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RENEWABLE ENERGY POLICY OUTSIDE THE UNITED STATES

by Curtis Moore[1] and Jack Ihle

Many industrialized nations have enacted a variety of policies to commercialize renewable energy—some are appropriate for the U.S. to pursue, others not. The U.S. can learn from all of them to expand its own domestic renewable energy market. But if the U.S. does not commit to a multi-year, diverse mix of commercialization strategies soon, it will continue to lose its share of a growing global market.

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A Message from the Staff of the Renewable Energy Policy Project

Consider this scenario for the next millennium's first decade: Average global temperatures are on the rise. Antarctic ice sheets crumble, and natural gas prices swing disconcertingly. U.S. political leaders are determined to catalyze the use of renewable energy technologies. They put into place programs to deploy wind turbines, photovoltaic cells, biomass gasifiers, and other technologies. Now the question is, "Where to find the renewable energy technologies?"

The unfortunate answer: overseas. In this scenario, dwindling U.S. demand has long since impoverished most American firms. The few that remain have abandoned any interest in domestic markets, and instead have built their factories in Europe, Japan and the developing world. Their former rivals from Germany, Japan, and India dominate the PV industry. Danes manufacture wind turbines. Biomass is the province of the British and the Chinese. Thus, as we wait for investment to return to the American renewable energy sector, we make the only possible decision: we import, abandoning for the moment economic development that would have come from domestic manufacturing and services.

Now, add to those conditions a falling dollar—almost inevitable, compared to current exchange rates. The economies of Japan and Southeast Asia rebound. The European Union consolidates and its firms become lean and competitive. Industrial development accelerates in India and China. In short, U.S. renewable energy policy becomes a hostage to the crosswinds of international economics, as well as potential international skirmishes over trade policy.

We find this scenario dishearteningly plausible, given current trends. As Curtis Moore and Jack Ihle outline in this report, our allies and competitors have not only crafted renewable energy policies with attention to commercial and consumer finance, community participation, and bold distributed energy policies; many also back up such programs with substantial funding. One purpose of these programs is to increase renewable energy capacity domestically. The other is to build a healthy renewable energy industry that can compete worldwide.

Meanwhile, demand for renewable energy in the U.S. has fallen off, as has the American share of the world market for renewable energy. Once the world leader in installed wind capacity, the U.S. has fallen behind Denmark and Germany, with other nations closing in fast. The one surviving U.S. manufacturer of large wind turbines faces a Danish juggernaut. The U.S. photovoltaic industry relies on exports to Europe, Japan, and the developing world for 75% of its sales. British Petroleum has merged with Amoco, giving the resulting amalgam ownership of the only remaining major American PV firm left, and, all told, 20% of the world market. And U.S. geothermal firms have largely turned to markets in Central America and Southeast Asia.

These trends should worry us. As Mr. Moore writes in his book *Green Gold* (co-authored with Alan Miller), "Important properties are passing out of American hands largely because U.S. businesses and U.S. policy makers still believe that economic progress is made despite the costs of environmental protection." In short, America is losing strategic advantage in a set of industries with enormous potential to improve our lives. In the process, we are crippling our future options to deploy renewables. We need to wake up. Examining the policies of our competition is an important start.

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RENEWABLE ENERGY POLICY OUTSIDE THE UNITED STATES

by Curtis Moore and Jack Ihle

EXECUTIVE SUMMARY

WHY ARE THEY DOING IT?

Europe's interest in renewable energy policy seems to go well beyond current U.S. policy. Why? First, it stems from collective environmental concerns, especially for climate change and urban air pollution. In addition, since Europe has fairly modest fossil fuel resources, coal and oil firms hold less political influence than they do in the U.S. Just as important, many electricity suppliers do not generate their own power, and thus have no vested interest in maximizing the use of a particular fuel. The European Union has reinforced individual nation's attitudes with tight emissions standards, policy positions advocating aggressive responses to climate change, and prohibitions on subsidies for fossil fuels.

In Japan, the main impetus for renewable energy development has the pursuit of energy independence, though climate change and the Kyoto Protocol has been added to the Japanese government's list of concerns. Japan has pursued nuclear energy even more vigorously than renewables to meet these needs.

NATIONAL POLICIES

Denmark

Denmark's government has designed programs that coaxed its wind industry and wind technologies into commercial maturity — so much so that the Danish wind industry is the most competitive in the world with over half the world's sales and 16,000 domestic jobs. The government began with vigorous research and development (R&D) for wind, followed shortly by safety and quality certification with the input of utilities, insurers and turbine manufacturers. As the technology matured, the government provided subsides for up to 30% of the investment costs of a turbine. The subsidy program lasted 10 years before its repeal. Now, the government requires Danish power companies to pay 85% of the retail electricity price of wind energy. The latest incentives, albeit indirect, involve energy taxes on fossil fuels for their air emissions. Wind energy receives rebates in the taxation scheme.

But the government was not alone in its efforts. The nation's wind guilds, or owners' co-operatives, helped to make wind turbines more palatable to communities and heightened confidence in the technology. Accordingly, insurance against the failure of the technology and the manufacturer became more affordable.

Denmark is embarking on a more competitive program, similar to the Renewable Portfolio Standard first developed in the U.S. This new direction is driven for several reasons—liberalization of Danish electricity markets, removal of trade barriers in the EU, and a desire to push cost-effective development of renewables by a maturing domestic industry.

Germany

Germany has relied principally on a combination of cheap loans and subsidies coupled with higher fixed payments for electricity produced by renewables. The 1990 *Stromeinspeisungsgesetz* , or Electricity Feed Law (EFL), requires medium to large utilities to pay 90% of the retail residential price for electricity produced by wind, solar, hydropower, and biomass resources. For wind energy, the German government provides subsidies based on electricity output or capital costs. National banks also offer loans at 1-2% below market levels to fund 75% of project costs for renewables.

German wind development experienced a slight setback in mid-1990's when the very success of the EFL program was concentrated in the windy North, thereby placing disproportionate costs on northern utilities and their ratepayers. Subsequent protests fueled uncertainty over the future of the program, and chilled wind power's growth into 1996. However, by the end of 1997 Germany had an installed wind capacity of 2,081 MW—first in the world.

For solar, the EFL's impact is also dramatic - 450% increase in PV installations from 1991 to 1997, with a 37% drop in prices. Investment in PV grew, making German firms such as Siemens lead the world in sales, and German PV factories a more frequent landmark. Building upon the EFL, Germany has begun a "100,000 Roofs" program for PV. The new program will include cheap loans issued by private banks directly to consumers, with little bureaucratic hassle. The program promises to be the largest single PV subsidy program in the world.

Japan

Until 1997, Japan's renewable energy policies focused on public-private collaboration for R&D, primarily for PVs and wind power. The only significant non-R&D program before 1997 was the "10,000 Roofs" Program, a successful subsidy program funded by electricity surcharges to pay one-third the installation costs of household PVs, with utilities purchasing any excess power at the retail price of electricity.

The New Energy Law of 1997 focuses on technology deployment so that 3.1% of Japan's primary energy supply comes from renewables by 2010. The primary method of implementation features powerful "requests" from the government to energy suppliers to buy electricity generated by renewables. Suppliers will have to pay the retail price of electricity paid by the facility that is generating the power. Generators can require contract periods for up to 15 years, with the price to be paid varying according to the contract period.

Japan's special push for PV—including a goal of 5,000 MW capacity by 2010—builds upon the 10,000 Roofs program with a 7-fold increase in program funding from 1994 ($20 million to $147 million). One of the aims of the program is to spur mass production of PV systems. So far, it is a major reason that Japanese PV firms shipped 35 MW in 1997.

The Netherlands

The Dutch government has worked with industry to develop compatible renewable energy policies that both protect the environment and strengthen the nation's trade balance. By 2020, the government aims for renewables to provide 10% of the nation's energy supply—a jump from 1% today. Dutch policy combines an impressive array of elements that:

- Provide preferential financing, including accelerated depreciation, tax deductions, and below-market-rate loans for renewable energy projects, and low-interest loans for homes with environmentally-friendly features such as renewables;
- Mandate purchases where electricity distribution companies purchase excess power to cover avoided fuel and capacity costs;
- Levy energy taxes that penalize polluting sources but not renewables;
- Create green pricing programs in which consumers can buy renewables at a small premium;
- Establish Certification for renewables-based power to support marketing efforts.

United Kingdom

Unlike the nations discussed above, the UK's primary renewable energy policy is the Non-Fossil Fuel Obligation (NFFO). The NFFO was not created primarily to advance renewables, but to protect a nuclear power industry that would have collapsed if it had to compete with coal power in a new open market for power. Still, the NFFO has spurred 840 MW worth of power delivered from wind plants.

Within the NFFO, electricity providers must purchase a certain quantity of non-fossil power. If the non-fossil power costs more than fossil-derived electricity, revenues from a special tax on coal power (about $160 million in 1995-96) would fund the difference. The government funds generators using non-fossil fuels through revenues from a tax on all electricity. Generators qualify for government funded through competition within technology bands, such as bands for wind or small hydro. Winners receive long-term power contracts up to 15 years. Competition is completed in rounds, with five rounds completed by 1999. The latest round may spur the installation of over 1,000 MW of new renewable energy capacity over the next 20 years. The likelihood of this is still in question, as many firms may wait until the end of their allotted commissioning period to install capacity.

Perhaps the biggest question for the NFFO is whether it can be credited with lowering renewable energy prices and minimizing costs for consumers, or whether it is merely squeezing profits and hindering the development of a healthy domestic renewable energy industry, which must rely on markets in nations with more nurturing policies in order to serve the British market. As is the question of total installation, these questions are also unresolved.

Have the Policies Worked? A Look At the Photovoltaic Market

The experiences of the nations discussed above generally point to the ability of concerted policies to spur the domestic installation of renewable energy capacity. Internationally, it appears that those nations with vigorous deployment strategies are capturing greater shares of the world PV market, with Japan and Germany leading the way in shipments. In addition, these nations are driving the global PV market—PV shipments worldwide have clearly responded to their new demand, which are helping to make PV a common commodity and not a high-cost niche product reserved for the space program.

Lessons for the United States

The experiences of industrial nations overseas yields several lessons for the U.S.:

- Examine the successes and failures of other programs.
- Renewable energy technologies cannot currently compete against fossil energy without government subsidies.
- A program of financial assistance must remain stable for at least 10 years.
- Energy independence is a strong driver for renewables overseas.
- Money must flow into and out of a financing scheme in a simple and "transparent" way so that it is clear what is being charged, what is being subsidize, and why.
- Any renewables policy must include non-financial assistance-including research, demonstration and development; product testing and certification; resource identification and mapping; and community participation.
- With time, the need for subsidies declines.

RENEWABLE ENERGY POLICY OUTSIDE THE UNITED STATES:

by Curtis Moore and Jack Ihle[2]

PART I. INTRODUCTION AND OVERVIEW

This report identifies and describes policies used by a variety of nations to encourage the development of renewable energy. Most of the information was collected through interviews and site visits in Denmark, Germany, Japan, the Netherlands, and the United Kingdom between December 1997 and December 1998.

