# Renewable Energy Policies and Barriers*

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**ABSTRACT**

The 1990s saw an explosion of energy policy changes around the globe. Driven by economic, environmental, security, and social concerns, energy regulation has been in great flux. Many of the changes are having a profound influence on renewable energy, both from policies explicitly designed to promote renewable energy and from other policies that indirectly influence incentives and barriers for renewable energy. This article considers six different types of policies that affect renewable energy development, both directly or indirectly: renewable energy promotion policies, transport biofuels policies, emissions reduction policies, electric power restructuring policies, distributed generation policies, and rural electrification policies. Each policy reduces one or more key barriers that impede development of renewable energy. These barriers are discussed first. In general, most renewable energy policies address cost-related barriers in some manner. Many policies address the requirements for utilities to purchase renewable energy from power producers. Most policies also address the perceived risks of renewable energy in one form or another (i.e., technical, financial, legal). Still others primarily address regulatory and institutional barriers. Some related policies may heighten barriers to renewable energy rather than reduce them. Table 1 summarizes the key renewable energy policies and barriers presented.

**Table 1: Summary of Renewable Energy Policies and Barriers**

| Policies | Description | Key Barriers Addressed |
|---|---|---|
| **RENEWABLE ENERGY PROMOTION POLICIES** | | |
| Price-setting and quantity-forcing policies | Mandates prices to be paid for renewable energy, or requires a fixed amount or share of generation to be renewable | High costs, unfavorable power pricing rules, perceived risks |
| Cost reduction policies | Reduces investment costs through subsidies, rebates, tax relief, loans, and grants | High costs, perceived risks |
| Public investments and market facilitation activities | Provides public funds for direct investments or for guarantees, information, training, etc. to facilitate investments | Transaction costs, perceived risks, lack of access to credit, information, and skills |
| Power grid access policies | Gives renewable energy equal or favorable treatment for access to power grids and transmission systems | Independent power producer frameworks, transmission access, inter-connection requirements |
| **TRANSPORT BIOFUELS POLICIES** | | |
| Biofuels mandates | Mandates specific shares of transport fuel consumption from biofuels | Lack of fuel production or delivery infrastructure |
| Biofuel tax policies | Provides tax relief for biofuels | High costs |
| **EMISSIONS REDUCTION POLICIES** | | |
| Renewable energy set-asides | Allocates, or sets aside, a percentage of mandated environmental emissions reductions to be met by renewable energy | Environmental externalities |
| Emissions cap and trade policies | Allows renewables to receive monetary credit for local pollutant emissions reductions | Environmental externalities |
| Greenhouse gas mitigation policies | Allows renewables to receive monetary credit for greenhouse-gas emissions reductions | Environmental externalities |
| **POWER SECTOR RESTRUCTURING POLICIES** | | |
| Competitive wholesale power markets | Allows competition in supplying wholesale generation to the utility network and eliminates wholesale pricing restrictions | May heighten barriers of high costs, lack of fuel price risk assessment, unfavorable power pricing rules |
| Self-generation by end-users | Allows end-users to generate their own electricity and either sell surplus power back to the grid or partly offset purchased power | May reduce barrier of inter-connection requirements, but heighten barriers of high costs, lack of fuel price risk assessment |
| Privatization and/or commercialization of utilities | Changes government-owned and operated utilities into private or commercial entities | May reduce barrier of subsidies, but heighten barriers of high capital costs and perceived risks |
| Unbundling of generation, transmission and distribution | Eliminates monopolies so that separate entities provide generation, transmission, and distribution | May provide greater incentives to self-generate, including with renewable energy |
| Competitive retail power markets | Provides competition at the retail level for power sales, including "green power" sales | May reduce barriers of high costs, lack of information, transaction costs |

**Table 1: Summary of Renewable Energy Policies and Barriers (continued)**

| Policies | Description | Key Barriers Addressed |
|---|---|---|
| **DISTRIBUTED GENERATION POLICIES** | | |
| Net metering | Values renewable energy production at the point of end-use and allow utility networks to provide “energy storage” for small users | Unfavorable power pricing rules |
| Real-time pricing | Values renewable energy production at the actual cost of avoided fossil fuel generation at any given time of the day | Unfavorable power pricing rules |
| Capacity credit | Provides credit for the value of standing renewable energy capacity, not just energy production | Unfavorable power pricing rules |
| Interconnection regulations | Creates consistent and transparent rules, norms, and standards for interconnection | Interconnection requirements, transaction costs |
| **RURAL ELECTRIFICATION POLICIES** | | |
| Rural electrification policy and energy service concessions | Makes renewable energy part of rural electrification policy and planning and creates regulated businesses to serve rural customers | Subsidies for competing fuels, lack of skills and information, high costs, lack of access to credit |
| Rural business development and microcredit | Supports private entrepreneurs to provide renewable energy products and services to end-users and offer consumer credit for purchases | Lack of skills, lack of access to credit |
| Comparative line extension analyses | Analyzes the relative costs of renewable energy with conventional fuels and power delivery | Subsidies for competing fuels, lack of information |

## I. BARRIERS TO RENEWABLE ENERGY

The need for enacting policies to support renewable energy is often attributed to a variety of “barriers” or conditions that prevent investments from occurring. Often the result of barriers is to put renewable energy at an economic, regulatory, or institutional disadvantage relative to other forms of energy supply. Barriers include subsidies for conventional forms of energy, high initial capital costs coupled with lack of fuel-price risk assessment, imperfect capital markets, lack of skills or information, poor market acceptance, technology prejudice, financing risks and uncertainties, high transactions costs, and a variety of regulatory and institutional factors. Many of these barriers could be considered “market distortions” that unfairly discriminate against renewable energy, while others have the effect of increasing the costs of renewable energy relative to the alternatives. Barriers are often quite situation-specific in any given region or country; nevertheless, three broad categories of barriers are discussed in this section.

### A. Costs and Pricing

Many argue that renewable energy “costs more” than other energy sources, resulting in cost-driven decisions and policies that avoid renewable energy. In practice, a variety of factors can distort the comparison. For example, public subsidies may lower the costs of competing fuels. Although it is true that initial capital costs for renewable energy technologies are often higher on a cost-per-unit basis (i.e., $/kW), it is widely accepted that a true comparison must be made on the basis of total “lifecycle” costs. Lifecycle costs account for initial capital costs, future fuel costs, future operation and maintenance costs, decommissioning costs, and equipment lifetime. Here lies part of the problem in making comparisons: What are fuel costs going to be in the future? How should future costs be discounted to allow comparison with present costs based on expected interest rates? The uncertainties inherent in these questions affect cost comparisons. Existing analytical tools for calculating and comparing costs can discriminate against renewable energy if they do not account for future uncertainties or make unrealistic assumptions.

Many policies attempt to compensate for cost-related barriers by providing additional subsidies for renewable energy in the form of tax credits or incentives, by establishing special pricing and power-purchasing rules, and by lowering transaction costs. Despite many calls for reducing subsidies for fossil fuels and nuclear power, in practice this proves politically difficult. Thus practical policies have tended to focus on increasing subsidies for renewable energy rather than reducing subsidies for fossil fuels and nuclear power.

