

STRATEGIES FOR THE ADOPTION OF RENEWABLE ENERGY TECHNOLOGIES

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Summary

There is a growing awareness of the severe environmental and ecosystem impacts associated with the use of fossil fuels, nuclear power, and large hydro systems. These impacts include land, water, and air pollution, widespread habitat destruction, as well as increasing evidence of links between fossil fuel use and climate change due to global warming. There are also social and political impacts associated with the availability and distribution of energy from these sources. Ownership and control over their exploitation is the cause of local and international conflict. Public opinion about these impacts, combined with the development of newer and more efficient technologies, is leading to widespread re-examination of the possibility of reliance on renewable energy systems. At the same time many countries are restructuring their energy industries and introducing more competition into energy markets. Restructuring can benefit renewables by facilitating consideration of distributed resources, because it aims to decentralize decision-making. However, successful restructuring relies on a high degree of sophistication among consumers and a strong legal framework to ensure that social, environmental, and economic aims are met.

The critical problems facing renewables lie with market distortions and lack of infrastructure, both of which require a long-term policy focus and consistent industry support. In addition, renewable energy sources and technologies are diverse and neither widely available nor well understood. Strategies being employed around the world to accelerate their introduction include mandatory targets and supportive tariffs, tax incentives, capital cost subsidies, support for research, development and demonstration,

facilitating customer choice of renewable options, education, and information. Nevertheless, concerted effort and strong political will is needed for a successful transition from central to distributed generation systems, from centralized to locally based decision making and from monopolistic to competitive energy supply services. The introduction of environmental regulations that target polluting sources is a key requirement, as is removal of restrictions to market access by new players. An understanding and acknowledgement of the potential economic benefits of renewable energy development and use is also required.

1. Introduction

Until the nineteenth and twentieth centuries, renewable sources provided the major portion of energy used by humans for food production, transport, production processes, and warmth. The mechanization of production processes, the advent of the motor car, and the increasing electrification of domestic, commercial, and industrial processes have been made possible over the last century by the exploitation of fossil fuel resources, nuclear energy, and large scale hydro-electric generators. The availability of convenient energy supplies is now closely linked to economic and social development, to the extent that inhabitants of rural and remote areas around the world are often at a severe disadvantage due to inadequate energy infrastructures.

However, there has been growing awareness, particularly in the second half of the twentieth century, of the severe environmental and ecosystem impacts associated with the use of fossil fuels, nuclear power, and large hydro systems. These impacts include land, water, and air pollution, and widespread habitat destruction, as well as increasing evidence of links between fossil fuel use and climate change due to global warming. There are also social and political impacts associated with the availability and distribution of energy from these sources. Ownership and control over the exploitation of these resources is the cause of local and international conflict.

Over the past two decades in particular, public opinion about these impacts, combined with the development of newer and more efficient technologies, is leading to widespread re-examination of the possibility of reliance on renewable energy systems. However, the transition will not be straight forward: vested interests are strong in the energy system that has developed over the last two centuries; the full costs of environmental impacts are not yet incorporated into energy prices; and economic systems are strongly linked to the availability of cheap fossil fuels. Renewable energy sources and technologies, on the other hand, are diverse and neither widely available nor well understood. This paper describes the energy and development opportunities renewables can provide, the policy environment in which they must compete, and the strategies being employed around the world to accelerate their introduction.

2. Background

2.1 United Nations Framework Convention on Climate Change (FCCC)

By 1998, 175 countries had ratified the 1992 United Nations Framework Convention on Climate Change (FCCC). The Convention aims to stabilize emissions of greenhouse

gases at a level that would prevent dangerous human-induced interference with the climate system. In Berlin, in 1995, the first Conference of the Parties (COP) to the FCCC decided that existing commitments to stabilize greenhouse gas emissions were insufficient. The Conference agreed to negotiate a protocol or other legally binding instrument to strengthen the commitments of developed countries to a response to climate change. Negotiations culminated at the third Conference of the Parties (COP3) in Kyoto in 1997, with the development of the Kyoto Protocol to the FCCC. By 2005, 150 countries accounting for 55% of the developed world's carbon emissions, had ratified the Kyoto Protocol and it came into effect. However, key energy intensive countries, including the US and Australia have so far chosen not to ratify.

