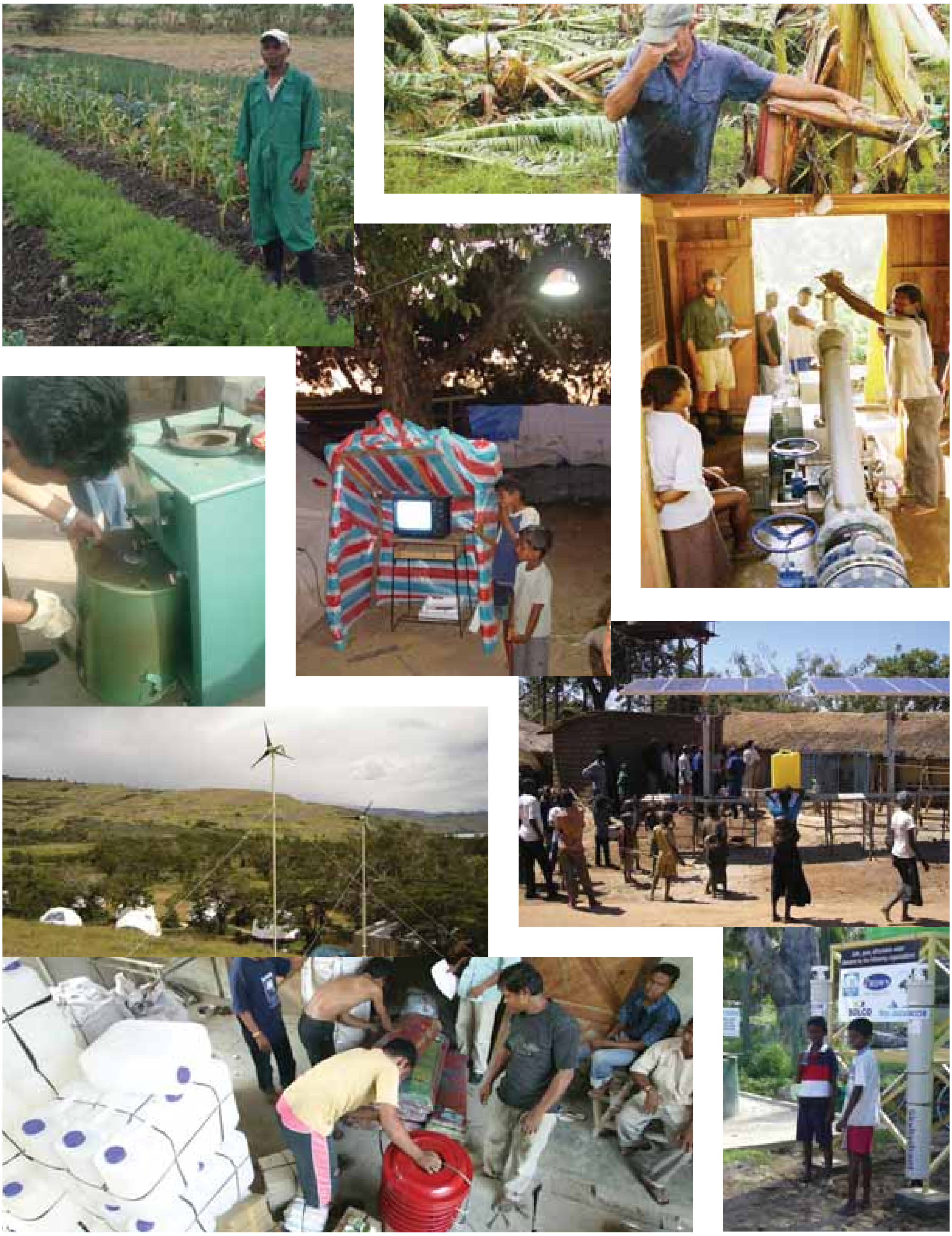
Facilitating Disaster Relief Operations and Sustainable Reconstruction The Enabling Role of Renewable Energy Technologies



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BCSE
Australian Business Council for Sustainable Energy

Disclaimers

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Executive Summary/Foreword

The impetus for developing this Guide came primarily from two situations. Firstly, the enormity of the Asian Tsunami disaster in 2004–2005 right on Australia's doorstep, and the inability of the renewable energy community to donate goods and services, highlighted a need to develop an understanding of a pathway with the aid and disaster relief organisations to overcome this situation.

Secondly, the increased debate about climate change globally led us to look at what is being done in post-disaster reconstruction, and to realise that in many situations "like" is being replaced with "like", rather than turning around a bad situation to make for a positive, sustainable and environment-friendly future.

In 2005, the Business Council for Sustainable Energy (BCSE) approached the Australian Government, through the Australian Greenhouse Office, for funding to research the impediments to the uptake of renewable energy products and services within the disaster relief response and aid organisations.

Pursuing this has led to a much better understanding of how procurement decisions are made in the aid sector, and how renewable energy goods and services can assist in the delivery of aid and reconstruction objectives. There have been three main deliverables achieved to provide for this outcome:

- Organisation of an 'Eco-Solutions' seminar and expo, which was held in Melbourne in December 2006. This allowed aid sector participants' access to international and Australian experts in renewable energy and reconstruction projects. In addition, the outdoor display facilitated working examples of how systems powered by renewable energy could assist the agencies in their own operations. Participants were thus able to see, touch and find out how systems worked from the exhibitors—many of whom are already participating in international development projects, and who were thus able to provide additional experience and knowledge for the participants.
- Development of an in-depth report on the different procurement methods globally for goods and services. This report, *Understanding the Aid Sector- finding pathways to increase the use of renewable energies,* researched the systems of delivering aid by the humanitarian aid industry, assess the technology needs they have and identify the RE products and services that exist in Australian sustainable energy industry that will fulfil their needs.
- Development of this Guide on the applicability of renewable energy technologies in the emergency relief, reconstruction and development contexts—with capabilities divided into immediate, medium-term and longer-term applications. It is hoped that the Guide will provide aid and development stakeholders with confidence that renewable energy technologies can facilitate the delivery of disaster relief services and provide a major role in sustainable reconstruction projects.

In writing the Guide, we have endeavoured to be as practical and objective as possible, using the learnings from interactions with aid sector workers, the research and findings of the Understanding the Aid Sector report, as well as the authors' own experience in international aid and development projects.

Chapter 1 therefore sets the scene and parameter for the Guide. It is important to remember that this is to be used as a *guide,* not a definitive text book, and thus we are only flagging issues and applications, not developing in-depth technical scenarios. The references and Annex 2 provide pathways for this information for those who want to learn more.

Chapter 2: *Energy and Development: A Cross-Cutting Issue,* looks at why it is so important to consider energy as a cross-cutting issue. This is put in the context of the Millennium Development Goals, the use of per capita energy consumption as an indicator of development, and the recognition globally that provision of appropriate energy services enables better community outcomes across all sectors: from education, health, poverty alleviation and livelihood development, to water supply, agriculture, personal and community security and gender issues. It looks at modern energy services and how renewable energy services can be incorporated into these. In terms of disaster relief and development, the global deployment of renewable energy is examined in order to show that such technologies are not, in the main, new, but have millions of systems deployed in both industrialised and developing nations, over the past 20 years or more. In terms of climate change and the sustainability of rebuilding communities, the legacy implications of disaster relief decisions are also discussed.

Chapter 2 also defines the three phases of disaster relief operations: Emergency Relief (immediate reactions and assistance); Stabilisation; and Reconstruction and Rehabilitation. Within these three categories, it outlines the renewable energy technologies and applications which could be suitable in facilitating desired outcomes.

Chapter 3 investigates the renewable energy *tools* for disaster relief, by looking at disaster relief operations in the three broad categories explained in Chapter 2 in more detail. It discusses the emergency response tools required, and when renewable energy technologies could be appropriate—such as for communications both within the camp/disaster zone, and with the outside world.

Once the situation has progressed from reaction to stabilisation, there are other renewable energy products and services which could be applicable. The first area looked at is power requirements for field offices. Semi-permanent, or fixed, power solutions for field coordination centres can be effectively achieved by installing a number of renewable energy technologies. Equipment needs are generally for relatively low electricity and heat consumption or intermittent devices—such as communications equipment, lights, computers, printers and fans.

Energy use for delivering health services is also addressed. The aim of health services in disaster relief situations is firstly to care for the physical victims of the disaster (dead and injured), and secondly to maintain the health of the survivors. Power for medical services—such as refrigeration for vaccines and antibiotics, lighting for operations, sterilisation equipment, and provision of clean water– is discussed in terms of how to provide the most effective power source and what are the renewable energy options. The chapter also looks at cooking methods, to identify where solar cookers and improved cookstoves could be used. The final section looks at the requirements for temporary shelter, and provides some additional options. This Chapter has case studies from in the field to illustrate where renewable energy has been successfully used already in similar situations. This format continues through to Chapter 5.

In Chapter 4 we look at the *Role of Renewable Energy in Reconstruction and Development,* in particular for the sustainable development opportunities in the reconstruction phase in the aftermath of a disaster. Once again, this investigates the integral role which renewable energy applications and service providers can play in delivering sustainable outcomes. Chapter 4 goes into more depth about the technologies and the specific applications. Aside from water supply and communications, the Chapter looks at community facilities (schools, community centres), medical services, reliable power for homes, offices and industry, and how to reduce demand but not amenity through the implementation of energy efficiency measures. Its aim is to empower people with knowledge which will enable them to rebuild their communities and their lives in a more environmentally-sustainable and long-term manner.

Chapter 5: *Sustainable Communities – Reconstruction, Building for the Future* looks at disaster relief and reconstruction from an implementation viewpoint: the cross-sectoral considerations, impacts on the local community, and technology considerations—such as safety aspects, quality hardware, local training requirements, financing systems.

There are four Annexes to the Guide. Annex 1 provides more information on individual renewable energy technologies and aims to give an overview of the wide variety of technologies which harness the power of water, air, sunshine and biomass. Checklists are an important way to make sure all aspects have been considered, and to identify issues missing in proposed actions or projects.

Annex 2 comprises a number of Checklists for various activities. These include Profiling the community and beneficiaries of energy systems; Community Consultation processes; how to establish a local financing scheme; and so on. It is not proposed that these Checklists should be considered definitive, but can be used to assist practitioners to make a first assessment of what renewable energy technologies and services could be applicable.

Annex 3 contains the references for information cited in this Guide. Annex 4 provides references for further reading and web-browsing. These references are not only for renewable energy systems, applications and projects, but also on other cross-cutting issues such as gender and energy, and poverty alleviation.

Finally, there is a Glossary and Abbreviations section for all acronyms and energy terms used within the Guide.

I would like to thank the team of people who have provided their time, knowledge and expertise to contributing to the Guide, without whom this Guide would not have been possible.

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May 2007

Chapter 1 Introduction

Lives and livelihoods turned upside down

For many people around the world, December 26 2004 was to be a day of fun and relaxation. Across Australia most families were happily enjoying the Boxing Day holiday, oblivious to the huge and terrible forces that were literally tearing apart the lives of millions of our regional neighbours.

At the same time, an earthquake measuring over 9.0 on the Richter scale hit the coast of Indonesia, triggering a massive tsunami that resulted in widespread death and destruction across South Asia. The earthquake and tsunami resulted in some 230,000 deaths and missing persons across 11 countries with Indonesia, Sri Lanka, India and Thailand being among the hardest hit. Over 5 million people were made homeless.

The Aceh earthquake and tsunami were not the first humanitarian disasters and sadly they will not be the last, but the terrible events of that day and the shocking realisation of the scale of the tragedy over subsequent days and weeks did bring some positives. Not least was the tremendous compassion displayed by many millions of people worldwide who wanted to try and help in whatever way possible. Many sent food, clothing, emergency aid kits and other supplies; many others contributed money.

In the renewable energy industry, both within Australia and elsewhere, that compassion was expressed with well-intentioned offers of equipment and expertise. It was with some amazement that the renewables community learned that getting their equipment into the affected areas—no matter how useful they believed them to be to the relief effort—would not be a simple task and might actually hamper the aid work.

While each disaster is unique, response efforts tend to occur in phases: search and rescue, immediate relief (for immediate medical, shelter, sanitation, and food), reconstruction and recovery, and long-term development. Many also classify ‘equipment and services preparation’ as the first phase in the disaster response process.

However, in recent years, there have been several reports showing how the introduction of non-essential or un-needed items can actually impede relief efforts by clogging in-country logistics and distribution channels.

It is therefore essential that the specific materials provided / specified are suitable for the circumstances in which they will be used.

This Guide aims to show how and in which phase renewable energy technologies could be appropriate, with the caveat that no two situations will be identical. It is also recognised that local climatic and social situations will also impact upon the use of renewable energy technologies.

Purpose of this Guide

This Guide resulted from the inability of the Australian renewable energy industry to help in the Asian tsunami situation. Research was undertaken to gain a better understanding of the practices and procedures of disaster relief agencies so that, in the future, this 'power for good' can more effectively support post-disaster community rebuilding.

Without question, the organisations and individuals that support the relief and reconstruction efforts are totally focused on achieving positive outcomes for the affected communities. At the same time, the apparently simple energy supply decisions made by relief, reconstruction and development agencies in the aftermath of a disaster can have profound long-term implications for communities, for the local economy and for the local and global environment. Significantly these choices can also have important implications on the resilience of communities to withstand and recover from future trauma.

This Guide is intended to highlight these implications, and to inform and support aid workers in their energy and power considerations. It will highlight practical, robust and reliable examples of sustainable energy technologies that can assist the relief and reconstruction effort, with the ultimate objective of achieving even stronger positive outcomes for the communities that are recovering from the impacts of a disaster event. In particular it will introduce renewable energy and other sustainable energy technologies and renewable energy based services as an alternative to 'conventional' petrol, diesel or other fossil-fuel options.

At the same time, the renewable energy for disaster relief, reconstruction and development projects have highlighted many misconceptions and shortcomings in the renewable energy community's knowledge about the way the disaster relief sector operates. In undertaking this work, we are now much more aware of the phasing and relationship between stabilisation and relief efforts immediately post disaster, ongoing relief efforts to overcome humanitarian emergencies, and community recovery including reconstruction and development. This is helping shape our own understanding about the realistic opportunities for renewable energy in a disaster situation and where RE technologies might deliver real benefits for the relief agencies and most importantly for the affected communities.

This Guide therefore also serves to continue informing the broader renewable energy industry and to offer some insight to energy technology providers as to the needs and complex considerations of agencies and of the communities they are helping to recover from the effects of disasters.

We hope that it stimulates synergies in the way we work together to support the rebuilding of thriving, secure, resilient and happy communities.

Definition of a Disaster

In this Guide we do not make any distinction between the scale, speed, cause and other features that may be used to define a disaster. The meaning here is simply a reflection of extreme events which involve significant numbers of people with consequential injury or fatalities, and involving severe damage to infrastructure, services and livelihoods.

For simplicity we also do not make a distinction between a disaster event and the emergency situations that may result from such events.

Of course, the Guide does not address issues relating to the psychological rehabilitation that is an essential component of community reconstruction efforts, except in so far as restoration of energy services may support restoration of day-to-day activities and re-establishment of livelihoods.

Chapter 2 Energy and Development: A Cross-Cutting Issue

For many people—particularly those who live in industrialised countries with seemingly limitless electricity available at the flick of a switch, and with well organised distribution networks for petrol, LPG and other fuels—we very rarely give a second thought to energy (either its supply or consumption). But it has a tremendous impact on virtually every aspect of our lives.

In the development context, per capita energy consumption is frequently used as an indicator of development. The World Energy Council[1], for example, reports a one-to-one correlation for developing market economies between each additional percentage of GNP growth and the percent growth of primary energy demand.

The Task Forces of the United Nations Millennium Project (established to identify practical strategies to achieve the Millennium Development Goals—MDGs), made a common finding of an urgent need to improve access to energy services as an essential input for meeting each MDG.[2] In adopting the eight MDGs in 2000, the international community—all 191 Member States of the United Nations—clearly expressed the intent to tackle head on the challenge of enabling the world's poor to achieve their basic rights to a better standard of life—safe water, sufficient food, sanitation, healthcare, basic education and gender equality.

What these acknowledgements highlight is that energy really is a cross-cutting issue, enabling better community outcomes across all sectors: from education, health, poverty alleviation and livelihood development; to water supply, agriculture, personal and community security and gender issues.

What is less apparent is that the energy supply choices to deliver these goals and broader socio-economic development may have severe environmental consequences. With as many as one third of the global population without access to electricity and other modern energy sources for fundamental services such as lighting and cooking, pursuing development based largely on fossil-fuels will inevitably result in sizeable increases in emissions of carbon dioxide—the chief greenhouse gas cited for its climate-change impact.

The Millennium Development Goals

By 2015, all 191 United Nations Member countries have pledged to meet these goals.

Eradicate extreme poverty and hunger	• Reduce by half the proportion of people living on less than a dollar a day • Reduce by half the proportion of people who suffer from hunger
Achieve universal primary education	• Ensure that all boys and girls complete a full course of primary schooling
Promote gender equality and empower women	• Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015
Reduce child mortality	• Reduce by two thirds the mortality rate among children under five
Improve maternal health	• Reduce by three quarters the maternal mortality ratio
Combat HIV/AIDS, malaria and other diseases	• Halt and begin to reverse the spread of HIV/AIDS • Halt and begin to reverse the incidence of malaria and other major diseases
Ensure environmental sustainability	• Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources • Reduce by half the proportion of people without sustainable access to safe drinking water • Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020
Develop a global partnership for development	This includes: • Address the special needs of landlocked and small island developing States • In cooperation with the developing countries, develop decent and productive work for youth • In cooperation with the private sector, make available the benefits of new technologies—especially information and communications technologies

Modern energy services

Developing communities tend to rely heavily on human and animal power (for mechanical tasks, agricultural activities and drawing water) and the use of traditional biomass (for instance wood and dung) for heating, basic lighting needs and cooking. As communities advance economically, traditional forms of energy are replaced with more time-effective methods, such as diesel generating sets.

Perhaps even more than per capita energy consumption, access to electricity has become a huge indicator of national development progress.[3] The reason for this is that electricity, although a secondary form of energy, (i.e. it is generated from the conversion of primary energy resources), can power numerous devices and so deliver countless and ever increasing range of services. It can also be delivered directly to homes and businesses. Access to electricity can truly be transformational in respect of individuals' livelihoods and lifestyles.

However, there remains some 1.6 billion people worldwide who do not have access to electricity, and this number is growing, as population growth in less developed countries outstrips the growth of access to electricity, either through connection to traditional grids or by connection to renewable energy systems. It is no small coincidence that these people, a third of the world's population, are—in economic terms—the world's least wealthy, and do not have access to other basic services, such as clean water and sanitation, that the rest of the world's population takes for granted.

Renewable energy services

Over the past 30 years in particular, renewable energy technologies have been increasingly used in developing countries. Yet there is still a huge gap between the services which can be powered by renewables and their uptake. The reasons vary from lack of knowledge amongst decision-makers, to policy and market failures which have favoured traditional supply-side approaches to energy use, that is, distribution of electricity from a centralised plant powered by fossil fuels connected to a grid system.

There are many renewable energy technologies which can provide baseload power (such as landfill gas and other bioenergy technologies, wind power, hydropower, geothermal etc); many others are suitable for providing power on a distributed grid basis. Other technologies provide energy directly to the services, not connected to any grid. This can be either in the form of heat (e.g. solar water heaters and solar stills) or electricity (e.g. solar photovoltaic systems, small wind generators).

The services needed for disaster relief, particularly in the reconstruction phase, require energy (either heat or electricity). Some of the time traditional energy systems will be appropriate; at other times renewable energy systems will be the most appropriate.

Table 1: Renewable energy markets in developing countries

Application	Indicators of existing installations and markets (as of 2000)
Rural residential and community lighting, TV, radio and telephony [a]	• Over 50 million households served by small hydro village-scale minigrids • 10 million households with lighting from biogas • Over 1.1 million households with solar PV home systems or solar lanterns • 10,000 households served by solar-wind-diesel hybrid minigrids
Rural small industry, agriculture, and other productive uses [b]	• Up to 1 million wind-driven water pumps and over 20,000 solar PV pumps • Up to 60,000 small enterprises served by small hydro village-scale minigrids • Thousands of communities with drinking water from solar PV-powered purifiers and pumps
Grid-based power generation [c]	• 48,000 MW installed capacity producing 130,000 GWh/year (mostly small hydro and biomass, with some geothermal and wind) • 25 countries with IPP (independent power producer) regulatory frameworks
Residential/commercial cooking and hot water	• 220 million more efficient biomass stoves • 10 million households with solar hot water systems • 800,000 solar cookers
Transport fuels	• 14 billion litres/year ethanol vehicle fuel produced from biomass • 180 million people live in countries mandating mixing of ethanol with petrol

a: Figures are authors' estimates based on tabulations of country-level statistics from sources cited in the text and other sources. Very few of these indicators are summarized well in a single source. Figures are approximate.
b: Agriculture and productive-use applications are difficult to estimate because little published data exists.
c: A share of stated grid-based power capacity serves small village mini-grids.

Source: Eric Martinot, Akanksha Chaurey, Debra Lew, José Roberto Moreira, and NjeriWamukonya, *Renewable Energy Markets in Developing Countries*, Annu. Rev. Energy Environ. 2002. 27:309–48

Disaster relief, development and renewable energy

Whilst recognising that there are significant differences between the needs of agencies responding to emergency/crisis situations and those addressing international development challenges, there are also many commonalities. By definition, *emergency relief* operations tend to be relatively short-term, rapid reactions to an unplanned event that may impact multiple communities across widespread areas, whereas *development* has long-term objectives, typically including the alleviation of poverty and improvement to community livelihoods.

