants;
- building codes and permits that determine the energy efficiency of residential and commercial buildings;
- landfill sites and the production of methane emissions;

- waste collection and management including recycling, compost or waste reduction programs;
- land use planning and development that determine the density, mixture and physical layout of buildings, neighbourhoods and communities; and
- transportation infrastructure that determines the transportation choices of residents and businesses, affecting the level and type of transportation energy consumed and the number and length of vehicle trips; and
- public works infrastructure such as water supply, sewage, and other public works.

Local Government in Australia, especially in some States, does have a fairly constrained and limited role, and so the potential in other countries for local governments to influence greenhouse gas emissions may well be more significant.

The Cities for Climate Protection (CCP™) program formalises the role of Local Government in addressing climate change, through a milestones based program.

THE CITIES FOR CLIMATE PROTECTION PROGRAM

Cities for Climate Protection is a campaign of the organisation International Council for Local Environmental Initiatives (ICLEI). The campaign was established by ICLEI in 1993 at an international summit of municipal leaders.

Put simply, CCP is a practical framework based approach for local governments to reduce greenhouse gas emissions. Over 400 local governments are now participating in CCP™ which represents 8% of global greenhouse gas emissions and the number of participants is growing constantly.

In Australia CCP™ is delivered in a partnership between ICLEI and the Australian Greenhouse Office (AGO) – with the Commonwealth Government providing $13 million in funding over five years. It is perhaps this support from the Commonwealth Government that his made the Australian CCP program into one of the most successful. In just three years, nearly 100 Local Governments have committed to the program translating to 44 % of Australia's population. That number also translates to the highest number of councils of any nation participating in CCP™ internationally, and the highest growth rate in councils been recruited.

In Western Australia, all 29 of the metropolitan Councils are currently involved in the CCP program at various stages, and they are also tackling the program in different and innovative ways. They are joining forces with local industry, forming partnerships with neighbour councils, and undertaking initiatives to empower and influence their local communities.

There is a noticeable lack of engagement in CCP so far from Councils outside the metropolitan area, which is understandable for small rural Shires, whose ability to influence greenhouse gas emissions in their jurisdiction might be quite limited.

THE MILESTONES

In order to participate in the CCP program, a Council must adopt a resolution, following which the local government body undertakes five performance milestones:

Milestone 1 – Conduct an energy and emissions inventory and forecast
The inventory profiles energy use and greenhouse gas (GHG) emissions for a base year, 1990 or 1995, and estimates growth in emissions for a target year, typically 2010 or 2015, for:
- municipal operations, including buildings, facilities, and waste streams (corporate);
- the wider community, including residential and commercial buildings, transportation, and industry (community).

Milestone 2 - Establish an emissions target
Adopting a target and timetable for its achievement is essential to foster not only political will but also to create a framework that guides planning and implementation of measures. Many CCP participants are striving to adopt the "Toronto target" to reduce GHG emissions by 20% from 1990 levels by the year 2005 or 2010. In cities in developing countries, however, stabilising per capita emissions may be a more realistic or even ambitious target, in order to allow them the ability to develop economically.

Milestone 3 - Develop Local Action Plan
A strategy to reduce GHG emissions is created by the Local Action Plan, which synthesizes the previous analysis, provides a rationale for the target and timetable, and outlines the policies and measures the local government will pursue to achieve the target. The Local Action Plan ideally incorporates public awareness and education campaigns, as well as direct GHG reduction measures.

Milestone 4 – Implement policies and measures
This step begins implementation of individual measures to reduce GHG emissions. This may begin once the Local Action Plan is developed and approved or may begin concurrent with Action Plan development, since the CCP participant may choose to start measures before adoption of the formal plan.

Milestone 5 – Monitor and verify results
Monitoring and verification of progress on the implementation of actions to reduce GHG emissions is an ongoing step that begins once measures are implemented and is formalized with the approval of the Local Action Plan. ICLEI's software tool assists in the quantification of emissions reductions and allows for uniform reporting of emissions reductions to ICLEI on a biennial basis.

CCP ACTIONS

Outlined below are some of the examples of action from Australian Local Governments, with an emphasis on energy use and energy efficiency.

Energy retrofit of municipal buildings
This is a fairly universal action undertaken by Councils to reduce their corporate emissions. It includes the purchase of energy efficient lighting and office equipment, and retrofitting for more passive energy efficiency, such as maximizing natural light. There is obviously a capital outlay, but the payback period with some of this technology can be as little as 2 years – after which significant savings in energy consumption will result in financial savings.

For example, by retrofitting lighting in the City Hall Function Centre, the City of Newcastle in NSW, has reduced the building's energy consumption by 80% - a saving of about 100 tonnes of CO_2 emissions per year. The initial costs of around $20,000 a year, were recouped within two to three years. Overall, Newcastle's energy efficiency initiatives have cut its $1 million dollar electricity bill by more than one-third.

Energy efficient requirements for urban development

Leichardt Council in Sydney have a particularly strong energy efficiency policy. Development approval from the Council for new developments and major renovations is conditional on meeting a range of passive and active energy conservation measures. For example, all new developments are required to install solar or heat pump water heaters.

Over four years, the Council estimates that 900 solar and heat pump water heaters have been installed, now collectively saving an estimated total of 3040 tonnes of CO_2 each year. Council has also installed solar water heaters and heat pumps in its own buildings: at a library, swimming pool, sports ground and on the town hall.

In Canberra, all residential design and siting applications must be accompanied by an energy rating assessment and all new residences must have a minimum energy rating of four stars for siting, design and construction. In addition, vendors must disclose the energy rating of existing dwellings prior to advertising them or entering into a contract for sales. It is estimated that this measure will save about 34,000 tonnes of CO_2 per year from 2008.

Purchase of Green Power

The Shire of Serpentine-Jarrahdale in WA purchase 100% of their power from Natural Power, a scheme to provide consumers with electricity guaranteed to be sourced from renewable energy. The Shire have off-set the extra cost of purchasing Natural Power by simultaneously implementing substantial energy efficiency measures. The Shire's commitment to renewable energy has assisted five local primary schools to become the first schools in the State to use Natural Power.

Renewable energy technologies

The City of Newcastle has a visionary approach to the promotion of renewable energy. Acknowledging the downturn in the region's heavy industry, the Council is seeking to develop new employment opportunities for its community, and sustainable energy has been identified as a major growth industry for the region. They have undertaken a variety of projects in partnership with Government and industry, for example, establishing a solar powered community park and amenities, which includes an interpretation room in a high profile public space.

NO-REGRETS ACTIONS

One of the most fortunate aspects of any of these policy measures identified is the flow on benefits of policy options to reduce greenhouse gas emissions. One Environment Officer in WA has termed this the "no-regrets" nature of greenhouse action within Local Government. These benefits include:

- financial savings through energy and fuel efficiency;
- local economic development and job creation through the demand for energy efficiency and new energy systems;
- a reduction in local air pollution;
- a reduction in traffic congestion;
- an improvement in community livability and other social benefits, and
- creating opportunities for partnerships with industry, community and government at a local, regional, national and international level.

INNOVATIVE POLICY SOLUTIONS

Revolving Energy Funds

A number of Councils have developed revolving energy funds where to fund the ongoing program of installing energy efficient technologies, etc, they reinvest all the savings made into funding further improvements.

Regional Partnerships

There are numerous examples of regional groupings of Councils to undertake the CCP program. Like all environmental issues, greenhouse related actions/initiatives don't stop at municipal boundaries. For example, 3 Councils on the outskirts of Perth, Serpentine-Jarrahdale, Gosnells and Armadale, found advantages in pooling resources and working together as a region, jointly employing a coordinator working across all three Councils.

Industry partnerships

Industry partnerships will be essential for Local Governments to have a significant impact in the abatement of greenhouse gas emissions. This is particularly true of any actions involving renewable energy, where the capital outlay required for this technology will not be affordable for most Local Governments. The City of Newcastle provide excellent examples of industry partnerships under the CCP program.