The Kyoto Protocol establishes legally binding emissions targets for developed countries, and sets out the rules and institutional frameworks for achieving those targets. The US was set a limit on its greenhouse gas emissions by 2010 of 93 percent of its 1990 base level, Europe 92 percent and Australia 108 percent. Targets were not set for developing countries, however, the Protocol includes “flexibility mechanisms,” which provide opportunities for developing countries to participate in global greenhouse gas reduction activities, whilst also improving their own energy services. These mechanisms include emissions trading between countries, “Clean Development Mechanisms” (CDM) whereby countries party to the Protocol can gain carbon credits by transferring clean technology and financing greenhouse gas reduction projects in developing countries, and “Actions Implemented Jointly” (AIJ), which provides for greenhouse gas reduction investments between countries.

The World Bank has established a Carbon Finance Fund into which industrialized countries can contribute money for distribution to agreed CDM or AIJ projects in developing countries. Carbon offsets are allocated on the basis of percentage contributions to the Fund. The Fund provides a means of reducing the problems of high capital and transaction costs by bundling small projects on behalf of investors. The Carbon Finance mechanism also provides consistent criteria and verification of projects proposed.

2.2 The Role of Renewables

Renewable energy forms, in a number of different roles, can help reduce the climate-change impacts associated with the electricity industry, for example:

- Large power stations based on concentrated renewable energy fluxes, for example bagasse produced at sugar mills or additional large hydro schemes.
- Small power stations exploiting distributed renewable energy fluxes, for example wind farms or rooftop photovoltaic generators. Small power stations are most valuable when located close to load centres.
- Substitution for electrical energy in end-use applications (a form of fuel switching), for example in solar water or space heating, or interior lighting.

Renewable energy forms have both advantages and disadvantages compared to non-renewable energy:

- Time-varying renewable energy fluxes may not match desired patterns of end-use, for example artificial lighting substituting for a lack of solar energy.
- Capital costs may be higher than for some non-renewable energy forms, although investment lead times are usually short and operating costs low.
- The environmental impacts associated with renewable energy forms, including greenhouse gas emissions, are often less severe than for non-renewable energy forms.
- Resource depletion is not an issue for renewable energy forms, if used within their sustainable yields.
- There are many opportunities to develop new renewable energy products and systems that may prove to be commercially successful.

Measures to improve end-use energy conversion efficiency are natural allies of distributed renewable energy resources because of the latter's high capital costs and resource flow constraints. Similarly, energy storage devices and demand-management techniques have synergies with distributed renewable energy forms. Collectively, distributed generation, energy storage devices, and demand side measures, including fuel switching, are known as distributed resources. If correctly located, distributed resources can avoid operating and new investment costs in transmission and distribution networks as well as in large-scale generation. This is because distributed resources can reduce peak power flows in transmission and distribution networks, thus reducing network losses and the need for network augmentation.

3. Electricity Industry Restructuring

3.1 Aims of Restructuring

The traditional organizational structure for the electricity industry consists of concentrated ownership on the supply side of the industry in vertically integrated utilities, combined with decentralized, dispersed ownership on the demand side of the industry. Vertically integrated utilities are sometimes publicly owned and sometimes privately owned. In the latter case, intrusive regulation has usually been adopted, so that governments retain strong influence over utility decision-making.

This organizational structure was appropriate to the development phase of the industry when there were high load growths and significant economies of scale to be captured in large power stations. However vertically integrated electricity utilities are less appropriate to the mature phase of the industry, when load growth is low and uncertain, and the best available sites for large power stations have been exploited. They are also less appropriate for low density, decentralized loads in rural areas. In such circumstances, greater consideration should be given to distributed resources, which are often independently owned and operated, and are suited to a decentralized supply industry structure. The increasing competitiveness of renewable energy technologies and the adverse environmental and social impacts associated with fossil fuels, nuclear energy, and large-scale hydro systems, provide additional motivation for adopting an industry structure that is more appropriate for distributed resources.

Many countries are now restructuring their electricity industries, usually with the stated objectives of introducing competition into the market and allowing greater customer choice, although there are often other objectives as well, such as obtaining government revenue through privatization and achieving changes in conditions of employment.

