Global Renewable Energy Markets and Policies

Eric Martinot[1]
University of Maryland, School of Public Affairs, College Park, MD, USA

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Global renewable energy markets have grown tremendously in the past decade. Few people realize that some forms of renewable energy have become big business. Annual investment in renewable energy was an estimated $17 billion worldwide in 2002, up from $6 billion in 1995.[2] And cumulative investment of at least $80 billion was made in renewable energy during the period 1995-2002, far surpassing investment in the decade prior to 1995. This growth has been driven first and foremost by supportive national and local policies, many of which have effectively overcome the barriers that continue to put renewable energy at a competitive disadvantage to fossil fuels. Aggressive technology improvements and cost reductions, better market information, growing awareness of global climate change, local environmental concerns, and rural development needs in the poorest countries have also been important drivers of this growth.

To put these numbers in some perspective, annual investment in conventional power generation is on the order of $100-150 billion (corresponding in rough numbers to an aggregate growth rate of 2.5%). So renewables' $17 billion annual investment is highly significant even though installed renewable energy capacity—about 100 gigawatts (GW)—still makes up only 3% of global installed power generation capacity (Martinot et al 2002). Wind power alone accounted for 31 GW of installed power generation capacity in 2002.[3]

Capital investment isn't a meaningful comparison by itself, however, without also considering the fuel costs associated with conventional power. While no figures are available for electric power fuel costs only, worldwide annual fuel expenditures for purchasing fossil fuels for all uses exceeded $1 trillion per year in 2000 (Goldemberg et al 2002). Fossil fuel prices—and the magnitude of these huge expenditures—can grow increasingly uncertain over time as political forces shaping fossil fuel markets clash and as resource estimates are revised. Renewable energy offers freedom from future fuel-price uncertainties, a factor that is dawning on more and more investors and is poised to become a market driver in addition to those mentioned above.

This paper provides a survey of the existing markets for renewable energy, the past and existing policies that have facilitated those markets, and the implications of electric power sector restructuring for renewable energy. The paper concludes by considering future prospects, from both economic and policy perspectives.

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[1] The research underlying this paper was conducted while the author served as a Climate Change Program Manager with the Global Environment Facility in Washington, DC, from 2000-2003. The author can be reached at contact@martinot.info.

[2] Figures are author's estimates, as such figures have not existed previously in the literature; see Martinot 2003 for details. The same $17 billion figure for 2002 was also obtained, entirely independently and using different methods, by Lisa Frantzis of Navigant Consulting, increasing the confidence level in the estimate.

[3] Total global power generation capacity was 3,400 GW in 2000. Of course, power generation shares for renewables are lower than the 3% capacity share due to lower renewable energy capacity factors relative to conventional power plants.

Global Renewable Energy Markets

The fastest growing renewable energy markets are for wind power and solar photovoltaics in a handful of developed countries, notably Japan, Germany, and Spain, with a recent resurgence in the United States (Sawin 2003). These markets have seen annual growth rates of 15-40% in recent years. Solar hot water markets in a few countries have been growing equally rapidly, with more modest investments in geothermal, small hydro, and biomass. Overall, technology shares for the $17 billion total invested in 2002 are estimated at wind 42%, solar photovoltaics 22%, solar hot water 17%, geothermal heat production 8%, small hydro power generation 6%, biomass power generation 2%, and geothermal power generation 2% (Martinot 2003).[4]

In developed countries, the leading applications of renewable energy are for power generation—from power-grid-connected wind and biomass, and from decentralized rooftop and remote solar photovoltaics. The most commercial markets continue to be solar photovoltaic power for remote telecommunications stations and for highway services and signs. But grid-connected wind power has also "come of age." Germany now has over one-third of worldwide wind power installations, and other leading countries are Spain, Denmark, and the United States, with several other European countries also expanding. Growth in all of these countries is expected to continue, with perhaps the exception of Denmark. Germany and Japan lead the household rooftop solar photovoltaic market, now numbering hundreds of thousands of homes (Maycock 2003).

