Chapter 1
Executive Summary

Introduction

The development and deployment of renewable energy technologies are important components for the future of a balanced global energy economy. Renewables can make major contributions to the diversity and security of energy supply, to economic development, and to addressing local environmental pollution. In addition, considerable attention has been attracted to their potential to address global warming through zero or near zero net greenhouse gas emissions.

Climate change was recognised by the G8 at their Gleneagles Summit as a serious and long-term challenge that has the potential to affect every part of the globe. According to the IEA's World Energy Outlook (WEO) 2005, if we continue on present policies, global energy-related CO_2 emissions are set to grow by 52% between 2003-30, an increase of almost 13 billion tonnes over the 2003 level and a growth rate of 1.6% p.a. The Alternative Policy Scenario of the WEO shows how CO_2 emissions could be reduced by 16% in 2030 – if governments gave effect, through new policy measures, to their stated intention to do more. The share of renewables in the primary energy mix would then rise to 16%, compared with 14% in the Reference Scenario.

There is growing interest in distributed energy systems as an adjunct or partial replacement of traditional electricity and heating grids. Distributed energy systems directly address the growing need for energy security, economic prosperity and environmental protection.

The research, development and demonstration (RD&D) programmes of governments will play a vital role in enabling renewable technologies to deliver their potential. This publication recommends priorities for this vitally important effort, drawing extensively on studies and analysis carried out by the IEA's Working Party on Renewable Energy Technologies and the associated international technology programmes (Implementing Agreements). It also reviews the trends in government RD&D spending.

Current status of renewables

Renewable energy technologies currently supply 13.3% of the world's primary energy supply. Most of this is accounted for by well-established technologies such as hydropower, biomass, and geothermal. The contribution of these renewables is stable or, indeed, in the case of biomass in the developing world, declining. Second-generation renewable energy technologies – including wind, solar hot water, solar photovoltaics, and advanced bioenergy – are starting from a much lower base but are now growing rapidly. This is the result of RD&D investments, mainly by IEA member countries, that began in the 1970s and were originally stimulated by the oil supply crisis. A third generation – comprising concentrated solar power, ocean energy, advanced geothermal, advanced biomass and biorefinery technologies – is still under development but has great promise for the future.

The IEA's World Energy Outlook 2004 forecasts that the global share of renewables in electricity generation will increase from 18% today to 19% by 2030. The development of renewable-based power is expected to cost about USD 1.6 trillion, nearly 40% of power generation investment over the period.

First-generation renewable technologies are mostly confined to locations where a particular resource is available. Their future potential depends on exploiting the remaining resource (particularly in developing countries), on overcoming environmental challenges and winning public acceptance.

The second generation of renewables have been commercially deployed, usually with incentives in place intended to ensure further cost reductions through increased scale and market learning. Markets for these technologies are strong and growing, but only in a few countries. Some of the technologies are already fully competitive in favourable circumstances but for others, and for more general deployment, further cost reductions are needed. The challenge is to continue to reduce costs and broaden the market base to ensure continued rapid market growth worldwide. These technologies have very broadly followed the rule that each doubling of deployed capacity leads to a 20% reduction in investment cost. On this basis the potential for further cost reductions is considerable.

Third-generation renewables are not yet widely demonstrated or commercialised. They are on the horizon and may have estimated high potential comparable to other renewable energy technologies. However, they still depend on attracting sufficient attention and RD&D funding.

Government RD&D budgets

Historically, government energy RD&D budgets in IEA member countries increased sharply after the oil price shocks of the 1970s. By 1987, they had declined to about two-thirds of their peak level and thereafter they remained relatively stable at this lower level through to 2003. The share of renewable energy technologies in total energy RD&D spending remained relatively stable, averaging 7.6% for the whole period.

Within this total the shares of biomass, solar photovoltaic, and wind have increased while those of ocean, geothermal and concentrating solar power have declined – broadly reflecting the evolving consensus as to where the greatest potential lay. Of course, there are great variations in the balance of spending of individual countries, reflecting resource potential and national energy policies. The United States, Japan and Germany are the biggest total spenders on energy technology RD&D although, on spending per capita, Switzerland, Denmark and the Netherlands are the leaders.

Priorities for key technologies

Experience over the last 30 years shows that the move towards sustainable renewable energy options depends on resource availability, technical maturity and a policy environment that is conducive to both technology improvements and commercialisation. Because of the diverse nature of renewables, each country or region must promote technologies and options best suited to its own resources and needs.

Bioenergy in all its forms represents the largest current source of renewable energy and could play a major role in a low carbon energy economy of the future. It includes traditional low technology practices in rural economies, some of which will run down as modern energy becomes available, as well as advanced technologies, such as ethanol vehicle fuels, which already play a major role. In the short term, the key challenge is to make available relatively cheap feedstocks and to develop standards and norms for trading. In the medium term, there is a range of advanced conversion technologies with great potential, including bio-refineries capable of simultaneously producing a range of products, including energy, as well as further development of facilities producing ethanol from lignocellulosics. Key technologies for the longer term include those for the production of hydrogen from biomass and the development of sustainable ways to produce large amounts of feedstock worldwide. More effort is needed on the social and environmental acceptability of large-scale bioenergy across the complete chain, *i.e.*, from biofuel production to the delivery of services to the consumer.