While there are differences in approach, the following elements of electricity industry restructuring are usually found:

- disaggregation of the functions of generation, transmission, distribution, and retailing, and the introduction of formal commercial interfaces between the separate organizations that provide these functions,
- the creation of competition between generation businesses and between retail supply businesses,
- network access to third parties,
- the implementation of new regulatory mechanisms appropriate to the restructured industry.

Industry restructuring can benefit renewables by facilitating consideration of distributed resources, because it aims to decentralize decision-making. However, one of the unresolved aspects of electricity industry restructuring is the extent to which the so-called “wires businesses” of transmission and distribution can be made contestable, either by other wires businesses or by distributed resources. For instance, under the Australian National Electricity Market, the formal monopoly on the wires business has been removed, but not the regulated franchises. Another unresolved issue is the implementation of effective environmental regulation, which can also provide advantages for renewables.

For developing countries, energy sector restructuring might play a key role in alleviating poverty and improving health and education outcomes, particularly for the rural sector, where current energy supply systems have not proven to be effective. Restructuring might be used to introduce much needed regulatory reform, including environmental regulations. It might also allow competitive markets, and perhaps private investment, to improve local participation in decision making and in finding more cost effective and appropriate options for energy supply. However, successful restructuring relies on a high degree of sophistication among consumers and a strong legal framework. Some developing countries may not yet have these prerequisites, in which case restructuring should be deferred and more effective means sought within existing structures for the provision of appropriate energy supplies.

The regulatory framework introduced with energy sector restructuring is critical to the effectiveness of the new system in meeting social, environmental, and economic aims. World Bank policy research has found that the basic assumptions that support the model of “optimal regulation” (full information and zero transactions costs) are not met in practice. This finding undermines the effectiveness of both traditional command-and-control regulation and economic instruments. Secondly, the regulator is not the sole source of pressure on plants to improve their environmental performance. Local communities and market agents also play important roles. As an alternative to the traditional view, the Bank proposes a model of interactions linking four agents: the

polluting plant, the state, the local community, and the market in which the plant operates. It should be possible to achieve improved outcomes by harnessing community pressure and market forces as well as by direct regulatory control. Again, this emphasises the need to promote an informed and active community before restructuring is undertaken.

3.2 Current Impacts of Restructuring on Renewable Energy

3.2.1 Electricity Prices

To date, the most obvious outcomes of electricity industry restructuring have been low grid electricity prices and substantial reductions in retail prices for large consumers. These price decreases reduce the competitiveness of renewable energy generation, but could also potentially reduce the likelihood of investment in new fossil fuel or nuclear capacity, as profit margins fall. However, despite this poor outlook for profits, new coal fired power stations have been announced in Australia and in several other countries that have fossil fuel reserves, often with direct or indirect support from government. It is obvious that stronger environmental impact signals are necessary, if the market is to move towards more sustainable energy systems. However, regulation of electricity industries with respect to climate change impacts is in its infancy.

3.2.2 Network Services

For most grid-connected customers, network costs account for a significant fraction of their electricity bills. Regulation of network service providers should take into account the fact that distributed resources can sometimes compete with investment in network augmentation or extension. This important principle has been recognized in the restructuring processes adopted by some countries. However it has proved difficult to implement effectively, with closed-door decision-making and non-compliant policies such as uniform pricing remaining common.

Ancillary services are resources used to maintain quality of supply, in particular voltage, frequency and waveform purity. The present arrangements for ancillary services in many electricity markets focus on large participants, and distributed options for ancillary services do not yet receive equal consideration. Arrangements for ancillary services are important to renewable options for a number of reasons:

- Renewable energy resources are often stochastic in nature and, without associated storage, many renewable energy generators are not “dispatchable.” Fluctuations in generator output may exacerbate quality of supply problems rather than improve them.
- Inverters used in association with DC generators, such as photovoltaic cells, must be designed to improve waveform quality, rather than worsen it.
- Investment decisions in network augmentation are often taken on the basis of quality of supply considerations. Excessive investment in network capacity may result unless distributed ancillary service options are given appropriate consideration.

