IEA Renewable Energy Working Party

Renewable Energy...

...into the Mainstream

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Acknowledgements

This publication by the International Energy Agency's Renewable Energy Working Party was prepared by Rodney Janssen with editorial support from the IEA Secretariat. Financial support was given by the Government of the Netherlands' Ministry of Economic Affairs and Novem (Netherlands Agency for Energy and the Environment).

SITTARD
The Netherlands
October 2002

Executive Summary

Introduction

Renewable energy is proving to be commercially viable for a growing list of consumers and uses. Renewable energy technologies provide many benefits that go well beyond energy alone. More and more, renewable energies are contributing to the three pillars of sustainable development – the economy, the environment and social well-being – not only in IEA countries, but globally.

In their 2001 communiqué, the IEA Ministers declared that they "intend for renewables to play an increasing role" in the energy sector. As the IEA's reference body on renewables, the Renewable Energy Working Party took this message as guidance to expand its work in facilitating the use of renewable energy to ensure that it can meet the expectations and challenges of the future, thus firmly fulfilling the IEA Ministers' intentions. This challenge requires that renewables should achieve expanded use in IEA members' energy sectors, while becoming increasingly low cost. This challenge is now being met. Over the past five years renewable energy prices have fallen to a point where most are now cost competitive with fossil technologies when all values (environment, jobs, security, etc.) are considered.

The global energy sector is in the throes of dynamic, fundamental change, driven by a move towards deregulation or liberalisation. This trend is increasing competition, particularly for energy carriers once considered the domain of monopolies. This has led energy officials to uncharted territory, as traditional energy industry models are unsuited to competition, the rapid adoption of new technology, the achievement of environmental targets and other aspects of new market conditions.

Environment issues linked closely with the move towards a more sustainable development path are leading the drive to develop and deploy cleaner technologies. Renewable energy technologies are well placed to contribute to improving environmental concerns.

There are several other factors, from improved energy security through to the generation of jobs at the local level, which make renewable energy more attractive today. The timing of renewables increased cost competitiveness is advantageous because there is a huge and growing demand for new capacity for utility power, and for millions of systems to serve the 1.6 billion people without electricity in rural areas of developing countries.

Given this host of positive attributes, renewable energy could play a significantly bigger role. While there is a convergence of positive factors, renewables are being held back from achieving their market potential due to a number of market failures and barriers. The policy framework to rectify these market barriers and failures is only slowly emerging but has not yet evolved sufficiently to sustain renewable energy as a commercially competitive alternative to fossil fuels.

The challenge is to take this cost-effective energy supply option and provide it with an appropriate policy framework that allows the market potential of renewables to be achieved. In this way, renewables will move from the margins of energy supply into the mainstream.

Renewable Energy Today

For the IEA region as a whole, the share of renewable energy (including both small and large hydro) in Total Primary Energy Supply (TPES) in 1999 was just over six per cent, compared to just 4.5 per cent in 1973 [1]. The share in OECD countries, however, did not really change throughout the 1990s, in part because overall energy demand in IEA countries was buoyant. This means that the market for renewable energy technologies is strong, but growing from a small base.

Several renewable energy technologies are established in world markets, and are building global industries and infrastructures. Other renewables are fast becoming competitive in growing markets, and some are widely recognised as the lowest cost option for stand-alone and offgrid applications. The capital costs for many renewable energy technologies have been halved over the last decade and these are expected to halve again over the next decade.
For example:

• Wind energy is seen as one of the most promising technologies for electricity generation and the costs, in good wind regimes, are comparable to fossil alternatives, particularly when economic or environmental circumstances are considered.

• Photovoltaics (PV), the use of semiconductor materials to convert sunlight directly into electricity, have dropped in price to between one-third and one-fifth their cost in 1980. PV is

1 IEA, Energy Balances of OECD Countries, 1998-1999, OECD, 2001.

now widely viewed as cost competitive for many grid-connected, building-integrated uses, and for off-grid applications ranging from telecommunications to village power.

• Solar thermal technologies provide heat and hot water for residential, commercial and industrial end uses, and have a long history of commercial use. For many of the applications the technologies are now reasonably mature, and recently developed cost reductions have brought them into the competitive range.

• Solar thermal electric technologies, also known as concentrating solar power (CSP), create heat to produce steam and/or electricity. Commercial applications, from a few kilowatts to hundreds of megawatts, are now technically feasible though not yet economically competitive. Plants can function in dispatchable, grid-connected markets or in distributed, stand-alone applications. CSP can meet dispatchability requirements through thermal storage or in a hybrid configuration with fossil generation.

• Biomass resources are available worldwide, coming in a variety of forms: wood, grasses, crops and crop residues. These can be converted to energy through thermal or biological conversion or as feedstock to produce different kinds of liquid or gaseous biofuels. A large number of projects are underway to determine how to use biomass even more cost-effectively for energy production. Biomass-based electricity has the important advantage of being a baseload technology and can be CO2 neutral.

• Geothermal technology is mostly used for power generation, though its use for space heating is becoming increasingly important. Geothermal electricity generation is a baseload technology, and can be a low-cost option if the hot water or steam resource is at a high temperature and near the earth's surface.

• Hydropower is the most mature form of renewable energy and has a significant share of electricity generation worldwide. While expansion of large-scale hydro has been hampered due to environmental constraints, there is considerable interest and potential in small hydro applications.

• Oceans contain various energy sources: tidal forces, ocean currents, wave power and thermal gradients can all be captured to produce electricity, using technology similar to underwater windmills, and these are starting to be deployed. Ocean energy systems need a relatively extended R&D effort, but full-scale prototypes have been constructed.

• Hydrogen [2], together with new and renewable energy technologies, has long been pinpointed by the IEA as a major potential contributor to the sustainability of the energy sector.

2 Only relating to hydrogen derived from renewable resources.

In the longer term, if costs can be dramatically reduced, hydrogen can act as the crucial storage medium and carrier of energy produced from renewables.

Renewable Energy Tomorrow

The IEA's latest World Energy Outlook 2000 (WEO 2000), in its reference case, shows the non-hydro share of renewables growing from the current 2 per cent of TPES to 4 per cent of TPES by 2020 in the OECD region. Non-hydro renewables are expected to be the fastest growing primary energy sources, with an annual growth rate averaging 2.8 per cent over the outlook period. Globally, hydroelectricity provided 18 per cent of electricity output in 1997. Throughout the world, hydroelectricity is expected to increase by 50 per cent between now and 2020, even though its overall share of TPES will decrease. More than 80 per cent of the increase will take place in developing countries.

WEO 2000 provides an alternative scenario showing that non-hydro renewables' share of electricity generation could increase significantly in the OECD region compared to the reference case, if policies to support their use are instituted. Renewables' share in 2020 could more than quadruple compared to 1997 (the base year) to 8.6 per cent if market barriers and failures were removed. There are also important reductions in CO_2 emissions in the alternative case compared to the reference case; emissions in the power sector could decrease by 6 per cent compared to the reference case – a dramatic improvement.

WEO 2000 shows that there is the potential to achieve a greater share for renewables, if more vigorous policies are implemented. The IEA's Renewable Energy Working Party has been assessing how to effectively accelerate the market deployment of these technologies. The strategies generally follow five separate steps to achieve market acceleration and commercial "take-off". These include:

- accelerating technology development,
- strengthening national policy frameworks,

- reducing market barriers and industry "start-up" costs,
- mobilising market investment, and
- promoting international cooperation.

These strategies are currently being prepared.

The Benefits of Renewables in IEA Countries

The potential contribution of renewables to IEA countries is growing, as the technologies mature and there is increasing awareness of the full contribution that renewables can make. The benefits from renewables amount to more than just their contribution to energy balance alone, because costs of energy output (e.g. per kWh) do not adequately capture a number of important values to society. Renewables add to the diversity of the energy supply portfolio and reduce the risks of continued (or expanded) use of fossil fuels and nuclear power. Distributed renewables provide options to consumers not otherwise available because of their deployment close to use. Renewable energy is also the most environmentally benign energy supply option available in current and near-term markets. Finally, renewables contribute to a healthy economy, both in their contribution to the efficiency of the energy system, and in the employment and investment opportunities that arise from continued rapid market growth.

The primary benefits to IEA countries are:

- *energy security*

Recent oil price volatility highlights the need to be continuously concerned about energy security. Dependency on oil imports for the IEA region as a whole was over 55 per cent of total oil requirements in 1998 and could grow significantly in coming decades. Such dependency over an extended period is unsustainable. Renewable energy can relieve some of that increasing need for imported fossil fuels, and reduce dependence on foreign sources.

The distributed capability of renewables-based generating capacity brings generation closer to the end-use, thus minimising transmission concerns and costs. The Renewable Energy Working Party also believes that greater use of renewables in the energy portfolio can minimise overall generation costs relative to the risk. Energy policies should focus on developing efficient generating portfolios that do not solely rely on stand-alone costs but also on expected portfolio risk, including year-to-year cost fluctuations.

- *environment*

Directly or indirectly, environmental concerns dominate the thrust for expanded deployment of renewable energy technologies. Climate change concerns that arose during the late 1980s have created a new impetus for clean, low-carbon energy technologies, such as renewable energy technologies.

Renewable energy received important backing from the Kyoto UN Climate Change Conference in December 1997. The greenhouse gas emissions reduction targets of the Kyoto Protocol imply that developed countries will pay particular attention to renewable energy because of its great potential for reducing global greenhouse gas emissions.

However, while renewables can contribute to resolving environmental issues, including global climate change, there are still some environmental issues to be addressed. Particularly at the local level, concerns such as land use, interruption of animal and bird migration patterns, noise and visual impacts, all need to be addressed in siting renewable facilities.

The Renewable Energy Working Party believes that, on balance, renewables offer the best-cost strategy in achieving environmental goals.

• *economic growth*

Renewable energy has several important economic benefits. In IEA countries, the main economic benefits are employment creation and increased trade of technologies and services.

• *employment*

There are important job creation benefits from a strategy for greater promotion of renewable energy technologies. Employment is created at different levels, from research and manufacturing to services, such as installers and distributors. Renewable energy has created more than 14 million jobs worldwide [3]; every renewable energy industry is rapidly expanding its workforce.

• *trading technologies and services*

Renewable energy technologies and related services have a domestic market appeal but they can also drive exports to meet the growing international demand. For example, Denmark's successful wind turbine industry is a model of how to become a world leader in exporting technology and services. Denmark maintains a hold on more than 40 per cent of the world market and its companies' sales increased 10 times in nominal terms between 1988 and 1997.

The Renewable Energy Working Party believes that renewables generate a wealth of economic benefits that increase their value to society beyond the power they provide.

3 Canadian Association for Renewable Energies, Trends in Renewable Energy, Issue #150, October 2-6, 2000.

The Benefits of Renewables in Non-OECD Countries

Renewables' benefits to non-IEA countries are many. In urban areas, renewables contribute to energy supply diversity and to local economic development. In rural areas, renewables can be the key to aspirations for development, and can contribute to agricultural productivity, health, education, communications, entrepreneurship, and home quality. They can contribute to local economic development, expanded industrial capacities and even export capabilities. In this regard, they can support aspirations for progress and equality.