Regardless of whether a disaster occurs in a developed or developing country, the effect of a disaster can be to plunge the affected communities into what is effectively a pre-development state. Essential services (such as water, sanitation, healthcare, communications) may be fractured or non-existent, compounded by and coupled to the breakdown of other community infrastructures such as businesses, schools and local government.

A second consideration is that, while disasters are by no means confined to less-developed communities, in general developing countries are less well equipped, often more vulnerable and less financially capable to respond to a disaster event. The result is that, almost by default, relief efforts can have a development aspect. For developing countries[4], the course of action by relief agencies in the immediate disaster aftermath can have significant long-term development implications. It is therefore vital that responsive agencies have an appreciation of the legacy implications of their responses. This should be a fundamental aspect of the restoration or rebuilding of services across a variety of sectors that rely on effective energy and power supplies.

Legacy implications of disaster relief decisions

While cost is not necessarily the principal influence on equipment selection decisions of operational and technical staff, it is likely to be a consideration at the procurement stage. One of the fundamental differences between most renewable energy technologies and conventional energy supply approaches is the life-cycle cost structure.

Renewable energy technologies are characterised by high capital investment, relative to equivalent non-renewable options. For instance the up-front cost of a solar PV or small wind generator is likely to be considerably higher than that of a comparable diesel generator. Conversely, the operation and maintenance costs—notably the fuel cost—are relatively low. This means that it is only when considered over a long operation cycle (typically several years) that a renewable energy system would often deliver a more cost-effective service solution than the conventional choice.

Given the comparatively short duration of typical emergency disaster relief efforts, conventional technologies tend to appear immediately more justifiable on economic grounds than the capital-intensive renewable solutions. But there is a strong likelihood that systems intended for short-term relief service provision will continue to be operated by the communities for many years after the relief teams have withdrawn or reduced their involvement.

In the recent cycle of oil price hikes, many families and businesses—particularly from economically under-developed remote and rural communities, but also from comparatively wealthy urban centres—have felt the pinch and have struggled to maintain lifestyles and livelihoods as more and more of their budget is diverted to meeting energy costs.

Balancing these two opposing concerns is clearly not an easy task. Obviously disaster relief agencies should not be forced to bear the additional cost of more capital-intensive solutions even in the expectation that they are likely to deliver better outcomes for the affected communities. Nor should the communities be saddled with spiralling energy service costs because of decisions taken by others. What is needed is a transitional cost and benefit sharing arrangement, or else a critical re-evaluation of the community's livelihood objectives and an assessment of the best means of delivering as part of the transition from aid agency support to local community self-management.

In combination, the renewable energy, disaster relief and development communities have the means to overcome these challenges and build strong, positive outcomes for all concerned.

Renewable energy and emergency aid

Historically there has not been a broad overlap of renewable energy and the emergency aid sectors. However, the potential for renewable energy technologies to support disaster relief efforts is significant.

For field operations, reliability, resilience and effectiveness are critical requirements of all tools and equipment. Renewable energy systems have been specified on precisely this basis for more than three decades. They are found in some of the harshest environments and most inaccessible locations around the world, where a system failure would be at best inconvenient and at worst catastrophic.

Notably in the field of telecommunications, solar PV systems are the power source of choice for situations where reliability is paramount: i.e. in remote and/or inaccessibility locations. Similarly for the marine environment—where tens of thousands of navigation buoys and lights operate without human intervention for months on end with faultless operational lifetimes of 10 years or more. Wind and more recently PV-powered pumps have been effectively delivering water for livestock, irrigation systems and for drinking water around the world for decades.

The renewable energy industry, particularly in Australia, has evolved with a strong focus on delivering dependable performance in extremely testing environments for a wide range of clients. This has been a symbiotic relationship, which has resulted in very high-quality, cost-effective solutions to some quite specific problems. Ideally, the relationship between the disaster relief agencies and the renewable energy industry could have parallels.

OVERVIEW Solar Photovoltaics (PV)

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- Generates electricity from sunlight (the only fuel is the sun)
- No moving parts, no noise
- Low-maintenance, low running costs
- No greenhouse gas emissions
- Totally scalable power (1 m^2 generates 50 to 180 W in full midday sun)
- Broad applications, particularly for low power equipment
- Small packaged systems available as well as large MW systems
- Economic long-term option to replace small diesel generators

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- *High initial capital outlay (unless progressive financing provided)*
- *Need to avoid shading of the modules*
- *Electrical (battery) storage required if services needed at night and to cover dull periods*
- *Not appropriate for long term heavy electrical demands*

Renewable energy and development

Developing countries as a group have a substantial proportion of renewable energy installations– 45% of global power capacity, 70% of global solar hot water capacity (mostly China), and almost 50% of annual global biofuels production (mostly Brazil).[5] This is despite developing countries having 80% of the world's population but consuming only 30% of global commercial energy.[6]

Despite their high initial capital cost, PV electric solar systems have been used for cost-effective water delivery in many rural and remote parts of the world for over a quarter of a century. Several million small PV systems have been deployed in homes around the world—for instance in Bangladesh, China, Kenya, Indonesia, India, Nepal, South Africa and Sri Lanka—to provide effective on-site electricity generation for lighting, radio and TV power. Larger PV and/or wind energy generators, often coupled to a standby diesel generator, provide grid quality power to numerous homes and stations in outback Australia, USA and other locations. Micro wind turbine generators and solar PV systems provide convenient and effective power for nomadic families in Mongolia. Several hundred thousand 'family-hydro' (a few kW—100 kW in size) units have been deployed in Vietnam, China and the Philippines for home power generation. Numerous village-scale micro-hydro systems provide electricity to homes and businesses including to local battery charging stations and direct mechanical power for grinding, milling, pressing or other rotating machines across Asia and Latin America. Some eleven square kilometres of solar water heaters are installed in China each year. The list goes on.

Of course, not all of these systems have performed flawlessly. As with any other technology, there has to be:

- sound planning and implementation,
- stakeholder consultation (understanding users' circumstances, expectations and needs)
- focus on quality hardware,
- proper system design and installation,
- adequate allowance for service / maintenance
- user training
- due consideration of any impacting gender issues

Table 2: Renewable electricity generation capacity installed, 2005

Technology	Worldwide capacity: all countries (GW)	Developing country capacity (GW)
Small hydro power	66	44
Biomass power	44	24
Wind power	59	6.3
Geothermal power	9.3	4.7
Solar thermal electric (STE) power	0.4	0
Solar PV powergrid	3.1	0
Ocean (tidal) power	0.3	0.3
Total renewable power capacity (excl. large hydro)	182	79
For comparison: Large hydro power	750	750
Total global electric power capacity	4,100	829

Source: *Renewables Global Status Report, 2006 Update, REW21*

Table 3: Applications for renewable energy equipment for disaster relief, reconstruction and development

PHASE	TIMEFRAME	EQUIPMENT TO CONSIDER
Emergency Relief (immediate reactions and assistance)	Weeks 1–3	Solar PV, SWH, micro wind generators, solar cookers, solar stills, batteries
NEEDS		SERVICES
Lighting		Portable lighting. street lighting
Water supply		Water pumping and distribution; purification
Healthcare		Field hospital, morgues, medical refrigerators
Refrigeration		Individual power kits
Safe food preparation		Cooking
Preventing diseases		Personal hygiene, insect and pest eradication, potable water
Communications		Radios, satellite communications systems, laptop and mobile charging systems
Security and women's safety		Alarm systems, lighting
Stabilisation	Weeks 3–12	
ADDITIONAL NEEDS		ADDITIONAL SERVICES
Temporary schools		Basic lighting systems
Community activities Health clinics Assisting livelihood development		Making fishing boats, enhancing agriculture, food processing
Living services for NGOs		Larger-scale office power – lighting, computer power, communications, refrigeration, fans, insect killers/repellers
Reconstruction/Rehabilitation	Weeks 12–3 years+	
ADDITIONAL NEEDS		RENEWABLE ENERGY EQUIPMENT POSSIBLE *(in addition to the above)*
Community water supply established for long-term use Agricultural water supply Buildings – earthquake safe and passive solar design		Biodigesters, landfill gas systems, bagasse (sugar mill) cogeneration, larger wind energy systems and wind farms, mechanical windpumps, hydropower, geothermal systems, ocean technologies (tidal, wave, current), hybrid energy systems, solar water heaters
		ADDITIONAL SERVICES
Livelihood development – refrigeration, fabrication workshops Power for schools & teachers' houses Clinics/hospitals Community electrification – towns & villages Communications Transport systems		Irrigation and stock watering systems Cool stores and refrigeration systems Community power systems (could be grid-connected or mini-grid systems) Air, sea, land transport beacons, signalling Refuse collection and disposal

Please note: Not all needs will be appropriate for all situations, and the same applies for services. This is to be read as an indicative guide only

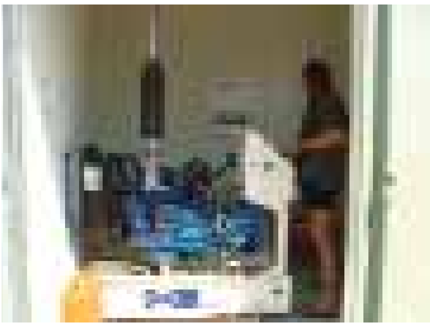
Chapter 3 Renewable Energy Tools for Disaster Relief

In the early hours and days immediately after a disaster, relief agencies are largely focused on stabilising the affected area, relieving suffering as quickly as possible, and attempting to limit the scale of the humanitarian emergency. Public health concerns therefore form a major part of the relief effort, with emphasis on providing shelter, potable water, food and emergency medical assistance.

Because many natural and man-made disasters sever or damage existing infrastructure—including water supplies, power and fuel services—temporary solutions are essential to the relief effort. In situations where there is barely enough time to draw breath, any solution must be easy to ship and install, dependable, extremely robust and simple, and have specific pre-identified purposes. The necessity and expectation is that these solutions are ready to go straight out of the container with minimal fuss, without long or complex set-up requirements. Once systems are operational, they need to remain functional with minimal intervention from field staff.

Diesel and smaller portable petrol generators have long been the source of electricity for all manner of functions such as pumping, emergency lighting and for operational communications. Generating sets (gensets) are relatively inexpensive, generally reliable and, by virtue of their widespread use, well understood. However, on the down-side, they do require frequent refuelling and servicing which also has monitoring, supply and storage implications. They are also noisy, polluting and require a high level of intervention.

But what are the alternatives?



There are numerous robust examples of renewable energy systems already in the field, but comparatively few that come out of the container ready to go i.e. they need some degree of familiarity or installation. To date, this has limited the opportunity for renewable energy technologies in this immediate relief situation, though many companies are now developing products which could suit rapid deployment situations.

The examples in Table 3 illustrate that there are a number of renewable energy solutions applicable for early relief effort (particularly in relation to equipment for field personnel and field coordination facilities). In particular, the focus on rapid reaction and the need for fast deployment of self-contained systems is predominantly suited to solar PV technologies and small-scale wind turbine generator systems.

OVERVIEW Micro/small wind generators

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- Small-scale electricity generation (appropriate power for homes, relief camps and small businesses)
- Suitable for remote locations with no access to an electrical network
- Can be erected quickly
- Can be suitable for local manufacture (business opportunity)
- Low maintenance, low running costs
- Moderate capital outlay

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- *Requires a fairly constant and reasonable wind regime*
- *Generation is intermittent—batteries and/or backup generation recommended*
- *Requires an open, unobstructed site*
- *Wind resource is very site specific—monitoring recommended for larger systems*

Table 4: Common existing applications of renewable energy in rural (off-grid) areas

Energy services	Renewable energy applications	Conventional alternatives
Cooking (homes, commercial stoves and ovens)	Biomass direct combustion (fuel, wood, crop wastes, forest wastes, dung, charcoal, and other forms)	LPG, kerosene
Lighting and other small electric needs (homes, schools, street lighting, telecommunications, hand tools, vaccine storage)	Hydropower (pico-scale, micro-scale, small-scale) Biogas from household-scale digesters Small-scale biogas gasification with gas engine Village-scale mini-grids and solar PV/wind hybrid systems Solar PV home systems	Candles, kerosene, disposable batteries, central battery recharging, diesel/petrol generators
Process motive power (small industry)	Small hydro (with electric motor) Biomass power generation and electric motor Biomass gasification with gas engine	Diesel or petrol engine
Water pumping (agriculture and drinking)	Mechanical windpumps Solar PV pumps	Diesel/petrol pumps
Heating and cooling (crop drying and other agricultural processing, hot water)	Biomass direct combustion Biomass from small – and medium-scale digesters Solar crop drying Solar water heaters Ice-making for food preservation	LPG, kerosene, diesel/petrol generators

Source: REN21, *Renewables 2005 Global Status Report,* Washington DC, 2005

Emergency response tools

Telecommunication is critical at all phases of disaster management, but no more so than in the immediate aftermath of a disaster.

In terms of telecommunications, the International Telecommunications Union (ITU)[7] identifies problems into three broad categories that may overlap:

- lack of infrastructure (even in normal times there are no communication facilities—remote areas/war torn countries etc.);
- sudden (or progressive) overload of the existing network (an existing infrastructure that cannot respond to an increase in demand due to more people wanting to phone); and
- destruction of existing telecommunication facilities which implies less means to communicate, usually coupled with more people wanting to phone.

CASE STUDY

Rapid-deployment critical power supply

One rapid-deploy solution when grid power or diesel generators are not an option comprises a 3m x 12m flexible solar PV module roll, charge control system and battery bank that delivers over 1.6 kW of DC power. Connecting the inverter provides grid quality AC power, meaning critical electrical services for communications, lighting, refrigeration, medical equipment and water treatment. It can be up and running in under an hour. All wiring uses quick-connect plug-and-play connections. The solar PV module system can be laid on the ground, hung from a tree or against a wall or converted into a canopy shade structure.
Web: www.environmentshop.com.au

They identify that extent of the problem depends on:

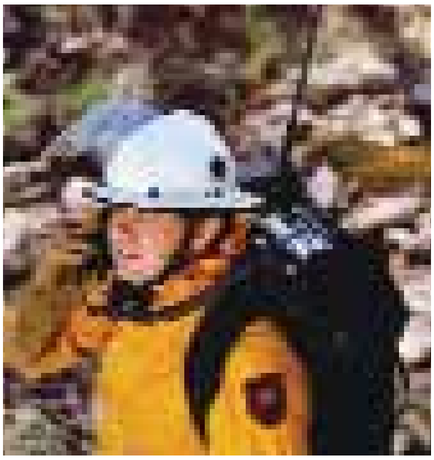
- the power autonomy of the existing telecommunication infrastructure (e.g. paradoxically, there can be a situation where there are telecoms in the first 24-48 hours because relay stations have some power autonomy until batteries are depleted and then there is a telecoms black out);
- the diversity of existing telecoms infrastructure (if there is only one system e.g. fixed lines, then it is more probable that there is a complete blackout than if there is a combination of telecom means: fixed lines, mobile phones etc.);
- the configuration, or "topology", of the infrastructure (e.g. if relay stations are distributed in a star shaped, or multi-path, system it will be more robust than a linear system where the destruction of one point of the line means a loss of communication); and
- the existing telecommunication company's capacity to respond to emergencies.

Progress in the development of communications technologies, particularly in respect of reducing power consumption, has made solar PV power supplies much more applicable. The relatively small power demands and improved power management of mobile processors, hard disks, screens and modems in the latest generation of laptops, and the rapidly evolving functionality of palm devices are well suited to recharging with modern, compact mobile solar PV devices. At the same time, developments with solar PV modules, particularly the evolution of more lightweight and robust technologies (including flexible cells) makes PV an extremely viable solution for recharging mobile devices in the field.

A 7 to 8 W solar PV module pack (measuring about 1 m x 60 cm when unfolded) will typically recharge a modern satellite phone in three hours in peak sunshine. Lightweight flexible versions, which may be rolled for easier transportation, are also available.

Field personnel communications systems

Once again, lessons learned from the ITU show that, in the initial phase of a disaster relief operation, the priority is to render relief efforts autonomous in their communications and to increase the speed of information flow between the affected area and the Crisis Coordination Centre (CCC). This involves above all getting the information from the affected area to the CCCs. These CCCs are not fixed entities: they can be fire services HQ; tents to which all relief efforts converge; Internally Displaced People centres etc. The importance of the CCC will also depend on its distance from the organisation's HQ.



Communication means must therefore be set up between:

- Field Operations (FOs) (teams dispatched throughout the affected area to provide relief and assessments) and the Crisis Coordination Centre
- the Crisis Coordination Centre and organisations' headquarters so they can take the necessary decisions concerning the nature and extent of relief efforts to send in
- Field Operations and Field Operations

Depending on the extent of the disaster, each of these will be more or less important. If the distance between FOs and CCC is small, teams can physically report back to the CCC. If the distance is large, providing telecom means will be vital. The same can be said of communications between FO and FO. In a large disaster area, there may well be several CCC that also need to be in contact between each other.

Irrespective of the primary focus of disaster relief agencies (e.g. food supply, medical assistance, infrastructure safety, etc.), one of the defining features of successful modern relief efforts is a strong communications capability. This assists rapid and effective liaison between field operatives and agencies' headquarters, and also supports better coordination between various agencies on the ground.

Other communications and logistical support is also required at this stage; indeed communications may be facilitated through equipment such as computers, as well as via radio satellite communications systems.

Power demand of a typical laptop can be reduced to only a few watts (typically 10 to 30 W), depending on screen and other hardware configurations, application demands and power management strategies. Portable plug-in solar PV chargers of 20 to 30W can now power many modern laptops in peak sunshine, and can recharge batteries during daylight hours. Again, foldable and/or flexible solar module solutions are available if required.

CASE STUDY

UHF emergency communication points and solar charged portable HF Radio

Communications are critical to an effective emergency response. In a disaster situation, when landline and mobile phone infrastructure is damaged, the most common systems for communication are satellite phones and HF radios. Satellite phones have a low power draw compared with HF radios, but they can be expensive to make calls on and are not always reliable if the satellites are not 'visible' due to the terrain or if the satellite is overloaded.

UHF radios offer an attractive solution for quickly re-establishing reliable essential local area communications over relatively short distances. Telstat can deliver emergency solar PV-powered radio or phone systems. SafeTee products are designed to be a permanent or semi permanent fixture across an emergency camp or large local area (within 5 km radius from the base station). An integrated solar power system at each of the communications points keeps the battery permanently charged ready to power the UHF radio. Some firms provide portable radios designed to be carried by one person for remote area use. Using just 1.5 watts of power when receiving and 50 watts while transmitting, this equates to approximately 50 hours of talk-time before re-charge is required. The battery charger can either be powered by a 15 watt flexible 'roll up' solar PV module or a hand crank.

The Codan "Manpack" with solar modules have been used by a leading international NGO, and are presently used by the Afghan Border Patrol.

Web: www.codan.com.au

Lighting

The needs for lighting at all stages range from small, low level personal lighting to high luminance search and rescue spot lighting.

Simple hand-held torches can assist people avoid danger areas, find their way to amenities or to locate items in tents and shelters. They can also be readily hung indoors. Lanterns provide lighting for larger areas, and can also double for finding the way in the dark. Solar PV cells can be integrated into hand-held torches. These can be recharged by placing them in sunlight.

Solar PV lighting can replace typical flame-based lanterns, providing better quality light with greatly improved safety (reduced fire risk and free from fumes), whilst also avoiding refuelling needs. A solar lantern pack has a small solar PV module, for daytime charging to provide three or more hours of light at night. PV modules for solar lanterns may be permanently mounted on a pole or roof of a shelter for convenience. Light Emitting Diode (LED) bulbs provide many more hours of good quality light and/or reduced recharging requirement (or alternatively can be recharged with a smaller solar module). This is due to their very low power consumption. An added feature is their robust construction and long life (up to 100,000 hours).

Outdoor lighting options can include perimeter security for displaced peoples' camps or street-lighting , which can be quickly installed without the need for cable runs, and operate quietly and effectively.

Other applications for solar PV lighting include runway strip markers, ablution blocks, other buildings, and low-intensity path markers.

Note: for high-intensity lighting needs, for instance spotlights for search and rescue operations, diesel generating sets (gensets) remain the best practical option due to the high power requirements of typical directional high intensity discharge (HID) lamps. However if required for only short periods, solar PV may suffice.

From reaction to stabilisation

Beyond the initial response, as the disaster situation is brought under control, the potential for renewable energy services to contribute to the relief effort expands rapidly.

Power solutions for field offices

Semi-permanent, or fixed, power solutions for field coordination centres can be effectively achieved by installing a number of renewable energy technologies. Equipment needs are generally for relatively low electricity and heat consumption or intermittent devices—such as communications equipment, lights, computers, printers and fans. This presents quite a similar energy demand and load profile to typical remote area power supply for households, for instance in outback Australia, where solar hot water systems (SWHs), solar PV and wind generators have proven extremely effective for many decades. Such renewable energy technologies can be readily integrated with a petrol or diesel genset if required, to provide supplementary power during periods of heavy demand or the wet season.

Conventionally, this supply would normally be met with a small generator, although the generally low power demand would mean that the genset would tend to be operating at very inefficient part load for most of the time. There are also the accompanying noise, pollution and fuel supply issues (noted earlier) to contend with.

