# RENEWABLES 2010
## GLOBAL STATUS REPORT










REN21 Renewable Energy Policy Network for the 21st Century


## Renewable Energy Policy Network for the 21st Century

REN21 convenes international multi-stakeholder leadership to enable a rapid global transition to renewable energy. It promotes 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. REN21 leverages their successes and strengthens their influence for the rapid expansion of renewable energy worldwide.

## REN21 Steering Committee



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## FOREWORD

Since the first edition of REN21's annual *Renewables Global Status Report* in 2005, the renewable energy sector has grown strongly and steadily. Even in 2009, when up against strong headwinds caused by the economic recession, low oil prices, and the lack of an international climate agreement, renewables managed to hold their own.

In 2009, governments stepped up efforts to steer their countries out of recession by transforming industries and creating jobs. This gave a boost to the renewable energy sector. By early 2010, more than 100 countries had some type of policy target and/or promotion policy related to renewable energy; this compares with 55 countries in early 2005. Wind power and solar PV additions reached a record high during 2009, and in both Europe and the United States, renewables accounted for over half of newly installed power capacity in 2009. More than $150 billion was invested in new renewable energy capacity and manufacturing plants—up from just $30 billion in 2004. For the second year in a row, more money was invested in new renewable energy capacity than in new fossil fuel capacity.

From the first 'Market Overview' section of this report to the 'Last Word' by Christopher Flavin, the picture here shows that renewable energy is reaching a tipping point and attaining great significance in the context of the global energy and climate situation. A remarkable development is the change in the geographic spread of renewable energy. And the adoption of renewable energy technologies is clearly no longer confined to the industrialized world—more than half of the existing renewable power capacity is now in developing countries.

The world has tapped only a small amount of the vast supply of renewable energy resources, despite the continuing upward trend of renewable energy growth and the positive achievements highlighted in this report. Policy efforts now need to be strengthened and taken to the next level in order to encourage a massive scale up of renewable technologies. That level of scale is needed to enable the renewables sector to play its critical role in building a long-term, stable, low-carbon global economy—one that promotes energy security, industrial development and competitiveness, local economic development and jobs, climate change mitigation, and universal access to energy.

Later this year, the Government of India's Ministry of New and Renewable Energy will host the 4th in a series of international renewable energy conferences that date back to 2004, and that bring together thousands of government representatives and stakeholders from around the world. The Delhi International Renewable Energy Conference (DIREC) 2010 will showcase broad, high-level commitment to the deployment of renewable energy as a key strategy for dealing with sustainable development, energy access, and climate change. For three days, government ministers and delegates from the private sector and civil society will exchange their visions, experiences, and solutions for accelerating the global scale-up of renewable energy. REN21 is pleased to be partnering with the Indian Government on organizing the DIREC and managing the DIREC International Action Programme (DIAP), which fosters voluntary actions, commitments, and targets for renewable energy policy in developed and developing countries.

The REN21 *Renewables Global Status Report* has grown significantly in size and richness over the past five years, and its production is a formidable challenge. Many institutions and individuals deserve special thanks: the German government and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) for financial and administrative support; the members of the REN21 Steering Committee for their guidance; the REN21 Secretariat for coordination and production; the 150 researchers and contributors; and the authors, led by Janet Sawin and Eric Martinot, for the huge task of pulling together and presenting all the data and trends in this unique synthesis.

This 2010 edition of the *Renewables Global Status Report* is being released together with its companion publication, the UNEP/SEFI report *Global Trends in Sustainable Energy Investment 2010*. The joint launch aims to draw attention to the inextricable link between policy and investment in driving the renewable energy sector forward.

REN21 is pleased and proud to present the *Renewables 2010 Global Status Report* to the global community.

Mohamed El-Ashry
*Chairman, REN21*

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## EXECUTIVE SUMMARY

Changes in renewable energy markets, investments, industries, and policies have been so rapid in recent years that perceptions of the status of renewable energy can lag years behind the reality. This report captures that reality and provides a unique overview of renewable energy worldwide as of early 2010. The report covers both current status and key trends. By design, the report does not provide analysis, discuss current issues, or forecast the future.

Many of the trends reflect the increasing significance of renewable energy relative to conventional energy sources (including coal, gas, oil, and nuclear). By 2010, renewable energy had reached a clear tipping point in the context of global energy supply. Renewables comprised fully one-quarter of global power capacity from all sources and delivered 18 percent of global electricity supply in 2009. In a number of countries, renewables represent a rapidly growing share of total energy supply—including heat and transport. The share of households worldwide employing solar hot water heating continues to increase and is now estimated at 70 million households. And investment in new renewable power capacity in both 2008 and 2009 represented over half of total global investment in new power generation.