The use of biofuels for transport is significant and growing in some countries. Germany leads the world in biodiesel use—more than 2 billion liters per year. Other countries using biodiesel include Austria, Belgium, France, Italy, Indonesia, and Malaysia. Brazil leads the world in ethanol use, about 14 billion liters in 2000, followed by the United States and Canada, with much smaller use in a few European countries.

Mature and commercial solar hot water markets are also expanding in several countries, particularly China, which alone accounted for half of global installations in 2001 and saw double-digit annual market growth in the early 2000s. Japan, the United States, Germany, Greece, Israel, and Australia are also active solar hot water markets. Driving growth in several countries are mandates that new home construction include solar hot water—notably in Japan, Greece, Israel, and parts of Australia.

In developing countries, renewable energy markets are more diverse than in developed countries, but could be grouped into five basic categories (Martinot et al 2002):

1. Rural residential and community lighting, television, radio and telephony. Roughly 400 million households, or 40% of the population of developing countries, do not have access to electricity. Household and community demand for lighting, television, radio and wireless telephony in rural areas without electricity has driven markets for solar home systems, biogas-fuelled lighting, small hydro minigrids, wind or solar hybrid minigrids, and household-scale wind turbines.

2. Rural small industry, agriculture and other productive uses. 'Productive uses' of renewable energy are those that increase incomes or provide other social services beyond home lighting, entertainment and increased conveniences. As incomes increase, rural populations become able to afford even greater levels of energy service. The major emerging productive uses of renewable energy are for agriculture, small industry, commercial services and social services, such as drinking water, education, and healthcare.

[4] Solar photovoltaic investment estimates include balance of plant in addition to panels.

3. Grid-based power generation. About 3% of electric power capacity in developing countries is renewables, mostly small hydropower in China and biomass power generation in a group of tropical countries with abundant vegetable oil, sugar cane, and/or forest products wastes. Small hydro power, biomass power, geothermal power and wind farms are all continuing and promising markets for grid-based power generation. India leads the developing world in wind power and continues to expand wind, although not as aggressively as in the 1990s.

4. Residential and commercial cooking and hot water. Residential and commercial cooking and hot water in rural areas are supplied primarily by direct combustion of biomass—in the form of wood, crop wastes, dung and charcoal. In recent decades, the decline in forest resources in many countries called attention to more efficient household use of biomass, as well as solar cookers. Markets for more efficient biomass stoves and solar cookers are found primarily in Asia and Africa.

5. Transport fuels. Over 40% of automotive vehicle fuel used in Brazil in 2000 was ethanol—a liquid fuel derived from biomass (sugarcane in Brazil). Indeed, Brazil represents more than two thirds of global ethanol consumption, due to extensive policies and infrastructure development over the past 20 years that have fostered both pure ('neat') ethanol cars and conventional cars using ethanol-petrol blends. Biodiesel fuel is produced in Indonesia and Malaysia from palm oil.

Supportive Renewable Energy Policies

Many of the growing markets discussed above have benefited from supportive renewable energy policies. In some cases policies have virtually created markets. The justification for enacting policies to support renewable energy is often attributed to a variety of “barriers” or conditions that prevent investments from occurring (see Table). Often these barriers unfairly put renewable energy at an economic, regulatory, or institutional disadvantage relative to other forms of energy supply. Some barriers could be considered “market distortions,” while others have the effect of increasing the economic costs of renewable energy. Subsidies for competing conventional forms of energy are often cited as one of the largest market distortions. An estimated $150 billion per year or more in explicit and implicit public subsides goes to fossil fuels, and continuing large public subsidies flow to nuclear power (Goldberg 2000, Jefferson et al 2000). Other significant barriers include lack of future fuel-price risk assessment for competing fuels (see Box), dependence on financing due to high initial capital costs, imperfect capital markets, financing risks and uncertainties, lack of skills or information, technology prejudice, transaction costs, and a host of regulatory factors (Beck and Martinot 2004).