CCP IN DEVELOPING COUNTRIES

The CCP program has been consciously designed to link the global issue of climate change with air quality and other local issues such as energy costs, traffic congestion, waste management and community livability. It is such links - the overlap in the causes of air pollution and global warming pollution, for instance - that would be likely to motivate local leaders to participate in a globally focused program. These links would appear to be especially important in developing countries where issues such as air quality, health, and economic development are pressing concerns.

However, the number of municipalities taking part in the CCP program throughout the developing world is very small in comparison with the developed world. Africa has only 12 municipalities, Asia Pacific (excluding Australia) has 31, and Latin America has 13 taking part.

It is of course, fitting that CCP focuses on the developed countries initially, in recognition of the far greater per capita greenhouse gas emissions from the North. However, the successes of CCP in Australia show that the no-regrets policy actions under this program can have a multitude of benefits for a local community.

Recently, a two-year pilot project was developed in Mexico and the Philippines by ICLEI, which were very successful, drawing more financial support from USAID and new support from (Canadian International Development Agency) that will see the CCP launched in Argentina, Brazil, Chile, India, Indonesia, South Africa and Thailand in this year alone.

WOMEN AND CCP

Local Government is notoriously a 'boys club', Here in Australia, and throughout the world there is extremely poor representation of women in Local Government, both as elected representatives and staff. Addressing this situation is actually a key concern of the International Union of Local Authorities (IULA), who have established a taskforce to examine policies and programs which enhance women's participation in local governance systems, and to promote proportional female representation within democratic local decision making.

Adding this gender inequality to that inequality inherent in energy and related industries (Wamukonya & Skutsch, 2001) would not appear to make a Local Government based program such as CCP very easily accessible for women in developing countries. However, CCP does offer an internationally tested and supported framework for addressing greenhouse gas emissions, and developing actions that have a multitude of benefits, at the local level. Clearly more effort must be directed at bringing women into the processes of Local Government and thereby involved in programs such as Cities for Climate Protection. As well, CCP programs in developing countries must take into consideration the particular needs of women, and seek to directly engage women and women's organisations.

FURTHER INFORMATION

For further information on the CCP Program, or any of the projects detailed in this paper, please contact the International Council for Local Environment Initiatives through their website www.iclei.org

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Energy, Sustainability and Development

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ABSTRACT

Sustainability is a crucial issue for society today. It is clear that current lifestyles and practices are causing irreversible ecological damage, which could hamper development programs and ultimately affect the survival of human society. Various efforts have been made to develop models and approaches to sustainable development and some progress has been made in articulating and implementing them. To be effective they need to address all aspects of human activity, including energy production and use.

Energy is used for a wide variety of purposes in modern society. Most of it comes from fossil fuels and this is causing increasing concern because of rising costs, declining reserves, pollution and global warming. Sustainable development requires the world to move towards a new approach to energy production and use.

Energy use is generally grouped into four main categories - industrial, transport, commercial and domestic. Each of these categories contains many different applications. An understanding of these patterns of energy use in a society is essential for developing a strategy for sustainability. Patterns of energy use differ considerably between developed and developing countries and also between different geographical areas. The patterns of use also change considerably throughout the year, especially in temperate regions.

Comparisons between different nations and regions can be useful in highlighting areas of efficiency and waste. End use analysis is an essential basis for addressing inefficiencies through technical, social and policy initiatives. Many of these improvements are cost-effective in the short term and they also bring benefits in the campaign against pollution and global warming. In the longer term energy efficiency must play a central role if we are to achieve a sustainable energy industry.

Energy efficiency often involves a combination of social and technical factors. Social change is difficult to legislate but it can be facilitated by education and consultation. Women have a crucial role to play in this process because they are the major users of domestic appliances and public transport and have a major say in technology choice in homes and offices. Women's networks and organisations can raise awareness and help to ensure that development is sustainable and that lifestyle changes are made to achieve sustainability.

INTRODUCTION

The focus of this seminar so far has been on sustainability and energy supply. In the long term it is essential that all sources of supply are sustainable but in the transition period it is essential that we make the best possible use of existing sources. The best way to do this is through energy efficiency and energy management. The focus of this session is therefore on end use efficiency.

This is an area where huge savings can be made very cost effectively with the knowledge we have today.

Energy is essential for all forms of life and most obtain it through natural processes associated with ecological cycles such as the hydrological and carbon cycles (Miller, 1980). Over the centuries humans recognised that they could improve their quality of life by exploiting natural resources such as plants, animals, minerals and fossil fuels. By utilising our scientific and technological knowledge, we have developed large industries devoted to agriculture, mining and power supply. However, because these industries are economically-driven they have tended to ignore ecological and social principles until quite recently, when serious problems have emerged (Ramage, 1997).

In our quest to increase power supply to meet the needs of development and a burgeoning human population we have begun to cause irreversible damage to the biosphere, which supports all forms of life. Serious air pollution problems have been caused by burning fossil fuels in motor vehicles, homes, factories and power stations. Climate change now appears to be under way as a result of the enhanced greenhouse effect, which is partly caused by our extensive use of hydrocarbon fuels (IGCC, 1995, 2001)

Concern about these problems has accelerated over the past decade and international action is now under way to address the causes. This is taking the form of international treaties with mandatory restrictions proposed on the use of fossil fuels by industrialised nations. These may be achieved via fuel substitution, energy management, improved energy efficiency, the use of renewable energy systems and restrictions on land clearing.(DFAT, 1997, UNFCCC)

Some of the solutions are technical but there are also other important ways of tackling these problems. They involve policies, legislation, economic incentives and education. All of these initiatives have an important role to play in modifying human behaviour and moving society towards a sustainable future.

Sustainability involves modifying traditional economic thinking to include social and ecological factors to ensure that development does not have adverse effects on society or the environment (IUCN, 1991; Earth Charter, 2000). Such thinking is becoming increasingly important in many aspects of education and it is therefore important to ensure that students are exposed to a range of relevant disciplines to prepare them for future careers in a world where sustainability is imperative for survival.

Energy and Sustainability

Ecologically sustainable development has been defined in various ways including :
"Development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987) ;and

"Improving the quality of life while living within the carrying capacity of supporting ecosystems" (IUCN 1991)

According to the IUCN (1991), sustainability is based on the following principles :

- respect and care for the community of life
- improving the quality of human life
- conserving the earth's vitality and diversity

- minimizing the depletion of non-renewable resources
- keeping within the earth's carrying capacity
- changing personal attitudes and perspectives
- enabling communities to care for their own environments
- providing a national framework for integrating development and conservation
- creating a global balance

This ambitious agenda was discussed and analysed in detail by many nations and by the international community at the original Earth Summit in Rio de Janiero in June 1992 and at the Earth Summit +5 in New York in 1997. A program of action called Agenda 21 was developed at Rio and this is gradually being implemented by the signatories. The Earth Charter secretariat has taken these principles and developed them into a statement on sustainability and this is now being promoted internationally prior to the UN World Summit for Sustainable Development (Rio+10) to be held in 2002.(Earth Charter, 2000)

For the energy industry the IUCN (1991) has developed a general strategy for sustainability, which contains the following seven elements :

- develop explicit national energy strategies
- reduce the use of fossil fuels
- reduce the wastage in energy production and distribution
- reduce pollution from power generation
- develop renewable energy sources
- use energy more efficiently in the home, industry, commerce and transport.
- Conduct publicity campaigns to promote energy conservation and energy efficient products.

The first of these points will be discussed on day seven. The fourth and fifth were discussed on day 2 and will be addressed again on day 6 and in the site visits. The seventh point will be addressed on day 5. In this session we will address points 2, 3 and 6. The site visits today will focus on energy efficiency issues.

ENERGY EFFICIENCY AND ENERGY USE

The IUCN (1991) advocates the following priorities for energy efficiency in the power generation industry:

- Increase efficiency in the power generation industry by imposing standards of fuel use efficiency, based on the best available technology. These should in turn promote the use of new technologies which are well suited to distributed generation and have higher efficiencies.
- Promote co-generation and demand management
- Use taxes and charges to promote energy efficiency.
- Set standards for the acceptable loss of energy or fuel in distribution and require that losses above that standard be charged against the profits of the industry rather than against the customer
- Where possible substitute natural gas for coal. This is because coal burning emits between 70 and 95% more carbon dioxide than gas per kWh of final energy produced. Oil is intermediate, producing 35 -45% more carbon dioxide per kWh than gas.
- The waste of natural gas by flaring during oil extraction should be eliminated wherever possible.