Trends reflect strong growth and investment across all market sectors—power generation, heating and cooling, and transport fuels. Grid-connected solar PV has grown by an average of 60 percent *every year* for the past *decade*, increasing 100-fold since 2000. During the past five years from 2005 to 2009, consistent high growth year-after-year marked virtually every other renewable technology. During those five years, wind power capacity grew an average of 27 percent annually, solar hot water by 19 percent annually, and ethanol production by 20 percent annually. Biomass and geothermal for power and heat also grew strongly.

Much more active policy development during the past several years culminated in a significant policy milestone in early 2010—more than 100 countries had enacted some type of policy target and/or promotion policy related to renewable energy, up from 55 countries in early 2005. Many new targets enacted in the past three years call for shares of energy or electricity from renewables in the 15–25 percent range by 2020. Most countries have adopted more than one promotion policy, and there is a huge diversity of policies in place at national, state/provincial, and local levels.

Many recent trends also reflect the increasing significance of developing countries in advancing renewable energy. Collectively, developing countries have more than half of global renewable power capacity. China now leads in several indicators of market growth. India is fifth worldwide in total existing wind power capacity and is rapidly expanding many forms of rural renewables such as biogas and solar PV. Brazil produces virtually all of the world's sugar-derived ethanol and has been adding new biomass and wind power plants. Many renewables markets are growing at rapid rates in countries such as Argentina, Costa Rica, Egypt, Indonesia, Kenya, Tanzania, Thailand, Tunisia, and Uruguay, to name a few. Developing countries now make up over half of all countries with policy targets (45 out of 85 countries) and also make up half of all countries with some type of renewable energy promotion policy (42 out of 83 countries).

The geography of renewable energy is changing in ways that suggest a new era of geographic diversity. For example, wind power existed in just a handful of countries in the 1990s but now exists in over 82 countries. Manufacturing leadership is shifting from Europe to Asia as countries like China, India, and South Korea continue to increase their commitments to renewable energy. In 2009, China produced 40 percent of the world's solar PV supply, 30 percent of the world's wind turbines (up from 10 percent in 2007), and 77 percent of the world's solar hot water collectors. Latin America is seeing many new biofuels producers in countries like Argentina, Brazil, Colombia, Ecuador, and Peru, as well as expansion in many other renewable technologies. At least 20 countries in the Middle East, North Africa, and sub-Saharan Africa have active renewable energy markets. Outside of Europe and the United States, other developed countries like Australia, Canada, and Japan are seeing recent gains and broader technology diversification. The increasing geographic diversity is boosting confidence that renewables are less vulnerable to policy or market dislocations in any specific country.

One of the forces propelling renewable energy development is the potential to create new industries and generate millions of new jobs. Jobs from renewables now number in the hundreds of thousands in several countries. Globally, there are an estimated 3 million direct jobs in renewable energy industries, about half of them in the biofuels industry, with additional indirect jobs well beyond this figure.

Greatly increased investment from both public-sector and development banks is also driving renewables development, particularly from banks based in Europe, Asia, and South America. The European Investment Bank and the Brazilian Development Bank (BNDES) are notable cases. A number of development banks have increased development assistance flows. Such flows jumped to over $5 billion in 2009, compared with some $2 billion in 2008. The largest providers are the World Bank Group, Germany's KfW, the Inter-American Development Bank, and the Asian Development Bank. Dozens of other development agencies provide growing amounts of loans, grants, and technical assistance for renewables.

Other ongoing market and industry trends include:

**Wind power.** Trends include new growth in off shore development, the growing popularity of distributed, small-scale grid-connected turbines, and new wind projects in a much wider variety of geographical locations around the world and within countries. Firms continue to increase average turbine sizes and improve technologies, such as with gearless designs.

**Biomass power.** Biomass power plants exist in over 50 countries around the world and supply a growing share of electricity. Several European countries are expanding their total share of power from biomass, including Austria (7 percent), Finland (20 percent), and Germany (5 percent). Biogas for power generation is also a growing trend in several countries.

**Grid-connected solar PV.** The industry has been responding to price declines and rapidly changing market conditions by consolidating, scaling up, and moving into project development. Thin-film PV has experienced a rapidly growing market share in recent years, reaching 25 percent. A growing of number of solar PV plants are so-called "utility-scale" plants 200-kW and larger, which now account for one-quarter of total grid-connected solar PV capacity.

**Geothermal power.** Geothermal power plants now exist in 19 countries, and new plants continue to be commissioned annually—for example in Indonesia, Italy, Turkey, and the United States in 2009.

**Concentrating solar thermal power (CSP).** CSP emerged as a significant new power source during 2006–2010, after initial stalled development some two decades earlier. By early 2010, 0.7 GW of CSP was in operation, all in the U.S. Southwest and Spain, with construction or planning under way for much more capacity in many more countries.