Work on network reliability by the US Department of Energy led to the following recommendations for better reflecting the value of reliability to customers, as well as providing them with opportunities to contribute:

- Promote market based approaches to ensure reliable electric services
- Enable customer participation in competitive markets
- Remove barriers to distributed energy resources
- Facilitate and empower regional solutions to the siting of generation and transmission facilities
- Promote public awareness of electricity reliability issues
- Encourage energy efficiency as a means of enhancing reliability.

4. Market Impediments Facing Renewables

Few developing countries have introduced transparency or competition into their energy markets. An estimated US\$100 billion per year is spent on fossil fuel subsidies and monopoly industries are protected, yet only a relatively small portion of the population receives the benefits of adequate energy supply. However, even in industrialized countries where the electricity industry has been restructured, the market does not yet provide a “level playing field” with respect to renewable energy. In many countries, government policies on renewable energy industry development have lacked consistency and effectiveness. Moreover, there is now evidence of policy confusion because of the apparently conflicting aims of greenhouse gas reduction at the lowest short-term cost and the development of local renewable energy industries. Such policy confusion can exacerbate the critical barriers facing the renewable energy industry internationally:

- Renewable energy markets are often small and fragmented and renewable energy products often have to compete with low-cost or subsidized fossil fuels and nuclear energy.
- Access to customers, to the grid, to energy planning information, and to investment capital is more difficult for renewables than it is for established fossil fuel and nuclear industries.
- Network services are not yet fully contestable by renewables, network prices are highly averaged, and the values of distributing ancillary services have yet to be recognized.
- Climate-change externalities are yet to be incorporated into energy markets in most countries. In addition, electricity customers are poorly informed with regard to the carbon intensity of electricity supplies.
- There is widespread mis-use of “commercial-in-confidence” within the newly corporatized electricity industry, as a means of restricting information that was previously in the public domain.
- Most countries, with the exception of countries such as Denmark and India, are yet to reach political consensus about renewable energy industry development and thus there is often little consistency in policy support programs for the renewable energy industry, with existing programs constantly under threat.

- In areas with grid access, renewables are usually at a significant price disadvantage compared to fossil fuels. This is caused not only by the relative immaturity of the renewable energy industry and its products, but also by the current exclusion of externalities in cost calculations and an inability to access cross subsidies that are available to the established fossil-fuel energy industry.
- There are significant differences in the way renewables and fossil fuel or nuclear-based energy sources are paid for, which typically places renewables at a disadvantage. One of the most important of these is payment of capital versus running costs. For example, capital costs for the conventional generating, transmission and distribution networks have typically been raised by electricity utilities, which until recently have usually been fully regulated. Favorable interest rates, and, sometimes, large government grants, have been available, and repayments have been made over 20–30 years, via revenue raised through electricity sales from large numbers of consumers. For many renewable energy technologies, particularly those best suited to distributed, rather than centralized, use, capital must be privately raised, at market rates. Even though running costs are low, this makes choice of a renewable option more difficult, since the perceived risk premium differs between large utilities and individual investors.
- The renewable energy industry consists of a few large companies and many small companies. It has received little government support compared to that received by the large and entrenched fossil fuel, nuclear, and large hydro industries with which it competes.
- The wide diversity of renewable energy technologies and end products, sources, locations, and skills required makes it difficult to address with generic industry policies.
- For the non-utility market in particular, there is a severe lack of basic infrastructure, such as supplier networks, maintenance facilities, and trained staff, as well as the support structures such as regulations and standards that would ensure industry credibility and build customer confidence.
- The final, but often the most critical, barrier to renewables at present is a general lack of awareness and information on what is available, where to source it, and how best to use it. Information on electric, diesel, petrol, and gas systems and supply is readily available from energy retailers, appliance stores, plumbers, and electricians so that, in most cases, potential customers are never given the choice of a renewable option when making an appliance or energy supply decision.

5. Current International Drivers for Renewables

Several key drivers are now impacting at various levels on renewable energy development and use around the world:

5.1 Greenhouse Gas Reduction Strategies

Greenhouse gas reduction strategies are becoming key energy policy drivers in industrialized countries, although renewables are not always the first or most cost effective options. Short-term greenhouse gas reduction measures are likely to emphasize other measures that do not require radical changes to the current system of energy supply and use. These might include shifts to gas based options, such as cogeneration

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Biographical Sketches

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