RENEWABLES 2007

GLOBAL STATUS REPORT

REN21 Renewable Energy Policy Network for the 21st Century

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REN21 is a global policy network in which ideas are shared and action is encouraged to promote renewable energy. It provides a forum for leadership and exchange in international policy processes. It bolsters appropriate policies that increase the wise use of renewable energies in developing and industrialized economies.

Open to a wide variety of dedicated stakeholders, REN21 connects governments, international institutions, nongovernmental organizations, industry associations, and other partnerships and initiatives. Linking actors from the energy, development, and environment communities, REN21 leverages their successes and strengthens their influence for the rapid expansion of renewable energy worldwide.

REN21 Steering Committee

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FOREWORD

Renewable energy offers our planet a chance to reduce carbon emissions, clean the air, and put our civilization on a more sustainable footing. It also offers countries around the world the chance to improve their energy security and spur economic development. So much has happened in the renewable energy sector during the past five years that our perceptions lag far behind the reality of where the industry is today. This report helps us to adjust those perceptions and to educate ourselves. It paints a remarkable overall picture of renewable energy markets, policies, industries, and rural applications around the world.

More than 65 countries now have goals for their own renewable energy futures, and are enacting a far-reaching array of policies to meet those goals. Multilateral agencies and private investors alike are “mainstreaming” renewable energy in their portfolios. And many renewables technologies and industries have been growing at rates of 20 to 60 percent, year after year, capturing the interest of the largest global companies. In 2007, more than $100 billion was invested in renewable energy production assets, manufacturing, research, and development—a true global milestone. Growth trends mean this figure will only continue to increase.

In 2004, 3,000 delegates from 150 countries came together to share ideas and make commitments at the “Renewables 2004” conference in Bonn, Germany. That conference launched many specific actions, which are now appearing in the global trends described in this report. It also launched the REN21 Global Policy Network. REN21 has grown to share ideas, facilitate action, and provide leadership to promote renewable energy. This type of leadership has never been more important, as renewable energy has reached the top of the agendas of international policy processes under the United Nations, the G8, and other multilateral fora.

This report gives us an integrated perspective on the global renewable energy situation that wasn’t available in 2004. It is the product of an international team of over 140 researchers and contributors from both developed and developing countries, drawing upon wide-ranging information and expertise. The report was first produced in 2005, was updated in 2006, and is now being issued again in early 2008.

I would like to thank the German government for its financial sponsorship, the Worldwatch Institute for leading the production, German Gesellschaft für Technische Zusammenarbeit (GTZ) for administration, the REN21 Secretariat for oversight and management, the members of the REN21 Steering Committee for their guidance, all of the researchers and contributors these past three years for the information that made it possible, and the report’s lead author, Eric Martinot, for the monumental work of putting it all together.

REN21 is proud to offer this picture of renewable energy to the global community.

Mohamed El-Ashry
Chairman, REN21

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EXECUTIVE SUMMARY

In 2007, more than $100 billion was invested in new renewable energy capacity, manufacturing plants, and research and development—a true global milestone. Yet perceptions lag behind the reality of renewable energy because change has been so rapid in recent years. This report captures that reality and provides an overview of the status of renewable energy worldwide in 2007. The report covers trends in markets, investments, industries, policies, and rural (off-grid) renewable energy. (By design, the report does not provide analysis, discuss current issues, or forecast the future.) Many of the trends reflect increasing significance relative to conventional energy.

- **Renewable electricity generation capacity** reached an estimated 240 gigawatts (GW) worldwide in 2007, an increase of 50 percent over 2004. Renewables represent 5 percent of global power capacity and 3.4 percent of global power generation. (Figures exclude large hydropower, which itself was 15 percent of global power generation.)
- Renewable energy generated as much **electric power** worldwide in 2006 as one-quarter of the world's nuclear power plants, not counting large hydropower. (And more than nuclear counting large hydropower.)
- The largest component of renewables generation capacity is **wind power**, which grew by 28 percent worldwide in 2007 to reach an estimated 95 GW. Annual capacity additions increased even more: 40 percent higher in 2007 compared to 2006.
- The fastest growing energy technology in the world is **grid-connected solar photovoltaics** (PV), with 50 percent annual increases in cumulative installed capacity in both 2006 and 2007, to an estimated 7.7 GW. This translates into 1.5 million homes with rooftop solar PV feeding into the grid worldwide.
- Rooftop **solar heat collectors** provide hot water to nearly 50 million households worldwide, and space heating to a growing number of homes. Existing solar hot water/heating capacity increased by 19 percent in 2006 to reach 105 gigawatts-thermal (GWth) globally.
- **Biomass and geothermal energy** are commonly employed for both power and heating, with recent increases in a number of countries, including uses for district heating. More than 2 million ground-source heat pumps are used in 30 countries for building heating and cooling.
- Production of **biofuels** (ethanol and biodiesel) exceeded an estimated 53 billion liters in 2007, up 43 percent from 2005. Ethanol production in 2007 represented about 4 percent of the 1,300 billion liters of gasoline consumed globally. Annual biodiesel production increased by more than 50 percent in 2006.
- **Renewable energy**, especially small hydropower, biomass, and solar PV, provides electricity, heat, motive power, and water pumping for tens of millions of people in rural areas of developing countries, serving agriculture, small industry, homes, schools, and community needs. Twenty-five million households cook and light their homes with biogas, and 2.5 million households use solar lighting systems.
- **Developing countries** as a group have more than 40 percent of existing renewable power capacity, more than 70 percent of existing solar hot water capacity, and 45 percent of biofuels production.

Including all these markets, an estimated $71 billion was invested in new renewable power and heating capacity worldwide in 2007 (excluding large hydropower), of which 47 percent was for wind power and 30 percent was for solar PV. Investment in large hydropower was an additional $15–20 billion. Investment flows became more diversified and mainstreamed during 2006/2007, including those from major commercial and investment banks, venture capital and private equity investors, multilateral and bilateral development organizations, and smaller local financiers.

The renewable energy industry saw many new companies, huge increases in company valuations, and many initial public offerings. Just counting the 140 highest-valued publicly traded renewable energy companies yields a combined market capitalization of over $100 billion. Companies also broadened expansion into emerging markets. Major industry growth is occurring in a number of emerging commercial technologies, including thin-film solar PV, concentrating solar thermal power generation, and advanced/second-generation biofuels (with first-ever commercial plants completed in 2007 or under construction). Jobs worldwide from renewable energy manufacturing, operations, and maintenance exceeded 2.4 million in 2006, including some 1.1 million for biofuels production.

Policy targets for renewable energy exist in at least 66 countries worldwide, including all 27 European Union countries, 29 U.S. states (and D.C.), and 9 Canadian provinces. Most targets are for shares of electricity production, primary energy, and/or final energy by a future year. Most targets aim for the 2010–2012 timeframe, although an increasing number of targets aim for 2020. There is now an EU-wide target of 20 percent of final energy by 2020, and a Chinese target of 15 percent of primary energy by 2020. Besides China, several other developing countries adopted or upgraded targets during 2006/2007. In addition, targets for biofuels as future shares of transport energy now exist in several countries, including an EU-wide target of 10 percent by 2020.

Policies to promote renewables have mushroomed in recent years. At least 60 countries—37 developed and transition countries and 23 developing countries—have some type of policy to promote renewable power generation. The most common policy is the feed-in law. By 2007, at least 37 countries and 9 states/provinces had adopted feed-in policies, more than half of which have been enacted since 2002. Strong momentum for feed-in tariffs continues around the world as countries enact new feed-in policies or revise existing ones. At least 44 states, provinces, and countries have enacted renewable portfolio standards (RPS), also called renewable obligations or quota policies.

There are many other forms of policy support for renewable power generation, including capital investment subsidies or rebates, tax incentives and credits, sales tax and value-added tax exemptions, energy production payments or tax credits, net metering, public investment or financing, and public competitive bidding. And many developing countries have greatly accelerated their renewable electricity promotion policies in recent years, enacting, strengthening, or considering a wide array of policies and programs.

Policies for solar hot water and biofuels have grown substantially in recent years. Mandates for incorporating solar hot water into new construction represent a strong and growing trend at both national and local levels. Many jurisdictions also offer capital subsidies and/or conduct solar hot water promotion programs.

Mandates for blending biofuels into vehicle fuels have been enacted in at least 36 states/provinces and 17 countries at the national level. Most mandates require blending 10–15 percent ethanol with gasoline or blending 2–5 percent biodiesel with diesel fuel. Fuel tax exemptions and/or production subsidies have become important biofuels policies in more than a dozen countries.

Below the national and state/provincial level, municipalities around the world are setting targets for future shares of renewable energy for government consumption or total city consumption, typically in the 10–20 percent range. Some cities have established carbon dioxide reduction targets. Many cities are enacting policies to promote solar hot water and solar PV, and are conducting urban planning that incorporates renewable energy.

Market facilitation organizations (MFOs) are also supporting the growth of renewable energy markets, investments, industries, and policies through networking, market research, training, project facilitation, consulting, financing, policy advice, and other technical assistance. There are now hundreds of such organizations around the world, including industry associations, nongovernmental organizations, multilateral and bilateral development agencies, international partnerships and networks, and government agencies.

SELECTED INDICATORS AND TOP FIVE COUNTRIES

Selected Indicators	**2005**	**2006**	**2007 (estimated)**
Investment in new renewable capacity (annual)	$40	55	71 billion
Renewables power capacity (existing, excl. large hydro)	182	207	240 GW
Renewables power capacity (existing, incl. large hydro)	930	970	1,010 GW
Wind power capacity (existing)	59	74	95 GW
Grid-connected solar PV capacity (existing)	3.5	5.1	7.8 GW
Solar PV production (annual)	1.8	2.5	3.8 GW
Solar hot water capacity (existing)	88	105	128 GWth
Ethanol production (annual)	33	39	46 billion liters
Biodiesel production (annual)	3.9	6	8 billion liters
Countries with policy targets	52		66
States/provinces/countries with feed-in policies	41		46
States/provinces/countries with RPS policies	38		44
States/provinces/countries with biofuels mandates	38		53

Top Five Countries	**#1**	**#2**	**#3**	**#4**	**#5**
Annual amounts for 2006					
New capacity investment	Germany	China	United States	Spain	Japan
Wind power added	United States	Germany	India	Spain	China
Solar PV added (grid-tied)	Germany	Japan	United States	Spain	South Korea
Solar hot water added	China	Germany	Turkey	India	Austria
Ethanol production	United States	Brazil	China	Germany	Spain
Biodiesel production	Germany	United States	France	Italy	Czech Republic
Existing capacity as of 2006					
Renewables power capacity	China	Germany	United States	Spain	India
Small hydro	China	Japan	United States	Italy	Brazil
Wind power	Germany	Spain/United States		India	Denmark
Biomass power	United States	Brazil	Philippines	Germany/Sweden/Finland	
Geothermal power	United States	Philippines	Mexico	Indonesia/Italy	
Solar PV (grid-connected)	Germany	Japan	United States	Spain	Netherlands/Italy
Solar hot water	China	Turkey	Germany	Japan	Israel

1. GLOBAL MARKET OVERVIEW

Renewable energy supplies 18 percent of the world's final energy consumption, counting traditional biomass, large hydropower, and "new" renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels).*† (See Figure 1.) Traditional biomass, primarily for cooking and heating, represents about 13 percent and is growing slowly or even declining in some regions as biomass is used more efficiently or replaced by more modern energy forms. Large hydropower represents 3 percent and is growing modestly, primarily in developing countries. New renewables represent 2.4 percent and are growing very rapidly in developed countries and in some developing countries.‡ Clearly, each of these three forms of renewable energy is unique in its characteristics and trends. This report focuses primarily on new renewables because of their large future potential and the critical need for market and policy support in accelerating their commercial use.§[1]

Renewable energy replaces conventional fuels in four distinct sectors: power generation, hot water and space heating, transport fuels, and rural (off-grid) energy. (See Table R1, page 37.) In power generation, renewable energy comprises about 5 percent of global power-generating capacity and supplies about 3.4 percent of global electricity production (excluding large hydropower). (See Figure 2.) Hot water and space heating for tens of millions of buildings is supplied by biomass, solar, and geothermal. Solar hot water collectors alone are now used by an estimated 50 million households worldwide, most of these in China. Biomass and geothermal also supply heat for industry, homes, and agriculture. Biofuels for transport make small but growing contributions in some countries and a very large contribution in Brazil, where ethanol from sugar cane displaces over 40 percent of the country's gasoline consumption. In developing countries, over 500 million households use traditional biomass for cooking and heating; 25 million households cook and light their homes with biogas (displacing kerosene and other cooking fuel); more than 3 million households light

Figure 1. Renewable Energy Share of Global Final Energy Consumption, 2006

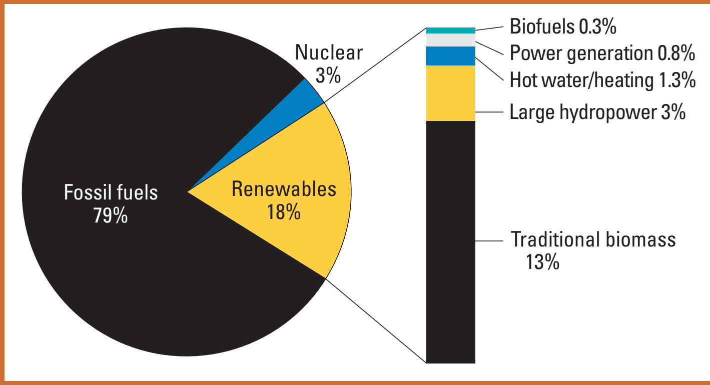
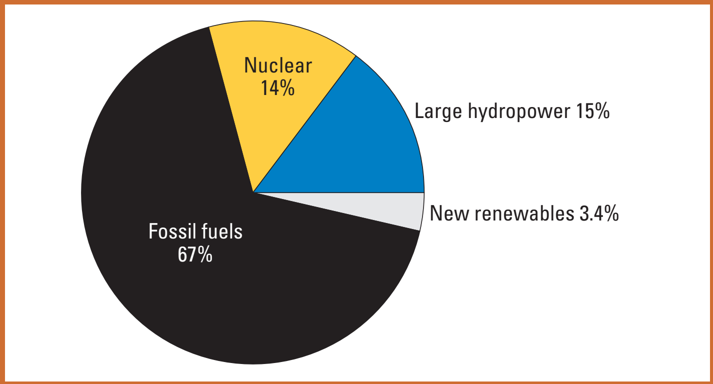


Figure 2. Share of Global Electricity from Renewable Energy, 2006



* Unless indicated otherwise, "renewable energy" in this report refers to "new" renewables. Common practice is to define large hydro as above 10 megawatts (MW), although small hydro statistics in this report include plants up to 50 MW in China and 30 MW in Brazil, as these countries define and report small hydro based on those thresholds.

† Figure 1 shows final energy consumption, which is different than the primary energy share shown in the 2005 report edition and commonly cited elsewhere; see Sidebar 1, page 21, for explanation of these indicators. Depending on methodology used, primary energy share of all renewables in 2006 was either 13 percent or 17 percent.

‡ "Developing country" is not an exact term, but refers generally to a country with low per-capita income. One metric is whether it qualifies for World Bank assistance. Developing countries in this report are non-OECD countries plus OECD members Mexico and Turkey, but excluding Russia and other formerly planned economies in transition.

§ This report covers only renewable energy technologies that are in commercial application on a significant global scale today. Other technologies showing commercial promise or already being employed in limited quantities on a commercial basis include active solar cooling (also called "solar assisted air conditioning"), ocean thermal energy conversion, tidal power, wave power, and hot dry/wet rock geothermal. In addition, passive solar heating and cooling is a commercially proven and widespread building design practice, but is not covered in this report.

their homes with solar photovoltaics (PV); and a growing number of small industries, including agricultural processing, obtain process heat and motive power from small-scale biogas digesters.[2]

Global renewable energy capacity grew at rates of 15–30 percent annually for many technologies during the five-year period 2002–2006, including wind power, solar hot water, geothermal heating, and off-grid solar PV. (See Figure 3.) The growth of grid-connected solar PV eclipsed all of these, with a 60 percent annual average growth rate for the period. Biofuels also grew rapidly during the period, at a 40 percent annual average for biodiesel and 15 percent for ethanol. Other technologies are growing at more ordinary rates of 3–5 percent, including large hydropower, biomass power and heat, and geothermal power, although in some countries these technologies are growing much more rapidly than the global average. These growth rates compare with global growth rates for fossil fuels of 2–4 percent in recent years (higher in some developing countries).[3]

For the power generation sector, large hydropower remains one of the lowest-cost energy technologies, although environmental constraints, resettlement impacts, and the availability of sites have limited further growth in many countries. Large hydro supplied 15 percent of global electricity production in 2006, down from 19 percent a decade ago. Large hydro grew during the five-year period 2002–2006 at a global average of 3 percent per year (less than 1 percent in developed countries). China has seen the highest growth, at over 8 percent per year during the period. The top five hydropower producers in 2006 were China (14 percent of world production), Canada and Brazil (12 percent each), the United States (10 percent), and Russia (6 percent). China's hydro growth has kept pace with its rapidly growing power sector, with about 6 gigawatts (GW) of large hydro and 6 GW of small hydro added in 2006. Many other developing countries continue to actively develop hydro. Small hydro is often used in autonomous or semi-autonomous applications in developing countries to replace diesel generators or other small-scale power plants or to provide electricity to rural populations.[4]

Wind power capacity increased more than any other renewable power technology in 2007 (even more than hydro), with an estimated 21 GW added. This represented a 28 percent increase over 2006. (See Figure 4.) Wind power has also become one of the broadest-based renewables technologies, with installations in more than 70 countries. Still, two-thirds of global wind power additions in 2006 (15 GW total) were concentrated in just five countries: the United States (2.5 GW), Germany (2.2 GW), India (1.8 GW), Spain (1.6 GW), and China (1.4 GW). (See Figure 5, and Table R2, page 37.) Many developing countries have been active—Brazil, Costa Rica, Egypt, Iran, Mexico, and Morocco all added capacity in 2006. Wind power in Brazil and Mexico combined increased 10-fold during 2006, from 30 megawatts (MW) to almost 300 MW.[5]

Offshore wind power installations are emerging slowly, due partly to higher costs and maintenance concerns compared with booming on-shore markets. Recent years have seen a few hundred megawatts added annually, mostly in Europe. In 2007, construction began on a 300 MW offshore wind farm in Belgium, Europe's largest. France, Sweden, and the United Kingdom all began offshore development during 2006/2007, with wind farms in the 100–150 MW range expected by 2008/2009.

Biomass is commonly employed for both power and heating, with recent increases in biomass use in a number of European countries, particularly Austria, Denmark, Germany, Hungary, the Netherlands, Sweden, and the United

Figure 3. Average Annual Growth Rates of Renewable Energy Capacity, 2002–2006

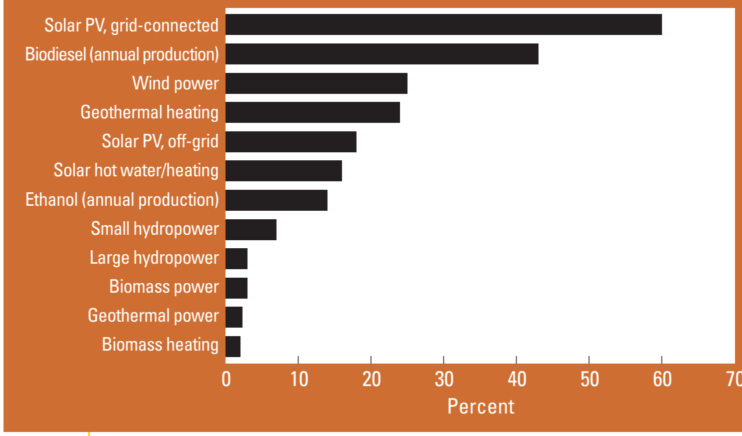


Figure 4. Wind Power, Existing World Capacity, 1995–2007

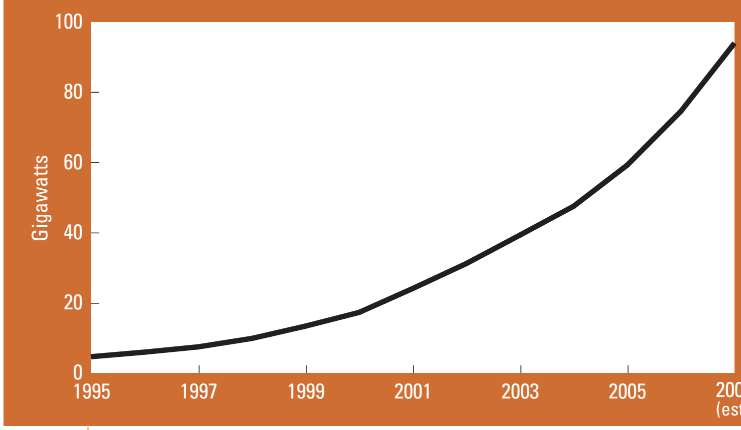


Figure 5. Wind Power Capacity, Top 10 Countries, 2006

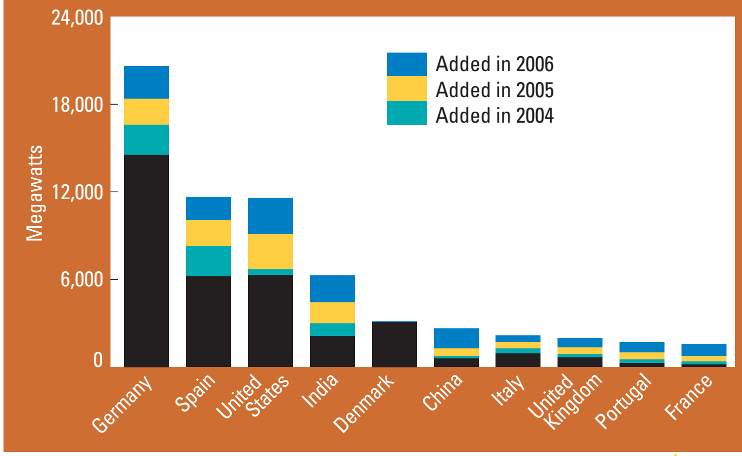
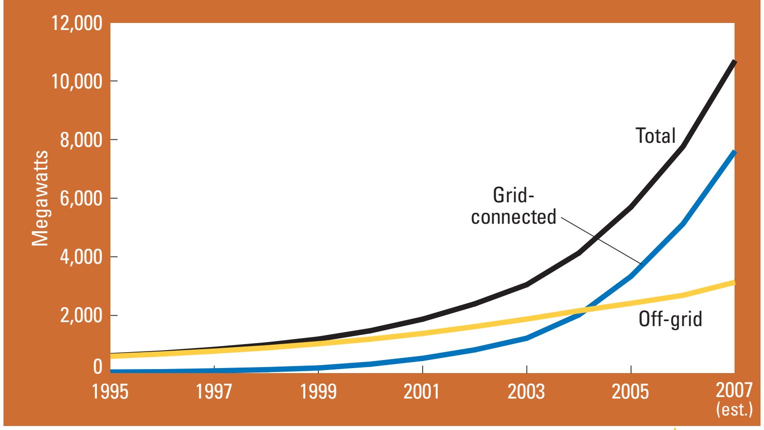