Twelve of the most notable types of policies that have promoted renewable energy and helped to overcome these barriers, either directly or indirectly, are elaborated below (Beck and Martinot 2004, Geller, 2003, IEA 2003, Reiche 2002, Sawin 2003, Wiser et al 2002):

1. U.S. Public Utility Regulatory Policies Act (PURPA) of 1978. PURPA required utilities to purchase power from small renewable generators and cogenerators—otherwise known as independent power producers (IPPs)—through long-term (10-year) contracts at prices approximating the “avoided costs” to the utilities. These avoided costs represented the marginal costs to the utilities of building new generation facilities, which could be avoided by purchasing power from the IPPs instead.

Table: Common Barriers to Renewable Energy

Category	Barriers
Cost and pricing related	Conventional fuels receive large public subsidies while renewables may not. Renewables have high initial capital costs but lower operating costs, making them more dependent on financing and the cost of capital. It is difficult to quantify future fuel-price risks for fossil fuels and incorporate monetary values for those risks into economic decision-making. Transaction costs are often higher for small, decentralized renewable energy facilities than for large centralized facilities. The real economic costs of environmental damages from fossil fuels (on human health, infrastructure, and ecosystems) are rarely priced into fuel costs.
Legal and regulatory	Independent power producers (IPPs) may be unable to sell into common power grids in the absence of adequate legal frameworks. Transmission access and pricing rules may penalize smaller and/or intermittent renewable energy sources. Permitting requirements and siting restrictions may be excessive. Utilities may set burdensome interconnection requirements that are inappropriate or unnecessary for small power producers. Requirements for liability insurance may be excessive.
Market performance	Consumers or investors may lack access to the credit required for capital-intensive renewable energy investments. Financiers, developers, and consumers may unfairly judge technology performance risks. Market participants may lack sufficient technical, geographical, and/or commercial information to make otherwise sound economic decisions.

Source: adapted from Beck and Martinot (2004)

Box: Valuation of Fuel-Price Risk for Fossil Fuels

Some recent economic work has shown that if future fuel-price risk assessment is properly factored into fossil fuel prices using accepted financial valuation tools, something any bottom-line oriented power generator should rationally do, then cost comparisons between renewable energy and fossil-based power can shift in favor of renewable energy (Awerbach 2003, Bolinger et al 2003). "Standard textbook finance-oriented valuation produces cost estimates for fossil-based generation that are considerably higher than those produced by traditional engineering economics approaches" writes Awerbach.

True technology cost comparisons must be made basis of total "lifecycle" costs, not simply initial capital costs. Lifecycle costs account for initial capital costs, future fuel costs, future operation and maintenance costs, decommissioning costs, and equipment lifetime. Herein lies part of the problem in making economic comparisons: what are fuel costs going to be in the future? How should future costs be discounted (with what expected interest rates) to allow comparison with present costs? The uncertainties and required assumptions inherent in these questions significantly affect cost comparisons. Existing analytical tools for calculating and comparing costs can discriminate against renewable energy if they do not account properly for future uncertainties or make unrealistic assumptions. "Arbitrary discount rates [in traditional engineering-economic analyses] create enormous distortions in estimated fossil-based generating costs" asserts Awerbach. And fuel-price risk valuations are usually absent in most traditional analyses, which simply assume a set of fixed future fuel prices.

2. Electricity feed-in laws. The electricity feed-in laws in Germany, and similar policies in other European countries in the 1990s, set a fixed price for utility purchases of renewable energy. For example, in Germany starting in 1991, renewable energy producers could sell their power to utilities at 90% of the retail market price. The utilities were obligated to purchase the power. The law changed in 2000 when pricing became based on fixed norms unique to each technology, which in turn were based upon estimates of power production costs and expectations of declines in those costs over time. Other countries in Europe with renewable electricity feed-in laws include Denmark, France, Greece, Italy, Portugal, Spain, and Sweden.