Over 1.6 billion people, in parts of the developing world where population is growing most rapidly, are still without modern energy services such as lighting, fresh water and many other services. While considerable efforts have been made through various bilateral and multilateral aid programmes to provide better services over the past two decades, there has been a large core of people who have not reaped the benefits of modern electric services. The new generation of renewable energy technologies provides a relatively low-cost, cost-effective means to provide such services.

Many renewables are well suited for off-grid uses. Their operational costs are often lower and, once operational, are not subject to the fluctuations of energy prices. Reducing the need to extend grids also reduces costs significantly. The expanded use of renewables can not only help support local manufacturing and thus create local employment, but their increased use can also provide environmental benefits. For example, by improving the efficiency of wood stoves, a new generation of renewable energy technologies can reduce the negative health effects of indoor pollution, as well as reducing the impacts of collecting wood for fuel from a widening area around a village.

What is needed to bring renewables into the mainstream

There is a convergence of important factors that affect the overall value of renewables. The market for renewable energy technologies is fairly robust. There is strong investment in new manufacturing capacity, there are more services available and, in some regions and technologies, there is important capacity expansion underway. However, while there is clear progress, renewables have not achieved "market take-off" whereby these technologies can compete in the marketplace on their own merits without added government support.

A policy framework must be created that will provide a more level "playing field" because rules, laws and systems have built up over the last century based primarily on fossil fuel-based systems.

Even with the market success that has so far been achieved, the new generation of renewable energy technologies do not have sufficient market experience to have lowered their overall systems costs to be commercially competitive without additional government support. Recent IEA analysis on experience curves shows that long-term support is needed, from technology development through to commercialisation. The results of this analysis, presented in the IEA publication, Experience Curves for Energy Technology Policy, provide an important justification for continued government support. However, the form of this support must clearly vary from technology to technology and from country to country, depending on the overall policy framework in place.

The appreciation of the "value" of renewables has evolved significantly in recent years, reflecting changes in the energy industry and the sense of growing urgency to rectify the consequences of energy use.

The IEA has also shown that this building upon the results of the past needs, in many respects, to be undertaken at an international level. International cooperation, whether for research and development, mobilising investment, creating markets or sharing experiences, is a powerful tool in itself.

The benefits of renewables are clear and straightforward. New analyses show that traditional approaches must be reconsidered because traditional solutions are not meeting the new challenges: environment, economy, and social well being. Renewable energy can be one of the new solutions to minimise future environmental degradation, assure reliability of services, and provide better services at lower overall costs.

However, the immediate challenge is to ensure that the energy framework reflects environmental security and social values, and is a step in the right direction to bringing renewables into the mainstream.

Chapter 1

Renewable Energy in the Context of the IEA

We recognise that each country will choose that mix of fuels it considers most appropriate: oil, gas, coal, nuclear or renewables. We intend that renewable energy should play an increasing role…
IEA Ministerial Communiqué, May 2001

IEA Ministers are giving much greater emphasis to renewable energy at a period when energy prices are volatile, there are localised energy supply problems, there are long-term energy security issues and there is urgent concern about the environment. Ministers also stated that: "the experiences of the last two years have underscored that a secure supply of affordable energy is not a foregone conclusion".

Affordability is a key issue, because energy security is unsustainable if not affordable. "Affordable" is not an absolute concept, because what is affordable in one region of the IE A may be prohibitively expensive in another. What is affordable in IEA countries may not be so in developing countries. What is affordable in special-purpose markets may not have sufficient affordability in baseload applications. Yet what has recently become affordable was not the case only a few years ago. However, Ministers believe it is possible to have both affordable energy and an increased role for renewable energy in the menu of options that will contribute towards energy security and other IEA priorities.

This report shows that renewable energy today is cost-competitive for many uses, and is more competitive than generally believed if a full accounting of environmental security and diversification costs are included in comparisons between different energy forms. Yet these "external" costs will certainly be paid for in other parts of the economy or society, either today or by future generations. This certainty underscores the justification for policymakers to provide incentives for renewable energy.

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.

As renewables have become increasingly cost competitive over the past decade, the IEA has been moving towards greater use of renewable energy. As recently as 1993, the Ministers agreed upon "Shared Goals," which referred to the development of economic non-fossil sources as a priority. The guiding principles of those Shared Goals – energy security, environmental protection and economic growth – underpin the activities of the IEA as well as policy analysis and decisions and, taken in their entirety, clearly imply the greater use of renewables. Further, in early 2001, the IEA included support for renewable energy in its strong statement supporting sustainable development: [4]

"The transition to a sustainable energy future will be complex and will take time. We need to change not only the structure of the energy sector, but also the behaviour in our societies and economies…"

"The challenge is to find worldwide economic growth with a secure and reliable energy supply, without despoiling our environment. It is possible. Energy supply needs to be further de-carbonised, diversified…"

This report represents the views of the IEA's Renewable Energy Working Party, the committee of national representatives tasked with advising the Member Governments on issues relating to renewable energy. This group received the IEA Ministers' intention that renewables should play an increasing role, as a call to expand its work in promoting renewable energy to ensure that it can meet the expectations and challenges of the future.

There are, indeed, many technologies available that could be deployed more widely to make an immediate, significant, cost-effective difference to energy balances. The moment is propitious for renewable energy with respect to the goals of energy diversification and security of supply. Moreover, with the concern raised by the protection of the environment and the need to have a sustainable energy system in the medium to long-term, there is growing public interest in, and acceptance of, renewable energy.

Renewable energy can contribute to IEA and global energy systems well beyond its cost per kilowatt-hour. Renewable energy is linked to many economic, environmental and social benefits that are sorely needed, both in the IEA and throughout the world. Renewable energy technologies can provide cost-effective energy services (electricity, heat and transport fuels) that are either not available through traditional sources or are too expensive for widespread use. They can create jobs, provide cleaner air, capital, trade opportunities and a wealth of other benefits, including diversification and a secure supply. Renewable energy is intrinsically linked to sustainable development.

4 www.iea.org

The technologies themselves have made great technical progress in recent years, reducing costs and improving reliability for baseload applications, as well as some important special-purpose markets. Prospects for further progress are promising, yet non-technical issues will largely determine the future direction.

The energy sector in IEA countries and, increasingly, globally as well, is in the throes of dynamic, fundamental changes. A trend in many regions of the world towards deregulation or liberalisation is leading to increased competition, particularly for energy utilities that were once considered the domain of monopolies. This is uncharted territory, and traditional energy industry models need to be reviewed because they do not thrive on these dynamic market conditions. How these new market circumstances will affect the deployment of renewables is unclear, but even deregulated markets can be subject to the impact of government priorities, such as energy security and a clean environment. However, policies to fully integrate energy security and environmental priorities into a competitive energy model have not been fully implemented. This market failure has left renewables competing in a framework designed around conventional technologies, where diversification, security and environmental considerations are "external" to cost comparisons.

Sustainable development depends on secure and reliable sources of energy, one of the key concerns of the IEA. As the IEA Statement on Sustainable Development says, "Policymakers must look to the long term, taking action today to avoid longer term social, economic or environmental disruptions, while retaining flexibility to alter course when the existing path proves to be unsustainable". Environmental issues are also linked closely with the drive towards a more sustainable development path and the related drive to develop and deploy cleaner technologies, including renewable energy. Renewable energy also supports the third pillar of sustainable development – social welfare – by contributing to social development, thus providing modern energy services that help improve education, public health and help alleviate poverty.

This report reviews renewable energy options individually in terms of their value – their benefits – to both IEA and non-OECD countries in terms of expanding the availability of energy services and contributing to sustainable energy development. This report is designed to contribute to the public discussion on clean energy technologies, and how they are to be deployed in a more dynamic, less regulated, energy system.

Renewables offer significant value to society, as well as to individual customers. The progression of renewables to the market can be understood as typical of any technology development that is encouraged by long-term government interest and support. The returns on such support can be measured in terms of the benefits to society from renewables market expansion. Government investment is most effective if coordinated among nations, as well as with the private sector.

Chapter 2

Renewable Energy Today

2.1 Introduction

For the IEA region as a whole, the share of renewable energy (including both small and large hydro) in Total Primary Energy Supply (TPES) in 1999 was just over 6 per cent, compared to just 4.5 per cent in 1973 [5] (see Table 2.1). The share in OECD countries, however, did not change significantly throughout the 1990s, in part because overall energy demand in IEA countries was buoyant. This means that the market for renewable energy technologies is strong, but growing from a small base in a growing energy market.

These aggregate data do not fully reflect the relative importance of renewable energy in all IEA countries. Renewables play a significant role in many regions and localities. In eight IEA countries, renewables represent more than 10 per cent of TPES, when both hydro (large and small) as well as non-hydro sources are included. Five IEA countries (Austria, Finland, New Zealand, Sweden and Turkey) report more than 10 per cent of their TPES from non-hydro renewable sources (see Table 2.1).

Table 2.1
Total Share of Renewable Energy and Energy from Wastes in TPES, 1999

	Hydro (%)	Non-Hydro (%)	Total (%)
Australia	1.3	5.0	6.3
Austria	12.3	11.6	23.9
Belgium	—	1.4	1.4
Canada	12.3	4.5	16.8
Denmark	—	9.3	9.3
Finland	3.3	18.8	22.1
France	2.4	4.6	7.0
Germany	0.5	1.4	1.9
Greece	1.5	4.1	5.6
Hungary	0.1	1.5	1.6
Ireland	0.5	1.3	1.8
Italy	2.3	2.8	5.1
Japan	1.4	1.9	3.3
Luxembourg	0.2	1.1	1.3
Netherlands	—	1.8	1.8
New Zealand	11.1	21.0	32.1
Norway	39.1	5.6	44.7
Portugal	2.7	5.5	8.2
Spain	1.7	3.6	5.3
Sweden	12.1	17.6	29.7
Switzerland	12.9	6.0	18.9
Turkey	4.2	10.2	14.4
United Kingdom	0.2	1.0	1.2
United States	1.1	4.3	5.4
Total IEA	**2.2**	**3.9**	**6.1**

5 IEA, Energy Balances of OECD Countries, 1998-1999, OECD, 2001.

OECD	2.2	4.0	6.2
OECD Europe	2.5	4.0	6.5
OECD Pacific	1.4	2.5	3.9
OECD N. Amer.	2.2	4.5	6.7

Source: IEA, Energy Balances of OECD Countries, 1998-1999

The World Energy Assessment [6] (WEA) estimates that approximately 14 per cent of world primary energy consumption in 1998 came from renewables. Most of that was in the form of traditional biomass or large hydropower. The WEA estimates that new renewables [7] provided around 2 per cent of global energy supply. The total renewable energy contribution is significantly higher than for the IEA as a whole.