The cost-effectiveness of renewable energy as a supply option can be greatly increased by a focus on the selection of energy-efficient appliances (e.g. lights, laptops, refrigerators). Generally, it is far more cost effective to invest in energy-efficient appliances, rather than to invest in additional power supply to match less efficient appliances. This is true even in situations where low-cost grid-based electricity is the power supply solution. And there is the environmental benefit of reduced greenhouse gas emissions.

Experts in renewable energy and energy efficiency will help identify appropriate appliance to optimise the investment (see also page 36).

CASE STUDY

Reliable Electricity Supplies for Regional Project Offices

The AusAID-funded Community Water Supply and Sanitation Program (CWSSP) for East Timor required the establishment of several regional offices and staff houses needed to be established. The offices were to be handed over to the local governments after programme completion to become part of the infrastructure required to run the ongoing local government water supply departments.

The unreliability of electricity supplies in the regional towns prompted the program managers, International Development Support Services (IDSS), to explore solar PV power for their remote offices and staff accommodation as a means of delivering an uninterrupted electricity supply. Choosing solar power also avoided dependence on regular delivery of diesel (which could not be guaranteed), and would not leave the local government with a fuel purchasing burden beyond the project.

The offices contained 4 computers (with CRT monitors), 1 laptop, 1 laser printer, 1 scanner, 6 lights, 3 fans, 1 small fridge and a water pump. This equipment used approximately 8.2 kWh of energy per day with a 2 kW peak load. In Maliana, for the staff accommodation, a small system was required for lights, fans, stereo/TV and a water pump. Refrigeration was provided by a gas fridge.

In the Maliana (Bobonaro District) office a full stand-alone solar PV system was identified as appropriate, although the building was connected to the town supply as a backup. For the Viqueque office it was determined that a battery bank without solar PV modules would be adequate. It was expected that the battery bank would generally power the office and be recharged by the town electricity grid when it was present. However, solar PV modules were eventually added to the Viqueque system too due to the fact that the town supply was so unreliable.

PHOTO: AUS AID

The solar PV and battery systems were required to provide five days of autonomy, before the portable generators (included as part of the system) were needed to boost the batteries. The systems were designed to last eight years.

The Bobonaro solar systems were comprised of twenty six 75 W modules and a 24V, 1000 Ah battery bank made up of 12 x 2V, 1000 Ah gel batteries. Also in the system was a battery charger, a 2.4 kW inverter and a 40A regulator. The cost per system before freight was approximately $37,000 including battery enclosure, switchboards and fusing, installation and training.

The systems ran for the entire duration of the project without any problems. The generators were only required a few times during the wet season. In March 2005 the offices were handed over to the council administration and continue to run as water supply council offices.

Web: www.ausaid.gov.au

In China, a Global Environment Facility (GEF) project is helping rural health clinics switch from coal-fired electricity to SWH and solar PV systems, at a 30% lower cost. As the health delivery expenses are reduced, the clinics become more self-sufficient and can re-channel income toward improving health services. The target is to rehabilitate from 2,000 to 4,000 clinics per year in 10 provinces throughout the country. The passive solar health clinics are designed by local villagers, who also volunteer their labour for construction and maintenance.[9]

Health services

The aim of health services in disaster relief situations is firstly to care for the physical victims of the disaster (dead and injured), and secondly to maintain the health of the survivors. Within those two categories, energy requirements are mainly in the following areas:

- Power for medical services (field hospital activities, mobile morgues, shelter for medical staff)
- Supply of clean water (avoidance of water-borne diseases)
- Water heating (sterilisation, personal hygiene)
- Cooking (avoidance of malnutrition and/or food-related diseases; reduction of injury/death from fuels)

Some of these have clear electrical power demands; others may be achieved more effectively by direct thermal (heat) processes.

POWER FOR MEDICAL SERVICES

Immunisations today save more than three million lives a year. However, millions of children still do not have access to basic immunisation and die from diseases that can be prevented by vaccines.

Maintaining the cold chain is critical for the preservation of vaccines (i.e. maintaining vaccine temperatures within the range 0—8°C at all stages between their manufacture and use). Where there is not a reliable electricity supply, highly efficient, well-insulated refrigerators or fridge-freezer vaccine refrigerators connected to a gas or kerosene-powered system or a battery bank and a solar PV or small wind energy system are used. Provision of live vaccines allows countries to scale-up the disease prevention and control programs required to meet the specific MDG health goals of reducing child and maternal mortality and rolling back HIV/AIDS, tuberculosis, and malaria.[8]

The World Health Organisation (WHO) and the United Nations Children’s Fund (particularly for their Expanded Program on Immunisation) and a number of aid organisations have used solar PV vaccine refrigerators since the 1990s, with significant successes. WHO programs, which have utilised renewable energy technologies in rural health centres, have been undertaken in Burkina Faso, Zaire and Ethiopia. Other programs using renewable energy in health clinics have operated in Uganda, Peru, Myanmar, Laos and Indonesia, to name just a few.

Solar PV-powered vaccine refrigerators are robust and have low maintenance requirements. They do not depend on fossil fuel supplies, and can be designed to provide additional electricity for lighting, minor operations and health workers’ residences in rural areas.

Even where ambient temperatures exceed 30°C, an energy efficient DC refrigerator with a cold storage volume of about 50 litres and additional capability for producing around 2 kg of ice per day could have an average energy demand of around 200—300 Wh/day. This demand can be met quite easily over the course of a day by just a few solar PV modules (e.g. 2 x 100 W modules). In situations where fuel supplies for kerosene fridges or diesel for generators cannot be guaranteed, solar medical refrigerators are the obvious, sensible solution to reduce vaccine losses caused by cold-storage chain failures.

Similarly, solar PV or small wind generators can support lighting for medical facilities, to extend the effective operating hours of hospitals and clinics. The power demands of communications and other systems required for effective health centre operations may also be readily achieved with small-scale renewables.

Depending on the scale of the operations, power needs may be met by relatively simple, small-scale systems comprising only a few solar modules and a small battery bank to power a few lights and a refrigerator, to a fully contained PV/diesel hybrid unit capable of delivering grid-quality power for multiple lights, fans, oxygen concentrators, nebulisers, microscopes and other vital medical equipment.

Emergency medical staff often sleep in the hospital, in corridors, wherever they can find room, alongside the dying, due to lack of temporary shelters. Temporary shelter for medical staff can be provided with similar power solutions as those for field staff.

Supply of clean water

In 2002, some 1.1 billion people—one sixth of the world's population—still lacked access to potable drinking water. The majority of these people live in Africa and Asia. Due to the increasing world population, that figure has risen to around 1.5 billion people and the number is growing. This translates into the establishment of new water supply services for an additional 275,000 people each day until 2015.

Another aspect of clean water supplies relates to sanitation. Sharp disparities in access to sanitation exist between urban and rural areas. Rural populations have less than half the coverage of urban areas. But statistics on coverage in urban areas mask the deprivation in urban slums. Both use of safe water and basic sanitation coverage remain extremely low in the burgeoning slums of the developing world. Overall in the developing world, the richest 20% of households are twice as likely to have access to safe drinking water sources as the poorest 20% of households, and four times more likely to have access to improved sanitation.

The 2004 situation in New Orleans after Hurricane Katrina clearly identified the mayhem which can occur in an industrialised country; when a disaster situation arises in the developing world, they are even less likely to have access to clean water and sanitation in the first place.

Usually clean water in big bottles is freighted into immediate and mid-term disaster relief situations. This is costly, but effective in preventing relief operatives from contracting water-borne diseases. However, there are other alternatives, such as solar stills and solar PV-powered water purification systems. These can be used to purify contaminated water for group use. Many of these are very simple to install and operate.

For large-scale emergencies, renewable energy technologies may not provide the most effective solution, due to the need to continuously pump very large volumes of water—either to rid an area of water, such as in New Orleans after Hurricane Katrina; or to provide drinking water for many thousands of displaced people.

Solar PV and/or mechanical windpumps may be very effective for longer-term solutions (for instance in longer-term displaced people's camps), pumping surface water or from relatively deep boreholes. The variability of the energy source can normally be accommodated by pumping excess water when the sun is shining or the wind is blowing, and storing in holding tanks for further treatment and/or storage as may be necessary.

For treatment of non-saline water, solar PV pumping systems can be readily coupled to suitable membrane filter arrangements (gravity driven), with individual pump and filter units capable of providing in the order of 10,000 litres of potable water per day—sufficient for 300 to 500 people. Larger volumes can be delivered by using multiple units.

CASE STUDY

Meeting drinking water needs in Sri Lanka

The SkyJuice Foundation is a non-government, non political, non sectarian, not-for-profit organisation. The SkyHydrant™ unit is a simple potable water filtration system intended for sustainable low-cost purification of non-saline waters. It can be used in areas without access to potable water, as well as in disaster relief situations. Operation and cleaning are simple and can be carried out by local people with no technical skills.

The unit operates under as little as one metre gravity head without the need for electric power. Solar PV systems have been integrated with the design to produce fully sustainable water extraction and purification units for communities, meeting international drinking water standards. The flexible design allows it to be operated in a range of configurations, for example, under pressure or suction.

In Sri Lanka, following the tsunami of December 2004, the local water infrastructure was damaged and the government and local NGOs were not equipped to supply the huge volumes of clean water required. The SkyJuice Foundation offered assistance via a number of NGOs, by providing SkyHydrant™ filter modules.

A further 220 SkyHydrants™ were deployed in Sri Lanka in 2005 via Oxfam (UK) and World Vision International to schools, IDPs, hospitals and clinics throughout Sri Lanka.

By mid 2006 some wells were repaired and a few internally displaced persons camps were disbanded in Sri Lanka. Some of the SkyHydrants™ were no longer required in the region and were redeployed by Oxfam to communities in Pakistan. Oxfam also expects to maintain a number of SkyHydrants™ for emergency monsoon responses in Bangladesh, Pakistan and India.

Installations can be scaled up for large volume potable water production. Oxfam has commissioned two facilities, one using nine units and the other using eight units in parallel configuration to produce a nominally 100,000 litres of potable water near Batticola and Ampara in Sri Lanka.

Web: www.skyjuice.com.au

For desalination of large volumes of salt or brackish water, non-renewable solutions such as diesel generators powering reverse osmosis systems are likely to remain the best practical solution for the foreseeable future, due to the relatively large continuous power demands of high pressure pumps matched to typical reverse osmosis membrane devices. However, there are a number of appropriate distillation and reverse osmosis solutions based on renewable energy technologies that can have a valuable contribution to make to the water needs of smaller communities.

CASE STUDY

Solar Water Purifier

The Solar Water Purifier is a new commercial solar still unit that can produce drinking water from a contaminated water supply to standards above those recommended by the World Health Organisation. The unit works by receiving non-potable water to an inlet at the top of a 'cascading tray'. The water trickles over a black plastic solar energy absorber module. As the temperature of the water rises, the water vaporises and then condenses on the under side of the glass module. Droplets of water run down the glass to a pure water channel which transfers the clean water into a container.

At an ambient temperature of 35°C, the water within the Solar Water Purifier is heated to more then 85°C. This pasteurizing effect partially kills bacteria and pathogens dramatically reducing the risk of water borne diseases. Prolonged exposure to ultra violet light transmitted by the special glass cover completes the germ killing process.

The Solar Water Purifier has no moving parts, no electronics, no costly filters and does not require chemicals. The purifiers are self-cleaning while water is running through the trays, and otherwise require little maintenance apart from periodic flushing with a citric acid solution. Multiple units can be banked together to increase the clean water output.

Web: www.solarwaterpurifier.com

Water heating

Low temperature hot water supplies to field hospitals helps to reduce disease transmission and cross-infection by enabling more effective hand washing and personal sanitation for medical staff and better patient cleanliness and hygiene. High temperature hot water also allows for sterilisation. These hot water requirements can be provided by a number of solar water heating technologies, such as flat-plate collectors, evacuated tube systems or heat pumps.

In relation to food safety, hot water supply for food preparation areas supports maintenance of proper sanitary conditions, for instance hand washing before and during food handling, and thorough cleaning of cooking utensils and preparation surfaces. As the water temperature in solar water heater storage tanks may exceed 65°C, the process can be sufficient to effectively pasteurise water, removing all of the human disease pathogens that are commonly borne by untreated water. Backup can be produced via electric/gas/donkey (wood chip) boiler.

For small volume batch water heating, including pasteurisation for personal consumption, heating water solar cookers can be very effective.

Cooking

In many developing countries, the lack of clean fuels has a direct impact on rural households. Indoor air pollution caused by these fuels is estimated to cause more than 1.6 million deaths per year, mostly among women and children.[10] This is in addition to the injury and death caused by home fires causes by fossil-fuel fired stoves.

Pulses, grains, dried legumes and many root vegetables, which should form a significant part of a nutritious diet, can require many hours of cooking. In much of Africa, central and east Asia, solar cookers can be used to prepare meals. Typically a family or small group of individuals can prepare two cooked meals a day using a single, simple solar cooker.

Aside from the nutritional benefits of cooking– notably the elimination of disease pathogens—in a disaster setting, solar cooking can reduce the demand for liquid or gas fuels which may be in limited supply, and can also reduce the burdensome task of securing scarce fuelwood, a function usually undertaken by women and girls. Solar cookers also avoid smoke and fume inhalation and fire safety issues that are associated with many forms of flame-based cooking.

Another important area that is frequently overlooked is the potential to pasteurise water to make it fit for human consumption. 80% of illnesses and deaths in developing countries result from preventable water-borne diseases. Raising water above 65°C for 20 minutes is sufficient to kill the biological pathogens responsible for such diseases. This is readily achievable with solar cookers in many parts of the world, with good family size box cookers capable of pasteurising as much as 30 litres of water per day. (Note this process will not remove salts or chemical pollutants.)

A number of solar cookers can be used, from simple box cookers made from cardboard and aluminium foil, to large community systems.

CASE STUDY

Solar cookers fill a critical gap for refugees in Kenya

Solar Cookers International (SCI) is a non-profit organisation operating since 1987 to spread solar cooking skills and technologies where they are needed most.

SCI's first field project—and its largest to date—began in January 1995 in Kakuma refugee camp in northwest Kenya. The camp grew from 28,000 refugees to nearly three times that number during SCI's eight-year presence. The project started as a field test to determine the usefulness of a simple, new module-style solar cooker (the "CooKit") among the refugee families from various cultures. The CooKit proved useful, and SCI was urged to expand to additional refugee camps.

Solar cookers make sense in this remote, sunny, arid camp where fuel gathering outside the camp is forbidden and firewood rations are usually only about one-third of what is needed to cook the food rations.

In 2003, after the project had transitioned to a sales-based

program in the camp, an independent evaluation was undertaken to review project outcomes. At the time of the study 20% of the camp residents reported using solar cookers, half of them nearly every day.

Amongst the many benefits of solar cooking identified by refugees, saving money was a primary outcome—often saving over 50% of monthly fuel expenditure. Often the only "money" refugees had was a portion of their sparse food rations to barter for essential fuel to cook the rest. Families could save over 20 kilograms of grains monthly by using their solar cooker rather than fuel-based options.

Women reported a dramatic change in daily routines, such as seeking firewood from the market, thereby releasing time for other activities. Refugees also praised solar water pasteurisation as a means of reducing incidences of waterborne diseases.

It was noted that one CooKit couldn't easily be used to cook food for large families, which is an important factor, where families have ten or more members.

Web: www.solarcooking.org/newsletters/scrnov04.htm#Final_Kakuma_evaluation

Temporary shelter

Shelter is a fundamental human need. For humanitarian workers, it also provides essential relief and a place to rest.

With the growing understanding of the needs of disaster relief agencies on the part of renewable energy system designers and other related sectors, a number of solutions are emerging for rapidly-deployable semi-permanent, secure staff accommodation units. Typically these are built from lightweight materials to allow for easy transportation, include insulation and passive design features to help moderate the indoor temperature, and can be shipped 'flat-packed', including with lighting and other electrical requirements powered by solar PV or wind generators.

Modular construction allows the rapid erection of complete, functional, secure earthquake resistant accommodation units by as few as two people.

CASE STUDY

Bridging the digital divide in the Solomon Islands

For people living in remote locations, telecommunication systems can provide invaluable links to the outside world, supporting more effective health and education services, and enabling families to maintain contact with distant relatives and friends. In an increasingly global market, they are also an important part of successful businesses.

The Solomon Islands is an archipelago comprising six main islands and 1,000 or so smaller islands. The numerous scattered, small communities mean low demand aggregation potential and logistical challenges for telecommunications, which has resulted in extremely high costs.

The main methods of communication with the outside world, for most remote locations in the Solomon Islands, are short-wave radios and satellite telephones. Using short-wave radios for voice communication often requires hours of queuing and retrials, at a cost which is still very high for those living in a non-cash subsistence economy. Satellite telephones, when available, are prohibitively expensive for most of the population.

The People First Network (Pfnet) is building a network of community-managed email stations located in remote islands across the country. The stations are usually hosted in provincial clinics, community schools, or other accessible and secure public facilities. Email operators assist customers to send and receive emails at a nominal cost.

The aim is to make this facility affordable for low-income users and sustainable over time, assisting the country, particularly low-income groups, to take charge of their own development through improved logistics, information and knowledge. Special attention is given to gender equity and democratic governance.

The stations use a simple, robust and well-proven technology, consisting of a short-wave radio (already ubiquitous and well-known in the South Pacific), a low-end computer, and solar PV electricity. On schedule, several times a day, each remote email station connects to the hub station in Honiara automatically. Incoming or outgoing emails are then transferred between the remote station and the hub, and between this hub and the wider Internet.

The network is supporting the rural networking needs of sectors such as education, health, women, sustainable livelihood programs, finance and agriculture. Pfnet is an increasingly important tool for small business entrepreneurs in fishing operations or agro-forestry, for example, to maintain contacts with clients, suppliers and shippers.

The standard costs, including the solar PV system and installation, are around AUD$11,000 per system. Once installed, there are very low running costs and no per-minute charges.

Web: www.peoplefirst.net.sb

Chapter 4

The Role of Renewable Energy in Reconstruction and Development

Reconstruction—a sustainable development opportunity

As the World Health Organisation notes, *one of the major goals of disaster management and one of the strongest links with development is the promotion of sustainable livelihoods and their protection and recovery during disaster.*[11]

Renewable energy technologies can contribute in many ways to the important *sustainable* qualifier of livelihoods development. There are some very clear examples of positive impacts on livelihoods resulting from improved access to renewable energy services.

By definition, *sustainable* implies a continuing resilience that is immune, or at least adaptable, to external influences. Renewable energy systems enable modern energy services to be decoupled from the vagaries of fuel supply (both control and competition), and from the pricing sensitivities that can change the economics and affordability of fossil fuel-based electricity in particular.

Small-scale, decentralised energy technologies further improve the security of service, by placing those energy services directly in the hands of the community—enabling the individual households or businesses to generate their own power at point of use.

Larger renewable energy community systems can provide power for the community or village. Such systems include bioenergy digesters and landfill gas systems, wind systems (e.g. up to 1 MW), pico—mini hydropower plants, packaged solar hybrid systems and so on.

With disaster management increasingly responding to climate events—droughts, storms, floods, mudslides and so on—it seems appropriate that efforts to rebuild communities and strengthen their resilience to such disasters should seek to minimise the influence on climate change.

The role of renewable energy

Once the immediate threats to survival have been tackled, aid workers can work with communities to restore services and rebuild livelihoods. Health related services continue to be high on the agenda, but whereas, for instance water needs in the disaster relief stages are predominantly for drinking and hygiene, additional requirements for irrigation and other productive applications may emerge in the reconstruction and development phases.

OVERVIEW Bioenergy

+

- Solid, liquid or gas fuels for direct heat or electricity generation
- Uses local resources, often waste products
- Can have sanitation benefits (waste disposal)
- Direct replacements for fossil-fuels, predictable heat and power
- Potential high value as greenhouse gas abatement projects
- Energy conversion technologies are largely determined by the fuel used

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- *Requires compatible and reliable feedstock supply*
- *May face competition for feedstock from other end-uses*
- *Each technology has specific requirements concerning dryness of matter content, shape, size, and particle consistency of the raw material*

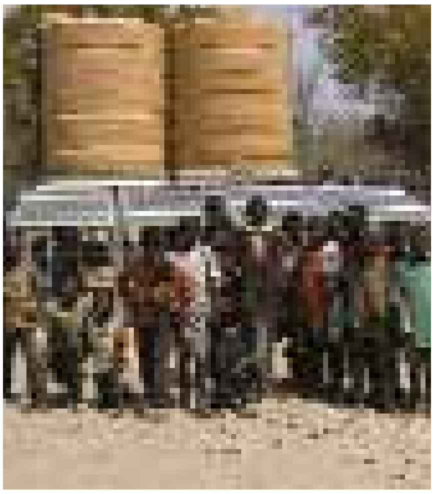
The ‘sustainable livelihoods’ approach to community development has a strong natural ally in renewable energy services, and the reconstruction and development efforts that follow a disaster can provide new opportunities for building more sustainable communities.

There are many opportunities to incorporate renewable energy and energy efficiency into longer-term planning and reconstruction. Natural sources of energy from the surrounding environment, such as the sun, the wind, water, biomass, geothermal energy, can be harnessed to provide heat and power.

Australia’s Bushlight project, major development initiatives such as China’s Brightness program, and the Municipal Solar Infrastructure Project in the Philippines support the development of increasingly sustainable livelihoods.[12]

In the following section, we identify some opportunities which are usually suitable for renewable energy systems. This is by no means exhaustive and there will be many other opportunities where renewable energy systems can be incorporated into sustainable livelihood rebuilding and development.