Figure 6. Solar PV, Existing World Capacity, 1995–2007



Kingdom, and in some developing countries. An estimated 45 GW of biomass power capacity existed in 2006. The United Kingdom has seen recent growth in "co-firing" (burning small shares of biomass in coal-fired power plants). The use of biomass for district heating and combined heat-and-power (CHP) has been expanding in Austria, Denmark, Finland, Sweden, and the Baltic countries, and provides substantial shares (5–50 percent) of district heating fuel. Among developing countries, small-scale power and heat production from agricultural waste is common, for example from rice or coconut husks. The use of bagasse (sugar cane after juice extraction) for power and heat production is significant in countries with a large sugar industry, including Australia, Brazil, China, Colombia, Cuba, India, the Philippines, and Thailand. Biomass pellets have become more common, with about 6 million tons consumed in Europe in 2005, about half for residential heating and half for power generation (often in small-scale CHP plants). The main European countries employing pellets are Austria, Belgium, Denmark, Germany, Italy, the Netherlands, and Sweden. Although a global division of biomass consumption for heating versus power is not available, in Europe two-thirds of biomass is used for heating.[6]

Geothermal provides almost 10 GW of power capacity, growing at roughly 2–3 percent per year. Most of this is in Italy, Indonesia, Japan, Mexico, New Zealand, the Philippines, and the United States, with additional capacity in several other countries. Iceland gets one-quarter of all its power from geothermal.[7]

Grid-connected solar photovoltaics (PV) continues to be the fastest-growing power generation technology in the world, with 50 percent annual increases in cumulative installed capacity in both 2006 and 2007, to an estimated 7.8 GW by the end of 2007. (See Figure 6.) This capacity translates into an estimated 1.5 million homes with rooftop solar PV feeding into the grid worldwide. Germany accounted for half the global market in 2006, with on the order of 850–1,000 GW added. Grid-connected solar PV increased by about 300 MW in Japan, 100 MW in the United States, and 100 MW in Spain in 2006. (See Table R3, page 38.) The Spanish solar PV market grew the fastest of any country during 2007, in part due to new and revised policies, and an estimated 400 MW was added in 2007, a fourfold increase over 2006 additions. Emerging strong growth in other European countries, especially Italy and Greece with the recent introductions of policies, is also changing the balance. France's recently revised feed-in policies are beginning to accelerate what had been slow growth. Italy looked set to install 20 MW in 2007 and France 15 MW, both double the 2006 installation amounts. In the United States, California remains the clear leader, after capturing 70 percent of the U.S. market in 2006. New Jersey is second, with other emerging markets in several southwestern and eastern states. Korea is also emerging as a strong market.[8]

Most solar PV installations are just a few kilowatts (kW) or tens of kilowatts in size. These include more and more "building-integrated" PV (BIPV), which has begun to capture the attention of the mainstream architecture community. In addition, the growth of large-scale solar PV installations accelerated during 2006/2007, including scales of hundreds of kilowatts and megawatts. One well-known example was Google's installation of a 1.6 MW array at its head office in California. And the 14 MW Nellis Air Force Base plant in Nevada recently became the largest solar PV plant in the United States. Spain now hosts the world's two largest solar PV power plants, at 20 MW each, in the cities of

Jumilla (Murcia region) and Beneixama (Alicante region). Altogether, there are over 800 plants worldwide with capacity greater than 200 kW and at least 9 plants larger than 10 MW—in Germany, Portugal, Spain, and the United States. On the other extreme are smaller off-grid installations of usually much less than a kilowatt for a variety of applications such as rural homes without access to electric power, remote telecommunications, road signs, streetlights, and consumer products. Including these off-grid installations of solar PV, which continue to grow at double-digit annual rates, cumulative existing solar PV worldwide is estimated to have reached 10.5 GW by the end of 2007, up from 7.7 GW in 2006.[9] (See Figure 6.)

The concentrating solar thermal power (CSP) market remained stagnant from the early 1990s through 2004, when investment in new commercial-scale plants resumed. Since then, commercial plans in Israel, Portugal, Spain, and the United States have led a huge resurgence of interest, technology evolution, and investment. Three plants were completed during 2006/2007: a 64 MW parabolic trough plant in Nevada, a 1 MW trough plant in Arizona, and an 11 MW central receiver plant in Spain. By 2007, there were over 20 new CSP projects around the world either under construction, in planning stages, or undergoing feasibility studies. In Spain, three 50 MW trough plants were under construction at the end of 2007 and 10 additional 50 MW plants were planned. In the United States, utilities in California and Florida announced plans or had already contracted for at least eight new projects totaling over 2,000 MW. In developing countries, three World Bank projects for integrated CSP/combined-cycle gas-turbine power plants in Egypt, Mexico, and Morocco were approved during 2006/2007, each with CSP components of 20–30 MW, and other projects were being considered or developed in Algeria, China, India, and South Africa. All of this activity has also revived CSP-related manufacturing (see Industry Trends section, page 18).[10]

Altogether, existing renewable electricity capacity worldwide reached an estimated 207 GW in 2006, up 14 percent from 2005, excluding large hydro. (See Figure 7, and Table R4, page 38.) Small hydro and wind power account for three-quarters of the total capacity. This 207 GW is about 5 percent of the 4,300 GW of installed capacity worldwide for all power generation. The top six countries were China (52 GW), Germany (27 GW), the United States (26 GW), Spain (14 GW), India (10 GW), and Japan (7 GW). Developing countries as a group, including China, have 88 GW (43 percent of the total), primarily biomass and small hydropower. Global capacity was estimated to reach 240 GW in 2007.[11]

Figure 7. Renewable Power Capacities, Developing World, EU, and Top Six Countries, 2006

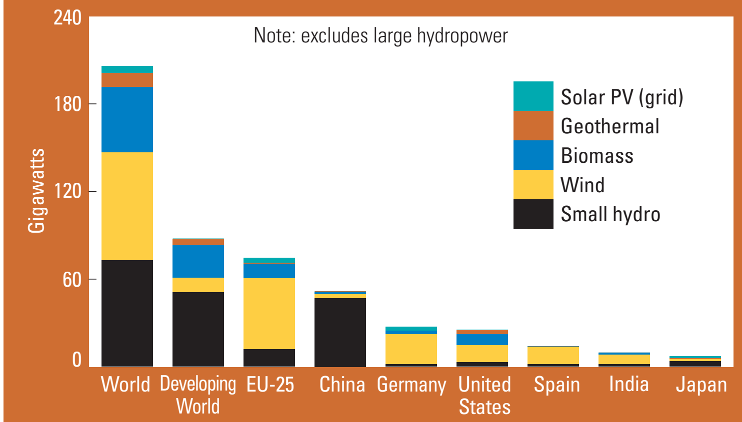
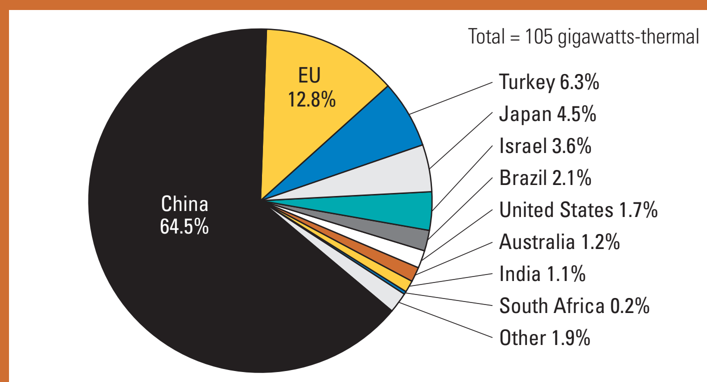


Figure 8. Solar Hot Water/Heating Capacity Existing, Selected Countries, 2006



For the hot water and heating sector, biomass heating and CHP plants provide the majority of heating from renewables globally. Solar hot water technologies are also becoming widespread and contribute significantly to hot water in China, Israel, Japan, Turkey, and several EU countries, as well as some smaller countries like Barbados. Dozens of other countries have emerging markets, including Brazil, Egypt, India, Jordan, Morocco, and Tunisia. With new policies, these markets are expected to grow rapidly in coming years (see Policy Landscape section, page 21). Existing solar hot water capacity increased by 19 percent in 2006 to reach 105 gigawatts-thermal (GWth) globally, excluding unglazed swimming pool heating. (See Figure 8, and Table R5, page 39.) Fully 75 percent of the global capacity added in 2006 was in China, which saw annual sales volume increase 35 percent to 14 GWth (20 million square meters). (See Figure 9.) Annual solar hot water installations in Europe increased by 50 percent in 2006, to more than 2 GWth, mostly in Austria, France, Germany, Greece, Italy,

Figure 9. Solar Hot Water/Heating Capacity Added, Selected Countries, 2006

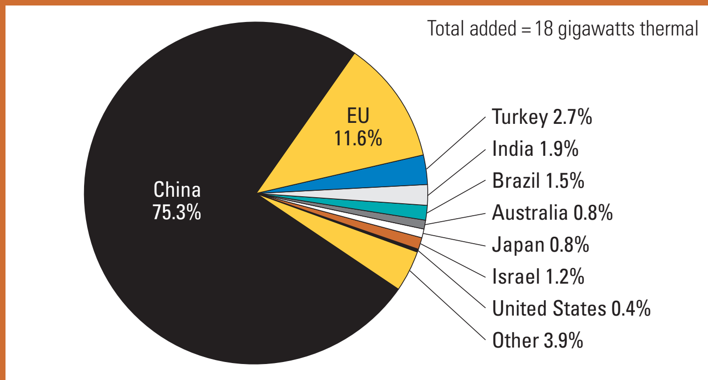
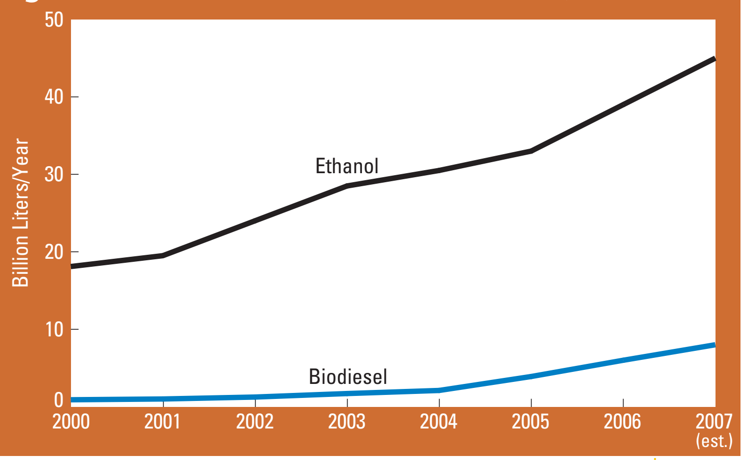


Figure 10. Ethanol and Biodiesel Production, 2000–2007



and Spain. Although solar hot water has historically predominated in residential markets, growing commercial and industrial markets represent a strong trend, in part due to new policies and mandates. Global capacity was expected to reach 125–128 GWth in 2007.[12]

Solar space heating and cooling is also gaining ground in a few countries. In Austria, Germany, and Sweden, more than 50 percent of the annually installed collector area is for combined hot water and space heating systems. Less than 5 percent of systems in China provide space heating in addition to hot water. During 2006/2007, solar assisted cooling attracted increased interest for a variety of commercial and industrial buildings; some dozens of large-scale systems (i.e., 100–500 square meters) entered service in Europe, mostly in Germany.[13]

Geothermal heating plants (including building-level heat pumps) are now present in at least 76 countries. Most of the geothermal power capacity in industrialized countries exists in Italy, Japan, New Zealand, and the United States. Power plants were under construction in several countries. Geothermal direct-heat utilization is growing much faster than geothermal power, with recent growth rates of 30–40 percent annually. Iceland leads the world in direct heating, supplying some 85 percent of its total space-heating needs from geothermal. About half of the existing geothermal heat capacity exists as geothermal heat pumps (also called ground-source heat pumps), which are used for both heating and cooling. Over 2 million ground-source heat pumps are used worldwide.[14]

For the transport fuels sector, production of fuel ethanol for vehicles reached 39 billion liters in 2006, an 18 percent increase from 2005. (See Figure 10, and Table R6, page 39.) Most of the increased production occurred in the United States, with significant increases also in Brazil, France, Germany, and Spain. The United States became the leading fuel ethanol producer in 2006, producing over 18 billion liters and jumping ahead of longstanding leader Brazil. U.S. production increased by 20 percent as dozens of new production plants came on-line. Even so, production of ethanol in the United States could not keep up with demand during 2006, and ethanol imports increased six-fold, with about 2.3 billion liters imported in 2006. By 2007, most gasoline sold in the country was being blended with some share of ethanol as a substitute oxygenator for the chemical compound methyl tertiary-butyl ether (MTBE), which more and more states have banned due to environmental concerns (although biofuels raise environmental concerns as well*).[15]

Brazilian ethanol production increased to almost 18 billion liters in 2006, nearly half the world's total. All fueling stations in Brazil sell both pure ethanol and gasohol, a 25 percent ethanol/75 percent gasoline blend. Demand for ethanol fuels, compared to gasoline, was very strong in 2007, due to the introduction of so-called "flexible-fuel" cars by automakers in Brazil over the past several years. Such cars are able to use either blend and have been widely embraced by drivers, with an 85 percent share of all auto sales in Brazil. In recent years, significant global trade in fuel ethanol has emerged, with Brazil being the leading exporter.

* Treatment of the many assessments of biofuels is beyond the scope of this report, but a growing number of these address the environmental and social issues associated with biofuels, such as land use and deforestation, water use, net energy and carbon balances, and impact on food markets, all of which can vary significantly country-by-country. See Worldwatch (2006) and Kammen et al. (2007).

Table 1. Status of Renewables Technologies—Characteristics and Cost

Technology	Typical Characteristics	Typical Energy Costs (U.S. cents/kilowatt-hour)
Power Generation		
Large hydro	*Plant size:* 10 megawatts (MW)–18,000 MW	3–4
Small hydro	*Plant size:* 1–10 MW	4–7
On-shore wind	*Turbine size:* 1–3 MW *Blade diameter:* 60–100 meters	5–8
Off-shore wind	*Turbine size:* 1.5–5 MW *Blade diameter:* 70–125 meters	8–12
Biomass power	*Plant size:* 1–20 MW	5–12
Geothermal power	*Plant size:* 1–100 MW *Type:* binary, single- and double-flash, natural steam	4–7
Solar PV (module)	*Cell type and efficiency:* single-crystal 17%; polycrystalline 15%; amorphous silicon 10%; thin film 9-12%	—
Rooftop solar PV	*Peak capacity:* 2–5 kilowatts-peak	20–80*
Concentrating solar thermal power (CSP)	*Plant size:* 50–500 MW (trough), 10-20 MW (tower); *Types:* trough, tower, dish	12–18†
Hot Water/Heating		
Biomass heat	*Plant size:* 1–20 MW	1–6
Solar hot water/heating	*Size:* 2–5 m² (household); 20–200 m² (medium/multi-family); 0.5–2 MWth (large/district heating); *Types:* evacuated tube, flat-plate	2–20 (household) 1–15 (medium) 1–8 (large)
Geothermal heating/cooling	*Plant capacity:* 1–10 MW; *Types:* heat pumps, direct use, chillers	0.5–2
Biofuels		
Ethanol	*Feedstocks:* sugar cane, sugar beets, corn, cassava, sorghum, wheat (and cellulose in the future)	25–30 cents/liter (sugar) 40–50 cents/liter (corn) (gasoline equivalent)
Biodiesel	*Feedstocks:* soy, rapeseed, mustard seed, palm, jatropha, or waste vegetable oils	40–80 cents/liter (diesel equivalent)
Rural (off-grid) Energy		
Mini-hydro	*Plant capacity:* 100–1,000 kilowatts (kW)	5–10
Micro-hydro	*Plant capacity:* 1–100 kW	7–20
Pico-hydro	*Plant capacity:* 0.1–1 kW	20–40
Biogas digester	*Digester size:* 6–8 cubic meters	n/a
Biomass gasifier	*Size:* 20–5,000 kW	8–12
Small wind turbine	*Turbine size:* 3–100 kW	15–25
Household wind turbine	*Turbine size:* 0.1–3 kW	15–35
Village-scale mini-grid	*System size:* 10–1,000 kW	25–100
Solar home system	*System size:* 20–100 watts	40–60

Note: Costs are economic costs, exclusive of subsidies or policy incentives. Typical energy costs are under best conditions, including system design, siting, and resource availability. Optimal conditions can yield lower costs, and less favorable conditions can yield substantially higher costs. Costs of off-grid hybrid power systems employing renewables depend strongly on system size, location, and associated items like diesel backup and battery storage. (*) Typical costs of 20–40 cents/kWh for low-latitudes with solar insolation of 2,500 kWh/m²/year, 30–50 cents/kWh for 1,500 kWh/m²/year (typical of Southern Europe), and 50–80 cents for 1,000 kWh/m²/year (higher latitudes). (†) Costs for trough plants; costs decrease as plant size increases. *Source:* See Endnote 18.

Other countries producing fuel ethanol include Australia, Canada, China, Colombia, the Dominican Republic, France, Germany, India, Jamaica, Malawi, Poland, South Africa, Spain, Sweden, Thailand, and Zambia.[16]

Biodiesel production jumped 50 percent in 2006, to over 6 billion liters globally. Half of world biodiesel production continued to be in Germany. Significant production increases also took place in Italy and the United States (where production more than tripled). In Europe, supported by new policies, biodiesel gained broader acceptance and market share. Aggressive expansion of biodiesel production was also occurring in Southeast Asia (Malaysia, Indonesia, Singapore, and China), Latin America (Argentina and Brazil), and Southeast Europe (Romania and Serbia). Malaysia's ambition is to capture 10 percent of the global biodiesel market by 2010 based on its palm oil plantations. Indonesia also planned to expand its palm oil plantations by 1.5 million hectares by 2008, to reach 7 million hectares total, as part of a biofuels expansion program that includes $100 million in subsidies for palm oil and other agro-fuels like soy and maize.* Other biodiesel producers are Austria, Belgium, the Czech Republic, Denmark, France, and the United Kingdom.[17]

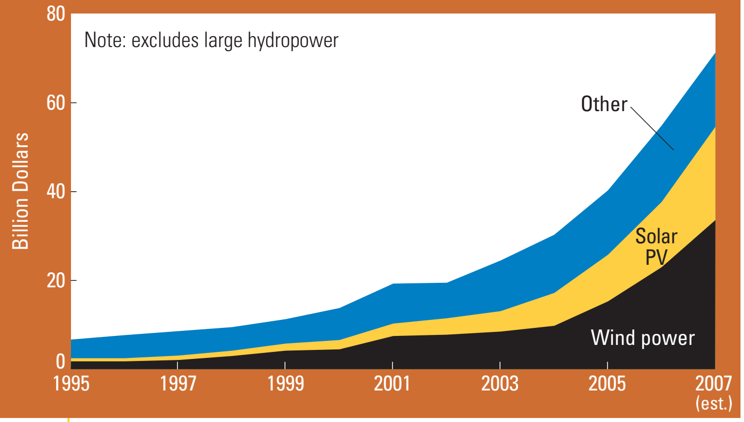
Characteristics and costs of the most common renewable energy applications are shown in Table 1. Many of these costs are still higher than conventional energy technologies. (Typical wholesale power generation costs from conventional fuels are in the range 4–8 cents per kilowatt-hour (kWh) for new base-load power, but can be higher for peak power and higher still for off-grid diesel generators.) Higher costs and other market barriers mean that most renewables continue to require policy support. However, economic competitiveness is not static. The costs of many renewables technologies have been declining significantly with technology improvements and market maturity (although short-term market factors have arrested some declines; see Industry Trends section, page 18). At the same time, some conventional technology costs are declining (for example with improvements in gas turbine technology), while others are increasing due to rising fuel costs and environmental requirements, among many factors. Future cost competitiveness also relates to uncertain future fossil fuel prices and future carbon-related policies.[18]

* All dollar and cent figures in this report are in U.S. dollars unless otherwise noted.