**1. Subsidies for competing fuels.** Large public subsidies, both implicit and explicit, are channeled in varying amounts to all forms of energy, which can distort investment cost decisions. Organizations such as the World Bank and International Energy Agency put global annual subsidies for fossil fuels in the range of $100-200 billion, although such figures are very difficult to estimate (for comparison, the world spends some $1 trillion annually on purchases of fossil fuels). Public subsidies can take many forms: direct budgetary transfers, tax incentives, R&D spending, liability insurance, leases, land rights-of-way, waste disposal, and guarantees to mitigate project financing or fuel price risks. Large subsidies for fossil fuels can significantly lower final energy prices, putting renewable energy at a competitive disadvantage if it does not enjoy equally large subsidies.

**2. High initial capital costs.** Even though lower fuel and operating costs may make renewable energy cost-competitive on a life-cycle basis, higher initial capital costs can mean that renewable energy provides less installed capacity per initial dollar invested than conventional energy sources. Thus, renewable energy investments generally require higher amounts of financing for the same capacity. Depending on the circumstances, capital markets may demand a premium in lending rates for financing renewable energy projects because more capital is being risked up front than in conventional energy projects. Renewable energy technologies may also face high taxes and import duties. These duties may exacerbate the high first-cost considerations relative to other technologies and fuels.

**3. Difficulty of fuel price risk assessment.** Risks associated with fluctuations in future fossil-fuel prices may not be quantitatively considered in decisions about new power generation capacity because these risks are inherently difficult to assess. Historically, future fuel price risk has not been considered an important factor because future fossil fuel prices have been assumed to be relatively stable or moderately increasing. Thus, risks of severe fluctuations are often ignored. However, with greater geopolitical uncertainties and energy market deregulation has come new awareness about future fuel price risks. Renewable energy technologies avoid fuel costs (with the exception of biomass) and so avoid fuel price risk. However, this benefit, or "risk-reduction premium," is often missing from economic comparisons and analytical tools because it is difficult to quantify. Further, for some regulated utilities, fuel costs are factored into regulated power rates, so that consumers rather than utilities bear the burden of fuel price risks, and utility investment decisions are made without considering fuel price risk.

**4. Unfavorable power pricing rules.** Renewable energy sources feeding into an electric power grid may not receive full credit for the value of their power. Two factors are at work. First, renewable energy generated on distribution networks near final consumers rather than at centralized generation facilities may not require transmission and distribution (i.e., would displace power coming from a transmission line into a node of a distribution network). But utilities may only pay wholesale rates for the power, as if the generation was located far from final consumers and required transmission and distribution. Thus, the "locational" value of the power is not captured by the producer. Second, renewable energy is often an "intermittent" source whose output level depends on the resource (i.e., wind and sun) and cannot be entirely controlled. Utilities cannot count on the power at any given time and may lower prices for it. Lower prices take two common forms: (i) a zero price for the "capacity value" of the generation (utility only pays for the "energy value"); (ii) an average price paid at peak times (when power is more valuable) which is lower than the value of the power to the utility—even though the renewable energy output may directly correspond with peak demand times and thus should be valued at peak prices.

**5. Transaction costs.** Renewable energy projects are typically smaller than conventional energy projects. Projects may require additional information not readily available, or may require additional time or attention to financing or permitting because of unfamiliarity with the technologies or uncertainties over performance. For these reasons, the transaction costs of renewable energy projects—including resource assessment, siting, permitting, planning, developing project proposals, assembling financing packages, and negotiating power-purchase contracts with utilities—may be much larger on a per-kilowatt (kW) capacity basis than for conventional power plants. Higher transaction costs are not necessarily an economic distortion in the same way as some other barriers, but simply make renewables more expensive. However, in practice some transaction costs may be unnecessarily high, for example, overly burdensome utility interconnection requirements and high utility fees for engineering reviews and inspection.

**6. Environmental externalities.** The environmental impacts of fossil fuels often result in real costs to society, in terms of human health (i.e., loss of work days, health care costs), infrastructure decay (i.e., from acid rain), declines in forests and fisheries, and perhaps ultimately, the costs associated with climate change. Dollar costs of environmental externalities are difficult to evaluate and depend on assumptions that can be subject to wide interpretation and discretion. Although environmental impacts and associated dollar costs are often included in economic comparisons between renewable and conventional energy, investors rarely include such environmental costs in the bottom line used to make decisions.

## B. Legal and Regulatory

**1. Lack of legal framework for independent power producers.** In many countries, power utilities still control a monopoly on electricity production and distribution. In these circumstances, in the absence of a legal framework, independent power producers may not be able to invest in renewable energy facilities and sell power to the utility or to third parties under so-called "power purchase agreements." Or utilities may negotiate power purchase agreements on an individual ad-hoc basis, making it difficult for project developers to plan and finance projects on the basis of known and consistent rules.

**2. Restrictions on siting and construction.** Wind turbines, rooftop solar hot-water heaters, photovoltaic installations, and biomass combustion facilities may all face building restrictions based upon height, aesthetics, noise, or safety, particularly in urban areas. Wind turbines have faced specific environmental concerns related to siting along migratory bird paths and coastal areas. Urban planning departments or building inspectors may be unfamiliar with renewable energy technologies and may not have established procedures for dealing with siting and permitting. Competition for land use with agricultural, recreational, scenic, or development interests can also occur.

**3. Transmission access.** Utilities may not allow favorable transmission access to renewable energy producers, or may charge high prices for transmission access. Transmission access is necessary because some renewable energy resources like windy sites and biomass fuels may be located far from population centers. Transmission or distribution access is also necessary for direct third-party sales between the renewable energy producer and a final consumer. New transmission access to remote renewable energy sites may be blocked by transmission-access rulings or right-of-way disputes.

**4. Utility interconnection requirements.** Individual home or commercial systems connected to utility grids can face burdensome, inconsistent, or unclear utility interconnection requirements. Lack of uniform requirements can add to transaction costs. Safety and power-quality risk from non-utility generation is a legitimate concern of utilities, but a utility may tend to set interconnection requirements that go beyond what is necessary or practical for small producers, in the absence of any incentive to set more reasonable but still technically sound requirements. In turn, the transaction costs of hiring legal and technical experts to understand and comply with interconnection requirements may be significant. Policies that create sound and uniform interconnection standards can reduce interconnection hurdles and costs.

**5. Liability insurance requirements.** Small power generators (particularly home PV systems feeding into the utility grid under "net metering" provisions) may face excessive requirements for liability insurance. The phenomenon of "islanding," which occurs when a self-generator continues to feed power into the grid when power flow from the central utility source has been interrupted, can result in serious injury or death to utility repair crews. Although proper equipment standards can prevent islanding, liability is still an issue. Several U.S. states have prohibited utilities from requiring additional insurance beyond normal homeowner liability coverage as part of net metering statutes.

### C. Market Performance

**1. Lack of access to credit.** Consumers or project developers may lack access to credit to purchase or invest in renewable energy because of lack of collateral, poor creditworthiness, or distorted capital markets. In rural areas, "microcredit" lending for household-scale renewable energy systems may not exist. Available loan terms may be too short relative to the equipment or investment lifetime. In some countries, power project developers have difficulty obtaining bank financing because of uncertainty as to whether utilities will continue to honor long-term power purchase agreements to buy the power.