Water supply



For many remote and rural communities in places such as West Africa and south-east Asia, solar PV pumps fulfil the vital function of village water supply. PV systems of around 1—1.5 kW, coupled via an inverter to a submersible AC motor pump, can typically deliver 20,000 to 40,000 litres per day—sufficient drinking water for some thousand inhabitants, cattle, sheep, goats and other livestock. This is assuming that the water source is capable of meeting that demand in the long-term.

For smaller communities, submersible DC pumps or mechanical windmills can provide more appropriate solutions. In other situations, where the water table is close to the surface, hand pumps could be the most suitable solution.

In general, solar PV systems for irrigation are less common than for drinking water supply, mainly due to seasonality of demand which means PV pumps may be under-utilised for parts of the year, effectively increasing the cost of delivered water. However, in the Philippines for example, solar PV irrigation systems are being introduced as part of a wider integrated community energy services project.

These larger-scale community water projects are predominantly funded by international donors; in some places, villagers themselves have established consumption charges to support ongoing service and maintenance requirements. This ensures the continued availability of a reliable water supply without the daily burden of long-distance collection.

For families and small communities in coastal and other areas where potable water access may be a challenge due to high salt content or other contaminants, there are a number of small-scale water purification options, such as solar stills or reverse osmosis (RO) solutions. Some recent improvements in small-scale RO system designs have led to units with greatly reduced electrical energy requirements, which have made them far more amenable to being coupled with small renewable energy generators.

CASE STUDY

Affordable water purification for small communities

For small communities, packaged purification systems combining a solar PV pump, water storage tank and reverse osmosis unit can deliver potable water for around 1 US cent per litre.

Solco's SolarFlow system uses an energy efficient reverse osmosis unit, designed for operation with solar PV modules coupled to a positive displacement 'Sun Mill' piston pump, which drives the raw water through some coarse filter screens into a header tank. The static pressure of water in the header tank helps force the water through a second filter before it is forced through a specially designed spiral osmotic membrane, housed in a corrosion-proof cylinder. About 15% of the pumped water is purified, leaving the remaining water to constantly flush the membrane, minimising contaminant build-up and maintenance requirements. The wastewater, which is still pressurised, is then used to pump more water through the system via a unique energy recovery system.

This arrangement makes the unit up to four times more efficient than a conventional reverse osmosis unit, and enables self-starting and self-regulation at all operational speeds from sunrise to sunset.

The system can treat brackish water up to 5,000 ppm, to deliver up to 600 litres of drinking water free from salts, chemical and biological pathogens each day. A further 4,000 litres per day can be pumped to meet non-potable water needs such as washing.

Web: www.solco.com.au

Information and communications

Renewable energy power solutions are now mainstream for telecommunications, such as telephone repeater stations in locations without grid electricity. Particularly in less accessible sites, battery banks coupled to solar PV or wind turbine generators provide high-reliability power without demanding frequent intervention for refuelling and maintenance of generators. Renewable-powered base stations are less common at present; however, in rural locations, this is certain to change in the not too distant future as fuel prices rise and renewable system prices continue to fall.

For communities reliant on rural services such as hospitals and health clinics, reliable communications can literally make the difference between life and death. High frequency radio networks linking clinics to regional facilities, mobile health workers and other medical outposts generally have very small power consumption (typically just a few watts in standby mode) and only short duration bursts of power are typically needed during transmission and reception. Relatively small (i.e. one or two module) PV systems with battery storage can be quite adequate to power such devices. Note though that communications power requirements may also be effectively amalgamated with the needs of other medical equipment and health centre services under an expanded power supply solution.

An emerging application is in supporting rural communities to gain access to information resources both for education activities and to assist business development. A personal computer with modem for internet access can bring news, health advice and other education material to rural communities, as well as news and entertainment. It may also be used to monitor market prices to help farmers, the fishing industry and others obtain fair market prices for their goods.

CASE STUDY

Solar powered HF radio network saving lives in the Pacific

High frequency (HF) radio had long been associated with health services in Australia due to its connection with the Royal Flying Doctor Service of Australia. New advances in HF technology, including remote diagnostics and reduced power consumption, are resulting in HF being used throughout the South Pacific to bring a level of health care not available before.

Under projects primarily funded by AusAID and the World Bank, Barrett Communications has helped to establish health radio networks in East Timor, PNG and the Solomon Islands.

Most sites consist of the HF radio, solar power supply and broadband antenna. The HF radios are generally 125 watts, 20 channel transceivers utilising selcall. As the sites are solar powered it is imperative the transceivers have low power consumption (less than 500 mA) in the standby mode. The solar power system consists of one or two modules charging a battery which powers the radio. The capacity of the modules and batteries is usually determined during the project design period and reflects the anticipated radio traffic flow and hours of sunlight in the area of operation.

Due to the extreme remote location of the health centres, equipment reliability is paramount. To repair or replace a radio in a remote location could incur expenses far in excess of the equipment value. Once equipment becomes inoperable it is difficult for technicians in the central control station to determine the cause or what replacement equipment may need to be taken to site for repairs. With remote diagnostics giving readings on battery condition and Standing Wave Ratio (SWR) as well as transceiver functions, technicians at the central control station can assess the condition of the remote transceiver and accessories to rectify minor concerns before they escalate.

Web: www.barrettcommunications.com.au (See also page 15.)

Note: old computers, particularly those with cathode ray tube monitors, have a considerably higher energy demand than the latest technology. For communities with limited power access, it may prove more cost-effective to invest in a newer LCD monitor than in providing an expanded power supply to run the old screen. Alternatively, laptop components may be used which have even lower energy demand than desktop units.

Community facilities

Re-establishing child care centres and schools can be important for the psychological healing process of young people. At the same time, schools and other youth centres may serve function as community centres and meeting points in the evenings. Simple lighting systems can significantly improve the amenity of the buildings, either for extending lessons, for providing a more comfortable environment for planning meetings, or to allow various other community development activities to take place after dark.

A range of options are available to satisfy lighting needs of communal facilities, with a single solar PV module or small wind turbine generator capable of powering a number of lamps. Multiple solar modules can be interconnected to power internal and outdoor lights, fans and audio-visual equipment.

Other sustainable community facilities could include water supply systems for drinking, irrigation and livestock watering, communal bathing centres and small health clinics.

CASE STUDY

Solar Hot Water for a High Altitude Community Bathing Centre

At least 85% of the rural population of Nepal has no access to electricity; many rely solely on fuel wood, crop residues or dung for cooking, heating, lighting and hot water. Although the country has little in the way of fossil fuel resources, it receives ample sunshine, enjoying some 300 sunny days a year and on average some 4.8 to 6 peak sun hours per day.

In the remote and difficult to access mountain communities, scabies, especially among children, is very common. This is a direct outcome of the extremely poor hygiene conditions. The harsh and cold climate does not encourage cold-water bathing, while scarcity of wood and other fuels (women and teenage girls already spend up to 42 hours per week on firewood collection) means there is little spare for heating water for showering or washing clothes. It is not uncommon that people in these remote communities do not bathe for months at a time while some rarely bathe at all.

Solar water heaters (SWHs) are widely used in the urban areas of Nepal, with 80,000 units believed to be operational. However, the local designs are not ideally suited for the harsh mountain climate.

The Mechanical Engineering Department at Kathmandu University has developed an improved design that accounts for the special requirements of the Himalayan environment, notably significantly increasing insulation levels to reduce heat losses and simplified system for draining the collectors to protect them from overnight freezing. The new design is being incorporated into a community bathing centre for the Dhadhaphaya village in Humla, which will allow each of the 1,100 locals to take a hot shower once every two weeks. The capacity of the bathing centre was designed to accommodate up to 80 people a day, with each person using approximately 10 litres of hot water at 50°C,

The bathing centre was discussed with the local people and they have enthusiastically agreed to provide all the locally available materials They paid for half of the land and a committee has been established to take responsibility for the bathing centre infrastructure. The committee has appointed a caretaker to oversee the daily operation, maintenance and protection of the centre, for which they earn a small monthly salary. Each family contributes 10 NRp (approx. 20 cents) a month for the hot water services received.

The bathing centre is one component of a multi-faceted and holistic community development project that will address a range of needs identified in consultation with the community. Other features of the project include:

- A basic rural village PV electrification scheme for 3 white LED (WLED) lights per household
- A smokeless metal cooking and heating stove for each household, designed to cook the local food according to the community's traditional eating habits whist reducing indoor pollution
- A pit latrine per household
- A village drinking water scheme with village tap stands
- Greenhouses to grow vegetables for up to 10 months per year (previously 3 months)
- Non-formal education classes for mothers and out-of-school children (mostly girls)

Web: www.anzses.org/docs/SOLAR06Papers1.pdf

Domestic applications

Domestic energy needs in a development context primarily revolve around cooking, lighting and space heating and cooling. Beyond these basic needs, aspirations may include a refrigerator and recreational appliances such as radio, TV and DVD and music players.

Burning wood for cooking and warmth still dominates household energy use in many parts of the world. As per the previous section, use of fuelwood and unimproved stoves, and kerosene lanterns, lead to many casualties from burns and air pollution.

Insulation and heat storage techniques incorporated into building designs are principal means of reducing additional energy demand for warmth. Wood consumption for cooking, on the other hand, may be reduced by use of 'improved cookstoves'[13] (which channel heat more effectively onto cooking pots and also reduce smoke by better fuel combustion), solar cookers[14] (as previously covered) or biogas stoves. In parts of Western China, a program of household biogas generation from controlled decomposition in 'digesters' of animal and human wastes and vegetable matter, helps maintain sanitation and also provides a gas supply which is piped to the kitchen to fuel a slightly modified gas hob.[15]

Biogas digesters convert animal and plant wastes into a fuel usable for lighting, heating, cooking, and electricity generation. Digesters can be house-hold scale, or community-scale shared by many households. Biogas programs have been challenging because a variety of technical options are needed. Community and political issues have also created challenges, along with the need for rural sales and service businesses and consumer credit. China, India, and Nepal have conducted the main biogas programs; all three countries now have large manufacturing industries for biogas plants.

Lighting and basic entertainment appliances can be powered by a range of renewable energy systems. As we saw in Table 1, there are more than 1.1 million Solar Home Systems (SHSs) installed; over 50 million households are served by family hydro grid systems; 10 million households get lighting from biogas; and more than 10,000 households are served by wind/diesel/solar mini-grid systems.

SHSs often comprise just a single solar PV module, battery and charge regulator. Where possible, solar batteries should be specified rather than simple car batteries, as these are designed to provide relatively limited current over a long period (as opposed to the short bursts of high current needed to start a car), and are capable of deeper more frequent discharge which results in a longer battery life (and therefore reduces disposal problems and lifecycle costs).

Small-scale or 'family' hydropower systems can be very effective where a river or stream is available. These operate on the flow of the river and do not necessarily require a large 'head' differential (available vertical fall in the water, from the upstream level to the downstream level) to generate power. For instance, popular propeller units in China and Vietnam are suitable for use with a head differential of just 1 to 2 metres. A number of options are available, depending on the topography, such as run-of-river systems, mill leat or feedstock pens, all of which can have minimal impact upon the environment.[16]

OVERVIEW Small-scale hydro

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- Range in size from a few kilowatts to <100 kW
- Electricity or mechanical shaft power from flow of rivers or streams
- Well understood, reliable technology
- High level of predictability, varying with annual rainfall patterns
- High efficiency (70—90%) and a high capacity factor (typically >50%)
- Slow rate of change; the output power varies only gradually from day to day
- Can operate 24 hours per day
- Can be very cost effective, competitive with conventional power solutions
- Can be connected to a local mini-grid or directly to demand (e.g. grain mill)

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- *Hydro resource is very site specific – site test recommended*
- *Not effective for locations with large seasonal water flow variations*
- *Service, maintenance support and parts for turbines may not be locally available*
- *Not scalable*
- *Not portable*

Businesses and livelihoods

There are a wealth of business and livelihood opportunities that modern energy services can support; practically all human endeavour and economic development is inextricably linked with energy services. These opportunities have a range of power requirements, and include:

- improvements to home lighting and community centres—enabling handicraft to be made in the evenings without eye-strain, or adult education undertaken after working hours
- refrigeration systems—enabling stores to provide cold drinks, and preserve meat and other perishables
- crop drying (including sun-dried produce)
- cool-stores
- ice-production for fish-processing
- milling and grinding machines
- power and lighting for light industry—such as sewing, carpentry, welding
- irrigation systems
- computers, fans, lights
- battery charging stations

Indirectly, energy services result in more productive applications (for instance, providing better light to improve productivity) and support health and education, thereby assisting communities to enhance their future economic and social prospects. Renewable technologies are not alone in supporting such opportunities, but increasingly they present a more sustainable path towards positive community development outcomes and long-term sustainability. For example, bioenergy has provided millions of households with incomes, livelihood activities and employment. The essence of sustainability of bioenergy projects from a social aspect is how they are perceived by society, and how different societies benefit from this activity. Avoiding carbon emissions, environment protection, security of energy supply on a national level or other 'big issues' are for local communities an added bonus, but the primary driving force are much more likely employment or job creation, contribution to regional economy and income improvement.[17]

Community power systems

Energy for business and larger households can be provided by larger solar PV systems (increasing the number of modules and batteries), or by using larger wind or hydro generators. Beyond meeting simple lighting requirements and power for radio and fans, systems are likely to incorporate an inverter which will deliver AC power equivalent to grid electricity.

As electrical power and energy needs increase, another option is to provide an interconnection to a community mini-grid supply.

For small (typically less than 50 households), dispersed or mobile communities, or where electrical energy demands are small, individual DC micro-generators are likely to be appropriate sustainable energy solutions. Examples of these are SHS, family hydro, micro wind and battery recharging stations.

As demand concentration (i.e. load per customer or load per area) grows, it can soon become more practical and economic to deliver AC electricity via a local grid system called a 'nano' or 'mini' grid.

Diesel generators or small gas turbines can be effective in mini-grid applications if fuel supply is not an issue—particularly if there is a local heat demand which can be met through waste heat recovery from the engine cooling or exhaust systems. But for such community power supply applications there are a variety of environmentally sustainable power solutions that might be considered as alternatives to (import-dependent) fossil fuels.

The application of small-scale hydropower is very well established, relatively simple and robust and can be one of the most economic means of generating electricity, where a suitable resource exists.

Large wind turbines or multiple wind turbine units in the form of wind 'farms' are also mainstream, although, like solar PV technologies, their intermittency introduces a requirement for some energy storage or, more commonly, integration with a 'dispatchable'[18] power supply such as a fuel-based generator to maintain the electricity grid.

In tropical climates, communities may be fortunate enough to have access to a naturally occurring biofuel resource. Coconuts, palm nuts and other oil bearing crops can be used as a direct fuel source replacement for diesel, or as bio-diesel blends.

OVERVIEW Community wind power

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- Large-scale electricity production using the power of the wind
- Well-understood, reliable technology
- Can be very cost effective, competitive even with large central fossil fuel power plants
- Reasonable wind sites can produce 2.4 GWh/year per installed MW
- Small land area required—sites can continue to support other applications
- Zero fuel costs
- Extremely low running costs
- Modern wind turbines are more efficient at converting wind into electricity than coal-powered plants

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- *Site specific—requires a fairly constant and reasonable wind regime and limited obstructions*
- *Generation is intermittent – backup generation recommended*
- *As any wind resource is very site specific, monitoring recommended*
- *Not effective for locations with large seasonal wind variations*

Geothermal energy is clean and is not vulnerable to droughts. It also is not prone to unpredictable price fluctuations as can be the case with oil-fired power generation. Certain parts of the world, notably Indonesia, the Philippines, parts of Central and Southern America and the rift valley region of Africa, have the potential for large-scale generation of heat and power from geothermal resources. For instance, Kenya, which has pioneered geothermal energy in the East Africa region, generates 45 MW of electricity from "hot rocks". Kenya has used geothermal energy for power generation for 22 years at greater than 97% availability.

In all communities, bioorganic wastes can be turned into bioenergy—using plant matter and wastes from the agricultural sector and urban areas to generate electricity and heat. A number of agricultural products can also be converted into liquid fuels, such as ethanol, and used for motor vehicles. Using bioenergy to produce electricity does impact on the role of biomass in producing liquid fuels, as the feedstocks are often very different.

CASE STUDY

Coconuts fuelling the Pacific

Maintaining an affordable supply of good quality diesel is an ongoing struggle for many rural and remote communities. In the Pacific region, for example, the vast distances between ports and the relatively small demand concentrations result in very high cost of diesel fuel deliveries. Added to which, the fuel quality delivered to many such island communities is invariably of a far lower quality than would be demanded or required by consumers and fuel standards organisations in major economies, resulting in less efficient engine performance and increased emissions. A further challenge is that most island communities are strongly reliant on the marine environment for their livelihoods—both for food, and increasingly as part of their economic development activities through tourism. A fuel spill into such a sensitive environment could be catastrophic for island life.

Ironically, many tropical islands have untapped biofuel potential, which could directly displace mineral diesel for both transport fuel and stationary power generation purposes. In Vanuatu, Samoa and PNG, amongst others, a variety of private and public ventures are switching to coconut oil or bio-diesel (mineral diesel blended with a vegetable oil).

Vanuatu has the most developed local bio-diesel production of anywhere in the pacific, with two organisations in Port Vila using two alternative methods to produce two alternative bio-diesel blends. Motor Traders' process uses a blend of coconut oil and Avgas (kerosene), to overcome problems associated with the poor mineral diesel fuel quality; regular diesel contains too much water which might otherwise cause emulsification problems—effectively contaminating the coconut oil. Now all of Vanuatu's government vehicles are operating on the blended fuel.

In PNG, another private businessman has established a small processing facility, buying bags of copra (coconut flesh) from local villages, drying, pressing and filtering the resulting oil that is squeezed from the copra. After a multi-stage settling and filtering process, the oil is suitable for use in engines, oil lamps as a lubricant or for cosmetics.

In Samoa, the national electricity utility, Electric Power Company, has been testing operation of a 400 kVA Cummins engine supplying the national power grid on various coconut oil fuel blends. A 15% blend of coconut oil with 85% diesel gave no performance problems on the unmodified engine. The company is now testing blends with a higher coconut oil component.

Typically one tonne of copra equates to 6,000-10,000 nuts and will produce of the order of 600-650 litres of raw coconut oil. Coconut trees may yield up to 200 nuts per year, but 75 to 100 nuts is typical. A family with a two-hectare plot could produce up to 12,000 nuts per year, sufficient for perhaps 800 litres of coconut oil per year for cooking oil, lighting and fuel uses.

Kokonut Pacific (Australia) developed a process to bypass copra-making and to enable farming communities to produce pure virgin coconut oil within one hour of opening a coconut. This process was called Direct Micro Expelling (DME). In 2004 Kokonut Pacific Solomon Islands was formed as a joint venture between ProSolutions Ltd, a church linked company, and Kokonut Pacific (Australia). The venture seeks to assist in the rehabilitation of the rural economy of the Solomon Islands and to significantly improve the livelihood of coastal peoples by helping them to make more effective use of their existing sustainable coconut resource through the production of export quality virgin coconut oil and local transport fuel at a local farm level.

With an average of 10 units in production, a total of over 86,000 litres of VCO have been produced since June 2004. About 80% has been exported, generating income of over $164,000. Oil is now selling into the local market for cooking, cosmetics, transport fuel and soap making. Rural tractors and diesel generator sets are also now running on the coconut oil in the project areas.

Not only does this provide direct income to the project areas it also alleviates imports by using local products and makes the area less reliant on outside supply. The impact on local rural communities in employment and income generation has been profound. In addition to the purchase of nuts from neighbouring farmers, typically 6 people work full time on each site for 6 days per week.

Web: www.kokonutpacific.com.au

There are a number of process and technologies to generate heat and power from biomass. These include the following.

- Landfill gas: Landfill gas is generated by the anaerobic decomposition of organic refuse in landfills. It consists mostly of methane and carbon dioxide, together with water vapour and minor quantities of organic compounds. The substantial methane content of landfill gas enables it to be utilised as a fuel for power generation or other industrial use.
- Anaerobic digestion and sewage gas: if organic material is broken down in the absence of air, it produces biogas (methane) that can be used to generate heat and electricity. Valuable by-products of organic fertilisers and nutrient-rich liquid can also be produced. All animal feed, plus the waste, can be used as fuel—as well as many common organic wastes.
- Cogeneration: heat generated during the production of biogas electricity can be used in heating systems, for instance, in chicken sheds or piggeries. The heat can also be used where required in industrial processes, such as in sugar mills.

Bioenergy technologies have a proven track record in delivering reliable energy to industry and households across the world.[19]

Building heating and cooling

Another important issue for redeveloping sustainable communities is building construction, which can have a major influence on overall energy demand, and internal comfort of the building.

In many countries, indigenous architecture makes use of building structure and components to harness the natural heating and cooling properties of the surrounding environment, in order to keep the building within an optimal internal temperature range. Solar chimneys in the Middle East are but one example. Over the years, indigenous principles have often been lost—particularly in the industrialised world—so that today's buildings often require constant power to heat and cool them.

The commercial sector has a big role to play in reducing electricity needs as well as the residential and industrial sectors of any country. The type of activities where energy is used in commercial buildings is shown in Table 4. This is based on typical commercial building practices in industrialised countries. Nearly two-thirds of all energy is used for the heating, cooling and ventilation of buildings, with lighting accounting for a further 18%. The use of office equipment accounts for a quite modest share of total consumption. Natural gas is the main fuel used for space heating, water heating and cooking, whilst use of electricity dominates all other activities.