These are issues for all nations to address via their responses to Agenda 21 and the UN Framework Convention on Climate Change. They are areas where considerable savings can be made by retrofitting or by fuel substitution. Some nations have already legislated to enforce such strategies.

There is also considerable scope to save energy and money through energy efficiency. This is particularly true in the domestic, transport and commercial sectors where women have considerable influence. In many countries the systems used for cooking and heating are very inefficient and huge savings of money and carbon dioxide can be made through efficiency measures. This is a very promising way to approach sustainability in energy use .

The IUCN (1991) advocates the following approach to sustainability in energy use.

- Establish, publish and enforce standards for energy efficiency in industry, space heating, building construction and transport.
- Use charging and pricing systems to achieve improved standards of efficiency.
- Encourage the development and rapid introduction in developing countries of more efficient cooking stoves. These have many benefits including the reduction in pollution and deafforestation and improvements in indoor air quality.
- Set performance standards for transport, covering energy use and pollution. Use fuel taxes to encourage the use of public transport and energy efficient vehicles.
- Ensure that transport modes are charged their full cost to the community, including their impact on roads, the environment and society. If heavy trucks were charged in this way there could be a major shift to the use of rail and a corresponding increase in efficiency.
- Require all government and public sector agencies to carry out regular energy audits to identify where significant savings could be made and implement these recommendations. Incentives should be offered to encourage the private sector to carry out similar programs.
- Ensure that the efficiency of all electrical appliances and vehicles is clearly stated on the product or in the user manual under standard test conditions.

All of these measures should be incorporated into a national energy efficiency strategy and many national and regional governments have already done so. Australia has a National Greenhouse Strategy (AGO, 1998) but there have been some difficulties in implementing it. This illustrates the point that policy alone will not solve the problem of changing social practices and technologies to achieve sustainability. Social change occurs slowly and it requires knowledge and awareness which often come through education, communication and consultation. Social change cannot be legislated, rather social change provides the foundation for effective legislation.

The IUCN (1991) has drawn attention to the need for community education and promotion in order to gain public support for this strategy and to train people to implement it. It recommends that Governments, industry and community groups collaborate to:

- Draw attention to and explain the energy efficiency labelling of consumer products such as appliances and vehicles.
- Explain the savings that householders, office managers and industrial firms can make through energy efficiency and energy management.
- Explain the value of energy audits and how to obtain one
- Ensure that energy efficiency information is readily available to the public.
- Introduce award schemes to reward people and companies whose performance in energy efficiency or energy innovation has been outstanding.

In addition to this the formal education sector needs to directly address the needs of the sustainable energy industry. Conventional energy education has generally failed to do this. Most energy professionals have been trained in either the technical or economic aspects of conventional energy conversion and until recently the technical aspects of energy management and renewable energy technology have been largely neglected. Very few energy professionals have had any formal training in energy policy, energy economics or the social and ecological aspects of energy production or use.

The Australian Cooperative Research Centre for Renewable Energy is dedicated to energy efficiency and the development of renewable energy solutions to power supply problems. Its education program was designed to provide a sound technical base in renewable energy technology (Jennings, 1996). However it also addresses the need for ecologically sustainable development by covering the social and environmental aspects of energy use as well as the economic and policy issues. The entire program is taught in the context of ecologically sustainable development (ESD) - that is, solutions should be economically, environmentally and socially acceptable in terms of the principles for ESD. In this way students receive an education that equips them to work on new energy systems which can be used to build a sustainable energy industry for the future.

Because many of the people who require this education are already in the workforce and often are working at remote locations the entire program has been placed on the world wide web so that students from any part of Australia or overseas can access this course. (see the ACRE web site and Lund and Jennings, 1998)

Education and training have a vital role to play in achieving sustainability. They create awareness of the issues and equip people with the technical, ecological and economic knowledge required to implement ESD. Education can provide examples of ESD in practise and through presentation of these examples create consumer confidence in renewable energy and energy management. Education is an essential foundation for market development of the renewable energy industry (Jennings, 1997)

WOMEN AND ENERGY USE

Women have a major role to play in developing and implementing this strategy for sustainability. In the area of energy use women are:

- the principal consumers and managers of household energy
- the primary purchasers of household appliances that consume energy
- the primary purchasers or collectors of cooking fuels in many developing countries
- the principal users of public transport
- the main victims of pollution from low grade fuels
- frequently involved in industries that are energy intensive

Women therefore have a central role in developing energy options in three of the four major sectors of energy use - domestic, transport and commercial. As a result of this women can:

- influence the choice of cooking fuels
- influence the choice of appliances
- influence transport options through consumer power
- influence energy management practices in the workplace
- through their purchases help to support the development of sustainable energy industries
- participate in energy policy development through their role as stakeholders

Many of the changes necessary for sustainable development involve changing attitudes to energy use in the home and the workplace. It is here that education, consultation and community groups can have a significant impact. Governments can provide incentives and assistance but these changes in lifestyles will only come about when people decide to make them. All community groups have a vital role to play in achieving sustainable development. This is something that Government agencies have often been slow to realise but there are now many examples of effective community action in this area and some of these will be discussed later in this seminar.

Because women often work in situations where they are able to influence people's attitudes to energy efficiency and energy use they can play a major role in achieving the social changes needed. In working with children the groundwork can also be laid for a sustainable future.

I would like to now briefly consider some examples of what can be done.

PATTERNS OF ENERGY USE

Full details of the patterns of energy use throughout the world are available from the IEA and the US Department of Energy web sites. (IEA, DOE)

Domestic energy use accounts for about 20% of all energy use worldwide. It includes four main components

- electricity for lighting and appliances
- high temperature heat for cooking
- medium temperature heat for water heating
- low temperature heat for space heating.

Typically in cool climates 50% of all domestic energy is used for space heating, 30% for water heating and 10% each for cooking and appliances. In warmer climates the space heating component is much lower although the space cooling costs may be substantial in some countries.

This analysis of energy use indicates that it is very wasteful to use high grade sources of energy for low grade applications such as space heating and cooling and hot water. Substantial cost savings and environmental and social benefits can be made by providing incentives for insulation, passive solar design, efficient heating, cooling and hot water systems. However social factors such as the way in which energy is used in the home can have just as great an impact.

Women can influence these choices through their role as home managers and consumers and through their influence on their family's use of energy in the home.

The transport sector uses about 20% of all primary energy worldwide. The patterns of use differ considerably between developing and industrialised nations (Ramage, 1997). In the former, public transport is the principal mode and women are the principal users. In industrialised countries private vehicles dominate the transport sector but women are still the principal users of public transport. Many public transport systems are very inefficient and new environmentally sensitive options, such as fuel cell powered buses are now becoming available. This sector is one where considerable amounts of energy are wasted and consumers have considerable opportunity to conserve energy and save money. Measures that are available include

- improved driving habits
- better vehicle maintenance
- improved vehicle design
- vehicle efficiency labelling
- incentives for use of public transport
- incentives for energy efficiency and clean technologies

The commercial sector also consumes about 20% of all primary energy produced worldwide. This energy is used primarily for

- running appliances
- lighting
- heating and cooling

In commercial offices and institutions considerable savings can be made through end use efficiency campaigns. Mandatory audits, employee consultation, staff training can all assist, together with expenditure on hardware and education in achieving these goals. We will hear more about successful campaigns in this sector later in these proceedings.

Industry uses the remaining 40% of primary energy. Much of it is in the power generation industry where energy efficiency and renewable energy technology are essential in the longer term. Governments can legislate the compel industry to adopt more efficient practices but they are unlikely to do so without public support. Many State and national energy policies and strategies are never implemented because Governments lack the will to act if industry is opposed to the proposals. There is a vital role here for community groups, including women's organisations, to campaign for cleaner production and sustainable development. Only when overwhelming public pressure is applied will Governments and industry make the necessary changes to achieve a more sustainable production and use of energy. International networks of community organisations have a central role to play in laying the groundwork for social change.

