The Role of Renewables in the Future of Electric Power Generation[i]

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Introduction

It is now 25 years since most of us began to take a serious look at that group of energy sources we call renewables (here defined as solar, wind, geothermal, biomass, and small scale hydro). At that time of rapidly rising oil prices and embargoes, the attraction of renewable lay mainly in their potential to reduce import dependence and therefore improve energy security. Even when plentiful, cheap oil became available in the 80s and 90s, renewables still remained an attractive proposition as concern about the environmental impact of fossil fuels, particularly their emissions of greenhouse gases, mounted. The present time seems propitious to consider both experience with renewables to date and what we might expect of their role in the future in one major market, electricity generation in the United States.

First a word of definition. The term "renewables" in relation to energy is difficult to define. Dictionaries are of little help as many of them were published well before we started using the term as a noun to describe certain types of energy. However, most of us have a good idea of what we mean by renewables. If pressed I think we would settle on a definition that included energy sources of boundless, cheap and inexhaustible supply. In fact very few "renewables" have these characteristics. Hydro power and geothermal power are in the end exhaustible, and sun and wind are only boundless when the sun is out and the wind is blowing.

Quibbling over definitions may seem rather petty, but the colloquial use of the term has certain disadvantages. It implies that all sources of energy can be categorized into two mutually exclusive groups called "renewables" and "non renewables". A more productive way of approaching the question is to consider and compare all sources of energy according to their different qualities, costs, and benefits. This approach identifies not only the benefits of renewables compared with other forms of energy but also the obstacles they must overcome if they are to provide a larger share of energy supplies.

Another disadvantage of the term "renewables" is that it obscures the fact that the constituent forms of energy vary greatly one from another. They do have some common characteristics - they are all site-specific, provide a diffuse energy flow, and have negligible fuel costs. But they differ in other respects. For example, they vary in availability, an important quality for electric power generation. They span a wide range of technologies used in converting renewable energy into electricity. For example, biomass conversion technologies are similar to those used in coal fired power plants, though on a much smaller scale. Exploring for geothermal resources shares much in common with oil and gas exploration. Photovoltaic devices depend on electronic technologies while wind turbines are derived from technologies from the aeronautics industry. These differences are important in determining the future role of renewables, and exploiting complementarities between different forms of energy in electricity generation.

The past 25 years

The history of renewables over the past 25 years is more appropriately measured qualitatively rather than quantitatively. They have increased their contribution to US electric power generation during this period, but still represent only a modest share of total US installed capacity. Roughly 8000 MW of bioelectric capacity is currently connected to the grid (up from 200 MW in 1979) and there is additional power capacity off-grid. Geothermal resources currently provide 2500 MW in the United States, up from 500 MW in 1979. Small scale hydro accounts for 7000 MW. About 1700 MW of wind energy is now grid connected. An estimated 354 MW of solar parabolic trough thermal capacity has been installed as well as some 15 MW of photovoltaics. Altogether these might account for about 2 percent of total installed capacity.

Despite this quantitatively modest contribution to power generation, significant progress in renewable energy has been made over the past 25 years. Major technological advances in some renewables has greatly increased their conversion efficiencies. For example, advances in genetic engineering and breeding techniques have enabled biomass yields to rise by 50 percent. Efficiencies of photovoltaic cells have increase from 5 percent to between 15 and 30 percent depending on the different materials and manufacturing processes used. Improvements in wind turbine blades, designs and materials also improved the efficiency of wind generated power. These technology advances were associated with strong RD&D efforts, especially in the earlier part of the period. The renewables program also became more focused on the types of renewables most likely to succeed. Some, such as OTEC, which enjoyed early support, have been abandoned at least for the moment in favor of more feasible projects.

These marked improvements in technology and efficiency were reflected in improved performance and reliability, and sharply falling prices of many forms of renewable energy. The cost of electricity produced from renewables is critical to their future. Renewables have small chance (in the absence of major governmental intervention) of capturing a larger share of generating capacity unless they can compete in price with conventional generating technologies - now in the (levelized) range of 3.5 cents to 6.5 cents per kwh in the United States. In the beginning, costs of renewables were much higher than this range, but in the last 25 years their costs have fallen sharply. Wind energy for example which cost as much as 80 cents per kwh (in constant 1992 dollars) in the early 1980s fell to just over 4 by 1995, and at this level can compete with coal and gas generation in some areas. Biomass systems are now cost competitive in many areas where low cost feedstock is available. Costs of solar photovoltaic power has decreased about ten times since the mid 1970s and now stand at about 16 cents per kwh. Although this is far above the costs of fossil fuel technologies, it is economically attractive for many remote, and not so remote, applications.