Implementing initiatives with a sustainability focus for existing buildings can result in significant increases in capital value as well as reductions in energy consumption and improvements in productivity and comfort. Simple and cost effective solutions exist to increase building performance and property values that will deliver worthwhile financial returns within realistic timeframes. For commercial buildings, large energy savings can be achieved through cost-effective energy savings measures already available in the marketplace including:

- installing more efficient lighting systems;
- replacing Heating, Ventilation and Air Conditioning (HVAC) equipment with more efficient units and improving the efficiency of existing HVAC systems;
- testing and sealing air distribution ducts;
- optimising performance and management of building energy systems;

Table 5: Typical energy use by activity in the commercial and services sector

Activity Share of total energy use[20]

ACTIVITY	PERCENTAGE
Air handling	15%
Space cooling	18%
Space heating	32%
Pumping	3%
Water heating, cooking etc.	6%
Lighting	18%
Other	8%

Table 6: Activity share of total energy use

APPLIANCE	PERCENTAGE
Electric appliances etc.	29%
Water heating	28%
Cooking	4%
Space heating and cooling	39%

- buying energy efficient office equipment (such as those with an Energy Star rating[21]);and
- replacing inefficient office equipment with more energy-efficient products.

Replacing lighting systems in commercial buildings with more efficient fixtures, lamps, ballasts, and improved controls can save more than 50% of lighting energy use.

In the residential sector, where houses have modern amenities and construction methods, the energy use by activity (in the Australian residential sector but applicable elsewhere around the world) is again predominantly for mitigating heating and cooling loads.

There are a number of principles which are applicable for buildings in all sectors of the community, for most construction types.

Passive design

Passive solar design makes the most of design to mitigate the extremes of outside temperature. Its principle's include:

- Orientating the living areas to the sun, and providing external shading which allows the sun's rays in during winter and keeps it out during summer.
- Using internal thermal mass (such as bricks or concrete) to moderate the internal temperature (in temperate zones). In the tropics, buildings should have low thermal mass.
- Installing insulating materials in roofs and walls.
- Providing adequate ventilation, which can be controlled to moderate the internal building temperature.

Passive solar design is very site-specific, as climates vary enormously even within a country or region. However, the principles do not vary although the designs need to take the climate and its characteristics into account (e.g. wind direction, extremes of temperature). There are many references[22]; indeed many industrialised countries now require minimum energy performance standards of domestic and commercial buildings.[23]

Active solutions

Fans create air movement for cooling and can be effectively powered by relatively small renewable energy systems. A typical ceiling fan will have a power consumption of maybe 40 or 50 watts (similar to that of a basic incandescent light bulb). Note though that fans may be called upon to operate for 12 or more hours per day, which can result in quite a sizeable energy demand.

Refrigerative air conditioners generally have very high electricity consumption. They should certainly not be considered alongside small solar PV or wind generators, and should really only be considered (and then very carefully) for use in tropical environments where grid power or robust mini-grids and appropriate levels of generation capacity can comfortably accommodate their load. It is also critical that users of such systems have a clear understanding of the electricity cost implications of their use.

In dry climates, evaporative air conditioners or thermal cooling systems that are now emerging onto the international market are a more appropriate solution than refrigerative systems.[24]

Chapter 5

Sustainable Communities – Reconstruction, Building for the Future

As the disaster response moves from emergency relief to reconstruction, new opportunities emerge for optimising energy services to support community development priorities .

A simple return to the pre-disaster way of doing things may, in some cases, be the best solution, but alternative approaches should not be discounted purely because 'we didn't used to do it that way'.

Planning for community sustainability

Access to reliable, affordable energy underlies the whole task of improving livelihoods and supporting communities. But while the energy *resource* may be sustainable, this is no guarantee that the *service* will be sustainable. In order to enable a scheme to be sustainable in the long-term, it must meet the users' needs and have the 'buy-in' of the local community.

In addition to an adequate energy resource (sun, wind, water, biomass), a number of other elements must be in place to support sustainable renewable energy services, including:

- appropriately-delivered information (for instance, no point having written materials if the villagers cannot read);
- training—of users, some-one to service and maintain the system/s;
- access to suitable finance (for instance, are there already micro-credit schemes operating in the village, or will a new scheme have to be set up, which takes into account local income patterns?);
- selection of appropriate hardware (what are the warranties, availability of spare parts, how complex is it, how robust is it for the terrain, etc.);
- having a plan to ensure good installation, service and maintenance of the system and access to spares.

To date, lack of knowledge and misunderstanding has been a major impediment to the successful deployment of renewable energy systems world-wide.[25] "*It doesn't work", "it's too expensive", "we prefer what we already know how to use", "it's too risky"* etc are common reactions. Whilst this Guide goes someway to overcoming the "knowledge" barrier, more research should be undertaken by decision-makers so that, if renewable solutions are considered unsuitable in a particular situation, the decision is based on fact, not inaccurate perceptions, and the sustainability of the community does not suffer as a result.

Cross-sectoral consideration

Energy overlaps with so many facets of our lives that it cannot be considered in isolation and really needs to be assessed in a multi-sectoral context. In the reconstruction phase, this can bring many positives, for instance:

- Optimal location of generating facilities to take best advantage of resources (or optimal siting of new amenities);
- More effective infrastructure investment (for instance, energy efficiency and passive design improvements);
- Co-location of facilities or multi-function centres (schools, community centres);
- Contributing to productive applications or new livelihoods ventures (for instance, new crops or other income-producing activities);
- Reducing the burden on women and girls to collect wood and water, leaving more time for education, work or leisure.

Energy within a multi-sectoral needs analysis can also strengthen the long-term sustainability of modern energy services, by creating a critical mass for local service technicians and customer base around which to build a profitable business.

Upfront capital cost is frequently one of the dominant factors in the decision-making process, which invariably puts renewable energy solutions at a disadvantage compared to fossil fuel-based approaches and systems. This is due to the higher initial cost of the majority of renewable energy technologies. A small solar PV power system may have a capital cost 10 to 15 times that of a petrol or diesel generator of a similar output—which, on first inspection, makes a cost-based choice a simple contest (or no contest).

Market distortions arising from conflicting government policies, e.g., subsidised energy prices used to deliver basic services to the most needy; and/or tariffs on imports also do not assist in making the capital cost of renewable energy technologies less.

But there are many other considerations and questions to be answered in the decision process. These include:

- Resilience to future disasters
- Ability of the proposed system/s to complement economic development activities
- Ability to enhance living standards
- Planning, siting, local consultations
- Ongoing costs of alternative fuels
- Future maintenance costs
- Modularity (i.e. how easy is it to add capacity in the future) and is the equipment robust
- Portability may be significant for remote, inaccessible areas
- Support infrastructure (e.g. repair facilities/spare parts) to service the equipment
- Are there standards relating to product design, quality and installation?
- Is the technology socially acceptable within the community?
- Are there any gender-based issues
- What will be the impact on the local natural environment (pollution, forest, soil or river degradation, visual amenity etc)

- Will there be a positive impact on air quality (indoor and outdoor)
- How will the systems be financed: by individuals, the local community, national government, international donations or international agencies? Will the rates be comparable to conventional energy options?
- What is most appropriate to be locally affordable and sustainable?

Impact on the local community

Resilience

Resilience to future disasters, be they natural or man-made, should be a strong factor in post-disaster planning decisions; in this respect many renewable energy alternatives score highly. Distributed (or 'decentralised') energy solutions (where the energy generator is located at or near to the point of use) tend to increase overall community resilience to future energy outages and consequent livelihoods repercussions. Distributed renewable energy systems also reduce the investment needed in traditional (centralised generation-based) transmission and distribution infrastructure.[26]

By their nature, renewable energy technologies take advantage of locally available and free energy resources that relieve users of fossil fuel supply constraints and exposure to external pricing controls. With the exception of major infrastructure projects, for instance—geothermal, large-hydro schemes and some bioenergy projects such as landfill gas, most renewable energy technologies are modular, allowing for additional capacity to be introduced as individual or community needs grow.

Additionally some technologies—such as the majority of solar products and wind turbines—can be temporarily dismantled, furled or stowed away to protect them from foreseeable impacts such as cyclones. Furthermore, well designed units can be built to withstand all but the most severe cyclones.

They can also be dismantled and put to other power uses—for instance, the solar PV modules supplying electricity to a water pump could be redeployed to light a community centre.

Sustainable livelihoods

Central to the rebuilding and development of vibrant secure communities is a focus on sustainable livelihoods opportunities. This revolves around directly working with communities to gain an understanding of their current resources or strengths (individual and group skills and links, natural local resources, physical 'infrastructure' and financial capacity) and building on these assets towards achieving individual or group aspirations which maintain or strengthen those resources and reduce vulnerability.

Again energy is not an aspiration or outcome in itself, but appropriate energy solutions can help communities' access services such as clean water, quality lighting, communications, better food, good health, and increased ability to improve wealth.

Renewable energy solutions can contribute to a positive 'asset balance', particularly for remote communities where conventional enabling energy networks may be very limited and expensive, but locally available natural energy resources may be abundant.

CASE STUDY

Turning a waste-disposal issue into a powerful ally

Malaysia is the world's leading producer of palm oil, which is used mainly in the food industry, but may also be used in soaps, plastics, skin care and cleaning products. Although palm oil is a naturally-occurring crop, extraction of the oil from the palm fruit, creates a waste product, which in turn presents problems. Notably, there is a ban on incineration of waste for environmental reasons, while some 2% of the oil remains locked in the waste, which leads to water pollution if not disposed of appropriately. Additionally the empty fruit is a haven for vermin if mulched, and can be prone to spontaneously igniting if stockpiled.

Using palm oil fruit waste as a bioenergy source, however, overcomes these problems and offers some attractions, notably the potential to create carbon credits under the Clean Development Mechanism. Australian firm, SMEC, saw the potential to build biomass power stations in Sabah, Malaysia, to use the palm oil residue to generate electricity. Two stations have been established to generate 10 MW of power disposing of 350,000 tonnes of waste each year. This also provides employment for local truck drivers in bringing the waste to the power stations.

Web: www.smec.com.au

Assessing the potential for renewable energy and other energy technologies should form an integral part of any community or regional planning process. Some questions which may be asked include the following:

- What natural energy sources are available locally? (e.g. plentiful wood, good sunlight, strong wind, a flowing river or stream.)
- What other assets might affect the community sustainability? For instance, drinking water sources, crops, fish, meat, fruit or other foodstuffs. Can better use be made of these resources, e.g. better preservation and/or storage?
- What services (infrastructure) currently exist and what needs further improvement? (e.g. water supply, transport systems, irrigation systems, housing and other buildings).
- What are the individual and group skills and knowledge that are endemic in the community and how might these be further developed? (e.g. handicrafts, artwork, farming, fishing, metal and word work skills).
- What are the possibilities for trading these commodities, and if appropriate, what may improve their potential? (tourist facilities and eco-tourism, better means of preserving foods, new opportunities for income such as oils, soaps).
- What local skills (mechanical or electrical capabilities) might be available to maintain services?
- How does this community work with and relate to others nearby, and further afield (existing trade, cash income, access to other resources and services—fuels, equipment, spares, maintenance, other food)?
- What is the individual and community cash income? Where is that derived from? What is exchanged or bartered? Are there any seasonal trends in income and trade? What is the current expenditure on fuels and other services (such as candles, batteries) and what are the trends in expenditure? Do credit or savings structures exist (who are the parties involved, what are their terms)? What is the capacity and willingness to pay for improved services?

There may be seasonal variations in some of these assets, and natural shocks (droughts, floods, hurricanes, etc.) that may periodically affect access to or effectiveness of these resources.

Even with this knowledge, there will inevitably not be a single 'best way' for communities to move towards achieving their goals; other factors such as strong leadership and governance, community mobilisation and participation will clearly have a tremendous impact on whether positive outcomes can be achieved.

Community consultation

A necessary precursor to a cross-sectoral community approach is an investment in communicating potential applications and opportunities for modern energy services—as well as other key information, such as typical costs and economics, differences in the level of service, advantages and shortcomings of the alternatives.

For users this may be achieved via community meetings, simple explanatory leaflets, theatre, radio or other media. Policy decision-makers and implementation agencies, on the other hand, may benefit from formal workshops, seminars, case study reports, technical tours, internships or other capacity building measures. Planners in particular are likely to require some exposure to life-cycle cost analysis as a critical component of a more complete understanding of the implications of alternative energy sources, technologies and other choices.

The pathway from disaster relief to rehabilitation, reconstruction and (re-) development will not be exactly identical in any two communities, and the opportunities and needs for energy services to support sustainable livelihoods may be very different.

However, there is some commonality—that the community must be involved in the decision-making process so that redevelopment can take account of, and design for (as far as possible), meeting the community's expressed needs and aspirations. Energy needs are frequently overlooked while communities discuss schools, clinics, businesses and a whole raft of other public and private goals. But energy, like water and sanitation, has multi-sectoral implications and needs to be considered as an enabler and cross cutting issue for improved services.

The consideration of renewable energy technologies and options at an early stage within community development strategies serves a number of important purposes:

- Systems can be designed for flexibility and resilience (for instance, in terms of siting, sizing and possible future expansion).
- Systems can be optimised in respect of locally available resources (e.g. tapping solar radiation, location of wind turbines, minimising impacts to flora and fauna).
- Consideration of energy efficiency ahead of over-sized supply systems. This generally supports improved outcomes (e.g. better comfort, more environmentally benign, reduced use of materials, better cost-effectiveness) and strengthens local independence.
- It can stimulate and support livelihoods innovation—for instance new business opportunities (including the energy technology service industry) or management of locally-produced food and exploitation of local water resources.
- Allows for a range of livelihood opportunities and options to be discussed and helps with prioritisation.
- It encourages an integrated life-cycle cost benefit analysis of alternative energy choices, and helps the community avoid subscribing to energy services that it may not be able to sustain.
- The community is enabled to participate fully in energy autonomy decisions, including identifying capacity needs and business potential.
- A sense of community ownership and collective responsibility is created, which can help prevent damage to or theft of equipment and subsequent loss of services.
- It provides an up-front opportunity to discuss the relative merits of energy solutions.

Early intervention and consultation may also assist in achieving additional representative gender balance in community services decisions—with better outcomes for women.

CASE STUDY

Light and Life in the Bush

There are over 1,200 remote indigenous communities throughout Australia, many of which are not connected to electricity grids. Now more than 2,000 of these people access reliable energy services from Bushlight renewable energy systems.

Bushlight is an initiative of the Australian Government. It aims to support life and livelihood opportunities for remote indigenous communities in the north and west of Australia. Since 2001, Bushlight has focused on establishing and supporting sustainable, affordable, consistent and reliable renewable energy services. This is a tremendous challenge, given the remote and harsh outback environment and limited technical and financial capacity of many aboriginal communities. Implicitly, the services delivered are broadly comparable to those that most urban Australian families would expect: light, refrigeration, building cooling, and recreational devices such as music facilities, TV and a video/DVD player.

A focus on sustainable livelihoods is the basis for Bushlight's engagement with the communities. Before any technical systems are proposed, the Bushlight team holds discussions with the community—as a group and individually as appropriate, to ensure that everyone—men and women, the elderly and children—have input. This process helps to identify personal and group aspirations, and highlights existing strengths and weaknesses in the community. It also serves to identify how renewable energy technologies might complement existing energy choices to support better services to help achieve those aspirations.

The energy planning process involves the entire community, to give an understanding of how energy is used for lighting, refrigeration, cooking and other services. Renewable energy electricity systems may also be supported by solar water heating systems, solar PV pumps, and separate communications systems. Families agree to a household energy budget; this is used as the basis for appropriate system sizing. The community involvement also extends to budget planning and establishing agreements for future system service and maintenance, and battery replacements. These service costs are typically financed from savings in diesel purchases which the RE systems displace.

Training is provided to communities post-installation to enable them to use the new systems most effectively and to be able to undertake simple preventive maintenance measures. The training has improved self reliance and enabled most operational issues to be resolved locally and without the need for expensive external assistance.

Hardware development has also been fundamental to the project. Systems are designed to withstand extremes of temperature as well as the ravages of insects, tropical rainstorms and, in some areas, cyclones. Typically individual household systems are designed to deliver 3 to 12 kWh of electricity per day.

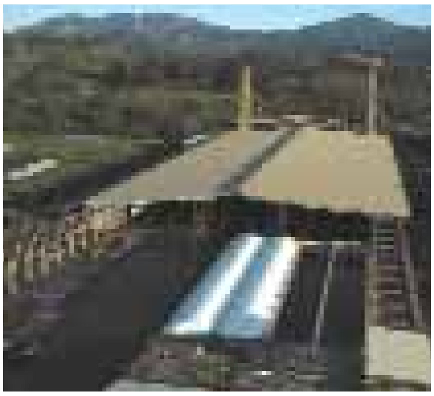
Bigger community systems may be installed in a mini-grid arrangement to serve a number of households and other community buildings. The systems also incorporate intuitive controls and energy management features to help users monitor their energy use, and if necessary force disconnect of non-essential circuits until batteries are recharged or a backup generator is switched on. Analysis of faults and outages over 2005-06, revealed that energy services installed by Bushlight operated with 99.9% availability at both community and individual house levels.

Aside from significantly reducing expenditure on diesel—average annual savings are AUD$8,000 for each participating community—the systems effectively deliver electricity 24 hours per day, whereas previously diesel generators would typically have operated for only 4 to 8 hours per day. This 24 hour availability makes refrigeration possible, which supports better nutrition and health. It also delivers more comfortable homes as cooling fans can be operated during the night.

The systems also result in annual abatement of more than 3,000 tonnes per annum of carbon dioxide emissions per community.

Web: www.bushlight.org.au

Technology considerations



Quality and safety aspects

The quality of energy services should also be a strong consideration when looking for solutions. Lighting decisions are prime examples, with electrical options offering many advantages over conventional flame-based technologies, most notably in respect of light quality, ease of use and output, which may in turn support a whole new array of activities (e.g. needlework, precision metalwork and/or better quality light for reading and homework).

Safety benefits—such as avoidance of noxious emissions and reduced fire risk—should also be compared, as well as availability, efficiency and quality of light. However, choices are not necessarily straightforward. Compact fluorescent lamps or light emitting diode (LED) options have better efficiency and lifetimes than incandescent globes and hence better lifecycle costs, but may not be as readily available or affordable.

Similarly cooking options present an array of considerations. Solar cookers would appear to be an ideal solution—they have no running costs, need no maintenance, have no apparent health risks and even offer prospects for local manufacture. But is the solar resource adequate? Does the timing suit users' other activities? Which solar cooker is best suited to different meal preparation requirements? Would an improved cookstove design be more appropriate?

For instance, in India, there are millions of solar cookers in use across the country. Most of these are the box cooker type, which suit slow cooked rice and vegetables in particular. They are prepared, put in the cooker, and left to slowly cook in the sun whilst the family is away from the home. Upon return, the food is usually ready to consume. However, this type of cooker would not work as efficiently in regions of low daily sun or different meal types.

Quality hardware

The selection of hardware naturally has a bearing on the long-term viability and sustainability of energy services, though these need to be considered in relation to other technical and non-technical factors (as discussed in following sections).

A focus on product quality may reap long-term benefits in relation to reliability of service, reduced maintenance requirements, replacement parts and other life-cycle cost parameters far beyond the initial cost difference. It is also important to ascertain if there are required national and/or international standards applicable for the hardware, in order to assess its durability and past performance. Where possible, hardware should conform to quality standards for performance and safety. For instance, solar PV modules need to be qualified by the International Electrotechnical Commission; many other solar system components are covered by 'PVGAP' (Photovoltaics Global Approval Program) standards.[27]

Another important consideration is whether components are capable of performing as specified in the particular local environment (e.g. aggressive maritime environments, extreme hot, cold or humid climates, dusty environments, vermin and insect infested environments, and during transport, withstand shock and vibration). Reputation in similar environments is a strong indicator in this respect.

CASE STUDY

Solar energy supporting communities in the Philippines

The Municipal Solar Infrastructure Project (MSIP), completed in mid-2001, adopted solar PV as the enabling technology to introduce improvements to the quality of life (notably better health services and water supplies, and improved opportunities for education), for the inhabitants of over 400 remote villages in the Visaya and Mindanao regions of the Philippines. Solar PV was identified as a lower cost, long-term alternative to extending power lines or regularly supplying fuel for diesel generators. BP Solar undertook the project design and managed its implementation on behalf of the Philippines Department of the Interior and Local Government, with funding from the Australian Government (EFIC and AusAID).

Many of the communities had never received or paid for such community services before, which meant that extensive social preparation and capacity building were crucial components of the project. This included initial introduction to and discussion of the project with local leaders as a precursor to needs assessments at the individual community level. The project team trained a number of community development officers from amongst the communities to assist with consultations in local dialects, to discuss and explain the anticipated outcomes.

Community participation was important for building ownership and responsibility for the ongoing long-term operation and maintenance of the energy service, including collection of fees where appropriate. Sustainability of the technical operations was supported by extensive training of local technicians and the provision of replacement parts. Barangay Technical Teams (BTTs), comprising two local technicians, were established in each village. These usually had at least a small amount of electrical experience, and were trained to ensure modules were washed correctly, to check electrolyte levels in batteries, and so on. Further technical training was provided for operatives and engineers in the main towns to allow for more complex repairs.

The project delivered fundamental improvements to the quality of life for a million plus people, through services such as vaccine refrigeration for district hospitals and rural health centres, community water supply, televisions, videos and ceiling fans for village halls and schools, and communal area lighting for markets and fishing wharves. Women particularly benefited through significant reduction of the time and effort required to collect water, allowing greater opportunity for education.