CONCLUSIONS

Sustainability and development are crucial issues for the modern world. Energy production and use are currently unsustainable and cannot form the basis for sustainable development. It is clear that massive changes in technology and social attitudes are necessary to achieve genuine sustainable development.

Efficiency in power generation is essential for sustainability. Efficiency is also important for renewable energy systems in order to make them cost effective and sustainable.

End use efficiency is a very promising area for achieving substantial savings of energy. It is also a promising path to sustainability in the energy industry. It is difficult to implement without changing people's attitudes to energy use.

Education and consultation are powerful agents of social change. They can change attitudes and practices and provide skilled people to install and maintain new technologies.

Women are the primary managers of energy use in the home and they also have considerable influence over energy options in the transport and commercial sectors. By establishing networks of community groups they can develop greater awareness of these issues and by sharing information about energy efficiency technology and policy women can play a major role in facilitating sustainable development in energy supply and use particularly in developing countries.

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Education and Training

Training Designers and Installers of Stand- Alone Power Systems - a Holistic Approach for a Sustainable Future

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ABSTRACT

Design of energy systems requires a holistic, systems approach to engineering, including consideration of environmental and social impacts. Engineering must adopt the principles of ecological sustainability as underpinning the application of technology. This is similar to that required for environmental planning and management. The staff of the Renewable Energy Centre have developed and delivered such training for the past 12 years. Key elements include:

- Utilising a course structure that provides multi-disciplinary knowledge and skills training

- Provision of an interactive learning environment to support delivery - students study within a fully renewable energy powered centre demonstrating SAPS, energy efficient building design and solar water heating in an integrated approach.

- Study of real-life case studies and associated practical work

- A commitment by staff to address sustainable development issues through the learning environment, learning materials and teaching strategies.

Changes to the training sector to offer courses more "flexibly" through traditional distance learning using paper based learning materials and more recently using internet learning have placed additional challenges on the delivery of holistic, multi-disciplinary training.

This paper will provide an overview of past successes and future challenges to training for an ecologically sustainable future. The key conclusions are:

- Make sustainability the core of engineering studies,
- Provide learning about the context of technology including the social, environmental and economic impacts and barriers to technology adoption,
- Provide a learning setting that demonstrates best practice in sustainable energy systems , energy efficient building design and waste management and hence motivates the learner,
- Teach a holistic systems approach to energy system design,
- Promote a supportive learning environment for women and other disadvantaged groups,
- Work on real world problems in the local community,
- Recognise the need for, but also the social constraints and costs of flexible learning.

INTRODUCTION

I want to start by examining the good, the bad and the ugly side of renewable energy (RE) technologies. I will not limit the discussion to stand-alone power systems (SPS) as the issues apply across all RE technologies. Then I want to address the components required to provide sustainable engineering training with a focus on small scale engineering projects such as stand alone power systems.

The good the bad and the ugly – the problems.....

The good side is that we know many RE technologies are well developed, proven technologies that, when the systems are designed, installed and maintained properly, work very well. They bring clear environmental, economic and social benefits in these cases.

The bad side is that when they are undersized, and/or poorly installed and maintained, they fail as does any poorly engineered system.

The ugly side is that there is still a significant number of installers who design and install systems to a cost and provide very little or no back-up service, not wanting to assist the system owner when things go wrong.

Examples include:

- An energy efficient demonstration house in Brisbane where the solar water heating system is out of sight on an eastern facing roof with a pitch of 30 degrees. The annual average reduction in performance is about 30 percent, and greater in winter when you need the hot water most.

- PV system cable sizing for extra-low voltage wiring is undersized on a 480 Watt (peak), 24 Volt system. The cable size installed was $10mm^2$. It should have been $35mm^2$. I have seen cases such as this where 20 percent of the array peak power is heating the cable. That's an expensive heater!!

- How many wind pumps and wind generators are no longer working satisfactorily due to tree growth around the site? A vegetation maintenance program is essential over the life of the wind turbine.

- Finally, the do-it-yourselfer!! Here's Joe Bloggs (invariably a male techno-twit) who likes to think that solar is simple - it's only 12 Volts. So what's wrong with a nail as a fuse anyway??

How do we overcome these problems? One word – training! I am not going to define training in the narrow sense of training an animal to do a set of tasks and not knowing why it does it . Instead **I will define training** as:

> ***the application of underpinning knowledge and appropriate skills to solving problems in the real world to meet peoples' needs for services eg. lighting, heating, cooling. This training must be provided in a social, environmental and economic context, recognising the benefits and constraints of technology.***

Let's start by looking at what might constitute sustainable engineering.

SUSTAINABLE ENGINEERING

Key principles of sustainable engineering within engineering curricula include:

- Making Sustainability a Central Theme,
- Learning within a Context - Economic/Political/Social/Cultural and Environmental,
- Providing a holistic, inter/multi-disciplinary approach (systems engineering),
- Learning in a motivating, experiential learning setting,
- Working on Real Problems - local/regional/global,
- Working with industry and the community on course development, implementation and review.

Within engineering manufacturing and product design, it will mean:

- Focusing on Service Provision rather than just the Product,
- Clean Production Methods,
- Maximising the Efficient Use of Resources through design which focuses on longer life, reuse, recycling,
- Life Cycle Costing of Products and Services.

Within engineering education and training institutions, it will mean:

- Setting the Example with Efficient Resource Use/Recycling/Waste Management/Green Power,
- Ethical Investment of Funds.

Let's look at some of these in more detail in relation to training institutions and course delivery.

Sustainability – Whose definition do we use?

Again we need to be clear how we define our terms. One of the best definitions I have found comes from the Environmental Defenders Fund (EDF) in the USA and is applied to community development. According to the EDF, sustainable community development involves:

- *Environmental integrity*
- *Quality of life*
- *Economic security*
- *Democratic participation*

(for more detailed info see `www.edf.org` *).*

I believe these principles should underpin all engineering training and form part of the environmental policy of training institutions.

Learning within a Context - Economic/Political/Social/Environmental

One cannot assume that just because a technology has clear social, economic and environmental benefits that it will be readily adopted by the community. The lack of solar water heaters on homes in our own state of Queensland, the so called "Sunshine State", is a classic example. There are many barriers to the adoption of new technologies including the influence of vested interests, institutional conservatism, change of government and policy, lack of public awareness and financial barriers.

As well there may be environmental and cultural barriers. Many wind farms developments have been slowed or stopped due to concerns raised over visual, noise and wildlife impacts. Cultural barriers may be as simple as which way do we face our homes or the type of clothes we wear and how well these fit the climate? Having an understanding of these issues and skills to deal with them constructively is part of the equation in the successful adoption of technology. This means good communication and negotiation skills.

Energy Service Focus – a Holistic / Multi-disciplinary approach
Energy supply and demand is an area where multi-disciplinary knowledge and skills is essential in providing energy efficiently, economically and cleanly. For example, if low environmental impact, economical energy supply systems are your goal, then an energy efficient home must include an integration of passive building design, solar water heating, energy efficient appliances and electricity from an appropriate renewable energy system, whether grid connected or stand-alone. Transportation, food and communications are also essential to consider in the Bigger Picture. The more we transport ourselves, food and materials around, the more energy we use.

For stand-alone power systems (SPS), this approach is even more effective as the energy unit cost is much higher and efficiency measures pay for themselves very rapidly. For example, an energy efficient light may pay for itself within 2 years in a grid home but within 2 months in a SPS where the unit cost of energy may be 10 times higher.

To provide this integrated, systems approach with an energy service focus effectively requires knowledge and skills in many aspects of engineering including fluid mechanics, heat transfer and electrical systems, as well as life cycle cost assessment.

Training Course Development, Implementation and Review
It's essential to have a strong association with local RE industry and to work closely with both industry, system users/owners and the community in training course development, implementation and on-going review so that all stakeholders benefit.