2. INVESTMENT FLOWS

An estimated $71 billion was invested in new renewable energy capacity worldwide in 2007, up from $55 billion in 2006 and $40 billion in 2005. (See Figure 11.) Almost all of the increase was due to increased investment in solar PV and wind power. Technology shares of the $71 billion annual investment were wind power (47 percent), solar PV (30 percent), and solar hot water (9 percent), followed by smaller shares of small hydropower, biomass power and heat, and geothermal power and heat. Concentrating solar thermal power received significant capacity investment, $0.25 billion, for the first time since 1990. An additional $15–20 billion continues to be invested annually in large hydropower. The largest country shares of renewables annual investment were in Germany, China, the United States, Spain, Japan, and India. Investment in Germany increased to over $14 billion in 2007, mostly for wind and solar PV, and investment in China was $12 billion, mostly in small hydropower, solar hot water, and wind power. The United States was number three, with over $10 billion.*[19]

Figure 11. Annual Investment in New Renewable Energy Capacity, 1995–2007



In addition to renewable energy capacity investment, there were substantial capital investments in new manufacturing plants and equipment during 2006/2007 for solar PV and biofuels. Investment in solar PV plant and equipment was expected to reach $10 billion in 2007, up from $8 billion in 2006. Investment in new biofuels production capacity worldwide has also been growing rapidly, and was expected to exceed $4 billion in 2007. The value of biofuels production plants under construction and announced construction plans through 2009 exceeded $4 billion in the United States, $4 billion in Brazil, and $2 billion in France.[20]

Considering investments in renewable energy capacity additions (excluding large hydropower), new manufacturing capacity, and research and development spending (estimated at over $16 billion in 2006 from both public and private sources), there is no doubt that more than $100 billion was invested in renewable energy in 2007—marking a significant global milestone. (Other recent analyses of renewables investment have also noted this milestone; see Endnote 21.) While most of this investment is taking place in Europe, China, and the United States, emerging markets are capturing increasing shares of investment in new capacity, manufacturing facilities, and R&D, notably Brazil and India.[21]

Sources of finance and investment for renewable energy now come from a diverse array of private and public institutions. From private sources, both mainstream and venture capital investment is accelerating, for both proven and developing technologies. The largest institutional investors and global banks have already been lending for renewable energy over the past several years. And more banks are serving the retail level, such as financiers in Ontario, Canada, who were developing new products like "green mortgages" and special loans for renewables in residences and small businesses. The U.S. firm Clean Edge had this to say about clean energy investment in 2007: "We have reached the point where the steady and rapid growth of clean energy has become an old story. Each year brings an ever-higher plateau of success. This appears to be the future of clean energy: landmark corporate investments and the not-infrequent emergence of new and sometimes surprising players."[22]

Venture capital financing for renewable energy boomed during 2006/2007, particularly for solar PV and biofuels, exceeding $3 billion worldwide in 2006. Individual venture capital sums now exceed the $100 million level, either in single funding rounds or spread over extended technology development periods. The United States leads in venture capital investment, with over 60 percent of the world's venture capital in clean energy during 2006, and a reported $800 million for biofuels alone, much of this for developing and commercializing technologies for converting cellulose to ethanol.[23]

Multilateral, bilateral, and other public financing flows for new renewables in developing countries (overseas devel-

* This section does not address subsidies and other forms of government support for renewable energy, whether direct (on-budget) or indirect (such as additional feed-in tariff costs). There are no comprehensive global data for subsidies or feed-in tariff costs. A figure of $10 billion was cited in the 2005 report edition for combined support in Europe and the United States, although there have been large increases in biofuels subsidies since then. Koplow (2007) puts the figure at closer to $20–30 billion globally, depending on what counts as a subsidy.

opment assistance) grew significantly during 2005–2007, exceeding $600–700 million per year. In addition to infrastructure investments, a significant portion of these funds supports training, policy development, market facilitation, technical assistance, and other non-investment needs. The three largest sources of funds have been Germany's KfW Entwicklungsbank (development bank), the World Bank Group, and the Global Environment Facility (GEF). KfW committed €210 million ($300 million) to renewables in developing countries in 2007, including both public budgetary funds and separate market funds.* KfW's "Special Facility for Renewable Energies and Energy Efficiency," established in 2005 to provide concessional loans as part of Germany's international development cooperation, was extended in 2007 to provide a total of €1.3 billion ($1.8 billion) for the period 2005–2011 (original funding was €500 million, or $700 million, for the period 2005–2009).[24]

The World Bank Group committed $220 million for new renewables plus $690 million for large hydropower using its own funds in fiscal 2007. It also committed an additional $130 million in GEF co-financing. Total World Bank commitment for renewables in fiscal 2007 was about $1.2 billion (including carbon finance), almost double the average amount for the previous two fiscal years. World Bank funding is expected to continue increasing through fiscal year 2009 consistent with the Bank's pledge made in Bonn, Germany, in 2004 to increase support for renewables and energy efficiency by 20 percent annually during the fiscal period 2005–2009. (In fact, by mid-2007, the end of fiscal year 2007, the cumulative target through 2009 was almost fully achieved.) Private-sector co-finance also expanded significantly through the World Bank Group's International Finance Corporation. The GEF has allocated an average of $100 million each calendar year for the past several years to co-finance renewable energy projects implemented by the World Bank, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), and several other agencies. Indirect or associated private-sector co-financing is often several times greater than the direct finance from these agencies, as many projects catalyze private investment. Recipient-country governments also contribute co-financing.[25]

Other sources of public financing include bilateral assistance agencies, United Nations agencies, and the contributions of recipient-country governments to development assistance projects. Several agencies and governments are providing aid for new renewables in the range of (typically) $5–25 million per year, including the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the Inter-American Development Bank (IDB), UNDP, UNEP, the U.N. Industrial Development Organization (UNIDO), Denmark (Danida), France (Ademe and FFEM), Germany (GTZ), Italy, Japan (JBIC), and Sweden (Sida). Other donors contributing technical assistance and financing on an annual basis include the U.N. Food and Agriculture Organization (FAO), Australia (AusAid), Canada (CIDA), the Netherlands (Novem), Switzerland (SDC), and the United Kingdom (DFID). Some of these donors are establishing specific-purpose investment funds and credit lines that combine additional private financing.[26]

Financing for renewable energy in developing countries has grown with the involvement of many public and private domestic banks, government funds, and rural microcredit lenders. India's Renewable Energy Development Agency (IREDA) is a good example of a national public source of funds. Brazil's PROINFA program, which started in 2002, saw major investments come on-line during 2006/2007, mostly from domestic banks. Throughout the Caribbean and Latin America, new wind projects, for example in Jamaica and Costa Rica, are receiving private finance. Thailand has been financing small power producers from public funds, with over 1,500 MW of renewable capacity installed by mid-2006—mostly biomass and biogas projects (average capacity about 20 MW). Many examples of rural microcredit throughout Asia and Africa can be found in recent years, with well-known initiatives, both public and private, in India, Sri Lanka, Bangladesh, Uganda, and elsewhere.[27]

* All euro amounts in this report are converted to U.S. dollars at a $1.40 exchange rate.

3. INDUSTRY TRENDS

The years 2006 and 2007 saw investors worldwide pay much greater attention to the renewable energy industry. This attention translated into higher stock valuations and more aggressive industry expansion. By mid-2007, at least 140 publicly traded renewable energy companies worldwide (or renewable energy divisions of major companies) each had a market capitalization greater than $40 million. The number of companies in this category jumped significantly, from around 85 in mid-2006. The estimated total market capitalization of these companies and divisions in mid-2007 was more than $100 billion. Dozens of other companies appeared poised to become public and/or attain the $40 million capitalization level, as initial public offering (IPO) and investment activity continued aggressively during 2007.[28]

Several renewable energy companies went through high-profile IPOs, generating market capitalization above or near $1 billion during 2006/2007. These included the solar PV companies First Solar (USA), Trina Solar (USA), Centrosolar (Germany), and Renesola (U.K.), wind company Iberdrola (Spain), and U.S. biofuels producers VeraSun Energy, Aventine, and Pacific Ethanol. Exuberance seemed to prevail in at least some cases, as, for example, the current $600 million capitalization of Pacific Ethanol followed a net loss of $10 million in 2005. First Solar was the largest IPO, with market value in excess of $4 billion by 2007. Several Chinese PV companies also went public in 2006 and early 2007. Indeed, many analysts considered 2006 the "year of the solar IPO," as solar PV companies continued to make up the largest portion of existing and additional companies to the top 140 identified. Overall, industry growth in late 2006 and 2007 was broader based in terms of technologies and companies, relative to the few "blockbuster" offerings that dominated 2005 and early 2006 (some of which led to capitalization greater than $5 billion).[29]

Altogether, clean-energy companies raised about $10 billion in 2006 via public stock markets, almost double the 2005 amount. More than half the 2006 total was raised on European markets, with the United States second at about $3 billion. London was a central locus, as the city's Alternative Investment Market (AIM) hosted 17 IPOs and 14 secondary offerings of clean energy and carbon-related companies, raising over $1.6 billion in new funds. By early 2007, there were approximately 50 clean-energy companies trading on AIM. Most of these companies were relatively small, but combined they had a market capitalization of almost $8 billion. During 2007, funds raised via public stock markets almost doubled again, to an estimated $17 billion.[30]

The period 2006/2007 saw accelerating investments in manufacturing plants for wind turbines, wind turbine components, conventional solar PV, thin-film solar PV, and concentrating solar thermal power plant components, along with continued rapid investment in conventional biofuels production plants in a few countries, and the beginning of commercial investment in advanced (second-generation) biofuels plants in Canada, Germany, Japan, the Netherlands, Sweden, and the United States.[31]

The top wind company globally was Vestas (Denmark), followed by Gamesa (Spain), GE (USA), Enercon (Germany), Suzlon (India), Siemens, Nordex, and Repower (Germany), Acciona (Spain), and Goldwind (China). Virtually every major wind turbine supplier increased production capacity during 2006/2007. And numerous local suppliers are focusing on key components like gearboxes, blades, bearings, towers, and castings. Still, the industry continues to experience supply-chain difficulties due to booming demand, putting unprecedented pressure on component manufacturers. Two consequences were an increase in turbine lead-times (some reaching up to two years) and higher turbine prices. Higher world commodity prices for steel, copper, and carbon fiber contributed to price increases. Also, increases in turbine sizes, now to 2 MW and larger, coupled with pressure generally in the global machine tools industry, has meant that component suppliers have been hard-pressed to produce the new components required for the larger sizes in sufficient quantities.[32]

The wind power industry saw an increase in wind manufacturing facilities in the United States, India, and China, broadening the manufacturing base away from Europe with the growth of more localized supply chains. India has been exporting components and turbines for many years, and it appeared that 2006/2007 marked a turning point for China as well, with deals announced for export of Chinese turbines and components. In China, the two primary domestic manufacturers were Goldwind and Sinovel Wind, with 33 percent and 6 percent of the Chinese market, respectively, in 2006. By 2007, there were more than 40 Chinese firms aspiring to manufacture wind turbines commercially, many of which were engaged in prototype development and testing, and a handful that were beginning to produce commercial turbines during 2006/2007. Continued manufacturing expansion is expected globally, particularly in emerging markets, and the Global Wind Energy Council noted in early 2007 that, "experts predict that there is no end in sight for this boom."[33]

The solar PV industry produced 2.5 GW in 2006, up 40 percent from 1.8 GW in 2005. Production was expected to reach 3.5–3.8 GW in 2007. The top five global producers in 2006 were Sharp (Japan), Q-cells (Germany), Kyocera (Japan), Suntech (China), and Sanyo (Japan). Together, these five accounted for almost half of global production. The highest ranked U.S. company was First Solar, ranked

13th globally. Investment in new solar PV manufacturing facilities was strong in Europe, Japan, China, Chinese Taipei, and the United States, with many new ventures reported. Notably, China production (370 MW) significantly surpassed the United States (200 MW) for the first time in 2006. Chinese Taipei was fast catching up to the United States as well, with 180 MW produced in 2006, double the 2005 level. A number of companies have announced intentions to scale up manufacturing with 1,000-MW size "mega" production plants.[34]

The solar PV industry also saw a boom in silicon production facilities around the world, responding to silicon feedstock shortages of recent years. Solar PV manufacturers were signing long-term contracts to ensure a growing supply, and silicon manufacturers are consistently announcing plans to build new plants. By the end of 2007, more than 70 silicon manufacturing facilities were being constructed or planned.

Thin-film PV still represents a small share of global solar PV production, about 6–8 percent in 2006. But thin film gained acceptance as a "mainstream" technology during 2006/2007, due partly to manufacturing maturity and lower production costs, and partly to its advantage in terms of silicon feedstock—it requires just one-hundredth as much silicon as conventional cells. Beyond the United States and Europe, at least a dozen manufacturers in China, Chinese Taipei, India, Japan, and South Africa are planning to expand thin-film production in the near future. Sharp of Japan announced plans in late 2007 to complete a new 1 GW thin-film production plant by 2010, bringing its total thin-film capacity to 1.2 GW by then. Sarasin Bank reported in late 2007 that "recent months have seen a sharp increase in new and existing activities in this field. There are now over 80 companies active in thin-film technology."[35]

The biodiesel industry opened many new production facilities during 2006/2007 and was continuing with aggressive expansion plans in a number of countries. New biodiesel capacity appeared throughout Europe, including in Belgium, Czech Republic, France, Germany, Italy, Poland, Portugal, Spain, Sweden, and the United Kingdom, with additions also under way in the Netherlands. Total European biodiesel production capacity increased to almost 7 billion liters/year at the end of 2006, from 4.5 billion liters/year in 2005. Among developing countries, Argentina had eight firms with 0.7 billion liters production capacity in 2007 and planned to double that capacity by 2008. Argentina also became a major biodiesel exporter, shipping almost 400 million liters in 2007. Nearby, Brazil saw a surge of investment in 2007 to cope with a B2 (2 percent) blending requirement starting in 2008 (see Policy Landscape section, page 21). In South Africa, the first commercial biodiesel plant began operation in 2007, using sunflower oil as feedstock. And many plans for new biodiesel plants and/or increased palm oil and jatropha plantations were announced in several countries during 2006/2007, including Brazil, Bulgaria, India, Indonesia, Malaysia, the Philippines, and Singapore, (although the expansion of palm oil plantations in some regions to serve biodiesel markets was posing environmental and social concerns).[36]

In the ethanol industry, the United States dominated, with 130 operating ethanol plants and production capacity of 26 billion liters/year by 2007, a 60 percent increase over 2005. Another 84 plants were under construction or expansion, which when completed would almost double production capacity. Brazil continued its ethanol expansion plans, begun in 2005, which now would more than double production by adding 22 billion liters/year of new sugar plantations and ethanol production capacity by 2012. Total investment required in Brazil during 2006–2012 may exceed $15 billion. Most of the sugarcane plantation and ethanol plant expansion is being carried out with national public financing, although a growing share comes from foreign investors. Spain had 16 biofuels production facilities operating by the end of 2006, although most production was exported.[37]

The beginning of serious commercial investment in second-generation biofuels was another milestone during 2006/2007. Much of this investment was going beyond pilot-scale plants. Government support tied to private investment was an important factor. Canada created a CAD $500 million ($500 million) fund to invest in private companies developing large-scale facilities for producing both ethanol and biodiesel from cellulose. Japan allocated 15 billion yen ($130 million) in 2006 for R&D, pilot projects, and market support. The United States announced in early 2007 that it would invest up to $390 million in six cellulosic ethanol production plants over the coming four years, with total capacity of 500 million liters/year. The world's first commercial wood-to-ethanol plant began operation in Japan in 2007, with a capacity of 1.4 million liters/year. The first wood-to-ethanol plant in the United States was planned to be completed by 2008 with an initial output of 75 million liters/year. A $200 million plant in Iowa, designed to digest corn fiber and stover (stalks and leaves), was set to begin construction in 2007 and be completed in 2009. In Europe, a Dutch firm was building a $200 million plant that would produce 200 million liters/year from wheat chaff and other wastes by late 2008. Large institutional investors got into the picture too, as illustrated by Goldman Sachs' $30 million investment in Iogen Corporation of Canada.[38]

The concentrating solar thermal power (CSP) industry finished a first round of new construction during 2006/2007, a resurgence after more than 15 years of commercial dormancy. Several industry players were planning new projects, including Abengoa Solar, Acciona, and Iberdrola (Spain), Solar Millennium (Germany), and Stirling Energy Systems (USA). Solar Millennium signed an agreement with two Chinese partners to develop 200 MW in Inner Mongolia by

2012, as part of a broader commercial framework for 1,000 MW of CSP in China by 2020. The manufacturing side of the CSP industry also appeared to signal greater growth in 2007, for example when U.S. firm Ausra announced a new manufacturing facility in Nevada that will begin to produce 700 MW of solar thermal power components by mid-2008. And Schott of Germany also plans to double its receiver production capacity in 2008 with new facilities in Spain and the United States.[39]

The company examples and industry trends touched on in this section are just a sampling of the enormous number of news stories about renewables that now appear daily; they illustrate how the renewable energy industry continues to grow and evolve rapidly. Beyond company valuations and an expanding list of announced projects and partnerships, one important consequence is an increase in jobs worldwide from renewable energy manufacturing, operations, and maintenance. Total jobs exceeded an estimated 2.4 million in 2006, including some 1.1 million for biofuels production. And the numbers grow daily.[40]

4. POLICY LANDSCAPE

Policies to promote renewable energy existed in a few countries in the 1980s and early 1990s, but renewable energy policies began to emerge in many more countries, states, provinces, and cities during the period 1998–2007, and especially in the past five years. Many of these policies have exerted substantial influence on the market development reviewed in the previous sections. This section first covers existing policy targets for renewables, and then reviews policies to promote renewable power generation, solar hot water/heating, and biofuels. It also discusses green power purchasing and certificates and municipal-level policies.[41]

It is beyond the scope of this report to provide analysis of policy impacts and lessons. Nevertheless, the policy literature clearly shows that policies have had a major impact on the speed and extent of renewable energy development, despite a myriad of design and implementation problems. The International Energy Agency observed in 2004, in its milestone book *Renewable Energy Market and Policy Trends in IEA Countries*, that significant market growth has always resulted from combinations of policies, rather than single policies, that longevity and predictability of policy support is important, that local and state/provincial authority and involvement are important, and that individual policy mechanisms are evolving as countries gain experience.[42]

Sidebar 1. Share of Energy from Renewables (Primary vs. Equivalent Primary vs. Final)

There are three different ways to count the share of renewable energy in global energy supply. All three are valid, but the differences between them sometimes cause confusion and distort perceptions about the relative contributions of different energy sources.

The most common method, employed in most policy targets and statistical reporting, is the share of primary energy according to the International Energy Agency (IEA) method. The IEA method counts total fuel consumed plus the energy value of electricity produced by renewables such as hydro or wind—which provides a literal, physical accounting. But a problem arises because of the large energy losses inherent in all electric power plants. The IEA method counts the power plant *input* for fossil fuels (and biomass and nuclear), but counts power plant *output* for wind, solar, and hydro. This problem becomes apparent when one considers that hydro and nuclear each produced about the same amount of useful electricity worldwide in 2006. Yet according to the IEA method, nuclear power provides 5–6 percent of global primary energy, while hydro provides a little more than 2 percent.

To solve this problem, some energy analysts define the share of primary energy according to the "substitution method" (also called the BP method). For renewable electricity, this method counts the equivalent primary energy of fossil fuels needed to generate that renewable electricity. BP uses this method for its annual *Statistical Review of World Energy*. The BP method is also used in other well-known portrayals of the global energy balance, such as the 2000 *World Energy Assessment* by the United Nations Development Programme, and has been used by analysts going back at least a decade. If hydro, solar, or wind power is involved, the share of renewables according to the BP method is significantly higher than the share according to the IEA method.

To avoid the ambiguities inherent in counting the share of primary energy according to either method, a third method is emerging: counting the share of final energy. (Final energy means at the point of end-use, as electricity, heat, and directly used fuels.) This method counts all forms of electricity equally, regardless of origin. The European Commission adopted this method in 2007 when setting the EU target of a 20 percent renewables share of energy by 2020. Thus, this third method could be called the "EC method." Table R7, page 40, shows existing shares and targets according to both EC and IEA methods. For further details, see Endnote 45.

Policy Targets for Renewable Energy

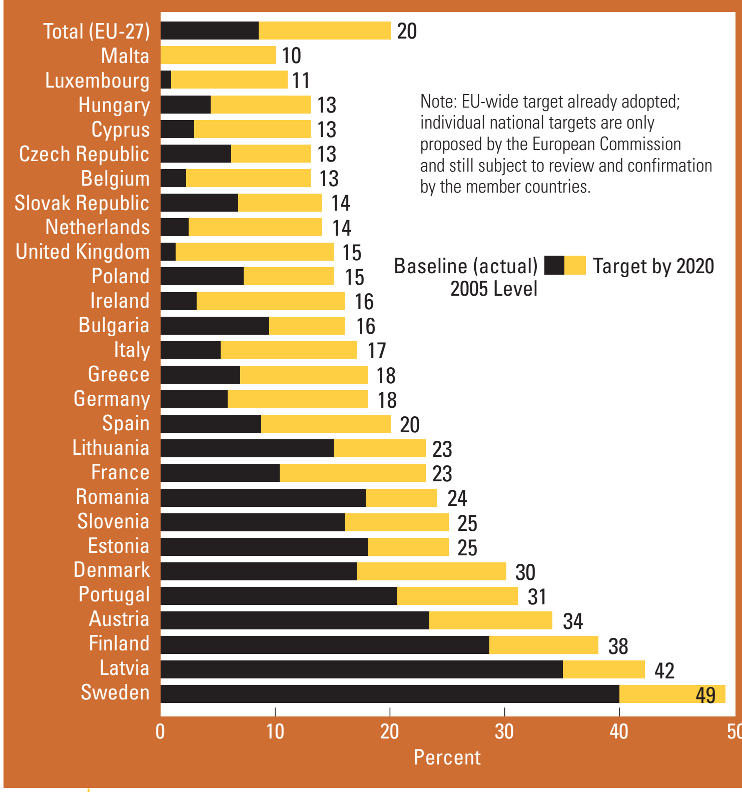
Policy targets for renewable energy exist in at least 66 countries worldwide. By 2007, at least 64 countries had a national target for renewable energy supply, including all 27 European Union countries. (See Tables R7–R9, pages 40–42.) In addition to these 64 countries, 29 U.S. states (and the District of Columbia) and 9 Canadian provinces have targets based on renewables portfolio standards or policy goals, although neither the United States nor Canada has a national target. Most national targets are for shares of electricity production, typically 5–30 percent, but ranging all the way from 2 percent to 78 percent. Other targets are for shares of total primary or final energy supply, specific installed capacity, or total amounts of energy production from renewables, including heat. (See Sidebar 1 for an explanation of final vs. primary energy targets.) Most targets aim for the 2010–2012 timeframe, although an increasing number of targets now aim for 2020 and 2025. Targets also exist for biofuels in many countries. (See Biofuels Policies section, page 27.)[43, 44, 45]

In early 2007, the European Commission adopted new binding targets for 2020, including 20 percent of final energy and 10 percent of transport fuels. (See Figure 12, next page.) These new targets extend the existing targets of 21 percent of electricity and 12 percent of primary energy by 2010. The 20 percent final energy target could imply 34 percent of electricity provided by renewables by 2020, according to the European Commission. Similar to the existing electricity targets, individual countries will need to agree on and adopt their own targets to meet the 20 percent EU-wide target. (See Table R7, page 40.) Some countries have already enacted individual measures: for example, the Netherlands had earlier adopted a 20 percent target for share of final energy by 2020. Germany plans to increase the share of electricity to 25–30 percent by 2020 and then continue to increase the share, with some proposals to 45 percent by 2030.[46]

The 64 countries with national targets include 22 developing countries: Algeria, Argentina, Brazil, China, the Dominican Republic, Egypt, India, Indonesia, Iran, Jordan, Malaysia, Mali, Morocco, Nigeria, Pakistan, the Philippines, Senegal, South Africa, Syria, Thailand, Tunisia, and Uganda. Among developing countries, China received considerable attention when it confirmed its targets in its new long-term renewables development plan, issued in September 2007. China's national target is 15 percent of primary energy by 2020, and there are individual technology targets as well, including 300 GW of hydro, 30 GW of wind, 30 GW of biomass, and 1.8 GW of solar PV. Meeting these targets would almost triple China's renewable energy capacity by 2020.[47]