3. Competitively bid renewable resource obligations. The United Kingdom tried competitive bidding for renewable energy resource obligations during the 1990s under its "Non-Fossil-Fuel Obligation" (NFFO) policy. Under the NFFO, power producers bid on providing a fixed quantity of renewable power, with the lowest-price bidder winning the contact. With each successive bidding round (there were four total), bidders reduced prices relative to the last round. The UK abandoned the NFFO approach after the fourth round of bidding in 1997. Other countries with similar competitively-bid renewable resource mechanisms have included Ireland, France, and Australia.

4. Renewable energy portfolio standards (RPS). An RPS requires that a minimum percentage of generation sold or capacity installed be provided by renewable energy. Obligated utilities must ensure that the target is met, either from their own generation, power purchases from other producers, or direct sales from third-parties to the utility's customers. Typically, RPS obligations are placed on the final retailers of power. At least twelve U.S. states have enacted an RPS, ranging from 1% to 30% of electricity generation. In Europe, the Netherlands has been a leader among RPS initiatives. Dutch utilities have adopted an RPS voluntarily, based on targets of 5% of electricity generation by 2010, increasing to 17% by 2020. Other countries with RPS-type regulatory requirements include Australia, Brazil, Belgium, Denmark, France, Japan, Spain, Sweden, and the United Kingdom.

5. Renewable energy (green) certificates. Renewable energy (green) certificates are emerging as a way for utilities and customers to trade renewable energy production and/or consumption credits in order to meet obligations under RPS and similar policies. Standardized certificates provide evidence of renewable energy production, and are coupled with institutions and rules for trading that separate out "renewable energy attributes" from the associated physical energy. This enables a "paper" market for renewable energy to be created independent of actual electricity sales and flows. Green certificate trading is gaining ground in the UK, Belgium, Denmark, Australia, and the United States. Europe embarked upon a "test phase" of an EU-wide renewable energy certificate trading system during 2001 and 2002.

6. Cost reduction policies. A number of policies are designed to provide incentives for voluntary investments in renewable energy by reducing the costs of such investments. These policies can be characterized into five broad categories. Policies can: (1) reduce capital costs up front (via subsidies and rebates); (2) reduce capital costs after purchase (via tax relief); (3) offset costs through a stream of payments based on power production (via production tax credits); (4) provide concessionary loans and other financial assistance, and (5) reduce capital and installation costs through economies of bulk procurement. Many examples of these policies exist in individual U.S. states, several countries in Europe, India, and Thailand.

7. Public benefit funds. In the United States, public funds for renewable energy development are raised through a "system benefits charge," which is a per-kWh levy on electric power consumption. Similar levies exist in some European countries for fossil-fuel-based generation. The funds collected in this manner serve a variety of purposes, such as subsidizing the cost difference between renewable and traditional generating facilities, reducing the cost of loans for renewable facilities, providing energy efficiency services, funding public energy education, providing low-income energy assistance, and supporting research and development.

8. Market infrastructure policies. A variety of market-facilitation policies are used to build and maintain renewable energy "market infrastructure"—the capabilities, institutions and rules which underlie a market—including design standards, siting and permitting requirements, equipment standards, and contractor education and licensing. Policies may also require that market participants have local on-the-ground presence (or joint-venture type requirements).

9. Net metering. Net metering allows a two-way flow of electricity between the distribution grid and customers with self-generation. When consumption exceeds self-generation, the meter runs forward, and when self-generation exceeds consumption, the meter runs backward. The customer pays only for the net amount of electricity used in each billing period, and is sometimes allowed to carryover net electricity generated from month to month. Net metering in effect allows customers to receive retail prices for their self-generation. At least 38 U.S. states now have net metering laws. Net metering is also common in parts of Germany, Switzerland and the Netherlands, and allowed by at least one utility in the UK. Thailand is one of the few developing countries to have enacted net metering laws.