LEARNING STRATEGIES & EXAMPLES

At Brisbane Institute of TAFE (BIT), the Renewable Energy Centre staff have been training RE system designers and installers for over 12 years. The students are usually mature students ranging in age from 25 to 50 years old and come from a range of backgrounds from trades to professional. Since 1999 ACRE and BIT have developed the course at BIT into distance learning so that it can be delivered anywhere in the world. Here are some key strategies and examples that we use in our teaching process:

Context - Non-technical Issues

- Students examine social, environmental, political and economic impacts of technology and barriers to the use of renewable energy technologies as part of their course.
- Students review and undertake presentations examining these issues.
- Students are encourage to become active as members of industry and professional associations as the Sustainable Energy Industries Association or the Solar Energy Society to lobby government for better policy or assist in community education.

Energy Services Focus
Students undertake an energy audit of their home and transport primary energy use. They use a holistic, systems approach by examining all of their energy service requirements. Students identify energy wastage and apply efficiency measures first, then renewable energy systems can be sized to meet a greatly reduced demand. In our experience, it's not hard to find fifty percent (50%) savings of current energy consumption in most cases.

Generalist rather than Specialist
We provide multi / interdisciplinary skills development and exchange. With adults, the skills are right there in the student group so it's easy to tap into this wealth of skills and knowledge. For

example, through group work, a student with a strong electrical background can assist (tutor) another student with less practical experience in electrical systems.

Interactive learning environment – "living with renewables"

Educational research and practice tells us that experiential learning is the best type of learning. Living and working in a renewable energy powered, learning environment is a continual, interactive learning experience for both students and teachers. The experience of "living with renewables" is a powerful and learning tool. Hence the Brisbane Institute of TAFE constructed a purpose made demonstration centre incorporating a classroom, office and small workshop. The Renewable Energy Centre demonstrates a very energy efficient home using about 1/5 of the current electricity demand of the average Queensland home (currently 20 kilowatt.hours per day and increasing) through:

- Use of efficient lighting and refrigeration, energy efficient building design principles, low embodied-energy building materials. Space cooling is accomplished through fans and night-time forced ventilation,
- Solar water heating,
- 1.2 kilowatt photovoltaic (PV) Stand-alone Power System (SPS),
- Waste water reuse.

Much of the equipment at the Centre was donated by renewable energy companies such as Solahart, Solar Edwards, BP Solar, Solarex/RF Industries, PV Solar, Selectronics/Solar Generation, Siemens/Butler Solar, Plasmatronics, Latronics, Choice Electrics, JP Technology and many more. Getting industry involved in the training course can start with this stage and develop into an ongoing exchange of work experience and employment.

Real live project work and cases studies

Centre staff include field trips to examine installations and project work on real case studies. This might range from performing energy audits at schools to assessing the cost effectiveness of a solar pool heating system. Examples of project work undertaken include:

- Sizing, configuration and costing of a solar pool heating system at a Special School,
- Design and maintenance of a hybrid power system at an environmental education centre.
- Designing a commercial solar hot water system for a nursing home??
- Installation of PV systems through work with local renewable energy companies.

Supportive learning environment

Centre staff are committed to social justice issues. We aim to provide a supportive environment for socially disadvantaged groups. Because we are dealing with adults, we encourage the learners to take control of their learning through democratic decision-making to tailor course content and delivery to student needs. We also encouraged cooperative work practices.

For women, engineering is still a very male dominated domain. To successfully encourage and support women in this often sexist environment requires a range of strategies including:

- Setting guidelines regarding appropriate behaviour – This is provided at student orientation evenings eg. videos and student handbook outlining sexual harassment guidelines.
- Enforcing behaviour guidelines.
- Providing both appropriate female and male role models as teachers/tutors.
- Allowing for student's differing and preferred learning modes - This may require discussion and agreement on a range of ways to undertake specific assignments or practical work eg. should women work together rather than with men on practical assignments or should it be varied.?

- Providing staff training through workshops to examine issues and develop appropriate teaching strategies.
- Valuing the skills that women bring to engineering such as communication, negotiation and problem solving that call on contextual influences such as events, personal circumstances and experiences.
- Training male teacher's in particular to provide for women's learning styles and experiences eg. ensuring they provide examples of engineering work that are within women's experience.
- Providing bridging courses to give women, and others with non- technical backgrounds, an opportunity to build electrical circuits and develop 'hands-on' skills. In this way students increase their 'technical'confidence and the experiences provide a context to allow the technical theory be more meaningful.

Flexible delivery

In recent years there has been a trend to focus on flexible delivery of courses to better meet student learning needs. This may include:

- Provision of flexible learning materials that support self-paced, distance learning (eg. while working from home),
- Courses being restructured to allow students to attend traditional face to face classes only when they can or need to through the use of flexible learning materials.

In view of this, the Renewable Energy Centre (REC) at the Brisbane Institute of Technical and Further Education (BIT), in collaboration with ACRE, has undertaken a major project to make high quality, practical, trade and post-trade level renewable energy training accessible to students anywhere in Australia, or the world. The project is producing flexible learning materials in both paper and internet formats. This includes learning guides and assessment books (in both formats), software and slide shows on CDRom, and resource books (in paper based format only). These materials have been developed to support delivery of the nationally (Australia) accredited technicians' course, ***Certificate IV in Renewable Energy Technology***. The course consists of approximately eleven modules and provides training in the design, installation and maintenance of renewable energy systems alongside computer and business studies. RE modules vary in length from 20 to 60 hours and include:

- Introduction to Renewable Energy Technologies,
- DC/AC Electrical Fundamentals
- Extra Low Voltage Electrical Wiring and Practice,
- Introduction to Electronics for Renewable Energy Systems,
- Solar Water Heating Systems,
- Photovoltaic Power Systems,
- Hybrid Energy Systems,
- Wind Energy Conversion Systems,
- Energy Efficient Building Design.

More details of the structure of the course, and content summaries of each module are available from the web site at **http://www.acre.murdoch.edu.au /rec/** .

As well, these modules are being modified were necessary and included in the electro-technology industry's National Training Package to provide a range of new qualifications including:

- Certificate II in Electro-technology (Renewable Energy Specialisation) – a tradespersons assistant able to work on installation of small PV systems

- Certificate IV in Renewable Energy – a post-electrical trades qualification for installation of domestic scale PV, wind and micro-hydro stand-alone power systems.

- Diploma in Renewable Energy – a post-electrical trades qualification for installation of large scale PV, wind and micro-hydro stand-alone and grid connected power systems.

THE CHALLENGES

There are a number of challenges we face in our endeavour to provide distance education in practical RE skills, both at the delivery end and nationally. These include:

Making flexible delivery work

This involves some considerable challenges as I believe that many students' preferred study method is still via face to face classroom interaction. After all, we are social animals. For successful flexible delivery, we need to address the following issues:

- Providing appropriate levels and frequency of communication to ensure that students feel like they are part of a learning community - Email and web-based chat groups provide great opportunities here.
- Having in place appropriate systems to track student progress and keep in close contact as to their progress,
- Providing suitable arrangements to assess practical components of the course, particular for students who can't easily access specialist RE training centres – We are currently working to establish a network of training providers across Australia for the practical work.
- Accepting higher "non-completion" rates as students more easily over commit themselves to "flexible learning" on the assumption that they can fit it in to their already busy lives.

Working to Change Engineering Culture

There are some Big Picture issues that I have alluded to above that need addressing also. I believe we need to:

- find ways to make the engineering field of study comfortable for women,
- recognising and providing training for a holistic, systems approach to engineering problems such as energy services and supply – We need to value generalist training equally to specialisation to better see the Big Picture.
- address barriers that exist within traditional training structures such as National Training Packages that reinforce specialisation and discourage multi-disciplinary training.

CONCLUSIONS

The essential elements of engineering education, whether for designers and installers of SPS or other areas must include the following:

- Make sustainability the core of engineering studies,
- Provide learning about the context of technology including the social, environmental and economic impacts and barriers to technology adoption,
- Provide a learning setting that demonstrates best practice in sustainable energy systems , energy efficient building design and waste management and hence motivates the learner,
- Teach a holistic systems approach to energy system design,
- Promote a supportive learning environment for women and other disadvantaged groups,

- Work on real world problems in the local community,
- Recognise the need for, but also the social constraints and costs of flexible learning.

