power to tackle poverty

getting renewable energy to the world's poor

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executive summary/

Two billion people – one in three of us on the planet – live without the basic energy services such as electricity that the rest of us take for granted. Every day they have to meet their essential needs with expensive, dirty and unreliable energy sources such as kerosene lamps, candles and fuel wood. These damage people's health, reinforce the cycle of poverty and contribute to environmental destruction. This can and must change.

Breaking out of this vicious circle by expanding the use of fossil fuels such as oil, gas and coal would be a profound mistake. Not least, burning even more fossil fuels will exacerbate global warming to which the world's poorest people are the most vulnerable. It would also compound the cycle of poverty for many nations.

It is in the interests of rich industrial countries to lead the way by taking big and rapid steps to reduce their own emissions of greenhouse gases, whether or not others follow. As the biggest polluters, it is also their duty to humanity and the living world. At the same time, renewable energy technologies – such as solar, wind and small hydropower – have the potential to meet the needs of the world's poorest people at an affordable price. Clean, affordable and friendly to the local environment, these technologies are better suited than those dependent on fossil fuels to meet the needs of people living in remote areas of poorer countries. Power to improve people's quality of life does not have to come at the cost of climate change.

This paper shows the rationale for, and feasibility of, providing renewable energy by 2012 to two billion people in the world's poorer countries who are currently 'off-grid' – that is, not connected to mains electricity. It shows that many renewable energy technologies are already being used to great success, but that the potential is vastly greater.

Providing renewable energy to so many communities is a huge challenge. It will need a radically different approach from those that have generally been promoted by major international institutions and donor governments. It will need a thorough overhaul of the current political view of energy development and very considerable political determination.

There are no insurmountable technical, financial or institutional barriers to achieving this goal, but it requires commitment from the international community to support changes in the way in which energy development is funded and subsidized.

action for clean energy

Greenpeace and The Body Shop are spearheading a global campaign to secure a commitment from the international community at the 2002 World Summit on Sustainable Development in South Africa to get renewable energy to two billion of the world's poorest people within ten years.

Getting clean renewable energy to two billion people presents a significant challenge, but it is one that can be met, given the political will to make it happen.

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introduction/ **power to the world's poor**

As we begin the 21st century, two billion people – one in three of us on the planet – have no access to electric lighting or decent cooking facilities. Getting people the clean and reliable energy necessary for essential needs such as clean water, health care facilities, heating and lighting is one of the most pressing problems facing humanity today [UNDP].

Global warming caused by burning fossil fuels threatens people's lives all over the world. Increased flooding, hurricanes and drought place severe stress on people's food and water resources and contribute to the spread of diseases such as malaria. Rising sea levels threaten to engulf entire countries in the Indian and Pacific Oceans. If we are going to stop the world's climate spinning out of control, most of the world's reserves of fossil fuels such as coal, oil and gas must stay underground.

Renewable energy technologies – powered by the sun, streams, wind, waves and tides – are the most affordable and environmentally friendly way to get essential energy services to poorer countries where 80% of the world's people live.

The alternative – investment in technologies dependent on fossil fuels – would have devastating consequences. While the world's poorest people use only a fraction of the world's oil, coal and gas, they are likely to suffer the most if action is not taken. Renewable energy technologies can meet people's needs. Power to improve people's quality of life does not have to come at the cost of climate change.

It is in the interest of rich industrial countries to lead the way in switching away from fossil fuels to renewable energy. Clearly these countries must also support renewable energy development in poorer countries if we are to protect the environment on which we all depend.

While the Kyoto Protocol places the initial onus for reducing emissions of greenhouse gases on rich industrial countries, it is critical that today's development does not lock poorer countries into a future dependent on costly fossil fuel imports. By contrast, renewable energy can help tackle poverty, since the equipment can often be manufactured in the country itself, helping local economies and keeping national funds available for essential services such as health care and education.

Chapter 2 discusses the basic energy needs of the world's poorest people, and the consequences of the current lack of adequate energy services. Chapter 3 examines the problems associated with trying to meet these needs through a conventional fossil fuel dependent approach. Chapter 4 goes on to describe how people's energy needs can be met sustainably and economically through the use of renewable energy. Case studies of successful renewable energy projects already up and running are described in Chapter 5. Chapter 6 presents a global action plan for renewable energy investment. Chapter 6 also describes the technical, financial and institutional changes that are necessary if we are to get renewable energy to two billion people.

2/ **our basic needs**

Clean and reliable supplies of energy are desperately needed to meet even the most basic daily needs of the world's poorest people. Every day, hundreds of millions suffer from a lack of access to essential services:

- **Clean water supplies** – without energy for water pumping, people are often forced to rely on water from streams polluted by cattle or human effluent.

- **Cooking and heating** – heating for cooking and warmth is one of life's most basic needs.

- **Lighting** – access to good lighting gives people the chance to study or work in the evenings.

- **Communication** – electricity for radios or a television gets critical information to farmers, schools and others living in remote areas.

- **Power for health centres and schools** – energy is needed to power vital equipment in rural health centres and schools such as refrigeration for vaccines and other basic facilities such as lighting.

- **Agricultural needs** – many crops need processing, such as de-husking rice or milling grain for flour, so that they can be used in food. Without mechanical power, this can be an enormously time consuming, almost backbreaking task.

But two billion people around the world do not have the energy resources necessary for a decent life because they are without access to electricity, or adequate cooking facilities. This number is growing as population growth outstrips the number of new grid connections and the provision of off-grid supply. Table 1 shows an estimate of the number of people in various parts of the world who are still living without access to electricity.

Table 1. Population without electricity in selected countries

Country	Population without electricity
Bangladesh	90 million
Brazil	30 million
China	60 million
India	400 million
Indonesia	125 million
Nigeria	60 million

The hard daily reality for hundreds of millions of people is inadequate, expensive, dirty and unreliable sources of energy such as kerosene lamps, candles and inefficient wood fuel stoves that damage both their health and the environment and help keep them in poverty. The impacts on people's health and livelihoods are appalling.

Damage to health

- Without energy for pumps and water treatment, many people lack clean water. Water-borne diseases are a huge global killer.

- Smoke inhalation from the use of inefficient stoves inside people's homes causes debilitating problems such as respiratory illnesses.

- Millions of people do not have access to vaccines because of a lack of reliable mobile cold storage equipment.

- Working by poor light from candles or kerosene lamps damages people's eyes.

- There is a significant fire risk from the use of kerosene and candles.

Air pollution from inefficient cook stoves

In many rural areas some of the highest concentrations of air pollutants occur indoors as a result of inefficient cooking and heating stoves. The associated health risks fall particularly heavily on women and children, who spend more time indoors. Figure 1 shows that the exposure to particulates from cookstoves inside homes in rural areas of developing countries is far higher than from vehicle emissions outdoors in urban areas [Grübler]. Levels are often greatly in excess of World Health Organization recommended safe levels.