**2. Perceived technology performance uncertainty and risk.** Proven, cost-effective technologies may still be perceived as risky if there is little experience with them in a new application or region. The lack of visible installations and familiarity with renewable energy technologies can lead to perceptions of greater technical risk than for conventional energy sources. These perceptions may increase required rates of return, result in less capital availability, or place more stringent requirements on technology selection and resource assessment. "Lack of utility acceptance" is a phrase used to describe the historical biases and prejudices on the part of traditional electric power utilities. Utilities may be hesitant to develop, acquire, and maintain unfamiliar technologies, or give them proper attention in planning frameworks. Finally, prejudice may exist because of poor past performance that is out of step with current performance norms.

**3. Lack of technical or commercial skills and information.** Markets function best when everyone has low-cost access to good information and the requisite skills. But in specific markets, skilled personnel who can install, operate, and maintain renewable energy technologies may not exist in large numbers. Project developers may lack sufficient technical, financial, and business development skills. Consumers, managers, engineers, architects, lenders, or planners may lack information about renewable energy technology characteristics, economic and financial costs and benefits, geographical resources, operating experience, maintenance requirements, sources of finance, and installation services. The lack of skills and information may increase perceived uncertainties and block decisions.

## II. RENEWABLE ENERGY PROMOTION POLICIES

Policies whose specific goal is to promote renewable energy fall into three main categories: (a) price-setting and quantity-forcing policies, which mandate prices or quantities; (b) investment cost reduction policies, which provide incentives in the form of lower investment costs; and (c) public investments and market facilitation activities, which offer a wide range of public policies that reduce market barriers and facilitate or accelerate renewable energy markets. Historically, governments have enacted these policies in a rather ad-hoc manner. More recently, national renewable energy targets (also referred to as goals) have emerged as a political context for promoting specific combinations of policies from all three categories. Such targets focus on the aggregate energy production of an entire country or group of countries. Targets may specify total primary energy from renewables and/or minimum renewable energy shares of electricity generation.

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, countries from around the world placed increased attention on renewable energy targets at the U.N. World Summit for Sustainable Development in 2002.

### A. Price-Setting and Quantity-Forcing Policies

Price-setting policies reduce cost- and pricing-related barriers by establishing favorable pricing regimes for renewable energy relative to other sources of power generation. The quantity of investment obtained under such regimes is unspecified, but prices are known in advance. Quantity-forcing policies do the opposite; they mandate a certain percentage or absolute quantity of generation to be supplied from renewable energy, at unspecified prices. Often price-setting or quantity-forcing policies occur in parallel with other policies, such as investment cost reduction policies.

The two main price-setting policies seen to-date are the PURPA legislation in the United States and “electricity feed-in laws” in Europe. The two main quantity-forcing policies seen to-date are competitively-bid renewable-resource obligations and renewable portfolio standards.

**1. U.S. Public Utility Regulatory Policies Act (PURPA).** PURPA was enacted in 1978 in part to encourage electric power production by small power producers using renewable resources to reduce U.S. dependence on foreign oil. The policy required utilities to purchase power from small renewable generators and cogenerators, known as “qualifying facilities,” through long-term (10-year) contracts at prices approximating the “avoided costs” of 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 qualifying facilities instead. Avoided cost calculations typically assumed an aggressive schedule of escalating future energy prices, making contract prices to qualifying facilities quite attractive.

For example, “standard offer” contracts under PURPA in California in the 1980’s set the avoided cost of generation in the range 6-10 cents/kWh—very favorable rates which initially spurred many investments by renewable energy producers. However, by the 1990s energy prices had not risen as originally expected and a large number of natural-gas fired independent generation came on-line in California.

Power surpluses emerged, wholesale power prices declined, and declining standard offer rates led to reduced competitiveness of renewable energy and a significant slowdown in construction of new capacity.

**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 German feed-in law led to a rapid increase in installed capacity and development of commercial renewable energy markets. Wind power purchase prices were highly favorable, amounting to about DM 0.17/kWh (US 10 cents/kWh), and applied over the entire life of the plant. Total wind power installed went from near zero in the early 1990s to over 8500 MW by 2001, making Germany the global leader in renewable energy investment.

Partly because retail electricity prices declined with increasing competition due to electricity deregulation, which made producers and financiers wary of new investments, a new German Renewable Energy Law of 2000 changed electricity feed-in pricing. 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. For example, wind power prices remained at the previous level of DM 0.17/kWh for plants commissioned in 2001, but only for the first five years of operation, after which prices paid declined. Solar PV prices were set initially at DM 0.99/kWh. All prices had build-in declines over time (i.e., 1.5% annual decreases in starting tariffs paid for wind power plants commissioned in subsequent years). This provision addressed one of the historical criticisms of feed-in approaches, which was that they did not encourage technology cost reductions or innovation. The new law's provisions for regular adjustments to prices addressed technological and market developments. The law also distributed the costs of the policy (i.e., the additional costs of wind power over conventional power) among all utility customers in the country. This issue of burden sharing had become a significant political issue in Germany by 2000 because the old law placed a disproportionate burden on utility customers in specific regions where wind power development was heaviest.

Other countries in Europe with renewable electricity feed-in laws include Denmark, France, Greece, Italy, Portugal, Spain, and Sweden. A combination of feed-in tariffs, production subsidies of DK 0.10/kWh, and a strong domestic market helped the Danish wind industry maintain a 50% market share of global wind turbine production for a number of years.

**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. For example, wind power contract prices declined from 10 p/kWh in 1990 under NFFO-1, to 4.5 p/kWh in 1997 under NFFO-4. One of the lessons some have drawn from the UK experience is that competitively determined subsidies can lead to rapidly declining prices for renewable energy. However, there has also been criticism that the NFFO process encouraged competing projects to bid below cost in order to capture contracts, with the result that successful bidders were unable to meet the terms of the bid or ended up insolvent. This criticism proved valid in practice; contracts awarded to low-bidders did not always translate into projects on the ground. 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 (under the "AER" program), France (under the "EOLE" program), and Australia (under the "RECP" program).

**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 are required to ensure that the target is met, either through 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, who must purchase either a portion of renewable power or the equivalent amount of green certificates (see next section). Two types of standards have emerged: *capacity-based standards* set a fixed amount of capacity by a given date, while *generation-based standards* mandate a given percentage of electricity generation that must come from renewable energy.

In the United States, many RPS policies have occurred as part of utility restructuring legislation. These are typically generation-based standards with phased implementation to allow utilities to reach incrementally increasing targets over a number of years. At least twelve U.S. states have enacted an RPS, ranging from 1% to 30% of electricity generation. However, the amount of *new and additional* generation expected from these standards varies widely depending on existing renewable energy capacity. For example, Maine historically generates over 40% of its power from renewable resources, so its 30% standard is unlikely to result in any new renewable generation. In contrast, California's requirement to increase renewable sales from 10.5% in 2001 to 20% by 2017 will likely result in a significant amount of new in-state renewable energy generation. Texas implemented an RPS in 2000 requiring 2000 MW of new renewable capacity by 2008. Partly due to federal production tax credits, Texas has been substantially ahead of schedule, with half of the targeted capacity in place by 2002.