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Information & Training Needs for Industry and Government

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ABSTRACT

The successful implementation of renewable energy and energy efficient policies and technologies will require people with some knowledge of the issues across all aspects of the community, especially in industry and government. Over the past five days, you have participated in sessions which have increased your knowledge of the social, technical and policy aspects surrounding sustainable energy resources as the first step in a global programme to improve women's awareness on these technologies and to help better access and utilize those resources. The potential for you to take this information and share it amongst your community at a local, national and regional level is great.

The aim of this session is to assist you to build on the information from this event to design and implement an information and training program for industry and government at all levels. The presentation will guide you through the important aspects of the design of programs which cater for the needs of your communities.

TRAINING PROGRAMMES

Whilst commonly used to describe education which leads to a qualification, or the development of a new skill, the level of training programmes can vary from information exchange through attitudinal change based on critical evaluation of the subject to capacity building through the development of new skills or processes.

PLANNING A TRAINING PROGRAMME

When considering developing training programmes, six key areas should be addressed in the planning stages:

- Training needs of the target audience
- Identifying programme resources
- Promotion of programme and selection of participants
- Evaluation of training
- Follow up activities / support

Training Needs Analysis

The first step in the process of developing a training program involves an analysis of the needs are of the training audience and an evaluation of whether training will be able to address these needs.

In the first stage of this process, a specific problem or issue should be identified. There are many ways of determining what the training needs of audiences are, including; questionnaires, focus or employer group interviews, knowledge or competency testing, national or international standards, benchmarking / skills reports.

It is important to acknowledge that formal training programmes may not be able to address the problem which you have identified, either through a lack of resources (both financial and human) or lack of acknowledgement of the problem or interest within the target audience.

Case Study 1 - Renewable Energy Information Files

A very basic level of training may include the development of an awareness-raising program, which focuses on providing the school students with moderately technical information, suitable for use in school projects, that is specific to their country or region.

In 1998, ACRE developed the RE-Files, a set of internet based fact sheets on 14 renewable energy technologies. The RE-Files were developed in response to the growing number of requests for quasi-technical information for senior school and university level projects. In this case, the training need was the development of suitable materials, as identified by the number of requests from the target audience.

Case Study 2 - Selection and Maintenance of Batteries for SAPS Short Course

At a more technical level, training may focus around the development of new knowledge or skills to ensure the safe installation of working renewable energy systems.

In 1999, Australian members of the International Energy Agency working party on stand-alone power systems identified that in general, there was little information or training available from independent sources on the selection and maintenance of batteries for renewable energy installers. This was resulting the in the haphazard selection of batteries for systems. Through the input and involvement of the IEA working party members, a short course, co-presented by a technical manager from a leading battery supplier was developed to address these concerns and presented in late 2000.

Programme Resources

The resources required for training should include financial, collateral (learning materials) and human.

Financial Support for Training

In an ideal world, all the money you need for your training would be available. Unfortunately, this is rarely the case, but a well-planned and budgeted training programme will help you in identifying where cost savings can be made. In kind support from government agencies, NGO's and other public institutions, can be particularly useful where money is tight. For example, presenters and facilitators may be available for your courses from NGOs.

Collateral Support

When designing your programme, you need to consider the objectives or outcomes identified in your training needs analysis and to identify what method, or methods, of presenting this information will suit the current knowledge or skill level of the participants, including literacy, numeracy and cultural issues. In some cases, suitable learning materials may already exist and can be applied to your training situation without adaptation. However, in most cases, adaptation of materials produced in other countries will be required.

Human Resources

Essential to all training programmes are the people who will be involved with the training, including the coordinators and facilitators as well as the participants.

Once you have identified the programme objectives, careful selection of suitable presenters and facilitators can begin. Although it is important to consider the knowledge and expertise of the potential presenters, thought should also given to their ability as an educator as well as their preferred method of delivery. Are there people within your own organization who would be suitable? Do you need to find suitable presenters (and can you afford them)? You will also need to consider what other logistical or administrative support you will need, from both within your organization and from participants or sponsors.

When considering the resources required for training programmes, it is also important to identify the training stakeholders, in addition to the target audience. These can include those directly involved with the training, as well as those at an arms length, such as Government agencies / departments, finance providers.

Promotion of programme and selection of participants

Now that you have a training programme, how can you ensure that the people you designed the programme for are the ones that attend? This is usually one of the hardest issues to address. Frequently, no matter how hard you try; you will attract potential participants with needs beyond that of the planned programme. If you are aware of this before the training commences, the programme can be adapted to ensure that all participants have some of their needs met and establish working groups or networks during the training to ensure that follow up activities and contacts address additional needs.

Sometimes, participant selection is easy, for example, in house training programmes on new products for sales staff in renewable energy shops. However, when a specific type of participant is required, consideration of this should be made when planning the promotion. One common approach is to ask potential participants to make a brief submission on why they would like to attend and how the training links in with existing or future activities. Whilst this can make selection easier, it is more time consuming on the organizers side, as each application needs to be considered.

Evaluation of Training Programmes

The evaluation of your training programme is essential in order for you to determine if the training achieved its objectives or desired outcomes. Careful consideration should be given to the evaluation tools during the planning stages of the training programme to ensure that the evaluation reflects the training programme.

In a classical sense, the evaluation of your training programme can use tests and exams to determine what new knowledge the participants have gained. However, this model is not suitable for all types of training, especially when the training is designed for attitudinal or behavioural change.

Strohmann (1998) suggests four key aspects to the evaluation of all levels of training programme that focus on environmentally sound technologies, to address participant reaction to the programme, what the participants learnt, were there any changes in the participant behaviour or values as a result of the training, and are there any tangible results or outcomes from the training programme.

Follow – Up

Often it is difficult to fully evaluate some of the outcomes of the training programme at its conclusion. The nature of training programmes is such that participants should feel highly motivated to make changes, both behavioural and attitudinal, with regard to the topic of the training, but how often is the motivation lost days or weeks after the event when you are back in your life, away from 'buzz' of the training.

Follow up activities can help maintain motivation, strengthen networks and contacts developed during training programmes. The can also help to address the some of the long-term goals of the training programme, for example in capacity building programmes, and for the development of new resources, methods or issues for training beyond the scope of the original training programme.

In regional or national training programmes, follow up activities and programme also provide an opportunity and mechanism for commitment to the broader training process from organizations and institutions, so that the longevity of the project is assured, without total reliance on the original project champion.

CONCLUSION

The development of training programmes is an integral part of building regional and national capacities for the introduction of renewable energy technologies. At the basic level, the community will need to know about renewable energy, what it is, and how it is different from traditional energy sources. At the next level, they will need to know how and where to seek additional information about the technologies so that they can form an opinion on the development of the technology for their situation. During this phase it is important to acknowledge that an increased awareness and knowledge level about the particular technology will not necessarily result in a positive attitude and a willingness to take up the technology. It simply means that the community are more able to make informed decisions about the technology. In the last (but not final) phase, you will need to develop the capacity to operate these systems, especially people who are able to design, install and maintain systems.

Through all phases you will need trainers, people who are able to train others about the technology, its use, its economics and any consequences of the technology, throughout all levels of the community and government.

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Energy Efficiency Training for Remote Communities

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ABSTRACT

An energy efficiency education program was delivered to 40 selected indigenous communities across the State of Western Australia in 6 different regions. A chief aim was to reduce the costs of fuel supply to the government service providers. A secondary aim was to raise awareness of energy conservation practices in local communities. The program was detailed in its design and scope. There was great potential to raise awareness and introduce energy efficient practices in communities and regions. However, numerous aspects of the education package were inappropriate or were too comprehensive to be sustained by regional service providers or local communities. Competing issues limited the effectiveness of the delivery program. A greater commitment to such a program needed to be given by the government service providers to ensure its sustainability. Under such conditions it is likely that the energy efficiency education program could deliver energy and cost savings.

PHILOSOPHY FOR ENERGY EFFICIENT TRAINING FOR REMOTE COMMUNITIES

In the State of Western Australia, the Commonwealth agency ATSIC (see glossary of terms at end of paper) contributes funds to remote Aboriginal communities to subsidise the cost of fuel to operate diesel-fuelled power stations. Operating costs associated with running these power stations are funded through a combination of State and Commonwealth programs (i.e., RAESP and Capital funds). In some smaller communities and outstations this is combined with solar powered inverters with battery storage. Town based or " town reserve" Aboriginal communities are connected to the mainstream power grid.