At the same time, some important lessons were learned from the project that are helping to further improve the potential for success of similar initiatives in future. In particular the next generation of projects is expanding on the community benefits model and including stronger emphasis on communal income generation and poverty alleviation aspects.

Source: *Developing Countries and Technology Cooperation: an industrial capacity-building perspective*, UNIDO & WBCSD, 2002

An important part of ensuring service continuity will be access to spare and replacement parts in the event of hardware failure. Local inventory may be held for many small items. For major components, there may be a need to source replacements from major urban centres or international suppliers. A strategy to address these needs, including anticipated replacement regimes for critical items such as batteries, inverters and pumps should be part of the sustainable service approach. As it is more efficient and cost-effective if internationally accepted measures are adopted where appropriate, World Bank staff are encouraged to inform partner countries undertaking PV projects that procurement specifications for procuring PV components, products or systems for use in Bank-assisted projects should conform with[28]:

- Global Approval Program for PV (PV-GAP);
- relevant international consensus standards issued by the IEC, ISO or similar standards of standards development organisations with international standing;

- PVRS specifications issued by PV GAP when international consensus standards are not available;
- a Conformity Assessment Certificate (CAC) issued by IECEE-PV[29]; or, in the absence of the above,
- the appropriate national-level Standards or project-level procurement specification as deemed appropriate by the responsible local authorities.

Local Training

Systems comprising excellent components can and do fail if they are not appropriate for the application (for instance, if they are undersized or not rated for the environment), if they are poorly installed (e.g. in the wrong location, under trees, with loose cabling connections, inadequate ventilation) or if recommended maintenance procedures are shortened or skipped.

Technician training may require technical assistance input from equipment suppliers and/or qualified trainers. Many rural technicians may benefit from simple business management training (e.g. record keeping, book keeping and stock control).

At the same time, users have a significant influence on the performance and reliability of energy systems, so pre-installation consultations with those who will use and benefit from the system is important to ensure that systems are designed to meet expectations or that expectations can be managed to match the system capabilities. Likewise post-installation user training is critical to reinforce how the system should be used, and to cover preventative maintenance requirements and safe system operation.

Financing

Multilateral, bilateral, and other public financing for new renewables in developing countries have reached almost $500 million per year in recent years. A significant portion of these funds support training, policy development, market facilitation, technical assistance, and other non-investment needs. The three largest sources of funds have been the German Development Finance Group (KfW), the World Bank Group, and the Global Environment Facility (GEF). KfW approved about US$180 million for renewables in 2004. The World Bank Group committed an average of US$110 million per year to new renewables during the three-year period 2002–2004 (and another US$170 million per year for large hydropower). The GEF allocated an average of US$100 million each year from 2002 to 2004 to co-finance renewable energy projects implemented by the World Bank, United Nations Development Programme (UNDP), United Nations Environment Program (UNEP), and several other agencies. Indirect or associated private-sector financing can be several times greater than the direct finance from these agencies[30].

Other sources of public financing include bilateral assistance agencies, United Nations agencies, and the contributions of recipient country governments to development assistance projects. Several agencies and governments are providing aid for new renewables in the range of $5–25 million per year, including the Asian Development Bank, the European Bank for Reconstruction and Development, the Inter-American Development Bank

(ADB). Other donors contributing technical assistance and financing on an annual basis include the UN Food and Agricultural Organisation (FAO), and government agencies from Australia, Canada, Netherlands, Switzerland, and United Kingdom.

From these programs, financing can be available to set up initiatives which reach right down to local level financing. For example, the Vietnam Women's Union and Grameen Shakti Bank[31] have accessed international funds and now their micro-credit structures support access at a local level to finance the purchase of Solar Home Systems and family hydropower systems.

As acknowledged elsewhere in this Guide, most renewable energy technologies (bioenergy generators may be the exception) have high initial capital costs and relatively low running costs—contrary to conventional technologies. However the cost of the renewable energy service may, over the life of the system, be more much affordable and/or more predictable than the conventional option (e.g. unpredictability being caused by volatile fuel prices and/or supply constraints). More importantly, the service provided by renewables is usually of better quality, and more reliable than the conventional systems.

For the many potential users who cannot afford to purchase a system outright, it may be possible to implement alternative financial models more appropriate to their income and use profiles.

CASE STUDY

Affordable energy services aid teacher retention in rural PNG

Less than 10% of Papua New Guinea's rural population has access to electricity. Most of the health and education facilities across the country have no provision for power supply at all. Primary schools typically do not have electricity or communications capabilities, and teachers posted to these schools and their families suffer from a lack of basic amenities. Isolation, lack of amenities and safety concerns are some of the reasons why teacher retention at remote primary schools is one of the biggest problems faced by the PNG Department of Education. The poor retention has a direct impact on education standards and outcomes for families throughout rural PNG.

Very few teachers have access to electricity from school generators or town supply. Most households have one or two kerosene hurricane lanterns; these cannot provide enough lighting for sustained school work, and pressure lanterns consume too much fuel for frequent or extended use.

The World Bank / GEF Teachers' Solar Lighting Project commenced mid 2000, to try and overcome the problems of teacher retention and the associated poor educational outcomes by improving access to modern energy services. Credit obtainable through salary deductions or other means helps smooth household cash flows and facilitates occasional large expenditures. Working with the PNG Teachers Savings and Loan Society, the project provides financial risk guarantees which enable the society to offer five year fixed-rate loans for solar home lighting kits to teachers and other government employees.

Teachers' salaries generally do not allow for much disposable income. Monthly expenditure on kerosene can vary from 30 to over 100 Kina against typical monthly salaries of 600 to 800 Kina. Expenditure on kerosene will be displaced by the solar lighting systems and will be sufficient to cover the monthly repayment on the new kits.

The initial project design planned for 3,000 solar home kits to be disseminated over five years. However, interest in the pilot scheme has been exceptional with 7,000 applications received in the first three months since it was publicised. The long-term objective is to create a revolving fund that can finance further customers, with the expectation that eventually the scheme will be extended to the general public.

Note that, as well as addressing the financial barriers that deter teachers and others from investing in the solar lighting kits, the project is also working to resolve awareness and perception issues through an information campaign and to ensure system reliability through appropriate system standards and use of quality-approved products.

Web: www.gefweb.org/Documents/Medium-Sized_Project_Proposals/MSP_Proposals/Papua_New_Guinea_-_Teachers_Solar_Lighting.pdf

Savings arrangements may be appropriate for relatively small-scale purchases. However, they may not be practical for technologies that would require savings to be deposited over many years and which are of a community rather than an individual nature.

Often displacing part of current energy expenditure (e.g. as might be incurred for kerosene, diesel, candles, batteries or wood) creates a financial capacity to repay a credit arrangement, loan or service fee. Energy service arrangements such as rural energy service companies (RESCOs), where business takes on the role of providing energy services in much the same way as utility companies provide such services in many urban locations, are emerging as a particularly attractive solution where there is an adequate customer base. Rather than users owning the generation equipment, the energy service company owns the energy systems (although these may still be installed at the customer's premises) and sells energy or energy services to the customer. This tends to make procuring modern energy services more affordable for customers as the RESCO takes a longer term view on recuperating its investment than is typical of a bank or equipment dealer, so service fees may be lower than repayment on a credit facility. This also tends to ensure that training; maintenance and servicing are undertaken as required as the RESCO has a strong interest in ensuring systems continue to deliver the contracted energy services in order to continue to collect service fees.

Technology costs

Renewable energy technologies increase diversity of energy supplies and can replace diminishing fossil fuel resources over the long run. In the case of a disaster situation they can provide power where traditional fuels are no longer available. In the longer term, replacing fossil fuels substantially reduces emissions of greenhouse gases and other pollutants, and thus has a positive effect upon the local economy in many ways.

In a response to the Group of Eight (G8) leaders at their Gleneagles Summit in July 2005, and to the International Energy Agency's (IEA) Energy Ministers who met two months earlier, the IEA developed alternative scenarios and strategies aimed at a clean, clever and competitive energy future. They believe that secure, reliable and affordable energy supplies are fundamental to economic stability and development. Alongside this, the threat of disruptive climate change, the erosion of energy security and the growing energy needs of the developing world all pose major challenges for energy decision makers. The IEA says that these can only be met through innovation, the adoption of new cost-effective technologies, and a better use of existing energy-efficient technologies. Their report, *Energy Technology Perspectives*[32], presents the status and prospects for key energy technologies and assesses their potential to make a difference by 2050. It also includes cost scenarios.

There are many situations in which renewable energy technologies are already cost-effective. For instance, where an adequate resource is available solar PV for lighting and portable telecommunications in disaster relief situations; wind farms and hydro-power for providing power in reconstruction phases; and solar cooking in refugee camps are already cost-competitive.

Table 7 and Figure 1 show the costs and trends globally for renewable energy technologies. As with any technology adoption curve, the trends are downward for costs as installations and experience increases. The European Commission's Renewable Energy Roadmap, released in January 2007, says: "Solar photovoltaic systems today are more than 60% cheaper than they were in 1990" with "PV costs… expected to fall by an additional 50% by 2020."[33]

Table 7: Global Renewable Energy Costs and Trends

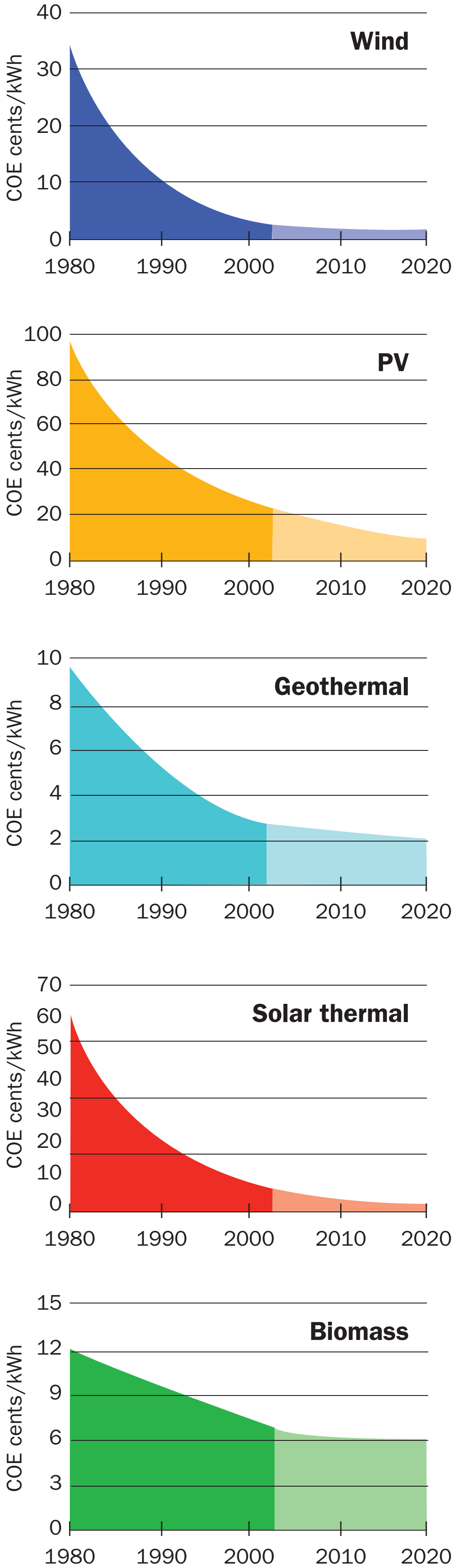
Technology[a]	Typical costs of energy (US cents/kWh)	Cost trends	Applicability to Disaster Relief Operations
Power Generation			
Large hydro	3–4	Stable	Reconstruction and development
Small hydro	4–7	Stable	
On-shore wind	4–6	Declining by 12–18% with each doubling of global installed capacity	
Off-shore wind	6–10	Market still small	
Biomass power	5–12	Stable	
Geothermal power	4–7	Declining modestly since 1970s	
Solar PV (module)	—	Declining 20% for each doubling of installed capacity	Applications in all phases
Rooftop solar PV	20–40	Declining due to lower solar PV module and balance of system costs	
Solar thermal power	12–18	Declining from 45 cents per kWh for the first plants in the 1980s	
Hot water / Heating			
Biomass heat	1–6	Stable	Reconstruction and development
Solar hot water heating	2–25	Modestly declining due to scale, materials, quality	
Geothermal heat	0.5–5	Declining modestly since 1970s	
Biofuels[b]			
Ethanol	25–50 c/litre	Declining in Brazil (sugar) but stable in USA (corn)	
Bioediesel	40–60 c/litre	Expected to decline to 35–70 cents/litre post 2010 (canola and soy); stable for waste oil at 25 c/litre	
Rural (off-grid) energy			
Mini-hydro	5–10	Costs generally stable to moderately declining. Will decline more as improvements in technology, scale and delivery infrastructures develop.	Reconstruction and development
Micro-hydro	7–10		
Pico-hydro	20–40		
Biogas digester	—		
Biomass gasifier	8–10		
Small wind turbine	15–30		Stabilisation
Household wind turbine	20–40		Stabilisation
Village-scale mini-grid	25–100		Reconstruction and development
Solar Home System	40–60		Stabilisation

a: Proven and installed over some years
b: Costs for ethanol and biodiesel are in US cents per litre diesel—or petrol—equivalent, corrected for the lower energy content per litre compared to conventional fuel (about 6–8% for ethanol and 87–95% for biofuels)

Source: *Renewables 2005 Global Status Report*, REN21, Washington DC

Figure 1: Renewable Energy Cost Trends

Levelized cents/kWh in constant $2000[1]



NOTES

Background

- The Cost Curves are expressed in constant, 2000 year dollars and based on a uniform set of financial assumptions consistent with Generating Company Ownership (balance-sheet financing).
- Actual project costs can vary substantially—not only over time, but from project to project—based on variables such as siting and permitting costs, land costs, transmission access, labor costs, and financing terms.
- The Cost Curves are not based on specific project data, but are composite representations derived from a variety of sources outlined below.
- Historic costs from 1980 to 1995 generally reflect costs that were published in various DOE Renewable Energy Program plans such as five-year program plans, annual budgets, and other program publications.
- The Future Cost Curves generally reflect how the DOE Renewable Energy Programs expect the costs of renewable energy to decrease through lowered technology costs and improved performances, resulting from R&D efforts and other factors.
- Projections of cost to 2020 for biomass, geothermal, and photovoltaic energy technologies are based on the DOE/EPRI Renewable Energy Technology Characterizations published in 1997. Wind and solar thermal costs represent more recent DOE Renewable Energy Program projections.
- The Cost Curves generally assume the availability of high-quality resources. This is an important point because systems using lower quality resources are being built, in some cases with costs as much as double those shown.
- The Cost Curves do not include the effects of tax credits or production tax incentives.

General Observations

- The renewable technology cost trends typically show a steep decline from 1980 to the present. Projections show this decline to continue, but at a slower absolute pace as the technologies mature.
- Historic cost of energy trends reflected in this chart are in broad agreement with the trends published in "Winner, Loser, or Innocent Victim? Has Renewable Energy Performed as Expected?" Renewable Energy Policy Project, Report No. 7, April 1999.

Technology Specific Notes

- Wind technology cost projections represent wind power systems in locations with Class 6 resources. Low wind-speed turbine technology is under development, which will make available large amounts of usable wind resources that are closer to transmission. Lower costs will result from design and technology improvements across the spectrum from foundations and towers, to turbine blades, hubs, generators, and electronics.
- Biomass cost projections are based on gasification technology. Lower costs will result from technology improvements indicated by current pilot plant operations and evaluation, including improvements in feedstock handling, gas processing/cleanup, and overall plant design optimization.
- Geothermal cost projections are for Flash technology. Cost reductions will result from more efficient and productive resource exploration and characterization as well as from continued

continued over page

Source: NREL Energy Analysis Office (www.nrel.gov/analysis/docs/cost_curves_2002.ppt)

1. These graphs are reflections of historical cost trends NOT precise annual historical data. Updated: October 2002

Figure 1: Renewable Energy Cost Trends

NOTES Continued

improvements in heat exchangers, fluid-handling technologies, turbines, and generators.

- Solar thermal cost projections are for Parabolic Trough and Power Tower Technologies and are based on a detailed due-diligence study completed in 2002 at the request of DOE. Cost reductions will result from improved reflectors and lower-cost heliostat designs, improved solar thermal receivers, heat exchangers and fluid handling technologies, and turbines and generators, as well as from volume manufacturing.
- Photovoltaic cost projections are based on increasing penetration of thin-film technology into the building sector. Likely technology improvements include higher efficiencies, increased reliability (which can reduce module prices), improved manufacturing processes, and lower balance of system costs through technology improvements and volume sales.

Not all applications appropriate for disaster relief and reconstruction applications are covered in this Table: for instance remote telecommunication systems powered with solar PV are considered to be cost-effective with fossil fuel power sources in remote areas globally; however, due to external considerations (such as distance from supply site, topography etc) it is not possible to estimate a global price. Suffice to say, there is a downward price trend for all renewables.

Boosting investment, in particular in energy efficiency and renewable energy should create jobs, promoting innovation and the knowledge-based economy in the EU. The European Union has a turnover of €20 billion and employs 300,000 people in the renewable energy sector.[34]

In Australia, the clean energy industry accounts for:

- $5.7 billion in annual sales;
- over $400 million in exports;
- direct employment of over 20,000 people;
- 22 % of electricity generation and 36,000 GWh of displaced power (equivalent to 15 per cent of current electricity generation); and
- avoided greenhouse emissions of 88 million tonnes (equivalent to 44 per cent of total electricity emissions).

In contrast to conventional energy sources, there has been a continued and significant reduction in the cost for renewables over the last 20 years. As an example, the cost of wind energy per kWh has fallen by 50% over the last 15 years while at the same time the size of the turbines has increased by a factor of 10. Solar photovoltaic systems today are more than 60% cheaper than they were in 1990.

Despite this, the cost of renewable energies varies significantly according to the resource base and the technologies concerned, but generally still exceeds that of conventional energy sources at present.

Chapter 6 Conclusions

The effects of climate change will continue to exacerbate the natural and human-induced disasters with which the world has to cope. Floods, fires, earthquakes, hurricanes will continue to ravage the land in increasing scale. Water levels will rise, contaminating drinking water and changing agricultural profiles. Human migration will increase due to civil unrest and land-bearing capacities; indeed Christian Aid in its report, *Human Trade: the real migration crises* (May 2007), predicts that, on current trends, a further 1 billion people will be forced from their homes between now and 2050.

Although the majority of emergency relief appears to be focused on less developed countries, developed countries are not immune to the effects of disasters; earthquakes, hurricanes and other extreme weather events, as well as terrorist actions can have a dramatic impact on even the most ‘advanced’ economies.

For the affected populations, relief requirements in the immediate aftermath of such disasters include provision of food, shelter/clothing, medical aid, lighting and safe drinking water. Sanitation quickly also becomes critical. For relief organisations, effective communications are essential for coordinating the response between field staff and headquarters and inter-agencies, for ensuring security, and for helping to reunite displaced families.

In these situations, reliable, rapidly deployable energy services can significantly aid the relief effort, for instance providing emergency light, pumping and water purification, and establishing critical power supplies for medical facilities and communications centres. Solar photovoltaics (electricity from sunlight, or ‘PV’) and other renewable energy sources, such as small wind turbine generators can be quickly deployed to provide such essential energy services. Diesel generators can be a viable alternative, provided fuel supplies can be maintained. However, infrastructure damage makes refuelling generators a challenge, as fuel pumping (“service”) stations are often inoperable and roads impassable. Power distribution lines are difficult to fix because of the impassable roads, much less transporting materials for reconstruction. When a disaster strikes an island and the port is destroyed, unloading fuel (for generators and transport) becomes a problem.

For medium-term rehabilitation, ensuring continuous access to healthcare services, safe water, nutrition and sanitation remain fundamental priorities; in the longer term, development may look more broadly towards establishing or improving educational opportunities, enabling local productivity (e.g. of tradable goods) and supporting general lifestyle improvements.

In both applying mitigating scenarios as well as providing sustainable energy solutions for the future, renewable energy and energy efficiency technologies and applications have a major role to play around the world. Many technologies are modular and can be moved from place to place, disaster to disaster (e.g. portable lighting systems, solar cookers and solar purifiers). All can involve local communities in their decision process, and all mitigate climate change to a larger or smaller degree due to the reduced contribution to global warming.

Australia has a long-established, world leading competence in renewable energy services for remote area applications. The harshness of (much of) the Australian environment, coupled with the frequent large distances between the installation and service or maintenance teams have required Australian energy service firms to develop highly robust and reliable systems, components and design/specification services to minimise costly outages. These are precisely the requirements for restoration and continued operation of critical services in many emergency and general development applications.

The examples and case studies given throughout the preceding chapters highlight the wide variety of opportunities to use renewable energy technologies in a plethora of applications—right from immediate response, through stabilisation to reconstruction and redevelopment.

Renewable energy applications provide solutions to power and heat needs around the world. However, there is no one solution that fits all situations. Rather, there are a range of solutions which will be appropriate for any given site or situation. It is hoped that the information given in this publication will enlighten the reader as to the possibilities and the positive outcomes from using renewable energy technologies where practical.

Annex 1

Energy in focus – Renewable Energy Technologies

Technology considerations

The term 'renewable energy' refers to all energy resources that do not have finite reserves; this effectively includes any energy source which is not extracted from deposits in the earth. Non-renewable energy sources derived from ancient organic-matter deposits are broadly referred to as 'fossil-fuels'. Uranium and other radioactive deposits which may be 'split' (i.e. are fissile) in fission reactors to release nuclear energy are also broadly non-renewable sources.