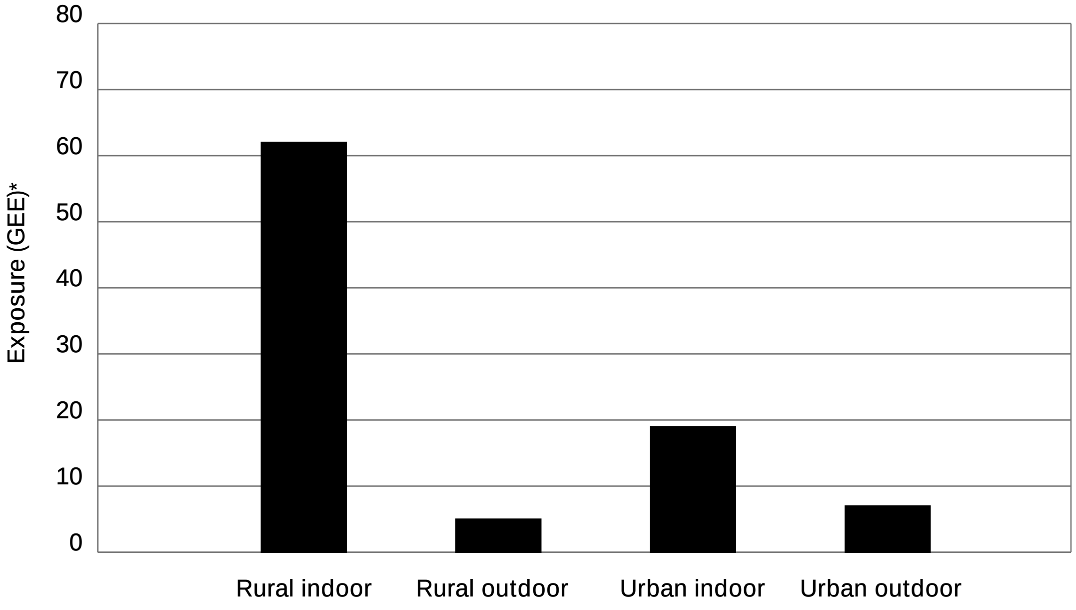
Impacts on livelihoods

- Women and children are often forced to spend hours each day collecting heating fuel. Studies in Nepal have shown that many women spend as much as two and a half hours every day searching for firewood and animal dung for cooking. This daily grind traps them in poverty by preventing them from putting their time to more productive uses.

- Without adequate lighting there is little chance for studying or reading, making it even harder for people to escape poverty through education.

- Without energy services, particularly electricity, employment opportunities are limited.

Figure 1. Particulate exposures in developing countries



* GEE is the Global Exposure Equivalent, based on the product of the pollutants concentration and the hours people are exposed to the pollutants.

- Seeking to escape the low quality of life found in the countryside, people move away from their communities into cities where they risk becoming exploited and trapped in low wage work or unemployment.

Environmental impacts

- Destruction of forests due to trees being used inefficiently for firewood. This deforestation leads to soil erosion, desertification and increased flooding as the trees that hold the soil are removed. More than 70% of the Earth's dry land that could potentially be used for agriculture has been affected by desertification, affecting one billion people in 100 countries.

- After fossil fuel use, deforestation is one of the most significant causes of global warming.

Health, economic and environmental problems related to inappropriate, unreliable, dirty and expensive sources of energy tend to exacerbate one other. For example, illness from unclean water or smoke inhalation means a person is less able to work and therefore less able to pay for clean water and clean energy.

3/ **the need for change is urgent**

The traditional approach to solving these problems has been to expand the use of technologies that burn fossil fuels such as coal, natural gas and oil including kerosene and diesel. But dependence on fossil fuels to meet people's legitimate energy needs will have wide repercussions for us all. Even 'mainstream' organizations like the International Energy Agency (IEA) recognize that the fossil fuel dependent energy path used throughout the 20th century is unsustainable. The IEA now argues that considerable changes in energy policy must be made in order to safeguard the global environment [IEA a]. Continued extensive use of fossil fuels has the following impacts on the environment and people's livelihoods.

Damage to the environment

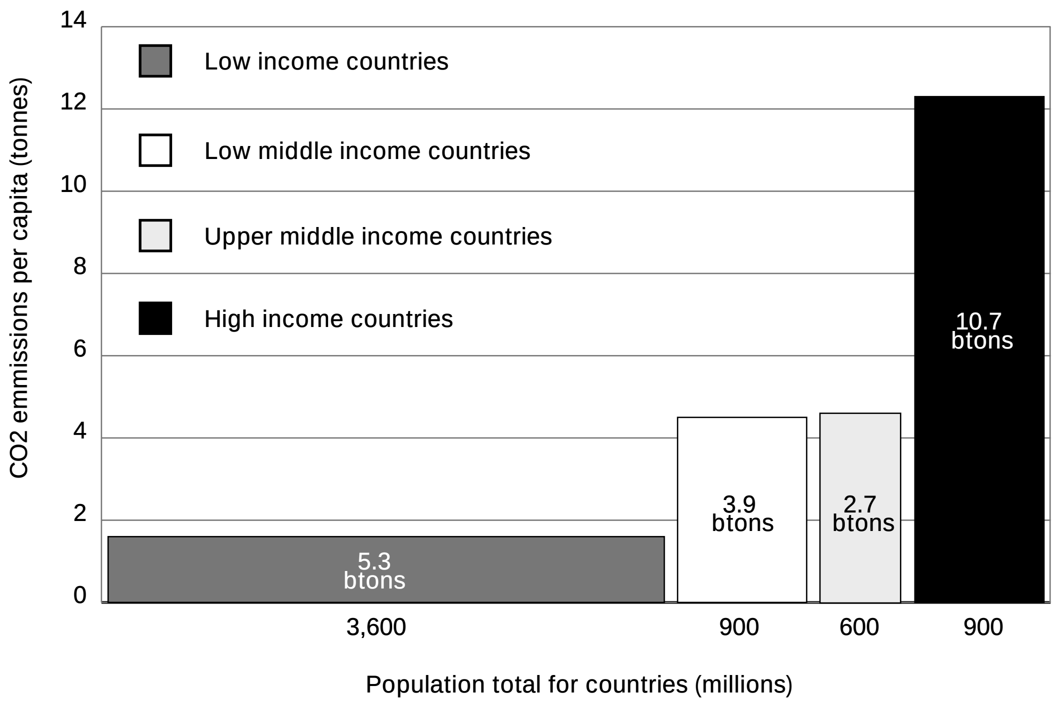
- Global warming is already occurring and will increase flooding, hurricanes, droughts and sea levels. The world's poorer countries will probably suffer much more severely from such change than the rich industrialized countries which have produced and continue to produce most of the pollution that causes the problem (see Figure 2).
- Acid rain damages crops, trees, lakes and buildings. A pollution cloud presently covers a large part of the Indian Ocean and sub-continent, resulting in acid rainfall at each monsoon [WEC].

Damage to livelihoods

Dependence upon imported fossil fuels is expensive for the world's poorest countries. This means that money that could be used for essential services such as education and health care is drained away. These nations are particularly vulnerable to spikes in world prices, resulting in governments resorting to cutbacks to inadequate existing budgets for health, education and welfare may suddenly be cut.

Even in countries that have large domestic reserves of coal, oil and gas, the majority of people do not necessarily benefit – especially not the poorest. Revenues are often distributed very unevenly, distorting the economy and undermining more balanced people-centred development. Local people often see little more than severe damage to the environment on which they depend from oil spillages and other destructive activity.

Figure 2. CO_2 emissions and population [World Bank]



In rural areas of poorer countries it is seldom economically feasible to provide a connection to a national electricity grid, and it is often inconvenient and expensive to bring in regular supplies of diesel and kerosene. In many cases, the costs of using fossil fuels to provide electricity in these remote regions are far higher than renewable energy alternatives that are already available. But even though they cost less over the lifetime of the product, renewables usually have higher up-front costs, while governments tend to subsidize kerosene and diesel. As a result, people become locked into the use of fossil fuels that neither they nor their country can afford.

