Chapter 5

Charting a New Energy Future

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For eight years, people in the Thai province of Prachuap Khiri Kan have fought proposals to build two large coal-fired power plants in the region out of concern for the environmental and health impacts of the plants. When Thailand's Prime Minister visited one possible site in January 2002, he was met by 20,000 protesters. With help from the international environmental organization Greenpeace, people of this province have begun installing what they really want—wind and solar power. Meanwhile, halfway around the world, the state legislature in California passed a groundbreaking law in September 2002 that sets a target of generating 20 percent of electricity from new renewable sources by 2017. From Southeast Asia to California, leaders in business, government, and civil society are calling for a transition to a renewable energy economy.[1]

Between the late 1990s and 2020, global energy consumption is projected to rise nearly 60 percent due to population growth, continued urbanization, and economic and industrial expansion. Consumption of electricity, the most versatile form of energy, will increase even more sharply by most estimates—nearly 70 percent. The largest share of this growth is expected to occur in the developing world, where some 2 billion people have no access to modern forms of energy such as electricity and piped gas. And most of the additional energy is projected to come from fossil fuels, according to national and international agency forecasts. But meeting these demands with conventional fuels and technologies will further threaten the natural environment, public health and welfare, and international stability.[2]

Renewable energy technologies have the potential to meet world energy demand many times over and are now ready for use on a large scale. Wind and solar power are the fastest-growing energy sources in the world. By some estimates, "new renewables" (which excludes large-scale hydropower and traditional biomass) already account for more than 100,000 megawatts (MW) of grid-connected electric capacity. Globally, new renewable energy supplies the equivalent of the residential electricity needs of more than 300 million people.[3]

In 1999, the International Energy Agency noted that "the world is in the early stages of an inevitable transition to a sustainable energy system that will be largely dependent on renewable resources." This is a bold statement for an organization that represents North America, Europe, and Japan—areas that depend so heavily on fossil fuels. But it seems logical, given the many problems associated with the use of conventional energy and the tremendous surge in renewable energy investments over recent years. The world now uses 10 times as much wind energy as it did only a decade ago, and solar power consumption has risen sevenfold. Political support for renewables is on the rise as well. Several countries have recently passed strong new legislation to support renewable energy, opening markets in a rapidly growing list of countries.[4]

Yet change is never easy, and there are strong forces—including politically powerful industries—that wish to maintain the status quo. The forces for and against change were on full display at the World Summit on Sustainable Development, held in Johannesburg, South Africa, in summer 2002. The European Union and Brazil proposed the adoption of specific numerical targets for the use of new renewable energy worldwide. Strong opposition arose from the fossil fuel industry and from the governments of most oil-producing nations and major fossil fuel users such as China and the United States. The battle in Johannesburg ended in a watered-down, non-numerical goal to increase renewable energy use. But the fact that the issue even arose at a global summit was highly significant. While the world is sharply divided on what kind of energy future must lie ahead, many nations now view renewable energy as a credible alternative to fossil fuels.[5]

Resistance to change is inevitable, but the world cannot afford to be held back indefinitely by those who are wedded to energy systems of the past. Each year new power plants, refineries, pipelines, and other forms of conventional infrastructure—facilities that will be around for at least a half-century—are added to the global energy system to replace existing capital stock and to meet ever-rising demand, much of it in the developing world. An estimated $200–250 billion is invested in energy-related infrastructure every year, and another $1.5 trillion is spent on energy consumption, with nearly all of this investment going to conventional energy. As a result, societies are in the process of further locking themselves into indefinite dependence on unhealthy, unsustainable, insecure energy structures.[6]

We have a brief window of opportunity to start down the path to a more sustainable world—one in which rising demand for energy is met without sacrificing the needs of current and future generations and the natural environment. Nongovernmental organizations, working with local communities, can make a difference on a small scale, as in Thailand, but alone they will not bring about the transformation necessary for movement toward a renewably powered world.

The rapid expansion of renewable technologies over the past decade has been fueled by a handful of countries that have adopted ambitious and deliberate government policies aimed to advance renewable energy. These successful policy innovations have been the most important drivers in the advancement and diffusion of renewable technologies such as wind and solar photovoltaics (PVs). By examining the policies that have worked toward this end over the past two decades, as well as those that have failed, we can get some idea of what is required to launch a global takeoff in renewables in the decade ahead.

The Case for Renewables

New renewable resources provide only a small share of global energy production today. (See Figures 5–1 and 5–2.) Yet the advantages of shifting away from fossil fuels and nuclear energy and toward greater reliance on renewables are numerous and enormous. Several countries have begun this transition in response to rising demand for energy, increasing concerns about fuel supplies and global security, the growing threat of climate change and other environmental crises, and significant advances in renewable technologies and the benefits they offer.[7]

Global oil production is expected to peak early in this century. "In 20–25 years the reserves of liquid hydrocarbons are beginning to go down so we have this window of time to convert over to renewables," according to Harry Shimp, president and chief executive officer of BP's solar division. But of greater concern to many is not when or if economically recoverable fossil fuel reserves will be depleted, but the fact that the world cannot afford to use all the conventional energy resources that remain.[8]

The Intergovernmental Panel on Climate Change, a body of approximately 2,000 scientists and economists who advise the United Nations on climate change, has concluded that global carbon dioxide (CO_2) emissions must be reduced at least 70 percent over the next 100 years to stabilize atmospheric CO_2 concentrations at 450 parts per million (ppm), which would be 60 percent higher than preindustrial levels. The sooner societies begin to make these reductions, the lower the impacts and the associated costs—of both climate change and emissions reductions—will be. (See Box 5–1.) Because more than 80 percent of human-made CO_2 emissions are due to the burning of fossil fuels, such reductions are not possible without significant and rapid improvements in energy efficiency and a shift to renewable energy.[9]

Additional environmental costs of conventional energy production and use include destruction wrought through resource extraction; air, soil, and water pollution; acid rain; and biodiversity loss. Conventional energy requires vast quantities of fresh water. Mining and drilling affect the way of life and the very existence of indigenous peoples worldwide. In China, the environmental and health costs of air pollution, due mainly to coal burning, totaled approximately 7 percent of gross domestic product (GDP) in 1995. The World Bank estimates that under business as usual, these costs could rise to 13 percent of China's GDP by 2020. After a decade-long study, U.S. and European researchers calculated that the environmental and health costs associated with conventional energy are equiv-

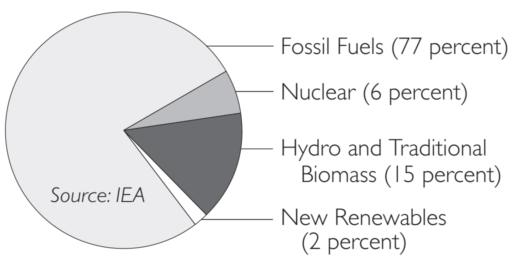

Figure 5–1. World Energy Consumption by Source, 2000

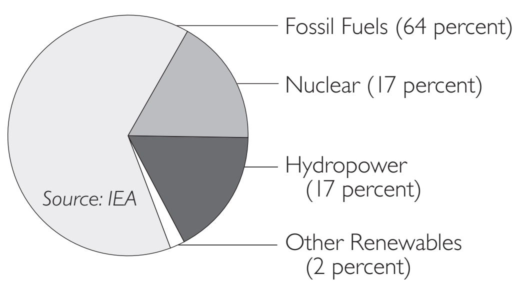

Figure 5–2. World Electricity Generation by Type, 2000

BOX 5–1. CLIMATE CHANGE AND THE KYOTO PROTOCOL

In its 2001 report, the Intergovernmental Panel on Climate Change found that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities" that have increased atmospheric concentrations of CO_2. Pre-industrial concentrations were 280 ppm; today they are 371 ppm. Between 1990 and 2100, global temperatures are projected to increase between 1.4 and 5.8 degrees Celsius, and land areas will likely warm faster than the global average. To stabilize CO_2 "at 450… ppm would require global anthropogenic [human-made] emissions to drop below 1990 levels, within a few decades." Even if greenhouse gas emissions were to stabilize at present levels, it is expected that average temperatures and sea level would continue rising for centuries, but the rate of change will slow once stabilization is achieved.