Because the United States was the first nation to enact modern environmental laws such as the Clean Air and Clean Water Acts, as well as the leading developer of a wide range of energy and environmental technologies, many Americans believe that the nation remains the preeminent leader in these fields. Indeed, during the 1980s and early 1990s, the United States developed a non-hydro renewable generation capacity that was larger than the rest of the world combined. However, during the last several years, the United States has lost the lead in renewable generation capacity. This report describes a series of national policies that other nations are using to grow their renewables base. Governments are consciously helping to pull wind, solar, biomass, and other forms of renewable energy into the marketplace.

RENEWABLE ENERGY IN EUROPE

American firms and individuals initially developed many of the renewable energy technologies that currently enjoy commercial viability or will soon reach that point, but Europeans have now seized the lead in deploying them. This turn of events has several explanations as summarized in a 1996 European Commission Green Paper:

> 1. Renewables go hand in hand with the objective of protecting the environment, and in particular help reduce [carbon dioxide] and other emissions;
>
> 2. Being indigenous sources renewables contribute to reducing dependency of energy imports;
>
> 3. Renewables are advanced technologies, which can play a role in revitalizing sectors of European industry and contribute to competitiveness;
>
> 4. They generate employment, in particular in [small and medium-sized enterprises];
>
> 5. They are an important aspect of regional development and are well-suited to decentralized energy systems;
>
> 6. Their development is favored by the general public, in particular for environmental reasons;
>
> 7. They contribute to solving energy and environmental problems in developing countries, and at the same time provide export opportunities for European industry, which enjoys world leadership of renewable energy technologies.[3]

Governments in Europe have adopted a variety of policies to encourage the development of renewable energy. The principal measures are financial, and include the following:

- Fossil fuel taxes: these increase the costs of energy from non-renewable resources.[4]
- Renewable energy subsidies: these lower the costs of energy from renewable resources by, for example, providing investment subsidies or fiscal benefits.
- Mandated purchases: these either compel purchases of renewable energy or mandate higher payments for it by, for example, setting the sales price at a minimum percentage of the residential electricity rate.

Most European countries use a mix of these financial measures to create a market for renewable energy, with the measures varying from nation to nation. Generally speaking, however, the Scandinavian countries rely on high taxes on fossil fuels, accompanied by tax exemptions for renewable energy. In the United Kingdom, a market-based system called the Non-Fossil Fuel Obligation (NFFO) incorporates a tax on electricity to fund a subsidy for renewables. Germany uses a combination of investment subsidies, high payments for renewables, and cheap loans.

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[2] The authors thank Alan Miller, Adam Serchuk, and Virinder Singh for their comments on this paper. The opinions expressed here are the authors, and do not necessarily reflect those of the reviewers, the Renewable Energy Policy Project, or its Board of Directors.

[3] European Commission, *Energy for the Future: Renewable Sources of Energy* (Brussels: 1996), available at <http://www.europa.eu.int/en/comm/dg17/renew42.htm>.

[4] The number and variety of tax provisions in Europe with a potential impact on environmental protection is almost bewildering. In 1996, the European Commission undertook a survey of such taxes that reviewed them on a sector-by-sector basis and summarized the major levies of member countries. Although the review was not exhaustive in its treatment of the tax structures of specific nations, it is very helpful in providing a sense of the effectiveness of taxation as an environmental policy mechanism in Europe. See European Commission, *Tax Provisions With a Potential Impact on Environmental Protection* (Brussels: 1996).

Financial measures, however, are by no means the only instruments through which renewable energy is encouraged. Governments also have established programs to map available resources, develop and incrementally improve technologies, and better the public perception of renewables. Substantial sums are devoted to R&D programs and other measures to coax the renewables industry toward commercial success.

The Importance of Environmental Awareness in Europe

Environmental awareness is very high in much of Europe, particularly in the middle and northern European nations—from Germany, Switzerland, and Austria west to the Netherlands and north to Scandinavia. Much of the support for renewables in Europe is driven by a prevailing hostility to the pollution generated by fossil fuels, whether that is expressed as acid rain, "summer smog," or climate change. Many policy decisions in these nations and in the European Union (EU) are imbued with environmental sensitivity. This helps explain why these governments have adopted many of the world's most stringent environmental standards, especially for energy-related activities. For example, emission limits for sulfur dioxide (SO_2) and oxides of nitrogen for coal-fired power plants are an order of magnitude more demanding than those in the United States.

The Role of the European Union (EU)

These individual national policies and attitudes are expressed as continental-scale requirements at the level of the EU. While space constraints preclude a review of EU requirements related to energy, a few examples make the EU's hostility to fossil-derived air pollution clear:

- At the outset of the negotiations that led to adoption of the Kyoto Protocol to the Framework Convention on Climate Change, the EU favored reducing emissions of carbon dioxide (CO_2) and other greenhouse gases by 15% from 1990 levels. (The initial U.S. position called for zero reduction.)

- EU emission standards for motor vehicles, fuels, fossil-fuel-fired power plants, and energy-intensive industries are the world's most stringent.

- The EU prohibits subsidies for fuels other than renewables, despite a labor movement that in many nations is much stronger than in the United States.

Collectively, these policies have lowered the price of renewable forms of energy and raised the price of fossil-fuel-based energy to the point where renewables can begin to compete on a cost-per-kilowatt basis. This is especially true of wind energy in Denmark, Germany, and the United Kingdom.

Renewable Energy in Japan

While Japan diversified its sources of energy supply following the oil disruptions of the 1970s and 1980s, Japan continued to rely heavily on imported fossil fuels. Until 1998, there was no underlying policy to encourage the commercialization of renewable technologies. Nevertheless, unlike the United States, the nation systematically laid the groundwork for a possible widescale deployment of renewable energy. That move toward renewables has now begun in earnest.

Prior to 1998, Japanese efforts focused on three areas:

- Fundamental technologies: Government and manufacturers collaborated to improve the efficiencies of PV cells, increasing the capacities of wind turbines, and field-testing specific equipment.[5]

- Grid integration: The government, the utility industry, and manufacturers of associated equipment such as inverters cooperated to identify and eliminate technological and other practical barriers to grid integration of renewable technologies.[6]

- Dispersed generation: Recognizing the potential benefits of dispersed power generation using renewable generating systems either in a stand-alone mode or in conjunction with advanced technologies such as fuel cells, government and industry collaborated in developing these as well. Wind conditions, for example, were mapped and prospective installation sites identified.[7]

Clearly, while Japan was unwilling to commit itself to renewable energy in the same way as Europe, it was just as committed to preserving its option to do so. Then in September 1997, barely three months before government representatives gathered in Japan to hammer out the terms of the Kyoto Protocol, the government adopted the Law on Special Measures to Promote Use of New Energies (also called the New Energy Law). Rules, regulations, and guidance for the implementation of that law began

[5] New Energy and Industrial Technology Development Organization (NEDO), *NEDO Creates New Energy* (Tokyo: September 1997).
[6] NEDO, *Development of Large-scale Wind Power Generation Systems* (Tokyo: August 1998).
[7] Shinji Fujino, Ministry of International Trade and Industry (MITI), Tokyo, private communication, December 1996.

to be issued in April 1998, spurring a sharp increase in entrepreneurial interest in renewable energy systems, especially wind turbines. Having carefully preserved its ability to deploy renewable energy rapidly, Japan has now positioned itself to do so.

According to the Ministry of International Trade and Industry (MITI), the current movement toward renewable energy has been spurred by twin concerns: "increased necessity to secure energy security" and "increased necessity to cope with the problem of global warming." These environmental and security concerns make it "indispensable to introduce new energy which has less restraints of resource and environment," according an internal MITI document.[8]

PART II. DENMARK'S WIND ENERGY PROGRAM

Denmark

National Energy From Renewables:	7.9% of TPES (non-hydro)*
Renewable Capacity:	1200 MW plus 1485 ktoe/yr thermal[ψ]
Recent RE Growth: 1998[γ]	317 MW wind installed in
Major Stated Goal:	35% of TPES from RE by 2030[γ]
Total Electrical Capacity:	11,100 MW**
TPES Mix:	44.0% oil*; 30.3% coal; 17.8% natural gas; 7.1%; combustible renewables; 8% other renewables
Population:	5.3 million*

*1997 IEA data found at <http://www.iea.org/stat.html>. TPES-Total Primary Energy Supply. [ψ]*Renewable Energy in the EU*, David Milborrow, Gaynor Hartnell, Niki Cutts, Financial Times Energy, 1998. [γ]Danish Energy Agency, <http://www.ens.dk>. **1997 Data from EIA World Energy Database at <http://www.eia.doe.gov>.

One of the greatest barriers to robust renewable energy support by the U.S. government is the notion that government programs necessarily create a reliance on subsidies that is ultimately self-defeating. In reality, properly designed and implemented programs can gradually coax an industry and specific technologies into commercial maturity. This is illustrated by the Danish government's coordinated and systematic efforts to build a wind industry that must now be considered the world's best.

Governmental support has made this small country not only a major center of wind power, but an industrial center for what is currently the only renewable energy technology that can compete head-to-head with fossil fuels in terms of costs—and the fastest growing energy source in the world.[9] Denmark is now manufacturing about 1 gigawatt of wind capacity a year, the rough equivalent of two large nuclear or coal-fired power stations, and creating about 16,000 jobs at the same time.

Denmark's success in the development of a wind turbine industry has been measurable: in 1983, Denmark exported 20 MW of wind turbines while in 1997 Danish wind turbine exports reached 681 MW. At home, wind energy generated 27 GWH of electricity in 1983 and steadily increased in each consecutive year to 1830 GWH of electricity in 1997.

Although Germany has recently overtaken Denmark in terms of installed wind capacity, the Danish wind turbine industry still produces more equipment than all other nations combined in the fast-growing global market. After establishing both a stable home market as the basis for development of wind turbine technology and a strong export sector, the Danish government is now extending that model into other areas of energy as well, including combined heat and power. Wind turbines now constitute the nation's second most important export.

Recently, sales of wind turbines in Denmark and elsewhere have been spurred by the need to reduce carbon emissions. Denmark's "Energy 21" policy aims to bring national carbon dioxide emissions by 2005 to 20% below the levels in 1988. Launched in 1996, Energy 21's goals for the longer term are even more ambitious: to halve carbon dioxide emissions by 2030.[10] Clearly, however, Danish wind power development predates current concerns over climate change.

[8] MITI, *New Energy Policies* (Tokyo: undated), provided by Fujino, op. cit. note 6.

[9] The information in this section is based on a site visit and on the Danish Wind Turbine Manufacturers Association excellent Web site, at <http://www.wind power.dk/> and its equally excellent CD-ROM, available free of charge.

[10] CADDET, "Danish Energy Plan: Energy 21," at <http://www.caddet-re.org/html/body_496art1.htm>.