The world's poorest people pay far more as a proportion of their income for energy than the richest and often they even pay more in absolute terms. Electricity from diesel generators typically costs around $0.30/kWh and light from kerosene can cost the equivalent of $20/kWh [IAEEL]. For someone earning $200 a year, paying $0.30/kWh is like someone in a rich country who earns $20,000 paying $30 for each unit of electricity, or three hundred times as much as they typically pay at present ($0.10/kWh).

In most rural areas, efficient and economic options such as solar lanterns are simply not available. Even where renewable energy systems are to be found, many people are unable to benefit from the lower overall lifetime costs since they cannot afford the higher upfront payment needed. Ways to overcome this problem, which include a shift in the use of subsidies away from fossil fuels and onto renewables, are discussed in Chapters 5 and 6.

Justice and thinking ahead

The rich industrial countries, which have been polluting for much longer as well as much more per person, must move first to reduce their emissions. But unless poorer and developing countries are given support to adopt renewable forms of energy generation, they too could soon play a serious role in causing global warming, as well as becoming its victims. In its 'Reference Scenario' the International Energy Agency predicts a 60% increase in CO_2 emissions by 2020, one third of which would result from new electricity generation in developing countries [IEA b]. But this kind of 'business as usual' approach would be both unjust and reckless. Renewable energy technologies can meet the energy needs of the world's poorest people and also help the world avoid the path to climate catastrophe.

4/ renewable energy solutions – serving people's needs

Renewable energy is already in use across the world, providing affordable and reliable power to people in rural areas on low incomes. Different renewable energy solutions are available for supplying different essential energy services. Here is an outline of key appropriate technologies, associated systems and the roles they play in delivering affordable, clean and sustainable improvements to people's quality of life and the environment.

Off-grid electricity in the home

- Solar home systems, small-scale wind and family-sized hydropower schemes provide electricity for lighting and low power appliances such as a radio or a cooling fan. Families also use portable solar lanterns with a fluorescent lamp, which provides better lighting than kerosene lamps or candles.

Power for health centres and schools

- Health centres use solar photovoltaic (PV) or wind power to generate electricity for the refrigeration of medical supplies, lighting, equipment sterilization and telecommunications.

- Affordable clean energy supports better education. Basic facilities such as lighting, computers and audio-visual equipment can make a huge difference in schools that previously had unreliable, little or no power.

Grid-connected supply

- Wind farms, small-scale hydropower, biomass, geothermal and other renewable energy technologies are cheaper than conventional alternatives in many situations. These renewable technologies can be connected either to small local grids or to a national grid.

Community water pumping

- Many communities use solar photovoltaic or wind powered equipment to pump water for drinking, livestock and in some cases irrigation. Renewable energy can also power water purification systems to make clean drinking water.

Cooking

- Biomass (such as wood, straw and animal dung) and biogas (principally methane from composting) provide the cheapest option for cooking in many rural areas and some rural communities are successfully using solar cookers.

- Millions of households now use improved cook stoves, which consume much less fuel.

Agricultural and commercial

- Small-scale hydropower provides direct mechanical power for processing agricultural crops such as grains. Water mills are still an important part of many rural economies.

- Solar photovoltaic systems can support income-generating applications such as evening lighting in shops and charging batteries for local people.

- Solar drying plays an important role in rural areas. Solar water distillation is of growing importance, particularly in places where global warming is exacerbating the problem of sea water contaminating fresh water supplies.

Some of these technologies are comparatively simple and can be deployed very rapidly. Others are more complex and require support structures, even though they may save money overall. Comparatively simple technologies such as improved cook stoves and solar lanterns reduce a family's dependency on costly fossil fuels and help slow global warming. The stoves and the lanterns can be deployed almost immediately.

In the longer term, the wider range of renewable energy systems must be made available to meet people's legitimate energy needs and the necessary support structures must be put in place. Action to deliver change is essential because without these low cost renewable options, developing countries will have no choice but to follow rich industrial countries' destructive reliance on fossil fuels.

4.1 Off-grid electricity in the home

Solar home systems

Solar photovoltaic (PV) panels convert sunlight directly into electricity. Solar home systems range from a single 12 watt-peak (W_p) panel connected directly to a battery to power a single light, to multi-kilowatt systems with charge controllers and inverters producing AC power for all types of appliances and systems. Modular solar home systems can be built up over time from a simple and comparatively cheap start. For example, a family can start by buying a battery and light, charging the battery at a central community point before moving on to buy a PV panel and other appliances such as a radio.

Small-scale wind power

Wind generators capture energy from the wind and convert it into electricity. For small systems, the power can charge a battery to power lighting and small appliances. For wind-generators to be viable, an annual average wind speed of at least four metres per second (m/s) is needed, and preferably 5-7m/s. This makes it a particularly suitable technology for certain regions like the plains of Mongolia, where the wind blows steadily. Here, portable wind generators are already widely used by nomadic herdspeople to run lights, radios and other appliances.

Family-hydropower
Family-hydropower units harness the energy from water flowing in small streams and irrigation canals to generate electricity – typically around 80W for low power applications in the home.

Solar lanterns
A growing number of families living in rural areas are using portable fluorescent lamps with a small integral PV module. A $4W_p$ solar lantern has a 100-fold higher energy-to-light conversion efficiency than a kerosene lamp. Its light output is twice as great and, of course, needs no fuel. They provide a huge improvement over candles and kerosene lamps, enabling people to extend their working day or study in the evenings at a more affordable price and without straining their eyes.

4.2 Power for health centres and schools

The energy needed to support health services in rural areas in developing countries is tiny compared to present requirements in rich industrial countries, but a huge amount can be delivered with that comparatively small supply. Energy for basic facilities such as lighting, computers and audio-visual equipment make a huge difference to schools that previously had no power.

The availability of a reliable, clean and affordable energy supply in health centres and hospitals can greatly improve health services for rural people. For example, immunization programmes need refrigeration to keep vaccines within a 0-8°C temperature range throughout transportation and storage. PV systems power electricity for lighting, vaccine storage, blood and drug refrigeration, sterilization, radio and telecommunications in off-grid health facilities around the world. In larger hospitals, PV can also supply energy for radiology, laboratory equipment, water pumping and water treatment. PV-powered refrigerators are extremely reliable compared to those run on kerosene. This means there are fewer incidences of vaccines being spoilt and wasted in breakdowns.

Where the natural resource is abundant, small wind or hydro systems can also provide the power source. And PV, small wind and hydro systems can also charge batteries for wider community use when they are not needed by the health centre or school.

4.3 Grid-connected supply

Renewable energy is particularly well suited to off-grid applications, to provide power in remote areas. But renewables can also be fed into a national grid system, reducing environmental impacts and dependence on costly energy imports. Wind farms, small-scale hydropower, biomass, geothermal and other renewable energy technologies are already economically competitive in many situations.

Renewables can also be connected to small local grid systems in remote areas. For example, many small-scale hydropower schemes in China are connected to local mini-grids, providing electricity to a number of health centres, craft workshops and local villages. In China, most new plants are owned, operated and maintained by local people.