Under provisions of the Kyoto Protocol to the U.N. Framework Convention on Climate Change, industrial countries must reduce their CO_2 emissions an average 5.2 percent below their 1990 levels by the end of the first "commitment period" (2008–12). The protocol will enter into force 90 days after ratification by 55 countries accounting for at least 55 percent of industrial-country 1990 CO_2 emissions. As of mid-October 2002, 96 nations had ratified Kyoto, including the European Union and Japan, representing 37.4 percent of industrial-country emissions. Russia (17.4 percent) and Poland (3 percent) have officially declared their intention to ratify it soon—which would raise the total to 57.8 percent and thus bring the protocol into effect.

The United States represents 25 percent of current global emissions, and 36.4 percent of industrial-country 1990 emissions. Its March 2001 withdrawal from negotiations on the protocol dealt a blow to international efforts to battle climate change, but it also pushed the rest of the world to move forward and reach final agreement on the treaty in July 2001.

SOURCE: See endnote 9.

alent to 1–2 percent of the European Union's annual GDP, and that the price paid for conventional energy is significantly lower than its total costs. (See Table 5–1.) These estimates do not include the costs of climate change—potentially the most expensive consequence. Global economic losses due to natural disasters, which are in line with events anticipated as a result of global warming, appear to be doubling with each decade, and annual losses from such events are expected to approach $150 billion over the next 10 years.[10]

The direct economic and security costs associated with conventional energy are also substantial. Nuclear power is one of the most expensive means of generating electricity, even without accounting for the risks of nuclear accidents, weapons proliferation, and problems associated with nuclear waste. Political, economic, and military conflicts over limited resources such as oil will become more significant as demand increases worldwide. Similarly, the price of fossil fuels will become increasingly erratic as demand rises and conflicts rage in oil-rich regions, which in turn would affect the stability of economies around the world. The economic costs of relying on imported fuels are extremely high—it is estimated that African countries spend 80 percent of their export earnings on imported oil. Likewise, the benefits of reducing imports can be significant. If not for Brazil's 25-year ethanol program, which now displaces 220,000 barrels of oil per day, the country's foreign debt would be about $140 billion higher, according to one estimate.[11]

Table 5–1. Costs of Electricity With and Without External Costs

Electricity Source	Generating Costs[1]	External Costs[2]	Total Costs
	(cents per kilowatt-hour)		
Coal/lignite	4.3–4.8	2–15	6.3–19.8
Natural gas (new)	3.4–5.0	1–4	4.4–9.0
Nuclear	10–14	0.2–0.7	10.2–14.7
Biomass	7–9	1–3	8–12
Hydropower	2.4–7.7	0–1	2.4–8.7
Photovoltaics	25–50	0.6	25.6–50.6
Wind	4–6	0.05–0.25	4.05–6.25

[1]For the United States and Europe. [2]Environmental and health costs for 15 countries in Europe.
SOURCE: See endnote 10.

Renewable resources are generally domestic, pose no fuel or transport hazards, and are much less vulnerable to terrorist attack. They can be installed rapidly and in dispersed small- or large-scale applications—getting power quickly to areas where it is urgently needed, delaying investment in expensive new electric plants or power lines, and reducing investment risk. All renewables except biomass energy avoid fuel costs and the risks associated with future fuel price fluctuations. They pose significantly lower social, environmental, and health costs than conventional energy fuels and technologies do.

Further, "renewables is not just about energy and the environment but also about manufacturing and jobs." This ringing endorsement came from U.K. Energy Minister Brian Wilson in July 2002, after the commissioning of a new 30-megawatt wind farm atop Beinn an Tuirc, a hill in the northern reaches of Argylle, Scotland. The Kintyre Peninsula of Argylle once thrived on its fisheries, whiskey production, and textile manufacture. These traditional sources of employment are in decline, and now wind power is breathing new life into the region's economy, generating enough electricity to supply 25,000 homes. A new turbine manufacturing plant on the peninsula will provide steady jobs and produce the first large-scale wind turbines ever built in Britain.[12]

Using renewables stimulates local economies by attracting investment and tourist money and by creating employment not only in northern Scotland but elsewhere around the world. Renewable energy provides more jobs per unit of capacity or output and per dollar spent than conventional energies do. Many of the jobs are high-wage and high-tech, and require a range of skills, often in areas that are rural or economically depressed. Economic woes and high unemployment rates influenced Spain's 1994 decision to invest in renewable energy. In Germany, the wind industry has created 40,000 jobs, compared with 38,000 in nuclear power—an industry that generates 30 percent of Germany's electricity.[13]

A recent study in California concluded that increasing renewable energy technologies in that state would create four times more jobs than continued operation of natural gas plants, while keeping billions of dollars in California that would otherwise go to out-of-state power purchases. According to Governor Gray Davis, over a five-year period the net benefits of renewable energy, compared with business as usual, include $11 billion in economic development benefits for California because of associated job creation and in-state investments.[14]

In developing countries such as Brazil and India, where millions of people lack access to power, renewables can provide electricity more cheaply and quickly than the extension of power lines and construction of new plants could, and can aid in economic development. Renewables are also sources of reliable power for businesses in countries such as India where power cuts are common. M. Kannappan, India's Minister of Non-Conventional Energy Sources, has stated that renewables have "enormous potential to meet the growing requirements of the increasing populations of the developing world, whilst offering sustainable solutions to the threat of global climate change."[15]

The energy services delivered by renewables provide communities with access to education, clean water, improved health care, communications, and entertainment. These resources, in turn, improve the quality of life (particularly for women), raise living standards, increase productivity, and reduce the potential for economic and political instability. In Inner Mongolia, thousands of people now have access to education, information, and other benefits for the first time thanks to the use of televisions and radios powered by small wind and solar systems. As a result, they have become more productive and increased their monthly household incomes by as much as $150. (The average per capita annual net income in Inner Mongolia ranges from about $120 to $240.)[16]

Many of the components if not the entire systems for solar homes, wind farms, and other renewable technologies are now manufactured or assembled in developing countries, creating local jobs, reducing costs, and keeping capital investments at home. China and India have both developed domestic wind turbine industries. Brazil's ethanol program, begun in 1975, has created more than 1 million jobs while also bringing the nation's CO_2 emissions 20 percent below what they would have been otherwise. Brazil now exports ethanol fuel and will soon begin exporting its technologies as well. And in Kenya, more than 100 firms (6 of them domestic) provide PV systems or service, with numerous companies selling solar home systems in almost every town.[17]

Developing countries that invest in renewables will discover that they are energy-rich—that they can leapfrog over dirty technologies relied on earlier in industrial countries and can develop their economies with clean, domestic, secure sources of energy that avoid long-term and costly imports.

In light of the many advantages of renewables, the Task Force on Renewable Energy of the Group of Eight industrial countries concluded in 2001 that "though there will be a higher cost in the first decades, measured solely in terms of the costs so far reflected in the market, successfully promoting renewables over the period to 2030 will prove less expensive than taking a 'business as usual' approach within any realistic range of discount rates."[18]

State of the Technologies 2003

Since the 1970s and 1980s, renewable technologies have improved significantly in both performance and cost. Some are experiencing rates of growth and technology advancement comparable only to the electronics industry. Global clean energy markets exceeded $10 billion in 2001 and are expected to surpass $82 billion by 2010, and major corporations are entering the renewables marketplace—including Royal Dutch/Shell, BP, and General Electric. Technical progress of many renewables—particularly wind power—has been faster than was anticipated even a few years ago, and this trend is expected to continue. While costs are still a concern with some technologies, these are falling rapidly due to technological advances, learning by doing, automated manufacturing, and economies of scale through increased production volumes.[19]

Solar and wind are the most commonly known renewables, but inexhaustible energy supplies are also offered by biomass; geothermal; hydropower; ocean energy from the tides, currents, and waves; and ocean thermal energy. This chapter principally focuses on wind power and solar photovoltaics—which produce electricity from sunlight—because they are the fastest-growing renewables and have the greatest potential for helping all countries achieve more sustainable development.