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 regulatory requirements for utilities or electricity retailers to purchase a percentage of renewable power include Australia, Brazil, Belgium, Denmark, France, Japan, Spain, Sweden, and the United Kingdom. The UK's `Renewables Obligation' on suppliers will rise in annual steps from 3% in 2003 to 10% in 2010. In Denmark, legislation obliges end users to purchase 20% of their electricity from renewable sources by 2003.

In Brazil, a policy enacted during the electricity crisis of 2001 requires national utilities to purchase over 3000 MW of renewable energy capacity by 2016. Purchase prices are set by the government at 80 percent of the national average electricity retail price. Thus, in contrast to most national policies elsewhere, Brazil's policy is effectively both "price-setting" and "quantity-forcing."

**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 renewable 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 markets are emerging in several countries, allowing producers or purchasers of renewable energy who earn green certificates to sell those certificates to those who need to meet obligations but haven't generated or purchased the renewable power themselves. Those without obligations, but wishing to voluntarily support green power for philosophical or public-relations reasons may also purchase certificates.

Public and private institutions are emerging that keep track of renewable energy generation, assign certificates to generators, and register trades and sales of certificates. 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; more than 40 companies in 7 countries had opened trading accounts, with a further 100 companies intending to join the test phase in late 2002. Certificates for over 1,000 GWh were issued through 2002.

## B. 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 as falling in five broad categories: policies that (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.

**1. Subsidies and Rebates.** Reduction in the initial capital outlay by consumers for renewable energy systems is accomplished through direct subsidies, or rebates. These subsidies are used to "buy down" the initial capital cost of the system, so that the consumer sees a lower price. In the United States, at least nineteen states offer rebate programs at the state, local, and/or utility level to promote the installation of renewable energy equipment. The majority of the programs are available from state agencies and municipally-owned utilities and support solar water heating and/or photovoltaic systems, though some include geothermal heat pumps, small wind generators, passive solar, biomass, and fuel cells. Homes and businesses are usually eligible, although some programs target industry and public institutions as well. In some cases, rebate programs are combined with low or no-interest loans.

Sustained efforts to increase the use of renewables have been made via coordinated, multi-year, multi-policy initiatives. For example, Japan, Germany, and the United States subsidize capital costs of solar PV as part of their "market transformation" programs.

- Japan's Sunshine Program provides capital subsidies and net metering for rooftop PV systems. From 1994 to 2000, the government invested 86 billion yen ($725 million USD), resulting in 58,000 system installations and over 220 MW of PV capacity. Subsidies began at 900,000 yen/peak-kW (US$5/peak-watt) in 1994, and were gradually reduced to 120,000 yen/peak-kW (US$1/peak-watt) in 2001 as PV prices fell.

- Germany began a "1000 solar roofs" program in 1991 that offered subsidies for individual household purchases of solar PV of up to 60% of capital system costs. The program was expanded in 1999 to 100,000 roofs over five years, providing 10-year low-interest loans to households and businesses. As a result of favorable feed-in tariffs and low-interest loans, the program was expected to provide 300 peak-MW of PV capacity.

- The United States launched a "million solar roofs" initiative in 1997 to install solar PV systems and solar thermal systems on one million buildings by 2010. The program includes long-term low-interest customer financing, government procurement for federal buildings, commercialization programs, and production incentives. Individual states also have capital subsidy programs for PV, with the California Energy Commission offering rebates of up to $4.50/peak-watt or 50 percent off the system purchase price, New York and New Jersey offering up to $5/peak-watt subsidies, and New York rebating as much as 70% of the cost of eligible equipment as of 2002.

Subsidy programs also exist for wind power, such as Denmark's DK 0.10/kWh (US 1.5 cents/kWh) production subsidy paid to utilities. Among developing countries, Thailand provided subsidies for small renewable energy power producers starting in 2000, soliciting bids for 300 MW of small renewable power, and providing production subsidies above standard power purchase rates for at least the first five years of operation of each facility.

**2. Tax Relief.** Tax relief policies to promote renewable energy have been employed in the United States, Europe, Japan, and India. Tax relief has been especially popular in the United States, where a host of federal and state tax policies address energy production, property investments, accelerated depreciation, and renewable fuels. State policies vary widely in scope and implementation. At least 17 states have personal tax incentives, 21 states have corporate tax incentives, 16 states have sales tax incentives, and 24 states have property tax incentives.

**a. Investment Tax Credits.** Investment tax credits for renewable energy have been offered for businesses and residences. In the United States, businesses receive a 10 percent tax credit for purchases of solar and geothermal renewable energy property, subject to certain limitations. Some U.S. states have investment tax credits of up to 35%.

**b. Accelerated Depreciation.** Accelerated depreciation allows renewable energy investors to receive the tax benefits sooner than under standard depreciation rules. The effect of accelerated depreciation is similar to that of investment tax credits. In the United States, businesses can recover investments in solar, wind, and geothermal property by depreciating them over a period of five years, rather than the 15- to 20-year depreciation lives of conventional power investments.

India's accelerated depreciation policy allowed 100% depreciation in the first year of operation, helping spur the largest wind power industry among developing countries. However, this policy led to large investments without sufficient regard to long-term operating performance and maintenance, resulting in capacity factors lower than for wind power installations elsewhere. This led many to conclude that production-based incentives are preferable to investment tax credits and accelerated depreciation, although Germany's investment tax credits accompanied by wind turbine technical standards and certification requirements avoided the problems found in India.

**c. Production Tax Credits.** A production tax credit provides the investor or owner of qualifying property with an annual tax credit based on the amount of electricity generated by that facility. By rewarding production, these tax credits encourage improved operating performance. A production tax credit in Denmark provides DK 0.10/kWh (US 1.5 cents/kWh) for wind power, but few other countries have adopted similar credits. In the United States the Renewable Electricity Production Credit (PTC) provides a per-kWh tax credit for electricity generated by qualified wind, closed-loop biomass, or poultry waste resources. Federal tax credits of 1.5 cents/kWh (adjusted annually for inflation) are provided for the first ten years of operation for all qualifying plants that entered service from 1992 through mid-1999, later extended to 2001 and then to 2003.

At least five U.S. states have state or local production incentives for distributed electrical generation, renewable fuels, or both. These policies are similar to the federal PTC, with specific limits on technologies, dates-in-service, and maximum payout per provider and per year. Funds to support the incentives are obtained from a mixture of sources, including general funds, public benefit or environmental funds, and green electricity sales (so-called "green tags").

**d. Property Tax Incentives.** At least 24 U.S. states have property tax incentives for renewable energy. These incentives are implemented on many scales--state, county, city, town, and municipality. These are generally implemented in one of three ways: (1) renewable energy property is partially or fully excluded from property tax assessment, (2) renewable energy property value is capped at the value of an equivalent conventional energy system providing the same service, and (3) tax credits are awarded to offset property taxes.