4.4 Community water pumping

Solar photovoltaic or wind power systems can provide water for drinking, livestock and in some cases irrigation. A PV pumping system comprises a PV array connected to an electric motor driving a pump via a power-conditioning unit. There is no need for batteries – the system pumps when the sun shines.

Wind pumps – windmills connected to simple mechanical pumps – have been used on farms for more than a hundred years to pump water for livestock and drinking supplies. They come in a range of sizes, producing between 250W and several kilowatts. If the average wind speed at a site is greater than about 4m/s, then wind pumps are often the most affordable pumping option and considerably cheaper than fossil fuel dependent systems.

4.5 Cooking and heating

The most widely available renewable source of energy in poorer countries is biomass – that is wood, dried animal dung and agricultural residues such as straw. These energy sources are used for cooking and heating. Where the main energy output required is heat, biomass fuels will remain one of the most suitable options for many rural communities. For example, in regions of India

Table 2. Matching renewable energy technologies with end-use applications

Need	Technology							
	Solar PV	Solar lanterns	Solar cookers & dryers	Wind pumps	Wind generators	Small hydro	Biomass/ biogas	Improved cookstoves
Off-grid electricity in the home	•	•			•	•		
Health centres & schools	•				•	•		
Grid connected supply	•				•	•	•	
Water pumping	•			•				
Cooking & heating			•				•	•
Agricultural and commercial	•		•		•	•		

and China, animal waste put into biogas pits produces gas for cooking and heating.

Burning biomass fuels inefficiently reduces people's quality of life and contributes to serious health and environmental problems. Fortunately, there are straightforward and affordable ways to improve efficiency. Improved stoves, less hungry for fuels such as wood, are often the best first step towards more efficient use of resources. By making the biomass resource go further, they can help to ease the pressure to switch to fossil fuels and help to reduce the pressure on threatened forests dramatically, slowing climate change and limiting the other negative impacts associated with deforestation. Energy efficient stoves would also lighten the burden on millions of women and children who often spend hours each day collecting firewood and greatly reduce the devastating health impacts of smoke inhalation. And they can be manufactured for as little as $3 each.

Improved efficiency cook stoves are not the only answer. Parabolic solar cookers, which concentrate the heat of the sun onto a cooking vessel, are also being used widely in many regions, including parts of China and Ethiopia. Solar cookers can deliver 200°C and are capable of boiling a litre of water in a matter of minutes. They can be built locally for around $70.

4.6 Agricultural and commercial

Small-scale hydropower can provide direct mechanical power for crop processing, sawmills, mechanical workshops and other activities. Early trials with such systems in Nepal focused on using the power in the daytime for agricultural processing (such as milling and grinding) and electricity generation by night. PV can be used for income-generating applications such as powering sewing machines and ice making. Solar dryers also play an important role in rural areas.

Table 2 summarizes the ability of different renewable technologies to meet a variety of end-use applications.

5/ **renewables in action today**

Renewable energy already provides energy to millions of families in less industrialized countries. For example:

- Developing countries have installed over one million solar home systems. There are around 150,000 in Kenya, more than 100,000 in China, 85,000 in Zimbabwe, 60,000 in Indonesia and 40,000 in Mexico.
- Around 150,000 PV and wind power systems are being used at health clinics, schools, and other communal buildings in developing countries.
- Over 45,000 small-scale hydro schemes are being used in China, providing power to over 50 million people.
- Over 100,000 families in Vietnam use very small water turbines to generate electricity.
- India has 300,000 solar lanterns in use.
- Over 50,000 small wind turbines provide electricity in remote rural areas around the world.
- Hundreds of thousands of PV and wind pumps are being used in Africa, Asia and Latin America.
- Some 120 million improved cook stoves have been installed in China, and a further 23 million in India.
- About 6 million domestic biogas pits have been built in China.

5.1 Solar home systems in Kenya – learning from early success

Since 1985, Kenya has nurtured a healthy solar PV market. Today, equipment worth between $2 million and $4 million is sold each year. The market is driven by strong rural demand and has grown exponentially. PV dealers now operate in almost every town across the country. There are now more PV systems installed in rural Kenya (approximately 150,000) than there are connections under the Kenya Power and Lighting Company's Rural Electrification Programme (just over 60,000). Roughly 4% of rural households now own solar home systems.

Most of the growth in the commercial PV market in Kenya has been in straight cash sales of systems to rural customers. But some customers have made partial payment on signing the contract with the remaining amount paid upon completion of installation. Others have benefited from hire purchase and instalment payment schemes [Agumba]. In general, formal credit is not available to the great majority on low incomes in rural areas, but informal credit agreements have been used successfully to expand the market to those who cannot afford the up-front costs.

In some areas, rural revenues are (by African standards) high due to income from cash crops such as coffee and tea. Demand for lights, radio and television in the face of slow grid expansion drove many farmers, teachers and businessmen to seek alternatives.

In the mid-1980s several small-scale demonstration and training initiatives, supported by relief agencies, NGOs and church organizations, stimulated interest in the technology among potential customers. Local technicians were trained to install systems for higher income customers. Local electricians and merchants were quick to realize that PV could fill a niche which at that time was dominated by diesel generators. The cost of a PV system – between $500 and $1000 – was often less than the initial cost of a generator. Demand for PV increased rapidly and there are now 15 distributors of systems in Nairobi.

What makes it work for people

In Kenya, two key ingredients have contributed to the successful growth of this industry:

- **Strong local demand** – solar power is the most economic option in many rural areas and a significant number of people can afford the systems. The success of early demonstration projects helped boost people's confidence in the technology.
- **Adequate infrastructure** – local installers and retailers in rural areas help guarantee performance and after sales service, supporting people's confidence in using the technology. Importers, technicians and manufacturers of system components such as batteries and lights also make the technology a practical option. Local manufacture has reduced system prices and ensures that spare parts are available. Cheap Chinese TV sets are also available and the TV network reaches most of the population.

These factors have reduced costs and increased demand. But there are still problems – for example some retailers sell inadequate, poor quality equipment, undercutting the good quality equipment available. Programmes such as the Photovoltaics Market Transformation Initiative (which works in Kenya and other countries) are working with businesses and government to deliver better service and reduce unhelpful financial barriers to market growth. The biggest challenges remain:

- **Unnecessarily high consumer prices** – high taxes on components and high transaction costs among dealers and distributors have contributed to high costs.

- **Poor quality equipment and services** – sometimes the up-front costs of systems are reduced by using low quality or under-capacity equipment. Ultimately, this results in higher overall costs to people as the equipment fails and needs replacement. These problems stem from a lack of quality standards and installation standards. Poor quality equipment and installation dents consumer confidence, but since there is a competitive market, customers have been able to switch to more reliable suppliers.

- **Lack of credit** – Before poorer people can afford solar home systems, some form of credit system with low interest rate loans will be required. The Kenyan government has only recently recognized the important role of PV in rural electrification.

5.2 Solar home systems in Kiribati – transforming a programme

Kiribati is a small island nation in the Pacific. Because it is so remote PV systems are the cheapest way to provide electricity. The first PV programme to provide solar home systems began in 1984 with government funds and foreign aid. The aim was to ensure that good quality systems were installed and end-users were adequately trained. The Solar Energy Company was formed as a private company with government ownership to implement the project.

However, demand soon dropped rapidly. Customers were extremely dissatisfied because the systems were not performing as expected. There were two main reasons for this: very poor maintenance and undersizing of systems to reduce up-front costs. So although there was a large demand for electricity, and sufficient ability to pay (even though Kiribati has one of the lowest per capita incomes in the world), people were not interested in PV.