To stimulate the development of wind energy, the Danish government has relied principally on a combination of taxes and subsidies. Relatively simple at its outset in the 1970s, wind policy became more complex in the 1990s with the introduction of new taxes designed to cope with SO_2 and CO_2 emissions, together with new subsidy schemes. Still, the Danish government has remained fixed on its goal of protecting the environment in a way that also shields and stimulates domestic industry.

The Original Incentives

Today's wind energy program is part of an overall energy plan published in 1976. Its main objective was to make Denmark less dependent on imported energy, especially oil. Since the mid-1980s, however, environmental concerns have propelled the Danish program. The initial steps taken in Denmark to build the turbine industry included the following:

- R&D: A comprehensive energy research and development program started in 1976 with wind energy as only one area of work. This funded efforts to collect fundamental information regarding the planning and construction of large (more than 500 kilowatts (kW)) wind turbines. About 10% of the total Danish energy research budget since 1976 has been devoted to wind.

- Turbine certification: The Risoe Test Station for Wind Turbines began in 1978 as a pilot project, paid for by the Danish Energy Agency. Initially, Denmark required certification only as a condition of eligibility for government subsidies, and manufacturers paid just a token fee for the procedure. Now, however, certification is required for connection to the Danish grid, and the process has evolved into a commercial activity for Risoe; manufacturers must pay the full cost of testing and certification. In addition, the government has extended the authority to issue certificates to other organizations. The certification standard is updated by the Danish Energy Agency with advice from an advisory committee that includes representatives from the Danish Wind Turbine Owners Association, the Danish Utilities Association, the Insurers Association, and the Wind Turbine Manufacturers Association. Risoe supplies a technical expert to advise the committee.

- Capital Subsidies: A subsidy equal to 30% of the investment costs of a wind turbine started in 1979, leading to the deployment of 200–300 machines a year. After steady increases in the reliability and cost-effectiveness of turbines, the subsidy for wind power was repealed in 1989. (It was retained for other forms of renewable energy, however, and is now helping spur an increase in electricity generation from bioenergy, principally from burning straw and wood chips.)

- Mandated electricity purchases: Danish power companies are required to pay 85% of the retail electricity price for the wind energy purchased from privately owned wind turbines.

As a result of these programs, Denmark has seized a position of clear dominance, with 58.5% of global sales in 1997, followed by Germany with 16%, the United Kingdom with 14.1%, and the United States with just 2.4% of global sales. From 1993 to 1995, the wind industry grew at a rate of 50% a year in Denmark, with annual growth rates of 10–20% projected through 2000.

The Wind Guilds

Because of the large size, location in visible wind-swept sites, noise, effect on wildlife, and other impacts of wind turbines, landowners, planners, environmentalists, and others sometimes resist these technologies. In the United States, such "environmental" opposition frequently proves the final barrier to the development of a project. The Danish solution to this—parts of which appear to have evolved independently of any overarching guidance from the government—was to allow turbine ownership by guilds or co-operatives, and to require member-owners to live within 3 kilometers of the site. The guilds eventually organized as the Danish Wind Turbine Owners Association, which became a powerful political force. Today, 100,000 Danish families own wind turbines or shares in wind co-operatives.

In the mid-1980s, this ownership rule was modified somewhat, to require that guild members live in or within 10 kilometers of the same borough as the turbine and to limit the share of any individual owner to the greater of 6,000 kilowatt-hours (kWh) per year or 135% of that person's electricity consumption. This change was made in part because of pressure from electric utilities, which were seeking to limit private ownership of generating facilities. Under pressure from the various guilds, the law was amended again in 1992 to relax ownership requirements. The geographic area of residency was expanded to include residents of the borough in which the turbine was located and those of neighboring boroughs. The ownership share was increased to the greater of 9,000 kWh per year or 150% of consumption. The rules were expanded further in 1996 to allow ownership of up to 30,000 kWh per year by any person who lived or worked in the borough or who owned a house or real estate there.

The guilds played a significant role in the steady technological improvement of Danish turbines by providing regular reports in the membership magazine, *Naturlig Energi*. Each month *Naturlig Energi* had a list of all turbines with an indication of what they produced and what technical problems were encountered. This accountability had a positive effect on development. The tur-

bine owners themselves had then the opportunity to explain how well or how badly their turbines produced, and the manufacturers discovered that their own turbines quickly became either a good or a bad advertisement for their business. In the process of development the statistics also showed the importance of good siting.

The association and its magazine also played a pivotal role in establishing the credibility of wind power and exploding myths of unreliability and high cost. And it helped create both a market for insurance and a free-standing firm to supply it. As a result, consumers can buy insurance at the same time as a turbine, providing protection not only against damage and losses but also against the risk of a manufacturer going bankrupt within the warranty period. By 1997, the association had a membership of 2,150 wind turbines, while the turbine guilds had 54,844 members.

Danish Taxes

With the advent of concerns over local air pollution and global warming, Danish support for wind energy has been revitalized. Denmark levies a tax on all electricity; the basic support mechanism for wind energy is a partial rebate of this tax. The actual tax structure is quite complex, for there are three environment-related taxes: an energy tax that varies for natural gas, unleaded gasoline, diesel fuel, and other energy; a carbon dioxide tax; and a sulfur dioxide tax. Denmark also applies different rates to space heating and to "heavy" and "light" uses of energy. Heavy uses include 35 different energy-intensive production process, such as cement production.

The taxes have three specific goals: to reduce CO_2 emissions from 1988 levels by 20% by 2005, to reduce SO_2 emissions from 1980 levels by 80% by 2000, and to increase the share of Denmark's gross energy consumption provided by renewable energy to 35%—or perhaps even 50%—by 2030. Of course, the taxes also provide income for the national government. Together, they account for about 7% of domestic revenue.

The tax system is further complicated by a set of 15 subsidy schemes related to energy production and consumption. The bulk of these are directed primarily at converting central and electric heating systems to district heating and to expanding and renovating the existing district heating network. But the largest one in terms of money is a production subsidy of 0.27 kroner (3.8¢) per kWh for electricity generated from renewable energy sources. In addition, natural gas generators receive a subsidy of 0.07 kroner (9.7¢) per kWh. These subsidies accounted for about 45% of the total subsidy budget, or about 855 million kroner ($119 million) in 1996. The share is expected to rise in coming years because of the increase in electricity production from natural gas and renewable energy sources.

Denmark's New Renewable Portfolio Standard

The liberalization of the electricity market has caused Denmark to enact a very recent and fundamental change in its support for renewables: from fixed payments to a renewable portfolio standard (RPS) system. This change is projected to happen gradually over the next decade, and the Danes are working on the details.[11] Most importantly, as the shift takes place, a system is being created to insure the survival of existing projects and the continual growth of near-term future renewables. Also, the Danes will maintain current taxes on electricity and carbon dioxide will adapt them to work with the RPS.

Very briefly, the RPS works as follows: a target for renewables is legislatively set, usually in terms of a percentage contribution from renewables. Electricity distributors are held responsible for meeting this target in most RPS systems. To meet their obligation, distribution companies may either develop renewable resources themselves or purchase renewable generation credits from other renewable generators as proxies for their own renewable generation. The RPS is competitive because electricity distributors will seek the lowest cost option to meet their obligation. No matter which option is chosen, the extra costs of renewable electricity are handed down to all of the consumers of the distribution company.[12]

The components of an RPS are all evident in Denmark's new system: renewable implementation targets, the creation of renewable energy certificates with the goal of creating a special market for renewables, and an obligation on all consumers to purchase electricity from renewables. It is notable that a nation recognized for being a world leader in renewable energy has chosen to implement a renewable support mechanism invented in the U.S.[13]

It should be noted at this stage, however, that the Danish RPS is a hybrid system retaining fixed payment characteristics: it maintains a guaranteed payment of .33 kroners (4.6¢) to renewable generators and then allows the market for renewable energy credits to determine the additional value of the renewable energy credit. This renewable energy credit is bounded between .10 kroner (1.4¢) and .27 kroner (3.8¢) by law.

[11] To observe current progress on Denmark's new RPS, please see the Danish Energy Agency's website at <http://www.ens.dk >.

[12] For more information on the RPS, see the American Wind Energy Association's website: <http://www.awea.org>.

[13] The RPS was originally developed by Nancy Rader, American Wind Association, Richard Norgaard, University of California at Berkeley, and Brent Haddad, University of California at Santa Cruz.

The adoption of an RPS represents a distinct transition from a steady, fixed premium system to a competitive system. This transition is consistent with a worldwide trend toward liberalization of markets. Denmark is moving towards a market system for its renewables to retain consistency with the liberalization in the rest of its electricity sector. The liberalization of its electricity sector, in turn, is consistent with trends in Europe to decrease market barriers between nations.

The decision to implement an RPS reflects a definite confidence in the Danish ability to achieve renewables targets, as targets are the focal point of the RPS. The benefits of competition also appear to be desired for the continual evolution of the renewables industry in Denmark: a recent policy paper by the Danish Energy Agency specifically identifies the element of competition to produce cost-effective development of renewables as a major driver for this shift in the renewable program.[14]

PART III. GERMANY'S ENCOURAGEMENT OF RENEWABLE ENERGY

Germany has relied principally on a relatively simple and straightforward mixture of mechanisms—higher fixed payments combined with subsidies and cheap loans—to encourage renewable energy.[15] The results have been remarkable: use of wind energy in Germany has shot up from almost nothing in 1990 to 2,875 megawatts in 1998.

The Electricity Feed Law

Much of the success of the German renewables program can be attributed to the 1990 *Stromeinspeisungsgesetz*, literally the Law on Feeding Electricity from Renewable Sources into the Public Network (usually referred to in English as the Electricity Feed Law, or EFL). The EFL requires electric utilities to pay a fixed rate, equal to 90% of the retail residential price, for electricity generated from wind energy, solar energy, hydropower, sewage or landfill gas, or biomass residues from agriculture and forestry. There are some exceptions to this mandate—for instance, small utilities for which the EFL would increase the average electricity price significantly.

Germany

National Energy From Renewables:	1.2% of TPES (non-hydro)*
Renewable Capacity:	3925 MW plus 3000 ktoe/yr thermal[y]
Recent RE Growth:	800 MW wind installed in 1998[g]
Major Stated Goal:	25% of electricity from wind by 2010 in the state of Schleswig-Holstein[g]
Total Electrical Capacity:	110,000 MW**
TPES Mix:	40.1% oil, 24.8% coal, 20.7% natural gas, 12.8% nuclear, 1.1% combustible renewables, 0.4% hydro, 0.1% other renewables
Population	82.1 million*

*1997 IEA data found at <http://www.iea.org/stat.html>. TPES-Total Primary Energy Supply. [y]Compiled from *Renewable Energy Policy in IEA Countries, Volume II*, IEA, 1998, Wagner, Andreas, *Wind Energy Development in Germany: A Joint Success Story of the Industry, Owners and Politics* (1999 Worldwatch Conference Paper), and Milborrow, et al, *Renewable Energy in the EU*, Financial Times, 1998. [g]Wagner, Andreas, *Wind Energy Development in Germany: A Joint Success Story of the Industry, Owners and Politics* (1999 Worldwatch Conference Paper). **1997 Data from EIA World Energy Database at www.eia.doe.gov.