**e. Personal Income Tax Incentives.** Credits against personal state income taxes are available in many U.S. states for purchase of and/or conversion to eligible renewable energy systems and renewable fuels. In some cases, taxpayers can deduct the interest paid on loans for renewable energy equipment.

**f. Sales Tax Incentives**. At least sixteen U.S. states have policies that provide retail sales tax exemptions for eligible renewable energy systems and renewable fuels. Most exempt 100% of the sales tax for capital expenses, and provide specific cents-per-gallon exemptions for renewable fuels. Some policies specify maximum or minimum sizes for eligible systems.

**g. Pollution Tax Exemptions.** The Netherlands is an example where "green" power is exempt from a new and rising fossil-fuel tax on electricity generation that is paid by end-users. Starting in 2001, that fossil-fuel tax rose to the equivalent of US 5 cents/kWh, providing a large tax incentive for Dutch consumers.

**h. Other Tax Policies.** A variety of other tax policies exist, such as income tax exemptions on income from renewable power production, excise duty and sales tax exemptions on equipment purchased, and reduced or zero import tax duties on assembled renewable energy equipment or on components. India, for example, has allowed five-year tax exemptions on income from sales of wind power.

**3. Grants.** Many countries have offered grants for renewable energy purchases. For example, beginning in 1979, Denmark provided rebates of up to 30% of capital costs for wind and other renewable energy technologies. These rebates declined over time. In the United States, county and state governments and utilities provide grants for renewable energy ranging in size from hundreds to millions of dollars.

**4. Loans.** Loan programs offer financing for the purchase of renewable energy equipment. Loans can be market-rate, low-interest (below market rate), or forgivable. In many U.S. states, loans are available to virtually all sectors—residential, commercial, industrial, transportation, public, and nonprofit. Repayment schedules vary, with terms of up to 10 years common. Interest rates for renewable energy investments can often be 1% or more higher than those for conventional power projects because of the higher perceived risks involved, so government-subsidized loans that offer below-market interest rates are also common.

Renewable energy loans can take many forms. Residential loans may range from $500 to $10,000 or more, while commercial and industrial loans may extend to the millions. Funding comes from a variety of sources, including municipal bonds, system benefit funds, revolving funds, and utility penalty or overcharge funds. Financing may be for a fraction to 100% of a project. Some loan programs have minimum or maximum limits, while others are open-ended. Loan terms range from 3 years to the life of a project. Some loans are contractor-driven, and may include service contracts in the loan amount. Sometimes grants and loans are combined; for example, Iowa provides a 20% forgivable loan combined with an 80% loan at prime rate for renewable fuels projects.

In some developing countries, notably India, China, and Sri Lanka, multilateral loans by lenders such as the World Bank have provided financing for renewable energy, usually in conjunction with commercial lending. One of the most prominent examples is the India Renewable Energy Development Agency (IREDA), which was formed in 1987 to provide assistance in obtaining international multilateral agency loans and in helping private power investors obtain commercial loans. By 2001, IREDA had disbursed the equivalent of over US$400 million in loans for renewable energy projects in India, resulting in over 1600 MW of renewable power generation.

## C. Public Investments and Market Facilitation Activities

**1. Public Benefit Funds.** In the United States, public funds for renewable energy development are raised through a System Benefits Charge (SBC), which is a per-kWh levy on electric power consumption. Some analysts suggest that state clean energy funds seem to be one of the more effective policies in promoting renewable energy development to result from electricity restructuring. It is estimated that fourteen U.S.

states will collect $3.5 billion through 2011 in system benefits charges. Similar levies exist in some European countries for fossil-fuel-based generation. In general, the funds serve a variety of purposes, such as paying for the difference between the cost of renewables and traditional generating facilities, reducing the cost of loans for renewable facilities, providing energy efficiency services, funding public education on energy-related issues, providing low-income energy assistance, and supporting research and development.

**2. Infrastructure Policies.** Market facilitation supports market institutions, participants, and rules to encourage renewable energy technology deployment. A variety of policies are used to build and maintain this "market infrastructure," including policies for design standards, accelerated siting and permitting, equipment standards, and contractor education and licensing. Additionally, policies to induce renewable technology manufactures to site locally, and direct sales of renewable systems to customers at concessionary rates facilitate market development.

**a. Construction and design policies.** Construction and design standards include building-code standards for PV installations, design standards evaluated on life-cycle cost basis, and performance requirements. Policy examples include Tucson, Arizona, which requires that commercial facilities achieve a 50% reduction in energy usage over 1995 Model Energy Code, and Florida, which requires that all new educational facilities include passive solar design.

**b. Site prospecting, review and permitting.** Federal and state programs reduce barriers to renewable energy development through resource, transmission, zoning, and permitting assessments. This particularly helped early promotion of wind energy projects in California. On a national scale the Utility Wind Resource Assessment Program funds a number of supporting activities, including up to 50% of the cost of wind resource assessments. India also has a large wind assessment program, with over 600 stations in 25 states providing information to project developers on the best sites for development.

**c. Equipment standards and contractor certification.** A variety of equipment-related standards and certification measures have been applied to ensure uniform quality of equipment and installation, increasing the likelihood of positive returns from renewable energy installations. Contractor licensing requirements ensure that contractors have the necessary experience and knowledge to properly install systems. Equipment certifications, ensure that equipment meets certain minimum standards of performance or safety.

**d. Industrial recruitment.** Industrial recruitment policies use financial incentives such as tax credits, grants, and government procurement commitments to attract renewable energy equipment manufacturers to locate in a particular area. These incentives are designed to create local jobs, strengthening the local economy and tax base, and improving the economics of local renewable development initiatives.

**e. Direct equipment sales.** These programs allow the consumer to buy or lease renewable energy systems directly from electric provider at below-retail rates. Some programs provide a capital buydown. Examples include Arizona, which provides a buydown of $2/peak-watt for PV, and California's SMUD, which offers a 50% buydown plus 10-year financed loans and net metering.

**3. Government Procurement.** Government procurement policies aim to promote sustained and orderly commercial development of renewable energy. Governmental purchase agreements can reduce uncertainty and spur market development through long-term contracts, pre-approved purchasing agreements, and volume purchases. Government purchases of renewable energy technologies in early market stages can help overcome institutional barriers to commercialization, encourage the development of appropriate infrastructure, and provide a “market path” for technologies that require integrated technical, infrastructure, and regulatory changes.

**4. Customer Education and Mandated Generation Disclosure Information.** U.S. restructuring and deregulation policies mandate that information be provided to customers about choice of electricity providers and “characteristics” of electricity being provided (such as emissions and fuel types). In many states, general education to raise customer awareness about renewable energy and the environmental impacts of energy generation is required, typically via websites and printed materials.

**5. Solar and Wind Access Laws.** Renewable access laws address access, easements, and covenants. Access laws provide a property owner the right to continued access to a renewable resource. Easements provide a privilege to have continued access to wind or sunlight, even though development or features of another person's property could reduce that access. Easements are often voluntary contracts, and may be transferred with the property title. Covenant laws prohibit neighborhood covenants from explicitly restricting the installation or use of renewable equipment. Policy mechanisms include access ordinances, development guidelines addressing street orientation, zoning ordinances with building height restrictions, and renewable permits.