During the past 15–20 years, wind energy technology has evolved to the point where it competes with most conventional forms of power generation. In many instances, wind is now the cheapest option on a per-kilowatt-hour (kWh) basis. The main trends in wind energy development are toward lighter, more flexible blades, variable speed operation, direct-drive generators, and taller machines with greater capacity. The average turbine size has increased from 100–200 kilowatts (kW) in the early 1990s to more than 900 kW today, making it possible to produce more power with fewer machines. (One 900 kW machine can provide the electricity needed for about 540 European homes.) Turbines with capacity ratings of 2,000–5,000 kW (2–5 MW) are being manufactured for use offshore. At the same time, small wind machines that can be installed close to the point of demand—atop buildings, for example—are also under development. (See Box 5–2.) Advances in turbine technology and power electronics, along with a better understanding of siting needs and wind energy resources, have combined to extend the lifetime of today's wind turbines, improve performance, and reduce costs.[20]

BOX 5–2. EXAMPLES OF ADVANCES IN WIND TECHNOLOGY

- At the Rocky Flats test site in Colorado, the U.S. Department of Energy is testing a lightweight turbine with two blades rather than the usual three. It is expected to be 40 percent lighter than today's standard turbines, require less material, and thus be 20–25 percent cheaper.
- Vestas is now equipping offshore turbines with sensors to detect wear and tear on components, along with backup systems in case of power electronic system failures.
- A turbine developed in Germany can desalinate water, generate electricity, or make hydrogen by electrolysis.
- Mathematical climatic models have been developed in Germany and Denmark to predict wind resources 24–36 hours in advance with reasonable accuracy. This will be important for managing wind power as it reaches a high percentage of the total electric system.

SOURCE: See endnote 20.

Since the early 1980s, the average cost of wind-generated electricity has fallen from about 44¢ (in 2001 dollars) per kilowatt-hour to 4–6¢ at good wind sites. Costs vary from one location to the next due primarily to variations in wind speed and also to different institutional frameworks and interest rates. Globally, wind costs have declined by some 20 percent over just the past five years, and the Danish turbine manufacturer Vestas predicts that the generating costs of wind energy will continue to drop annually by 3–5 percent. As this happens, it will become economical to site turbines in regions with lower wind speeds, increasing the global potential for wind-generated electricity.[21]

Global wind capacity has grown at an average annual rate over 30 percent during the past decade. (See Figure 5–3.) An estimated 6,824 MW of wind capacity were added worldwide in 2001, bringing the total to more than 24,900 MW—enough to provide power to approximately 14 million households. While Europe accounts for more than 70 percent of total capacity, wind is now generating electricity in at least 45 countries. Sales in 2001 surpassed $6 billion, nearly double the total two years earlier, and it is estimated that more than 100,000 people are now employed in the wind industry worldwide.[22]

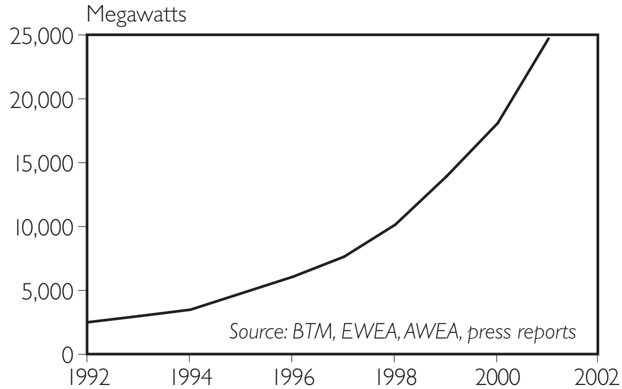

Figure 5–3. Cumulative Global Wind Capacity, 1992–2001

The majority of turbines operating today are on land, but wind power is now moving offshore. This is due to a shortage of sites on land, particularly in Europe, and the fact that wind speeds offshore are significantly higher and more consistent. Stronger winds generate more electricity, while consistency reduces wear and tear on machines. More than 80 MW of turbines are now spinning offshore, all of them in Europe, with an additional 5,000 MW in the pipeline worldwide and more than 20,000 MW proposed for areas surrounding northern Europe.[23]

Experts estimate that onshore wind resources could provide more than four times global electricity consumption. Offshore resources are substantial as well. While some of that potential is too costly to exploit over the near term, the promise of large amounts of wind power at competitive prices is enormous.[24]

As with all energy technologies, there are disadvantages associated with wind power. The environmental factor that has caused the most controversy and concern is bird mortality. This is a site-specific problem, however, and it is relatively low compared with other threats to birds such as vehicles, buildings, and cell phone towers. (See Chapter 2.) Further, such problems have been mitigated in recent years through the use of painted blades, slower rotational speeds, tubular turbine towers, and careful siting of projects.[25]

Both wind and sun are intermittent resources, meaning they cannot be turned on and off as needed. But there is no guarantee that any resource will be available when it is required, and utilities must have backup power for generation every day. Assessments in Europe and the United States have concluded that intermittent sources can account for up to 20 percent of an electric system without posing technical problems; higher levels might demand minor changes in operational practices. The wind already provides electricity to the grid (transmission lines) that greatly exceeds 20 percent in regions of Germany, Denmark, and Spain, and distributed generation—for example, the use of solar panels on rooftops, or clusters of turbines along the path of a power line—can improve electric system reliability.[26]

The challenges posed by intermittency are not of immediate concern in most countries and will be overcome with hybrid systems, improvements in wind forecasting technology, and further development of storage technologies. New storage technologies could also help tap renewable resources that are far from demand centers. Furthermore, what is most significant is the per kilowatt-hour cost of electricity generated. Wind power is already cost-competitive with most conventional technologies. Solar PVs are likely to see dramatic cost reductions, and they produce power in the middle of hot summer days when demand is greatest and electricity costs are highest.[27]

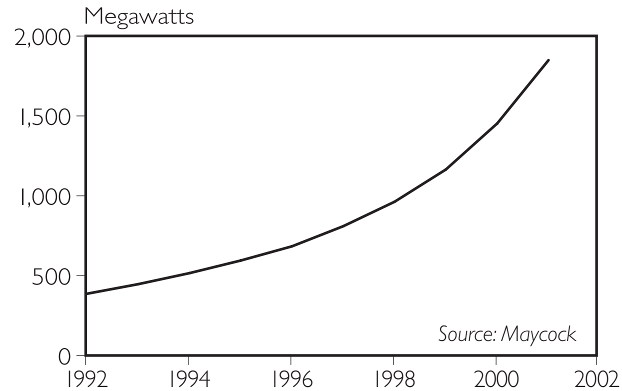

Figure 5–4. Cumulative Global Photovoltaic Capacity, 1992–2001

According to the U.S. National Renewable Energy Laboratory (NREL), PVs have the "potential to become one of the world's most important industries." The potential PV market is huge, ranging from consumer products (such as calculators and watches) and remote standalone systems for electricity and water pumping to grid-connected systems on buildings and large-scale power plants.[28]

Each year the sun delivers to Earth more than 10,000 times the energy that humans currently use. While PVs account for a small share of global electricity generation, they have experienced dramatic growth over the past decade. Since 1996, global PV shipments have increased at an average annual rate of 33 percent. It took nearly 30 years, up until 1999, for the world to produce its first gigawatt (GW) of solar PVs (see Figure 5–4), but some experts expect a doubling as soon as 2003. The PV industry generates business worth more than $2 billion annually and provides tens of thousands of jobs. More than a million households in the developing world now have electricity for the first time from solar PVs, while more than 100,000 households in industrial countries supplement their utility power with PV systems.[29]

The production of solar cells is concentrated in Japan, Europe, and the United States, but there are growing markets and manufacturing bases in developing countries as well, including China and India. Global PV output is expected to increase at annual rates of 40–50 percent over the next few years. As larger factories come into operation, manufacturers can increase the degree of automation.[30]

Such evolving industrial processes, along with technological advances in PVs and economies of scale, have led already to significant cost reductions. Since 1976, costs have dropped 20 percent for every doubling of installed PV capacity, or about 5 percent annually. PVs are now the cheapest option for many remote or off-grid functions. When used for facades of buildings, PVs can be cheaper than other materials such as marble or granite, with the added advantage of producing electricity. Currently, generating costs range from 25¢ to $1 per kWh, which is still extremely high, and cost remains the primary barrier to more widespread use of solar PVs. But companies around the world are in a race to create future generations of products to make PVs cost-competitive even for on-grid use. (See Box 5–3.)[31]

In addition to cost, one of the primary concerns regarding PVs' ability to meet a

BOX 5–3. THE SOLAR RACE

- An Australian company is the first to manufacture solar PVs that can be incorporated into glass walls of buildings. When light falls on the glass from any angle, it will generate electricity.
- The U.S. National Renewable Energy Laboratory and Spectrolabs have developed a Triple-Junction Terrestrial Concentrator Solar Cell that is 34 percent efficient and that can be manufactured for less than $1 per watt, according to NREL. (The maximum recorded laboratory efficiency is 24.7 percent, while the average cost of today's PVs is $5–12 per watt.)
- Spheral solar technology, being developed in Canada, will bond tiny silicon beads into an aluminum foil. While mass market application could take decades, this technology could halve the cost of power generation.