Aside from the limited reserves of non-renewable energy sources, fossil-fuel consumption is also directly linked to climate change due to the associated atmospheric emission of carbon dioxide and other greenhouse gases.[35]

Fossil fuels have become highly-valued in the modern industrial era because of their convenience as concentrated energy stores that can be 'unlocked' on demand through controlled burning either as open flames for heat or light or in internal combustion engines for mechanical power. This 'convenience' does require extensive and expensive supply networks that have been created over many decades to extract, process and distribute these resources.

One of the principal attractions of renewable energy sources is that at least one of the resources is usually available locally, giving renewable energy users a degree of autonomy from, and resilience to, changes in the fossil fuel supply structures and prices.

Renewable energy technologies

Renewable energy technologies cover a very broad range of devices that harness the energy of natural resources such as the sun, wind, waves, tides, river flow, geothermal and certain crops, and convert these to a more directly manageable and useful form. This chapter presents an overview of the principal commercially available technologies, highlights some of their potential applications as well as their limitations and other considerations.

Solar technologies

Solar technologies broadly fall into two categories: those that generate electricity and those that output heat.

ELECTRICITY GENERATION

Solar Photovoltaic Systems

The principal solar energy generation technology available today is photovoltaic (PV). PV devices consist of photo-electric cells which generate an electric current when exposed to light. A number of the cells are electrically connected within a PV module to deliver power at a useful current and voltage (typically for charging a 12V or 24V battery). The interconnected cells are laminated between a form of plastic sheeting and normally further sealed between a glass front and metal, plastic or glass back cover to provide further protection against the elements and other mechanical damage. Often these basic glazed modules are given additional mechanical strength and edge protection by enclosing them in a metal frame which typically also allows for easier mounting. A junction box with electrical connection points is provided to allow these modules to be connected to electrical loads.

Modules can be interconnected in series and parallel, in much the same way as we might string together dry cell batteries, to increase current and/or voltage and power output as required. A single small module may produce a few watts, while a large array of modules may produce many kW, still larger systems may produce MW or conceivably GW, although such very large-scale systems have not as yet been implemented.

Electrical output is of direct current (DC) form which can be directly used to recharge batteries or to power a range of DC appliances such as lights, radios and TVs. Solar cells are directly integrated into a number of low-power devices such as calculators, torches and small transistor radios and provide very reliable and very cost-effective power compared to dry-cell batteries. A variety of more specialist DC appliances are also compatible with solar PV and other DC outputs, notably some high efficiency pumps and refrigerators. Many other common AC appliances can be powered by solar PV by including a DC to AC inverter in the system. Inverters for off-grid systems are different to those for grid-interactive applications, but prices are comparable for similar power inputs and outputs.

PV systems can be 'stand-alone'—i.e. not connected to any electricity grid, whereby the electricity generated is either used directly (for instance, by a water pump), or stored for later use in batteries.

Grid-connected systems put electricity into the grid as it is generated (where there is an excess after the building's demand is taken out). At nighttime or when demand is greater than supply electricity is drawn from the grid as required to supply the building.

PV modules require little maintenance other than occasional cleaning. A stand-alone system requires routine battery maintenance . Quality products are supported by robust warranties (in many cases up to 25 years), while low quality, cheap products may have only a very short or no warranty. As stated previously, there are a number of Australian and international Standards and protocols which relate to PV system components and systems, and it is advisable to procure components and systems with such certifications.

PV modules do not just generate electricity in direct sun. Electricity is generated on overcast days from diffuse sunlight. However, output is proportional to the strength of the sunlight falling on the cells so more electricity will be generated in peak sun than on dull days and at noon compared to early morning or late evening. Shading even a small part of a module should be avoided, as this can significantly affect the whole system output (depending on module type and inter-module connections). At the same time, modules actually perform better when cool, so mounting arrangements should allow for modules to be adequately ventilated.[36]

Concentrating PV Systems

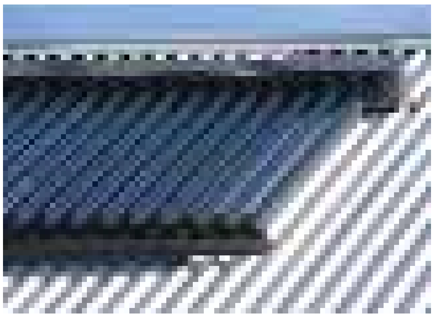
Solar PV concentrators fundamentally use the same conversion principle as conventional (flat-plate) solar PV modules described above. Sunlight is converted directly to electricity via a photo-reactive cell. The primary difference however, is that sunlight is concentrated via a parabolic dish or an array of suitably oriented mirrors or via a suitable lens onto a relatively small area, high efficiency receiver cell located at the focal point. To achieve this, concentrator systems constantly ‘track’ and move with the sun as it crosses the sky.

The solar concentration at the focus is typically equivalent to 500 suns. In other words, the sunlight reaching the active cell of a concentrator system is 500 times more intense than that typically received by flat-plate modules.

The minimum scale of commercially available concentrating PV units is currently around 20 to 40 kW, although typical configurations involve a number of such units.

Solar Concentrating Systems

Concentrating solar power systems use concentrated solar radiation as a high temperature energy source to produce electrical power or drive chemical reactions. These clean energy technologies are appropriate for Sunbelt applications where direct solar radiation is high. The first commercial plants have been in operation in California since the mid-1980s, providing 354 megawatts of the world’s lowest-cost solar power at that time. The many types of systems under development (including parabolic dishes and troughs, power towers, and dish/engine systems) for different markets vary according to the concentration devices, energy conversion methods, storage options and other design variables. Much attention is focused on the multi-megawatt systems that are appropriate for the on-grid market, complementing flat plate photovoltaics. Large advances have been made in recent times in solar PV for concentrating systems. Solar chemical energy systems use concentrated solar radiation to drive chemical reactions for the production of fuels and chemicals. Additional uses include environmentally benign technologies in fields such as detoxification of chemical wastes and energy storage which are aimed at the medium to long term.[37]



HEAT GENERATION AND MANAGEMENT

Solar water heating

In the disaster relief and development context, hot water supports sanitation at both the primary health-care level and also for more effective medical services. Particularly in cooler climates, warm showers and warm water supply can encourage personal hygiene which can directly help to combat diseases such as dysentery, scabies and worms. In the field hospital or clinic, hot water is critical for effective medical staff scrubs, patient and equipment cleaning to reduce possibilities for cross-infection.

At its simplest, a solar water heater (SWH) is a black container that is placed in direct sunlight to absorb solar radiation and transfer the heat directly to the water inside. This is the principle behind the black PVC bags that have become popular as camping showers. More commonly, and to achieve higher water temperatures, the heat absorber is placed within an insulated frame and generally behind a glass sheet to reduce convection and conduction heat losses.

In these flat plate collectors, water passes through channels within the absorber, gaining temperature as it does so. The hot water is stored in an insulated tank for use as required.

The collector and storage tank are generally made of a robust material such as metal (e.g. copper collector and enamelled steel tank) or plastic.

Evacuated tube collectors have their heat absorbing fin shrouded by a vacuum-tube (similar to a thermos flask), which reduces convective and conductive heat losses. Water flows through the collector and is stored in a suitable tank for use on demand.

Evacuated tubes are generally more efficient and can produce higher temperatures than flat plate collectors, though they also require more careful handling during transportation and installation as the evacuated tubes are typically made of glass.

A hot water system that combines a heat pump with a fine coil evaporator is described as a solar heat pump water heater. The system works on the principle of a refrigeration circuit, drawing heat out of one space and discharging it into another. In operation, the evaporator absorbs whatever heat energy is available to it from the atmosphere (air) to vaporise the refrigerant. The vapour is then compressed raising its pressure and temperature. This high temperature vapour is passed through special pipes permanently bonded around the outside of the insulated water storage tank, forming the condenser. As the refrigerant vapour condenses back to its liquid form, it gives off its heat to the stored water.

As this happens, the condensed refrigerant liquid passes back to the evaporator panels through an expansion device (TX Valve), is vaporised, and the cycle is then repeated.

Typical ‘close-coupled’ SWH (where the insulated storage tanks sits directly above the collector) allows natural convection currents to drive the water around the collector and tank. This removes the need for ancillary pumps in the heating circuit. Where collecters are above the insulated storage tank, a small PV module can be included to power a pump to circulate water around the system.

SWHs usually incorporate gas or electrical heating elements for 'boosting' the water temperature on dull days. Wet backs on wood stoves have been used for many decades to heat water. These can be used in conjunction with a solar heat collector.

The required collector area depends on the available solar resource and the daily volume and temperature of water required. In Australia, a typical family system is of the order of 2-4 square metres combined with a 200–600 litre insulated storage tank.[38]

Solar Cookers

There is a wide variety of solar cooking technologies available, though there are two main categories: the box and the concentrator. The cooker design dictates the temperatures that can be achieved and the rate of cooking.

Box cookers include a simple reflector arrangement that directs solar energy via a transparent cover into the inside of an insulated box. Food (or water) is placed in a black pot within the oven. The pot absorbs solar radiation and transfers the heat to the contents. Box ovens are not particularly rapid, however they are simple, robust and can be very effective for relatively slow cooking for midday and early evening meals. They generally require very little intervention, so that users can undertake other activities while meals are cooking, with little risk of food spoiling.

In the concentrator arrangement, typically the pot or kettle is suspended at the focal point of a reflective dish. The dish is oriented towards the sun, with the sun's rays focussed onto the food container. Some concentrators can achieve very high temperatures and may be suitable for rapid cooking, including frying. However, this also means they have the potential to cause burns and they generally require quite frequent intervention to keep the suns rays focused on the cooking vessel and to prevent food from burning. They also tend to be more affected by intermittent clouds than are box cookers.

Solar cookers can be very affordable, and many designs can be constructed at home from materials such as cardboard boxes and aluminium foil. Several commercial lightweight folding designs exist that allow easy transportation and rapid construction in the field.[39]

Solar cookers are usually for individual families, though there are many community-sized systems in operation, particularly in India.[40]

Solar Dryers

Solar dryers provide a very attractive, practical and simple method of accelerating drying to preserve fruit, vegetables, grains and other foodstuffs. This can be a real benefit for communities that have traditionally used open air methods and regularly suffer substantial post-harvest losses of food.

The dryers typically consist of a drying chamber coupled to a solar air heater (an absorber somewhat similar to a solar water heater collector). Warm air passes from the absorber through the chamber either by natural ventilation or aided by fans, extracting moisture before being vented to the outside. Forced (i.e. fan-assisted) ventilation arrangements increase the system complexity but can significantly reduce the drying time (by 50% or more) compared to naturally-vented methods.[41]

Solar Stills

For relatively small-scale distillation of contaminated water, including from brackish or chemically polluted sources, a solar still can be a very effective, simple solution.

Solar stills can be designed to have no moving parts. Water is simply held in a shallow container and caused to evaporate by solar radiation heating an absorber surface (a wicking pad in some designs). The vapour condenses on the underside of a tilted glass cover and runs down to a gutter where it is collected as potable water.

Typical outputs are 2–3 litres per hour per square metre of still surface area. A still of 10 m^2 could therefore deliver sufficient potable water for a small family in a tropical climate.[42]

Wind energy systems

Wind can be used to generate electricity or to provide mechanical power, primarily for water pumping.

WIND ELECTRICITY GENERATION

Wind turbines capture energy contained within a mass of air flowing through an area swept by a number of blades connected to a rotating shaft. The rotor-shaft is connected to an electric generator, often through a gearbox.

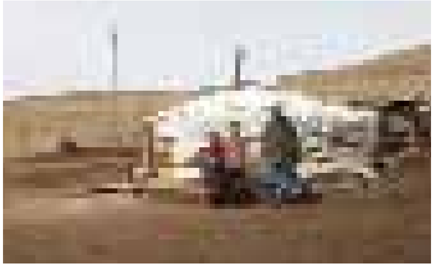
The amount of power available depends on the area swept by the blades and is proportional to the cube of the wind speed—i.e. as the wind speed doubles, power output will increase by a factor of eight. Turbines should therefore be sited away from or above natural or man-made obstacles (such as buildings and trees) which can significantly slow the available wind, and away from buildings, trees and bluff obstacles such as cliffs or sharp inclines that may introduce turbulence. Natural indicators (such as tree deformation) can signal promising wind regimes, although ideally it is preferable to monitor at the location and 'hub-height' of the proposed wind turbine over a sustained period (e.g. one year) to verify the potential generation regime.

Wind turbines come in a range of sizes from tens of watts to 5 MW and characteristically have 2 to 3 blades. They can be used to feed power to the electricity network, power isolated networks for community supply or small wind turbines can generate power for local or on-site use.

As wind is intermittent, some form of storage or back-up power supply is required to supply demand as required. Battery storage or diesel back-up generators can be used to maintain supply over low wind periods. Alternatively connecting the turbines to an electricity network with other generators can ensure continuous supply.

All wind turbines are best sited where there is minimal disturbance of wind flow to the turbine blades (disturbances, for instance from abrupt changes in terrain, buildings, trees etc.) to maximise energy generation and reduce wear of the components.[43]

Community wind power



Wind turbines are connected together in ‘farms’ to provide the required power output. Restrictions on the size of the wind farm can include: power demand, availability of space suitable for wind generation, and the capacity of the local electrical network to accept the power. In designing a wind farm, consideration must be given to the environmental impacts of the turbines, such as noise or impacts on flora and fauna. The turbine bases take up only a small proportion of land area and the land around the turbines remains suitable for agricultural purposes such as the grazing of livestock.

For large wind turbines electricity is generated between wind speeds of 4 m/s and 25 m/s (14-90 km/h). Maximum electricity is generated at around 11-16 m/s (40-58 km/h). Although turbines can tolerate much higher wind speeds, special attention to design tolerances and site conditions should be paid in areas that experience cyclones. Demountable turbines are available for cyclone areas.

During normal operation the wind farm will not require operator input, as the wind turbines will be monitored and controlled by a central computer system. Maintenance operators are required to be on-call to resolve non-routine issues and regular quarterly maintenance is required for the turbines. Turbines are designed for a 20 year life.

For a site with an annual mean wind speed of 7 m/s (25 km/hr) the energy output from a typical 1 MW turbine would be around 2.4 GWh/yr. The 1 MW turbine would have a rotor diameter (distance from the tip of one blade to the tip of another blade) of around 54 m and might have a hub height (height above ground to the centre of rotation of the blades) of around 50 m. As an approximation, around 10 MW of turbines can be installed for every square km of land.

Construction of large wind turbines requires construction expertise and equipment including cranes for the erection of the towers, blades and other equipment. Construction will take several months to a couple of years depending on the size of the wind farm.

Small wind turbine generators

Small wind turbines can be used for battery charging or to provide household electricity. Turbines smaller than 100 W are often used to charge 12V to 24V batteries for small stand-alone systems such as home lighting kits or for field monitoring equipment. Turbines from 0.6 kW to 50 kW are suitable for individual houses and businesses. The turbine units are generally mounted on a pole in the ground, however some rooftop models exist.

Small wind turbines start generating power at 2.5 to 4 m/s (9–14 km/h) and start to generate at full power at around 10–12 m/s (36–43 km/h). For a site with an annual mean wind speed of 5 m/s (18 km/h) the energy output from a typical 1 kW turbine would be around 2 MWh/yr.

Small wind turbines do not require much maintenance, but they should be sited with a view to access for maintenance at least yearly. They would be expected to have a lifetime of up to 20 years. Erection time is no more than a few days, with micro-turbines able to be installed in a few hours.[44]

MECHANICAL WIND SYSTEMS

Windmills for water pumping

Similar to electrical wind turbines, mechanical wind pumps (usually referred to as windmills) take advantage of air flowing through an area swept by a number of blades to drive a rotating shaft. The rotor head sits on top of a tower, typically 10 to 20 m above ground level. The rotational motion is normally converted via a gearbox to a reciprocating vertical motion to drive a mechanical piston pump. No additional power is required to operate the pump making the system very suitable for remote locations with no access to an electrical network or access to a limited supply of electrical power.

Unlike wind turbines, windmills have numerous blades to maximise the surface area in contact with the wind for maximum torque advantage. This is critical for achieving a reasonable starting performance when the drive system must overcome the weight of the water column and pump rods that must be lifted and frictional forces within the pump and pipe work.

Once the starting inertia has been overcome the windpump can generally continue to operate at slightly lower wind speeds and will generally perform in wind speeds of 4 to 13 m/s (14 to 50 km/hr). Most systems incorporate a self-furling mechanism, which turns the rotor away from the wind to prevent system damage when the wind speed approaches a predefined limit. As with wind turbine generators, the wind pump tower is best sited in areas where obstructions to the wind flow are minimised.

At a wind speed of 25 km/h, a cylinder pump lifting the water by 15 m can achieve a pumping rate of 32 litres per minute. 6 to 8 hours pumping would be expected on average per day at this rate. In the design of the system, it is recommended that storage facilities should be used to provide 3 to 4 days water demand to cover periods of low wind.

Wind powered pumping systems generally require little maintenance, however regular preventive maintenance, notably lubrication of gearboxes and bearings is essential. Annual checks of specific components are recommended. The lifetime of the wind pump can be over 20 years if routine maintenance is undertaken.

Wind pump systems are often constructed from steel sheet, angle-iron and other metal components, which lends the technology to local manufacture. They can generally be installed in a matter of days, assuming the borehole already exists.

Hydro

Hydropower schemes harness the energy that is contained within the flow of water within streams or rivers to generate electricity.

LARGE HYDROPOWER SYSTEMS (10 MW+)

'Large hydro' generally refers to schemes with a nominal power output of 10 MW or more, and typically requires construction of large dams and flooding of sizeable areas. These are major construction projects requiring specialist design, build and management capacity. There are also very few remaining unexploited locations suitable for large hydro internationally.[45]

SMALL-SCALE HYDRO (MW–kW)

The main components of a small-scale hydro (SSH) system are the turbine and the generator. Other components include the physical structures to direct and control the flow of water, mechanical and/or electronic controllers, and structures to house the associated equipment. Different types of turbines are available and the optimum choice depends strongly on the head and the water flow rate. Generally, a high head site will require smaller, less expensive turbines and equipment.[46]

More than half of the world's small hydropower capacity exists in China, where an ongoing boom in small hydro construction added nearly 4 GW of capacity in 2004. Other countries with active efforts include Australia, Canada, India, Nepal, and New Zealand.

Small hydro refers to schemes nominally below 10 MW capacity that can often be developed at existing river structures (e.g. flow control barrages) or by diverting a part of the river flow via a suitable channel onto the blades (or 'buckets') of a turbine or waterwheel.

There are various subcategories—and varying definitions of these—banded under the small hydro heading. For the purposes of this Guide the primary subcategories of interest are mini-hydro (nominally 100 kW to 1000 kW), micro-hydro (nominally 10 kW to 100 kW) and pico or 'family' hydro which nominally implies systems of up to 10 kW.

The main components of a typical small hydro system are a weir, a long large pipe (penstock) or water channel (typically between 50 m to 1 km long) and a turbine connected to an electrical generator. Often the hydro resource may be located some distance from the demand centre, requiring electricity to be transmitted from the generation 'power-house' to the town or village.

Output power for a given unit is proportional to the height difference between the water intake and the turbine (the "head"), and to the volume flow rate of the water that impacts on the turbine blades. As a result, hydropower schemes will generally increase in viability where a large volume of water flows (in which case a low-head turbine solution may be possible) and/or a relatively high head exists for the water flow (e.g. a hilly location).

The available head can be determined using standard topographical survey techniques, while short-term flow can be determined by measuring the stream width and average depth to determine cross-sectional area and by timing the progress of a suitable float over a known distance.

An attraction of hydropower solutions is that flow over the long-term tends to be quite predictable, although wide seasonal variations need to be acknowledged in any feasibility assessment, and droughts and upstream extraction can also affect power output.

Over the short-term flow rates are relatively constant and continuous so battery storage is often unnecessary. Where a suitable resource exists relatively close to the load centre, small hydro can be one of the most cost-effective electricity generation approaches. Overall viability will depend on a variety of other issues including the site accessibility and civil construction works, and system design will invariably require some advice from suppliers or consultants.

Land ownership can be an important consideration in hydro scheme planning. This covers water course ownership, land for civil works and power plants. Where generation occurs many kilometres from the users, it will be necessary to involve all affected land owners along the transmission line route from the river to the local delivery point.

Mini and micro hydro systems can often satisfy the electricity needs of a whole village or town, providing reliable low-cost power 24 hours a day. Unlike many other small-scale renewable technologies however, it is generally not easy to increase the generation capacity of mini- and micro-hydro schemes, so careful demand analysis is needed at the planning stage.[47]

FAMILY HYDROPOWER (PICO HYDRO)

Very small-scale hydro-power systems can be used to provide electricity for a house, a mill or a collection of few houses.

The construction of pico-scale schemes can be very simple; indeed several hundred thousand families in Asia have installed their own systems close to their homes. Typically these comprise brushless permanent magnet alternators attached to a propeller turbine.

Construction requires a small dam and water diversion onto the propeller head. Cheap turbine-generator units often do not incorporate any power conditioning or regulation and are often installed so as to be easily removable from the stream when not needed. The lack of regulation does have some disadvantages in that sensitive electronic equipment can be damaged by such fluctuations. However, electronic load controllers can be included to provide stable voltages to overcome this.[48]

Bioenergy

Energy is bound into all forms of organic matter, including trees, crops and other plant matter, as well as organic wastes such as animal manure and human sewage. This is known as “biomass”, and the stored energy is referred to as “bioenergy”. The energy in biomass can be converted into heat and power. Liquid biofuels can also be derived from biomass crops such as canola and sugar cane. Organic matter often considered waste can also be converted into energy—therefore becoming a clean source of energy—without otherwise impacting existing agricultural and food production.