Further, considerable progress was made in the manufacturing and commercialization of the new technologies. After a number of tumultuous years when energy prices fell and renewables tax credits expired, the renewables industry is a much more mature industry. Each form of renewable energy now has a range of established manufacturers and suppliers with several years of experience, better able than before to withstand changes in market conditions, and better situated to take advantage of economies of scale in manufacturing. The existence of an established industry with field experience and well developed after sales service is important as it reduces the risk of using renewable energy. In some cases, for example bioenergy, there has been a move to industry consolidation, with the original 40 to 50 companies involved in the 1980s falling now to 20 or fewer. In other cases, such as photovoltaics, greater vertical integration is taking place, which again reduces purchasers' risk. Some large firms which previously left the industry may again be re-entering. All in all, renewables will embark on their future development with a more stable and established supplier base.

The Future

Despite these solid achievements, the future role of renewables could remain quite modest. The Department of Energy's EIA projects renewable energy in electricity generation to more than double between 1993 and 2010 (from 52 to 118 billion kwh) when it will provide 3 percent of total US electricity generation. While projections are frequently inaccurate descriptions of future outcomes, they have the advantage of illustrating orders of magnitude under different, reasonable assumptions, and in this case they serve to make the point that renewable energy must overcome many challenges if it is to provide a substantially higher share of electricity generation than that forecast. Three main areas of challenge are: the future development of renewable technology, its adoption by the utility sector which itself is undergoing major change, and government policies with regard to renewables.

The first challenge is the extent to which renewables can become competitive with fossil fuel electricity generation. Some already are, and forecasts suggest further steady declines in costs over the next 30 years to levels well within the current range of fossil fuel generation costs. A number of qualifications must be borne in mind, however. First, fossil fuel generating costs are a moving target. They too may decline over the next thirty years to continually lower the threshold of competitiveness. Perhaps the greatest challenge to renewables in power generation over the past 15 to 20 years has been the development of the gas turbine. Second, cost reductions that took place over the past 25 years owed much to relatively high and steady RD&D expenditures which will be essential in future if technologies are to improve and enable costs to fall. Government efforts are likely to be critical here, as many of the firms in the renewables industry are too small to sustain major RD&D efforts. The PCAST report recommends doubling renewables RD&D to over $600 million a year by the early years of the next century. The utilities have sponsored RD&D programs in the past and it would be of interest to have their views on RD&D in a deregulated future.

Another source of cost reductions in the renewables industry (particularly in wind energy and solar photovoltaics) is their ability to capture economies of scale in manufacture. This is in the nature of a chicken and egg situation. When markets are small, unit costs are high which in turn keeps the market from growing to a size where economies of scale could reduce unit costs and further expand the market. Industry consolidation may position the remaining firms to capture some economies of scale. In the case of photovoltaics, exports to the growing global market, which far exceeds the domestic market, may help reduce costs.

Even if levelized costs continue to decline, there remains a potential financing problem. Renewable systems, like large scale hydro and nuclear, have high front end capital costs. In the current utility privatizing and deregulating environment where investment horizons are shortening, these capital intensive technologies are less attractive to investors than fossil fuel plants, whose low up front capital costs reduces investors risks in the event of failure. Project finance, the mode adopted by the non utility groups who are likely to grow in importance in the future, is in practice limited to 15 years which is a short time horizon for renewables financing.

The second challenge is the extent to which renewables fit easily into the existing utility structure. In some respects, renewables offer advantages to utilities over fossil fuels. They reduce fuel cost risks, although the impact of this feature in practice depends critically on the regulatory regime. Regulated utilities in the United States are allowed to pass on fuel costs to rate payers, a feature which negates the renewables advantage to the utility, though not to the rate payer. However, as deregulation proceeds, these fuel cost risks may assume greater importance in utility decision making. Another advantage of renewables for utilities is that, unlike coal or nuclear generation, they do not incur long term liabilities for waste disposal. Further, being small scale and modular, they can be tailored to match load growth, unlike larger scale conventional plants that may cause capacity to run ahead of load growth for considerable periods. (Gas turbines, however, also share these qualities of scale and modularity).

On the other hand, the widespread introduction of renewables into utility use could be impeded by institutional considerations. Renewables introduce a new set of technologies that are unfamiliar to many utility decision makers. According to one commentator[ii] with extensive utility experience, distributed generation which could well become the most prevalent form in which renewables are used in electricity generation, is classed as a "disruptive"[iii] technology that disturbs accustomed ways of doing things and is therefore unsettling to decision makers. These technologies require rethinking procedures, may entail unforeseen consequences, and often have high transactions costs. "Better the devil you know than the devil you don't know" may be a common and understandable attitude in regulated utilities that are held to high standards of reliability.