2.2 The Technologies

Renewable energy technologies, particularly hydropower, traditional biomass, solar thermal and wind, are well established in world markets (or are rapidly establishing themselves, e.g. photovoltaics), and have established industries and infrastructures. Other renewables are fast becoming competitive in widening markets, and some have already become the lowest cost option for stand-alone and off-grid applications. The capital costs for many renewable energy technologies have been halved over the last decade and are expected to halve again over the next decade.

The following table, prepared for the World Energy Assessment, provides an overview of the renewable energy sources, the technologies involved and their uses (see Table 2.2).

Table 2.2
Categories of Renewable Energy Conversion Technologies

Technology	Energy Product	Application
Biomass energy		
Combustion (domestic scale)	Heat (cooking, space heating)	Widely applied; improved tech. Available
Combustion (industrial scale)	Process heat, steam, electricity	Widely applied; potential for improvement
Gasification/power production	Electricity/heat (CHP)	Demonstration phase
Gasification/fuel production	Hydrocarbons, methanol, H2	Development phase
Hydrolysis and fermentation	Ethanol	Commercially applied for sugar/starch crops; production from wood under development
Pyrolysis/production of liquid fuels	Bio-oils	Pilot phase; some technical barriers
Pyrolysis/production of solid fuels	Charcoal	Widely applied; wide range of efficiencies
Extraction	Biodiesel	Applied
Digestion	Biogas	Commercially applicable

6 UNDP, UN Department of Economic and Social Affairs and World Energy Council, World Energy Assessment, Energy and the Challenge of Sustainability, New York, 2000, p. 220.

7 'New renewables' are defined in the WEA report as modern biofuels, wind, solar, small hydropower, marine and geothermal energy. WEA, op.cit., p. 480

Technology	Energy Product	Application
Wind energy		
Water pumping and battery charging	Movement, power	Small wind machines, widely applied
Onshore wind turbines	Electricity	Widely applied commercially
Offshore wind turbines	Electricity	Development and demonstration phase
Solar energy		
Photovoltaic solar energy conversion	Electricity	Widely applied; rather expensive; further development needed
Solar thermal electricity	Heat, steam, electricity	Demonstrated; further development needed
Low-temperature solar energy use	Heat (water and space heating, cooking, drying) and cold	Solar collectors commercially applied; solar cookers widely applied in some regions; solar drying demonstrated and applied
Passive solar energy use	Heat, cold, light, ventilation	Demonstrations and applications; no active parts
Artificial photosynthesis	H2 or hydrogen-rich fuels	Fundamental and applied research
Hydropower		
	Power, electricity	Commercially applied; both small and large-scale applications
Geothermal energy		
	Heat, steam, electricity	Commercially applied
		Ocean energy

Source: adapted from UNDP, UN Department of Economic and Social Affairs and World Energy Council, World Energy Assessment, Energy and the Challenge of Sustainability, New York, 2000, p. 221.

The following section describes the main technologies, including a review of their key attributes and the value they bring to the energy system.

Bioenergy

a) Current Situation and Applications

Bioenergy resources are widely available worldwide and have the largest share of all renewable energy sources. Biomass resources come in many forms. Traditionally, wood, crop residues and animal waste have been used for heating or cooking, but today biomass is also used in many other ways. Municipal solid waste (MSW) can be used for heat or electricity. Landfill gases can be used for heat, electricity or fuels. Biological conversion of MSW using anaerobic digestion can produce electricity, heat or fuel gas. Wood and wood wastes can be used to produce electricity, heat for industrial purposes or domestic space heating.

Combustion of Solid Wastes

MSW is used to produce heat or electricity, or both, in cogeneration systems. It is an excellent feedstock for district heating or cogeneration, offering a tremendous potential to local

authorities that must deal with growing waste concerns. This is equally true in IEA and non-OECD countries.
The technology is well proven and cost effective.

Anaerobic Digestion of Wastes

MSW or industrial waste is used to produce biogas that, in turn, can produce heat, electricity or fuel gas. It is an emerging technology that is moving closer to full commercialisation.

Landfill Gas from Wastes

Recovering energy from landfill gases is a mature technology that is being utilised in more than 500 schemes in 20 countries. The energy can be converted to heat electricity or engine fuel. The markets can be local or grid-based.

Energy Forestry and Energy Crops

These technologies range from traditional stoves and heaters through to modern, innovative systems. In many regions of the world this is the most common form of energy use for heating and cooking. However, it has been difficult to measure usage because of its diverse applications and the fact that many biomass projects are non-commercial.

Modern applications range from individual use for heat or cooking through to district heating and cogeneration systems, and biomass can also be used for larger commercial or multi-family dwellings.

Biofuels

There has recently been growing interest in producing liquid fuels from grain and dedicated energy crops (often sugar crops). This is the only renewable source of liquid transportation fuels, which can be in the form of ethanol or biodiesel. Ethanol is the more common application and has been used extensively in the United States and Brazil. Ethanol is generally blended with petrol at concentrations of 5-10 per cent. The addition of oxygenates, such as ethanol, to petrol can reduce the emission of unburned hydrocarbons.

Biodiesel is extracted from seed crops such as rape and soy. Market penetration is relatively small but interest is great. While the technology is commercially available, the cost of biodiesel production is relatively high. Biodiesel is often blended with automotive diesel in concentrations of 10-15 per cent.

b) Benefits

There is a wide variety of feedstock available. Much of that feedstock, e.g. municipal solid waste, solves disposal problems faced by local authorities.

Energy crops can bring major benefits to farming communities to supplement their income.

In many developing countries, improved combustion efficiency can bring many benefits relating to the pressure on woodlands (e.g. reduced resource base) and the problem of desertification.

Biofuels have important environmental benefits because they reduce exhaust emissions and their biodegradability means that fuel spills can be much less damaging.

c) Potential

The potential has been estimated to be in the range of 200-300 EJ/a (Exajoules per annum), up from the current 50 EJ/a. The potential is high due to the extent of the resource base in all countries, which can be expanded through bioenergy crops.

There is a great potential in both IEA and non-OECD countries for using municipal waste, because anaerobic digestion of wastes provides a strong alternative to landfill and yet deals effectively with much of the local waste concerns.

Wind Energy

a) Current Situation and Applications

Wind energy is considered one of the most promising technologies for electricity generation. Its recent deployment has been one of the fastest growing renewable technologies world-wide. Technical advances over the past two decades, combined with innovative marketing, have expanded capacity from around 2,000 MW in 1990 to 17,300 MW by the end of 2000 [8]. Europe is the leader with a total of over 12,500 MW by the end of 2000. The United States also has a large capacity, with more than 2,500 MW by the end of 2000. Outside the IEA, India leads the group with over 1,100 MW installed by 2000, followed by China with 265

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MW. Not generally included in the figures are approximately 1 million wind turbines used for water pumping in developing countries as well as tens of thousands used to charge batteries.

Wind turbines are seen to be increasingly competitive with conventional generating sources. They can be used as individual turbines or combined in wind farms. They can feed into electricity grids (either from large wind farms or individual producers) or used in stand-alone, off-grid applications. Costs have come down appreciably over the past decade and are now considered commercially viable in many situations.

Wind turbines have proven successful in locations such as islands, northern areas and other remote regions not adequately serviced by grids. They have also proven valuable in providing power for irrigation, watering cattle, cooling and desalination. [9] There is increasing interest in offshore applications, partially due to the stronger wind regimes, and partially to overcome siting limitations on land. The first offshore wind farm was constructed in 1991 in Denmark; a wind farm in deeper water opened in November 2000 in the United Kingdom.

b) Benefits

Wind turbine systems can be stand-alone or for grid-based electricity. Wind turbines come in a variety of sizes that can be as small as a few kilowatts, although the average new turbine is over 500 kW with a growing number exceeding 1 MW. Turbines have recently been getting larger as interest in wind farms increases. However, in some parts of the IEA region, small turbines for individuals are becoming more popular. They are important in remote regions, including islands and cold climates. Landowners can also make money by leasing land for wind farms.

Using wind turbines for mechanical pumping for irrigation and watering cattle is particularly important in developing countries.

Wind turbines have fairly low environmental impact, though noise, visual and siting limitations must be considered.

c) Potential

Global wind resources are ample and are theoretically capable of supplying a large percentage of energy needs. However, the practical potential is limited by a number of factors, including cost, variability and intermittency, and siting. There have been questions about wind potential, due to variability of output from changing wind speeds. Some researchers feel that these concerns are exaggerated and believe that contributions of up to 1020 per cent and more of total electricity supply are possible without compromising grid reliability [10].

9 See WEA, op. cit., p. 233.

10 See Michael Grubb with Roberto Vigotti, Renewable Energy Strategies for Europe, Volume II, Electricity Systems and Primary Electricity Sources, The Royal Institute of International Affairs, London, 1997, p. II.27.

Overall, the wind power market appears likely to continue to be strong. Industry representatives continue to revise their expansion plans upwards. Wind turbines are proving very popular in developing countries such as India, China and Latin America, which is aided through increasing support from IFIs (international financial institutions).

Solar Thermal Heating and Cooling

a) Current Situation and Applications

Solar thermal technologies, which provide heating and hot water for residential, commercial and industrial end uses, have a long history of commercial application. Several million hot water systems have already been sold worldwide. They have been used widely in building design and hot water heating, which are considered the easiest and most direct applications of solar energy. Solar space heating systems can be either water systems or air heating systems. The technologies are well developed for many of the applications, although more cost reductions to improve competitiveness are still being achieved. They are considered cost effective in countries with favourable climates, for example those below 40 degrees latitude, and increasingly there are new applications that are also cost effective above 40 degrees latitude.

Growth in the installation of new systems is strong, estimated at between 10 and 30 per cent per year, depending on the country concerned.

Solar thermal systems have proven popular for a variety of special-purpose markets, e.g. for heating swimming pools, where there are between 1 and 2 million m2 of collectors installed worldwide. Solar thermal systems supply hot water or cooling in hotels and other service areas such as hospitals where hot water consumption is high. There are several technologies available that provide space cooling.

Solar desalination is important in many parts of the world where fresh water for irrigation is at a premium.

Solar cooking has also proven popular. There are over 450,000 solar cookers installed in India, and a further 100,000 in China. An adapted form of solar cooker can be used to dry crops. This has proven effective in northern countries such as Finland, Norway and Switzerland.

b) Benefits

One of the main benefits of solar thermal systems is that there are no emissions. This is particularly beneficial for solar cooking as it avoids indoor air pollution, a major health concern in developing countries. Solar cooking is also important in regions where there is increasing scarcity of firewood or other options. However, one of the limits of solar cookers is that they can only supplement, and not fully replace, other cooking systems. It is estimated that they can save a third to a half of conventional fuel used for cooking [11].

Solar systems can be installed in most types of buildings throughout the world and they can easily be installed during renovation of existing buildings.

Solar desalination is important because around 30,000 square kilometres of land are taken out of use annually due to salt levels in the ground being too high.