In addition to the federal law, some German states have adopted their own laws to encourage renewable energy. For example, North-Rhine Westphalia has allowed its utilities to raise customers' prices by as much as 1% to pay for electricity from renewable sources, including the full cost of PV installations.

National banks, including Kreditanstalt für Wiederaufbau and Deutsche Ausgleichbank, offer loans at rates 1–2% below market levels for investments in renewable energy. These loans may fund 75% of project costs.

[14] *The Electricity Reform*, March 3, 1999, Danish Energy Agency.

[15] The information in this section was collected during site visits to the Federal Environment Agency, from Horst Mierheim, "Integrated Strategies and Measures to Improve Air Quality in Germany," presented at the International Seminar on Environmental Policies, September 23–26, 1997 Seoul, Korea, and from Umweltbundesamt, *Sustainable Germany—Towards an Environmentally Sound Development* (Berlin: 1997).

To facilitate the development of wind turbine technology, Germany also adopted in 1990 a new large-scale demonstration effort called the 250-MW Wind Program. It provides a subsidy based on either electricity output or capital costs. The program provides investment subsidies of 200 deutsche marks ($106) per kilowatt, up to a ceiling of 100,000 deutsche marks ($53,000) per project or to 150,000 deutsche marks ($80,000) for facilities larger than 1 megawatt (MW).

As with other European nations, these subsidies for renewable energy have particularly stimulated growth of wind energy. In Germany, the incentives have not only spurred the rapid development of the world's largest installed wind capacity, they have created a wind turbine manufacturing industry where one scarcely existed.

The success of the German wind energy program has even created pressure to reduce or modify incentives: Because most of the wind resource in Germany is located in the northern regions, the rapid expansion imposed the bulk of the mandatory subsidy on a limited number of ratepayers, driving up their electricity prices. After these ratepayers and their utilities protested, uncertainty about continuation of the tariffs chilled investment and sharply slowed the growth rate of wind power in Germany (this reaction also demonstrates that the most important aspect of a subsidy may not be its specific elements or amounts, but its certainty).

After the relative collapse of the turbine market in 1996, Germany's wind sector rebounded the following year, however. Due to the use of ever larger machines, installed capacity jumped by 24.9% in 1997, although the number of new turbines rose by only 5.7%. As of December 31, 1997, Germany had 5,193 wind turbine generator systems, with an installed power of 2,081 MW. The average installed power per system was about 400 kW and growing. In 1997, developers added 849 systems, with a combined capacity of 533 MW, representing a system average of about 630 kW. Thus German machines are moving beyond the 500/600 kW class, and are approaching the megawatt range.

Despite the recovery of domestic installations, German turbine exports slumped badly in 1997. This was due in part to the bankruptcy of Germany's largest manufacturer, Tacke Windtechnik, and its reorganization (Tacke has since been purchased by Enron). Still, Germany only exported turbines equivalent to 54 MW of capacity in 1997, despite very rapid growth in both European and global markets.

The Electricity Feed Law has been a major factor in the dramatic growth in photovoltaic sales in Germany. Installations of grid-connected PVs rose from 2 MW in 1991 to more than 11 MW in 1997—a 450% spurt. Prices have also fallen during this period, from 27,000 to 17,000 deutsche marks per kW—a drop of more than one-third. These market developments are attracting more firms and investments, which should boost competition and drive prices down even further. Deutsche Shell AG (German Shell) is building a PV factory with an annual capacity of 25 MW that is due to go into operation in late 1999.

The 100,000 Roofs Program

Germany is not resting on its success with the feed law for solar. On January 1, 1999, the government launched a 100,000 Roofs program for photovoltaics. Under the six-year program, the German government assigned a bank to issue 10-year, interest-free loans that recipients must repay in eight annual installments. The bank assumes liability for the loans, which can then be issued by smaller "house" banks to purchasers of PV systems. Banks make loan commitments within five days to minimize red tape and uncertainty, and can even issue the loan in full immediately, to cover almost 40% of the cost of a PV system. The program, which will cost almost 1.1 billion deutsche marks ($583 million), should be the largest single PV subsidy program in the world. If the government has its way, it will also be one of the least bureaucratic renewable energy subsidy programs.[16]

[16] *PV News*, Vol. 18, No. 3: March 1999.

PART IV. UNITED KINGDOM: THE NON-FOSSIL FUEL OBLIGATION

United Kingdom	
National Energy From Renewables:	0.7% of Total Primary Energy Supply (non-hydro)*
Renewable Capacity:	580 MW[g]
Recent RE Growth:	94% annual growth, 1990-1996[y]
Major Stated Goal:	10% of electricity from renewables by 2010
Total Electrical Capacity:	70,500 MW**
TPES Mix:	36.4% oil*, 33.7% natural gas, 17.7% coal, 11.3% nuclear, 0.7% combustible renewables, 0.2% hydro
Population:	59.0 million*

1997 IEA data found at <http://www.iea.org/stat.html>. TPES-Total Primary Energy Supply. [g]As of June 30, 1998, ETSU Commercialization Program, Harwell, UK. [y]Solar, wind, wave, tide: Renewable Energy Policy in IEA Countries, Volume II*. IEA, 1998. **1997 Data from EIA World Energy Database at www.eia.doe.gov.

When the UK deregulated the electricity utility industry, it faced the very difficult question of how to deal with the nation's nuclear power plants.[17] Private investors appeared ready to buy coal-fired power stations on the open market. Yet several factors dampened enthusiasm for the nuclear plants, such as the lack of a fund to pay for inevitable decommissioning.

Unable to privatize nuclear power, the government instead sought to subsidize it in a way that would complement the market system and—above all—not conflict with the European Union's prohibition against subsidizing forms of energy other than renewables. The government solved this by selling the coal plants but imposing on the Regional Electricity Companies (RECs) an obligation to buy a certain quantity of non-fossil power. If the non-fossil power cost more than fossil-derived electricity, a tax imposed on coal-derived electricity would make up the difference. The European Commission approved this subsidy of "non-fossil" electricity for eight years; the initial subsidies terminated at the end of 1998.

This system came to be known as the Non-Fossil Fuel Obligation, or NFFO. Although initially designed to support nuclear energy, it has stimulated the rapid growth of renewable electricity, which in this case includes wind power, hydropower, municipal and industrial waste, energy crops and agricultural and forestry waste, and sewage gas. Since 1990, the price of renewable energy purchased by the RECs has fallen markedly—although it is not clear whether the NFFO itself is the cause or if instead market developments and subsidies in other nations have brought down industry prices worldwide.

The government placed five successive "orders" for non-fossil electricity between 1990 and 1999. NFFO-5, the largest order so far, was announced in September 1998. If all the 261 new projects are successful, this will provide some 1,177 MW of energy from landfill gas, waste, hydro, and large and small wind farms. It is also the cheapest NFFO so far. The average price of power expected to be generated is only 2.71 pence (4.3¢) per kWh (compared with the electricity pool price of 2.67 pence (4.2¢))—down from 4.35 pence (6.7¢) per kWh under NFFO-3.

DETAILS OF THE NFFO

Because some renewables (such as wind and solar) are intermittent, the orders are expressed in terms of delivered net capacity (DNC) of electricity, which equates roughly to that same amount of thermally generated power. That is, a DNC of 50 MW of wind roughly equals 50 MW of natural-gas-fueled electricity in terms of the amount that is ultimately delivered. Thus the nameplate capacity of an intermittent renewable facility is higher than its DNC.

Although the initial target was for 1,500 megawatts, orders for over 3,271 megawatts of DNC have actually been entered into in NFFO-1 through NFFO-5.

Competition for orders occurs within technology "bands," so that wind competes against wind, nuclear against nuclear, and so on. The law does not define "non-fossil" electricity, nor does it set

[17] Much of the information in this section was collected during a site visit to the United Kingdom, including interviews with Dr. Catherine Mitchell and the Hon. John Gummer, as well as from Catherine Mitchell, Renewable Energy in the UK: Policies for the Future (London: Council for the Protection of Rural England, 1998). The Network for Alternative Technology and Technology Assessment maintains an excellent Web site on which its bimonthly newsletter, Renew, is published; see <http://www-tec.open.ac.uk/eeru/natta/natta94.html>. It is the source of some information here on NFFO-5.

shares for specific technologies. It merely provides that the government may "by order oblige" suppliers to accept electricity. These blanks are filled in by the Department of Trade and Industry, which merely declares a technology—chicken litter, for example—eligible or ineligible as non-fossil fuel.

The payments to NFFO electricity generators are funded through a mechanism known as the "fossil fuel levy," which despite its name is a tax on all electricity, not just that generated by fossil fuels. The levy is recalculated annually to raise the amount of money required for the previous year's obligation. Each regional electricity company (REC) pays a sum directly proportional to the amount of electricity that it supplies. That is, an REC that accounts for 25% of the national electricity total would pay 25% of the fossil fuel levy.[18]

The winning offers are selected by the Non-Fossil Purchasing Agency (NFPA), a wholly owned accounting agency of the 12 RECs, based solely on bid price. The lowest bidder within a technology band wins. The winners receive long-term contracts to supply electricity to the grid.

The NFPA reimburses the RECs for the difference between the average monthly pool selling price and the premium price, using the fossil fuel levy on electricity bills, which cost around £95 million (about $151 million) in 1995/96. (See Table 1.) Similar mechanisms exist in Scotland (the Scottish Renewable Order) and in Northern Ireland (the Northern Ireland NFFO).

Table 1. England and Wales: Allocation of the Fossil Fuel Levy

Year	Total	Nuclear	Renewables	Renewables as Share of Total
	(million pounds)		(percent)	
1990/91	1,175	1,175	0	0
1991/92	1,324	1,311	13	1
1992/93	1,348	1,322	26	2
1993/94	1,234	1,166	68	5.5
1994/95	1,205	1,109	96	8
1995/96	1,105	1,010	95	8.6

Source: Catherine Mitchell, Renewable Energy in the UK: Policies for the Future (London: Council for the Protection of Rural England, 1998).

When the original NFFO program expired at the end of 1998, many interests vied for favorable treatment under any extension. The direction that the new Labour government would take was unclear. It was obvious that the NFFO had succeeded both in bringing renewable technologies to market and in driving down the price of renewable electricity. NFFO-5 confirmed that success, and thus seems to have guaranteed not only continuation but expansion of the program.

When he unveiled the results of NFFO-5, Energy Minister John Battle also announced a new government review of its policy on renewables, saying that "from work undertaken so far it seems that the achievement of 10% of the UK's electricity from renewables by 2010 would almost certainly require bringing forward technologies in addition to those supported under NFFO-5, including offshore wind energy and energy crops." Battle was particularly interested in offshore wind energy, and announced a government consultation on including a specific band for it in future NFFOs. The minister was "impressed by the extraordinarily low price bid, reflecting the seriousness of the bids, and the imminence of onshore wind energy competing in the open market."[19]

[18] Catherine Mitchell, "Evidence on Renewable Energy," testimony before the Trade and Industry Select Committee, Aspects of Energy Policy (London: 1998).