Achieving greater energy supply from **hydropower** does not require technological breakthroughs, huge RD&D expenditures, or radical changes to the development of hydropower resources. Current requirements include continuous improvements in technology, increased public acceptance, and more efficient hydropower project approval processes supported by government policy. The technology is at a stage where implementation and development should be financed and supported jointly by the public and private sectors.

Geothermal power is, in some respects, a mature technology with a long history in many countries. However, there are several priority RD&D areas that offer the potential to accelerate its advancement worldwide. These would provide cost reduction, sustainable use, and the expansion of the technology for new applications. The benefits would include an extension of the use of geothermal, both for power generation and direct heat use, to cover much larger regions that are farther away from tectonic plate boundaries. More funding and manpower is needed for more rapid achievement of these priorities.

During the last five years, industry RD&D placed emphasis on developing larger and more effective **wind** energy systems, using knowledge developed from national and international generic RD&D programmes. Between 1981-98, production costs of wind turbines have been reduced by a factor of four, making wind energy cost competitive with other forms of electricity generation in favourable locations. Continued RD&D is essential to explore revolutionary new designs as well as for incremental improvements to provide the reductions in cost and uncertainty needed for widespread deployment. Research is needed to improve our understanding of aerodynamics and extreme wind situations, on aspects of grid integration, forecasting techniques, minimising environmental impacts, and on public attitudes to deployment.

In addition to space exploration and consumer products, **photovoltaics (PV)** are now in fully commercial use for illuminating signs, for water pumping, for lighting at remote locations, and for many other purposes. For mainstream power use, however, PV costs must come down substantially. While costs of PV are currently very high compared to other forms of generation, PV has great potential for future cost reductions. It is estimated that about half of the future cost reductions for PV will be the result of RD&D to improve materials, processes, conversion efficiency and design. Substantial cost reductions can also be gained through increasing manufacturing volume and streamlining installation procedures.

A comprehensive and ambitious applied RD&D programme is needed to develop competitive, advanced **solar heating and cooling (SHC)** systems. These systems would eventually be able to provide, cost effectively, 5% to 10% of the overall low-temperature heat demand of the IEA member countries. RD&D efforts need to focus on technical advances in material and components, storage, scaling up and increasing efficiency. They also need to include architecture, so that solar thermal collectors can gain the status of standard building components.

Solar radiation is the largest renewable source on Earth and **concentrating solar power (CSP)** is a serious candidate to provide a major share of the clean renewable energy that will be needed in the future. It can be sized for remote village applications as well as for grid-connected applications. However substantial cost reductions are needed before it can compete directly with conventional grid sources. There is considerable potential for cost reductions through increased scale; for this reason, incentive schemes should avoid restrictions on size. Better technology, including improvements in concentrator performance and cost, could also bring down the cost of CSP electricity dramatically. Improved storage systems could also contribute to cost reductions. New deployment efforts are also needed for CSP, which is not well served by many existing national renewable electricity incentive schemes. There may be potential for exporting CSP, for instance from well-endowed regions such as North Africa into Europe.

The oceans contain a huge amount of power capable of being exploited to generate useful energy. However, technologies to extract **ocean energy** are at an early stage compared to other sources of renewable energy, with a wide range of prototypes under consideration. Ocean energy technologies must solve two major problems concurrently: proving the energy conversion potential and overcoming a very high technical risk from the harsh environment of strong waves or currents. They also need to fulfil basic economic and environmental requirements including low cost, safety, reliability, simplicity, and low environmental impact. Every ocean energy concept has its own technical challenges that require RD&D work. However R&D on resource potential, energy production forecasting, simulation tools, test and measurement standards, and environmental impact, can address common barriers. Additional RD&D funding is needed to mitigate the substantial technical risk faced by device developers daring to harness the vast energies of the marine environment.

Conclusion

The purpose of this book is to assist governments in prioritising their RD&D efforts for renewable energy.

These RD&D activities have played a major role in the successful development and commercialisation of a range of new renewable energy technologies in recent years.

The Governing Board of the IEA, and the G8 leaders at their Gleneagles Summit, responded to the environmental, security, and economic challenges in the energy sector by calling for a "clean, clever, and competitive" energy future. Renewable energy technologies will need to play a major role in this future. This calls, amongst other things, for a redoubling of government RD&D efforts.

Successful RD&D programmes need to be well focused and of high quality. They need to be integrated with the efforts of industry towards commercialisation in the market, and they need to be co-ordinated with international programmes. In addition, they must reflect national energy resources, needs, and policies, and they form a coherent part of wider government strategies for the incentivisation and deployment of new energy technologies. They also need to have roots in basic science research.