Besides China, several other developing countries adopted or upgraded targets during 2006/2007. Argentina set a target of 8 percent of electricity from renewables by 2016 (excluding large hydro). Egypt revised its target to 20 percent share of electricity by 2020, up from the previous target of 14 percent (which included 7 percent from hydro). This new target entails more than 12 percent for wind power, which is expected to reach 8 GW by 2020. The provincial government of the Western Cape in South Africa set a target of 15 percent of electricity by 2014. Morocco was drafting a new renewable energy law that would target a 10 percent share of primary energy and 20 percent share of electricity by 2012, which would imply 1 GW of new renewables capacity. And Uganda enacted a comprehensive set of targets through 2017 in a new 2007 renewable energy strategy. A number of other developing countries were working on targets expected in the near future, including a proposed "Brasilia Platform on Renewable Energies" by a group of 21 Latin American and Caribbean countries for 10 percent of primary energy from renewables. Mexico is considering a target of 8 percent of electricity by 2012, excluding large hydro. And India has proposed long-term goals by 2032 in several categories, including 15 percent of power capacity, 10 percent of oil use substituted by biofuels and synthetic fuels, and enhanced use of solar hot water where possible.[48]

Figure 12. EU Renewable Energy Targets—Share of Final Energy by 2020



Power Generation Promotion Policies

At least 60 countries—37 developed and transition countries and 23 developing countries—have some type of policy to promote renewable power generation. (See Table 2.) The most common policy is the feed-in law, which has been enacted in many new countries and regions in recent years. The United States was the first country to enact a national feed-in law, in 1978. Feed-in policies were next adopted in Denmark, Germany, Greece, India, Italy, Spain, and Switzerland in the early 1990s. By 2007, at least 37 countries and 9 states/provinces had adopted such policies, more than half of which have been enacted since 2002. (See Table R10, page 43.) Feed-in tariffs have clearly spurred innovation and increased interest and investment in many countries. These policies have had the largest effect on wind power, but have also influenced solar PV, biomass and small hydro development.[49]

Strong momentum for feed-in tariffs continues around the world as countries enact new feed-in policies or revise existing ones. Many changes and additions were made during 2006/2007, particularly in Europe. For example, Portugal modified its feed-in tariff to account for technology differences, environmental impacts, and inflation. Austria amended its renewable electricity law to permit a new feed-

Table 2. Renewable Energy Promotion Policies

Country	Feed-in tariff	Renewable portfolio standard	Capital subsidies, grants, or rebates	Investment or other tax credits	Sales tax, energy tax, excise tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
Developed and transition countries										
Australia		✓	✓			✓			✓	
Austria	✓		✓	✓		✓			✓	
Belgium		✓	✓		✓	✓		✓		
Canada	(*)	(*)	✓	✓	✓			(*)	✓	(*)
Croatia	✓			✓					✓	
Cyprus	✓		✓							
Czech Republic	✓		✓	✓	✓	✓		✓		
Denmark	✓				✓	✓		✓	✓	✓
Estonia	✓				✓					
Finland			✓		✓	✓	✓			
France	✓		✓	✓	✓	✓			✓	✓
Germany	✓		✓	✓	✓				✓	
Greece	✓		✓	✓						
Hungary	✓				✓	✓			✓	
Ireland	✓		✓	✓		✓				✓
Italy	✓	✓	✓	✓		✓		✓		
Israel	✓									
Japan	(*)	✓	✓			✓		✓	✓	
Korea	✓		✓	✓	✓				✓	
Latvia	✓								✓	✓
Lithuania	✓		✓	✓					✓	
Luxembourg	✓		✓	✓						
Malta	✓				✓					
Netherlands	✓		✓	✓		✓	✓			
New Zealand			✓						✓	
Norway			✓	✓		✓				✓
Poland		✓	✓		✓				✓	✓
Portugal	✓		✓	✓	✓					
Romania					✓					
Russia			✓			✓				
Slovak Republic	✓			✓					✓	
Slovenia	✓								✓	
Spain	✓		✓	✓					✓	
Sweden		✓	✓	✓	✓	✓	✓			
Switzerland	✓									
United Kingdom		✓	✓		✓	✓				
United States	(*)	(*)	✓	✓	(*)	(*)	✓	(*)	(*)	(*)
Developing countries										
Algeria	✓			✓	✓	✓				
Argentina	✓		✓	(*)	✓		✓			
Brazil	✓								✓	✓

Table 2. *continued*

Country	Feed-in tariff	Renewable portfolio standard	Capital subsidies, grants, or rebates	Investment excise, or other tax credits	Sales tax, energy tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Public competitive bidding
Cambodia			✓							
Chile			✓							
China	✓		✓	✓	✓				✓	✓
Costa Rica	✓									
Ecuador	✓			✓						
Guatemala				✓	✓					
Honduras				✓	✓					
India	(*)	(*)	✓	✓	✓		✓		✓	✓
Indonesia	✓									
Mexico				✓				✓		
Morocco				✓						
Nicaragua	✓			✓	✓					
Panama							✓			
Philippines			✓	✓	✓				✓	
South Africa			✓							
Sri Lanka	✓									
Thailand	✓		✓					✓	✓	
Tunisia			✓	✓						
Turkey	✓		✓							
Uganda	✓								✓	

Note: Entries with an asterisk (*) mean that some states/provinces within these countries have state/province-level policies but there is no national-level policy. Only enacted policies are included in table; however, for some policies shown, implementing regulations may not yet be developed or effective, leading to lack of implementation or impacts. Policies known to be discontinued have been omitted. Many feed-in policies are limited in scope or technology. Some policies shown may apply to other markets beside power generation, for example solar hot water and biofuels. *Source:* All available policy references, including the IEA online Global Renewable Energy Policies and Measures database and submissions from report contributors.

in tariff system. Spain modified feed-in tariff premiums (which are added to base power prices) to de-couple premiums from electricity prices and avoid windfall profits when electricity prices rose significantly. And Germany proposed modifications to its "EEG" feed-in law. Elsewhere, Indonesia revised its feed-in tariff to cover plants up to 10 MW in size, from a previous limit of 1 MW. Thailand adopted a new feed-in policy for wind, solar, biomass, and micro-hydro. The Canadian province of Ontario enacted a feed-in tariff for a similar set of technologies. At the national level, Canada adopted the equivalent of a feed-in tariff premium, which will provide CAD 1 cent/kWh to almost all types of renewables power projects constructed through 2011 and which is expected to cover an additional 4 GW of capacity.[50]

Many new feed-in tariffs directed specifically at solar PV appeared during 2006/2007. In Europe, Italy's new feed-in tariff targets 3,000 MW of solar PV by 2016, or almost a million homes if used for residential installations. Italy's policy contains an increasingly common provision: tariffs are 5 eurocents/kWh (7 cents/kWh) higher for architecturally building-integrated installations than for ordinary rooftop installations. France re-evaluated its feed-in policies for solar PV and increased tariffs to 30 eurocents/kWh (42 cents/kWh) for metropolitan areas, with a 25 eurocents/kWh (35 cents/kWh) bonus for building-integrated installations. Greece's new Renewable Energy Law provides 40–50 eurocents/kWh (55–70 cents/kWh) depending on system size and location. Austria's new tariffs range from 32–49 eurocents/kWh (45–70 cents/kWh) depending on system size. Portugal now provides 31–45 eurocents/kWh depending on system size. Outside of Europe, South Korea added solar PV to its existing feed-in policy, with a tariff of KRW 677 per kWh (74 cents/kWh). The state of South Australia established a new feed-in tariff of AUD 44 cents/kWh (40 cents/kWh). Argentina enacted a feed-in policy in 2006 that provides the equivalent of 30 cents/kWh for solar PV (along with a premium of 0.5 cents/kWh for other renewables). And India announced the equivalent of 30 cents/kWh premium for solar PV (and 25 cents/kWh for solar thermal power).[51]

Several other countries and states/provinces continue to debate and formulate feed-in policies for the future. Jurisdictions considering new feed-in policies include Bulgaria, the Indian state of West Bengal, the Canadian province of British Columbia, and the U.S. states of California and Michigan. The Netherlands, following the 2006 expiration of one form of feed-in tariff using electricity production premiums, subsequently began to formulate a new premium-based system expected for 2008. In general, common points of debate for both new and revisionist efforts include tariff levels, graduated tariff decreases over time, time periods for support, cost sharing burdens for different segments of consumers, minimum or maximum capacity limits, limitations based on type of ownership, and differential treatment of technology sub-classes.[52]

Renewable portfolio standard (RPS) policies, also called renewable obligations or quota policies, exist at the state/provincial level in the United States, Canada, and India, and at the national level in seven countries—Australia, China, Italy, Japan, Poland, Sweden, and the United Kingdom. (See Table R11, page 43.) Globally, there were 44 states, provinces, or countries with RPS policies by 2007. Most RPS policies require renewable power shares in the range of 5–20 percent, typically by 2010 or 2012, although more recent policies are extending targets to 2015, 2020, and even 2025. Most RPS targets translate into large expected future investments, although the specific means (and effectiveness) of achieving quotas can vary greatly among countries or states. In the United States, five states enacted new RPS policies during 2006/2007 (Illinois, New Hampshire, North Carolina, Oregon, and Washington State), bringing the total number of U.S. states with RPS policies to 25 plus the District of Columbia (as well as another four states with policy goals). In addition, nine U.S. states revised existing RPS targets, including California, which accelerated to 2010 an existing target of 20 percent by 2017. Beyond the United States, Canada has three provinces with RPS policies and seven more with some form of planning targets, and India has at least six states with RPS policies.[53]

At the national level, China in late 2007 announced RPS mandates that are part of its existing policy framework for supporting renewables. The share of non-hydro renewables should be 1 percent of total power generation by 2010 and 3 percent by 2020. In addition, any power producer in China with capacity greater than 5 GW must increase its actual ownership of power capacity from non-hydro renewables to 3 percent by 2010 and 8 percent by 2020. Also in 2007, Japan revised its RPS policy to 1.63 percent by 2014 (previously 1.35 percent by 2010), for an expected 16 terrawatt-hours (TWh) by 2014.[54]

There are many other forms of policy support for renewable power generation, including direct capital investment subsidies or rebates, tax incentives and credits, sales tax and value-added tax (VAT) exemptions, direct production payments or tax credits (i.e., per kWh), green certificate trading, net metering, and direct public investment or financing. (See Table 2.) Some type of direct capital investment subsidy, grant, or rebate is offered in at least 35 countries. Russia joined this category in late 2007 with legislation providing investment subsidies for grid interconnection of renewable electricity producers, along with renewable energy certificates and other measures. Tax incentives and credits are also common ways of providing financial support. Most U.S. states, some states in Argentina, and at least 40 countries offer a variety of tax incentives and credits for renewable energy. A number of countries, states, and provinces have established special renewable energy funds used to directly finance investments, provide low-interest loans, or facilitate markets in other ways, for example through research, education, and standards.

Public competitive bidding for fixed quantities of renewable power capacity is another policy seen in a handful of countries and provinces in past years. China's wind power "concession" policy is the most notable example currently, with four rounds of bidding during 2003–2006 and a fifth round starting in late 2007. Altogether, capacity from the five rounds could reach 3.6 GW total. Brazil has also been conducting bidding for small hydro, wind, and biomass power as part of its PROINFA program.[55]

Two important policy developments for renewable electricity occurred at the federal level in the United States during 2006/2007. The first was extension of the U.S. production tax credit (PTC) through the end of 2008, along with further legislative discussion about longer-term extensions to 2012–2013. Originally established in 1994 at 1.5 cents/kWh and inflation-adjusted over time to 2 cents/kWh by 2007, the credit has supported wind power and other renewables in conjunction with state-level policies. Second, a landmark national open-access transmission rule puts renewable energy on more equal footing with conventional electricity. That rule creates a new category of transmission service, called "conditional firm" service, which recognizes the intermittent nature of some renewable resources. Imbalance charges, which reflect differences between scheduled and actual energy, must account for renewables' limited ability to forecast or control output. Other transmission measures have appeared at the state level in the United States; for instance, Colorado requires that electric utilities identify windy regions that are transmission-constrained and develop plans to improve transmission capacity; New Mexico established a Renewable Energy Transmission

Authority to improve transmission access; and California adopted new transmission pricing rules to help renewables.

Policies to promote grid-tied rooftop solar PV, beyond feed-in tariffs, now exist in several countries. These policies have been responsible for rapid market growth over the past several years. Capital subsidies are becoming common at national, state, local, and utility levels, typically for 30–50 percent of installed costs. About half of all U.S. states had such subsidy programs (or tax-credit policies), either statewide or for specific utilities. California's subsidy programs have existed the longest, and its new "Solar Initiative" calls for 3 GW of solar PV by 2017 for homes, schools, businesses, and farms. Korea has a similar program and expects 300 MW by 2011 through its 100,000-rooftop program, which initially provided 70 percent capital subsidies. Both the United States and Sweden provide a 30 percent national tax credit for solar PV (although the U.S. policy was set to expire in 2008). France provides a 50 percent income tax credit. Australia provides rebates up to AUD $8/watt ($7/watt). The United Kingdom restarted a grants program in 2007 that subsidizes household solar PV, micro-scale wind, and solar hot water. In Japan, over 300 municipalities continue to provide subsidies for solar PV after the expiration of Japan's national subsidy in 2005. New solar PV rooftop programs have been announced in several other countries.[56]

Net metering (also called "net billing") is also an important policy for rooftop solar PV (as well as other renewables) to allow excess power to be sold back to the grid. Net metering now exists in at least 10 countries and 39 U.S. states. Most net metering is only for small installations, but a growing number of regulations allow larger sizes to qualify. For example, Maryland increased its net-metering capacity limit from 200 kW to 2 MW, and New Mexico increased the limit from 10 kW to as large as 80 MW. In addition to subsidies and net metering, a few jurisdictions are beginning to mandate solar PV in selected types of new construction through building codes. Notable is Spain's 2006 building code, which mandates solar PV for certain types of new construction and renovations (also solar hot water; see next section). California's new "Solar Homes Partnership" will require home builders to offer solar as a standard feature in new developments of 50 buildings or more starting in 2011.

Developing countries have greatly accelerated their renewable electricity promotion policies in recent years, enacting, strengthening, or considering a wide array of policies and programs (some of which apply beyond electricity). Some examples follow. In Latin America, Mexico was considering a new renewable energy law that would facilitate wind power development, establish methodologies for valuing renewables electricity, and create a national fund for renewables. Argentina already created a national fund in 2006 to promote renewables. Four Argentine provinces (Santa Cruz, Buenos Aires, Santa Fe, and Chubut) also have their own renewables laws, enacted in previous years, containing property and income tax exemptions and electricity production subsidies. Ecuador enacted a feed-in tariff in 2005 for wind, solar PV, and biomass, as well as reduced or exempted some taxes and duties. In Asia, India announced a new national tariff policy in early 2006 that aims to promote renewable power generation, including quotas, preferential tariffs, and guidelines for pricing "non-firm" power. The Philippines was considering a number of possible measures, including a feed-in tariff, portfolio standards, import and income tax reductions, net metering, and a national renewable energy fund (in addition to existing support policies for small hydro and geothermal). Indonesia was discussing tariff incentives for small renewable electricity projects. Pakistan initiated a limited feed-in tariff for wind power development, waived import duties for wind turbines, and was considering a broader renewable energy promotion law. In Africa and the Middle East, Uganda passed a comprehensive renewable energy strategy through 2017 and was providing feed-in tariffs on a project-by-project basis. Egypt was working to develop wind power. Madagascar established a new program for hydropower. Iran was developing a new promotion law and also started to allow independent power producers. Turkey passed a new renewable energy promotion law in 2005. And Jordan drafted a proposed law with a number of provisions, including free leases of public land to wind farms, grid interconnections paid by utilities, a production tax credit, exemptions from customs duties and income taxes, and a renewable energy investment fund.

Solar Hot Water and Heating

Mandates for solar hot water in new construction represent a strong and growing trend at both national and local levels. Israel for a long time was the only country with a national-level mandate, but Spain followed with a national building code in 2006 that requires minimum levels of solar hot water and solar PV in new construction and renovation. Solar hot water must meet 30–70 percent of hot water energy needs, depending on climatic zone, consumption level, and back-up fuel. At least four other countries adopted national solar hot water mandates during 2007: India enacted new nationwide energy conservation codes for residential buildings, hotels, and hospitals with centralized hot water systems, requiring at least 20 percent of water heating capacity from solar; Korea requires a 5 percent minimum share of investment cost in renewables for new public buildings larger than 3,000 square meters; China issued a plan to soon mandate solar hot water in certain types of new construction nationwide; and Germany's Renewable Energies Heating Law will require all new residential buildings, starting in 2009, to obtain at least 14 percent of household heating and hot water energy from renewables, including solar, biomass, and geothermal. Existing German buildings will need to be retrofitted to meet 10 percent of their heating energy from renewables. As part of the law, Germany allocated 350 million ($490 million) in 2008 for capital grants to homeowners.[57]

Municipal governments have also been enacting solar hot water mandates. Ordinances by over 70 municipalities throughout Spain preceded Spain's national mandate. Barcelona was the first Spanish city with such an ordinance, first enacted in 2000 and subsequently updated in 2006 to cover all new construction and renovations. Barcelona requires 60 percent of the energy for water heating to come from solar. Other municipal examples include the Chinese cities of Rizhao, which mandates solar hot water in all new buildings, and Shenzhen, which mandates solar hot water in new residential buildings below 12 stories in height. In India, the city of Nagpur requires solar hot water in new residential buildings larger than 1,500 square meters, with a 10 percent property tax rebate as an added incentive. Cape Town, South Africa, drafted a bylaw in 2007 requiring solar hot water in new houses for middle- and high-income groups that was undergoing review. Brazil's largest city, São Paulo, adopted a law in 2007 requiring solar hot water in all new buildings larger than 800 square meters. Other cities were working on solar hot water policies, including Rome, which would require 30–50 percent of hot water energy from solar for new buildings.[58]

China is the only major country with long-term national goals for solar hot water, with targets of 150 million square meters by 2010 and 300 million square meters by 2020 (compared to 100 million square meters in 2006). Achieving these targets would likely mean that over one-quarter of all Chinese households would employ solar hot water by 2020, along with significant shares of commercial and public buildings. Building design and construction in many urban areas of China now incorporates solar hot water, as China's urban population continues to swell (reaching 580 million in 2006).

Capital subsidies for solar hot water are now a common policy in many states and countries. At least 19 countries, and probably several more, provide capital grants, rebates, or investment tax credits for solar hot water/heating investments, including Australia, Austria, Belgium, Canada, Cyprus, Finland, France, Germany, Greece, Hungary, Japan, the Netherlands, New Zealand, Portugal, Spain, Sweden, the United Kingdom, and the United States. Capital grants are typically 20–40 percent of system cost. Investment tax credits may allow deduction of all or part of the investment cost from tax liability, such as the U.S. 30 percent federal tax credit for solar hot water (which was valid until the end of 2007, with extension under consideration). Germany recently introduced new incentives for large-scale solar hot water installations, with low-interest loans and 30 percent capital-cost subsidies for large systems greater than 40 square meters for heating, cooling, and industrial process heat. Many U.S. states and some Canadian provinces also offer capital subsidies. The largest subsidy program in the United States was enacted by California in late 2007, offering $250 million in rebates over 10 years for a targeted 200,000 residential and commercial systems. The goal of the program is to establish a thriving statewide market. And recently the province of Ontario in Canada enacted a home retrofit program providing up to CAD $5,000 per home (including solar hot water), established zero-interest loans to homeowners, and set a target of 100,000 installed solar hot water systems. Some utility companies offer capital subsidies in order to reduce electricity demand, such as ESKOM in South Africa, which incorporated solar hot water into its demand-side management program in 2007 and planned 1 million new systems over five years.

Other policies or proposals to support solar hot water exist or are under consideration. The city of Betim, Brazil, is installing solar hot water in all new public housing. Italy's renewable energy certificates (so-called "white certificates") also apply to solar hot water. The European Commission was to consider promotion policies for renewable heating, including solar, potentially leading to a new directive (and thus a full compliment of directives for electricity, transport, and heating). A number of countries in North Africa and the Middle East were continuing to develop solar hot water policies, building codes, and/or promotion programs, including Tunisia, Morocco, Egypt, Jordan, and Syria. Tunisia's PROSOL "market transformation" program includes both demand-side and supply-side measures, such as 20–30 percent capital subsidies, support for manufacturers and installers, and improved quality standards.

Biofuels Policies

Mandates for blending biofuels into vehicle fuels have been enacted in at least 36 states/provinces and 17 countries at the national level. (See Table R12, page 44.) Most mandates require blending 10–15 percent ethanol with gasoline or blending 2–5 percent biodiesel with diesel fuel. And most mandates are fairly recent, enacted over the past 2–3 years. Mandates can now be found in at least 13 Indian states/territories, 9 Chinese provinces, 9 U.S. states, 3 Canadian provinces, 2 Australian states, and at least 9 developing countries at the national level. Among the most recently enacted are Canada's blending mandates, E5 by 2010 and B2 by 2012, the Philippines' mandates for B1 and E10 by 2010, and Australia's first state-level blending mandate for ethanol, which began in 2007 in New South Wales. The United Kingdom's national mandate takes effect in 2008. The Canadian provinces of British Columbia and Quebec announced they would also mandate ethanol blending but had not yet specified percentages. Many jurisdictions are also starting to mandate biofuels use in government vehicles, including several U.S. states.

Brazil has been the world leader in mandated blending of biofuels for 30 years under its "ProAlcool" program. The blending shares are adjusted occasionally, but have remained in the range of 20–25 percent. All gas stations are required to sell both gasohol (E25) and pure ethanol (E100). The blending mandate has also been accompanied by a host of supporting policies, including retail distribution requirements, production subsidies, and tax preferences for vehicles (both "flex-fuel" vehicles and those that run on pure ethanol).

In addition to mandated blending, several new biofuels targets and plans appeared during 2006/2007, defining future levels of biofuels use. A new U.S. renewable fuels standard requires fuel distributors to increase the annual volume of biofuels blended to 36 billion gallons (136 billion liters) by 2022, extending a previous standard of 7.5 billion gallons (28 billion liters) by 2012. The new standard implies that 20 percent of gasoline for road transport would be biofuels by 2022. The United Kingdom has a similar renewable fuels obligation, targeting 5 percent by 2010. Japan's new strategy for long-term ethanol production targets 6 billion liters/year by 2030, representing 5 percent of transport energy. China finalized targets for the equivalent of 13 billion liters of ethanol and 2.3 billion liters of biodiesel per year by 2020. South Africa's new biofuels strategy targets 4.5 percent biofuels. Portugal and France both adopted a target of 10 percent of transport energy, by 2010 and 2015 respectively. Belgium and Croatia adopted a target 5.75 percent by 2010. And the European Commission established a new EU-wide target of 10 percent of transport energy by 2020, extending the previous EU-wide target of 5.75 percent by 2010.[59]

Fuel tax exemptions and production subsidies have become important biofuels policies. The largest production subsidies exist in the United States, where the federal government provides a 51 cents/gallon (14 cents/liter) tax credit for ethanol blending through 2010, and a 43 cents/gallon (12 cents/liter) tax credit for biodiesel through 2008. A number of U.S. states also offer production incentives and sales tax reductions or exemptions. Canada also recently enacted federal biofuels production subsidies of CAD 10 cents/liter (10 cents/liter) for ethanol and CAD 20 cents/liter (20 cents/liter) for biodiesel. The subsidies apply to the first three years and then decline thereafter, and are expected to increase ethanol production to 2 billion liters/year and biodiesel production to 0.6 billion liters/year. Other countries with tax incentives for production include Argentina, Bolivia, Brazil, Colombia, and Paraguay.[60]

Biofuels tax exemptions exist in at least 10 EU countries, including Belgium, France, Greece, Ireland, Italy, Lithuania, Slovenia, Spain, Sweden, and the United Kingdom. Germany had an exemption but rescinded it in 2007. Ireland in 2006 announced €265 million ($370 million) in extra subsides through 2010, including €200 million ($280 million) in excise tax relief for biofuels. Other OECD countries with fuel-tax exemptions include Canada (starting in 2008) and Australia. Fuel-tax exemptions also exist in a number of developing countries, including Argentina, Bolivia, Colombia, and South Africa. Fuel-tax exemptions often coincide with other types of tax benefits for biofuels investment and trade.