[19] Department of Trade and Industry, "John Battle Launches Bidding For Fifth Non-Fossil Fuel Obligation," press release, November 25, 1997, found at <http://www.coi.gov.uk/coi/depts/GTI/coi5019d.ok>.

Keys to NFFO Success

NFFO success to date can be traced to three key factors. First, awards have been been made in rounds over time, from 1990 through September 1998. This has allowed the technologies, as well as the bidding mechanism, to mature, with each round incorporating improvements from lessons learned in earlier phases.

Second, NFFO contracts are awarded as a result of a competitive bidding process within technology "bands" so that a landfill gas project is considered against other landfill gas projects, and so on. This has allowed each technology to progress at an appropriate pace rather than forcing it to compete against dissimilar technologies. In addition, it allows the development of altogether new bands or technologies, such as gasification of animal waste.

Third, NFFO contracts have been granted with long enough payment periods to allow reasonable financing of projects. Although NFFO-1 and NFFO-2 had contracts until the end of 1998, NFFO-3, NFFO-4 and NFFO-5 have 15-year contracts with 5-year grace periods, allowing projects to develop without time pressure.

The result of these strategies has been a steady decline in the price of renewable electricity. In NFFO-4, for example, winning bids were awarded an average price of 3.46 pence per kWh (about 5.8¢) from 840 MW DNC of projects. This is comparable to the average selling price of the current grid mix. It is also, however, higher than the projected selling price of around 2.5 pence per kWh (about 3.9¢) of new combined-cycle gas turbines (CCGT). By NFFO-5, however, the average price for winning bids had dropped again, this time reaching a new low of 2.71 pence per kWh (about 4.3¢)—still higher than a CCGT, but just barely.

Weaknesses of the NFFO

The NFFO has been an innovative solution to the policy problem of how to implement renewable energy, and it has achieved some unique successes, discussed above. There have been some noted drawbacks to the NFFO, however: the NFFO's intense competition has favored large, deep-pocketed companies. It has therefore discouraged small investors, independent developers, and the domestic renewable energy manufacturing industry.

Small investors, independent developers, and domestic manufacturers form strong lobbying coalitions for renewables in other nations. By contrast, in the UK, developers have tended to be large energy companies with little inherent interest in the success of renewables versus other energy technologies. These large developers have also built projects against stiff local opposition to siting, producing ill will toward renewables in some communities. (In Denmark, this problem is mitigated by a strong tradition of local cooperative ownership of renewables.) Furthermore, the lack of a domestic renewable manufacturing industry is a serious impediment to reaping the economic development benefits that renewables can provide.

Most significantly, the ability of the NFFO to commission actual projects, rather than awarded contracts, is still somewhat unknown. As discussed above, for NFFO3 through NFFO5, the contracts for projects were made much more favorable to the financing needs of renewable developers by lengthening contract terms and allowing for a 5-year period before projects must be commissioned. NFFO3 contracts were awarded in 1994, NFFO4 in 1997, and NFFO5 in 1998, thus, commissioning of these projects is not required until 1999, 2002, and 2003, respectively. Because bid-winning developers may opt out of the contracts at any time without penalty, it is difficult to predict the likely rate of commissioning for the current contracts. It is conceivable that developers are waiting as long as possible before commissioning projects, in order to capitalize on lower prices for renewable energy equipment. Price reductions for this equipment are likely in the next few years, while the payments made to the developers under the contract are fixed.

These last three rounds represent 2,647 MW (out of 3,271 MW total) of NFFO contracts, and because only approximately 200 MW of contracts from the last three rounds have been commissioned, it is premature to evaluate the overall success of the NFFO in commissioning renewables.

THE NFFO COST QUESTION

by Jack Ihle

Historically, the first major renewable energy implementation policies in Europe were fixed higher payments to generators. The UK's NFFO became the most visible alternative to fixed higher payments, and since its implementation, an active discussion has taken place about which system produces renewables most cheaply.

The NFFO has been touted for its ability to cut costs of renewables development, and within the UK the contract prices awarded have indeed fallen significantly since 1990. But it is important to separate the concepts of *price*, or the amount of money customers pay, and *cost*, or the amount of money suppliers pay to deliver a product to the customer.

The NFFO's competitive aspect is thought to be the key to its *price* reductions. In nations with fixed higher payments, such as Germany and Denmark, developers do not need to reduce prices to win contracts over their competitors. By contrast, UK developers must propose a bid price lower than competitors to win a contract. For example, in Germany, the price paid to wind energy generators hardly varied from 1991 (.1661 DM/kWh-9.5¢/kWh) to 1999 (.1652 DM/kWh-8.8¢/kWh). During roughly the same time period, the *price* for award-winning wind bids in the NFFO went from 10.0 p/kWh (18.9¢/kWh) to 2.71 p/kWh (4.3¢/kWh).

While the NFFO has brought down prices, has it brought down *costs*? There are reasons to believe that falling costs in the UK are not solely due to NFFO-driven competition. At least part of the cost decline is due to technological improvements in a burgeoning worldwide renewable technology market strongly driven by nations with fixed-payment incentives.[20] Also, even under fixed higher payment systems, developers—or firms in charge of installing projects—are still motivated to reduce costs to increase profits. And data indicates that costs to developers are similar worldwide, as prices charged by developers tend to be between 4-6¢/kWh in nearly all competitive situations.[21]

Another factor in the cost debate is the competition among manufacturers of renewable equipment. For example, there are today at least a dozen major manufacturers of wind turbines. Given that equipment typically represents about 70% of the cost of a renewable project it is fair to say that even with fixed higher payment systems (that are sometimes referred to as "non-competitive"), a reasonable amount of competition exists de facto, and is helping to drive costs downward.[22] This competition is a result of wind turbine manufacturers vying to win bids from developers who purchase the turbines and install them in the electricity grid.

Naturally, what a developer and manufacturer sees as price is seen as cost to society, which is paying the premium for the renewables. It appears that the NFFO has cut costs to society through lower prices paid to developers (in conjunction with falling costs for renewables worldwide). It is much less clear that the NFFO has produced cost reductions from the perspective of the developer, because much of the renewable technology implemented under the NFFO is imported, frequently from Denmark and Germany.

NFFO cost reductions likely come at the expense of profits to the renewable industry. This has produced low-cost renewable implementation in the UK, as well as some of the problems discussed above in the UK section. By contrast, renewables have been more expensive to implement in the fixed higher payment nations, which are sometimes paying twice as much for implementation today compared to current NFFO prices. But their renewables industries are much stronger, and their implementation rates much higher.

The combination of industry maturity in nations with fixed payments, and lower prices in nations relying on competition, may be causing a re-examination of the fixed payment systems: Denmark's new renewable portfolio standard incorporates elements of both competition and fixed payments. Also, the European Commission, seeking more competition in renewables, is beginning to put pressure on Germany to reduce its level of support for wind energy.[23]

Ultimately, the ability of the NFFO to cut costs will be seen within a few years as the later NFFO contracts are actually commissioned.

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[20] Flavin, Christopher, and Seth Dunn, *Rising Sun, Gathering Winds: Policies to Stabilize the Climate and Strengthen Economies*. Worldwatch paper 138, 1997.

[21] International Energy Agency, *Renewable Energy Policy in IEA Countries, Volume II: Country Reports*, IEA, 1998.

[22] Wagner, Andreas, *Wind Energy Development in Germany: A Joint Success Story of the Industry, Owners, and Politics*, 1999 Worldwatch conference.

[23] Environmental News Daily, July 21, 1999.

PART V. THE DUTCH NATIONAL ENVIRONMENTAL PLANS

Netherlands	
National Energy From Renewables:	1.4 % of TPES (non-hydro)*
Renewable Capacity:	631 MW plus 190 ktoe/yr thermal[g]
Recent RE Growth:	40% annual growth rate 1990-1996[y]
Major Stated Goal:	10% of TPES from renewables by 2020.
Total Electrical Capacity:	20,400 MW**
TPES Mix:	47.8% natural gas*, 37.4% oil, 12.5% coal, 1.3% combustible renewables, 0.9% nuclear, 0.1% other renewables
Population:	15.6 million*

*1997 IEA data found at <http://www.iea.org/stat.html>. TPES-Total Primary Energy Supply. [y] Solar, wind, wave, tide: *Renewable Energy Policy in IEA Countries*, Volume II, IEA, 1998. [g] Derived from *Renewable Energy Policy in IEA Countries, Volume II*, using estimated capacity factor of 0.8 for biomass and waste generation. **1997 Data from EIA World Energy Database at www.eia.doe.gov.

Dutch encouragement of renewable energy dates to the oil crises of the mid- and late 1970s.[24] Interest in renewables quickened with rising concerns over ozone and other local air pollution problems in the 1980s, leading the government to prepare its first National Environmental Policy Plan (NEPP). This was later supplemented by an update, National Environmental Policy Plan-Plus, and as of February 5, 1998, a Third National Environmental Policy Plan.[25] The latter plans explicitly address climate change and establish the fundamentals of Dutch policy. They include stricter energy efficiency standards for new buildings, voluntary agreements with manufacturing sectors, and accelerated use of combined heat and power, as well as development of renewable energy.

The Dutch national plans have effectively altered the behavior of business and industry. The only other nation with such a national program is New Zealand, which, unlike the Netherlands, is an essentially rural and agrarian country. The Netherlands, in contrast, is an industrial nation with steel mills, refineries, and a wide variety of other manufacturing facilities that produce goods for the international market.

By establishing overarching national environmental objectives—which are developed with trade implications in mind—the plans have provided a framework within which both government and industry can develop compatible policies. Yet the details adopted to flesh out the objectives of the National Plan are, in many respects, less important than the document itself. Its mere existence provides incentives and structure for government, industry, and the public. Thus within the context of the plan, policies can be developed that are consistent with national objectives. One area where this has happened is renewable energy, where other smaller-scale innovations have been adopted.

Under its energy policy framework through the year 2020, the Dutch government intends to increase renewable energy's share of total energy supply from 1 to roughly 10%—about 6% from electricity generation (meaning that renewables will supply roughly 17% of the national electricity supply); about 3% from heat production, principally from solar hot water systems and heat pumps; and less than 1% from the transportation sector. With the adoption of this plan and the development of specific efforts to support the Kyoto Protocol to deal with climate change, programs to spur the use of renewable energy—especially wind power and solar hot water—have been reinvigorated.