ATSIC funding to purchase diesel fuel is capped and the provision of electricity supply in remote communities is dependent on the capacity of the community managers to recover costs from energy users. In addition to this, the Commonwealth, through the HIPP and NAHS, and the State through the ACSIP, have allocated funds towards major infrastructure development to raise service standards in many remote communities. As a consequence of this growth, user expectations have been raised and the demand for electricity supply increased. Coupled together with the rising cost of diesel fuel, complexities of compliance with the diesel fuel rebate scheme, higher management services overheads and the introduction of the GST, remote communities have consistently turned to the ATSIC to provide additional funds to meet shortfalls in projected budgets.

The Commonwealth government approach to this issue has been to negotiate with the State government for a Bi-lateral Agreement that places the responsibility for provision of essential services to Aboriginal communities in WA within the context of the State's broader mainstream service delivery policy framework.

A more specific response has been to establish a State/Commonwealth initiative, the ECEP Working Group. The ECEPWG's role is to implement strategies that increase awareness in remote communities on energy efficiency issues with a view to enabling better energy management and making cost savings. An education and awareness-raising package (the EEEPack) was developed to be used as a base tool to satisfy this goal. The RADG of Murdoch University, a small research group with many years experience working in the area of technology exchange with remote Aboriginal communities, were engaged to deliver the EEEPack to 40 selected remote communities. The EEEPack was previously developed by CASE on behalf of the ECEPWG.

While community energy conservation education had not previously been addressed in remote communities, ATSIC Regional Councils and Community Management Councils are well aware of budgetary pressures to make savings. The EEEPack was aimed at increasing awareness of where energy is used, how energy can be saved and what energy management strategies could be implemented. It was also intended to promote the principles of user pays principles within the constraints of Aboriginal corporations benevolent institution status. It was an ambitious project to be undertaken in a complex cross cultural context where literacy and numeracy levels are far below the mainstream. Furthermore, in most cases, community members were occupying their first homes and had no historical knowledge of such technologies. Primarily, energy generation was regarded as "white fella business" and electricity should be provided like it is in town.

The project also focussed on the education of executive bodies (Community councils, ATSIC councils and their staff) and service providers (AAD, AHIU and EDWA etc) who are responsible for resource allocation and monitoring. These bodies are most aware of the resource constraints being experienced by remote communities in relation to the funding of energy generation, distribution, maintenance and training.

Outcomes sought from the project were to achieve an increased individual and collective awareness of effective energy consumption saving practices by residents in remote communities. It was envisaged that this collective awareness would result in lowering energy use and provide savings in power generation cost to remote communities. It was also expected to create an environment conducive to the implementation of user pays consumption metering systems. Education outcomes sought included incorporating the EEEPack with the WA Curriculum Framework and the development of an appropriate adult lesson plan for inclusion in related adult training programs such as the Indigenous Environmental Health Worker and Essential Service Operator training.

EEEP DELIVERY OUTCOMES IN WESTERN AUSTRALIA

Review of EEEPack

The essential feature of the EEEPack was a two-pronged educational program. One part was a program for community management to use with community residents and promoted the Energy Efficiency Champion. The other part was a program for schools to use in their curriculum for children and promoted the Energy Ranger. Each had teaching resources, promotional tools and reward mechanisms.

The first task of the delivery phase was to review the EEEPack. The review was necessary before producing the quantities necessary for delivery to the 7 regional workshops and 40 selected remote communities. Given the timeframe to work within the review had to be completed quickly and then sent to print to enable the delivery program to commence.

The review was undertaken by consultation with ECEPWG members, educational and curricular review by ACRE Education Officer Katrina Lyon, and technical review by RADG members.

The ECEPWG advised that the visual representation of indigenous people in the materials was demeaning and the requested changes were made. It was later found that indigenous people still considered the representation as unsatisfactory.

The educational review found that there were a number of teaching exercises that were inappropriate for the learning intended and alternative exercises were substituted.

The curricular review involved consultation with the WA Curriculum Council and serious deficiencies were found. It became apparent that the Teacher Reference Guide had been prepared with reference to an early draft of the Curriculum Framework and consequently the Guide was obsolete. Revisions were made and the booklet printed. Further consultation with other staff at the Curriculum Council has indicated that further revisions may be necessary to both the Resource File and Guide to satisfy the preferences of the Council.

The technical review found a number of deficiencies and these were rectified prior to production for delivery.

Delivery methodology
A delivery methodology was proposed as follows:

- Train the trainers – RSP staff at regional workshops
- Evaluate and refine delivery techniques for future regional workshops
- Deliver community based training with designated RSP officer (to continue train the trainer process)
- Propose a regional model for a sustained EEEP, as well as a future expanded program, and develop a regional capacity to implement this where possible
- Monitor, evaluate continuously and modify as required

The actual process that occurred in the regions is described below.

The Project Team consulted with the RSP, community management and school prior to each delivery, devised the program with them, and then revised this each time based on the experience gained and recommendations made by participants.

The delivery program could only be tailored to meet the specific needs of the RSP to a limited extent, as their own busy schedules generally precluded extensive participation. When the regional workshops were actually conducted, and extensive information obtained on regional specific issues, it was during this time, in consultation with the RSP, that further consideration of the delivery method for communities was made.

Participation in regional workshops and community visits by the RSP was critical to the success of the future program (the same applied for community managers in community workshops). It was concluded that the EEEP could not be sustained if their participation did not occur. A strategy of the Project Team was to seek a meeting with the ATSIC Regional Manager the day before the workshop to get a full understanding of the regional issues so that the workshop could be delivered in a suitable context the following day. In the regional workshops, conducted at the regional centre, information was gathered on the local issues and simultaneously awareness of RSP staff was raised on energy efficiency strategies to deal with these specific energy-related issues.

The Project Team, with the RSP wherever possible, delivered the community-based training in each region after the workshop in the regional centre. The delivery to community management was made in the context of regional issues derived from the regional workshop. Consequently, the delivery raised awareness not only on energy efficiency strategies but also on state and regional policy issues. This awareness raising occurred immediately and the technique was used to motivate administrative changes in the short term.

The delivery of the EEEP to schools serving each community occurred concurrently with delivery to community management. As with eventual implementation of the Adult Lesson Plans, the school delivery could lead to longer-term behavioral changes with the children. The delivery approach was developed adaptively through trials in different communities and schools using a blend of technical and educational expertise.

An key aim of the methodological framework was to support a regional, preferably indigenous, capacity to continue to deliver the program so that a regional self-managing delivery and evaluation process could be sustained.

Evaluation of EEEPack delivery

A comprehensive evaluation program was designed for the delivery program in consultation with Professor Ralph Stratton of the Institute of Social Evaluation. A key element of the evaluation was to have ATSIC and AAD field staff in the post delivery phase. The involvement of field staff was viewed as crucial to the future success of the EEEP and their involvement in the evaluation process ensures they become involved in the EEEP to understand the issues and to support the community. It is clear from the information gathered during and post delivery that there has not yet been a substantial impact of the EEEPack on regional and community policy formulation, practice, teaching or training programs. There is however, evidence that there is substantial activity in the regions towards comprehensive metering and monitoring of housing and other facilities in communities. It is within these activities that the EEEP will need to be included for future energy efficiency achievements.

EEEPACK DELIVERY LESSONS

Local context of the EEEPack

In general, the EEEPack was viewed positively in most forums. It was concluded that for an effective delivery of the EEEPack with community management there needs to be resource support at a regional level to sustain energy efficiency training for remote communities. It was also apparent that the resource materials will require substantial further development to provide the level of information necessary for an ongoing community-based program. Moreover, occasional additional support will sometimes be required over the duration of such a program. This could be in the form of ongoing training by a Regional Training Provider, future visits by energy education consultants, technical support from the visiting RAESP personnel, through further training of the ESO's and EHW's and mutual support between community management and the school.