SOURCE: See endnote 31.

major portion of global electricity demand is the length of time they must operate to produce as much energy as was used to manufacture them. The energy "pay-back" period for today's cells in rooftop systems is one to four years, with expected lifetimes of up to 30 years, depending on the technology. The manufacture of PVs also requires a number of hazardous materials, including many of the chemicals and heavy metals used in the semiconductor electronics industry. There are techniques and equipment to reduce environmental and safety risks, however, and these problems are minimal compared with those associated with conventional energy technologies.[32]

Global markets for renewables such as solar and wind power are only just beginning a dramatic expansion, starting from relatively low levels. It is useful to point out, however, that despite increasing concerns regarding safety and high costs, it took less than 30 years for nuclear power to develop into an industry that provides 16–17 percent of global electricity. The same can happen with renewable technologies. In fact, during 2001 the nuclear industry added only 25 percent as much capacity to the grid as wind did. If the average growth rates of wind and solar PV over the past decade were to continue to 2020, the world would have about 48,000 MW of installed solar PV capacity and more than 2.6 million MW of wind—equivalent to 78 percent of global electric capacity in 2000, or about 45 percent of projected 2020 capacity. Such continued growth is unlikely, but recent industry reports have concluded that if the necessary institutional framework is put in place, it is feasible for wind to meet 12 percent of global electricity demand by 2020 and for PVs to meet 26 percent by 2040.[33]

The German Story

When the 1990s began, Germany had virtually no renewable energy industry, and in the view of most Germans the country was unlikely ever to be in the forefront of these alternative energy sources. Regulations governing the electricity sector, which dated from the 1930s, granted utilities monopoly rights to produce, distribute, and sell electricity. Utility opposition, entrenched nuclear and coal industries, and a general tendency to conservatism made Germany barren ground for renewable energy advocates. Jochen Twele, a German wind energy expert, recalls that, "when I started my job on wind energy in 1981, I thought that wind energy had only a chance in remote areas of developing countries. So I concentrated on Africa." Due to the strength of labor unions—traditionally strategic partners with the Social Democratic Party (known as SPD)—the indifference to renewables in the German left was at least as strong as it was among the industry-friendly and strongly pro-nuclear Christian Democrats. Even today, utilities and the government maintain strong ties. For example, in the state of North Rhine–Westphalia, many local political representatives are board members of the state utility company.[34]

Yet by the end of the 1990s, Germany had been transformed into a renewable energy leader. With a fraction as much potential in wind and solar power as the United States, Germany has almost three times as much installed wind capacity (more than one third of total global capacity) and is a world leader in solar PVs as well. In the space of a decade, Germany created a new, multibillion-dollar industry and tens of thousands of new jobs. This metamorphosis provides helpful lessons for the scores of countries that have not yet determined how to unleash the potential of their own indigenous renewable energy sources.

The German story began in the 1970s, when high oil prices sparked a growing interest in alternative sources of energy and the government began funding renewable energy research and development (R&D). But the resulting sporadic efforts were unsuccessful in spurring commercial development. The major political parties remained comfortable with the strategy that nuclear power would be the long-run replacement for fossil fuel plants.

All of this changed with the Chernobyl nuclear power plant accident in 1986, which led the public to turn firmly against nuclear power and to begin a serious search for alternatives. For the first time, Germans began to question their energy supply system. Two years later, rising awareness of climate change, brought on by record high temperatures and mounting scientific evidence of human-induced warming, heightened people's concerns. In 1990, the German Bundestag prepared a study on protecting Earth's climate, with the goal of developing new strategies for a less risky (meaning less nuclear power) and less carbon-intensive energy future.[35]

In response to mounting public pressure, in late 1990 the Bundestag passed a new energy law that required utilities to purchase the electricity generated from all renewable technologies in their supply area, and to pay a minimum price for it—at least 90 percent of the retail price in the case of wind and solar power. This new "Electricity Feed-in Law" (EFL)—Stromeinspeisungsgesetz—provided fair access and standard pricing for new renewables. It was a dramatic break from past regulation as it enabled private producers to sell their renewably generated electricity to utilities at a competitive price, and it prevented electric utilities from further stalling development.[36]

The German law was inspired in part by similar policies that had proved effective in Denmark. It was strongly supported by owners of small hydropower plants in southern mountainous areas of Germany and by farmers on the northern plains who envied their Danish neighbors' ability to profitably install wind turbines and sell their power. These conservative Christian Democrat supporters of renewables were joined by Social Democrats and Greens who favored legislation to protect the environment and create a market for renewable energy. Hermann Scheer, a Social Democrat in the Bundestag who is considered one of the "fathers" of German renewable energy policy, also played an important role by helping to draft and push through the revolutionary one-page EFL. For their part, the coal industry and electric utilities did not take renewables seriously, and chose not to actively oppose the legislation, and the law was adopted unanimously by the German Bundestag.[37]

Wind energy development began a steady and dramatic surge soon after the EFL entered into force on 1 January 1991. Farmers, small investors, and start-up manufacturers created a new industry from scratch, and a growing number of turbines rose up from the flat plains of the northern coast where the wind blows strongest.

The average cost of manufacturing wind turbines in Germany fell by 43 percent between 1990 and 2000.

Because most of the initial wind development was in the north, the coastal states and their utilities bore the greatest financial burden for Germany's renewable energy projects. The strong regional variations fostered opposition to the law and to wind power itself among utilities and conservative factions of the German government, leading to efforts to declare the EFL unconstitutional. But there was increasing support for renewables as well. In September 1997, 5,000 people flocked to the streets of Bonn to rally in favor of wind power and continuation of the EFL. Opponents failed to overturn the law, although it was amended in 1998 to set a cap on electricity generated by renewable energy.[38]

The 5 percent cap, combined with falling electricity prices (and thus declining payments for renewable electricity) due to deregulation of the market, threatened the viability of existing and planned renewable energy projects. This was of great concern not only to renewable energy developers and producers, but also to major German financial institutions that were underwriting these projects. In response, the Bundestag adopted the Renewable Energy Law (REL) in April 2000.[39]

The Renewable Energy Law removed the cap on renewables, and required that renewable electricity be distributed among all suppliers based on their total electricity sales, ensuring that no one region would be overly burdened. The law also required companies that operate the transmission system to pay the costs of connection to the electric grid, eliminating barriers that arose when utilities discouraged wind development through inflated connection charges. Perhaps most important, it established specific per kilowatt-hour payments for each renewable technology based on the real costs of generation. Electric utilities qualify for these payments as well, a change driven by liberalization of the electricity sector, which the government correctly expected would reduce utility opposition while further stimulating the renewables market.[40]

Although the vote on this new law was not unanimous, broad support from the German public—including labor unions, farmers, environmentalists, and renewable industries—enabled the SPD-Green coalition to push it through Parliament. Again, utilities challenged the law, claiming that it was a subsidy and not legal within the European Union. The government responded that preferential payments for renewable energy were intended to internalize the costs of conventional energy and compensate for the benefits of renewables. In March 2001, the European Court of Justice ruled that the payments were not state aid and therefore not a subsidy. Utilities have since realized that they, too, can benefit from the REL.[41]

After the first access and pricing law was enacted, some barriers to wind energy remained. A major obstacle to German wind development in the mid-1990s was lengthy, inconsistent, and complex procedures for siting wind turbines. As the number of turbines installed in some regions began to skyrocket, local opposition to wind power started to emerge as well. The German government responded by encouraging communities to zone specific areas for wind—a step that both addressed issues that created opposition to wind power, such as noise and concern about aesthetic impacts, and assured prospective turbine owners that they would find sites for their machines.