Green Power Purchasing and Renewable Electricity Certificates

There are currently more than 4 million green power consumers in Europe, the United States, Canada, Australia, and Japan. Green power purchasing and utility green pricing programs are growing, aided by a combination of supporting policies, private initiatives, utility programs, and government purchases. The three main vehicles for green power purchases are: utility green pricing programs, competitive retail sales by third-party producers enabled through electricity deregulation/liberalization (also called "green marketing"), and voluntary trading of renewable energy certificates.* As markets expand, the price premiums for green power over conventional power have generally continued to decline.[61]

In Europe, green power purchasing and utility green pricing have existed in some countries since the late 1990s. In most countries, the market share of green power is still small, less than 5 percent, even in countries with liberalized retail markets, such as Finland, Germany, Sweden, Switzerland, and the United Kingdom. The Netherlands has been the leader in the number of green power consumers, due in part to large fossil-fuel electricity taxes combined with tax exemptions for green power, along with media campaigns. During 2006/2007 there were an estimated 2.3 million green power consumers, about 30 percent of all Dutch households. However, this number had declined from more than 3 million in earlier years, as the fossil-fuel tax and exemption were rescinded. Sweden also has a sizable green power market, composed largely of non-residential purchasers. Germany's green power market has grown steadily since 1998, with more than 750,000 consumers in 2006. In some European countries, green power labels have been introduced to strengthen consumer confidence, such as "ok-power" in Germany and "nature-made star" in Switzerland. By 2005, the estimated size of the annual European green power market was 27 terrawatt-hours (TWh), including 15 TWh in the Netherlands, 7.5 TWh in Sweden, and 2 TWh in Germany.

Twenty-one European countries are members of the European Energy Certificate System (EECS), a framework

* Renewable energy certificates in some countries may perform another role distinct from voluntary trading: that of enabling quota obligations to be met.

that allows the issue, transfer, and redemption of voluntary renewable energy certificates (RECs). The EECS has also begun to provide "guarantee-of-origin" certificates in combination with RECs, which enable producers of renewable electricity to prove origination from a renewable source (as laid down by a 2001 EU Directive and 2004 Executive Order). During the first 10 months of 2007, 100 TWh of certificates were issued, up from 67 TWh for all of 2006. Hydropower increasingly dominates certificate trading, with 93 percent of certificates in 2007, compared with 81 percent in 2006. (Norway, a major hydro producer, issued 60 percent of all certificates in 2007.) Excluding hydropower, about 4 TWh was issued during the first 10 months of 2007, compared with 12 TWh for all of 2006. A growing share of RECs incorporate guarantee-of-origin disclosure as more countries and issuers are registered.

The United States had more than 600,000 green power consumers purchasing an estimated 12 TWh in 2006, up from 8.5 TWh in 2005. Retail green power premiums for residential and small commercial consumers are typically 1–3 cents/kWh, with some premiums now below 1 cent/kWh. Green power purchasing began in earnest in the late 1990s and the market has grown rapidly in recent years. At least 3 GW of renewable energy capacity is supported by the green power market. Currently, more than 700 utilities throughout the United States offer green pricing programs. Regulations in more than half a dozen states require utilities or electricity suppliers to offer green power products to their customers. Many large companies in the United States, from aerospace contractors to natural foods companies, are voluntarily buying green power products. The U. S. Environmental Protection Agency's "Green Power Partnership" had more than 700 partners who were collectively purchasing 9 TWh of green power annually as of mid-2007. And a voluntary "Green-e" certification program has helped build credibility in the market.

Other countries have also seen gains in green power purchasing. Australia had 650,000 green power consumers purchasing 400 gigawatt-hours (GWh) from a variety of retailers at the end of 2007, and the market is growing rapidly. Australia also developed renewable energy certificate trading to facilitate compliance with its national portfolio standard. In Canada, about a dozen organizations, including utilities and independent marketers, offer green power options to consumers. At the end of 2003, about 20,000 consumers were purchasing renewable energy through these programs. In South Africa, one company has started offering green power to retail customers; so far bagasse power from sugar mills has been sold, but the company plans to expand to wind and other sources when available.

Japan's Green Power Certification system sold 58 GWh of certificates in 2006, primarily to corporate, non-profit, and municipal customers, with a small share to individual households. The Japan Natural Energy Company is the main seller of certificates, and counts among its clients more than 50 large companies like Sony, Asahi, Toyota, and Hitachi. Green power premiums are typically 3–4 yen/kWh (2.5–3.4 cents/kWh). Other initiatives for green power in Japan are under way, such as the Green Energy Purchasing Network established by the Tokyo government in 2007 to pool municipal governments from all over Japan willing to promote green power. Several electric utilities offer a Green Power Fund that allows customers to contribute voluntarily to support green power investments (as monthly "donations"); some 35,000 customers were doing so in early 2007.

Municipal Policies

Cities around the world continue to enact policies to reduce greenhouse gas emissions and promote renewable energy. (See Table 3, next page.) Motives are multi-faceted, including climate protection, improved air quality, and sustainable local development. Several major cities made new commitments during 2006/2007. For example, London announced a target to reduce carbon dioxide (CO_2) emissions by 20 percent by 2010, relative to 1990 levels, and by 60 percent by 2050. New York City announced its "PlaNYC 2030," which includes policies encouraging solar installations, a pilot project for the city's first carbon-neutral building, and increased distributed generation. Tokyo proposed an ambitious target of 20 percent of total energy consumption in the city by 2020, up from less than 3 percent currently. The Tokyo target was to be formally adopted in 2008 as part of Tokyo's "Environment Basic Plan," and a number of new policies were under consideration. Tokyo subsequently adopted a budget of 50 billion yen ($450 million) to achieve its parallel target of 25 percent CO_2 reduction from 2000 levels by 2020, part of which will be used for renewable energy. In conjunction with this target, a council of private companies and electricity producers formed a "Solar Energy Expansion Committee" to target 1 GW of new solar PV and solar hot water capacity within Tokyo by 2017.[62]

Many other cities around the world also adopted new policies during 2006/2007. For example, in Germany, the city of Freiburg increased its CO_2 reduction target to 30 percent by 2030, with measures such as co-generation and the building of passive solar houses. In Canada, Vancouver set a goal that all new construction in the city should be carbon neutral by 2030, and Toronto enacted a $20 million "Green Energy Fund" to support renewable energy investments. In the United States, the city of Austin, Texas, adopted a climate protection resolution calling for a stronger renewable portfolio standard of 30 percent renewable electricity by 2020, with municipal buildings receiving 100 percent of their energy from renewable sources by 2012. The city of Boulder, Colorado, passed the first U.S. carbon tax, assessed on fossil fuel electricity purchases, from which renewable energy (green power) purchases will be exempt. Some local govern-

Table 3. Selected Cities with Renewable Energy Goals and/or Policies

City	Renewable energy goals	CO_2 reduction goals	Policies for for solar hot water	Policies for solar PV	Urban planning, pilots, and other policies
Adelaide, Australia	✓	✓			✓
Austin (Texas), USA	✓	✓			✓
Barcelona, Spain			✓		
Berlin, Germany		✓	✓	✓	
Betim, Brazil		✓	✓		✓
Cape Town, South Africa	✓	✓			✓
Chicago, USA	✓				
Daegu, Korea	✓	✓			✓
Freiburg, Germany	✓	✓	✓	✓	✓
Gwangju, Korea	✓	✓			✓
The Hague, Netherlands		✓			
Leicester, UK	✓				✓
London, UK		✓			
Malmö, Sweden		✓			✓
Melbourne, Australia	✓	✓			✓
Mexico City, Mexico				✓	✓
Minneapolis, USA	✓				✓
Nagpur, India		✓	✓	✓	
New York, USA		✓		✓	✓
Oxford, UK	✓	✓	✓	✓	✓
Portland, United States	✓	✓	✓	✓	✓
Rizhao, China			✓	✓	
Salt Lake City, USA	✓	✓			✓
Santa Monica, USA	✓				✓
São Paulo, Brazil			✓		
Sapporo, Japan		✓			✓
Stockholm, Sweden	✓	✓			✓
Toronto, Canada		✓			
Tokyo, Japan	✓		✓	✓	✓
Townsville, Australia			✓	✓	
Vancouver, Canada		✓			
Växjö, Sweden	✓	✓	✓	✓	✓
Woking, UK	✓	✓	✓	✓	✓

Source: See Endnote 62.

ments in the United Kingdom now require on-site renewables for all new buildings over specific size thresholds.[63]

There is considerable diversity in the types of renewable energy targets being adopted. Many cities have adopted future targets for 10–20 percent share of all electricity consumption. Examples are Adelaide, Australia; Cape Town, South Africa; Freiberg, Germany; Sacramento, United States, and Woking, United Kingdom. These targets typically aim for some year in the 2010–2020 timeframe. Some targets are for share of total energy consumption, rather than just electricity, such as Leicester, United Kingdom, with a target of 20 percent by 2020, and Daegu, Korea, with a target of 5 percent by 2010. (Nationally, Korea in 2006 adopted "Energy Vision 2030," a plan for local governments to achieve 9 percent shares of energy by 2030.) Other types of city targets address installed capacity, such as Oxford, United Kingdom, and Cape Town, South Africa, both of which target 10 percent of homes with solar hot water by 2010 (and solar PV as well in Oxford). Barcelona, Spain, is targeting 100,000 square meters of solar hot water by 2010. Salt Lake City in the United States is targeting 10 percent of energy used by new buildings. Melbourne, Australia, is targeting 25 percent of residential electricity and 50 percent of public lighting from renewables by 2010.

Cities have also adopted CO_2 emissions-reduction goals, typically a 10–20 percent reduction over a baseline level (usually 1990 levels) by 2010–2012, consistent with the form of Kyoto Protocol targets. Examples are Berlin, Germany (25 percent); Freiburg, Germany (25 percent); Gwangju, Korea (20 percent); Malmö, Sweden (25 percent), Melbourne, Australia (20 percent); Portland, Oregon, United States (10 percent); Sapporo, Japan (10 percent); Växjö, Sweden (70 percent by 2025 in selected target areas); and Toronto and Vancouver, Canada (both 30 percent by 2020). The Hague, the Netherlands, planned for municipal government consumption to be CO_2-neutral (zero net emissions) by 2006 and for the whole city to be CO_2-neutral in the long term. Adelaide, Australia, plans zero net emissions by 2012 in buildings and by 2020 in transport. And Stockholm, Sweden, proposes to reduce emissions below a per-capita threshold. There is often a strong linkage at the city level between CO_2 emissions-reductions goals and renewable energy targets, policies, and programs. For example, Växjö, Sweden has already reduced emissions by 24 percent relative to 1993 levels in target areas through a combination of biomass for district heating and transport, and solar electricity and heat for buildings.[64]

A number of cities have decided to purchase green power for municipal government buildings and operations. Examples are Portland, Oregon, and Santa Monica, California, in the United States, which purchase 100 percent of their power needs as green power. Woking, United Kingdom, aims for 100 percent by 2011. Other U.S. cities currently purchasing green power, typically for 10–20 percent of their municipal needs, include Chicago, Los Angeles, Minneapolis, and San Diego. Melbourne, Australia, is targeting zero net carbon emissions from municipal operations by 2020 with renewables and other measures. In addition to green power, some cities require biofuels in public transport and/or municipal vehicles, such as Betim, Brazil, and Stockholm, Sweden.

Urban planning incorporating renewable energy is appearing in large numbers of cities worldwide. More than half of all municipalities in Japan have created such visions as part of a "Regional New Energy Vision" program, as well as several prefectures and Yokohama City. Other examples include Gothenberg and Stockholm in Sweden, both with visions and long-term planning to 2050 to become mostly or fully fossil-fuel free, and "Salt Lake City Green," a comprehensive long-term environmental planning program in the United States.

Community-driven renewables development is also emerging in some countries. In a group of Japanese towns, nine community-owned and financed wind farms totaling 20 MW were completed by 2007, and fundraising was ongoing for more investments. A community-directed investment fund for solar PV and energy efficiency of over 200 million yen ($2 million) has been operating in Iida City of Nagano prefecture since 2005. In Spain, a 10 MW citizen-owned solar PV plant started operation in 2007. The plant is owned by about 750 people in the municipality of Milagro in Navarra and is contributing to a large share (60 percent) of renewables in Navarra's electricity supply.

Municipal governments are joining forces to share resources and make joint commitments through associations or support networks. For example, the World Mayors and Local Governments Climate Protection Agreement was launched in December 2007 at the United Nations Climate Change Conference in Bali, Indonesia. Signatories agree to measure and report on annual reductions of greenhouse gas emissions and effect emissions reductions, including renewable energy, toward a goal of reducing worldwide greenhouse gas emissions by 60 percent from 1990 levels by 2050. This agreement followed several others, such as the U.S. Mayors' Climate Protection Agreement, which targets a 7 percent reduction from 1990 levels by 2012 and now involves more than 700 U.S. cities. Many associations or initiatives with similar goals now exist, such as the World Mayors Council on Climate Change, the European Solar Cities Initiative, the Australia Solar Cities Program, the International Solar Cities Initiative, the ICLEI Local Renewables Model Communities Initiative, and the ICLEI Cities for Climate Protection campaign.[65]

5. RURAL (OFF-GRID) RENEWABLE ENERGY

The most common applications of renewable energy for rural (off-grid) energy services are cooking, lighting and other small electric needs, process motive power, water pumping, and heating and cooling. These applications are described in Table 4, which blends "first-generation" or "traditional" applications and technologies (i.e., unprocessed biomass and small-scale hydro) with "second-generation" applications and technologies (i.e., wind, solar PV, biomass gasification, and pico-scale hydro). Although much development attention has focused on second-generation technologies, rural development professionals are continually reminding the development and renewable energy communities about the continued importance of first-generation technologies, especially in the least-developed countries. This section discusses some of the rural energy applications from Table 4 and then discusses rural electrification policy.[66]

"Traditional" applications mean primarily burning fuel wood, agricultural and forestry wastes (residues), dung, and other unprocessed biomass fuels for home cooking and heating and other process-heating needs. Some biomass is converted to charcoal and sold in commercial markets. Biomass accounts for a large share of total primary energy supply in many developing countries. In 2001, this share was 49 percent in Africa, 25 percent in Asia, and 18 percent in Latin America. In some African countries, the share is much higher, such as 90 percent in Guinea and Niger, and 80 percent in Mali. In 2000, households in sub-Saharan Africa consumed nearly 470 million tons of wood fuels (0.72 tons per capita) in the form of wood and charcoal. In comparison, India and China together consumed 340 million tons. In sub-Saharan Africa, wood or crop residues are the primary source of household energy for 94 percent of rural households and 41 percent of urban households. Charcoal is the primary source of household energy for 4 percent of rural households and 34 percent of urban households. And kerosene is the primary source of household energy for 2 percent of rural households and 13 percent of urban households.[67]

The costs and health impacts of traditional biomass use (and the corresponding benefits of improved biomass stoves and other technologies) are beyond the scope of this report but still highly significant. Much of the biomass fuel is collected outside of the commercial economy, with collection time being a large non-monetary expenditure, especially for women. Researchers Majid Ezzati and Daniel Kammen, in a comprehensive literature review, state that "conservative estimates of global mortality as a result of exposure to indoor air pollution from solid fuels show that in 2000 between 1.5 million and 2 million deaths were attributed to this risk factor, accounting for 3–4 percent of total mortality worldwide."[68]

Cooking: Improved Biomass Cook Stoves

Improved biomass stoves save from 10 to 50 percent of biomass consumption for the same cooking service provided and can dramatically improve indoor air quality, as well as reduce greenhouse gases. Improved stoves have been produced and commercialized to the largest extent in China and India, where governments have promoted their use, and in Kenya, where a large commercial market developed. There are 220 million improved stoves now in use around the world, due to a variety of public programs and successful private markets over the past two decades. This number compares with the roughly 570 million households worldwide that depend on traditional biomass as their primary cooking fuel. China's 180 million existing improved stoves now represent about 95 percent of such households. India's 34 million improved stoves represent about 25 percent of such households.[69]

In Africa, research, dissemination, and commercialization efforts over the past few decades have brought a range of improved charcoal—and now wood-burning—stoves into use. Many of these stove designs, as well as the programs and policies that have supported their commercialization, have been highly successful, with accompanying networks of manufacturers, distributors, and retailers. Both nongovernmental organizations and small enterprises continue to promote and market stoves. Africa now has over 8 million improved stoves. Kenya has been the leader, with over 3 million stoves. The Kenya Ceramic Jiko stove (KCJ) is found in more than half of all urban homes and roughly 16–20 percent of rural homes in Kenya. KCJ-type improved stoves are also in widespread use throughout sub-Saharan Africa, including in Burkina Faso, Burundi, Ethiopia, Ghana, Mali, Rwanda, Senegal, Sudan, Tanzania, and Uganda. Of all types, there are now at least 3 million improved stoves in Ethiopia, 1.3 million in South Africa, 250,000 in Senegal, 200,000 in both Niger and Burkina Faso, 170,000 in Uganda, 150,000 in Ghana, and significant numbers in Eritrea, Tanzania, and Zimbabwe. In Sudan, 100,000 improved stoves (known locally as Tara stoves) have been disseminated among internally displaced people in the Darfur region and plans are under way to bring the number to 300,000.

At least one-third of African countries have programs for improved biomass cook stoves, and many more have pledged to help develop the technology, spread information, foster projects, and generally promote access to modern cooking energy for rural populations currently using traditional biomass—including Botswana, Malawi, Namibia, Swaziland, Tanzania, Uganda, and Zambia. Most recently, Uganda announced in 2007 a target to increase the number of improved stoves to 4 million by 2017. In addition, the

Table 4. Common Existing Applications of Renewable Energy in Rural (Off-Grid) Areas

Energy Services	Renewable Energy Applications	Conventional Fuels
Cooking (homes, commercial stoves and ovens)	• biomass direct combustion (fuel wood, crop wastes, forest wastes, dung, charcoal, and other forms) • biogas from household-scale digester • solar cookers	LPG, kerosene
Lighting and other small electric needs (homes, schools, street lighting, telecom, hand tools, vaccine storage)	• hydropower (pico-scale, micro-scale, small-scale) • biogas from household-scale digester • small-scale biomass gasifier with gas engine • village-scale mini-grids and solar/wind hybrid systems • solar home systems	candles, kerosene, batteries, central battery recharging, diesel generators
Process motive power (small industry)	• small hydro with electric motor • biomass power generation and electric motor • biomass gasification with gas engine	diesel engines and generators
Water pumping (agriculture and drinking)	• mechanical wind pumps • solar PV pumps	diesel pumps
Heating and cooling (crop drying and other agricultural processing, hot water)	• biomass direct combustion • biogas from small- and medium-scale digesters • solar crop dryers • solar water heaters • ice making for food preservation	LPG, kerosene, diesel generators

Forum of Energy Ministers of Africa committed broadly to ensuring access to modern energy services, such as improved cook stoves, to African rural households within 10 years. The Economic Community of West African States committed to providing modern cooking energy to the entire rural population—over 300 million people. And Morocco pledged 1 million improved stoves by 2015.

Cooking and Lighting: Biogas Digesters

About 25 million households worldwide receive energy for lighting and cooking from biogas produced in household-scale plants (called anaerobic digesters). That includes 20 million households in China, 3.9 million households in India, and 150,000 households in Nepal. In addition to providing energy for cooking and lighting, biogas has improved the livelihood of rural households in indirect ways. For example, analysis of the benefits of biogas in Nepal shows a reduction of workload for women and girls of three hours/day per household, annual savings of kerosene of 25 liters/household, and annual savings of fuel wood, agricultural waste, and dung of 3 tons/household.[70]

In China, household-scale biogas for rural home lighting and cooking is a widespread application. A typical digester, sized 6–8 cubic meters, produces 300 cubic meters of biogas per year and costs 1,500–2,000 RMB ($200–250), depending on the province. Because digesters are a simple technology, they can be supplied by local small companies, or built by farmers themselves. In 2006, the Chinese government provided 2.5 billion RMB ($320 million) in subsidies for biogas digesters (about 800–1,200 RMB, or $110–160, per unit). Some analysts estimate that more than 1 million biogas digesters are now being produced each year in China, and the government has set targets for 30 million digesters by 2010 and 45 million by 2020. Beyond household scale, a few thousand medium and large-scale industrial biogas plants were operating in China, with a recent national biogas action plan expected to expand the numbers of such plants.

In India, the Ministry of New and Renewable Energy has been promoting household-scale biogas plants since the early 1980s. The ministry provides subsidies and financing for constructing and maintaining biogas plants, training, public awareness, technical centers, and support to local implementing agencies. The well-known Khadi and Village Industries commission also supports biogas plants. Nepal was providing 75 percent subsidies for family-scale biogas plants, along with the SNV/Biogas Support Programme, during which 60 private biogas companies increased their technical and market capabilities, 100 microcredit organizations provided loans, quality standards were adopted, and a permanent market facilitation organization was created.

Electricity, Heat, and Motive Power: Biomass Gasification

Small-scale thermal biomass gasification is a growing commercial technology in some developing countries, notably China and India. Gas from a gasifier can be burned directly for heat or used in gas turbines or gas engines for electricity and/or motive power. In a few Chinese provinces, biogas from thermal gasifiers also provides cooking fuel through piped distribution networks. The total capacity of gasifiers in India was estimated at 35 MW in 2002, and 10 manufacturers were selling small-scale gasifiers together with engines. In the Philippines, gasifiers have been coupled to dual-fuel diesel engines and used for rice milling and irrigation since the 1980s. Gasifiers have also been demonstrated in Indonesia, Sri Lanka, and Thailand.