## III. TRANSPORT BIOFUELS POLICIES

Biofuels mandates and tax policies in Brazil, the United States, and Europe have supported accelerating development of biofuels. Biofuels mandates require that 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 been quite successful with biofuels mandates under its “ProAlcool” program, which has promoted the use ethanol for transportation fuel since the 1980s. In addition to a variety of economic incentives and subsidies, Brazil has mandated that ethanol be blended with all gasoline sold in the country. Brazil has also required that all gas stations sell pure ethanol. This last requirement made it commercially viable for the automotive industry to produce ethanol-only (neat ethanol) cars. However, the share of ethanol-only cars purchased annually, after rising to 95% by 1985, subsequently declined for a number of reasons. Today, most cars use the “gasohol” ethanol/gasoline blend, and more than 60 percent of Brazil’s sugar cane production goes to produce 18 billion gallons of ethanol each year, representing 90% of global ethanol production. In 2000, over 40% of automobile fuel consumption in Brazil was ethanol.

The United States, the world’s second largest ethanol producer after Brazil, has a number of biofuels tax policies and mandates. The Energy Security Act of 1979 created a federal ethanol tax credit of up to 60 cents per gallon for businesses that sell or use alcohol as a fuel. Gasoline refiners and distributors may also receive an excise tax exemption of up to 5 cents/gallon for blending their fuels with ethanol. State-level ethanol policies also exist, whose origins in the 1980s can be traced back to initiatives by Iowa to use its corn crop for energy. Several policies in Iowa were established to encourage ethanol consumption, including a mandate for government vehicles to use ethanol-blended fuel, and a one-cent-per-gallon fuel sales tax exemption for ethanol-blended fuels. In 1998, both the federal government and the State of Iowa extended their ethanol tax exemptions until the year 2007. In part due to ethanol incentives, over sixty ethanol production facilities have become operational in the U.S. since 1976, with a production capacity of more than 2.4 billion gallons per year. A recent U.S. legislative proposal, called a “renewable fuels standard,” would triple biofuel use within 10 years.

In Europe, Germany is the largest user of biodiesel and provides tax incentives for 100% pure biodiesel. These incentives have had a large effect; German consumption of biodiesel went from 200 million gallons in 1991 to 750 million gallons in 2002. Other EU members provide tax incentives for 2-5% biodiesel blends. Germany, Austria, and Sweden use 100% pure biodiesel in specially adapted vehicles, and biodiesel is mandated in environmentally sensitive areas in Germany and Austria. Other countries producing biodiesel are Belgium, France, and Italy, the later two also providing tax incentives. The European Commission has recently proposed a biofuel directive with targets or mandates for biofuels up to 6% of all transportation fuel sold.

Among other developing countries, Thailand is considering tax policies for biofuels, including excise tax exemptions for ethanol and income tax waivers for investments in biofuels facilities. Malaysia and Indonesia also utilize biodiesel.

## IV. EMISSIONS REDUCTION 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 available to renewable energy generation can “offset” these allowed emissions. Such credits have market value, and are often traded to allow electricity generators to comply with emission regulations at least cost. Three innovative examples of U.S. air quality standards, acid rain prevention programs, and state-level greenhouse-gas reduction initiatives illustrate the potential of emissions reductions policies to affect renewable energy.

### A. Renewable Energy Set-Asides

To meet National Ambient Air Quality Standards, the U.S. Environmental Protection Agency requires twenty-two U.S. states and the District of Columbia to reduce NOx emissions significantly by 2007. States can meet emission reduction targets through actual emission reductions and/or purchase of emission reduction credits from other states participating in a region-wide NOx trading program. States can allocate, or “set-aside,” a percentage of the total state NOx allowances to energy efficiency and renewable energy. Eligible renewable energy producers receive these set-aside allowances and can sell them to fossil-fuel-based electricity generators to enable those generators to stay within their NOx allocation. The additional revenue from sales of these set-aside allowances can potentially provide stimulus for renewable energy development, although to date few states have implemented renewable energy set-asides.

### B. Emissions Cap-and-Trade Policies

Under the 1990 Clean Air Act the United States instituted a cap-and-trade mechanism to reduce SO2 emissions and facilitate least-cost compliance. Under the Acid Rain sub-program, 300,000 SO2 emissions allowances (rights to emit SO2) were set aside for utilities that employed renewable energy or energy efficiency measures. Allowances were to be earned from 1992 through 1999, allocated at a rate of one allowance (one ton of SO2 avoided) per 500 MWh of generation produced by renewable energy or avoided through increased energy efficiency. This program was not particularly effective, as only one-tenth of the 300,000 allowances were allocated to energy efficiency or renewable energy. Analysis suggests that allowance prices set by the market were not high enough to justify renewable energy investments. In addition, the program restricted participation to utilities, excluding other power generators, which also contributed to under-subscription.

### C. Greenhouse Gas Mitigation Policies

The New Jersey Sustainability Greenhouse Gas (GHG) Action Plan was designed to promote the capture of landfill methane gas for power generation, thus avoiding methane emissions (methane has a high "global warming potential"). A loan fund provides New Jersey companies with low-interest loans to support initiatives including development of biomass/landfill methane energy resources, and emission offsets from landfill methane and other renewable power generation could potentially be included in GHG trading systems.

## V. POWER SECTOR RESTRUCTURING POLICIES

Power sector restructuring 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. There are five key trends underway that continue to influence renewable energy development, both positively and negatively, as discussed below.

### A. Competitive Wholesale Power Markets and Removal of Price Regulation on Generation

Power generation is usually one of the first aspects of utility systems to be deregulated. The trend is away from utilities monopolies towards open competition, where power contracts are signed between buyers and sellers in wholesale "power markets." Distribution utilities and industrial customers gain more choices in obtaining wholesale power. Such markets may often begin with independent-power-producer (IPP) frameworks. As wholesale electricity becomes more of a competitive market commodity, price becomes relatively more important than other factors in determining a buyer's choice of electricity supplier.

The potential effects of competitive wholesale markets and IPPs on renewable energy are significant. Wholesale power markets allow IPPs to bypass the biases against renewables that traditional utility monopolies have had. Indeed, one of the very first major markets for renewable energy in the 1980s was in California, spurred by the PURPA legislation discussed earlier. In some countries, IPP frameworks have been explicitly enacted to support renewable energy. Examples are Sri Lanka and Thailand, where utility monopolies were broken and renewable energy IPPs can sell power to the grid. However, other effects of wholesale competition may stifle renewable energy development. As low-cost combined-cycle gas turbines begin to dominate new generation, renewable energy has difficulty competing on the basis of price alone. In addition, the emergence of short-term power contracts and 'spot' markets favor generation technologies with higher variable costs and lower capital costs, like fossil fuels, rather than capital-intensive but low-operating-cost technologies like renewables.