The project leaders decided to shift the focus away from selling hardware to selling energy services. Instead of selling systems, the Solar Energy Company became a rural utility. It installed systems, but retained ownership and responsibility for them, and charged around $7 a month for the use of three lights and a radio. Trained technicians perform monthly preventative maintenance. This approach worked extremely well, and other island nations are now developing similar programmes.

What makes it work for people

Experience in Kenya, Kiribati and elsewhere shows that there is no one size fits all solution for rural energy provision. But there are common factors for success. These include:

- consultation with local people to establish their real needs

- strong local demand for the service

- good on-going support

- ability to pay

Similar problems tend to arise as well:

- poor quality service

- high up-front costs, leading to undersizing of systems and consequent poor performance

5.3 Biomass in India – meeting people’s energy needs

In the village of Pura, near Bangalore, there was an attempt to promote community biogas systems in place of traditional wood fuel for cooking. It seemed like an excellent and fairly straightforward proposal. Biogas is extracted from agricultural waste by composting and capturing the fumes. A clean, cheap source of energy would be made available at the same time as producing useful compost and relieving pressure on surrounding woodlands. But in Pura, villagers didn’t maintain the biogas systems after the renewable energy specialists left.

This was a classic case of a programme designed by outsiders without sufficient understanding of the local situation. Collecting firewood in Pura is relatively easy, and so villagers had little need for biogas for cooking. When, after the failure of the first biogas systems, the villagers were properly consulted on what they actually wanted and needed, the answer was clean water and a reliable electricity supply. So the biogas system was adapted to power a community electricity supply and a small motor to pump clean water direct to homes. Families now pay an affordable fixed monthly rate for the water and electricity connection.

What makes it work for people
The case of Pura shows the importance of:

- involving the local community at the planning stage
- understanding the nature of the service required rather than just a technology that works well

These lessons may seem obvious now, but it has taken trial and error to get there.

5.4 Solar lanterns in India – switching subsidies away from fossil fuels towards renewable energy

Latuu is an agricultural labourer who lives in the village of Mangraulli, India. Laatu and his family used to have a kerosene lamp for lighting their hut, but it did not provide good quality light for reading and the lamp was unusable during windy weather. Fortunately, a government subsidy of 1600 Rupees ($34) meant Latuu's family could afford to buy a solar lantern. Latuu's son, the first in the family to study for high school examinations, remarked: 'The kerosene lamp only chases away shadows. This solar lantern lights up the whole room.' [Mathur].

What makes it work for people
In India, kerosene for lighting is subsidized at the rate of Rs. 5.15 ($0.11) per litre. This adds up to an enormous cost borne by Indian taxpayers. When they got a solar lantern, Latuu's family cut their kerosene use from 120 litres to fewer than 20 litres per year. Not only does the solar lantern provide better light, but it also represents a substantial saving for Latuu's family and the government in real terms over its lifetime.

5.5 Family-hydro in Vietnam

Family-hydro systems are widely used in Vietnam. Made up of a generator and a 50W to 1kW water turbine that sits in the stream but does not block its flow, they can be bought in Hanoi and other markets throughout the country. Less than $30 buys a turbine and generator that will deliver about 80W – enough for several light bulbs and a radio. Family-hydro also charges batteries, which then run lights and even a television.

Of the 78 million people in Vietnam, 12 million live in areas that will not be connected to the national electricity grid in the foreseeable future because the high costs of extending the system. Many of them live in hilly regions of the country where there is vast potential for small hydro systems. But even in lowland areas, family-hydro systems are being used – a drop of just one to two metres is enough. Often, turbines can be installed in the small streams and irrigation canals next to rice farmers' homes.

What makes it work for people
The systems are cheap and easy to install, and the majority of families have set up the equipment themselves without expert help. Today there are over 120,000 family hydro systems in use in Vietnam – up from just 3,000 in 1993. This tremendous growth has been driven entirely by local demand, without any government support. But there is still a huge untapped market for more, both in Vietnam and elsewhere.

6/ investing in power and people – global action plan

Greenpeace and The Body Shop have a vision of appropriate and affordable renewable energy to be made available to the world's two billion poorest people by 2012. To get renewable energy to two billion people will require many well-targeted initiatives. Local communities must be involved in projects from the earliest stages so that they are designed to meet people's most pressing needs. A range of renewable energy technologies are needed to serve the legitimate energy needs of the world's poorest people, and Table 3 gives an idea of the scale of the challenge.

6.1 Is it possible?

This is an ambitious vision, but by no means an impossible one. It will take committed effort in three interrelated areas: technical, financial and institutional capacity building – that is, fostering the commercial organizations and community structures that can bring it all together and ensure programmes sustain themselves.

Technical feasibility

Meeting this challenge means a tenfold increase in the number of renewable systems available. It also means supplying the entire supporting infrastructure. That seems a lot to ask, but internet and mobile phone use grew even faster than this during the 1990s.

Table 3. Meeting people's needs

Application	No. of systems* (millions)	No. of people served** (millions)	Approximate cost ($ billion)
Local & national grid-connected renewable energy schemes ***	0.03-0.05	400-650	80-130
Off-grid electricity for the home	100-200	500-1,000	65-130
Cooking	70-120	350-600	2-4
Water pumping	1-2	100-200	4-8
Health centres, schools & other public buildings	0.5-1.0	300-600	7-14
Total	~250	2,000**	200-250

* These are in addition to existing installations.

** There will be some overlap in provision, e.g. in some areas both solar lighting and water pumping may be needed.

*** Includes commercial applications.

Figure 3. Annual PV price and production [IT Power]

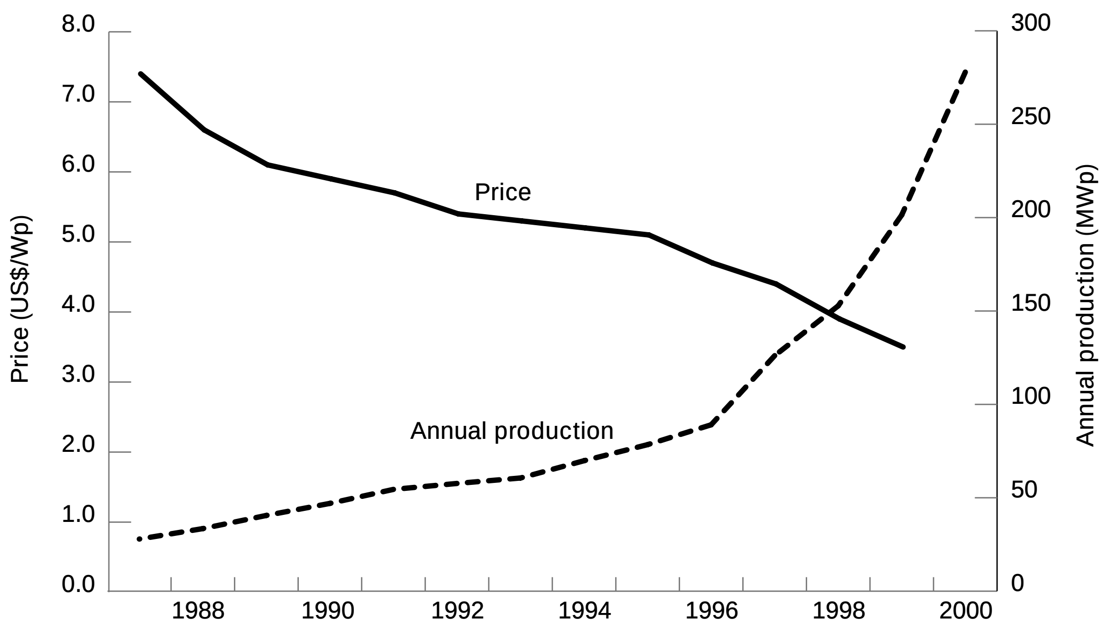


Table 4. Approximate PV capacity required to meet needs

Application	Number of systems (millions)	Typical system size (W_p)	Capacity (GW_p)
Solar lanterns	50-100	10	0.5-1.0
Solar home systems	40-80	50	2.0-4.0
Health centre/school systems	0.5-1.0	1000	0.5-1.0
Total			3.0-6.0