In India, projects involving biomass gasification in silk and other textile production and processing have been demonstrated on a commercial basis, involving local entrepreneurs and economic payback periods as short as one year. Spice (cardamom) drying with gasifiers yields a higher-quality product in a shorter drying period. More than 85 percent of the beneficiaries are small producers who own less than two hectares. The drying of rubber also offers payback times of less than one year. Gasifiers are also used to dry bricks before firing in a kiln. The use of a gasifier reduces fuel consumption and associated smoke and decreases the drying time (increasing productivity) while improving working conditions. By 2006, India had achieved 70 MW of small-scale biomass gasification systems for rural (off-grid) power generation.

Electricity: Village-Scale Mini-Grids/Hybrid Systems

Village-scale mini-grids can serve tens or hundreds of households. Traditionally, mini-grids in remote areas and on islands have been powered by diesel generators or small hydro. Generation from solar PV, wind, or biomass, often in hybrid combinations including batteries and/or a supplementary diesel generator, is slowly providing alternatives to the traditional model, mostly in Asia. Tens of thousands of mini-grids exist in China, based primarily on small hydro, while hundreds or thousands exist in India, Nepal, Vietnam, and Sri Lanka. The use of wind and solar PV technologies in mini-grids and hybrid systems is still on the order of a thousand systems worldwide, mostly installed in China since 2000. China's "Township Electrification Program" from 2002–2004 electrified 1.5 million rural people in 1,000 townships (about 300,000 households) with electricity from solar PV, wind-solar PV hybrid systems, and small hydropower systems. During 2002–2004, more than 700 townships received village-scale solar PV stations of approximately 30–150 kW (about 15 MW total). A few of these were hybrid systems with wind power (about 800 kW of wind total). India, the other main location for village-scale power systems, has 550 kW of solar/wind hybrid systems installed, which serve on the order of a few thousand households in several dozen villages.

Water Pumping: Wind and Solar PV

Solar PV and wind power for water pumping (both irrigation and drinking water) are gaining widespread acceptance, and many more projects and investments are occurring. On the order of 1 million mechanical wind pumps are in use for water pumping, primarily in Argentina, following decades of development. Large numbers of wind pumps are also used in Africa, including in South Africa (300,000), Namibia (30,000), Cape Verde (800), Zimbabwe (650), and several other countries (another 2,000). There are now more than 50,000 solar-PV pumps worldwide, many of these in India. Over 4,000 solar pumps (ranging from 200–2,000 watts) were recently installed in rural areas as part of the Indian Solar PV Water Pumping Programme. There are an estimated 1,000 solar water pumps in use in West Africa. Donor programs for PV-powered drinking water have appeared in Argentina, Brazil, Indonesia, Jordan, Namibia, Niger, the Philippines, Tunisia, and Zimbabwe, among others. A growing cohort of commercial projects for solar PV-powered drinking water, including both pumping and purification, has appeared in recent years, notably in India, the Maldives, and the Philippines.

Electricity: Solar Home and Community Systems

By 2007, more than 2.5 million households in developing countries were receiving electricity from solar home systems. Most growth has been occurring in a few specific Asian countries (Bangladesh, China, India, Nepal, Sri Lanka, and Thailand), where the affordability problem has been overcome either with microcredit or by selling small systems for cash, and where government and international donor programs have supported markets. In each of these countries, monthly additions in the hundreds or thousands of new household installations have occurred in recent years. China has been by far the largest market, with over 400,000 systems added. In Bangladesh, there are now over 150,000 households with solar home systems, and 7,000 are being added monthly. Outside Asia, other large markets include Kenya, Mexico, and Morocco. The plans of a number of Latin American countries may shift solar home system growth toward that region if promising approaches to affordability, including government subsidies and/or fee-for-service models, continue to be followed. Solar street lighting is another growing application, with 55,000 solar streetlights now in India. Solar electricity for rural schools, health clinics, and community buildings has also grown.[71]

Africa, with its very low rural-electrification rates and low per-capita income, has experienced slower growth in solar home systems, with the exception of a few countries. Still, there were at least half a million systems installed in Africa. Kenya has 200,000 systems and continuing market growth, driven by cash sales of small modules to households in rural and peri-urban areas. South Africa has 150,000 systems, and smaller numbers exist in several other countries. Uganda has a 10-year program that targets solar home systems and other productive uses in small industry, education, and health care. Other countries like Mali, Senegal, and Tanzania were trying to provide limited subsidies for rural renewables like solar home systems. In Morocco, solar PV programs by the national utility and fee-for-service concessions have achieved more than 37,000 systems in thousands of villages, with a program for another 80,000 systems under way and a target of 150,000 by 2010 as part of rural electrification planning.

Other Productive Uses of Heat and Electricity

Productive uses of heat and electricity for small-scale industry, agriculture, telecommunications, health, and education in rural areas are a growing area of attention for applying modern renewable energy technologies. Examples of industrial applications include silk production, brick making, rubber drying, handicraft production, sewing, welding, and woodworking. Examples of agricultural and food processing applications include irrigation, food drying, grain grinding and milling, stoves and ovens, ice making, livestock fences, and milk chilling. Health applications include vaccine refrigeration and lighting. Communication applications include village cinema, telephone, computers, and broadcast radio. Other community applications include school and street lighting, and drinking water purification. Despite this diversity of potential applications, existing projects are still small demonstrations. However, approaches to financing small and medium-scale rural enterprises engaged in renewable energy-related productive business have gained considerable attention in recent years, and received financing from commercial banks and international donors.

Even as applications of renewable electricity for lighting, water pumping, medical refrigeration, and motive power are beginning to receive greater attention, application of modern renewables to heating needs is still much less discussed or practiced. Traditional biomass fuels are used to produce heat and heat-related services such as cooking, space heating, crop drying, roasting, agricultural processing, kilns, ovens, and commercial food processing. Applications of solar heating and advanced biomass technologies are just beginning to attract the attention of the development community. Developing-country governments are focusing more on these areas as well. For example, the Indian government has launched comprehensive programs promoting biomass for electricity, heat, and motive power in rural areas, including combustion, co-generation, and gasification. These rural energy programs target all forms of household, community, and productive needs in hundreds of rural districts.

Rural Electrification Policies and Programs

National rural electrification policies and programs, together with international donor programs, have employed renewable energy as an adjunct to "access" strategies, thereby serving increasing percentages of rural populations who do not have access to central electric power networks. An estimated 350 million households worldwide still lack such access. In Africa, the share of rural populations with access to electricity is extremely low in many countries—for example, 24 percent in Côte d'Ivoire and Ghana, 16 percent in Senegal, 5 percent in Kenya and Mali, and 2 percent in Zambia. The main electrification options include power grid extension, diesel generators connected in mini-grids, renewable energy connected in mini-grids (using mini- and micro-hydro, solar, wind, and/or biomass gasification, sometimes combined with diesel), and household-scale renewable energy (using micro- and pico-hydro, solar home systems, and small wind turbines). Often the cost of traditional grid extension is prohibitive: in Kenya, for example, the average cost of a new connection for a rural home is seven times the national per-capita income.

Interest in using renewable energy technologies to provide electricity to rural and remote areas as a cost-effective alternative to grid extension is gathering momentum in many developing countries. Rural electrification programs in several countries, particularly in Latin America, are explicitly incorporating large-scale investment in solar home systems for some of the homes to be electrified. Governments are recognizing geographic rural areas that are non-viable for grid-extension, and enacting explicit policies and subsidies for renewables in these areas to supplement line-extension electrification programs. This is happening worldwide. Brazil planned to electrify 2.5 million households by 2008 under the "Luz para Todos" program, and targeted 200,000, or about 10 percent of these households, for renewable energy. China's "Township Electrification Program," which was substantially completed during 2004, provided power to 1 million people in rural areas with renewable energy. The Indian government's "Remote Village Electrification Programme" has identified 18,000 villages for electrification, partly with renewable energy technologies like biomass gasifiers. Senegal has incorporated solar PV into its rural electrification efforts and increased the rural electrification rate by an additional 3 percent.

Several Latin American countries have recently launched or revamped new rural electrification programs, including Bolivia, Chile, Guatemala, Mexico, Nicaragua, and Peru. Most of these countries have launched efforts to "mainstream" renewable energy as a standard option of new rural electrification efforts. For example, Chile has recognized renewables as a key technology as it enters a second phase of a national rural electrification program. Bolivia is targeting 50 percent access by 2015 and full access by 2025, including some 25,000 solar home systems and micro-hydro (5–100 kW) for thousands of households. Honduras announced a new universal access goal for a share of households to be served with renewables. Given this planned scale-up of renewables for rural electrification, regulators and utilities have realized that legal and regulatory frameworks need to be adopted quickly. Indeed, new laws or regulations have appeared in recent years in Argentina, Bolivia, Brazil, Chile, the Dominican Republic, Guatemala, and Nicaragua.

Asian examples of countries with explicit mandates for renewable energy for rural electrification include Bangladesh, China, India, Indonesia, Nepal, the Philippines, Sri Lanka, Thailand, and Vietnam. For example, the Philippines was undertaking a strategy to achieve full rural village electrification by 2009, including renewable energy explicitly in that strategy. Indonesia allocated $75 million equivalent during the two year period 2006/2007 for rural electrification using micro-hydro, wind power, and solar PV, channeled through local governments. Sri Lanka was targeting 85 percent of the population with access to electricity and was directly subsidizing rural solar home systems to help achieve this goal; there are now over 110,000 households with solar home systems. Thailand electrified 200,000 off-grid households with solar home systems during 2003–2006, essentially completing 100 percent electrification nationwide. Nepal completed a rural electrification program for some 20,000 households with 170 micro-hydro power projects. And India's Integrated Rural Energy Program using renewable energy had served over 300 districts and 2,200 villages by 2006, with additional projects under implementation in over 800 villages and 700 hamlets in 13 states and federal territories. India proposed to augment cooking, lighting, and motive power with renewables in 600,000 villages by 2032, starting with 10,000 remote unelectrified villages by 2012.

REFERENCE TABLES

Table R1. Renewable Energy Added and Existing Capacities, 2006

	Added during 2006	Existing at end of 2006
Power generation (GW)		
Large hydropower	12-14	770
Wind turbines	15	74
Small hydropower	7	73
Biomass power	n/a	45
Geothermal power	0.2	9.5
Solar PV, grid-connected	1.6	5.1
Solar PV, off-grid	0.3	2.7
Concentrating solar thermal power (CSP)	< 0.1	0.4
Ocean (tidal) power	~ 0	0.3
Hot water/heating (GWth)		
Biomass heating	n/a	235
Solar collectors for hot water/heating (glazed)	18	105
Geothermal heating	n/a	33
Transport fuels (billion liters/year)		
Ethanol production	5	39
Biodiesel production	2.1	6

Source: See Endnote 2.

Table R2. Added and Existing Wind Power, Top 10 Countries, 2005 and 2006

Country	Added in 2005	Existing in 2005	Added in 2006	Existing in 2006
		megawatts		
Germany	1,810	18,420	2,230	20,620
Spain	1,760	10,030	1,590	11,620
United States	2,430	9,150	2,450	11,600
India	1,430	4,430	1,840	6,270
Denmark	20	3,120	10	3,140
China	500	1,260	1,350	2,600
Italy	450	1,720	420	2,120
United Kingdom	450	1,330	630	1,960
Portugal	500	1,020	690	1,720
France	370	760	810	1,570

Note: Global total in 2006 was 15 GW added, 74 GW cumulative. Global estimate for 2007 is 21 GW added, 95 GW cumulative. *Source:* See Endnote 5.

Table R3. Grid-Connected Solar Rooftop Programs, 2002–2006

Country	Added 2002	Added 2003	Added 2004	Added 2005	Added 2006	Existing 2005	Existing 2006
				megawatts			
Japan (Sunshine)	140	170	230	—	—	1,250	1,540
Japan (other)	40	50	40	310	290		
Germany	80	150	600	860	830*	1,900	2,800*
California	—	—	47	55	70	220	320
Other USA	—	—	10	10	30		
Spain	5	5	12	23	106	50	160
Other EU	—	—	—	—	30	130	160
South Korea	—	—	3	5	20	15	35
Other World	—	—	—	> 20	> 50	> 30	> 80
Total Added	270	400	900	1,250	1,600		
Cumulative						3,500	5,100

Note: Estimates for 2007 are 2.7 GW added and 7.8 GW existing (grid-tied only). Figures are approximate and subject to revision with future data. An unknown share of the data for Germany and Japan are off-grid; amounts for Germany are likely small. The amount for Japan is assumed to be about 150 MW cumulative as of 2005. For Japan, data are reported on a fiscal year basis, ending in March, but figures in this table are corrected for calendar years. (*) German additions for 2006 were reported in the range 830–1,050 MW from different sources, and cumulative up to 3,050 MW. *Source:* See Endnote 8.

Table R4. Renewable Electric Power Capacity, Existing as of 2006

Technology	World Total	Developing Countries	EU-25	China	Germany	United States	Spain	India	Japan
					gigawatts				
Wind power	74	10.1	48.5	2.6	20.6	11.6	11.6	6.3	1.6
Small hydropower	73	51	12	47	1.7	3.0	1.8	1.9	3.5
Biomass power	45	22	10	2.0	2.3	7.6	0.5	1.5	> 0.1
Geothermal power	9.5	4.7	0.8	~ 0	0	2.8	0	0	0.5
Solar photovoltaic-grid	5.1	~ 0	3.2	~ 0	2.8	0.3	0.1	~ 0	1.5
Solar thermal power-CSP	0.4	0	~ 0	0	0	0.4	< 0.1	0	0
Ocean (tidal) power	0.3	0	0.3	0	0	0	0	0	0
Total renewable power capacity (excluding large hydro)	207	88	75	52	27	26	14	10	7
For comparison									
Large hydropower	770	355	115	100	7	95	17	35	45
Total electric power capacity	4,300	1,650	720	620	130	1,100	79	140	290

Note: Small amounts, on the order of a few megawatts, are designated by "~ 0." Biomass power, large hydropower, and total electric power capacity are approximate. Global estimate for 2007 total renewable power capacity is 240 GW. *Source:* See Endnote 10.

Table R5. Solar Hot Water Installed Capacity, Top 10 Countries/EU and World Total, 2005 and 2006

Country/EU	Additions 2005	Existing 2005	Additions 2006	Existing 2006	Existing 2006
	million square meters				gigawatts-thermal
China	14.5	78	19.5	97	67.9
European Union	2.0	16.0	3.0	19.3	13.5
Turkey	0.4	9.0	0.7	9.4	6.6
Japan	0.3	7.0	0.2	6.7	4.7
Israel	0.2	5.3	0.3	5.4	3.8
Brazil	0.4	2.7	0.4	3.1	2.2
United States	0.1	2.6	0.1	2.6	1.8
Australia	0.2	1.6	0.2	1.8	1.3
India	0.5	1.3	0.6	1.8	1.2
Jordan	—	—	—	0.7	0.5
(other countries)	< 1	< 2	< 1	< 3	< 2
World Total	**19**	**126**	**25**	**150**	**105**

Note: Figures do not include swimming pool heating (unglazed collectors). Global estimate for 2007 is 24 GWth added, 128 GWth cumulative. Existing figures include allowances for retirements. By accepted convention, 1 million square meters = 0.7 GWth. *Source:* See Endnote 12.

Table R6. Biofuels Production, Top 15 Countries plus EU, 2006

Country	Fuel ethanol	Biodiesel
	billion liters	
1. United States	18.3	0.85
2. Brazil	17.5	0.07
3. Germany	0.5	2.80
4. China	1.0	0.07
5. France	0.25	0.63
6. Italy	0.13	0.57
7. Spain	0.40	0.14
8. India	0.30	0.03
9. Canada	0.20	0.05
9. Poland	0.12	0.13
9. Czech Republic	0.02	0.15
9. Colombia	0.20	0.06
13. Sweden	0.14	—
13. Malaysia	—	0.14
15. United Kingdom	—	0.11
EU Total	**1.6**	**4.5**
World Total	**39**	**6**

Note: Numbers for fuel ethanol only; total ethanol production figures will be significantly higher. Table ranking by total biofuels. *Source:* See Endnotes 15 and 17.

Table R7. Share of Primary and Final Energy from Renewables, Existing in 2006 and Targets

	Primary energy (IEA method)		Final energy (EC method)	
Country/region	**Existing share (2006)**	**Future target**	**Existing share (2005–06)**	**Future target**
World	13%	—	18%	—
EU-25/EU-27	6.5%	12% by 2010	8.5%	20% by 2020
Selected EU Countries				
Austria	20%	—	23%	34% by 2020
Czech Republic	4.1%	8–10% by 2020	6.1%	13% by 2020
Denmark	15%	30% by 2025	17%	30% by 2020
France	6.0%	7% by 2010	10%	23% by 2020
Germany	5.6%	4% by 2010	5.8%	18% by 2020
Italy	6.5%	—	5.2%	17% by 2020
Latvia	36%	6% by 2010	35%	42% by 2020
Lithuania	8.8%	12% by 2010	15%	23% by 2020
Netherlands	2.7%	—	2.4%	14% by 2020
Poland	4.6%	14% by 2020	7.2%	15% by 2020
Spain	6.5%	12.1% by 2010	8.7%	20% by 2020
Sweden	28%	—	40%	49% by 2020
United Kingdom	1.7%	—	1.3%	15% by 2020
Other Developed/OECD Countries				
Canada	16%	—	20%	—
Japan	3.2%	—	3.2%	—
Korea	0.5%	5% by 2011	0.6%	—
Mexico	9.4%	—	9.3%	—
United States	4.8%	—	5.3%	—
Developing Countries				
Argentina	8.2%	—	—	—
Brazil	43%	—	—	—
China*	8%	15% by 2020	—	—
Egypt	4.2%	14% by 2020	—	—
India	31%	—	—	—
Indonesia	3%	15% by 2025	—	—
Jordan	1.1%	10% by 2020	—	—
Kenya	81%	—	—	—
Mali	—	15% by 2020	—	—
Morocco*	4.3%	10% by 2010	—	—
Senegal	40%	15% by 2025	—	—
South Africa	11%	—	—	—
Thailand*	4%	8% by 2011	—	—

Note: Not all countries with primary energy targets are included in table; see Endnote 43 for countries not shown. Targets for final energy by 2020 for EU countries were proposed in January 2008 by the European Commission and were subject to review and confirmation by the member countries. Final energy existing share is 2005 for EU countries and 2006 for world and other countries. EU primary energy target by 2010 applies to EU-25; final energy target by 2020 applies to EU-27. (*) Existing share and targets for China, Morocco, and Thailand exclude traditional biomass. Some countries shown also have other types of targets; see Tables R8 and R9. *Source:* See Endnote 43.

Table R8. Share of Electricity from Renewables, Existing in 2006 and Targets

Country/region	Existing share (2006)	Future target
World	18%	—
EU-25	14%	21% by 2010
Selected EU Countries		
Austria	62%	78% by 2010
Belgium	2.8%	6.0% by 2010
Czech Republic	4.2%	8.0% by 2010
Denmark	26%	29% by 2010
Finland	29%	31.5% by 2010
France	10.9%	21% by 2010
Germany	11.5%	12.5% by 2010
Greece	13%	20.1% by 2010
Hungary	4.4%	3.6% by 2010
Ireland	10%	13.2% by 2010
Italy	16%	25% by 2010
Luxembourg	6.9%	5.7% by 2010
Netherlands	8.2%	9.0% by 2010
Poland	2.6%	7.5% by 2010
Portugal	32%	45% by 2010
Slovak Republic	14%	31% by 2010
Spain	19%	29.4% by 2010
Sweden	49%	60% by 2010
United Kingdom	4.1%	10% by 2010

Country/region	Existing share (2006)	Future target
Other Developed/OECD Countries		
Australia	7.9%	—
Canada	59%	—
Israel	—	5% by 2016
Japan*	0.4%	1.63% by 2014
Korea	1.0%	7% by 2010
Mexico	16%	—
New Zealand	65%	90% by 2025
Switzerland	52%	—
United States	9.2%	—
Developing Countries		
Argentina*	1.3%	8% by 2016
Brazil*	5%	—
China	17%	—
Egypt	15%	20% by 2020
India	4%	—
Malaysia	—	5% by 2005
Morocco	10%	20% by 2012
Nigeria	—	7% by 2025
Pakistan	—	10% by 2015
Thailand	7%	—

Note: Not all countries with electricity targets are included in table; see Endnote 44 for countries not shown. All EU countries have electricity share targets for 2010, not just the ones shown in the table. Some countries shown also have other types of targets; see Tables R7 and R9. (*) Argentina, Brazil, and Japan figures in table do not include large hydro; with large hydro, figures are 35%, 75%, and 10%, respectively. Percentages above 10% rounded to nearest whole number. The United States and Canada have de-facto state- or province-level targets through existing RPS policies; see Table R11. *Source:* See Endnote 44.

Table R9. Other Renewable Energy Targets

Country	Target(s)
Australia	9.5 TWh of electricity annually by 2010 (RPS)
Brazil	3.3 GW added by 2006 from wind, biomass, small hydro
Canada	3.5% to 15% of electricity in 4 provinces (RPS); other types of targets in 5 provinces
China	300 GW hydro, 30 GW wind, 30 GW biomass, 1.8 GW PV, 300 million square meters solar hot water by 2020
Croatia	400 MW by 2010, excluding large hydropower
Dominican Republic	500 MW wind power capacity by 2015
India	10% of added electric power capacity during 2003–2012 (expected 10 GW). 10.5 GW total wind power existing by 2012; other long-term goals to 2032
Italy	3 GW of solar PV by 2016
Iran	500 MW of electricity output by 2010
Korea	1.3 GW of grid-connected solar PV by 2011, including 100,000 solar homes
Mexico	4 GW added by 2014
Morocco	1 GW wind power by 2012 and 400,000 square meters solar hot water added by 2015
New Zealand	30 PJ of added capacity (including heat and transport fuels) by 2012
Norway	7 TWh from heat and wind by 2010
Philippines	4.7 GW total existing capacity by 2013
Singapore	50,000 square meters (~35 MWth) solar hot water by 2012
South Africa	10 TWh added final energy by 2013
Switzerland	3.5 TWh from electricity and heat by 2010
Spain	500 MW solar power by 2010
Tunisia	500,000 square meters solar hot water by 2009 and 300 MW added wind by 2011
Turkey	2% of electricity from wind by 2010
Uganda	100 MW small hydro and 45 GW geothermal by 2017; other rural electricity and productive-uses targets
United States	5% to 30% (typical) of electricity in 26 states and District of Columbia (RPS)

Note: Countries on this list may also have primary energy or electricity targets; see Tables R7, R8. *Source:* Compiled from all available policy references plus submissions from report contributors. See Endnote 48.