**Solar hot water/heating.** China continues to dominate the world market for solar hot water collectors, with some 70 percent of the existing global capacity. Europe is a distant second with 12 percent. Virtually all installations in China are for hot water only. But there is a trend in Europe toward larger 'combi' systems that provide both water and space heating; such systems now account for half of the annual market.

**Biomass and geothermal heating.** Biomass heating markets are expanding steadily, particularly in Europe. Trends include growing use of solid biomass pellets, use of biomass in building-scale or community-scale combined-heat-and-power plants (CHP), and use of biomass for centralized district heating systems. Use of geothermal direct-use heat plants and ground-source heat pumps is also growing.

Globally, there exists some 500 gigawatts-thermal (GWth) of heating capacity from biomass (270 GWth), solar (170 GWth), and geothermal (60 GWth).

**Biofuels.** Corn ethanol, sugar ethanol, and biodiesel are the primary biofuels markets, although others like biogas for transport and other forms of ethanol are also significant. Corn accounts for more than half of global ethanol production, and sugar cane for more than one-third. The United States and Brazil accounted for almost 90 percent of global ethanol production. The second-generation biofuels industry has seen many research and pilot-production plants commissioned, most with some form of partial public funding.

## Highlights of 2009

The year 2009 was unprecedented in the history of renewable energy, despite the headwinds posed by the global financial crisis, lower oil prices, and slow progress with climate policy. Indeed, as other economic sectors declined around the world, existing renewable capacity continued to grow at rates close to those in previous years, including grid-connected solar PV (53 percent), wind power (32 percent), solar hot water/heating (21 percent), geothermal power (4 percent), and hydropower (3 percent). Annual production of ethanol and biodiesel increased 10 percent and 9 percent, respectively, despite layoffs and ethanol plant closures in the United States and Brazil.

Highlights of 2009 include:

- For the second year in a row, in both the United States and Europe, more renewable power capacity was added than conventional power capacity (coal, gas, nuclear). Renewables accounted for 60 percent of newly installed power capacity in Europe in 2009, and nearly 20 percent of annual power production.
- China added 37 GW of renewable power capacity, more than any other country in the world, to reach 226 GW of total renewables capacity. Globally, nearly 80 GW of renewable capacity was added, including 31 GW of hydro and 48 GW of non-hydro capacity.
- Wind power additions reached a record high of 38 GW. China was the top market, with 13.8 GW added, representing more than one-third of the world market—up from just a 2 percent market share in 2004. The United States was second, with 10 GW added. The share of wind power generation in several countries reached record highs, including 6.5 percent in Germany and 14 percent in Spain.
- Solar PV additions reached a record high of 7 GW. Germany was the top market, with 3.8 GW added, or

more than half the global market. Other large markets were Italy, Japan, the United States, Czech Republic, and Belgium. Spain, the world leader in 2008, saw installations plunge to a low level in 2009 after a policy cap was exceeded.

- Many countries saw record biomass use. Notable was Sweden, where biomass accounted for a larger share of energy supply than oil for the first time.
- Biofuels production contributed the energy equivalent of 5 percent of world gasoline output.
- Almost all renewable energy industries experienced manufacturing growth in 2009, despite the continuing global economic crisis, although many capital expansion plans were scaled back or postponed. Impaired access to equity markets, difficulty in obtaining finance, and industry consolidations negatively affected almost all companies.
- Nearly 11 GW of solar PV was produced, a 50-percent increase over 2008. First Solar (USA) became the first firm ever to produce over 1 GW in a single year. Major crystalline module price declines took place, by 50–60 percent by some estimates, from highs of $3.50 per watt in 2008 to lows approaching $2 per watt.
- Wind power received more than 60 percent of utility-scale renewables investment in 2009 (excluding small projects), due mostly to rapid expansion in China.
- Investment totals in utility-scale solar PV declined relative to 2008, partly an artifact of large drops in the costs of solar PV. However, this decline was offset by record investment in small-scale (rooftop) solar PV projects.
- Investment in new biofuels plants declined from 2008 rates, as corn ethanol production capacity was not fully utilized in the United States and several firms went bankrupt. The Brazilian sugar ethanol industry likewise faced economic troubles, with no growth despite ongoing expansion plans. Europe faced similar softening in biodiesel, with low production capacity utilization.
- "Green stimulus" efforts since late-2008 by many of the world's major economies totaled close to $200 billion, although most stimulus was slow to start and less than 10 percent of green stimulus funds was spent during 2009.

For more 2009 data and country rankings, see the Selected Indicators and Top Five Countries tables on page 13.

## A Dynamic Policy Landscape

Policies to promote renewable energy existed in a few countries in the 1980s and early 1990s, but policies emerged in many more countries, states, provinces, and cities during the past 15 years and especially during the period 2005–2010.