Using biomass in this way avoids greenhouse gas emissions by displacing use of fossil fuels for transport or electricity generation. It also avoids the greenhouse gases that would be released if organic matter was simply left to decompose (such as in municipal tips), and provides ongoing benefits for managing our waste. The methane produced is much more damaging than carbon dioxide.

Bioenergy plants are operated on a natural fuel source that can be stored and controlled. In many cases, plants can generate electricity 24 hours a day, all year round, as baseload power. Landfill gas plants in operation across all Australian capital cities often operate for over 90% of the year, better than many coal-fired plants. Bioenergy technologies have a proven track record in delivering reliable energy to industry and households across the world.

Wood and various agricultural wastes remain the central energy resources for the majority of the world's population—particularly in rural and remote areas of less developed countries for heating, cooking and lighting. Such use of an indigenous low-cost naturally occurring renewable fuel source should be positive, but competition for fuelwood can result in eventual deforestation. This can have very significant impacts on soil fertility and can affect land stability in hilly regions, leaving little to resist land and mudslides after heavy rainfall. It can also place a tremendous burden on families—particularly women and girls—to gather sufficient fuel. Another side effect of reliance on open fires is poor health caused by regular exposure to smoke and particulates.

IMPROVED COOKSTOVES

Improved cookstoves are one means of reducing some of the negative impacts of traditional biomass use. These simple units—often locally manufactured—burn fuel more efficiently and more effectively direct the heat energy onto the cooking vessel. This means less fuelwood is required and smoke emissions are substantially reduced.[49]

LARGER-SCALE PROCESS HEAT AND ELECTRICITY GENERATION

Where a suitable resource exists—for instance alongside sawmills, sugar refineries and other food processing facilities—biomass can be used on a large-scale for process heat and/or electricity generation. The waste product of processing plants (sawdust and off-cuts, sugar bagasse, pineapple and coconut husks, etc.) can be burnt directly on a grate to create heat for hot water boilers, low pressure steam for process applications or higher pressure steam to drive a turbine for electricity generation.

From a global environmental perspective, combustion of such biomass by-products and utilisation of the resultant heat often has twin benefits. Not only is the use of the waste product displacing combustion of fossil fuels, but it also avoids the normal organic breakdown of the waste, which results in emissions of methane, a greenhouse gas with 30 times the potency of carbon dioxide. Biomass projects in developing countries may be able to capture additional financial value in recognition of this through the creation of emission reduction certificates under the Clean Development Mechanism of the Kyoto Protocol.

The suitability of a biomass resource as a fuel depends particularly on its water content, which in turn is dependent on when the fuel was 'cut' and may vary seasonally if dried in air. Oven drying will generally yield a fuel with a higher calorific value (i.e. useful energy content). The fuel may also require some processing to make it suitable for handling and combustion. This might include chipping of large wood off cuts or densification (compacting), briquette or palletisation of certain crop residues and sawdust.

Following appropriate preparation, the biomass fuel can be used as a direct replacement for traditional solid fuels such as coal or peat. Refuelling may be achieved manually in batches for small village applications or may be fully automated for larger schemes.

CHARCOAL

Like conventional carbon-based solid fuels, biomass can also be converted to charcoal. Coconut shells and solid timber wastes are particularly suitable for charcoal production.[50]

PRODUCER GAS

Some biomass varieties can also be processed in a gasifier at temperatures above 700°C and in a restricted airflow as the feedstock for 'producer gas' (or 'town' gas). The gas can be used as an alternative to natural gas. This makes it suitable for use as a relatively clean cooking fuel or as the fuel for a boiler or gas internal combustion engine, the latter predominantly for electricity generation.

BIOGAS

Biogas (as distinct from biomass-derived producer gas) consists mainly of methane as the combustible gas and is created through the anaerobic digestion (i.e. fermentation) of organic matter. Animal dung and human faeces are particularly good feedstocks being easily broken down, although agricultural residues and other organic materials can be used.

Processing human and animal wastes in this way may offer sanitation benefits in locations where disposal of faecal matter is problematic. The processed effluent can also be used as an effective fertiliser.

India and China have extensive experience of digesters and these two countries are responsible for the two principal designs that exist for biogas production. Both are possible to manufacture and construct locally from relatively simple materials.

Digesters can be sized for individual household use right through to municipal-scale systems. The volume of gas produced is dependent on the volume of feedstock available (for small systems this is the number and type of animals and effectiveness of waste recovery practices), and the digestion temperature. Digestion time will vary with the temperature in the process chamber which in turn can be affected by the ambient temperature. Tropical climates with consistent high temperatures generally will yield gas in as little as $^1/_3$ to $^1/_2$ the time of digesters in temperate locations.

Household demand for cooking and lighting might typically amount to 2000 litres per day. This is the volume of gas that might be expected from the daily dung produced by 10 pigs or 5 cows.[51]

Geothermal

In some regions of the world geothermal energy may be a viable option for a variety of process heating applications or for large-scale electricity generation. There are at least 76 countries with geothermal heating and 24 countries with geothermal electricity. More than 1 GW of geothermal power was added between 2000 and 2004, including significant increases in France, Iceland, Indonesia, Kenya, Mexico, the Philippines, and Russia. Geothermal direct heat utilization nearly doubled from 2000 to 2005, an increase of 13 GWth, with at least 13 new countries using geothermal heat. Half of the existing capacity exists as geothermal heat pumps for building heating and cooling, with 2 million pumps in over 30 countries.

Geothermal energy arises from the transfer of heat from deep in the earth's molten core to the mantle layer. Heat from the magma transfers to the barrier rock layer, which may transfer heat to water flowing through natural fissures in the rock.

In some locations this may be released as steam or hot water fountains—i.e. geysers. This provides an opportunity to use the geothermal energy for direct heating applications, for instance slow-cooking (as practised traditionally by Maoris in New Zealand), for greenhouse heating or even for relatively large-scale community district heating schemes.

Electricity generation usually requires drilling a bore hole or production well into known geothermal reservoirs to bring the hot water or steam to the surface. If temperatures are sufficiently high this can then be used directly to power a steam turbine or otherwise the heat may be transferred via a suitable heat exchanger to vaporise a second low boiling point fluid that drives a turbine.

Such high-temperature applications of geothermal energy are restricted to a number of locations around the world, particularly bordering the Pacific Ocean notably Indonesia, the Philippines and New Zealand, certain parts of Central and Southern America and into the Western USA and Canada.[52]

Ocean energy

There are a variety of different ocean energy resources that can be used for electricity generation: tidal power and marine currents, waves, and ocean thermal gradients. A variety of technologies have been developed to exploit these energy resources; generating energy from ocean swells some distance from the coast, on shoreline breaks, from the difference in water heights between low tides and high tides and from the flow of water between tides. Potentially these technologies could make valuable future contributions to electricity generation for maritime countries, including small islands. However, while some large-scale demonstrations are in place, all the ocean technologies are pre-commercial at this stage.[53]

Annex 2 Renewable Energy Checklists

How to identify when renewable energy systems are suitable

These checklists are not meant to be definitive. Instead, they are to be used as a guide to questions which need to be asked and answered, in order to assist making an informed choice about if a renewable energy system is appropriate for the circumstance. These checklists also relate more to the restructuring and development phase, rather than the first two stages of disaster relief operations. The reason for this is simple—the energy equipment specified at this stage of disaster recovery operations will have a profound effect on the sustainability of the community for years to come. So it is imperative that the right decisions are made for the right reasons.

Checklist 1: Profile of the community and likely energy systems beneficiaries

QUESTIONS	EXAMPLES
Who are the beneficiaries?	• Individuals, community, business, industry, farmers, fishermen
What energy services are required?	• TV, radio, spot lighting, lighting systems, electricity, heat for entire buildings, cooking, power for industry, agricultural uses (from high energy consumption, such as ice making, to low energy use such as irrigation)
How much can the beneficiaries afford to pay for energy services?	• Review of proposed services, and the amount of money each person would be required to pay
	• Review of collection methods and payment amounts
	• Are the proposed systems for livelihood development or for improvement of living conditions (no additional income generated)
Will these payments be seasonal?	• Seasonal crops
Is there existing local experience with rural credit?	• Formal and non-formal sectors
If so, is this experience positive?	• Prompt repayments, few bad debts
What type of community consultation will be most appropriate?	• Working though existing hierarchy (e.g. councillors, head of the community, head of each household)
	• Community discussion groups
Are there likely to be any gender issues which could impact upon the success of the project?	• The women of the community prioritise clean water, improved cooking and lighting; the men prioritise TV, radio and power businesses

Checklist 2: Identifying appropriate renewable energy technologies

QUESTIONS	EXAMPLES
Have there been any experiences to date with renewable energy systems?	• The informal and semi-formal financial sectors often have a critical role in developing countries, particularly in regional areas where there are no formal financial institutions (e.g. banks).
Have these been positive?	• If experiences to date within the community have not been positive with repayment of credit, then the existing schemes are inappropriate, and there will be a high risk for any new scheme
Is the area already serviced by renewable energy component suppliers and maintenance providers? If not, can this be easily developed?	• Part of existing business • Establishment of new business/es
Is the area and/or community likely to be connected to a centralised electricity grid within the next few years?	• If "Yes", is there a case for "pre-grid" electrification (e.g. if it will take several years)
Is there sufficient local natural resource/s to warrant a renewable energy system?	• Sun, wind, water, bioenergy
Are there existing skills within the local community to install and maintain proposed systems, or able to be trained ? • Is the local community skilled as 'handymen' or are they not knowledgeable about mechanical processes? • Will it be difficult to train some of the community (men and/or women) to undertake routine maintenance of the system/s?	• Welding • Electrical • Are there local training organisations which could be empowered to undertake appropriate training in renewable energy technologies • Cultural norms for male and female roles
If the community is remote, will this inhibit supply, installation, service and maintenance of the system/s?	• Cannot get large-scale boilers or generators to site due to rugged terrain • Communities too dispersed to be viable proposition to support a regional equipment service and maintenance business
Are there any environmental or cultural impediments?	• River too dangerous or otherwise unsuitable for a hydro installation • Cooking patterns do not suit improved cookstove designs or particular solar cookers • Natural resource already in productive use (e.g. biomass as fertiliser)

Checklist 3: Establishing a local financing scheme

QUESTIONS	EXAMPLES
If there are existing mechanisms, are they appropriate to consider for energy financing?	• Revolving funds, formal and semi-formal institutions, seed banks
If not, would it be possible culturally to establish a simple scheme to finance either an organisation establishing a fund, or community finance project?	• Cultural mores may prohibit some activities (e.g. lending to particular segments of the community)
What are the risks? How can they be mitigated?	• Little experience in saving for future purchases; little experience in paying off a loan • Information and household training sessions may be appropriate
Is the scheme to be permanent or transitional	• As a pre-development initiative before financial institutions are re/established • As a permanent community structure
Is there seed monies or international funds which can be used to establish a renewable energy financing fund?	• World Bank • Gates Foundation • Global Environment Facility • Bilateral donor funds
Who will administer and run the financing scheme?	• Existing bank staff • Newly trained staff • Existing local ‘financiers’

For more information on financing renewable energy systems, please refer: www.environmental-finance.com/2004/0504may/financ.htm, and www.unepfi.org/fileadmin/documents/financing_sust_energy_directory_2002.pdf (Eric Usher, UNEP, Paris).

Checklist 4: Community Consultation

QUESTIONS	EXAMPLES
How many people live in the community?	• 500 in the immediate community; as many dispersed.
What is the best approach to engaging the community?	• Written materials • Verbal discussions and presentations • Information through mime and role playing • Identify local language
Is the society hierarchical? If so, how can these social mores be used for the proposed discussions?	• Use head-man or head-woman as the role model • Get the chief 'decision former' involved
What are/were their sources at home?	• Candles • Cookstove • Kerosene lantern • Batteries • Wood
What are/were their current energy usages in the home? Are they the same at work? If not, how do they differ?	• Lighting • TV • Radio
What are/were their uses at work? (industry, commerce, farming)	• Crops, animal husbandry, fishing • Handicrafts, bakery, pottery • Power for light industry and commerce
How business savvy are members of the community?	• Segment/s of the population able to identify and act upon new opportunities
What are their aspirations – at a personal level; as a family; and as a community?	• Want better health services, better education for their children, access to improved "mother" opportunities, and access to new business opportunities

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Organisations and websites

Australian Business Council for Sustainable Energy: BCSE is a member-based industry association representing the sustainable energy industry in Australia. It represents the broader sustainable energy industry—covering renewables, waste-to-energy, gas-fired generation and energy efficiency. There are over 300 members, including installers and designers of renewable energy systems; large project developers and project service providers—including consulting engineers, economists, financial and legal advisors; equipment and component manufacturers and suppliers; researchers and academics; energy retailers, and energy service providers. The common feature of the membership is the interest in meeting Australia's energy needs with lower greenhouse emissions. Please visit the membership section for a complete list of current members. www.bcse.org.au/default.asp?id=90

Bushlight: Aims to improve livelihood choices for indigenous people in remote areas of Australia through increased access to sustainable renewable energy services. The program has developed an excellent range of resources for planning and implementing energy projects via community consultation approaches. Robust technical systems have also been developed as an integral part of the program. www.bushlight.org.au

Development Bookshop (formerly Intermediate Technology Publications Ltd.). A wide range of books and resources on energy and aspects of development are available from the Practical Action Publishing. http://developmentbookshop.com

Global Village Energy Partnership (GVEP): aims to promote social and economic development in rural and peri-urban areas of developing countries via increased access to appropriate modern energy services. A range of knowledge resources on aspects such as Finance facilitation, Capacity Building, Monitoring & Evaluation, Activity Mapping and Technologies, Equipment and Suppliers is accessible via the Partnership's website. www.gvep.org

InforSE, the International Networks for Sustainable Energy, is a worldwide network consisting of 140 Non Governmental Organisations working in about 60 countries to promote sustainable energy and social development. www.inforse.dk

International Energy Agency's Photovoltaics Power Systems Programme (IEA-PVPS) incorporates a specific work area focusing on supporting successful applications of renewable energy systems in developing countries. This includes a number of recommended practice guides for aspects of project implementation. www.iea-pvps.org/tasks/task9.htm

International Solar Energy Society (ISES): ISES has been serving the needs of the renewable energy community since its founding in 1954. A UN-accredited NGO present in more than 50 countries, the Society supports its members in the advancement of renewable energy technology, implementation and education all over the world. www.ises.org/ises.nsf!Open

International Telecommunication Union: The International Telecommunication Union was founded on the principle of cooperation between governments and the private sector. With a membership encompassing telecommunication policy-makers and regulators, network operators, equipment manufacturers, hardware and software developers, regional standards-making organizations and financing institutions, ITU's activities, policies and strategic direction are determined and shaped by the industry it serves. The role of the Telecommunication Development Sector (ITU-D) is to facilitate and enhance telecommunication development through advice and direct technical assistance. www.itu.int/ITU-T/worksem/ets/ai-008.html

National Renewable Energy Laboratory: NREL is a leader in the U.S. Department of Energy's effort to secure an energy future for the nation that is environmentally and economically sustainable. Its website has a variety of information about renewable energy applications and technologies. www.nrel.gov/learning/

Solar Cookers International assists communities to use the power of the sun to cook food and pasteurize water for the benefit of people and environments. www.solarcookers.org/

Solar Energy International provides education and technical assistance so that others will be empowered to use renewable energy technologies. In particular, SEI offers hands-on workshops in solar, wind and water power and natural building technologies. www.solarenergy.org/

World Health Organisation: WHO is the United Nations specialized agency for health. WHO has included solar PV to power vaccine refrigeration systems in remote areas for some decades. Its reference library is worth visiting for more information. (http://search.who.int/search?ie=utf8&site=default_collection&client=WHO&proxystylesheet=WHO&output=xml_no_dtd&oe=utf8&q=solar+energy). It also has a specific network, called TechNet, which was developed to discuss technical questions around the preservation and use of vaccines. www.who.int/about/en/

Abbreviations

AC	Alternating current
Ah	Ampere hour
AUD	Australian dollars
AusAID	The Australian Government's overseas aid program
BCSE	[Australian] Business Council for Sustainable Energy
CCC	Crisis Coordination Centre
CHP	Combined Heat and Power (cogeneration)
CO_2	Carbon Dioxide (combustion product and greenhouse gas)
DC	Direct current
ESCO	Energy Service Company
ESD	Ecologically Sustainable Design (passive design, sustainable building materials, energy efficiency appliances and fittings, powered by sustainable energy)
FO	Field Office
GEF	Global Environment Facility
Gensets	Generating sets (typically fuelled by petrol or diesel)
GNP	Gross National Product
GW	Gigawatt
GWh	Gigawatt hour
HF	High frequency
HID	High Intensity Discharge
IDSS	International Development Support Service
IEA	International Energy Agency
IEC	International Electrotechnical Commission
ISO	International Standards Organisation
ITU	International Telecommunications Union
kg	Kilogram
km/h	Kilometre per hour
kVA	Kilovolt-Ampere
kW	Kilowatt
kWh	Kilowatt hour
LCD	Liquid Crystal display
LED	Light Emitting Diode
LPG	Liquefied Petroleum Gas
m/s	Metres per second
MDG	Millennium Development Goal
MW	Megawatt
PFnet	People First Network
ppm	Parts per million
PV	Solar photovoltaic
RE	Renewable energy
RESCO	Renewable Energy Service Company
RO	Reverse osmosis
Selcal	Selective Calling Systems (aviation)
SWH	Solar Water Heater (including heat pumps that are directly or indirectly solar heated)
SWR	Standing Wave Ratio
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United nations Education, Scientific and Cultural Organisation
UNIDO	United Nations Industrial Development Organisation
V	Volt
VCO	Voltage Controlled Oscillator
W	Watt
WHO	World Health Organisation

Definitions

AC Alternating current. Electric current in which the direction of flow alternates regularly. The frequency of change is measured in Hertz (abbrev Hz) (1 Hertz equals 1 cycle per second). 50 Hz and 60 Hz AC supplies are common. Usually electrical supply grids and associated equipment operate on AC.

Ampere (colloq., amp; abbrev A) Unit of electrical current. Higher currents require larger conductors.

Ampere hour (colloq., Amp-hour; abbrev Ah) One Ampere-hour is the amount of charge that is transferred if a current of one Ampere flows for one hour. Commonly used as a measure of the capacity of a battery.

Cold Chain System of people and equipment that attempts to keep vaccines at the correct temperature as they are distributed from the manufacturer to the locations where they are administrated.

DC Direct current. Electric current in which the flow is unidirectional. DC sources are polarised. The connections being positive (commonly coded with '+' or red colouring) and negative (commonly coded '-' or black colouring). Batteries and PV sources are DC.

Energy fundamental concept but notoriously difficult to formally define. A measure of the ability to do work. It is a quantity value. Contrast with power which is an "at this instant" value. Energy is the product of power and time. Though the formal unit is Joule the common practical unit is kilowatt-hour.

G Giga. Prefix for units, a billion, 10^9.

HF High frequency. In reference to radio communication. Frequencies in the range 2–30 MHz (traditionally 'short wave'). High frequency radio waves may travel as: ground waves following the earth's surface, direct waves following line of sight or sky waves reflected off the ionosphere. HF communication is achievable over long distances (thousands of kilometres) but is dependant on the current atmospheric conditions.

Inverter A solid-state device that changes a DC input to an AC output.

k kilo. Prefix for units, a thousand, 10^3.

M Mega. Prefix for units, a million, 10^6

Micro hydro <100 kW

Micro wind generator < 10 kW

Mini hydro <1 MW

Peak load The maximum load or electrical power consumption occurring in a period of time

Pico hydro <1 kW

Power The rate which energy is converted from one form to another. Examples of energy conversions: electrical to mechanical (electric motor), chemical to mechanic (internal combustion motor). Unit Watt, W, common variant kilowatt, kW. Electrical power is the product of voltage and current.

PV cell A semi-conductor junction that generates electrical power when subject to solar radiation.

PV module, PV panel A defined electrical configuration of PV cells in a mechanical assembly.

PV system An aggregate of PV modules, power conditioning (for example an inverter) and other components (commonly including a battery bank) that provides electrical power.

Solar A term for techniques that employ the sun as an energy source, generally for heating or electrical supply.

Stand-alone system A system that can supply electrical power independently of the main supply grid.

Sustainable A resource or system which meets the present needs without compromising future needs.

SWR Standing Wave Ratio. A measure of the mismatch between a transmitter and an antenna. An SWR of 1.0 is ideal; a high value will result in a loss of effectiveness and possible damage to the transmitter.

UHF Ultra high frequency. In reference to radio communication. Frequencies in the range 300–1000 MHz. UHF transceivers are readily available for communication between any combination of handheld, vehicle mounted and base station units. Depending on local conditions (hills, heavy foliage, buildings) the range between handheld units may be a kilometre or two. And for a vehicle unit to base station unit, in excess of 10 kilometres.

VCO A VCO is an oscillator specifically designed to be controlled in oscillating frequency by a voltage input

Volt (abbrev V) Unit of electrical pressure or driving force. Higher voltages require better insulation.

Watt See power.

Watt-hour See energy.

VA "vee ay" (or common variant kVA, "kay vee ay") is the product of voltage and current. Used in AC systems as a measure of apparent power. kVA differs, sometimes significantly, from real power (commonly KW).

VHF Very high frequency. In reference to radio communication. Frequencies in the range 30–300 MHz. Useful only over short distances.