Table R10. Cumulative Number of Countries/States/Provinces Enacting Feed-in Policies

Year	Cumulative Number	Countries/States/Provinces Added That Year
1978	1	United States
1990	2	Germany
1991	3	Switzerland
1992	4	Italy
1993	6	Denmark, India
1994	8	Spain, Greece
1997	9	Sri Lanka
1998	10	Sweden
1999	13	Portugal, Norway, Slovenia
2000	13	—
2001	15	France, Latvia
2002	21	Algeria, Austria, Brazil, Czech Republic, Indonesia,Lithuania
2003	28	Cyprus, Estonia, Hungary, South Korea, Slovak Republic, Maharashtra (India)
2004	34	Italy, Israel, Nicaragua, Prince Edward Island (Canada), Andhra Pradesh and Madhya Pradesh (India)
2005	41	Karnataka, Uttaranchal, and Uttar Pradesh (India); China; Turkey; Ecuador; Ireland
2006	44	Ontario (Canada), Argentina, Thailand
2007	46	South Australia (Australia), Croatia

Note: Cumulative number refers to number of jurisdictions that had enacted feed-in policies as of the given year. A few feed-in policies shown have been discontinued. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors.

Table R11. Cumulative Number of Countries/States/Provinces Enacting RPS Policies

Year	Cumulative Number	Countries/States/Provinces Added
1983	1	Iowa (USA)
1994	2	MInnesota (USA)
1996	3	Arizona (USA)
1997	6	Maine, Massachusetts, Nevada (USA)
1998	9	Connecticut, Pennsylvania, Wisconsin (USA)
1999	12	New Jersey, Texas (USA); Italy
2000	13	New Mexico (USA)
2001	15	Flanders (Belgium); Australia
2002	18	California (USA); Wallonia (Belgium); United Kingdom
2003	19	Japan; Sweden; Maharashtra (India)
2004	34	Colorado, Hawaii, Maryland, New York, Rhode Island (USA); Nova Scotia, Ontario, Prince Edward Island (Canada); Andhra Pradesh, Karnataka, Madhya Pradesh, Orissa (India); Poland
2005	38	District of Columbia, Delaware, Montana (USA); Gujarat (India)
2006	39	Washington State (USA)
2007	44	Illinois, New Hampshire, North Carolina, Oregon (USA); China

Note: Cumulative number refers to number of jurisdictions that had enacted RPS policies as of the given year. Jurisdictions listed under year of first policy enactment; many policies are revised in subsequent years. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors. For U.S. RPS policies, see Wiser et al. (2008).

Table R12. Biofuels Blending Mandates

Country	Mandate
Australia	E2 in New South Wales, increasing to E10 by 2011; E5 in Queensland by 2010
Argentina	E5 and B5 by 2010
Bolivia	B2.5 by 2007 and B20 by 2015
Brazil	E22 to E25 existing (slight variation over time); B2 by 2008 and B5 by 2013
Canada	E5 by 2010 and B2 by 2012; E7.5 in Saskatchewan and Manitoba; E5 by 2007 in Ontario
China	E10 in 9 provinces
Colombia	E10 existing; B5 by 2008
Dominican Republic	E15 and B2 by 2015
Germany	E2 and B4.4 by 2007; B5.75 by 2010
India	E10 in 13 states/territories
Italy	E1 and B1
Malaysia	B5 by 2008
New Zealand	3.4 percent total biofuels by 2012 (ethanol or biodiesel or combination)
Paraguay	B1 by 2007, B3 by 2008, and B5 by 2009
Peru	B5 and E7.8 by 2010 nationally; starting regionally by 2006 (ethanol) and 2008 (biodiesel)
Philippines	B1 and E5 by 2008; B2 and E10 by 2011
South Africa	E8-E10 and B2-B5 (proposed)
Thailand	E10 by 2007; 3 percent biodiesel share by 2011
United Kingdom	E2.5/B2.5 by 2008; E5/B5 by 2010
United States	Nationally, 130 billion liters/year by 2022 (36 billion gallons); E10 in Iowa, Hawaii, Missouri, and Montana; E20 in Minnesota; B5 in New Mexico; E2 and B2 in Louisiana and Washington State; Pennsylvania 3.4 billion liters/year biofuels by 2017 (0.9 billion gallons)
Uruguay	E5 by 2014; B2 from 2008-2011 and B5 by 2012

Note: Table shows binding obligations on fuel suppliers; there are other countries with future indicative targets that are not shown here; see the Biofuels Policies section, page 27. Mandates in some U.S. states take effect only in future years or under certain future conditions, or apply only to portions of gasoline sold. *Source:* All available policy references, including the IEA on-line Global Renewable Energy Policies and Measures database and submissions from report contributors.

GLOSSARY

Biodiesel. A vehicle fuel for diesel-powered cars, trucks, buses, and other vehicles. Biodiesel is produced from oilseed crops such as soy, rapeseed (canola), and mustard, or from other vegetable oil sources such as waste cooking oil.

Biogas digester. Converts animal and plant wastes into gas usable for lighting, cooking, heating, and electricity generation.

Biomass power and heat. Power and/or heat generation from solid biomass, which includes forest product wastes, agricultural residues and waste, energy crops, and the organic component of municipal solid waste and industrial waste. Also includes power and process heat from biogas.

Capital subsidies or consumer grants. One-time payments by the government or utility to cover a percentage of the capital cost of an investment, such as a solar hot water system or rooftop solar PV system.

Ethanol. A vehicle fuel made from biomass (typically corn, sugar cane, or wheat) that can replace ordinary gasoline in modest percentages or be used in pure form in specially modified vehicles.

Feed-in tariff. A policy that sets a fixed guaranteed price at which power producers can sell renewable power into the electric power network. Some policies provide a fixed tariff while others provide fixed premiums added to market- or cost-related tariffs.

Geothermal power and heat. Heat energy emitted from within the Earth, usually in the form of hot water or steam, which can be used to produce electricity or direct heat for buildings, industry, and agriculture.

Green power. Voluntary purchases of renewable electricity by residential, commercial, government, or industrial customers, directly from utility companies, from a third-party renewable energy generator, or through the trading of renewable energy certificates (RECs).

Investment tax credit. Allows investments in renewable energy to be fully or partially deducted from tax obligations or income.

Large hydropower. Electricity from water flowing downhill, typically from behind a dam. Large hydro usually entails a substantial reservoir and is usually defined as larger than 10 megawatts; the definition can vary by country.

Modern biomass. Biomass-utilization technologies other than those defined for traditional biomass, such as biomass co-generation for power and heat, biomass gasification, biogas anaerobic digesters, and liquid biofuels for vehicles.

Net metering. Allows a two-way flow of electricity between the electricity distribution grid and customers with their own generation. The customer pays only for the net electricity used.

Production tax credit. Provides the investor or owner of qualifying property with an annual tax credit based on the amount of electricity generated by that facility.

Renewable energy target. A commitment, plan, or goal by a country to achieve a certain level of renewable energy by a future date. Some targets are legislated while others are set by regulatory agencies or ministries.

Renewable portfolio standard (RPS). Also called renewables obligations or quota policies. A standard requiring that a minimum percentage of generation sold or capacity installed be provided by renewable energy. Obligated utilities are required to ensure that the target is met.

Small/mini/micro/pico hydropower. Small installations drawing power from running water, usually without a large reservoir. The prefix defines the scale.

Solar home system. A rooftop solar panel, battery, and charge controller that can provide modest amounts of power to rural homes not connected to the electric grid.

Solar hot water/heating. Rooftop solar collectors that heat water and store it in a tank for use as domestic hot water or for space heating.

Solar photovoltaic (PV) panel/module/cell. Converts sunlight into electricity. Cells are the basic building block, which is then manufactured into modules and panels.

Tradable renewable energy certificates (RECs). Each certificate represents the certified generation of one unit of renewable energy (typically one megawatt-hour). Certificates provide a tool for trading and meeting renewable energy obligations among consumers and/or producers, and also a means for voluntary green power purchases.

Traditional biomass. Unprocessed biomass, including agricultural waste, forest products waste, collected fuel wood, and animal dung, that is burned in stoves or furnaces to provide heat energy for cooking, heating, and agricultural and industrial processing, typically in rural areas.

ENDNOTES

Further Information and Sources of Data

This 2007 report edition follows previous 2005 and 2006 editions (*Renewables 2005 Global Status Report* and *Renewables Global Status Report 2006 Update*). To save space, these notes highlight the most important considerations and details and refer the reader elsewhere for further information and sources, including the Annexes to this 2007 edition, Endnotes 1 through 43 of the 2006 edition, and Notes N1 through N44 of the 2005 edition (which are contained in the separate 80-page *Renewables 2005 Global Status Report—Notes and References Companion Document*). A full list of references from all three years 2005–2007 is contained in the *Renewables 2007 Global Status Report—References* document. All of these documents can be found on the REN21 Web site, at www.ren21.net.

Most figures of global capacity, growth, and investment portrayed in this report are not exact, but are approximate to two significant digits. Where necessary, triangulation of conflicting, partial, or older information is made using assumptions and growth trends. The original 2005 report drew from over 250 published references, plus a variety of electronic newsletters, numerous unpublished submissions from contributors, personal communications, and Web sites. The 2006 edition and this 2007 edition add many more sources. There has generally been no single source of information for any fact globally, as most existing sources report only on developed (OECD) countries or on regional or national levels, such as Europe or the United States, although global sources have emerged in recent years for wind power, solar PV, solar hot water, and biodiesel. Some global aggregates must be built from the bottom up, adding or aggregating individual country information. Very little material exists that covers developing countries as a group. Data for developing countries is often some years older than data for developed countries, and thus extrapolations to the present must be made from older data, based on assumed and historical growth rates. This is one of the reasons that capacity data (kilowatts) instead of energy data (kilowatt-hours) are reported, as capacity expansion is easier to extrapolate than energy production and is less prone to seasonal and annual variations that are common to many forms of renewables. (Other reasons are that capacity data better mimic investment trends over time, as capacity is usually directly proportion to investment, while energy production is not; and capacity data is generally more available for developing countries than energy production.) Annual increments to capacity are generally available only for wind, solar PV, and solar hot water.

Endnotes

1. See Endnote 43, Annex 1, and Martinot et al. (2007) for methodological details of calculating shares of primary energy supply and final energy consumption. Figure 1 is based on the following data for 2006: (a) total final energy consumption 8,150 million tons of oil equivalent (Mtoe), including traditional biomass (from IEA 2007a adjusted for 2006); (b) traditional biomass 1,050 Mtoe (adjusted by 2 percent/year growth from 2001 estimate by Johansson and Goldemberg, although there are no consistent global estimates for growth of traditional biomass); and (c) large hydro 2,850 terrawatt-hours (TWh), small hydro 260 TWh, biomass power 230 TWh, wind power 155 TWh, final biomass heat 4,000 petajoules (PJ), geothermal heat 280 PJ, solar hot water 250 PJ, and biofuels 1,100 PJ. All traditional biomass supply is considered final energy consumption for purposes of this analysis. For heat from modern biomass, there is some ambiguity as to what constitutes "final energy consumption." Typically, it includes the heat content of steam and hot water produced from central biomass boilers and heat-and-power plants, but analyses can vary depending on how building-level heating boilers are counted. Few global estimates exist for modern biomass heat consumption, including district heating supply and direct industry use. IEA SHC (2007) gives 4000 PJ heat from modern bioenergy, and Johansson and Turkemburg (2004) give 730 TWh(th), or 2600 PJ final heat in 2001. Figures from IEA and other sources suggest that biomass for final heat consumption in industry is substantial (although there are few published studies on this topic), and therefore that heating/hot water from new renewables could be higher than shown in Figure 1.

2. For technology-by-technology sources, see Endnotes 4–17. For historical data and sources, see Note N3 of the 2005 report edition. Electricity data for 2006 from BP (2007) *Statistical Review of World Energy*. As of this writing, global electricity statistics by the IEA were only available for 2005. IEA (2007b) *Renewables Information 2007*, gives renewables a 17.9 percent electricity share for 2005, including 16.0 percent for hydro (both large and small). BP gives 19,028 TWh total for 2006, including 2,808 TWh for nuclear and 3,040 TWh for hydro. BP figure adjusted upwards by 520 TWh to account for new renewables minus a share of small hydro assumed not counted in statistics, for 19,550 TWh total; shares in Figure 2 based on this total plus numbers from Endnote 1. Number of homes with solar hot water collectors estimated based on 2.5 square meters (m2)/home average for developing countries and 4 m2/home for developed countries, with a modest total share for commercial use.

3. For technology-by-technology sources for Figure 3, see Endnotes 4–17.

4. For more details on large hydro in recent years, see Endnote 1 of the 2006 report edition and Note N5 of the 2005 report edition. Global generation statistics from BP (2007), with further information from International Hydro Association (2007). Hydro in China for 2006 from Martinot and Li (2007). Initial 2007 estimates for China are 5.5 gigawatts (GW) small hydro and 7.5 GW large hydro. Small hydro total from Martinot's database of country-by-country information. In the last few years, more emphasis has been put on the environmental integration of small hydro plants into river systems in order to minimize environmental impacts, incorporating new technology and operating methods.

5. Table R2 and Figures 4 and 5 from Global Wind Energy Council (GWEC) (2007). GWEC in January 2008 estimated 94 GW for global wind power in 2007, with 20 GW added, including 8.5 GW in Europe (including 3.5 GW in Spain), 5.2 GW in the United States, and 3.4 GW in China. Other late-2007 projections were 2 GW in India, and 0.5 GW in Japan.

6. For further details, see Endnote 2 of the 2006 report edition and Note N6 of the 2005 report edition. OECD biomass power capacity was 24 GW in 2005 (IEA 2007b), including 0.4 GW in Mexico and Turkey (which are counted in the developing country total). European biomass information from European Biomass Association (2007). Biomass power-generation capacity figures presented here do not include electricity from municipal solid waste (MSW) or industrial waste. Many sources include MSW in biomass figures, although there is no universally accepted definition. If MSW were to be included, the global biomass power generation figure might increase by 9–10 GW. OECD power capacity from MSW was 8.5 GW in 2005 (IEA 2007b). Developing country numbers for MSW are difficult to estimate. Growth rate for biomass heating is taken from Johansson and Turkenburg (2004) and reflects growth rate for the period 1997–2001; more recent worldwide growth rates are not available. Developing country total for biomass power capacity revised downward slightly for previous years due to new information.

7. Geothermal power capacity grew by an average of 2.4 percent from 2000–2004 (World Geothermal Council 2005 and Lund 2005). Geothermal generation in OECD countries grew by 1.9 percent in 2006 (IEA *Renewables Information 2007*).

8. Solar PV is separated into grid-connected and off-grid to reflect the different market characteristics of each application, such as costs relative to competing alternatives and types of policy support. Recent sources include Photon Consulting (2007), Sarasin (2007), *PV News* by Prometheus Institute (various issues), *Solar Buzz* (various issues), *EurObserver* 178 (2007), the Center for Solar Energy and Hydrogen Research (ZSW) (2008), the German Photovoltaic Industries Association (BSW) (2007), and *Greenprices* 41 and 43 (2007). Korea data from Korea Institute of Energy Research and Korea Photovoltaic Development Organization. There was agreement by Sarasin and *PV News* on 2.5 GW production in 2006. Figures for 2007 are still preliminary estimates. Photon Consulting estimated 3.8 to 4.0 GW of solar PV production in 2007, which might imply more than 3 GW of total installations during 2007, given historical ratios of installations (market volume) to total production, of which about 0.4–0.5 GW is probably off-grid. However, the European Photovoltaic Industries Association (EPIA) in December 2007 estimated added global solar PV capacity of just 2.3 GW in 2007. Cumulative solar PV figures from different sources are difficult to reconcile; Table R3 provides a best estimate for various years and countries from conflicting historical sources. Particularly installations in Germany have been the subject of contention in previous years (see Note N7 of the 2005 report edition and the notes associated with Table 3 of the 2006 report edition for extensive discussion and sources). EPIA estimated in December 2007 that global cumulative PV capacity reached 9 GW in 2007, but a historical database of additions by country maintained by Martinot suggests a cumulative total of more than 10.5 GW by 2007. According to the Spanish Solar PV Industries Association (ASIF), Spain added 400 MW of solar PV in 2007, up from 106 MW added in 2006, to reach a cumulative 560 MW in 2007. Global number of homes with solar PV is approximate, assuming an average 4 kW for new installations in Japan and Germany, coupled with historical figures (see Note N7 of 2005 report edition).

9. Project descriptions from sources in Endnote 8 plus other news reports. The Jumilla plant was inaugurated in December 2007; see www.jumilla.org/noticias/noticia.asp?cat=815&ver=t. The Beneixama plant was inaugurated in September 2007. List of 800 plants over 200 kW from "World's Largest Photovoltaic Systems" Web site, www.pvresources.com/en/top50pv.php. These 800 plants totaled about 875 MW in 2007.

10. CSP sources include Sarasin (2007), submissions from report contributors, and news reports. Solar Millennium is building four 50 MW plants, three of which began construction during 2006/2007. In addition, Iberdrola is planning nine 50 MW plants in Spain. World Bank project IDs are P041396, P050567, and P066426. Eskom in South Africa is planning a 100 MW CSP plant in Northern Cape Province by 2009–2010.

11. Table R4 numbers and sources from Endnotes 4–10; see also Notes N3 through N7 from the 2005 report edition, and the notes associated with Table 4 in the 2006 report edition. Figures in Table R4 should not be compared with previous versions of this table or similar tables to get growth rates. Adjustments from previous versions are a combination of real growth plus adjustment due to improved data. GEA/Gawell and Greenberg (2007) also a source.

12. Table R5 and Figures 8 and 9 compiled and estimated based on Weiss and Bergmann/IEA SHC (2007), Sarasin (2007), Martinot and Li (2007), European Solar Thermal Industry Federation (ESTIF) (2007), and individual country reports by report contributors. See also Note N8 from the 2005 report edition. Solar hot water retirements are significant in some countries, particularly countries with older markets like Japan and Turkey, and data reporting here attempts to account for these retirements. Sarasin (2007) predicted 23 gigawatts-thermal (GWth) added in 2007, which accounting for retirements would bring total global capacity to 125 GWth in 2007. Countries in North Africa and the Middle East were engaged in ambitious programs; Morocco reached 150,000 square meters (m^{2}) cumulative by mid-2006 and expected 400,000 m^2 by 2012 and 1 million m^2 by 2020; Egypt had 400,000 m^2 and Jordan had 660,000 m^2 cumulative by 2006 (Claus and Mostert 2007).

13. "Solar hot water/heating" is also commonly called "solar heating and cooling" to emphasize that solar cooling (solar-assisted air conditioning) is also a commercial technology. This report uses "solar hot water/heating" because hot water alone constitutes the vast majority of installed capacity. Some capacity worldwide, particularly in Europe, does serve space heating, although space heating is a small share of total heat even in combined systems. Solar cooling is not yet in widespread commercial use but many believe its future is promising. Sarasin (2007) reported around 40 systems in service in Europe solar-assisted air conditioning of buildings, with total capacity 4.4 MWth. See IEA/RETD (2007) for a comprehensive report on the subject.

14. Geothermal heat figures include shallow geothermal energy and ground-source heat pumps. See Note N6 of the 2005 report edition for further details. Geothermal heating capacity grew by an average of 12.9 percent from 2000–2004 (World Geothermal Council 2005 and Lund 2005). Lund (2005) reported 1.7 million ground-source heat pumps with 56 percent of total geothermal heat capacity (27,600 GWth), but noted that the data are incomplete. Ground-source heat pumps grew by 24 percent per year from 2000–2005.

15. Table R6 and Figure 10 from Worldwatch (2007), Pinto and Hunt (2007), Etter (2007), *Greenprices* 47 (2007), European Bioethanol Fuel Association (eBIO) (2007), U.S. Renewable Fuels Association (2007), Canada Renewable Fuels Association (2007), and submissions from report contributors. Table R6 and Figure 10 only report fuel ethanol for vehicles; F.O. Licht (2007) and others report total ethanol production, which includes non-fuel uses and is substantially higher. Thus there is no published number for global fuel-ethanol-only production. The global ethanol total in Table R6 is a bottom-up accounting given best estimates for all significant countries. See Endnotes 5 and 6 of the 2006 report edition and Notes N9 and N10 of the 2005 report edition for extensive discussions of biofuels production and cost analyses, particularly with reference to Brazil's plan to add 5 billion liters/year of production capacity by 2009. Ethanol figures do not include production of ethyl tertiary butyl ether (ETBE) in Europe.

16. Other uses for ethanol are emerging in Brazil, including for airplane fuel and as a feedstock for the chemical industry, which also occurred in the 1980s. DATAGRO (2007) issued a forecast in

March 2007 for 20.6 billion liters of production for 2007. Vehicle statistics from National Association of Auto Manufacturers of Brazil (ANFAVEA) (2007).

17. Table R6 and Figure 10 from F.O. Licht (2007), supplemented by European Biodiesel Board (2007) and submissions from report contributors. Biodiesel trends also from Krbitz (2007). There are serious concerns among many environmental groups about the growth of tropical oil plantations.

18. Data for Table 1 compiled from a variety of sources, including the National Renewable Energy Laboratory, World Bank, and the International Energy Agency and its various Implementing Agreements. Many current estimates are unpublished. No single published source provides a comprehensive or authoritative view on all costs. Changes in costs from the 2005 report edition reflect a combination of refined estimates, technology changes, and commercial market changes. See World Bank (2007b) for treatment of many technologies. See Note N11 of the 2005 report edition for further historical sources.

19. Global investment numbers are rough approximations and reflect a database by Eric Martinot of installed capacity by technology and by year. These installed capacity figures are multiplied by assumed average capacity costs (i.e., in \$/kW or \$/m^2). Capacity costs are taken globally, with the exception of small hydropower and solar hot water in China, to which lower cost estimates are applied. Some costs, such as biomass power generation, vary widely, and a global average becomes problematic. See Note N12 of the 2005 report edition for full methodological details. Figures used for 2006 and 2007 capacity additions are (respectively): 15.3 GW and 21 GW of wind power at \$1,600/kW, 2.15 GW and 3.0 GW of solar PV at \$7,000/kW (total system cost), 21.8 million m^2 and 23 million m^2 of solar hot water at \$130/m^2 (China, Turkey, India, other), 3.1 million m^2 and 3.6 million m^2 of solar hot water at \$800/m^2 (EU and other developed countries), on the order of 2 GW biomass power additions at \$2,000/kW, on the order of 250 MW geothermal power additions at \$1,600/kW, 6.5 GW and 5.5 GW of small hydro in China at \$800/kW, and on the order of 400 MW of small hydro elsewhere at \$1,300/kW, plus smaller amounts for solar thermal power, biomass heating, and geothermal heating. Navigant Consulting (2008) also produces an annual estimate of investment in new capacity, which was \$47 billion for 2006 and \$55 billion preliminary for 2007, excluding solar hot water and small hydro, which confirm the estimates here accounting for solar hot water and small hydro. Figure 11, based on above capacity costs, approximates real 2007 dollars and adjusts for historical capacity costs but does not take into account exchange rate fluctuations. See Endnote 21 for other investment estimates.