Just as sharply falling costs led to a rapid takeoff in petroleum use at the start of the 20th century, so renewables such as wind and PV are close to takeoff today. In many cases, PV will be the most appropriate technology for rural off-grid domestic electrification. The worldwide market for PV has grown exponentially over the last ten years as PV costs have dropped dramatically (see Figure 3). The cost of PV is likely to fall further over the next ten years, particularly if wide-scale rural electrification programmes go ahead.

To meet the 2012 target, between $3GW_p$ and $6GW_p$ off-grid PV will be needed. An indication of the number of systems required is shown in Table 4.

Between 1993 and 2000, the growth rate of the world PV industry averaged 24.5% per year. If this were to continue, total world PV installed capacity would reach $17GW_p$ by 2012. Recently, however, the market has been growing even faster, reaching 35%. At this rate, total world capacity would reach $39GW_p$ by 2012.

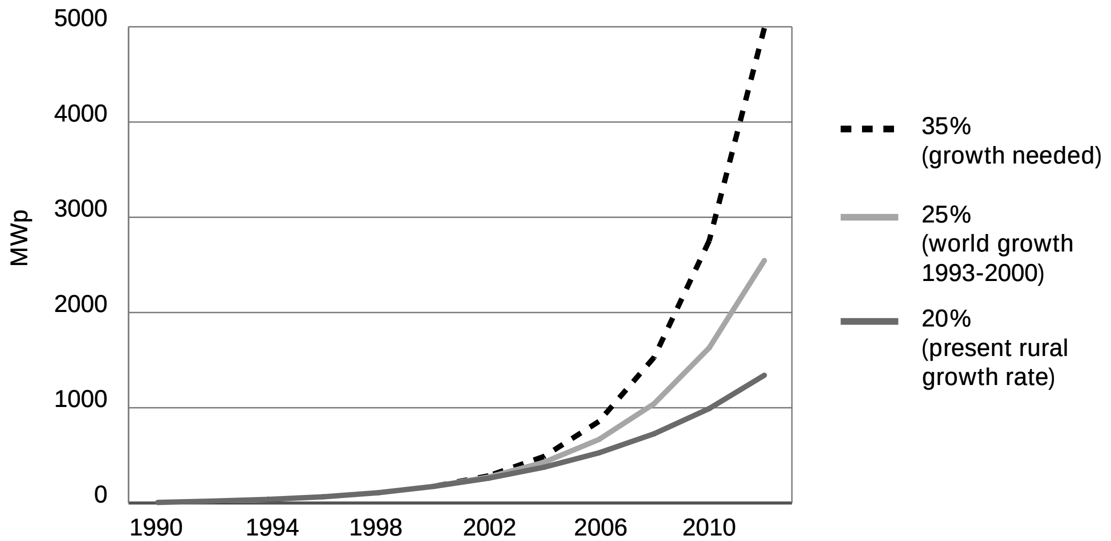
But these startling growth rates apply to the whole PV industry, including applications such as rooftop PV systems in rich industrialized countries that are connected to the grid. At 20% a year, the rate of growth rate in rural off-grid PV applications has been slightly slower than the industry as a whole [Maycock]. This needs to increase to 34% in order to reach a total installed capacity of 4.5GW by 2012, as shown in Figure 4.

$4.5GW_p$ of rural off-grid PV in developing countries by 2012 is feasible – but only if there is sufficient political support. The present growth rate of 20% is a reflection of the current lack of support for the rural off-grid sector. By contrast, in Japan and Germany, where government support schemes and targets are in place, growth rates for PV have exceeded 70% in recent years. Japan alone has a domestic target for 2010 of $5GW_p$ of PV.

Small-scale hydropower will often be the most suitable option in areas where there is a natural hydro resource located close to the demand for power. Small-scale hydropower is a well-established technology. The rate of growth does not need to be as fast as for PV.

The opportunities for wind power technology are substantial, though not as great as those for PV systems. Building the required infrastructure over the coming decade is well within the means of the industry – so long as political and financial support is provided. Wind powered battery-charging is more economical than PV in areas with high average wind

Figure 4. Cumulative off-grid rural PV capacity



speeds. On the plains of Mongolia, for example, where the wind blows steadily, nomadic herdspeople use portable wind generators for powering lights, radio and other appliances.

Batteries

It is important to consider how many batteries will be required to meet the targets, and the environmental impact of those batteries. For the foreseeable future lead-acid batteries will be used for most PV and stand-alone wind systems since they remain the most affordable and widely available energy storage technology. Although they are far from ideal, car batteries will be used in many cases, and specially designed solar batteries in others. In both cases there will be an environmental impact due to lead mining and processing and other parts of the manufacturing process. Batteries have a lifetime of around two to three years, depending on climate and mode of use.

A total of approximately 175 million large (around 80Ah) batteries will be needed in addition to 100 million smaller batteries for lanterns. In comparison there are currently 600 million passenger cars worldwide and this figure is expected to continue growing faster than the population growth at least until 2020. From these figures it would seem that the additional battery requirements are not overly challenging. However, the distribution of cars is extremely uneven and so the increase in batteries in selected countries is likely to be large. For example in India there are currently around 7.5 million vehicles compared with 400 million people without electricity. Around 30 million large batteries and 25 million smaller batteries would be required for rural electrification in India.

How much lead is released into the living environment depends on the battery lifetime [Real]. More widespread maintenance of systems to ensure optimal battery life is essential, as is more capacity for reconditioning and recycling of battery components, including the lead.

A good way of promoting this is in tandem with a fee-for-service type of arrangement, whereby the battery remains the property of the rural utility. In such a case, part of the company's obligation should be to maintain and perhaps ensure the recycling of batteries. Alternatively, a single dealer providing customer credit, installation, maintenance, spare parts, training and battery recycling may also be appropriate.

Financial feasibility

The total cost of providing renewable energy to two billion people is estimated to be between $200 billion and $250 billion – a huge sum until one compares this to the fossil fuel alternative. The IEA estimates that $850 billion will have to be invested in 'conventional' fossil fuel powered generating plant over the next two decades in order to meet a business as usual target [IEA b]. And that is before one accounts for the roughly $480 billion that people on low incomes will have to spend on unsustainable and unsatisfactory energy sources such as kerosene and candles over the same period if they do not have access to renewables.