Worldwide, one of the major barriers to renewable technologies has been the high initial capital costs of these projects. Thus the cost of borrowing plays a major role in the viability of renewable energy markets. Germany addressed this through low-interest loans offered by major banks and refinanced by the federal government. In addition, income tax credits granted only to projects and equipment that meet specified standards have enabled people to take tax deductions against their investments in renewable energy projects. Over the years, these credits have drawn billions of dollars to the wind industry. The combination of these two policies and the access and pricing laws has enabled a diverse group of Germans to invest in wind power, leading to significant increases in installed capacity, associated jobs, and a broad base of political support for the industry.[42]

In the late 1980s, before the access and pricing laws and investment tax credits, the German government established a small, subsidized demonstration program that was inspired by Denmark's experiences, in an effort to change its approach to R&D. The program offered a one-time investment rebate or an on-going production payment to people who installed wind turbines, in exchange for participation in a long-term measurement and evaluation effort. It funded the installation of only 350 MW, a fraction of today's total wind capacity, but was significant because it encouraged wind development and enabled German manufacturers to sell their machines at higher prices to finance internal R&D. The program has also made it possible for the German government to track and publish years of useful data on capacity, generation, and operation of wind machines, which continues to this day.[43]

Several state governments have offered incentives for renewable projects, have funded studies of onshore wind potential, and have established institutes to collect and publish wind energy data. The federal government recently carried out an offshore resource study, and has advanced awareness about renewable technologies through architectural, engineering, and other relevant vocational training programs, as well as through publications on the potential of renewables and available subsidies.[44]

Although all these policies have played an important role, the fair access and standard pricing laws (EFL and REL) have had the greatest impact on Germany's renewables industries, particularly wind power. They ended uncertainties regarding whether producers could sell their electricity into the grid and at what price, and they provided investor confidence—making it easier for even small producers to obtain bank loans and drawing investment money into the industries. Increased investment drove improvements in technology, advanced learning and experience, and produced economies of scale that have led to dramatic cost reductions. The average cost of manufacturing turbines in Germany fell by 43 percent between 1990 and 2000. As a result, it became more profitable to install turbines in areas with lower wind speeds, thereby distributing turbines more evenly around Germany and reducing conflicts with competing land uses.[45]

German wind capacity mushroomed from 56 MW at the beginning of 1991 to more than 6,100 MW a decade later, with additions increasing steadily each year. Wind capacity was expected to reach nearly 12,000 MW by the end of 2002, meeting 3.75 percent of Germany's electricity needs. In northern reaches of the country, where most of the development is concentrated, wind power provides as much as 26 percent of annual electricity needs, close to nuclear power's share for Germany as a whole. Some 40,000 people work in Germany's wind industry, producing turbines for domestic use and export. So many Germans own shares in turbines or work in the industry that there is now broad public support for wind power.[46]

Germany has promoted solar energy with policies similar to those for wind power. Incentives to encourage PVs began in 1991 with the 1,000 Roofs program, which like the early wind programs offered support in exchange for ongoing evaluation and monitoring of systems. It was upgraded in 1999 to 100,000 Roofs, a five-year program that offers 10-year low-interest loans to individuals and businesses for installation of solar PVs. Since 1992, PVs have experienced an average annual growth rate of nearly 49 percent. Germany surpassed the United States in 2001, ending the year with 192 MW of capacity, most of which is on-grid. When the 100,000 Solar Roofs program expires at the end of 2003, it is expected that Germany's PV capacity could reach nearly 440 MW.[47]

By lowering the cost of capital, the 100,000 Solar Roofs program effectively reduced the price of PV installation by 37 percent. Combined with the mandated payments of 45¢ per kWh under the REL, this program has had a major impact on the PV market. Total PV system prices have fallen 39 percent over the past decade, and full-time jobs in the PV industry have more than quadrupled, to 6,000, since 1995. To meet rapidly rising demand, major German manufacturers plan to expand PV manufacturing facilities significantly over the next five years, which will further reduce costs and increase employment.[48]

Germany has pledged to reduce its CO_2 emissions 21 percent below 1990 levels by 2010, and the nation will accomplish much of this through increased use of renewable energy. Total renewable energy revenues in Germany and electricity produced by renewable sources both increased 35 percent between 2000 and 2001. For the longer term, the German government aims for wind to generate 25 percent of electricity needs by 2025, with 20,000–25,000 MW of capacity offshore, and considers solar PVs as a viable long-term option for large-scale power generation.[49]

Policy Lessons From Around the World

It is difficult to claim that something is impossible once it has already occurred. This is why it is globally significant that the world's third largest economy, a country with no tradition of renewable energy development, was able to transform itself from laggard to leader in less than a decade. What Germany has accomplished can be replicated elsewhere—if a successful mix of policies is in place.

The main obstacles that have kept new renewables from producing more than a small share of energy in most of the world, despite their tremendous advantages and potential, are lack of access to the grid, high cost, lack of information, and biased, inappropriate, and inconsistent government policies. Germany's dramatic success over the past decade stems from a range of policies introduced to address all these barriers. The experiences of Germany and other countries provide an array of promising policy options that can be disseminated around the world.

There are five major categories of relevant policies:

- regulations that govern capacity access to the grid and utility obligations,
- financial incentives,
- education and information dissemination,
- stakeholder involvement, and
- industry standards and permitting.

There is not necessarily a direct link between these policy types and the four obstacles just described, as some of the policy options tackle a combination of barriers. An additional critical element is the need for a general change in government perspective and approach to energy policy.

As Germany's experience demonstrates, access to the grid is imperative for renewables to gain a foothold. Three main types of regulatory policies have been used to open the grid to renewables. One guarantees price, another ensures market share (mandated targets), and the third guarantees utility purchase of excess electricity from small-scale, distributed systems. The first is the fair access and standard pricing law. The marriage of a guaranteed market and long-term minimum payments has reduced the risks associated with investing in renewables, making it profitable to invest in wind, solar, and other technologies and easier to obtain financing. By creating demand for renewable electricity, the access and pricing law has attracted private investment for R&D, has spread the costs of technology advancement and diffusion relatively evenly across a nation's population, and has enabled the scale-up in production and experience in installation, operation, and maintenance needed to bring down the costs of renewable technologies and the power they produce.

Laws similar to Germany's access and pricing law have been enacted in Denmark, Spain, and several other European countries, including France, Italy, Portugal, and Greece. When Spain passed an access and pricing law in 1994, relatively few wind turbines were spinning in the Spanish plains or mountains; by the end of 2000, the country ranked third in the world for wind installations, surpassed only by Germany and the United States. Spain now generates 2 percent of its electricity with the wind—but more than 20 percent in some regions—and is home to the world's second largest wind turbine manufacturer.[50]

While fair access and standard pricing laws establish the price and let the market determine capacity and generation, mandated targets work in reverse—the government sets a target and lets the market determine the price. (See Box 5–4.) A mandated capacity target, called a Renewables Portfolio Standard (RPS), is primarily responsible for the rapid growth of wind energy in Texas since 1999, when the state required that 2,000 MW of additional renewable capacity be installed within a decade. Texas was more than halfway there with wind alone by mid-2002, and the target will likely be met before 2009. But the mandates have done little to encourage the use of more expensive technologies such as solar PVs, despite vast solar resources in Texas. Nationwide, about a third of the 50 states have RPS laws, many of them with less success than Texas.[51]

The United Kingdom passed legislation on mandated targets in 1989. Between 1990 and 1998, renewable energy developers competed for contracts to provide electric capacity in a series of bidding rounds. While this system made it easier to obtain financing and drove wind costs down through competition, it created major problems. The bidding system led to flurries of activity followed by long lulls with no development, making it difficult to build a domestic turbine manufacturing industry and infeasible for small firms or cooperatives to take part. In addition,

BOX 5–4. RENEWABLE ENERGY TARGETS

Although no agreement was reached at the World Summit on Sustainable Development on numerical targets for new renewables with specific deadlines, countries around the world are setting their own targets. "Targets" can be goals or obligations. They can be highly effective if used to guide policies that encourage the use of renewables. But targets alone achieve little. For example, renewable energy targets for capacity and generation have been set in the United States since the mid-1970s, often in federal legislation, but rarely achieved. An extreme example is President Jimmy Carter's goal for wind energy to produce 500 billion kWh of electricity by 2000—actual wind generation reached only about 1 percent of this target.