20. Solar PV manufacturing investment estimated by Photon Consulting. For biofuels, from market reports, it appeared that typical costs of new biodiesel production plants were in the range of \$0.6 to \$0.8 billion per billion liters/year of production capacity. (See Endnote 7 of the 2006 report edition for further methodological details.) The 2006 report edition used \$0.3 to \$0.6 billion per billion liters/year of production capacity for ethanol. Using these figures and averaging new ethanol and biodiesel capacity increases for 2006/2007, about 6 billion liters/year ethanol capacity installed per year at \$0.4 billion, plus 2 billion liters/year biodiesel capacity installed per year at \$0.7 billion, yields \$2.4 billion/year for ethanol and \$1.4 billion/year for biodiesel, or a total of \$3.8 billion/year. These numbers are significantly higher than the totals estimated in the 2006 report edition: \$1 billion for 2005 and \$2 billion for 2006. The 2006 report edition applied the per-unit investment cost for ethanol to biodiesel, which resulted in lower estimates. There is also much greater investment in Brazil expected through 2009; considering capacity increases in Brazil during 2006/2007, it is likely that about \$1.5 billion of investment occurred during 2006 in Brazil and \$2 billion in 2007.

21. Further insight into investment and finance trends can be found in the REN21-associated report *Global Trends in Sustainable Energy Investment 2007*, published as collaborative of the United Nations Environment Programme (UNEP) Sustainable Energy Finance Initiative (SEFI) and New Energy Finance (UNEP/NEF 2007). Future editions of that report are contemplated. That report provides an alternate measure of sustainable energy investment, one that is more transaction-oriented and includes components that the \$71 billion estimate for 2007 cited in this report does not. The UNEP/NEF report shows \$75 billion of investment in "sustainable energy" during 2006 (and \$117 billion for 2007 estimated in an early-2008 update). This measure includes venture capital and private equity investments, capital raised on public markets, and R&D expenditures, as well as smaller amounts for other technologies like energy efficiency and fuel cells. Merger and acquisition activity is also contained in another UNEP/NEF aggregate total. Just considering new capacity investments, the UNEP/NEF number for 2006 for "asset financing" is approximately \$39 billion, which is the most directly comparable with the \$55 billion given in this report for 2006. Differences in methodology account for part of the discrepancy. The latest UNEP/NEF asset-financing estimate for 2007 was \$55 billion, comparable with the \$71 billion estimate in this report allowing for other factors. The UNEP/NEF report also gives \$7 billion in venture capital and private equity, and \$16 billion in R&D for 2006.

22. Clean Edge (2007); Pinto and Hunt (2007); New Energy Finance (2007). This report does not cover carbon finance or Clean Development Mechanism (CDM) projects. Renewable energy projects incorporating these financing vehicles were completed, ongoing, and planned in several countries.

23. Ibid.

24. Multilateral funding figures from World Bank (2007a), GEF (2007), and personal communication with Claudia Fersen, KfW, December 2007. See also Note N15 from the 2005 report edition and Endnote 8 of the 2006 report edition.

25. Ibid. World Bank total funding for renewables included \$150 million in carbon finance in fiscal year 2007, although this report does not cover carbon finance.

26. Ibid.

27. See 2005 report edition for further examples of financing programs in developing countries. The Brazil PROINFA program had added 850 MW by mid-2007, with another 950 MW under construction; of the total, 1,076 MW was small hydro, 514 MW biomass, and 216 MW wind (Porto 2007).

28. The methodology for this calculation is described in Endnote 10 of the 2006 report edition and Note N17 of the 2005 report edition. Annex 2 contains the updated list of companies. Sources include Bloomberg, MarketWatch.com, InvestGreen.ca, Investext, *Reuters*, and company data.

29. Sources include news reports and original research by report contributors. For examples of past sources and industry trends, see Notes N18 through N23 of the 2005 report edition.

30. New Energy Finance (2007).

31. Winds of caution could sometimes be felt, as price increases in 2005–2007 have hindered solar PV, wind, and biofuels. Solar PV has not declined from the \$3.00–3.50/watt range due to high demand and silicon feedstock shortages. Wind turbine costs actually rose, from $1,000–1,100/kW in 2003 to $1,500/kW or more in 2006, partly due to high prices for steel and fiberglass. Biofuels profit margins in the United States disappeared in 2006 as the price of corn doubled in just two years due in part to demand by ethanol producers. These could all be viewed as shortterm, as markets will adjust with increased capacity, but these cost trends still captured industry attention.

32. Global Wind Energy Council (2007); Emerging Energy Research (2007).

33. Global Wind Energy Council (2007); GreenHunter energy; Martinot and Li (2007).

34. *PV News* March, April, October, and December 2007; Photon Consulting (2007); Sarasin (2007).

35. *PV News* March, April, October, and December 2007; Sarasin (2007). Sarasin (2007) reports 200 MW of thin-film production in 2006, or 7.8 percent, while *PV News* reported only about 6 percent in 2006.

36. *Kingsman Biodiesel News*, 2 December 2007. See also *New Energy Finance* 124NS (2007) for examples of the difficulties recently faced by biofuels producers in some countries, including high feedstock prices, overcapacity, cheap imported ethanol from Brazil, and hesitant fulfillment of mandatory blending rules.

37. U.S. Renewable Fuels Association Web site, www.ethanolrfa.org, viewed 12 November 2007.

38. News articles; *New Energy Finance* issue 121NS; www.rangefuels.com; ir.verenium.com.

39. Sarasin (2007); news reports; submissions from report contributors. In the U.S. state of Nevada, the 64 MW "Solar One" plant came on-line and was expected to produce electricity at a cost of around 15–17 cents/kWh. In Spain, the 11 MW solar thermal plant (tower type) at the Sanlcar la Mayor (Sevilla) came on-line in early 2007. Construction of two additional solar thermal plants was scheduled to begin at the same site in Spain (20 MW and 50 MW), with the entire project planned for 300 MW by 2013.

40. For methodology of jobs estimate, see Annex 3 and also Note N24 of the 2005 report edition. Renner, Sweeny, and Kubit (2008, preliminary) provide a similar estimate of 2.3 million jobs globally, including 1.2 million for biofuels in the four leading biofuels-producing countries (figures include indirect jobs). The greatest uncertainties in jobs estimates concern biofuels, and there are also issues concerning the quality and social impacts of biofuels jobs. For the 2005 report edition, the jobs estimate was based on analytical factors for jobs-per-existing-capacity and jobs-per-unit-of-produced-capacity. Total jobs were based on existing capacity (i.e., operation and maintenance) plus newly manufactured/installed capacity (i.e., construction). There is also the issue of estimating "indirect jobs"—whose definition is not always clear. Biofuels jobs estimates based partly on parameters from the Brazil sugarcane association, which include some plantation-based jobs.

41. This section is only intended to be indicative of the overall landscape of policy activity. Policies listed are generally those that have been enacted by legislative bodies. Some of the policies listed may not yet be implemented, or are awaiting detailed implementing regulations. It is obviously difficult to capture every policy, so some policies may be unintentionally omitted or incorrectly listed. Some policies may also be discontinued or very recently enacted. The terms "targets" and "goals" are used loosely and interchangeably, as many different types of targets and goals exist, ranging from domestic planning to multi-lateral commitments, and it would be impossible to qualify them all properly. This report does not cover policies and activities related to technology transfer, capacity building, carbon finance, and Clean Development Mechanism projects, nor does it highlight broader framework and strategic policies—all of which are still important to renewable energy progress. For the most part, this report also does not cover policies that are still under discussion or formulation, except to highlight overall trends, particularly for developing countries where policy action is relatively newer. Policy information comes from a wide variety of sources, and particularly from unpublished submissions from report contributors. The on-line IEA Global Renewable Energy Policy and Measures database (http://renewables.iea.org) provides one of the most comprehensive sources of policy information. For details of policies and sources covered in past years, see Notes N25 through N35 of the 2005 report edition, and Endnotes 16 through 40 of the 2006 report edition. Details from policy submissions by report contributors compiled into Annex 4.

42. A new policy and market review by the IEA, building on the original 2004 book, is forthcoming in 2008 and will contain substantial policy details and experience for IEA countries.

43. Table R7: Other energy share targets not shown include Algeria (5 percent by 2020), Armenia (35 percent by 2020), Barbados (over 20 percent by 2012), Romania (11 percent by 2010 and 15 percent by 2015), Syria (4 percent by 2010 and 10 percent by 2020), and Uganda (61 percent by 2017). Czech Republic and Poland also have targets for 2010 (5–6 percent and 7.5 percent respectively), and Morocco was discussing targets. Existing shares of primary energy are for 2006; for most countries they come from IEA (2007b) *Renewables Information* (according to IEA method), and include traditional biomass, municipal solid waste, and large hydro. Shares of final energy are estimated for OECD countries using the following (preliminary) methodology (see also Annex 1): Share of final energy calculated by dividing total renewable energy final consumption by Total Final Consumption (TFC) in IEA energy balances available at www.iea.org for 2004, adjusted upwards for 2006 by the ratio of primary energy for 2006 vs. 2004 from BP (2007). Total renewables final consumption is the sum of four components: (1) renewable-produced electricity, (2) final heat consumption from renewables after transformation in heating and combined heat-and-power plants, (3) final direct consumption of solar heat, geothermal heat, municipal waste, biomass, and gas-from-biomass, and (4) final liquid biofuels consumption. Components 1–3 are available for 2006 from the IEA (2007b) *Renewables Information*, but not component 4, which is derived instead from Table R6. Power losses and self-consumption for renewable-produced electricity should be netted out but were ignored. Global share of final energy calculated using data from Figure 1 (see Endnote 1), plus TFC for 2005 from IEA (2007a) *Key World Energy Statistics*, adjusted to 2006. Final energy shares lower than primary energy shares for some countries may be due to a high share of biomass for electricity. Global final energy share is higher than primary energy share partly due to traditional biomass, which is entirely final energy consumption. German figures supplied separately from ZSW/Center for Solar Energy and Hydrogen Research.

44. Table R8: Other countries with electricity share targets not shown are Croatia (5.8 percent by 2010 excluding large hydro) and Moldova (2.5–3 percent). Israel also has a 2 percent target by 2007 and Egypt also has a 3 percent target by 2010. Existing shares are IEA preliminary estimates for 2006 given in *Renewables Information 2007.* Japan's target also excludes geothermal. In Canada and the United States, provinces and states have individual de facto targets in the form of renewable energy portfolio standards; see

Table R11. Morocco was discussing targets for share of energy and electricity. Sources for targets: submissions by report contributors; see also Note N25 from 2005 report edition.

45. Sidebar 1: Rather than count primary or final energy shares, many targets use the share of electricity from renewables instead. (See Table R8 and Figure 2.) This avoids the need to choose a method of counting energy, although it does not capture the contributions made from heating and transport fuels. With the IEA method, the IEA assumes a 33 percent power plant efficiency for nuclear, when counting primary energy associated with nuclear electricity. With the BP method, BP assumes a 38 percent power plant efficiency when counting primary energy associated with both nuclear and hydro. The difference between these assumed efficiencies can cause discrepancies when trying to reconcile IEA and BP statistics for primary energy. There is also the issue of whether traditional biomass is counted in the primary energy total, which if so lowers the shares of hydro and nuclear (because total primary energy is higher). And there is the issue of whether or not small hydro is included in the hydro share. With all of these methodological differences and options, the shares for nuclear and hydro in reported statistics can vary. Thus, exact figures are not given in Sidebar 1 to avoid confusion. See Endnote 43, Annex 1, and Martinot et al. (2007) for further methodological details for calculating shares of primary and final energy.

46. In contrast to the burden sharing associated with the final energy target, the transport fuels target applies the same 10 percent share to every country equally. And the transport fuels target is binding only if production proves "sustainable" and only if second-generation biofuels become commercially available. A 2007 EC "green paper" on market-based mechanisms for energy- and environment-related policy emphasizes that future biofuels development should avoid unsustainable forms in favor of second-generation biofuels. See *Greenprices* 36 (2007).

47. China finalized its "Medium and Long-term Renewable Energy Development Plan" in September 2007 and issued a final set of targets through 2020. The share of total primary energy by 2020 was revised slightly downward, to 15 percent, from a previously discussed 16 percent. See Martinot and Li (2007).

48. Eighteen new countries were added to the list of countries with renewable energy targets since the 2005 report edition: Algeria, Argentina, Armenia, Barbados, Bulgaria, Croatia, Iran, Jordan, Mexico, Moldova, Morocco, Nigeria, Pakistan, Romania, Senegal, Syria, Tunisia, and Uganda. (See Tables R7–R9 for target details.) The year of enactment is unclear for some of these and the status of targets in Iran and Mali is uncertain. Uganda announced in 2007 a comprehensive set of targets for renewables in 2012 and 2017, including for power generation, rural electrification, rural productive uses, solar hot water, and biofuels (see Ministry of Energy and Mineral Development 2007). Egypt expects wind power to grow by at least 500 MW per year starting in 2011; there were also separate targets for 750 MW solar thermal power capacity by 2017. India's proposed goals now specify enhanced use of solar hot water in hotels, hospitals, and similar uses by 2022, 10 years earlier than previously stated goals. New short-term targets in India by 2012 include maximal use of cogeneration in the sugar and other biomass-based industries. Bulgaria is included by virtue of its EU ascension, although specific targets were not available.

49. The U.S. national feed-in law was the Public Utility Regulatory Policy Act (PURPA), although some analysts do not consider PURPA to have been a true national feed-in law. Several states actively implemented PURPA but most discontinued implementation in the 1990s. In general, feed-in tariffs vary significantly in design from country to country (see Mendonca 2007). Some policies apply only to certain technologies or maximum capacity. Most policies establish different tariffs for different technologies, usually related to the cost of generation, for example distinguishing between off-shore and on-shore wind power. Some policies also differentiate tariffs by size of plant, location/region, year of initial plant operation, and operational season of the year. Tariffs for a given plant may decline incrementally over time, but typically last for 10–20 years.

50. Details of feed-in tariffs for the countries mentioned are provided in Annex 5, including price levels, eligible capacity ranges, time periods, special rules, and further expectations. Some tariffs are based on more complicated formulas, such as Spain's tariff for solar PV, which is derived from a multiple of mean conventional electricity prices over specified time periods. See Mendonca (2007) for a comprehensive treatment of feed-in tariffs. First year feed-in tariffs for a survey of 10 countries by Gipe (2007) show feed-in prices for wind power in the range 7–11 cents/kWh, for solar PV in the range 37–74 cents/kWh, and for biomass in the range 8–23 cents/kWh. The survey was for Austria, Brazil, California, the Czech Republic, France, Germany, Italy, Minnesota, Ontario, Portugal, South Korea, Spain (less than 50 MW), Turkey, and Washington State. See also *EurObserver* 178 (2007).

51. Ibid. Germany was considering lower solar PV feed-in tariffs for 2009 than provided in current law, which might lead to an accelerated market in 2008 in advance of the decreases. Spain faces a similar phenomenon, since it reached its program cap in September 2007 (85 percent of 400 MW), with the existing tariff only valid for systems installed through September 2008. Expectations were for lower tariffs (but a larger cap) after that. Italy terminated its existing program in 2006 and then adopted a new program that led to an acceleration of installations. An added 20 MW is expected in 2007, following 11 MW in 2006. France increased incentives for solar PV due to lower-than-expected installations; an added 15 MW is expected in 2007, following 6 MW in 2006. Greece adopted a new renewable energy law in 2007 that improves feed-in tariff conditions. Korea's solar PV program also includes R&D support, targets for homes and public buildings, loans, and local government support. India now provides a subsidy of 12 rupees/kWh for solar PV and 10 rupees/kWh for CSP, limited to 10 MW in each state.

52. For details on the Netherlands, see *Greenprices* 27 (2006) and 39 (2007).

53. In the United States, there are four additional states with policy goals that are not legally binding renewable portfolio standards: Missouri, North Dakota, Vermont, and Virginia. New RPS targets enacted during 2006/2007 are Illinois (10 percent by 2015 and 25 percent by 2025), New Hampshire (25 percent by 2025), North Carolina (12.5 percent by 2018), Oregon (25 percent by 2025), and Washington (15 percent by 2020). In addition, New Mexico and Colorado both doubled their existing targets to reach 20 percent by 2020; Nevada will reach 20 percent by 2015; Minnesota will attain 25–30 percent by 2020–2025; and Maryland added a 2 percent solar PV requirement by 2022 that could result in 1.5 GW of added capacity. See Wiser et al. (2008) for more details on U.S. RPS policies. In Canada, British Columbia targets 50 percent from clean energy; Alberta and Manitoba target 900 MW and 1,000 MW of wind power, respectively; Ontario RPS is 5 percent by 2007 and 10 percent by 2010; Quebec targets 4,000 MW of wind by 2015; New Brunswick RPS is 10 percent by 2016 and 400 MW of wind by 2016; Nova Scotia RPS is 5 percent by 2010 and 20 percent by 2013; Newfoundland/Labrador targets 150 MW of wind; and Prince Edward Island targets 15 percent by 2010 (achieved) and 100 percent by 2015.

54. See Martinot and Li (2007) for more on China's policies.

55. Awarded prices under China's concession policy have been low, however, in the range of 0.42–0.50 RMB/kWh (5.0–6.3 cents/kWh) during 2005 and 2006. Some observers believe not all awarded projects will actually be built given the low prices. See Martinot and Li (2007) for more on China's policies.

56. Solar PV tax credits and subsidy and rebate programs vary in design. Some specify maximum size limits, such as 10 kW. Some provide higher subsidies up to a capacity limit and lower subsidies beyond that limit. Some are capped at a total program monetary amount. Some apply to equipment cost but not installation cost. See Annex 6 for country-by-country details.

57. China's National Development and Reform Commission issued its "Plan on Enforcement of Utilization of Solar Energy Heating Nationwide" in 2007, which is expected to apply to hospitals, schools, and hotels; see Martinot and Li (2007). India's national codes are initially voluntary, but will later become mandatory.

58. São Paulo's solar collector mandate applies to all new residences with more than three bathrooms and all industrial and commercial buildings.

59. Biofuels policies from a wide variety of sources. See Kojima, Mitchell, and Ward (2007) for a good summary, and also *Greenprices* 42 (2007). California in 2007 adopted a new type of biofuels-related policy, a "low-carbon fuel standard" (LCFS) that targets a 10 percent reduction in the average carbon intensity of vehicle fuels by 2020. The United States at the federal level and European Commission have also been considering LCFS policies.

60. In addition to the policies mentioned, there are a growing number of international collaborations and initiatives with respect to biofuels, such as the International Biofuels Forum launched in 2007 with the participation of Brazil, the United States, China, India, the European Union, and South Africa to promote an international market; and a 2007 memorandum of understanding between Brazil and the United States on research for second-generation biofuels. For a recent analysis of biofuels trade policies and issues, see Kojima, Mitchell, and Ward (2007).

61. Recent sources of information on green power include RECS International (2005), *Greenprices* (2006), Brger (2007), www.recs.org, Association of Issuing Bodies (2007), Bird and Swezey (2006), Bird (2007), U.S. EPA Green Power Partnership (2007), GreenPower Accreditation Program (2007), and Whitmore and Bramley (2004).

62. Information on individual cities supplied by ICLEI-Europe, www.martinot.info/solarcities.htm, Worldwatch Institute, and Cathy Kunkel, Princeton University and visiting researcher at Tsinghua University. For more detailed descriptions and sources, see Note N35 from 2005 report edition, and 2007 Annex 7.

63. Many smaller regions, counties, and villages are also engaged in local renewable energy policies and programs. Some of these are aiming for or achieving 100 percent renewables use, including more than a dozen localities in Germany such as Juehnde in Lower Saxony. In Bavaria, six rural counties declared their intention to become 100 percent energy autonomous by 2035.

64. At the city level, however, such target setting is complicated by industrial production, as emissions from industry are not necessary attributable to residents of the city. There are a growing number of "100 percent cities" that target full consumption supplied by renewables, such as the Germany cities of Emden, Kassel, Nuremberg, and Wolfhagen.

65. The World Mayors and Local Governments Climate Protection Agreement builds on the existing commitments of local governments and their associations, including the ICLEI Cities for Climate Protection Campaign, World Mayors Council on Climate Change, U.S. Mayors' Climate Protection Agreement, C40 Climate Leadership Group, and United Cities and Local Government (UCLG) Jeju Declaration. See www.iclei.org/climateagreement. The C40 Large Cities Climate Summit in the United States is not mentioned in the text because it is primarily aimed at helping cities finance energy efficiency improvements. The Australian Solar Cities program has now selected four cities: Adelaide, Blacktown, Townsville, and Alice Springs. ICLEI's Local Renewables Initiative began in 2005 and aims to create a network of model cities, with initial activities in Europe, India, and Brazil.

66. Progress with rural use of renewable energy is difficult to track comprehensively on a year-by-year basis, particularly traditional and modern biomass use, which continues to dominate rural energy consumption. Data collection is extremely time and people intensive. A comprehensive update of the rural energy section for this edition has not been possible. See Notes N36 to N44 of the 2005 report edition for original sources and data for much of the background information in this section.

67. Supplemented with data from Enda Energy (2006).

68. Ezzati and Kammen (2002). See also Note N37 from the 2005 report edition.

69. Improved biomass cook stoves are more properly considered a fuel-efficiency technology rather than a renewable energy production technology. Nevertheless, they are clearly a form of rural renewable energy use, one with enormous scope and consequences of use. Policies and programs to promote efficient stoves are therefore not renewable energy "promotion" policies, as is typical with other renewables covered in this report, but rather are designed to improve the health, economic, and resource impacts of an existing renewable energy use (and thus closely linked to sustainable forestry and land management). The number of existing and operating improved stoves may be significantly less than reported figures given here; for example, in India some estimates say a majority of stoves have passed their useful lifetimes and no longer operate. See AFRENPREN/FWD (2006). UNDP et al. (2000) *World Energy Assessment* discusses the environmental impacts, including greenhouse gases, of traditional biomass cookstoves.

70. Updates on China and India from Martinot and Li (2007) and from India Ministry of New and Renewable Energy (2007).

71. Figures include solar lanterns in India. Further details on solar home systems statistics and business-model characteristics can be found in Annex 8, Note N34 of the 2005 report edition, and Endnote 43 and associated text in the 2006 report edition. See also World Bank (2007a) for recent multilateral programs.

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