### B. Self-Generation By End-Users and Distributed Generation Technologies

Independent power producers may be the end-users themselves rather than just dedicated generation companies. With the advent of IPP frameworks, utility buy-back schemes (including net metering), and cogeneration technology options, more and more end-users, from large industrial customers to small residential users, are generating their own electricity. Their self-generation offsets purchased power and they may even sell surplus power back to the grid. Traditionally, regulated monopoly utilities have enjoyed economic advantages from large power plants and increasing economies of scale. These advantages are eroding due to new distributed generation technologies that are cost-competitive and even more efficient at increasingly smaller scales. In fact, newer technologies reduce investment risks and costs at smaller scales by providing modular and rapid capacity increments.

Renewable energy is well suited to self-generation, but faces competition from other distributed generation technologies, especially those based on natural gas. Gas has become the fuel of choice for small self-producers because of short construction lead times, low fuel and maintenance costs, and modular small-scale technology. However, with restructuring, a host of distributed generation policies, including net metering, become possible (see the section on distributed generation policies). These policies often spur renewable energy investments. On the other hand, self-generators may be penalized by utility-wide surcharges that accompany restructuring, such as those for stranded generation assets (called "non-bypassable competitive transition charges" in the U.S.). Self-generators who use renewable energy must still pay these charges, based on the amount of electricity they *would* have purchased from the grid, even if actual grid consumption is small.

### C. Privatization and/or Commercialization of Utilities

In many countries, utilities, historically government-owned and operated, are becoming private for-profit entities that must act like commercial corporations. Even if utilities remain state-owned, they are becoming "commercialized"—losing state subsidies and becoming subject to the same tax laws and accounting rules as private firms. In both cases, staffing may be reduced and management must make independent decisions on the basis of profitability.

The effects of privatization and commercialization on renewable energy are difficult to judge. The environmental effects of privatization can be positive or negative, depending on such factors as the strength of the regulatory body and the political and environmental policy situation in a country. Private utilities are more likely to focus more on costs and less on public benefits, unless specific public mandates exist. On the positive side, privatization may promote capital-intensive renewable energy by providing a new source of finance—capital from private debt and equity markets. However, the transition from public to private may shorten time horizons, increase borrowing costs, and increase requirements for high rates of return. All of these factors would limit investments in capital-intensive renewable energy projects, in favor of lower-capital-cost, higher-operating-cost fossil-fuel technologies.

### D. Unbundling of Generation, Transmission and Distribution

Utilities have traditionally been vertically integrated, including generation, transmission and distribution functions. Under some restructuring programs, each of these functions is being "unbundled" into different commercial entities, some retaining a regulated monopoly status (particularly distribution utilities) and others starting to face competition (particularly generators).

Unbundling can provide greater consumer incentives to self-generate using renewable energy. If retail tariffs are "unbundled" as well, so that generation, transmission and distribution costs are separated, customers have more incentive to self-generate, thereby avoiding transmission and distribution charges. In addition, open-access transmission policies that go along with unbundling have been explicitly targeted to promote renewable energy in some countries. In India, open-access policies helped catalyze the wind industry there, by allowed firms to produce wind power in remote regions with good wind resources and then "wheel" the power over the transmission system to their own facilities or to third parties. Brazil enacted a 50% reduction of transmission wheeling fees for renewable energy producers, which has been credited with promoting a booming small hydro industry there. However, unbundling can also penalize inherently intermittent renewable energy if producers have to pay transmission charges on a per-capacity basis. That is, even when the transmission capacity is not being used (say the wind is not blowing), transmission charges must be paid, resulting in high average transmission costs per kWh.

### E. Competitive Retail Power Markets and "Green Power" Sales

Competition at the retail level, the newest phenomena in power sector restructuring, means that individual consumers are free to select their power supplier from among all those operating in a given market. Competitive retail power markets have allowed the emergence of "green power" suppliers who offer to sell renewable energy, usually at a premium. As green power sales grow, these suppliers are forced to investment in new renewable energy capacity to meet demand, or buy power from other renewable energy producers. 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, one million green power customers signed up within the first year. However, incentives played a role; a large tax on fossil-fuel generated electricity, from which green power sales were exempt, made green power economically competitive with conventional power. In the U.S., green power markets are emerging in several states in response to state incentives and aggressive marketing campaigns by green power suppliers. At least 30 U.S. states have green pricing programs. Four states have mandatory green power policies that require utilities to offer customers opportunities to support renewable energy. California became one of the largest markets, with over 200,000 customers, but this was aided by a 1 cent/kWh subsidy to green power, paid for by a system benefits charge (see section on renewable energy promotion policies).

## VI. DISTRIBUTED GENERATION POLICIES

Distributed generation avoids some of the costs of transmission and distribution infrastructure and power losses, which together can total up to half of delivered power costs. Policies to promote distributed generation—including net metering, real-time pricing, and interconnection regulations—do not apply only to renewable energy, but nevertheless can strongly influence renewable energy investments.

### A. Net Metering

Net metering allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. When a customer consumes more power than it generates, power flows from the grid and the meter runs forward. When a customer installation generates more power than it consumes, power flows into the grid and 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 allows customers to receive retail prices for the excess electricity they generate at any given time. This encourages customers to invest in renewable energy because the retail price received for power is usually much greater than it would be if net metering were not allowed and customers had to sell excess power to the utility at wholesale rates or avoided costs. Electricity providers may also benefit from net metering programs, particularly with customer-sited PV which produces electricity during peak periods. Such peak power can offset the need for new central generation and improve system load factors.

At least 38 U.S. states now have net metering laws. Size limits on net metered systems typically range from 10kW to 100kW, with the exception of a few states that do not limit system size or overall enrollment. Net metering is 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, following a pilot project for net-metered rooftop PV in the 1990's.

### B. Real-Time Pricing

Real-time pricing, also known as dynamic pricing, is a utility rate structure in which the per-kWh charge varies each hour based on the utility's real-time production costs. Because peaking plants are more expensive to run than baseload plants, retail electricity rates are higher during peak times than during shoulder and off-peak times under real-time pricing. When used in conjunction with net metering, customers receive higher peak rates when selling power into the grid at peak times. At off-peak times the customer is likely purchasing power from the grid, but at the lower off-peak rate. Photovoltaic power is often a good candidate for real-time pricing, especially if maximum solar radiation occurs at peak-demand times of day when power purchase prices are higher. Real-time metering equipment is necessary, which adds complexity and expense to metering hardware and administration.

Real-time pricing has been used with some large power consumers for decades. For example, power companies in Nova Scotia and New York state offer real time pricing rates for large commercial and industrial customers that vary hourly according to the varying cost of generation. In a recent pilot project, California installed 23,000 real-time meters for large customers at a cost of $35 million. In response, summer peak demand by those customers dropped by 500 MW under time-of-use pricing, which would allow the utility to avoid $250-300 million in capacity additions. Although real-time pricing has not become widespread, with favorable rate structures it has the potential to provide significant incentives for grid-connected renewable development.

### C. Interconnection Regulations

Non-discriminatory interconnection laws and regulations are needed to address a number of crucial barriers to interconnection of renewable energy with the grid. Interconnection regulations often apply to both distributed generation and "remote" generation with renewable energy that requires transmission access, such as wind power.

**1. Legal Access.** The ability to legally connect a renewable energy system to a grid depends on federal, state, and local government rules and regulations. These policies both allow connection and determine how physical connection is achieved. In the U.S., the legal right to connect to the grid is provided for in federal laws such as the Public Utilities Regulatory Policies Act (PURPA) of 1978, and by state net metering statutes.