In 1997, the government identified three specific areas of focus for the following four years: improvement in the price/performance ratio of renewable energy through improvements in technologies, stimulation of the market demand for renewables, and elimination of administrative obstacles to the deployment and integration of renewables. To achieve these long-range goals, the government adopted a wide range of specific measures:

- Accelerated depreciation on environmental investments (VAMIL): Equipment on the "VAMIL list" of renewable energy and other environmentally friendly technologies can be depreciated at a rate faster than normal, thus increasing profits by reducing taxes.[26]

[24] Much of the information in this section is drawn from site visits and interviews, as well as from the White Paper on Renewable Energy, issued on March 4, 1997, by the Dutch Minister of Economic Affairs, Dr. Hans Wijers. For further information, see K.W. Kwant, "Fiscal Support for Renewables in the Netherlands," CADDET Newsletter, <http://www.caddet-re.org/org/html/body_septart7.ht>, and International Energy Agency, Energy Policies of IEA Countries—The Netherlands 1996 Review, <http://www.iea.org/pubs/reviews/files/neth.ht>.

[25] Royal Netherlands Embassy, Third National Environmental Policy Plan, press release, <http://www.netherlands-embassy.org/env_nmp.htm>.

[26] These programs are coordinated by the Netherlands Agency for Energy and the Environment (Novem), which provides a wide range of information at <http://www.novem.org/netherl/green.htm>.

- **Tax deductions for investments in renewable energy:** Since January 1997, companies investing in specific renewable energy applications have been allowed to reduce their taxable profit by a percentage of the amount invested. The reduction ranges from 52% for small investments (which must be at least 3,600 guilders, or $1,695) to 40% for those larger than 475,000 guilders ($223,000).

- **Green funding:** Loans for so-called green projects, which includes virtually all renewable energy systems, are available at rates 1–2% lower than the prevailing rate. In addition, investment income (such as interest or dividends) derived from green funds are exempt from income tax.

- **Mandated purchases:** Electricity distribution companies are required to purchase excess power from independent producers of electricity at rates that include avoided fuel and power (that is, capacity) costs.

- **Household and business energy tax:** Small households and small- to medium-sized businesses are required to pay an energy tax on electricity of 0.014 ECU/kWh (1 ECU = $1.04) and on natural gas of 0.49 ECU per gigajoule (GJ) (increasing to 1.41 ECU/GJ in 1999) when consumption exceeds a minimum demand. The tax on nonrenewable energy is transferred from utility companies to the Dutch government, but the income from renewable electricity is instead paid to the generators.

- **Green electricity:** Some utility providers sell green electricity at a premium rate of 0.02–0.03 ECU/kWh (2–3¢/kWh) above the normal price. The additional income is dedicated to the construction of renewable energy projects or the subsidization of renewable electricity.

- **Green label for electricity:** Those who generate electricity from renewable energy are entitled to a use a "green label." The generator can also authorize the use of this label by distribution companies, thus establishing a market for renewable electricity.

- **Green mortgages:** For two years starting in November 1996, "sustainably built" houses could be financed in part with lower interest rate loans. Houses costing 400,000 guilders ($188,000) or less could qualify for a green mortgage. A buyer could get a loan of up to 75,000 guilders ($35,000) for 10 years at a rate roughly 20% below the prevailing market price (at about 4% instead of 5%). The so-called green mortgage let a buyer recoup roughly 75% of the additional costs of environmental extras. A total of 5,000 mortgages could have been issued for two years, after which the program was suspended for evaluation.

The Netherlands has also adopted a program designed to stimulate competition and create a market for solar hot water heaters. Starting in 1996, energy consumption in new homes was regulated by the energy performance coefficient, which requires that in certain circumstances houses must incorporate either a heat recovery system or a solar domestic hot water system. This is intended to promote both of these as well as the competition between them.

As of this writing, it is too early to tell how the latest Dutch National Environmental Policy Plan has affected renewables development in the Netherlands.

PART VI. JAPAN: THE WORLD'S MOST EFFICIENT ECONOMY

	Japan
National Energy From Renewables:	2.1% of TPES (non-hydro)*
Renewable Capacity:	1500MW[g]
Recent RE Growth:	n.a.
Stated Goal:	3% Renewables by 2010[y]
Total Electrical Capacity:	210,600 MW**
TPES Mix:	52.7% oil*, 16.8% coal, 16.1% nuclear, 10.7%, natural gas, 1.5% hydro, 1.4% combustible renewables, 0.7% other renewables
Population:	126.2 million*

*1997 IEA data found at <http://www.iea.org/stat.html>. TPES-Total Primary Energy Supply. [y]*Renewable Energy Policy in IEA Countries, Volume II*, IEA, 1998. Compiled from *PV News*, June 1999, *Renewable Energy Policy in IEA Countries, Volume II*, IEA, 1998, and MITI, *New Energy Policies*. **1997 Data from EIA World Energy Database at www.eia.doe.gov.

With no oil or natural gas, and very little coal, Japan has historically depended on imported fuels to sustain its economy. After the oil shocks of the 1970s and 1980s, the nation embarked on focused and intensive programs to increase the security and diversity of its energy supplies. One component of these efforts was to increase the efficiency with which energy is used.

Another element of Japan's efforts to reduce energy dependence was the development of new and alternative sources of energy, such as solar and wind power, first under Project Sunshine. Although this program funded a wide array of R&D both inside and outside Japan, the government made relatively little effort to deploy the resulting technologies. Indeed, until 1997–98, Japan had virtually no policies aimed explicitly at encouraging the adoption of renewable energy. Instead, the government focused on what it termed "promotion," which was effectively mere encouragement, if that.

Of all the world's industrial nations, Japan's task in meeting targets set in the Kyoto Protocol in 1997 are perhaps the most formidable. Its economy is stagnant while its carbon emissions per unit of industrial output are already the world's lowest, yet the government has committed to a 6% reduction in greenhouse gases, which is only a 1% smaller reduction than that proposed for the United States.[27]

Utility companies, the nuclear industry, and MITI backed the inclusion of nuclear power as a climate change mitigation option in the recent Global Warming Prevention Law.[28] Perhaps because of the challenge of the climate change situation, Japan is still quite serious about maintaining and expanding the nuclear option, both to alleviate energy dependence and to reduce greenhouse gas emissions. The Japanese government's budget for nuclear power in fiscal year 1999 is 477 billion yen ($4.03 billion), while the budget for renewables is 87.5 billion yen ($739 million).[29] The Global Warming Prevention Law, passed in October of 1998, sets the stabilization of greenhouse gas emissions at 1990 levels as a goal, and promotes the addition of twenty new nuclear power plants in Japan as one way to achieve the goal. Clearly, nuclear power is a major component of Japan's climate change strategy.

However, signs of increased citizen activism in energy siting decisionmaking in Japan may result in fewer nuclear plants than the Japanese government is hoping for. Plebiscites such as one in the town of Maki, whose citizens voted against a 825-MW nuclear plant in 1996, portend greater popular focus on nuclear safety and waste issues, and greater awareness of other energy options that offer energy independence—such as renewables.[30]

The Roles of MITI and NEDO

To understand Japan's current policy and its likely future direction, it is helpful to know something of the government's organization and its relationship to domestic industries. The administrative agency charged with implementing national energy policy is the Ministry of International Trade and Industry (MITI), easily the most influential of Japan's government units.

MITI implements its energy-related responsibilities in large part through the New Energy and Industrial Technology Development Organization (NEDO). This quasi-governmental agency receives its funding from the government. Its staff, however, consists of government and private-sector employees on secondment who rotate through for two- to three-year tours. Thus a NEDO project might fall under the supervision of a MITI executive in one year and an executive of the Tokyo Electric Power Company the next. This has fostered an informal collaborative network throughout government and industry. Indeed, the interrelationship between different manufacturers, users, and the government is the typical way of promoting Japanese learning projects, according to R. Anahara, a retired senior executive of Fuji Electric.

NEDO is responsible for developing renewable energy technologies under Project Sunshine. Most of Japan's efforts have focused on solar power, especially photovoltaics. In its 1997 budget, for example, MITI allocated 11.1 billion yen (about $94 million) for the promotion of PVs, compared with 460 million yen (about $3.9 million) for development of wind power.

Ten Thousand Roofs: An Early Deployment Program

Until September 1997, the primary affirmative action taken to encourage the actual adoption of renewable energy technology had been the Ten Thousand Roofs Program.[31] Under this, the government paid one-third of the installation cost for household roof–mounted PV panels; funds for the program were collected through an electricity surcharge. Although electricity

[27] Toshio Aritake, "Kyoto Meeting Ends With Agreement, Leaving Details for 1998 in Buenos Aires," Bureau of National Affairs, Inc., <http://www.bna.com/prodhome/ens/story66.htm>.

[28] Sources: Yurika Ayukawa, World Wide Fund for Nature (WWF Japan), e-mail: yurikaa@ibm.net, and Mie Asoka, Kiko Network, e-mail: kikonet@jca.ax.apc.org.

[29] Ministry of International Trade and Industry (MITI).

[30] Jon Choy, "Japanese Town Vote Jolts Tokyo's Nuclear Power Plans," *JEI Report*, No. 31 B, p. 3.

[31] The information in this section was provided by Fujino, op. cit. note 6.

generated by PVs currently costs about 65–80 yen (55¢-68¢) per kilowatt-hour, compared with about 20–30 yen (17¢-25¢) for grid-provided electricity, the roof program provided no compensation for this difference. But local electric utilities had to purchase excess power generated by the PV systems at the retail price of electricity. In addition, businesses that installed new technologies (such as wind turbines) could apply to NEDO for a grant to subsidize the project under a program funded at 1.12 billion yen ($9.5 million). These programs have since been overtaken by new measures, but the changes—and the policy that has caused their creation—must be considered in the context of the government-industry collaboration in such matters that is uniquely Japanese.

One noteworthy example of this unusual collaboration is the Rokko Island Test Center, located on an artificial island near Kobe, which currently focuses on potential safety and reliability issues raised by dispersed generating systems and the quality of the power that such systems generate. The center was designed by the Kansai Electric Power Company (KEPCO), Japan's second largest utility, at the request of NEDO. NEDO has now assumed funding responsibility for Rokko Island; while KEPCO owns the island itself, the government owns the buildings and equipment there.

New Policies to Encourage Renewable Energy

Using the same public-private collaborative approach that typifies NEDO and MITI, Japan is now beginning to deploy renewable technologies under the Law on Special Measures to Promote Use of New Energies, sometimes called the New Energy Law. Enacted in September 1997, the law and its underlying rules establish a mix of subsidies and other policies designed to promote adoption of wind, solar, ocean, hydro, geothermal, and waste energy in Japan. The goal is to provide 3.1% of Japan's primary energy supply from renewable resources by 2010 versus 2.1% in 1996 (See Table 2).

Table 2. Japan: New Energy Installation Record and Targets

Technology Area	FY 1996 Record	FY 2010 Target
Photovoltaic power generation	57 MW	5000 MW
Wind power generation	14 MW	150 MW
Geothermal power generation	530 MW	2800 MW
Waste power generation	890 MW	4,000 MW

Sources: MITI, *New Energy Policies* (Tokyo: undated); *Renewable Energy Policy in IEA Countries*, IEA, 1998.