Germany, on the other hand, has exceeded most if not all of its targets to date. Denmark has also set national targets, or goals, for wind and other renewables since the country's earliest national energy plans, nearly three decades ago. Time and again, Denmark's targets for wind energy have been surpassed: for example, in 1981, the national energy plan called for wind to generate 10 percent of the nation's electricity by 2000; this target was met three years early. In 1999 the government aimed to double the nation's share of electricity generated by renewables to 20 percent by the beginning of 2003, a goal that has been met with wind alone. The current energy plan aims for renewable resources to meet 35 percent of Denmark's energy needs by 2030 in order to meet ambitious CO_2 emissions reduction targets. Such policies send strong signals to the market, announcing that the wind industry is a good place to invest for the long term. But targets in Denmark and Germany have had meaning only because appropriate, consistent, long-term policies have been enacted to achieve them. Unfortunately, changes in Danish policies since 1999 could jeopardize existing targets.

SOURCE: See endnote 51.

competition to reduce costs and win contracts led developers to seek sites with the highest wind speeds, which are often also areas of scenic beauty. This increased public opposition to wind energy and made it more difficult to obtain project permits. When the program ended in late 1999, more than 2,670 MW of wind capacity were under contract, but only 344 MW had been installed.[52]

Another option used in a number of countries, including Japan, Thailand, Canada, and several states in the United States, permits consumers to install small renewable systems at their homes or businesses and then to sell excess electricity into the grid. This "net metering" is different from the access and pricing laws in Europe primarily in scale and implementation. In the United States, 36 states—including California and Texas—had net metering laws by mid-2002, with varying degrees of success. Neither California nor Texas saw much benefit for wind power, let alone for more costly renewables like solar PVs, until other incentives were added to the mix. Success in attracting new renewable energy investments and capacity depends on limits set on participation (capacity caps, number of customers, or share of peak demand); on the price paid, if any, for net excess generation; on the existence of grid-connection standards; on enforcement mechanisms; and on other available incentives. Mandated targets and net metering can be used simultaneously.[53]

Of all these regulatory options, the fair access and standard pricing laws have consistently proved to be the most successful. While more than 45 countries have installed wind capacity during the 1990s, just three—Germany, Denmark, and Spain—accounted for more than 59 percent of total additions for the period 1991 through 2001. More than 80 percent of the 1,388 MW of wind capacity installed worldwide during the first half of 2002 was located in three countries with guaranteed minimum prices—Germany, Spain, and Italy. (See Figure 5–5.)[54]

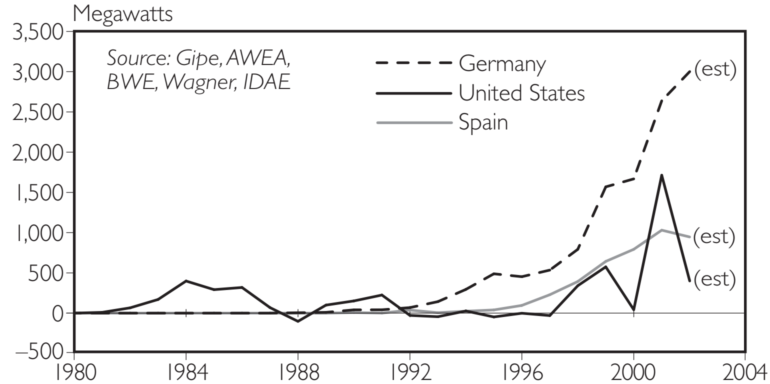

Figure 5–5. Wind Power Capacity Additions in Germany, Spain, and the United States, 1980–2002

Financial incentives, the second category of policies, directly reduce the costs of renewable energy. Market compensation in the form of tax credits, rebates, and payments subsidizes investment in a technology or the production of power. (See Box 5–5.) This has been used extensively in Europe, Japan, the United States, and India (the only developing country that has enacted tax credits to date).[55]

In the early 1980s, the initial capital costs of renewable projects were far higher than they are today. To encourage investment in renewables, the U.S. government and California offered investors credit against their income tax, making it possible for people to recoup a significant share of their money in the first few years and reducing their level of risk. The credits played a major role in a wind boom that many called California's second gold rush. The lessons learned and economies of scale gained through this experience advanced wind technology and reduced its costs. But enormous tax breaks and a lack of technology standards encouraged fraud and the use of substandard equipment. Inexperienced financial companies and former shopping center developers flocked to the wind business, and untested designs were rushed into production—all to take advantage of credits that enabled wealthy investors to recoup anywhere from 66 to 95 percent of their investment over the first few years, in some cases without even generating a kilowatt-hour of power.[56]

A decade later, India saw a similar boom, due to a combination of investment tax credits, financing assistance, and accelerated depreciation. India is now the world's fifth largest producer of wind power and has developed a domestic manufacturing industry. As in California, however, investment-based subsidies and a lack of turbine standards or production requirements led wealthy investors to use wind farms as tax shelters, and several projects experienced poor performance despite the significant technology advancements since the early 1980s. In both cases, wind energy markets and industries slowed considerably when investment credits expired.[57]

Japan has provided investment subsidies through rebates and has seen dramatic success with PVs. As with the early wind subsidies in Germany and a similar effort in Denmark, PV

BOX 5–5. THE CASE FOR RENEWABLE ENERGY SUBSIDIES

While some observers argue that incentives to encourage the development and use of renewables are costly and unnecessary, market compensation is warranted for several reasons. First, it begins to account for the environmental, social, and security costs of conventional energy that are not incorporated into the price of the energy. Second, nuclear power and fossil fuels have feasted on decades of subsidies, and in most cases continue to receive far more subsidies than renewables, creating an uneven "playing field." Renewables have been competing against moving targets, as continued subsidies and research for conventional energy have reduced their costs as well. As a result, renewables are behind on the learning curve and need compensation in order to close the gap. German parliamentarian Hermann Scheer has noted that "no energy source was ever established without political support. Policy support for the initiation of renewable energy is a matter of market fairness for abolishing the existing bias." Finally, the electricity sector in most countries is governed by regulations that were enacted to aid in the development of conventional electric systems and now favor them at the expense of renewables.

SOURCE: See endnote 55.

users receive a rebate in return for providing data about system operations. By 2000, the Japanese government was investing $200 million annually in this program. The goal was to create market awareness and stimulate PV production in order to reduce costs through economies of scale and technology improvements, and thereby enable large-scale power generation and the export of PVs to the rest of the world. And the policy has succeeded. Total capacity has increased an average of more than 41 percent annually since 1992, and Japan now leads the world in the manufacture and use of solar PVs, having surpassed the United States at both in the late 1990s. (See Figure 5–6.) To keep up with demand, Japanese PV manufacturers have dramatically increased their production capacity. As a result, PV system costs in Japan have dropped 75 percent since the mid-1990s, and Sharp is now the world's leading producer of solar cells.[58]

Since 1994, the U.S. government has offered a production tax credit for people who supply wind-generated electricity to the grid. The credit has encouraged wind development, but only in those states with additional incentives, and it provides greater benefit to those with higher income levels and tax loads. California has enacted a production incentive that awards a per kWh payment, rather than a tax credit, for existing and new wind projects. The program has kept 4,400 MW of existing renewable capacity online and led to the development of another 1,300 MW. It is financed through a small per kWh charge on electricity use, meaning that Californians share the cost of the program according to the amount of power they consume. Provided that such payments are high enough to cover the costs of renewable generation and are guaranteed over a long enough time period, this policy is a possible alternative to the fair access and standard pricing law—similar in effect and perhaps more politically feasible in some countries.[59]

Experiences to date demonstrate that payments and rebates are preferable to tax credits. Unlike tax credits, the benefits of payments and rebates are equal for people of all income levels. In addition, investment grants result in more even growth over time rather than encouraging people to invest at the end of tax periods (as tax credits tend to do). Further, production incentives are generally preferable to investment subsidies because they promote the desired outcome—generation of electricity. They are most likely to encourage optimum performance and a sustained industry. However, policies must be tailored to particular technologies and stages of maturation. Investment subsidies in the form of tax credits or, preferably, rebates can be helpful when a technology is still maturing and relatively expensive, as seen with PVs in Japan.[60]