Solar district heating can be an attractive way of supplying solar heat to existing district heating systems. An advantage is that they can be combined with other sources of energy. By including seasonal storage, as much as 50-70 per cent of the heat can be supplied by solar energy in countries with moderate climates.

c) Potential

Growth remains strong in many regions. In Europe, for example, the market is expected to expand by around 20 per cent per year. The market is also strong in developing countries, and is particularly buoyant in China. The potential for solar crop drying is high. The potential for solar drying worldwide is estimated to be between 600-900 PJ. The expanded use of electric heat pumps also shows good potential.

Solar heating can be constrained because of the mismatch between demand and supply (which is available when there is sun), thus requiring some form of storage. There are a variety of storage systems available, and a new generation of storage technologies are at the demonstration stage. There is still strong potential for cost reductions for hot water and space heating systems, which will make them even more competitive.

Cost reductions of up to 50 per cent for collections and around 30-40 per cent for total systems could be achieved by expanding manufacturing facilities in developing countries.

Photovoltaics

a) Current Situation and Applications

Photovoltaic (PV) systems use semiconductor materials to convert sunlight directly into electricity. They can be used separately or in hybrid form, in combination with another generating option such as other renewables or fossil fuels. The market for photovoltaics is expanding at 20-35 per cent per year. Costs have dropped to between one-third and

11 Ibid., p. 250.

one-fifth of 1980 levels. Total installed capacity is over 800 MW worldwide and, in 1999 alone, PV module production stood at 200 MWp worldwide.
As stepping-stones to a large-scale power market, PV is now cost effective in many specific-purpose applications, such as telecommunications, lighting, water pumping, leisure and signalling. Applications in hospitals can be valuable in regions where conventional energy supply is unreliable. Solar-based refrigeration is important for transporting medical supplies (particularly in rural areas) but also for transporting refrigerated goods in IEA countries. For example, in the United Kingdom, the success of a prototype trailer that uses solar power for refrigeration has led to one UK company commissioning two more trailers. These are used to transport perishable foods for a nationwide supermarket chain. One of the main benefits is the reduced emissions and noise from avoiding diesel generators for cooling [12].

A recent application, which shows good promise worldwide, is a PV system that floats and purifies water in landlocked areas [13].

b) Benefits

The popularity of PV systems springs from many positive attributes. They have been most successful in stand-alone applications, representing up to 80 per cent of total installations. They are highly reliable, with few breakdowns and are easy to use. They have few detrimental effects on the environment, with minimal visual impact. Their modularity makes them flexible and easy to increase capacity depending on demand requirements. Installation is quick and easy and they can be arranged to meet a wide range of power requirements. PV systems can be integrated into building materials (for example, roofing tiles or walls), thus reducing both capital and installation costs. In rural areas of developing countries, PV systems have proven important, as shown above, for transporting medical supplies.

12 CADDET Renewables Newsletter, Dec. 2000
13 CADDET Renewables Newsletter, Dec. 2000

Hybrid systems offer the benefit of continuous electricity generation, which is useful in stand-alone projects such as telecommunications, remote housing or tourist facilities. Hybrid systems are also useful on small islands or for village power.

Operating and maintenance costs are generally quite low, as PV systems are highly reliable. PV can be important in developing countries where the electricity infrastructure is poor or non-existent. The flexibility of PV has led to its increased use as roofing or other building-integrated system, thus reducing overall cost.

c) Potential

Some estimates suggest that total capacity could reach almost 12,000 MWp by 2010. Stand-alone applications will continue solid growth according to all assessments. Some consider that by 2010 the total installed capacity for grid purposes worldwide might be 4001,000 MWp.

A recent market assessment of the potential for using solar photovoltaic technology in Bangladesh concluded that half a million rural households could afford solar home systems as a source of electric power. It is estimated that only 15 per cent of rural households have received grid electricity in Bangladesh. PV could therefore be used to provide energy services currently not available. The global potential is high, considering that PV systems could be used in most of the 400 million households currently without electricity.

Solar Thermal Electric Power

a) Current Situation and Applications

High-temperature solar thermal power systems – also known as concentrating solar power – to produce electricity, and to some extent hot water, are showing good promise. These large-scale systems are on a path to becoming cost effective. Plants in operation are achieving costs of approximately US$ 0.12/kWh, which are the lowest of any solar technology. The technology can also be combined in hybrid form (solar thermal plants coupled with diesel generators), achieving costs of around US$ 0.08/kWh.

b) Benefits

The main benefit of solar thermal power technologies is that they can provide dispatchable power for peak or intermediate loads. These technologies can also be used in distributed, stand-alone applications and are suitable for fossil-hybrid operation or can include cost-effective storage to meet dispatchability requirements. The systems have low environmental impact and could be beneficial in remote areas as a source of electricity to small communities.

c) Potential

Siting is restricted to regions with the best solar resources but globally there is significant potential, especially in latitudes +/- 40 degrees latitude. This is not limited to the IEA region, which includes Australia, the Mediterranean region and southwest United States, as there are many appropriate locations in developing countries around the world on all continents.

Hydropower

a) Current Situation and Applications

Hydropower is the most mature form of renewable energy and accounts for a significant share of electricity generation worldwide. It is primarily used for baseload generation and can be used for peak power production. Hydropower represented approximately 18 per cent of world electricity production in 1997. Most hydropower comes from large hydro dams (greater than 10 MW). In 1997, only around 3.5 per cent of hydroelectricity came from small hydro plants. However, increasing focus on the potential and advantages of small hydropower has led to increasing attention to refine the technology and reduce site costs. Hydropower is mainly used for electricity production.

b) Benefits

Hydroelectricity causes no direct emissions; it is easy to quickly adjust the amount of power produced in response to shifts in demand. When power is not needed, large amounts of energy can be stored in high-level reservoirs, in so-called pumped storage. This can supplement intermittent power produced from other renewables, such as wind or solar. Hydropower operates successfully in regulated as well as in de-regulated markets, such as in the Nordic region.

There are some drawbacks because hydro dams can affect water flow, fish spawning patterns and flood considerable areas of land. Initial construction costs of large hydro can be a barrier. These disadvantages have often made large hydro schemes controversial. Electricity production can be affected during periods of drought or reduced precipitation but these factors are often predictable and thus reasonably wellmanaged. Ancillary benefits can include flood controls, irrigation, and recreation.

Because of the range of hydro system capacities, they can be sized according to the available resources as well as the needs of the consumer.

Small hydro is a simple technique that is easy to maintain and is well suited for distributed or stand-alone production.

c) Potential

There remains large, untapped potential for expanded large-scale hydropower, particularly in developing countries. In OECD countries, approximately 50-80 per cent of the potential has been achieved. While expansion of large-scale hydro has been hampered due to environmental concerns, there is tremendous interest in small hydro applications. Most future large hydropower projects are expected to be in non-OECD countries.

Small or micro-hydro schemes show great potential in both IEA and developing countries.[14-18]

Geothermal Power and Heat

a) Current Situation and Applications

Geothermal is used for power generation [19] or space heating. Electricity generation by geothermal is a baseload technology, and can be a low-cost option if the hot water or steam resource is at high temperature and near the earth's surface. With more than 70 years of commercial application, the technology is well established and commercially viable.

The use of geothermal is expanding, growing between 1975 and 1995 by around 9 per cent per year (for electricity production) and 6 per cent per year (for direct use) [20].

Over 46 countries are currently exploiting geothermal power and heat resources. The largest capacity gains through the 1990s were in the Philippines and Indonesia but they still trail the United States in total installed capacity.

The use of heat pumps is becoming more popular in countries such as the United States.

b) Benefits

Emissions can result from geothermal production, including carbon dioxide and hydrogen sulphide, but they are considered to be much lower than emissions from fossil fuels. Brines can be produced in sedimentary basins, which are re-injected into the reservoir.

Because the environmental impacts are not yet fully understood, the IEA relies on a task force from one of its Implementing Agreements to provide a comprehensive environmental assessment.

14 CADDET Renewables Newsletter, Dec. 2000
15 CADDET Renewables Newsletter, Dec. 2000
16 Ibid.
17 www.awea.org
18 See WEA, op. cit., p. 233.
19 See Michael Grubb with Roberto Vigotti, Renewable Energy Strategies for Europe, Volume II, Electricity Systems and Primary Electricity Sources, The Royal Institute of International Affairs, London, 1997, p. II.27.
20 WEA, op. cit., p. 255.

c) Potential

There are identified geothermal resources in more than 80 countries and the accessible resource base is estimated at 600,000 EJ. The useful accessible resource base for electricity production is estimated at 12,000 TWh/year [21]. Only a small fraction of that has been exploited.

Ocean Energy Systems

a) Current Situation and Applications

Oceans provide a number of recoverable energy sources through technologies such as tidal barrage, wave energy, tidal/marine currents, OTEC (ocean thermal energy conversion), salinity gradient/osmotic energy and marine biomass.

Of the ocean technologies, tidal energy is considered the most predictable because its variation over the tidal cycles can be predicted with considerable accuracy. Wave power depends on the weather and so is more intermittent. Ocean currents are relatively constant, but have not been fully mapped for their commercial potential.

b) Benefits

The environmental impact is low. There have been some concerns raised about tidal systems interfering with wetlands and basins, and concerns about interference with ocean transport have been raised for wave and current systems.

c) Potential

Few schemes are currently commercial and the results obtained to date are very site-specific. However, most marine technologies are considered commercially immature, are not well developed, and will require additional work with respect to their integration. But the technical feasibility of ocean systems has now been definitely proven, especially by the prototypes of the most recent generation of technologies.

There is strong interest in ocean energy, which is justified by the huge amount of energy supply it represents as well as by the worldwide availability of this energy source. This is a renewable energy field that needs more R&D effort to make it a more viable option.

Ocean energy systems offer the promise of lowcost reliable electricity principally to coastal regions. Ocean systems have shown themselves to be technically viable, but have not yet proven their economic competitiveness. Still at the beginning of the commercialisation process, ocean systems require demonstration and a protected entry market in order to thrive.

21 Ibid., p. 255.

Hydrogen

a) Current Situation and Applications

Hydrogen [22], together with new and renewable energy technologies, has long been identified by the IEA as a major potential contributor to the sustainability of the energy sector. In the longer term, it can indeed act as the crucial storage and carrier of energy produced from renewables, in other primary sources.

It is now mainly at the demonstration stage, although there is a growing market for stand-alone systems in buildings and vehicles.

b) Benefits

One of the main benefits is the size of the resource base. Used in fuel cells, hydrogen also has the advantage of being a good source of energy for off-grid, grid or transport purposes, but hydrogen is currently relatively expensive, requiring more R&D to reduce costs.

c) Potential

There are high expectations for the future use of hydrogen and there are significant RD&D efforts underway for all applications. One of the concerns relates to the size of the fuel cells needed, and efforts are underway to reduce dimensions, to make them more appropriate for vehicles and stationary applications.

22 Only relating to hydrogen derived from renewable resources.

2.3 Concluding Comments

Renewables today provide an abundant array of technologies to satisfy a wide range of energy needs. For those technologies that are already commercially available, the markets are fairly robust. While the overall share of renewables has not changed significantly in the portfolio, the technologies are competing in an increasingly dynamic energy environment and are learning to compete well.