Deregulation and increased competition within the utility sector could, however, change many of these attitudes. The elimination of fuel cost risk will add to the attraction of renewables, which could also benefit from the appearance of new high value niches in the new market conditions. Increased competition will lead to new service providers who may lack the institutional reticence referred to earlier, and also induce changes in attitudes of established service providers. On the other hand, as we have seen, high up front capital requirements may prove an important obstacle to rapid dissemination of renewables. The net impact of a more competitive market on renewables remains unclear.

Third, the role of renewables in future will be strongly influenced by the policy environment. In the United States at least, and probably in other countries, renewables along with all other forms of energy, are affected by a panoply of government interventions on the federal, state and local levels that have grown over time often in a very piecemeal fashion. These include R&D programs, ratings and code standards, subsidies, federal procurement requirements, taxes and tax credits. The complexity of these policy interventions makes it difficult to answer the question: how do government programs treat renewables compared with other forms of energy that generate power? The history has been mixed. In the 1970s renewables benefited from federal and state tax credits, and from the Public Utility Regulatory Policies Act (PURPA) of 1978 which required utilities to purchase power based on renewables and cogeneration generated by qualifying facilities if it could be shown that these forms were cheaper than the "avoided cost" of fossil fuel generation. Both of these initiatives led to a high level of interest in renewables, reinforced by the Clean Air Act. At the same time, however, PURPA, and the later Energy Policy Act of 1992, also introduced an element of competition into the power sector by allowing competitive bidding from non utility generators. As before, the impacts of competition on renewables are mixed, but it is noticeable that renewables contribution to non utility generation has declined in recent years as competitive bidding has increased. The tax system may also penalize renewables. One study[iv] concludes that except for the Renewable Energy Production Credit (REPC) which is to expire at the end of 1999, renewables are generally taxed higher than fossil fuels.

On balance, therefore, it seems that renewables do not receive markedly more favorable treatment than other forms of power generation in government decision making. This prompts the further question: why should they? The argument for preferential treatment for renewables is based on the belief that their costs in the market do not wholly reflect their benefits, particularly their benefits to environmental improvement. Renewable energy emits few pollutants. In particular, emission of carbon dioxide, the main anthropogenic greenhouse gas, is minute compared with fossil fuels. Geothermal is the highest emitter among the renewables with emissions of 57 tonnes of carbon dioxide per GWh. Most of the other renewables are under 10 tonnes per GWh. By comparison, coal emits 1000 tonnes per GWh and natural gas turbines 500 tonnes. Preferential treatment of renewables could therefore be justified as part of a policy to contain emissions of greenhouse gases.

Conclusion

Over the past 25 years, the development of renewable energy has made considerable progress. Major technological development has taken place, costs have fallen sharply to competitive or near competitive levels, and the supplier industry has matured. But the future is uncertain. Though the advantages of renewables are widely recognized -- indeed its broad-based public support may be one of its greatest assets -- recent and prospective changes in the structure of the electric utility sector, and continuing technology improvements in fossil fuel generation, may impede large scale deployment. A larger role for renewables would have to be based on a more explicit support for technologies that reduce greenhouse gas emission.

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[i] The analysis in this paper owes much to *Renewing our Energy Future*, OTA-ETI-614, Washington DC: US Government Printing Office, September 1995, and *Federal Energy Research and Development for the Challenges of the Twenty First Century*, Report of the Energy Research and Development Panel, The President's Committee of Advisors on Science and Technology, November 1997, and to conversations with Dr. Samuel Baldwin, the Executive Director of both of these reports. The conclusions drawn however are those of the author.

[ii] Carl Weinberg in session on the Role of Electric Utilities in Rural Electrification at Village Power 98 workshop of NREL and World Bank Washington DC 1998.

[iii] An extension of this theory is that large established organization are not good at dealing with "disruptive" technologies, which are typically never introduced by market leaders on the grounds that they do not satisfy revenue needs, lack quantitative data on which to make decisions, require new organizational structures and challenge established decision procedures. A frequent example quoted is of IBM's slowness to adopt PCs.

[iv] Dallas Burtrow and Pallavi Shah "Fiscal Effects of Electricity Generation Technology Choice: a Full Fuel Cycle Analysis" report [prepared for the Office of Technology Assessment June 1994, reported in op. cit. *Renewing Our Energy Future* page 216