10. Transport biofuels policies. Biofuels mandates and tax policies in Brazil, the United States, and Europe have accelerating development of biofuels. Biofuels mandates require a certain percentage of all liquid transport fuels be derived from renewable resources. Tax policies may provide tax credits or exemptions for production or purchase of biofuels. Brazil has long mandated blending of ethanol with all vehicle fuels sold in the country, as well as the availability of pure ethanol fuels at service stations. India has recently mandated blending in some states. The United States has several policies, such as a federal ethanol tax credit and an Iowa mandate that government vehicles use ethanol-blended fuel. Many European countries utilize small amounts of biodiesel blended with conventional diesel, and some, like France and Italy, also provide tax incentives. Germany provides tax exemptions for pure biodiesel.

11. Emissions trading policies. Policies to reduce power plant emissions, including NOx, SOx, and CO2, have the potential to affect renewable energy development. Many emissions-reduction policies create "allowances" for certain emissions (representing the right to emit a certain amount of that pollutant). Credits made available to renewable energy generators can "offset" these allowed emissions and can be sold by renewable energy producers at market value to other electricity generators who must comply with emissions limits.

12. Renewable energy targets. Several countries have adopted or are proposing national renewable energy targets. The European Union collectively has adopted a target of 22% of total electricity generation from renewables by 2010, with individual member states having individual targets above or below that amount. Japan has adopted a target of 3% of total primary energy by 2010. Recent legislative proposals in the United States would require 10% of electricity generation from renewables by 2020. China and India are the first developing countries to propose renewable energy targets. India has proposed that by 2012, 10% of annual additions to power generation would be from renewable energy; China has a similar goal of 5% by 2010. Other countries with existing or proposed targets are Australia, Brazil, Malaysia, and Thailand. In addition, a group of countries from around the world placed increased attention on renewable energy targets at the U.N. World Summit for Sustainable Development in 2002.

Power Sector Restructuring and Renewable Energy

Power sector restructuring in many countries is having a profound effect on electric power technologies, costs, prices, institutions, and regulatory frameworks. Restructuring trends are changing the traditional mission and mandates of electric utilities in complex ways, and affecting environmental, social, and political conditions (Hirsh and Serchuk 1999). There are five key trends underway that will continue to influence renewable energy development, both positively and negatively (Martinot 2002):

1. *Competitive wholesale power markets and removal of price regulation on generation* have allowed independent power producers (IPPs) to invest in renewable energy, thereby avoiding the biases against renewable energy that traditional utility monopolies have had. At the same time, however, competition has fostered low-cost combined-cycle gas turbines as the technology of choice for many IPPs, making it more difficult for renewable energy to compete on the basis of price alone. The trend towards "merchant plants" and spot-market pricing of wholesale power, rather than long-term contracts, is also making it more difficult for renewable energy to compete, given its high fixed costs.

2. *Self-generation by end-users and distributed generation technologies* have followed the introduction of utility buy-back schemes from end-users, including net metering. Once again, renewable energy investments, as one form of distributed generation technology, have been facilitated by net metering and other policies allowing self-generation, but at the same time so have other distributed generation technologies, especially those based on natural gas.

3. *Privatization and/or commercialization of utilities* may promote capital-intensive renewable energy by providing a new source of finance—capital from private debt and equity markets—but the transition from public to private ownership and/or management may shorten time horizons, increase borrowing costs, and increase requirements for high rates of return, discouraging renewable energy investment. Private utilities are more likely to focus more on costs and less on public benefits, unless specific public mandates exist.

4. *Unbundling of generation, transmission and distribution* may provide greater consumer incentives to self-generate using renewable energy. By separating out transmission and distribution charges at the retail level, consumers who self-generate can avoid these charges. In addition, open-access transmission policies that go along with unbundling have been explicitly targeted to promote renewable energy in some countries, notably Brazil and India.