The law does not require the nation's electricity suppliers to purchase a minimum amount of renewably generated electricity, nor does it establish a single fixed price. The government "requests" that suppliers buy solar, wind, and other renewables-based electricity. They "have an obligation to make efforts to develop the environment for promoting the use of new energy by other energy users," according to one official. Thus, in response to an April 1998 "general request" from MITI, electricity suppliers have voluntarily committed themselves to purchase renewably derived electricity when it is offered.

Depending on the actual growth rate of renewables, this component of Japanese renewables policy may need to be revised in the future: suppliers are paying considerably higher prices than their in-house generating costs for outside power, and their voluntary cooperation may reach limits as the amount of renewables-based electricity increases.[32]

When suppliers do buy renewably generated electricity, they must pay the contract, or retail, price applicable to that class of users that is the source of the renewables-based electricity. This varies according to the quantity of electricity purchased, so larger consumers—factories, for example—pay a lower price per kilowatt-hour purchased, and therefore receive this same lower price when they sell. In the case of PVs, which are typically installed on residential rooftops, the buy/sell price is about 24 yen (20¢) per kilowatt-hour.

[32] Shoda, Takeshi, of the Energy Policy and Forecast Research Group, The Institute of Energy Economics, Japan. "Outlook for Introduction of Renewable Energy Sources in Japan", *Energy Policy* 27, 1999, pp. 57-68.

Contracts for wind-derived electricity can be either long-term or short-term, at the option of the generator. Suppliers are required to enter into a contract for at least 15 years if the generator requests, in which case the price is 11–12 yen (about 9.7¢) per kilowatt-hour. Starting in April 1998, private electricity companies were asked by MITI to enter into contracts for the purchase of wind-derived electricity. However, the generator can opt for a one-year agreement at a price of 16 yen (14¢). Electricity suppliers are not required to renew these contracts. Although the long-term purchase prices are established separately by each of the 12 electricity suppliers, they all are within the range of 11–12 yen (9.7¢) per kWh.

In response to these incentives, new wind capacity is already being constructed, principally using Danish wind turbines. The official target for 2010 is 150 MW. This figure is somewhat lower than the goals that some other nations are setting (and reaching), but Japan's wind potential is limited because areas with wind potential are isolated from population and industrial centers, and land prices near such centers are expensive. At least one author in Japan, however, has called for substantially higher wind energy targets: Minoru Nagai has proposed to the Japanese government that the goal for wind could feasibly be 3000 MW by 2010, based on a wind survey conducted by NEDO.[33]

Building on the success of the Ten Thousand Roofs program, Japan's most ambitious new goal is to install 5,000 megawatts of solar PV capacity by 2010, roughly 80% of which would be from residential rooftop systems. MITI began its support for residential PV systems in fiscal 1994, when subsidies covered 50% of the cost of PV modules, peripheral equipment, distribution lines, and installation work. The 1994 budget was 2 billion yen ($20.3 million); by 1998 it had reached 14.7 billion yen (about $124 million).

Japan has a long way to go to reach the 5,000 MW of PV goal (Japan's PV production was 49.2 MW in 1998) but the market certainly is growing: production was only 21.2 MW in 1996. It is important that the government has boldly set a high target as part of its subsidy program-this gives the PV industry a clear signal about what the government seeks to achieve, and it is also a strong statement of political will. This goal may or may not be reached, but along with the increasing budget for PVs, it reflects the level of commitment Japan has to the technology.

By 1997, the subsidy program for a large number of PV installations was aimed at reducing costs by achieving mass production of PV systems. Subsidies are available for private residential housing, apartment buildings, and municipalities. Homeowners seeking the subsidy apply to the New Energy Foundation, a government-supported agency. Applicants qualify for the grant "semi-automatically"—that is, if they satisfy certain requirements (such as approved grid connection), they receive one-third of the costs of purchase and installation. The current program budget will pay for roughly 10,000 residential installations.

The subsidies for wind power, cogeneration, waste power, and other "new energies" are also semi-automatic, although the funds are dispensed by NEDO, not the New Energy Foundation. The maximum subsidy is one-third of the total installation cost, excluding land costs. Local governments are eligible for comparable subsidies under a parallel program also administered by NEDO.

PART VII. THE CASE OF PVS: SUCCESS INDUCED BY GOVERNMENT SUPPORT

Earlier sections considered the various ways that governments outside the United States support and nurture renewable energy technologies. This section looks at the effect of such support on one particular technology—photovoltaics, which have potentially widespread applications—in order to gauge whether these policies really work.

The question of what works is not straightforward. The definition of success will be different for an environmentalist concerned about reducing local air pollution and executive of a PV firm. One might care about installed capacity and electricity production domestically, while the other might care more about total sales, regardless of the destination. And the workers at the plant are likely to care about domestic jobs, not the nationality of the job providers.

Here, however, success in PVs will be examined as a function of ownership of manufacturing firms and share of the global market. With those criteria in mind, the evidence is compelling that the policies described in this report have not only encouraged the deployment of renewable energy technologies, they also stimulated the development of their manufacturing sectors.

Since 1988, the global market for solar photovoltaics has changed dramatically in several ways. First, the market for solar photo-

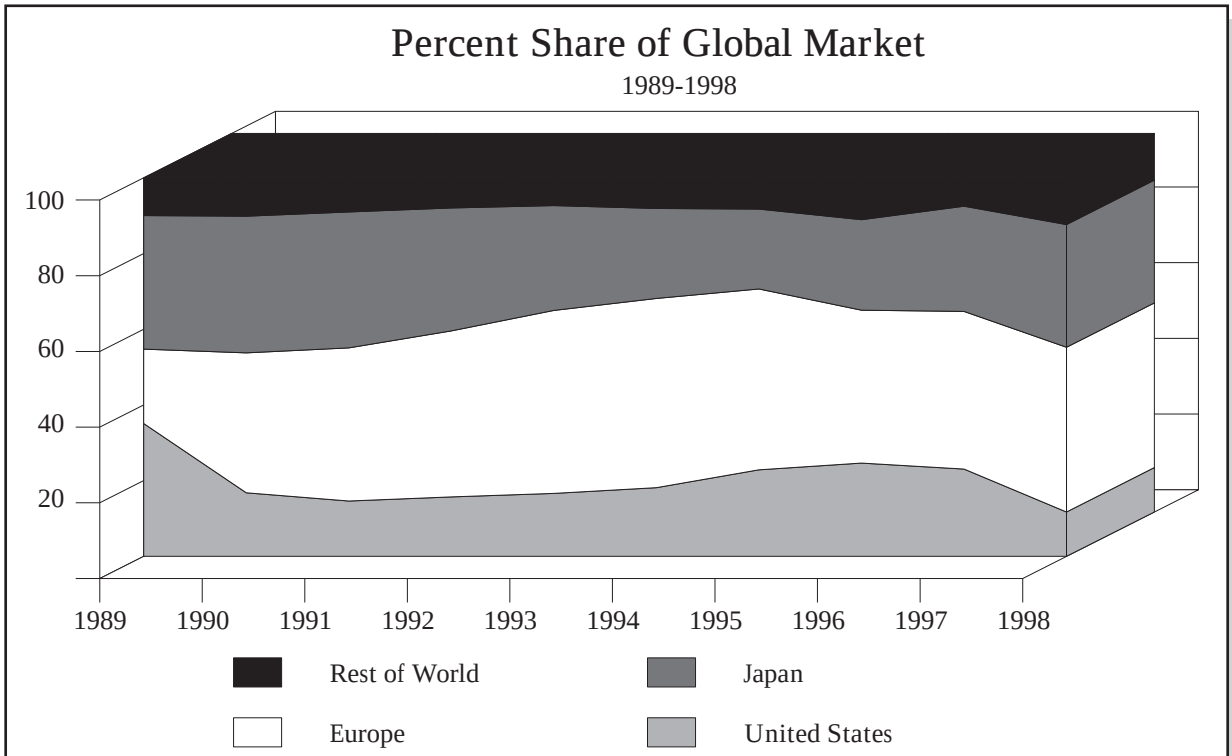
[33] Nagai, M., "Capability of wind turbine generator systems in Japan," Text for the 14th new energy industrial symposium, 1994-10, New Energy Foundation Japan, pp. 16-30.

voltaics has grown rapidly. Global shipments jumped from 40.2 megawatts in 1989 to 151.7 megawatts in 1998—an increase of 480% in just 10 years. Annual percentage increases in shipments were consistently in the double digits.[34] These changes have been prompted in large measure by the policies of Japan and Europe in support of PVs, especially in contrast to the attitudes of U.S. policymakers, which have sometimes amounted to outright hostility. The domestic U.S. market for photovoltaics has been in decline at a time when global sales are booming, eroding the ability of U.S. firms to compete globally. (See Figure 4.) Governments have played a significant role in this reversal.

From 1974 to 1984, the U.S. solar industry soared from 45 solar collector manufacturers with 1.3 million square feet of annual production to 225 firms and 17.2 million square feet. The solar market was helped during this period by government assistance, both federal and state, mainly in the form of tax credits. As these tax credits began to expire, however, and as oil prices dropped significantly, the industry began to shrink. From 1984 to 1986, the number of manufacturers dropped by 127, more than half. After 1990, the rate of growth of solar collector shipments stabilized at about 4% per year.[35]

Despite slack domestic demand compared with growth elsewhere, export sales have continued to drive the expansion of the U.S. photovoltaic industry. For example, total shipments of PV cells and modules reached 31 peak megawatts in 1995, a 19-percent increase from 1994. Much of that was driven by exports, which accounted for 64% of total shipments that year.[36]

Finally, the U.S. manufacturing presence has declined sharply in favor of Japan and Europe. The two leading U.S. manufacturers, Siemens and Solarex, remain nominally American companies, but each has been acquired in whole or part by a European concern. In 1990, the German conglomerate Siemens bought ARCO Solar, while in 1998 British Petroleum acquired Amoco, the parent (with Enron) of Solarex.



Source: PV News. Production of Siemens (ARCO) Solar attributed to Europe starting in 1990. Production of Solarex attributed to Europe starting in 1998.

[34] This discussion is based on data reported in *PV News*, February 1995 and February 1999.

[35] Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, *Renewable Energy Annual* 1996 (Washington, DC: U.S. Department of Energy, 1997).

[36] Ibid.

The most important question for the purposes of this report is whether these shifts were induced by government policies. It seems obvious that they were.

There are essentially two different sets of forces at play. First, U.S. policymakers have chosen to reject strategies designed to commercialize renewable energy in favor of continued reliance on fossil fuels, especially oil[37] In contrast, Europe and Japan have sought to stimulate both the deployment of renewable energy technology and the development of manufacturing capacity. The effectiveness of these contrasting policies is illustrated by the fact that the U.S. solar industry continues to grow, but largely because of non-U.S. demands. These exports are fueled in part by demands in Japan and Germany, which in 1995 accounted respectively for 18.2% and 18.9% of U.S. exports.[38] Whether that growth will continue if Japan and Europe successfully establish their own manufacturing capacity, as they are now doing, is an open question.