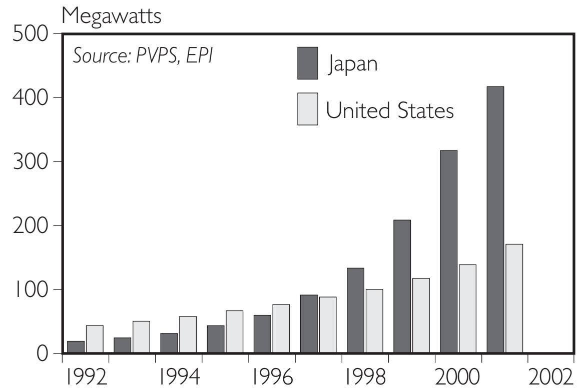

Figure 5–6. Cumulative Photovoltaic Capacity in Japan and the United States, 1992–2001

Financing assistance in the form of low-interest, long-term loans and loan guarantees is also essential to overcome barriers due to the high up-front capital costs of renewables. Lowering the cost of capital can bring down the average cost of electricity and reduce the risk of investment, as seen in Germany. Even in the developing world, all but the very poorest people are able and willing to pay for reliable energy services, and the rate of on-time payment is extremely high. But the poor also need access to low-cost capital and the opportunity to lease systems.[61]

One of the most successful means for disseminating household-scale renewable technologies in rural China has been through local public-private bodies that offer such services as technical support, materials sale, subsidies, and government loans for locally manufactured technology. These bodies frequently provide revolving credit, with repayment linked to the timing of a household's income stream—for example, payments come due after crops have been harvested. As a result of this program more than 140,000 small wind turbines, producing power for more than a half-million people, have been installed in Inner Mongolia—the greatest number of household-scale wind plants operating anywhere in the world. In India, the terms of long-term, low-interest loans vary by technology, with the most favorable ones being for PVs. Through small-scale lending programs, even low-income people are able to purchase small systems. In addition, the national government has worked to obtain bilateral and multilateral funding for large-scale projects, particularly wind.[62]

Information dissemination is the third key policy component. Even if a government offers generous incentives and low-cost capital, people will not invest in renewable energy if they lack information regarding resource availability, technology development, the numerous advantages and potential of renewables, the fuel mix of the energy they use, and the incentives themselves. During the 1980s, several states in the United States offered substantial subsidies for wind energy—including a 100 percent tax credit in Arkansas, a state with enough wind to generate half of its electricity. But these subsidies evoked little interest due to a lack of knowledge about wind resources. By contrast, it was wind resource studies in California, Hawaii, and Minnesota that led to interest in wind energy there.[63]

Past experiences—from failed Californian wind projects in the 1980s to early development projects in Africa—or lack of experience have left people in much of the world with a perception that renewables do not work, are inadequate to meet their needs, are too expensive, or are too risky as investments. Above all, it is essential that government leaders recognize the inherent value of renewable energy. Then governments, nongovernmental organizations, and industry must work together to educate labor organizations about employment benefits, architects and city planners about ways to incorporate renewables into building projects and their value to local communities, agricultural communities about their potential to increase farming incomes, and so on. In India, the government's Solar Finance Capacity Building Initiative educates Indian bank officials about solar technologies and encourages them to invest in projects. The Indian government has also used print, radio, songs, and theater to educate the public about the benefits of renewable energy and government incentives, and has established training programs.[64]

Knowledge is power, as the saying goes, and disseminating information about renewables far and wide will beget more renewable power. At the local, national, and international levels, it is essential to share information regarding technology performance and cost, capacity and generation statistics, and policy successes and failures in order to increase awareness and to avoid reinventing the wheel each time. While several countries now do this on a national level, a centralized global clearinghouse for such information is clearly needed.

A fourth strategy that has increased support for renewables—particularly wind power—is encouraging individual and cooperative ownership. In Germany and Denmark, where individuals singly or as members of cooperatives still own most of the turbines installed, there is strong and broad public support for wind energy. Farmers, doctors, and many others own turbines or shares of wind farms, and stand beside labor and environmental groups in backing policies that support wind power. The largest offshore wind farm in the world as of late 2002—the 40 MW Middelgrunden project off the coast of Copenhagen—is co-owned by a utility and several thousand Danes who have purchased shares in the project. Through cooperatives, people share in the risks and benefits of wind power; often avoid the problems associated with obtaining financing and paying interest; play a direct role in the siting, planning, and operation of machines; and gain a sense of pride and community. Several surveys have demonstrated that those who own shares of projects and those living closest to wind turbines view wind power more positively than those who have no economic interest or experience with it.[65]

Public participation and a sense of ownership are as important in the South as in the North. When technologies are "forced" on people without consultation regarding their needs or desires or are donated as part of an aid package, people often place little value on them and do not feel they have a stake in maintaining them. On the flip side, when individuals and communities play a role in decisionmaking and ownership, they are literally empowered and become invested in the success of the technologies.

The fifth essential ingredient in the policy package is industry standards—ranging from technology certification to siting and permitting requirements. Germany established an investment tax credit for wind energy in 1991, and while it too has been abused as a tax loophole for the wealthy, Germany has avoided the quality control problems experienced in California and India by enacting turbine standards and certification requirements. Standards can include everything from turbine blades, electronics, and safety systems to performance and compatibility with the transmissions system. Denmark adopted wind turbine standards in 1979, largely due to pressure from the wind industry itself. The sharing of information among turbine owners and manufacturers and the Danish technology standards program have combined to enable manufacturers to recognize and address problems with their technologies and to create pride in Danish machines. Standards prevent substandard technologies from entering the marketplace and generate greater confidence in the product, reducing risk. They are credited with playing a major role in Denmark's rise to become the world's leading turbine manufacturer. Eventually, technology standards should be established at the international level.[66]

Standards and planning requirements can also reduce opposition to renewables if they address other potential issues of concern, such as noise and visual or environmental impacts. Siting or planning laws can be used to set aside specific locations for development or to restrict areas at higher risk of environmental damage or injury to birds, for example. Both Germany and Denmark have required municipalities to reserve specific areas for wind turbines and have set restrictions on proximity to buildings and lakes, among other things. These policies have been extremely successful, reducing uncertainty about if and where turbines can be sited and expediting the planning process. The United Kingdom offers the best example of how the lack of planning regulations can paralyze an industry. Despite having the best wind resources in Europe, the nation added little wind capacity under its renewables obligation regulations, in great part because a lack of planning regulations virtually halted the process for obtaining planning and environmental permits.[67]

Perhaps the most important step governments can take to advance renewables is to make a comprehensive change in their perspective and approach to energy policy. Governments need to eliminate inappropriate, inconsistent, and inadequate policies that favor conventional fuels and technologies and that fail to recognize the social, environmental, and economic advantages of renewable energy. Fossil fuels and nuclear power have received the lion's share of government support to date, and continue to get $150–300 billion a year in subsidies worldwide. Most of these subsidies—80–90 percent by some estimates—are found in the developing world, where the price for energy is often set well below the true costs of production and delivery. Even relatively small subsidies in developing countries for kerosene and diesel can discourage the use of renewable energy.[68]

Every dollar spent subsidizing conventional energy is a dollar not invested in clean, secure renewable energy.

Mature technologies and fuels should not require subsidization, and every dollar spent on conventional energy is a dollar not invested in clean, secure renewable energy. These subsidies should either be eliminated or shifted to wind, solar PVs, and other renewable technologies. Pricing structures must account for the significant external costs of conventional energy and the advantages of renewable energy, as Germany has begun to do through the Renewable Energy Law and other countries are doing with energy or carbon taxes. As the single largest consumers of energy in most, if not all, countries, governments should purchase ever-larger shares of energy from renewables and thereby set an example, increase public awareness, reduce perceived risks associated with renewable technologies, and reduce costs through economies of scale.

At the international level, the Global Environment Facility has allocated $650 million to renewable energy projects in developing countries since 1992. However, this is but a small fraction of global investments in carbon-intensive energy projects through international financial institutions like the World Bank and taxpayer-funded export credit agencies. According to one study, between 1992 and 1998, the World Bank Group put 100 times more money into fossil fuels than it did in renewables. Even a small shift in resources would have a tremendous impact on renewables industries and markets, although more than a small shift is needed.[69]

The United States is the only country to have seen a decline in total wind generating capacity over the last decade.