Delivering the necessary growth in renewables will mean making money available to help stimulate the market for renewable energy technologies. This includes:

- providing credit to end-users via distributors or local banks to stimulate demand
- providing loans to retailers to enable them to build up their businesses
- providing seed funding to banks to offset the perceived risk of new technologies
- providing grants and support to initiate the required training schemes

Market surveys in Africa and Asia have found that around 5% of rural populations could pay cash for a solar home system. A further 20-30% could afford a solar home system if short or medium term credit were available and another 25% could afford a solar home system with long term credit or leasing. Other renewable options are generally cheaper than PV where there is an adequate wind, hydro or biomass resource and so will be even more affordable in these situations.

People in rural communities in developing countries typically spend between $3-$20/month on kerosene, candles, or other energy products – an extremely high energy cost both to themselves and the environment for the low quality service received. With suitable financing, a solar home system could be made available at around $10 a month, allowing people to buy them over several years, or use them on a fee-for-service basis.

In many situations, renewable energy can put in place at no extra cost or even at a saving by switching subsidies away from traditional fossil fuels towards renewable energy (see section 5.4).

A survey in Madagascar found that the average household of six people spends about 2800

Malagasy francs ($2.50) each month on cooking fuel. Improved cook stoves, which improve efficiency by 60%, cost 1750 Malagasy francs ($1.55), paying back the initial investment in just three months.

To deliver the vision of sustainable power for all, key financial barriers must be brought down. These include:

- **Subsidized conventional electricity supplies** – kerosene and other fossil fuels are frequently heavily subsidized, undercutting otherwise economically competitive renewables options.

- **Uncertainty surrounding the extension of electricity grids** – many rural householders have seen off-grid renewable energy as a second-class 'interim' measure. In South Africa, for example, people who could have benefited from renewable energy systems have chosen to wait for a heavily subsidized grid connection.

- **Lack of affordable finance** – many local banks have been reluctant to provide small amounts of credit to rural people, or charge very high interest rates, since the transaction costs are high and the risks of non-payment are perceived to be high.

It is important too that governments reassure investors that policies will not be changed over-night; that support and access to training will be provided for installers and maintenance engineers; and that distribution rights will be honoured.

Institutional Feasibility

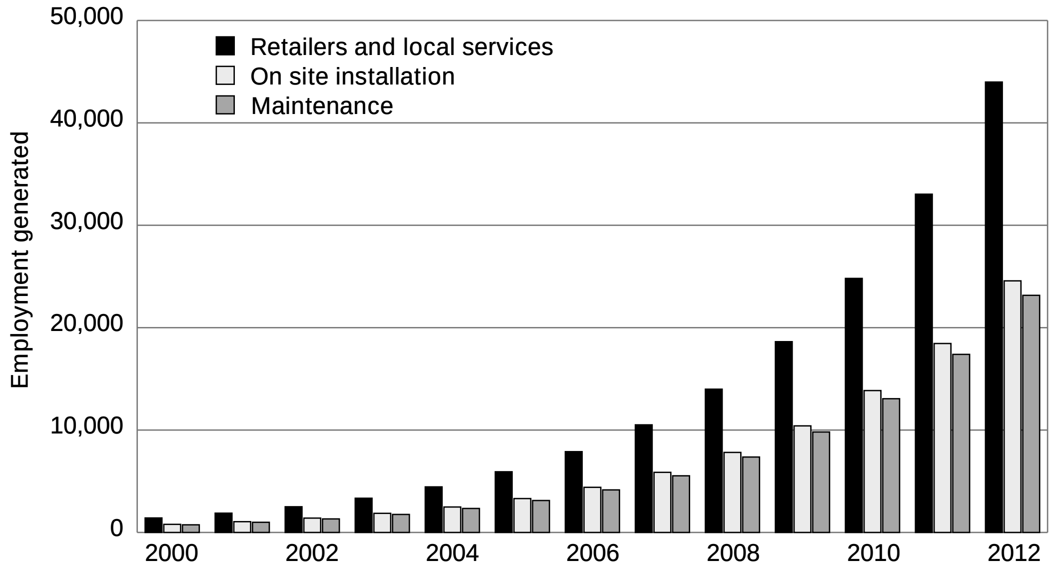
Building up local skills and infrastructure is a vital part of ensuring the long-term success of development programmes.

Taking PV as an example, an installed capacity of 4.5GW_p by 2012 requires an annual production rate reaching over 1GW_p by 2012. Assuming that one third of this is manufactured or assembled in the countries themselves, rather than imported, then a production/assembly capacity of around 0.7 GW_p needs to be created in developing countries (assuming 50% capacity utilization). This is equivalent to around 1000 factories producing 50 solar home systems (SHS) a day.

European experience has shown that each MW_p of PV installed per year creates 40 jobs in retailer and local services, 23 in on-site installation, and 21 in maintenance. Drawing on these estimates, the employment generated to meet the targets is shown in Figure 5 [IT Power]. The figures are likely to be somewhat higher in developing countries, where labour is cheaper. There will also be many more jobs in the manufacture, retail, installation and servicing of the wide range of other renewable technologies besides PV for both off-grid and grid connected use.

A major barrier to the growth in the use of renewable energy is the lack of awareness of the potential and characteristics of renewable energy. So education of people at all levels must be a priority. Crucially, technical training on manufacture, assembly, financing, installation,

Figure 5. Jobs created for 4.5GW of PV



maintenance and use of renewable energy systems will be needed.

In areas where people have little experience of renewables experience. it is best to start with demonstration projects. These stimulate interest and provide the chance to train local technicians.

6.2 Making it work for people

It is important to learn the lessons from past mistakes, some of which were shown in Chapter 5. Although millions of renewable energy systems operate successfully around the world, poorer countries are also littered with failed projects, where systems have been wrongly specified, used incorrectly, or badly maintained. Despite the many different situations where renewable energy has a valuable contribution to make, similar barriers must be faced. Decades of experience shows that for a project to be successful, it needs to meet people's real needs, be affordable and reliable. Several key ingredients help lead to a successful project:

Appropriateness
A successful programme must be based on the wishes and needs of the people who will use it, and must be driven by their demand for services (light, water pumping, etc), rather than simply focusing on providing energy technologies.

Local input is vital to ensure the appropriateness of a system. Renewable energy systems cannot simply be 'parachuted in' en masse. Without first investigating the needs, preferences, and abilities of the local people, systems may be badly specified and fall into disuse. Ultimately it is the local people who will use, maintain, guard and take pride in the system. Therefore there must be participation at all stages of the project, starting from concept development.

Many different, well-targeted projects need to be developed, aimed at the needs and situations of thousands of different communities.

Affordability
Well-designed subsidy programmes – particularly so-called 'smart subsidies' which are temporary, competitively administered and performance-based – should be given a role in developing country markets. Examples from the past 20 years of using subsidies to introduce renewable energy technologies – particularly PV in rural areas – show very clearly how subsidies are best implemented. In countries where there are already emerging renewable energy markets, care must be taken to ensure that subsidies do not kill off these markets. Table 5 gives a brief outline of some of the most important lessons learnt.

If those who benefit from them have an appropriate financial commitment, projects are far more likely to be viable in the long-term. One approach that often works very well is fee-for-service, whereby a company owns and maintains the system and users pay a monthly fee for use of the system. This makes it possible for people to get appropriate systems without needing to find the large up-front costs.

Reliability
Ensuring that systems are well designed and installed using quality components, with adequate ongoing service and maintenance is vital to ensure the success of renewable energy programmes. This means putting in place training programmes for those who will install, use and maintain the systems.