While acknowledging that those renewables with large future potential still require considerable R&D, it is worth noting that they have already proven to be technically feasible. Given that renewables are needed to build a sustainable, diversified and secure energy system in the long term, these R&D efforts should be sustained and even increased.

The following chapter builds on the current progress to develop a better understanding of where renewable energy is going in the future. Chapters 4 and 5 contain a more complete assessment of renewable energy benefits.

Chapter 3

Renewable Energy Tomorrow

3.1 Introduction

The future of renewable energy is affected by a number of factors, perhaps the first of which is technology. Renewables have experienced significant technological progress to improve reliability, efficiency and reduce overall costs, not only in the specific technologies themselves but also in the integration into grids, improving materials, modularity, better control systems etc. Hybrid systems provide one solution to help improve the market penetration of renewable energy technologies.

There is a push and pull effect that will crucially affect the future. There is a push by governments as they set policies to promote a more diversified and robust energy system. The renewable energy manufacturing industry is also setting targets and implementing measures to ensure that these targets are met. There is also the push from other policies, such as environmental protection, which indirectly support renewables by underpinning development of appropriate, clean technologies for the future. This redefining of the policy framework can provide strong support for renewables.

The pull comes from end users who are demanding more services. In some cases there is demand to introduce renewables based on the intuition or calculation of their benefits. In other cases the demand is for cheaper, more reliable, or cleaner energy production. There are many forms of expression for these needs. (Chapters 4 and 5 provide more details of the benefits that can be derived from the wider deployment of renewable energy technologies.)

The future, however, is perhaps primarily a function of the value that is placed on such concepts as sustainable development, rural development and electrification, eradication of poverty, greater equity in providing energy services globally, diversification of the energy mix, and cleaning up the environment. The IEA's recent World Energy Outlook provides a better understanding of the potential in the future use of renewable energy.

It is also important to look at the different technology areas in terms of their pathway to full market "take-off". The paths that each of the technologies will follow are unique, but each is likely to achieve a point in the future where government intervention to achieve competitiveness with conventional technologies is no longer necessary. This market "take-off" can be seen as the transition point to broad acceptance of renewables as being competitive against conventional alternatives. This will occur when reducing costs intersect the strengthening policy frameworks.

3.2 The IEA's World Energy Outlook 2000

The IEA's latest World Energy Outlook 2000 (WEO 2000), in its reference case ("business-as-usual"), shows the non-hydro share of renewables growing from the current 2 per cent of TPES to 4 per cent of TPES by 2020 in the OECD region, but dropping from 3 per cent of TPES globally to 2 per cent by 2020. Globally, hydroelectricity provided 18 per cent of electricity output in 1997. Throughout the world, hydroelectricity is expected to increase by 50 per cent between now and 2020, even though its overall share of TPES will decrease. More than 80 per cent of the increase will take place in developing countries.

Non-hydro renewables are expected to be the fastest growing primary energy sources, with an annual growth rate averaging 2.8 per cent over the period to 2020. Even then, the non-hydro renewables share of global primary energy will only increase from the current 2 per cent to 3 per cent.

For the first time, the World Energy Outlook 2000 provides an Alternative Case with a higher environmental sensitivity for OECD countries, [23] showing non-hydro renewables' share of electricity generation increasing significantly in OECD countries compared to the reference case, rising more than four times, from 2 per cent in 1997 to 8.6 per cent in 2020. The WEO 2000 states that to achieve the Alternative Case, "more aggressive policies to increase the contribution of renewables substantially may be put into place during the projection period [24] ". This also includes additional emphasis on R&D. The Alternate Scenario anticipates cost reductions of renewable energy technologies to decline at a more rapid rate, becoming cost-effective in a wider market than the reference scenario.

There are also important CO2 emission reductions in the alternative case compared to the reference case, decreasing by 6 per cent in the electricity sector by 2020, due to the increased use of renewables.

3.3 Market Pathways

WEO 2000 shows that there is the potential to achieve a greater share for renewables under the Alternative Case, if more vigorous policies are implemented. General policies to support renewables normally have limited effects because each renewable energy technology, as seen above, follows its own path of marketability according to its attributes, applications and state of technical development. It is believed that more targeted interventions will provide better impact.

23 There is no projection in the Alternative Case for non-OECD countries.
24 WEO 2000, p. 292.

To this end, the IEA's Renewable Energy Working Party has been assessing how to effectively accelerate the market deployment of these technologies. Discussion focuses on market "take-off", where further government support is not needed. A strategy must be unique for each technology area in order to reflect individual pathways and, conceivably, there will be sub-sets within technology areas because of the differing applications (e.g. for electricity generation or for heat).

The strategies generally follow five steps to achieve market acceleration and the sought after market "take-off." These include:

- *Accelerate technology development*

Even in the most advanced technologies, such as hydropower, further technology development will reduce costs to improve market competitiveness. Strategies are being developed concerning the R&D or demonstration projects that are needed, and who is best placed to undertake these activities.

- *Strengthen national policy frameworks*

For renewables to compete fairly, a policy framework must be established that rewards technologies for delivering on environmental, economic and social objectives, and penalises those technologies that do not. As long as policy frameworks ignore environmental, economic, diversification and social goals in the calculus of competition, incentives to spur renewables are justified. However, a long-term policy framework that reflects and values sustainable development and objectives is a preferable environment to spur renewables growth.

An important task is to identify national factors hindering development and help countries identify ways of eliminating them. For example, there is often low public and decision-maker awareness of the potential, or the state of, these technologies. Policy frameworks often advantage the more conventional, higher pollution technologies. Utilities have less experience with renewable energy and thus gravitate towards conventional fuels.

- *Reduce market barriers and industry startup costs*

Barriers to renewables have arisen due to their emergence into the market while the characteristics of renewables are not yet reflected in policy mechanisms. For example, renewables were not well understood or appreciated when some international agreements were signed, raising obstacles to renewables in otherwise important agreements. Similarly, important duties are sometimes applied, based on classifications developed for mature commercial products, not renewable energy. These barriers have a significant negative impact on renewables competitiveness and should be relatively easy to remove.

Transitional overheads include all initial cost elements to develop the infrastructure to support commercial products in a national market. Once these investments are made, they do not need to be repeated, as they are typically “start-up costs”. Targeted national policies to mitigate these costs would boost potential market growth. Examples include assessing market potential, completing exploration and pre-feasibility activities (e.g. in the case of geothermal), investing in new transmission lines where needed to connect renewables to the grid, and examining the possibilities for new financing and insurance instruments to decrease induced risk and reduce the cost of capital in project cash flows.

• *Mobilise market investment*

Many of the technologies need greater participation from the private sector. More effort can be made to attract private sector financing by increasing the visibility of the technologies and providing information on market opportunities and conditions. There are cases where this is working, e.g. the private sector is taking much of the lead in PV technology.

• *Promote international cooperation*

Bringing together a number of like-minded countries that wish to develop a specific resource can strengthen markets. By combining forces even more than is occurring today, project and infrastructure costs could be reduced significantly. International cooperation can also play an important role in developing technical standards as well as RD&D. In effect, international cooperation ensures more efficient use of all human and financial resources. International cooperation can strengthen capacity building in developing countries as well as supplying business and technology components needed to develop and maintain projects. International cooperation can also mobilise investments through such mechanisms as the Clean Development Mechanism or many of the renewable energy funds set up by the international finance institutions.

3.4 Conclusions

The WEO 2000 Alternative Case shows that there is a good possibility of having renewables achieve more than the business-as-usual scenario. The WEO 2000 explains that it will take new policies to accelerate renewables, and the REWP is developing strategies so that these technologies can be embraced in the market. Understandably each technology area will follow a different path.

Chapter 4

The Benefits of Renewables in IEA Countries

4.1 Introduction

The potential contribution of renewables to IEA countries is growing, as the technologies mature and there is growing awareness of the full contribution that renewables can make. Those benefits go well beyond their contribution to energy balances alone. The generally high costs of energy output (e.g. per kWh) for many renewable energy technologies often do not account for the full economic and social benefits. Without calculating such benefits the perceived high capital cost may be misleading, potentially leading to poor investment decisions in the long run. This chapter assesses the benefits of renewables to IEA countries, while the following chapter considers the main benefits to non-OECD countries.

Sustainable development has become an important goal for the IEA and its member countries. In early 2001 [25], the IEA published a statement on sustainable development that further supports renewables. Two excerpts are particularly relevant:

Sustainability demands that we seek to change present trends. The challenge is to fuel worldwide economic growth with a secure and reliable energy supply, without despoiling our environment. It is possible. Energy supply needs to be further de-carbonised, diversified and the energy intensity of economic growth reduced.

The transition to a sustainable energy future will be complex and will take time. We need to change not only the structure of the energy sector, but also behaviour in our societies and economies.

The benefits of renewable energy are divided into three main categories: energy security, the environment, and contributions to economic growth. These categories effectively relate to the guiding principles of the IEA "Shared Goals". As the IEA Ministers stated in May 2001, these three guiding principles remain essential to sustainable development.

4.2 Energy Security

Energy security remains at the top of energy policy concerns in IEA countries because of the continuing dependency on fossil fuel imports for the IEA region as a whole and the importance that energy plays in modern economies. Oil imports were over 55 per cent of

25 www.iea.org

total oil requirements in 1998, and this is unlikely to change significantly in coming years. Although IEA countries have been successful in expanding markets for other resources, oil remains a major component of energy balances. Much of that oil is imported from regions where there are security concerns. The WEO 2000 reference case, for example, forecasts OPEC's share of world oil supply growing from 40 per cent in 1997 to 54 per cent in 2020 [26]. The IEA is sponsoring a number of activities to reduce these risks, e.g. the producer-consumer dialogue, but diversification remains an important objective.

IEA Ministers stated at their Ministerial Meeting in May 2001 that while oil, coal, natural gas and nuclear energy will dominate the energy mix for years to come, the "experiences of the last two years have underscored that a secure supply of affordable energy is not a foregone conclusion" and that they "support the continuing diversification of our energy systems – both by energy type and by source". Ministers specifically mentioned renewables in this context.

Renewable energy should be seen as a cost-effective means of providing some relief to energy security concerns because it is indigenous. For this reason, the WEO 2000 Alternative Case (see Chapter 3) is particularly positive because it will lead to a decrease in gas and some coal for electricity generation. The use of each fuel will drop by 2 per cent by 2020 for the OECD as a whole under the alternative scenario. The WEO 2000 does not see renewables eroding the dominant shares of fossil fuels [27].

The inherent characteristics of renewable energy technologies reduce or eliminate a number of risks and this adds to their overall value. Renewable energy is a domestic resource and thus less subject to transportation or supply disruptions. Renewable energy technologies can generally be sited closer to the end-use. Renewables-based generating capacity closer to the end-user minimises both transmission losses and costs. While there are relatively high capital costs, for most renewable energy technologies the fuel input has minimal cost. This means that the electricity or heat supplied is not prone to price fluctuations, as fossil fuels are.