Policies enacted to advance renewable energy can slow the transition if they are not well formulated or are inconsistent, piecemeal, or unsustained. For example, because early investment credits in California were short-lived and extensions were often uncertain, many equipment manufacturers could not begin mass production for fear that credits would end too soon. When incentives expired, interest waned and the industries and markets died with them. In the case of wind power, the impact was felt as far away as Denmark, which relied on selling its turbines in California. The U.S. Production Tax Credit for wind energy has been allowed to expire several times, only to be extended months later. As a result, the credit has stimulated wind capacity growth but has created cycles of boom and bust in the market.[70]

This on-and-off approach to renewables has caused significant uncertainties, bankruptcies, and other problems and has made the development of a strong industry in the United States a challenge, at best. Indeed, the United States is the only country to have seen a decline in total wind generating capacity over the last decade. In India, uncoordinated, inconsistent state policies and bottlenecks imposed by state electricity boards have acted as barriers to renewables development. Even in Denmark, years of successful wind energy growth ended in 1999 when the government changed course, and uncertainty overtook years of investor confidence. The future of some planned offshore wind farms is now uncertain, as is Denmark's target to produce half its electricity with wind by 2030.[71]

Consistent policy environments are necessary for the health of all industries. Consistency is critical for ensuring stability in the market, enabling the development of a domestic manufacturing industry, reducing the risk of investing in a technology, and making it easier to obtain financing. It is also cheaper. Government commitment to develop renewable energy markets and industries must be strong and long-term (see Box 5–6), just as it has been with fossil fuels and nuclear power.[72]

Unlocking Our Energy Future

Renewable energy has come of age. After more than a decade of double-digit growth, renewable energy is a multibillion-dollar global business. Wind power is leading the way in many nations, generating more than 20 percent of the electricity needs in some regions and countries, and is cost-competitive with many conventional energy technologies. Solar cells are already the most affordable option for getting modern energy services to hundreds of millions of people in developing countries. Renewable energy can

BOX 5–6. FORGING A NEW ENERGY FUTURE

- Enact renewable energy policies that are consistent, long-term, and flexible, with enough lead time to allow industries and markets to adjust
- Emphasize renewable energy market creation.
- Provide access to the electric grid and standardized payments that cover the costs of generation with policies similar to the fair access and standard pricing laws used in much of Europe.
- Provide financing assistance to reduce up-front costs through long-term, low-interest loans, through production payments for more advanced technologies, and through investment rebates for more expensive technologies such as solar PV, with gradual phaseout.
- Disseminate information regarding resource availability, the benefits and potential of renewable energy, capacity and generation statistics, government incentives, and policy successes and failures on local, national, and international levels.
- Encourage individual and cooperative ownership of renewable energy projects, and ensure that all stakeholders are involved in the decisionmaking process.
- Establish standards for performance, safety, and siting.
- Incorporate all costs into the price of energy, and shift government subsidies and purchases from conventional to renewable energies.

generate electricity, can heat and cool space, can do mechanical work such as water pumping, and can produce fuels—in other words, everything that conventional energy does.[73]

Renewable technologies are now attracting the funds of venture capitalists and multinational corporations alike. The major oil companies BP and Royal Dutch/Shell have invested hundreds of millions of dollars in renewable energy development. While this is a fraction of what they devote to oil and gas, it is a move in the right direction. BP currently has 20 percent of the global market share for solar cells and plans to enlarge its solar business to $1 billion by 2007, while Shell intends to become an industry leader in offshore wind energy. Commitments from major firms to invest in renewable energy over the next few years total at least $10–15 billion, and clean energy investment worldwide is expected to increase more than eightfold between 2001 and 2010, to over $80 billion annually.[74]

As a result of such investments, the use of renewable energy is expanding rapidly. If current growth rates continue, economies of scale and additional private investments in R&D and manufacturing capability will achieve further dramatic cost reductions, making renewable energy even more affordable in both North and South. A classic example of the impacts of scale economies and learning is Ford's Model T car, which declined in price by two thirds between 1909 and 1923 as production increased from 34,000 to 2.7 million. A simple calculation shows that if wind power continues to grow at the pace of the past decade, it will exceed 2.6 million MW by 2020. At that level, wind energy alone would provide nearly three times as much electricity as nuclear power does today.[75]

Whether growth continues at this level

will hinge largely on policy decisions by governments around the world. The growth of the past decade has occurred because of substantial policy changes in a half-dozen countries, and those nations alone are not large enough to sustain the needed growth at the global level. But recent developments suggest that political support for renewables is rising around the world.

The European Union has a goal of having renewables generate 22 percent of Europe's electricity by 2010.

One example is Europe, where the wind power industry is now centered. Tony Blair, Prime Minister of the United Kingdom, which so far has been a European straggler on renewables, calls his nation's investment in renewable energy technology "a major downpayment in our future" that will "open up huge commercial opportunities." And the European Union has adopted the goal of having renewables generate 22 percent of Europe's electricity by 2010. Developing countries such as China and India have recently strengthened their renewable energy policies, and Brazil is leading the way in Latin America with a comprehensive and ambitious renewable energy law. Even in the United States, despite an oil-oriented White House, nearly half the members of Congress have joined the Renewable Energy and Energy Efficiency Caucus. Although this political support has not yet translated into the needed federal legislation, many states—including Arizona, California, Nevada, and Texas—have enacted pioneering laws in recent years.[76]

Despite the substantial strides being made in technology, investment, and policy, renewables continue to face a "credibility gap." Many people remain unconvinced that renewable energy could one day be harnessed on a scale that would meet most of the world's energy needs. Renewable energy sources appear too ephemeral and sparsely distributed to provide the energy required by a modern post-industrial economy. But those assumptions are outdated. In the words of Paul Appleby of BP's solar division, "the natural flows of energy are so large relative to human needs for energy services that renewable energy sources have the technical potential to meet those needs indefinitely."[77]

The Group of Eight Renewable Energy Task Force projects that in the next decade up to a billion people could be served with renewable energy. BP and Shell have predicted that renewable sources could account for 50 percent of world energy production by 2050, and David Jones of Shell has forecast that renewables could emulate the rise of oil a century ago, when it surpassed coal and wood as the primary source of fuel.[78]

Not only is solar energy alone sufficiently abundant to meet all of today's energy needs thousands of times over, harnessing it is not particularly land- or resource-intensive. All U.S. electricity could be provided by wind turbines in just three states—Kansas, North Dakota, and South Dakota—or with solar energy on a plot of land 100 miles square in Nevada. Farming under the wind turbines could continue as before, while farmers enjoyed the supplementary revenues from spinning wind into electricity. In cities around the world, much of the local power needs could be met by covering existing roofs with solar cells—requiring no land at all. Additional energy will be provided by wind and ocean energy installations located several kilometers offshore, where the energy flows are abundant.[79]

The other credibility gap that must be filled is how to provide renewable energy when and where it is needed—how do you get wind or sunshine into a gas tank, for example, and on a still, dark night? That question, which has stumped generations of engineers, has now been answered by automobile and energy companies around the world. Hydrogen will be the fuel of choice—to be produced from renewable energy, stored underground, and carried to our cities and factories by pipeline. Major automobile manufacturers around the world are developing hydrogen fuel cell–powered cars that will emit only water from their tailpipes. DaimlerChrysler, BMW, General Motors, and Nissan plan to sell their first such cars in 2003, and in 2002 Toyota and Honda raced to see who would be first to put a fuel cell car on the road. Full commercialization of fuel cell cars is expected as soon as 2010.[80]

In early 2001, the Intergovernmental Panel on Climate Change released its most recent report, confirming that in order to stabilize the world's climate, "eventually CO_2 emissions would need to decline to a very small fraction of current emissions"—meaning close to zero. If the world is to achieve this—which it must—countries must begin today, not tomorrow, to make the transition to a renewable, sustainable energy future.[81]

We still have a long way to go to achieve these visions. Today most of the world is locked into a carbon-based energy system that is neither better nor necessarily cheaper than renewable energy—it is the product of past policies and investment decisions. Breaking the lock will not be easy. But Germany and other countries are proving that change is indeed possible. The key is ambitious, forward-looking, consistent government policies that drive demand for renewable energy and create a self-reinforcing market.