Often the up-front capital costs of systems have been reduced by using components that are undersized or shoddily put together. This results in a shorter product lifetime and – ironically – higher overall costs. This has undermined people's confidence in several programmes in the past.

Without a local infrastructure for maintenance and after sales service, systems may fall into disuse. Some degree of local manufacture or assembly is needed so that parts and knowledge are available locally. Local manufacture is also important for reducing costs and reliance on imports, which are subject to fluctuations in exchange rates. In addition, there are many advantages to be gained from making use of existing networks to establish distribution, servicing and financing infrastructures.

For systems to provide long-term and ongoing benefits it is essential to have a thriving commercial renewable energy business infrastructure including importers, manufacturers, distributors, installers and maintenance engineers, owned and operated by people in the countries themselves.

Getting renewable energy to two billion people living in the world's poorest countries must be a global priority. If we are to stop global warming, political thinking needs to shift away from increasing the global dependence on fossil fuels. Meeting the essential energy needs of the world's poorest people with renewable energy is a significant challenge. The good news is that there are no insurmountable technical, financial or institutional barriers to achieving this goal. But the change will not just happen by itself. We need the political will to make it happen. Getting renewable energy to those most in need means changing current attitudes toward energy development.

Table 5: 'Smart' subsidies

Smart subsidy	Not smart
Fulfils a genuine energy need of the local community, although can be targeted to only one area or group (eg farmers, small business, home owners)	Does not fulfil a genuine energy need of the local community
Scheme assists in buying down cost of lending without being seen as a 'gift'	Creates market distortion so that the private market outside the subsidy scheme is halted or reduced
Subsidy duration is known by all players and widely publicized	Unknown longevity of the scheme
All players signed up, including all relevant government departments	Affected by competing national, regional and local politics
Investment in local infrastructure and human capital (eg training, assistance to develop distribution chains etc)	Investment is site specific and totally installation-related, leading to over-optimistic price expectations by other potential users
Time is taken to consult with local people and businesses about what they want and need, and to ascertain which scheme best fits in to the local social infrastructure	'One size fits all' mentality, resulting in no community involvement and high default rates
Replicable (with some local modifications)	One-off approach
Simple to administer and understand, with local responsibilities	Complicated, not transparent and centrally controlled
Reporting and management structure, which allows regulation of the scheme without over-burdening it	Over-heavy bureaucracy, too little regulation, or incorrect management and reporting structure
Stimulates local economic growth (eg encourages local manufacturing & service sectors)	'The rich grow richer, the poor grow poorer' syndrome
Successful demonstration projects undertaken in the area, and well-received by the community	No previous demonstrations, or use of poor quality equipment for demonstration purposes
Appropriately priced credit for target groups (householders, small businesses, equipment & services, financiers etc)	Low priced credit stimulating excess demand, resulting in either rationing or over-stretched installation programme

conclusions/ **the challenge for the 2002 world summit on sustainable development**

Getting renewable energy to two billion people living in the world's poorest countries must be a global priority. If we are to stop global warming, political thinking needs to shift away from increasing the global dependence on fossil fuels. Meeting the essential energy needs of the world's poorest people with renewable energy is a significant challenge. The good news is that there are no insurmountable technical, financial or institutional barriers to achieving this goal. But the change will not just happen by itself. We need the political will to make it happen. Getting renewable enrgy to those most in need means changing current attitudes toward energy development.

It is wrong to deny people access to clean reliable energy. Present trends will leave the great majority of the world's poorest two billion without access to affordable, clean energy. Extending subsidies and support for technologies dependent on fossil fuels will be both disastrous for the environment and will leave many poorer countries dependent on costly energy imports. By contrast, renewable energy technologies will generate energy locally and deliver both immediate and longer term environmental benefits. The sooner governments, communities and businesses recognize this, and switch subsidies and support away from fossil fuels and towards renewables, the sooner the world can meet the legitimate needs of the world's poorest people. Key international organizations such as the World Bank and the United Nations, working together with donor governments and other key institutions, must use their funds to help bring about the necessary transformation in the countries where the world's poorest people live.

If, over the next ten years, the world develops a renewable energy industry of the size and kind described here, it will put in place the cornerstone for a truly sustainable economy that can support all the world's people and their legitimate energy needs.

At the 2002 World Summit on Sustainable Development in South Africa, Greenpeace and The Body Shop will call for a commitment from the international community to make a sea change in how the world's energy infrastructure is funded and subsidized. Important measures include:

- **Shifting investments into renewable energy instead of building fossil fuel power stations.**
- **Stopping subsidies and dismantling tax regimes that favour fossil fuels – shifting this support to renewable energy.**
- **Committing to genuinely sustainable development – based on meeting people's real needs and demands for services, rather than providing unsustainable energy technologies.**

By acting now we can quickly improve the lives of the world's poorest people, reduce the risk of climate catastrophe and move toward a fairer, more sustainable world.

appendix/
renewable energy sources

Biogas – Agricultural, sewage, landfilled and industrial organic wastes produce a methane gas that can be collected and burnt to produce electricity. Burning the gas results in emissions of carbon dioxide. Since methane is a much more potent greenhouse gas, there are advantages in extracting the energy via a combustion process.

Biomass – Forestry and agricultural residues can be used as a fuel to produce electricity and heat, provided the material used does not contain chemical residues. In addition, energy crops can be grown specifically for fuel. Use of biomass does not add any extra carbon dioxide into the atmosphere, as plants absorb carbon dioxide when they grow and this is then released when the plants are burnt.

Geothermal – Geothermal energy, coming from hot underground rocks. In some places steam comes to the surface naturally, while in others water can be pumped down and heated by the rocks to produce steam.

Small-scale hydropower – Small-scale hydropower schemes typically use the natural flow of water in a 'run of the river' system to generate electricity. Family-hydro units are very small turbines that use small flows of water to generate electricity for individual homes.

Hydropower also has a role to play in generating mechanical power, useful for agricultural processes such as milling grain.

Solar – A solar photovoltaic (PV) panel generates electricity directly from light. Solar home systems combine a PV panel with a battery and controller to provide power for home appliances and lights.

Wave and tidal energy – The energy in waves can be captured in a number of ways. One method is to build a structure on the shore to guide waves into a channel. The motion of the waves forces air back and forth over a bi-directional turbine, producing electricity. Several other types of wave energy device are currently under development. Tidal energy can also be captured by storing water behind a barrage at high tide and releasing it at low tide, or by using underwater turbines, which can also extract energy from other marine currents.

Wind – Wind turbines, which capture the energy from the wind to produce electricity, have been developed for various purposes, from large groups of grid connected wind turbines, both on-shore and off-shore, to independent turbines used for battery charging. Mechanical wind pumps have been used in rural areas for hundreds of years to provide fresh water supplies.

abbreviations, acronyms and units

AC	alternating current
Ah	ampere-hour
btons	billion tonnes
CO_2	carbon dioxide
GW	gigawatt (one billion watts)
GW_p	gigawatt-peak
IEA	International Energy Agency
kW	kilowatt (one thousand watts)
kWh	kilowatt-hour
m/s	metres per second
MW	megawatt (one million watts)
MWh	megawatt-hour
MW_p	megawatt-peak
NGO	non-governmental organization
PV	photovoltaic (solar cell)
SHS	solar home system
$	United States dollar
V	volt
W	watt
W_p	watt-peak

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