Supply swings, in terms of shortages or large inventories, can also create even greater swings in end-use prices, which can have economic and social repercussions (see below) that in turn can affect energy supply industries as well as all categories of end-users. This is also an energy security concern, although of a different nature.

Accordingly, by providing an important contribution to energy supply, renewable energy also reduces risk. This is why renewable energy technologies provide inherent important financial benefits that challenge traditional analysis, once the basic financial fluxes have been implemented. Indeed, engineering cost models that are currently used for financial analysis in

26 WEO 2000, p. 77
27 WEO 2000, p. 298

the energy sector work reasonably well in an environment characterised by technological stasis and homogeneity – i.e. in an environment where all technology alternatives have similar financial characteristics and a similar mix of operating and capital costs. However, the current energy system is changing radically and the old environment no longer exists. Rather, in today's environment, the variety of resources options is broad and ranges from traditional, risky fossil alternatives to low-risk, passive, capital-intensive renewables with minimal operating cost risk. Renewables offer unique cost-risk choices as well as valuable flexibility and modularity attributes that traditional valuation models cannot assess because they were designed for a different technological era. Properly understood and exploited, the attributes of renewables could undoubtedly form the basis for re-engineering the electricity production and delivery process to create cost reductions in ways that cannot yet be imagined.

When correctly evaluated using modern financial analysis techniques, renewables are considerably more cost-effective relative to traditional fossil-based generation than widely believed, even without taking account of the avoided external environmental costs. This requires evaluating the technologies based on their contribution to overall financial risk. Passive, capital-intensive renewables, such as photovoltaics and wind, are essentially risk-free because their year-to-year costs remain unchanged and, even if there are some minor variations due to variable maintenance costs, these are not related to price variations of fossil fuels. Even though, on a stand-alone basis, renewables are often seen as expensive, modern financial analysis techniques, which focus on the medium-term evolution of the energy-based portfolio, show that a certain percentage of renewables in the overall fuel mix of a utility reduces the overall risk and the overall portfolio cost.

Undoubtedly, there are some risks with renewables such as equipment failure, but these are random and unsystematic and thus easily diversifiable. These costs can also be planned for and thus are not considered 'risky' in a financial sense.

Any portfolio should include some proportion of fixed-price power. Building optimal generation portfolios that include renewables is one alternative to dealing with price risk. The other alternative for individual firms is financial hedging strategies, but there is no evidence that financial hedging is superior or less costly [28].

4.3 Environment

Environmental concerns have been affecting energy policy for more than a decade as the energy sector has been identified as a major contributor to recent environmental degradation. Directly or indirectly, environmental concerns are one of the main drivers for expanded deployment of renewable energy technologies. As the IEA has stated for several years, the

28 Shimon Awerbuch, "Getting it Right: The Real Cost Impacts of a Renewables Portfolio Standard", in Public Utilities Fortnightly, February 15, 2000.

main benefit of renewable energy technologies is that they reduce emissions by displacing some fossil fuels [29].

Climate change concerns that arose in the late 1980s have created a new impetus for clean, low carbon energy technologies, such as renewable energy technologies. Renewables have also been promoted to reduce other emissions, such as SO_2 and NO_x [30]. Renewables also improve the general air quality, an important consideration in many locations.

Renewable energy received important backing from the Kyoto UN Climate Change Conference in December 1997, when the so-called Kyoto Protocol was agreed and where developed countries agreed to specific greenhouse gas (GHG) emission reduction targets. These GHG emissions reduction targets imply that developed countries will pay particular attention to renewable energy because of its great potential for reducing global greenhouse gas emissions.

Life cycle analysis shows that all renewable energy technologies emit significantly less carbon dioxide and other emissions than the three major fossil fuels. Carbon dioxide emissions based on life cycle analysis from coal for electricity generation are more than four times higher than for photovoltaics, which are seen as the worst of the renewables [31].
Tables 4.1 and 4.2 describe these emissions in more detail.

Table 4.1
Life Cycle Emissions from Renewables

	Energy Crops Current Practice (g/kWh)	**Energy Crops** Future Practice (g/kWh)	**Hydro** Small-scale (g/kWh)	**Hydro** Large-scale (g/kWh)	**Solar** PV (g/kWh)	**Solar** Thermal Electric (g/kWh)	**Wind** (g/kWh)	**Geotherm** (g/kWh)
CO2	17-27	15-18	9	3.6-11.6	98-167	26-38	7-9	79
SO2	0.07-0.16	0.06-0.08	0.03	0.009-0.024	0.20-0.34	0.13-0.27	0.02-0.09	0.02
NOx	1.1-2.5	0.35-0.51	0.07	0.003-0.006	0.18-0.30	0.06-0.13	0.02-0.06	0.28

Source: IEA, Benign Energy? The Environmental Implications of Renewables, OECD, Paris, 1998, p.45

29 See IEA, Benign Energy? The Environmental Implications of Renewables, OECD, Paris, 1998, p. 15.
30 According to the American Wind Energy Association, an "acid rain report, undertaken by the Hubbard Brook Research Foundation and published in the journal BioScience (vol. 51, no.3, 2001), found that, while sulphur dioxide (SO2) emissions have been reduced since 1970, ecosystems are not recovering as expected from acid rain damage in sensitive areas of the northeast. Emissions of SO2 from electricity generation need to be cut by an additional 80 per cent, with cuts in emissions of nitrogen oxides (NOx) as well in order for affected streams and other ecosystems to come back within the next 20-25 years, according to the study". See press release of May 2, 2001 on the AWEA's website, www.awea.org.
31 Ibid., p. 15.

Table 4.2
Life Cycle Emissions from Conventional Electricity Generation in the UK

	Coal Best Practice (g/kWh)	**Coal** FGD & Low NOx (g/kWh)	**Oil** Best Practice (g/kWh)	**Gas** CCGT (g/kWh)	**Diesel** Embedded (g/kWh)
CO2	955	987	818	430	772
SO2	11.8	1.5	14.2	-	1.6
NOx	4.3	2.9	4.0	0.5	12.3

Source: IEA, Benign Energy? The Environmental Implications of Renewables, OECD, Paris, 1998, p.45

There are also other important environmental benefits. These include improved water quality, reclamation of degraded land and habitats, abatement of pollution from transport and the reduced need to upgrade electricity distribution systems or for building new line capacity.

No conventional energy supply option is entirely environmentally benign, and the same is true for all renewable energy sources. These impacts can range from serious, sometimes almost irreversible damages to the biosphere or the atmosphere, to more essentially subjective consequences (e.g. visual) impacts, or those involving local or worldwide impacts (e.g. the increased greenhouse gas effect).

Bearing in mind the wide range of possibly unavoidable consequences of energy-linked activities, renewables seem particularly helpful in reducing the negative environmental impacts of energy use.

On the one hand, as with any technology, one has to acknowledge the concerns regarding land use, visual intrusion, noise and damage to ecosystems, and balance these against emissions advantages. Some concerns are local and site-specific and have hindered the deployment of renewable energy technologies. Noise, visual intrusion and land use of wind turbines, for example, have posed major problems in several countries. These concerns cannot be dismissed easily, but some IEA countries have been successful in addressing them through better planning and siting. For example, successful use of offshore sites or upgrading existing sites for wind turbines and better integration of PV cells on roofs and walls in building designs.

On the other hand, new “experiences” emerge where the disturbance brought about by a renewable energy technology (e.g. installing a new wind turbine) can be used by the local authority involved to begin a dialogue with the general public on energy generation. This allows them to take the opportunity created by the "visual" disturbance as a way of actively, but positively, letting citizens express their views and learn about the meaning of sustainable development at the local level. This indicates a new economic and sociological approach to the energy system.

4.3 Economic Growth

Renewable energy also offers several important economic benefits. As shown in Chapter 2, renewable energy technologies are cost-competitive and even less expensive in many circumstances, offering a big economic boost. Special-purpose markets are very important, because they are expensive to serve by conventional energy sources. In many developing countries (less so in IEA countries), these services simply cannot be provided by conventional sources.

In IEA countries, the other main economic benefits are employment creation and increased trade of technologies and services. These are described below.

• *employment*

There are important job creation benefits to be gained from the greater deployment of renewable energy technologies. Employment is created at different levels, from research and manufacturing to services, such as installers and distributors. One estimate shows renewable energy creating more than 14 million jobs worldwide [32]. Many of the new renewable energy industries (e.g. wind turbines or photovoltaics) are rapidly expanding their workforces.

32 Canadian Association for Renewable Energies, Trends in Renewable Energy, Issue #150, October 2-6, 2000

33 The study was undertaken by EUFORES. See www.eufores.org.

34 See Michael Renner, Working for the Environment: A Growing Source of Jobs, Worldwatch Paper 152, Worldwatch Institute, Washington, D.C., September 2000, p. 42. In the same report, Greenpeace Germany estimates that 14 jobs are created for every MW manufactured and installed.

One recently completed study funded by the European Union shows that more than 900,000 new jobs will be created across Europe by 2020 as a result of the increased use of renewable energy [33]. Of those, 385,000 will come from developing renewable electricity and a further 515,000 from biomass fuel production. The study found that renewable energy technologies are more labour intensive than conventional technologies for the same energy output. The study shows that conventional energy companies would lose less than 2 per cent of their workforce by 2020 as a result of the shift towards renewables.

A 1999 European study assumes that 17 job-years of employment are created for every megawatt of wind energy capacity manufactured, and a further five job-years for the installation of every megawatt, bringing the total to 22 job-years [34]. The study calculates that labour input will gradually decrease to 15.5 job-years per megawatt manufactured by 2010 and 12.3 by 2020 due to improvements in manufacturing productivity. Using the study's assumptions for the expansion of the wind turbine industry, it projects worldwide wind power employment to rise from 67,000 jobs in 1999 to approximately 1.7 million by 2020.

Direct employment in Danish wind turbine manufacturing increased to 3,800 jobs at the end of 1999, with a further 10,000 jobs in Danish component manufacturing.

The Solar Energy Industry Association (SEIA) in the United States reports that around 3,800 jobs are created for every $100 million of PV cell sales [35]. The SEIA estimates that there are approximately 20,000 employed in the PV industry in the United States, with 2,013 directly involved in manufacturing PV cells [36].

These employment figures illustrate the great potential for job creation by expanding the renewables industries. The renewable energy industries are increasingly high-tech industries that are relatively labour-intensive, providing a range of jobs from manufacturing, sales and installation. One of the advantages is that many of these jobs are created locally, thus contributing to the local economy and regional economic development. This is particularly true with respect to biomass industries that, according to European analyses, will be the biggest job creator in coming years.

• *trading technologies and services*

Renewable energy technology manufacturing and related installation and services, while often driven by local needs, can also be stimulated to meet growing international demand. Many of the technologies are taking advantage of economies of scale to expand manufacturing capability oriented to export markets.

35 Ibid., p. 44.

36 For direct employment statistics, see Energy Information Agency, Renewable Energy Annual 2000, Department of Energy, Washington, D.C., March 2001, p. 25.