**2. Dynamic Generation and Transmission Scheduling.** Historically, transmission policies have often imposed severe penalties on unscheduled deviations from projected (advance-scheduled) power generation. These penalty structures render intermittent generation, such as wind or PV, uneconomic. Real-time accounting of power transfer deviations that provides charges or credits to producers based upon the value of energy at the time of the deviation, as well as elimination of discriminatory deviation penalties, allows intermittent renewable energy to compete more equitably with traditional generation.

Policies that allow near-time or real-time scheduling of the output levels of intermittent resources can further reduce deviation costs. For example, wind farms are able to predict their output much more accurately up to an hour in advance of generation, and thus can be better scheduled hour-by-hour rather than day-ahead.

**3. Elimination of Rate "Pancaking."** Because distributed renewables, such as wind, are often remotely located, they can incur high transmission fees as power crosses multiple jurisdictions to get to the customer. Such cumulative addition of transmission fees is known as "rate pancaking." Elimination of access rate pancaking, either by consolidation of long-distance tariffs under a regional transmission organization, and/or by creating access waiver agreements between multiple owner/operators, can reduce discrimination against wind and other remote distributed renewables.

**4. Capacity Allocation.** When demand for a transmission path exceeds its reliable capacity, transmission congestion occurs. In such circumstances, system operators must allocate available capacity among competing users. Traditional utility policies often favor early market entrants, "grandfathering" them into capacity allocation rules. Wind power is particularly susceptible to transmission constraints, as it is generally located far from load. Elimination of grandfathering would allow transmission users to bid for congested capacity on an equal-footing. Allowing wind to bid for congested capacity closer to the operating hour, and reducing congestion through transmission line upgrades would also reduce barriers to wind energy development.

**5. Standard Interconnection Agreements.** Utilities may require the same interconnection procedures for small systems as are required for large independent power production facilities. The process of negotiating a power purchase/sale contract with the utility can be very expensive, and utilities can charge miscellaneous fees that greatly reduce the financial feasibility of small grid-connected renewable installations. Standardized interconnection agreements can expedite this process. Some believe that Texas provides a good model for renewable interconnection. Under a standard agreement, renewable developers pay only for the direct costs of connecting the plant to the local system, but not for upgrades to the grid necessary to carry additional capacity. This allows generators to compete more equally.

## VII. RURAL ELECTRIFICATION POLICIES

Historically, renewable energy in developing countries has come from direct donor assistance and grants for equipment purchases and demonstrations. In recent years a number of new approaches have emerged for promoting renewable energy in off-grid rural areas, including energy service concessions, private entrepreneurship, microcredit, and comparative line extension analysis.

### A. Rural Electrification Policy and Energy Service Concessions

Many developing countries have explicit policies to extend electric networks to large shares of rural populations that remain unconnected to power grids (globally, an estimated 1.7 billion people). However, in many areas, full grid extension is too costly and unrealistic. Policies and rural electrification planning frameworks have recently started to emerge that designate certain geographic areas as targets for off-grid renewable energy development. These policies may also provide explicit government financial support for renewable energy in these areas. Such financial support is starting to be recognized as a competitive alternative to government subsidies for conventional grid extensions. Countries taking the lead with such policies include Argentina, China, India, Morocco, the Philippines, South Africa, and Sri Lanka.

One form this government support can take is so-called "energy service concessions." With a concession, the government selects one company to exclusively serve a specific geographic region, with an obligation to serve all customers who request service. The government also provides subsidies and regulates the fees and operations of the concession. Rural energy-service concessions may employ a mixture of energy sources to serve customers, including diesel generators, mini-hydro, photovoltaic, wind, and biomass. Argentina, Morocco, and South Africa have initiated policies to develop rural concessions, with ambitious targets of 200,000 rural households in South Africa and 60,000 in Argentina. But the actual experience with this approach has been very limited so far to just a few thousand installations.

### B. Rural Business Development and Microcredit

Private entrepreneurship is increasingly recognized as an important strategy to fulfill rural energy goals. Thus, rural electrification policies have begun to promote entrepreneurship. Promising approaches are emerging that support rural entrepreneurs with training, marketing, feasibility studies, business planning, management, financing, and connections to banks and community organizations. These approaches include "bundling" renewable energy with existing products. Bundling can reduce costs if vendors of existing products and services add renewable energy to their activities—and use their existing networks of sales outlets, dealers, and service personnel. Dealers of farm machinery, fertilizers, pumps, generators, batteries, kerosene, LPG, water, electronics, telecommunications, and other rural services can "bundle" renewable energy with these services.

In conjunction with entrepreneurship, consumer microcredit has emerged as an important tool for facilitating individual household purchases of renewable energy systems like solar home systems. Credit may be provided either by the system vendors themselves, by rural development banks, or by dedicated microcredit organizations. Notable examples of consumer microcredit for solar home systems have emerged in five developing countries. In Bangladesh, Grameen Shakti, a non-profit vendor, has offered consumer credit for terms up to 3 years. The Vietnam Women's Union offered similar credit terms for systems sold by private vendors. In Sri Lanka, Sarvodaya, a national microfinance organization, has offered credit on terms up to 5 years. In Zimbabwe, vendors sold several thousand systems on credit provided by the Agricultural Finance Corporation. And in India, new forms of rural microcredit have started to emerge. By 2002, the cumulative number of solar home system purchases made with credit in these countries had exceeded 50,000, but this was still a small fraction of the total number of solar home systems worldwide, estimated at 1.2 million.

### C. Comparative Line Extension Analyses

Economic comparisons of line extension versus distributed renewable energy investment are also emerging in developed countries. At least four U.S. states have power line extension policies requiring that, in cases where utility customers must pay a portion of construction costs for utility power line extension to a remote location, the utility must provide information about on-site renewable energy technology options. Some of these policies require the utility to perform a cost/benefit analysis comparing line extension with off-grid renewable energy. Renewable energy options may be less expensive for rural customers, but without line extension policies, many customers would not be aware of this.

## VIII. SUMMARY

Public support for renewable energy expanded rapidly in the late 1990s and early 2000s. A wide variety of policies are designed explicitly to promote renewable energy, while other policies focus on power sector restructuring or environmental issues more broadly and have more indirectly affected renewable energy. Experience with renewable energy policies around the world is still emerging and more understanding is needed of the impacts of various policies. Thus, many policies could still be considered "experimental" in nature. Of all the policies surveyed in this article, the ones that appear to have contributed the most to renewable energy development during the 1990s and early 2000s are: (a) direct equipment subsidies and rebates, net metering laws, and technical interconnection standards in the case of solar PV; (b) investment tax credits, production tax credits, and European electricity feed-in laws in the case of wind; (c) grid-access and wheeling policies supporting independent power producers and third-party sales in the case of biomass and small hydro power. Many of the trends towards restructuring of power-sector institutions and regulation that were underway throughout the 1990s have had both positive and negative influences on renewable energy. Policy makers and policy advocates have many options from which to choose, and a slowly emerging body of experience and results to guide those choices.

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