5. *Competitive retail power markets* have allowed the emergence of "green power" suppliers who offer to sell renewable-generated power at the retail level, usually at a premium. Green power markets have begun to flourish where retail competition is allowed, but often only in conjunction with other renewable energy promotion policies. The Netherlands is perhaps the best-known example. Following restructuring in 2001, and driven by a large tax levied on retail electricity generated from fossil fuels, one million green power customers signed up within the first year. In the U.S., green power markets are emerging in several states

Overall, power sector restructuring seems to be having a negative effect on renewable energy, although there are clear exceptions, particularly where supportive renewable energy policies have occurred in parallel with restructuring. Policy-makers need to recognize that it is much easier to incorporate supportive renewable policies and provisions when power sector restructuring is on the agenda. It is much more difficult to do so after new rules and institutions have already been created and are operating.

Conclusion

Grid-based wind power, distributed solar photovoltaic, and household solar hot water markets are growing extremely quickly worldwide, and can be expected to continue to do so. Other markets, such as geothermal and biomass for both power and heat, show some growth and offer future promise of more. The use of biodiesel transport fuels could greatly expand. In developing countries, "productive uses" of renewable energy for drinking water, irrigation, other agricultural uses, small industry, education, and health care are very slow to emerge but show great promise. Small hydro power in China and a few other countries continues to expand. Many firms, from large multinationals to small entrepreneurs, are beginning to recognize all of these opportunities.

At the same time, continued public policies in support of renewable energy are crucial and remain justified by the many barriers and market distortions discussed earlier. Renewable energy targets already set by several countries and being considered by many more are perhaps the best political message that governments can send to markets, and can also lead to concrete public policies and programs to help achieve the targets.

As to the choice of specific policies, some policies have been more effective than others, and there is a growing literature on assessing the effectiveness of renewable energy policies (Beck and Martinot 2004, Dijk et al 2003, Sawin 2001, Shepherd 1998, Wiser et al 2001). Experience with policies around the world is still emerging. Our understanding of this experience must go beyond specific policy provisions, however, to include the impact of policies over the longer term. Not surprisingly, the effectiveness and impact of various policies are the subject of much controversy. Nevertheless, assessment of policy experience, and the work to share, adapt, and learn from that experience, is crucial.

It is no longer possible to dismiss renewable energy as too expensive. Present market trends, expected future technology cost reductions, uncertainties in future fossil-fuel prices and the proper valuation of those uncertainties, the hidden social and political costs of trying to keep fossil-fuel prices stable, the subsidies paid to fossil fuels and nuclear power, the environmental costs that are not included in market prices, the unquantifiable but real benefits of a more decentralized and resilient energy infrastructure, and other factors which skew economic comparisons all mean that cost is no longer the primary issue. Higher financial costs are still a reality for many renewable energy applications, but many of the cost gaps are narrowing to the point where they hardly provide justification for ignoring the unquantifiable and public benefits sides of the equation. A greater public role in technology choice is justified—expressed partly through supportive public policies.

Renewable energy is essential for mitigating climate change. Because most human-induced greenhouse gases come from burning fossil fuels, there are three basic options—energy efficiency, renewable energy and nuclear power—for mitigating those emissions. Energy efficiency improvements must be made in any case. If one rejects the (rather arrogant) claim that we know how to safely store dangerous nuclear wastes for thousands of years without serious environmental implications for future generations, as well as considers the huge (but still hidden) real costs of nuclear waste disposal, then renewable energy is really the only option. It is also easy to imagine escalating global conflict over control of fossil fuel resources and prices in the years ahead. Thus, for economic, environmental, and geopolitical stability reasons, the share of our energy supply from renewable energy must increase dramatically. In 2001, Royal Dutch/Shell put forth a scenario showing half of global energy from renewable sources by 2050 (Shell 2001). Most would consider this impossible, but it is not—it is essential.

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