Denmark's successful wind turbine industry is a model for world leadership in exporting technology and services. Denmark maintained 50 per cent of the world market in 1999 and, if joint ventures are included, Danish companies are involved in around 65 per cent of the world market. The domestic market could absorb only 17 per cent of Danish companies' production, with the rest exported. As electricity liberalisation in Europe is taking hold and because renewables do not have a guaranteed share of electricity production, domestic sales in Denmark are expected to contract, thus putting even more pressure on the need to expand export markets.

The PV industry is also largely driven by export potential. For example, in 1999, 72 per cent of production in the United States was exported.

The European Commission's 1997 White Paper on renewable energy [37] forecast a possible export trade of over $19 billion annually by 2010. Whether this is achieved or surpassed, this forecast shows the magnitude of the industry and its important contribution to the economy.

4.4 Concluding Remarks

For IEA countries, renewable energy technologies are already contributing to a wide range of needs and, in particular, the three pillars of sustainable development to which all IEA countries subscribe. While the positive evidence is mounting, it is still uncertain how renewables are being fully accepted and whether support is being converted into action.

While the global environmental benefits from renewables are many, particularly with respect to the greenhouse gas effect, and the IEA is definitely in favour of introducing more renewable energy sources into the energy portfolio in both IEA and other countries, additional advantages should also be remembered. In the medium term, introducing more renewables into the portfolio enables costs to be reduced, even without taking into account the external costs, with substantial employment possibilities in both high technology fields and more traditional ones. While renewables ensure both security of supply and access to energy, especially electricity in developing countries, through their diversity and distributed development renewables also offer the possibility to actively involve the population in participating in sustainable development. This is why a greater role for renewable energy should definitely be given in IEA countries.

37 European Commission, Energy for the Future: Renewable Sources of Energy, White Paper for a Community Strategy and Action Plan, COM (97) 599 final.

Chapter 5

The Benefits of Renewables in Non-OECD Countries

5.1 Introduction

Energy is a dominant issue in the development process. Human development depends on adequate energy. The price of energy affects all economic activities. The World Bank estimates that people in developing countries spend 12 per cent of their income on energy [38], which is five times more than the average person in OECD countries. In the poorest countries, much of the day is spent gathering fuel. For example, in Bangladesh it is estimated that women spend one to five hours daily to produce, collect, store and use fuel in cooking [39].

The benefits of renewable energy to non-OECD countries are perhaps even more important than in IEA countries. Non-OECD countries have always used traditional fuels for heating, lighting and cooking. Now there is the opportunity to use modern renewable energy technologies to expand the services available. New renewable energy technologies become all the more relevant as the costs associated with renewable energy development drop and become increasingly competitive in specific markets.

Non-OECD countries are not homogenous and the needs and benefits of renewable energy will vary. There are countries with fairly modern energy systems and needs similar to those of IEA countries. However, there are also countries that are expanding rapidly, but the cost of expanding and modernising their energy systems to keep pace with economic growth is prohibitive. This places a major burden on their economies and threatens to grind the development process to a halt. Several countries are in the transition process from a command to a market economy. There are also a number of countries and regions with poorly developed energy systems that do not adequately provide the benefits of modern energy services to move along the development process.

The WEO 2000 points out that continuation of past trends will mean a 60 per cent increase in world energy demand by 2020. Developing regions will account for 68 per cent of the increase between 1997 and 2020. By 2020 the developing countries will account for 50 per cent of carbon dioxide emissions, the OECD countries for 40 per cent and the transition economies for 10 per cent. By comparison, OECD countries were responsible for 51 per cent of global CO2 emissions in 1997. These trends mean that, from a strategic

38 World Bank Group Sector Strategy Paper, Fuel for Thought, Environmental Strategy for the Energy Sector, Draft June 29, 1999, World Bank Group, p. 1.

39 See www.worldbank.org, Seminar on Introduction of Renewable Energy Technology in Development Projects. Seminar in Dhaka, Bangladesh, November 18, 2000.

energy and environmental perspective, it is in everyone's interest to support the use of renewable energy in non-OECD countries.
In the more developed non-OECD countries and in urban areas, renewables can contribute to energy supply diversity and to local economic development. The increasing demand for energy probably cannot be met by any single source, so diversification, including renewables, is essential. In rural areas, renewables can make a major contribution to agricultural productivity, health, education, communications, entrepreneurship, and home quality. They can contribute to local economic development, expanded industrial capacities and even export capabilities – all of which can fulfil aspirations for social equity.

Many of the benefits described in Chapter 4 for IEA countries also pertain to non-OECD countries. The following section describes the main benefits of renewable energy specific to non-OECD countries, avoiding repetition of the benefits that also pertain to IEA countries.

5.2 Energy security and energy policy

Energy security is a priority policy concern for non-OECD countries. Their dependence on fossil fuels, often through imports, is often high. The fragility of many of the economies means that increased price volatility wreaks hardship, can have severe effects on their balance of payments and has relatively more detrimental social effects than in IEA countries. As seen in Chapter 4, renewable energy is virtually risk-free, particularly with respect to input prices, and this plays an important stabilising role. The risk assessment analysis in Chapter 4 also pertains to non-OECD countries.

Renewable energies are indigenous, not only at the national level but also at the local level, thus minimising energy supply disruptions. Indigenous sources reduce reliance on energy imports. Given the expectation that non-OECD energy demand will expand significantly over the next two decades, any reduction in imports will have important economic and energy security benefits.

From an energy policy perspective, expansion of the grid in developing countries is warranted and should be encouraged. However, cost and relatively low population densities often make expansion too costly to justify, because incomes are low and there is a poor economic base. The World Bank raises an important issue about affordability [40]:

The problem is not necessarily that people are unwilling to pay. Evidence suggests that people will spend a significant proportion of their income on better energy, which improves their quality of life or enables them to become more productive. In Bangladesh even the poorest people are connecting to the grid when service is available...

The problem is that rural customers often cannot get affordable credit...

To provide services without necessarily expanding the grid, there are several cost-effective options provided by renewables. Technologies such as small wind turbines, PV and small-scale or micro-hydro are well suited for off-grid uses [41]. This is particularly important in countries that have dispersed populations and undeveloped grid systems. Entire communities that are unconnected to the grid can receive electricity in this way. Where communities have electricity provided by diesel generators, renewables can reduce the need for, and transport of, fossil fuels. Renewable energy technologies are also often easier to maintain, thus reducing operating costs.

In colder climates, biomass can be used in district heating systems, reducing the need for fossil fuels. Using biomass can reduce price fluctuations that can occur with fossil fuels.

Modern wood stoves have a higher efficiency than older models. While the new ones have environmental benefits such as reduced emissions, they are also more efficient, requiring less fuel input for a given output. This reduces the quantity of wood required and reduces the time to collect the fuel. Currently, in many countries, many hours are spent gathering wood or other forms of biomass. The use of modern stoves can also substitute for kerosene-fuelled stoves, thus reducing the need for fossil fuels.

40 World Bank, Meeting the Challenge for Rural Energy and Development for Two Billion People, World Bank, Washington, D.C. See www.worldbank.org.

41 This benefit also holds true for IEA countries with communities that are not connected to a grid.

5.3 Environment

Environmental problems are of great concern to non-OECD countries. There are global issues such as climate change, but there are also many local environmental concerns, from air quality in cities, industry or homes, and desertification to water quality. The problems often take on a different character than in IEA countries because priorities such as economic development often relegate the environment to a lower priority. Despite high concern, countries often cannot afford to take adequate measures to alleviate the problems without bilateral or multilateral support.

The environmental benefits of renewable energy technologies have the same, as described in Chapter 4 for IEA countries, are the same in developing countries. Their life-cycle environmental benefits with respect to harmful emissions (carbon dioxide, sulphur dioxide and nitrous oxides), compared to fossil fuels, are well documented. Reducing these emissions is important globally because, as shown above, non-OECD countries are expected to cause 50 per cent of global carbon dioxide emissions by 2020. But the problems today are generally more local. For example, using kerosene for lighting has a harmful effect on air quality in houses. It must be added that inefficient use of biofuels in the home (for cooking, lighting or heating) can also have harmful effects on air quality. Using renewables to generate electricity for lighting can significantly improve indoor air quality.

The World Bank estimates that only one-third of developing country homes were connected to a grid in 1990 [42]. Understandably, a major aim of national governments, as well as bilateral and multilateral donors, is to expand rural electrification. However, one concern is that large-scale electrification, if fuelled by fossil fuels, will severely increase greenhouse gas emissions. Using photovoltaics, wind turbines or small hydro schemes would have considerable impact on reducing the potential increase of GHG emissions.

Renewables can improve water quality [43]. Energy plantations can substitute for arable crops, resulting decreased erosion rates and a parallel lowering of agrochemical levels that flow into water supplies. Energy crops can also treat sewage sludge. Solar thermal technologies can also be used to dispose of water pollutants such as agricultural and industrial wastes. Establishing an energy crop in an area formerly under relatively intensive agriculture can also stabilise and improve soil conditions as well as leading to increased wildlife diversity.

In December 2000, over 170 countries agreed that renewable energy is an important way to combat desertification around the world [44]. The fourth Conference of the Parties (COP 4) of the UN Convention to Combat Desertification and Drought approved a Declaration to mitigate

42 See Steven Kaufman, Rural Electrification with Solar Energy as a Climate Protection Strategy, Research Report No. 9, Renewable Energy Policy Project (REPP), Washington, D.C., www.repp.org

43 See IEA, Benign Energy? The Environmental Implications of Renewables, OECD, Paris, 1998, p. 48.

44 See www.unccd.int.

the effects of desertification by 2010 via a number of measures, including the development of renewable energy and reforestation. Desertification, which is occurring on all continents, is caused by many factors, including acid rain and other forms of pollution, population growth, industrial development and the overuse of land, often due to poor agricultural practices. Deforestation from the inefficient use of wood for cooking can also cause severe problems. It is estimated that 1.2 billion people are threatened by desertification. Over 30 national plans have already been prepared to tackle this problem, and other countries are now also working on developing national plans.

5.4 Economic and Social Development

It has been estimated that more than 1.6 billion people, in parts of the developing world where population is growing most rapidly, are still without modern energy services such as lighting, clean water and other services. To put this problem into perspective, in countries such as Bangladesh, only 15 per cent of the population have access to electricity. Over the past two decades, considerable efforts have been made through various bilateral and multilateral aid programmes to provide better services because a large proportion of the population have not reaped the benefits of modern services. The new generation of renewable energy technologies provides a relatively low-cost, cost-effective means to provide such services.

Providing electricity to a town or region previously without it opens a wealth of opportunities. Besides providing necessary lighting, electricity can encourage communications, provide refrigeration, allow modern health equipment to be used, improve agricultural productivity and lead to new enterprises of all types. Residents can have access to radio, possibly television, telephones and the Internet. Schools, health facilities and community recreation facilities can be improved by electricity for lighting or communications. Having electricity can also improve water supplies through better pumping facilities and sewage treatment.