Second, the market has shifted in the direction of grid-interactive installations. For example, in 1995 U.S. shipments for grid-interactive electricity generation doubled for the second year in a row, to 4.6 peak megawatts.[39] Similarly, Japanese shipments jumped from 35 MW in 1997 to 49.2 in 1998, and all of this capacity growth was to serve grid-connected PV systems. Capacity growth the previous year had also been devoted exclusively to the new program in Japan.[40]

Japan's renewable energy efforts are focused most specifically on solar photovoltaics for a relatively straightforward reason: there is room for PVs on rooftops, but little or no room on the ground for wind turbines, biomass facilities, and most other forms of renewable energy.[41] As a result of Japan's decision in the early 1990s to develop a set of policy initiatives designed to deploy solar PVs on rooftops, the installed PV capacity in Japan has increased steadily, and so has its manufacturing potential. It can be no coincidence that between 1993 and 1998, Kyocera's production rose about 500%, while Sharp's jumped an astonishing 1,400%. Although it is true that Siemen's shipments from its U.S. facility rose during that same period from 12.5 megawatts to 20, the increase was largely to satisfy export demands, especially in Japan.

In Europe, solar photovoltaic installation and manufacture have been encouraged through policies designed to stimulate renewable energy generically, unlike the directed programs in Japan. Perhaps because of this broader-brush approach, solar photovoltaics have not climbed so dramatically in Europe. Still, shipments from European-based factories roughly kept pace with growth in the United States: between 1988 and 1998, shipments from the U.S. rose 484%, while those from Europe increased 449%.

Critics of government subsidies will argue that these shifts demonstrate the obvious: without government support, renewable energy technologies—especially solar photovoltaics—cannot compete on a cost basis in grid-connected applications. Supporters of subsidies can reply that subsidies have facilitated improvements that have allowed photovoltaics to penetrate larger and larger niche markets, and that grid-connected applications are almost within reach. In essence, these are arguments about whether government programs should be deployed at all, not whether they work. There can be no question that they do. In the case of PVs, they moved technology from space to the ground, then from a rarity to a relatively commonplace commodity.

PART VIII. LESSONS FOR THE UNITED STATES

Lesson #1: Examine the successes and failures of other programs.

European nations looked at and benefited from the renewable energy programs introduced in California during the 1980s. For instance, European countries link financial subsidies to the actual production of electricity rather than the mere construction of a facility—a valuable lesson from the windfarms of California. At the same time, European governments study the experiences of their neighbors. After the success of the NFFO program in the United Kingdom, France adopted one of its own. Switzerland is considering a "charge" system comparable to Sweden's,

[37] Curtis A. Moore and Alan S. Miller, *Green Gold: Japan, Germany, the United States and the Race for Environmental Technology* (Boston: Beacon Press, 1994), pp. 98–104.
[38] Office of Coal, Nuclear, Electric and Alternate Fuels, op. cit. note 23.
[39] Ibid.
[40] "1998 PV World Cell/Module Shipments," *PV News*, February 1999.
[41] Yoshihiro Kageyama, Deputy General Manager, Siting and Environment, The Federation of Electric Power Companies, Tokyo, private communication, December 7, 1998.

and Austria has adopted a program of subsidized loans like Germany's.

Lesson #2: A wide variety of market mechanisms are being used worldwide to promote renewable energy technologies versus other technologies.

The countries considered during the preparation of this report—especially Germany, the Netherlands, and Denmark—rank among the most environmentally conscious in the world. Yet renewable energy could not establish itself without government intervention in these nations. Usually that intervention must take the form of a financial mechanism.

Most of these countries provide higher payments for energy generated from renewable resources. Sometimes, as in Denmark, the payments are combined with a high tax on fossil fuels. This approach typically fits very well with market mechanisms already in place, and requires very little tinkering with other laws. The specific mechanism through which renewable energy technologies are made more competitive with other technologies varies from nation to nation:

- Fixed higher payments upon delivery: These can be established through legislation, regulation, or agreements. In Germany, for example, generators of renewable electricity are entitled by law to 90% of the retail residential price. Because fixed higher payments can be applied for at any time, this approach tends to make it easier for small-scale developments to enter the market. This is a simple, straightforward, and highly effective mechanism.

- Competition: The NFFO, for example, requires bidders to compete for awards within technology bands. The approach seems to have worked quite well in the United Kingdom. Denmark's new RPS is another example of a competitive system. It also represents the first major national shift away from a fixed higher payment system to a competitive system.

- Higher payments subject to negotiated agreements: In some countries, agreements must be renegotiated annually. Frequent renegotiation discourages project planning. This is the case in Italy where, according to one observer, "yearly negotiations about a tariff without legislative obligations tend to lead to marginal tariffs and late results and thus low usage of the agreement."

- Green pricing: In the Netherlands, the price difference between renewable, or "green," electricity and fossil power is reduced by a refund of the energy tax. This system tends to emphasize overtly only one of the many differences between the two types of electricity—price—rather than the many other dissimilarities, which are not reflected in the lower charge for fossil-fueled power. This places renewable electricity at a subtle but nevertheless very real disadvantage. It suggests that solar, wind, biomass, and other forms of renewable electricity are too expensive to compete in an open market, rather than focusing on the failure of current pricing systems to incorporate the true cost of fossil electricity in its price.

- Carbon tax: A tax on fossil fuels—or for the pollution that they produce, such as carbon dioxide, oxides of nitrogen, fine particles, and heavy metals such as mercury—is an attempt to level the economic playing field by removing the hidden subsidy for coal, oil and, to a lesser degree, natural gas. To the extent that pollution or energy taxes serve that end, they have garnered public support in the Netherlands, Sweden and other nations.

Whatever financing mechanism policymakers select, they ought also to adopt both strict eligibility rules and a control system after the subsidy is awarded. Applicants for a limited supply of money can outstrip available funds either because a program generates a large demand (which is good) or because the qualification criteria are lax (which is bad). Lax eligibility criteria—especially when successful bidders are selected solely on the basis of price, as in the NFFO—can inflate demand artificially, damage a program's reputation when participants fail to perform, and waste a subsidy that otherwise could have been put to good use. To prevent such waste and inefficiency, fairly tight rules of eligibility for support mechanisms are necessary. Oversight criteria for project implementation need to be fairly stringent for the same reason.

Lesson #3: A program of financial assistance must remain stable for at least 10 years.

Quite dissimilar renewable energy programs have succeeded in, for example, California, Denmark, Germany, and the United Kingdom. Significantly, they share in common the qualities of predictability and stability. Indeed, these characteristics may be more important than the specific details of the financial mechanisms.

Banks, insurance companies, and venture capitalists will provide financing for new technologies only when they are confident of long-term stability, with the assurance of a profit over a number of years, not just a few. In successful renewable energy financing programs, such as those of Denmark and the United Kingdom, developers, investors, and purchasers of renewable energy all know who will be paid, how much, and for how long. By contrast, the lack of year-to-year certainty regarding tax subsidies, along with other factors, ultimately killed the innovative Luz company's solar thermal projects in California even while

Luz was reducing costs with each project developed. Similarly, wind energy in Germany expanded rapidly and steadily until discussion of program revisions began in about 1996. The uncertainty caused the development pace to slow abruptly. Similar uncertainties are blamed for developments in the Netherlands and Sweden that fail to keep pace with demand.

Lesson #4: Energy dependency is a strong driver for renewables.

Some of the nations with the most progressive renewables policies have a very strong current interest in reducing their energy dependency. For example, Japan relies on imports for 80% of its energy[42] and Denmark's entire supply of coal, supplying 75-80% of its electricity, is imported.[43] By contrast, 96% of electricity in the U.S. (coal, nuclear, natural gas, hydro, and renewable) is from sources that are almost entirely domestic.[44]

The United States imports over half of its petroleum, but in the electricity sector, where renewables have been most technically able to substitute for fossil sources, the vulnerability of the U.S. is quite low. This is not the case for other nations such as Denmark and Japan, and the language of their energy plans and public statements reflects the high priority given to energy dependence.

Vulnerability of energy supplies is not the only reason to consider the benefits of locally-developed renewables. Renewable energy also tends to create more jobs than other sources of energy, and states and communities experience local employment benefits when implementing renewables.

There are also reasons why the United States should take action on the national level. Climate change is arguably the strongest driver for renewables development today, and the United States is the largest national greenhouse gas emitter. Also, development of renewables in the electricity sector today not only reduces our climate impact but also increases our options tomorrow for substitutions into other sectors.

Lesson #5: Money must flow into and out of a financing scheme in a simple and "transparent" way so that it is clear what is being charged, what is being subsidized, and why.

The success of new policies based on the voluntary participation of consumers, such as the "green pricing" programs in vogue among some U.S. utilities, demonstrates that some ratepayers are willing to pay for the intangible benefits of renewable electricity. An even larger segment is willing to support subsidies for renewable energy through taxes on pollution or fossil energy, judging from the success of duties on carbon dioxide (Denmark), as well as on energy or electricity generally (United Kingdom and Germany).

Lesson #6: Any renewables policy must include non-financial assistance.

A renewables strategy should be comprehensive, including R&D on generating technologies and associated equipment, grid integration or development of free-standing applications, product testing and certification, resource identification and mapping, and community participation, possibly including ownership. Japan and Denmark provide good examples of this comprehensive approach.

Non-financial assistance might or might not spell the difference between overall program success or failure. It can, however, be critically important in specific cases. For example, the local opposition to the construction of wind turbines hindered the ability of successful NFFO bidders in the United Kingdom to fulfill their contracts. Similar opposition has been overcome in Denmark by establishing local co-operatives, which derive a profit from the turbines.

Demonstrations and pilot-sized plants are essential for providing early operating experience for improvement of the technology. Direct subsidies can be used to reduce the risks of introducing a new technology, especially for capital-intensive undertakings such as demonstration projects and pilot plants.

Adequate testing and demonstration of both generating and associated equipment can eliminate problems and lessen fears. In Japan, the fact that both the renewable technologies themselves and the associated equipment (such as power conditioning) have been tested in a program designed and managed by the utility industry itself has helped reduce fear of damage to the grid and other customers now that the national energy policy has been revised to seek sharp increases in wind, solar, and other non-fossil electricity.

Lesson #7: With time, the need for subsidies declines.

A wide variety of experience indicates that the need for subsidies declines as technologies mature. These experiences include:

- the steady decline of prices in the NFFO system in several of the technologies being bid, especially wind energy and biowaste;
- the decline in the cost of wind-generated electricity in Denmark, and its consequent spread to other nations; and
- the decline in the cost of waste-generated electricity throughout Europe and the United States.

[42] Energy in Japan, August 1997: <http://www.miti.go.jp/intro-e/a2312003.html>.
[43] Danish Energy Agency, <http://www.ens.dk>, and Renewable Energy in the EU, Financial Times
[44] Energy Information Agency, *Electric Power Annual, Volume I*, 1998.

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Curtis Moore and Jack Ihle, *Renewable Energy Policy Outside the United States*, Renewable Energy Policy Project Issue Brief No. 14 (Washington, DC: October 1999).

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