This issue is not so critical for the schools because the teachers with initiative have access to additional resources and are familiar with the tasks necessary to generate the required information. The issue for schools is more about whether the principal and/or staff are motivated to take on this additional curricular material and this is discussed in subsequent sections. In addition, the Ranger or school program would require a substantial amount of further revision to the materials.

Both programs will require several years of operation before they could possibly become fully effective, as has been the case with the Environmental Health Worker Training Program, which commenced in 1985. This timeframe takes into account the pace of activity in a community, the competing agendas and timetables, the normal duration of a technical education program for people with other commitments, and the amount of time typically taken for behavioural change.

Because of the generic nature of the EEEP material and to more effectively satisfy the diverse needs and cultures (language, cultural beliefs, literacy and numeracy levels, community characteristics, etc.) across regions the EEEPack could be made available in an electronic format to allow for local adaptation, i.e. CD copy to be provided with the hardcopy. While it would be ideal to have the EEEPack upgraded for a future expanded program, especially the school materials, an electronic version will be a more valuable education tool and allow improvements to be made via local adaptation.

In addition to giving the EEEP greater flexibility by provision of the materials in electronic format it may also be necessary to have a centralised support role either at a regional or State level, preferably by an indigenous education officer with a Regional Training Provider. This would be to develop and produce additional resource materials, provide technical support, source funding to grow and professionalise the program, administer an annual Energy Efficient Community competition, and ongoing development of a career path.

The regional workshops

The regional workshops were clearly useful in bringing staff together and collectively increasing their awareness on energy issues as well as to promote discussion on this area between the regional managers and the project officers. There is a need for staff to raise their awareness of energy efficiency issues to be able to support communities in an ongoing EEEP. They are generally conscious of the impact of fuel or electricity costs on community municipal services budgets. They are also generally conscious of the limited financial management skills, capacity and systems within communities that could enable more effective energy management.

There was significant concern at a regional level about the total impact of the rapidly changing policy environment and its impact on the communities' capacity to manage. Energy efficient design and construction of housing was considered to be of great importance. When houses are built or upgraded in communities' energy efficient principles should be inclusive within the terms of contract of design and construction or, where the community has a builder, are included in specification development. The concept of developing regional energy management policies and plans was discussed extensively in regional workshops.

The Community Workshops

Awareness of energy efficiency issues was low in most communities. There was a positive response to the EEEP but not always a willingness to take up the message. It was apparent that the community strategies needed to be supported by a regional plan that was described above. There was a need for effective financial management with special emphasis on energy management. Community-based financial management of energy use needs to separately account for energy use by municipal services, community facilities as well as community residential and non-indigenous staff residential. Ideally, future metering and auditing projects should seek to describe and quantify these different consumption levels within these sectors. This will allow more effective management of diesel fuel rebate accounting, effective use of metering if introduced, and better control of energy use in each of the sectors mentioned.

Staff were often paying a fixed 'chuck-in' (a community-based system of collective cost recovery) but this is no incentive to turn off appliances. Community management may be satisfied with this income but it was generally not enough to recover costs. Staff ideally needed to be paying for their actual use at the commercial tariff plus supply charge. However, employers would need to provide an entitlement to cover this cost to some extent, e.g. an air-conditioning allowance, otherwise retaining staff in remote communities will be difficult.

Given the difficulties often faced by community management it was clear that a holistic, multi-faceted approach needs to be taken to energy management in communities. The implementation of the EEEP in a community needs to ultimately lead to the establishment of a Community Energy Management Plan. In many cases it was apparent from the regional and community deliveries that this will need to be enabled and supported through a Regional Energy Management Policy Framework guided by the RSPs.

The implementation of an "Energy Efficient Community Competition" across the State, similar to the "Tidy Towns Competition" that has contributions from relevant State and Commonwealth government departments could be an effective additional mechanism to promote more efficiency measures. This could be administered by either Office of Energy or Ministry of Housing in collaboration with the RAESP.

Metering

In general it appeared that the introduction of metering may be too rapid for remote communities normally used to "chuck-in" systems. In some cases, there was evidence that the introduction of pre-payment meters was not accompanied by sufficient training for residents. Where there is cost recovery through chuck-in and this is not sufficient to cover the total costs of energy use then communities sometimes recover these costs from other sources i.e., rental payments. This is not an effective accounting approach.

Moreover, it was apparent that metering and cost-recovery from the community residential sector had not been accompanied by the development of a holistic cost recovery plan for the community where all the sectors of electricity consumption are considered. It was apparent that communities may not only require further support from the RSPs in energy efficiency awareness-raising, but also in better financial management so as to ensure there is effective and equitable cost recovery across all sectors of electricity consumption.

The introduction of pre-payment metering to residential housing in remote communities that generate their own power may also enable better financial management in these communities along with metering of the diesel-fuel-rebate-ineligible facilities. There should be consultation with community management and residents to determine which type of meter best suits the householder and community needs. There are several important factors to understand regarding the Diesel Fuel Rebate Scheme: the ATO requires substantiation of fuel used for electricity supply to eligible facilities but is not asking communities to install meters; once remote communities start charging residents for electricity supply then this proportion of fuel may no longer be eligible. Consequently an effective "chuck-in" system where a "contribution" only towards diesel fuel is charged may be preferred.

The work to date showed that the EEEP had too much emphasis on community residential user pays consumption metering. The ability to recover energy costs from the non-residential sector is crucial for remote communities and their capacity to produce and distribute energy services.

Adult lesson plans

The delivery of the EEEPack indicated that there was no well-organised framework for supporting a Champions program as there was within the schools for a Ranger program. This situation could be improved through implementation of energy efficiency adult lesson plans in housing management, ESOP and EHW training so graduates become overseers of the energy management program in their communities. The energy efficiency adult lesson plans were drafted in a similar format to the housing management, ESOP and EHW training programs (i.e. as module descriptors) in anticipation that they would be delivered within these programs. The format of the module descriptors is consistent with the standard for accreditation by the State training authority. There was much support for less formal community based training that is relevant to the communities needs and able to be delivered by Regional Training Providers.

CONCLUSIONS

There are some conclusions that can be derived from the above EEEP project conducted in Western Australia that may be worthy of further discussion for other settings internationally:

- An energy efficiency education program that targets certain sectors of a society needs to be designed very carefully, particularly if it is intended for a cross-cultural setting by a mainstream provider. The benefits to be achieved at National, State or Provincial levels may not be seen as benefits at a community level.
- Regional support agencies need to be involved very early in the process of design and delivery, however, it may also be the case that these agencies are too busy for intensive participation.
- The design of an education/training package for energy efficiency must involve effective collaboration with the intended recipients and the program content must be relevant to the regional or local circumstances.
- Communities need to see clear benefits that can be derived from taking on the energy efficiency education program. There may also need to be strong and positive incentives to inspire action as great hardship and limited resources may already exist in the communities. Existing problems may far outweigh the possible benefits.
- Proposals for community-based actions may initially need to be clear, simple and achievable in the short term. Only later after visible achievements have been made should more comprehensive programs be proposed.
- Energy efficiency can often only be achieved through behavioural change. Such change may require a long term and active educational program. This will require ongoing support by the provider.
- The methodology for delivery should make use of appropriate mediums that could be used to create awareness (eg. radio programs).
- Renewable energy options can be promoted in future energy efficiency training packages.
- Technological solutions for energy generation and distribution must be accompanied by effective maintenance and monitoring practices.

GLOSSARY

AAD – Aboriginal Affairs Department
ACRE – Australian CRC for Renewable Energy Ltd
ACSIP - Aboriginal Communities Strategic Investment Program
AHIU – Aboriginal Housing and Infrastructure Unit
ATO - Australian Tax Office
ATSIC – Aboriginal and Torres Strait Islander Commission
CASE – Centre for the Application of Solar Energy

ECEPWG – Energy Conservation Education Project Working Group
ECEP – Energy Conservation Education Project
EDWA – Education Department of WA
EEEP – Energy Efficiency Education Package
EHW – Environmental Health Worker
ESOP – Essential Service Operator
GST – Goods and Services Tax
HIPP – Housing and Infrastructure Priorities Program
NAHS – National Aboriginal Health Strategy
RAESP – Remote Areas Essential Service Provider
RADG – Remote Area Developments Group
RSP – Regional Service Providers