Medical services can be greatly enhanced by renewables. For example, photovoltaics are used to transport vaccines that need temperature control to remote regions. Photovoltaic refrigeration systems are considered preferable to those fuelled by kerosene, gas or other fuels. Medical facilities value renewables because of their low maintenance, long-term unattended operation, reliability, lack of pollution and cost-effectiveness. Reliable electricity supply is particularly important for surgery and operating sophisticated equipment.

Electricity from renewables can also reduce the risk of power outages, which can be important for many industries ranging from manufacturing to tourism.

Wind turbines can be used for mechanical pumping of water for personal use or irrigation. Photovoltaic systems can also be used for pumping water. One project in India shows that there are many advantages to using photovoltaics for pumping [45]. These include minimising fuel transportation and electrical distribution losses, reliability, silence, clean, long lifespan, little maintenance, ease of operation, and independence from other forms of fuels. This independence from other forms of fuel is important in areas where other forms are not available, are unreliable or are too expensive for the end-user.

Renewable energy technologies can also lead to local employment. While initially many of the new renewable energy technologies may be imported, eventually they will have to be manufactured or assembled locally. This can bring needed capital into the region. Many non-OECD countries already have significant manufacturing capability and, in the afore-mentioned Indian PV project, most of the systems were built in India. Many countries have PV manufacturing facilities although, increasingly, they are either owned by, or are an alliance with, a handful of major global PV manufacturers. The same holds true for wind turbines, hydro facilities and modern wood stoves. But ownership and licensing aside, manufacturing renewable energy technologies do provide employment opportunities as well as reducing imports of such technologies, thus providing a greater local multiplier effect. [46]

There are many jobs available in the service industries, from sales to consulting, research, engineering, and installation through to maintenance. There are many examples in non-OECD countries, e.g. using alcohol fuels in Brazil stimulated over 700,00 rural jobs in the sugar-alcohol industry [47]. One international database lists over 5,000 companies in 120 countries [48].

Also, as shown by the examples of Germany and Denmark where many of the wind turbines are located in rural areas, this can provide an important source of income to rural areas of non-OECD countries as well by providing excess electricity to grids (transmission or distribution).

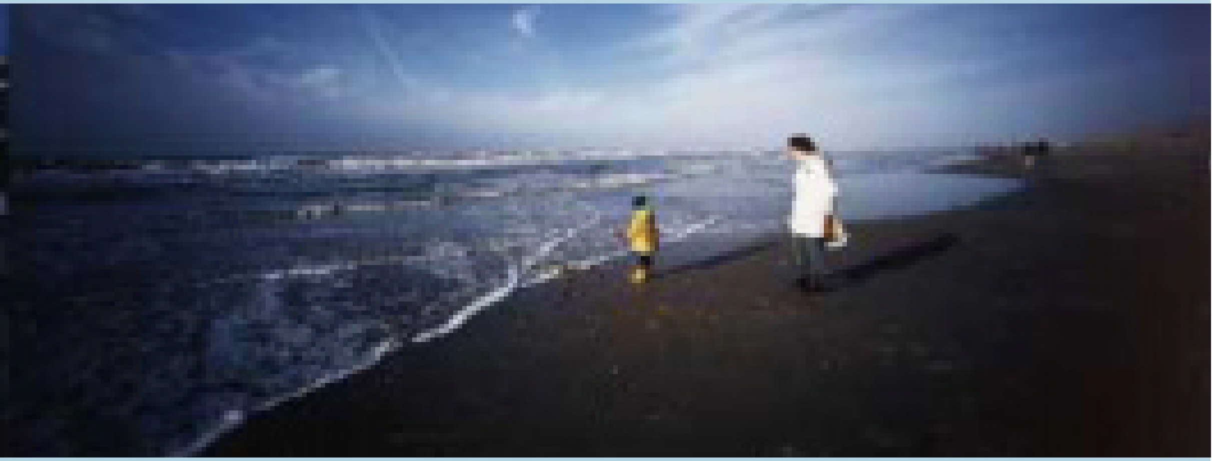
One of the major social benefits of modern renewables in many developing countries is that women and children are freed from the burden of collecting water and wood for fuel. The importance of this cannot be underestimated, as it allows women to do more productive tasks and reduces the burden on children, allowing them to attend school or undertake other activities.

45 Solar Pumping in India, Technical Brochure No. 152, CADDET Renewable Energy, March 2001.

46 See B. Mulliken, ENERGIES... week of February 11, 2001, bmulliken@nrglink.com

47 WEA, op. cit., p. 229.

48 See James & James (Science Publishers) Limited, www.jxj.com



Chapter 6

Conclusions

6.1 Introduction

This report has argued that there is a convergence of important factors affecting the overall value of renewables. Several renewable energy technologies deliver many commercial, cost-effective services, while others have been making strong technical progress and could become commercially viable soon. The market for renewable energy technologies is robust, albeit growing from a relatively small base. This means that there is growing investment in new manufacturing capacity, with more services available and important new deployment underway. There is also a fairly convincing need in all regions of the world for greater use of renewables and a greater understanding of the benefits to be derived from renewable energy technologies.

While there is clear progress, renewables have generally not achieved market "take-off" whereby those technologies can compete in the marketplace on their own merits without government support. In some cases the technologies are still "immature", needing significant cost reductions to make them more competitive. Other cases show that market barriers or entrenched beliefs are leading to continued use of conventional fuels. A long-term commitment and strategy are needed to ensure renewables are not sidelined, bypassing their full potential.

The IEA, through its Implementing Agreements and recent policy analysis is, itself, placing a high value on renewables and has increased its commitment for renewables, as seen by the recent Ministerial Communiqué. The World Energy Outlook 2000 provided the IEA with its first ever scenario on a more ambitious renewable energy path, one based on environmental value. The REWP is developing market-initiative strategies for each of the technologies as a consequence of their realistic and achievable potential.

6.2 A Level Playing Field

A policy framework must be created that will provide a more level playing field because rules, laws and systems have built up over the last century, based primarily on fossil-fuel-based systems. For renewable energy markets to flourish, it is necessary to redress the imbalance of those traditional approaches. The policy framework must keep pace with the dynamic changes underway within the overall energy sector, as well as reflecting social, economic and environmental priorities.

It is instructive how the European Union is planning to require that a specific percentage of electricity generation must come from renewables, even as liberalisation of the electricity market takes hold. Many states in the US are introducing Renewables Portfolio Standards, and a natural target is being debated. Other countries have instituted, or are considering, similar obligations.

Outside the OECD, many countries have benefited from support given by the World Bank and other regional international financial institutions (IFI). Efforts such as the World Energy Assessment, prepared for the Ninth Session of the UN's Commission on Sustainable Development, make a strong case for more renewables. While financial support by IFIs and bilateral donors was traditionally often for large hydroelectric projects, which have become increasingly controversial, there has now been a shift in support towards geothermal, solar and other new renewables.

Financing is crucial and the IFIs are only part of the solution. A new framework under the Kyoto Protocol is currently being negotiated. It now appears that the flexible mechanisms of Joint Implementation (JI) and the Clean Development Mechanism (CDM) [49] might be approved and implemented in the not too distant future. These two mechanisms will be important vehicles for western countries and industry investing in renewable energy projects in non-OECD countries that are signatory to the Protocol.

6.3 The Need for Market Experience

Even with the market success that has so far been achieved, many of the new generation of renewable energy technologies do not have sufficient market experience to reduce their overall systems costs to sufficiently increase their marketability. Recent IEA analysis on experience curves shows that long-term support is needed from technology development through to commercialisation [50]. There is a steady, progressive price reduction through cumulative sales, which is used as a measure of the experience accumulated within the specific technology industry. Young technologies learn faster from market experience than old technologies. For example, in photovoltaics, market experience from 1-2 MW reduces prices by 18 per cent, but at a volume of 100 MW, the market has to deploy a further 100 MW to obtain another 18 per cent price reduction [51].

49 The Kyoto Protocol also opened JI up for cooperation between Annex 1 industrial countries (Art. 6). With developing countries, cooperation is through the Clean Development Mechanism (CDM), which was defined rather vaguely (Art. 12) in the Protocol. JI allows countries to negotiate a framework agreement setting criteria and rules for crediting. Projects are negotiated freely between entities of both countries. Helio International, an NGO based in France, developed implementing indicators for CDM that are now being tested in four countries.

50 IEA, Experience Curves for Energy Technology Policy, OECD, 2000. Experience curves provide a rational and systematic methodology to describe the historical development and performance of technologies. They are also used to assess the prospects for future improvements in the performance of a technology. The curves show that cumulative production for the market reduces prices. (page 15)

51 Ibid., p. 11

The results of the analysis, fully presented in the IEA publication, Experience Curves for Energy Technology Policy, provide an important justification for continued government support. The form of support clearly varies from technology to technology and from country to country, depending on the overall policy framework in place. Support includes not only financial incentives but also a package of long-term measures (legislative, regulatory, R&D, awareness, etc.), which reflect the long-term needs of the industry and the new value given to renewable energy technologies. These are forms of support already commonly used. The importance of the IEA analysis is that it shows that this support is needed for a considerable period, adjusted for the changing market results. Importantly for policymakers, the analysis shows that the support is cost-effective, and reaps financial returns over time. Conversely, the lack of support at early stages can seriously set back the entire technology development timetable.

There are implications at the international level because efficient strategies to make low-carbon technologies available in the near term must rely on international cooperation. Technology learning needs to be global, even though technology deployment will be local. This requires a long-term, collective effort, requiring local actions that lead to joint, coherent learning on a global scale.

There is a growing renewable energy manufacturing and service industry that, if scaled up more intensively, can reduce costs further. As the IEA analysis shows, niche markets are not only important, but also fundamental. However, renewable energy can also play a cost-effective role beyond niche markets.

6.4 Final Remarks

This report has shown that our understanding of the "value" of renewables has evolved significantly in recent years, following the increased understanding that security diversity and the environment are goals that matter, and that can be measured. Because of this new understanding of "value", we need to reassess how renewable energy should increase its share of total energy consumption.

The energy sector is made up of many parties that have contributed to creating an energy system that has completely transformed modern society. Yet, there is a cost in terms of energy security and to the environment, to name but two of the most important factors, that makes it questionable whether the traditional model can continue in its current form, particularly when so much of the world has little or no access to modern energy services.

There is a need to build on the accomplishments of the past. The energy sector is evolving rapidly and this provides many opportunities. In particular, the electricity sector is becoming increasingly more competitive through greater deregulation. There is a need to build upon these changes while still ensuring energy security, environmental protection and social equity.

The IEA has shown that building upon the accomplishments of the past needs to be undertaken at an international level. International cooperation, whether for research and development, mobilising investment, creating markets or sharing experiences, is a powerful tool for commercialising clean energy technologies.

The benefits of renewables are clear and significant. Getting the energy framework to reflect the full and total costs of the environment and energy security is a challenge. However, doing so creates a framework where renewables can compete fairly with other technologies that are also needed in the energy mix, thus leading to a sustainable and vibrant energy sector.