By 2009, over 85 countries had some type of policy target, up from 45 countries in 2005. Many national targets are for shares of electricity production, typically 5–30 percent, but range as high as 90 percent. Other targets are for shares of total primary or final energy supply (typically 10–20 percent), specific installed capacities of various technologies, or total amounts of energy production from renewables. Most recent targets aim for 2020 and beyond. Europe's target (20 percent of final energy by 2020) is prominent among OECD countries. Among developing countries, examples include Brazil (75 percent of electricity by 2030), China (15 percent of final energy by 2020), India (20 GW solar by 2022), and Kenya (4 GW of geothermal by 2030). Many targets also exist at the state, provincial, and local levels.

At least 83 countries have some type of policy to promote renewable power generation. The most common policy is the feed-in tariff, which has been enacted in many new countries and regions in recent years. By early 2010, at least 50 countries and 25 states/provinces had feed-in tariffs, more than half of these adopted only since 2005. Strong momentum for feed-in tariffs continues around the world as countries continue to establish or revise policies. States and provinces have been adopting feed-in tariffs in increasing numbers as well.

Renewable portfolio standard (RPS) policies, also called renewable obligations or quotas, have been enacted by 10 national governments and 46 state/provincial governments around the world. Most RPS policies require renewable power shares in the range of 5–20 percent, with many targets extending to 2020 and beyond.

Many other types of policies have been adopted, most often in combination. Some type of direct capital investment subsidy, grant, or rebate is offered in at least 45 countries. Investment tax credits, import duty reductions, and/or other tax incentives are also common policies at national and state/provincial levels. Capital subsidies and tax credits have been particularly instrumental in supporting solar PV markets, with new solar PV rooftop programs announced in several countries in 2009. Energy production payments, sometimes called "premiums," exist in a handful of countries. Countries continue to adopt public competitive bidding for fixed quantities of renewable power capacity. And net metering laws for distributed generation now exist in at least 10 countries and in 43 U.S. states.

Policies for solar and other renewable hot water and heating were adopted with increasing frequency during 2006–2010. A growing number of countries, states, and cities mandate solar hot water in new building construction, spanning all continents and economic development levels. In Europe, a new crop of policies supporting renewable heating has emerged in recent years, such as Germany's Renewable Heating Law, which requires 20 percent minimum heating from renewables in new residential buildings. And at least 20 countries, and probably several more, provide capital grants, rebates, VAT exemptions, or investment tax credits for solar hot water/heating investments.

Mandates for blending biofuels into vehicle fuels have been enacted in at least 41 states/provinces and 24 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 production subsidies are also common. In addition, biofuels targets or plans exist in more than 10 countries and the EU. These targets call for specific shares of transport energy from biofuels (e.g., 10 percent by 2020 in the EU) or total annual biofuels production (e.g., 130 billion liters/year by 2022 in the United States).

City and local governments around the world are also enacting renewable energy promotion policies. Hundreds of cities and local governments have established future targets for renewables; urban planning that incorporates renewables into city development; building codes that mandate or promote renewables; tax credits and exemptions; purchases of renewable power or fuels for public buildings and transit; innovative electric utility policies; subsidies, grants, or loans; and many information and promotion activities.

## Rural Renewable Energy

Renewable energy has an important role in providing modern energy access to the billions of people in developing countries that continue to depend on more traditional sources of energy. Some 1.5 billion people worldwide still lack access to electricity, and approximately 2.6 billion are reliant on wood, straw, charcoal, or dung for cooking their daily meals. A rural transition from traditional to more modern forms of energy is under way in households and small industries in many countries.

Renewable energy is playing a key role in this transition. In even the most remote areas, renewable energy technologies such as solar PV household systems, micro-hydro mini-grids, biogas digesters, biofuels engines, solar- and wind-powered water pumps, and solar water heaters are providing basic necessities of modern life, including lighting, cooking, communications, motive power, irrigation, water purification, and heating and cooling. Most renewable technologies can be employed in homes, schools, hospitals, agriculture, and small industry.

The number of rural households served by renewable energy is difficult to estimate, but runs into the tens of millions considering all forms of renewables. Micro-hydro configured into village-scale or county-scale mini-grids serves many of these. More than 30 million households get lighting and cooking from biogas made in household-scale digesters. An estimated 3 million households get power from small solar PV systems. Biomass cookstoves are used by 40 percent of the world's population, and a new generation of more-efficient "improved" biomass cook stoves has emerged over the years. These stoves are being manufactured in factories and workshops worldwide, and more than 160 million households now use them.



## SELECTED INDICATORS AND TOP FIVE COUNTRIES

| SELECTED INDICATORS | 2007 | 2008 | 2009 |
|---|---|---|---|
| Investment in new renewable capacity (annual) | 104 | 130 | 150 billion USD |
| Renewables power capacity (including only small hydro)[1] | 210 | 250 | 305 GW |
| Renewables power capacity (including all hydro) | 1,085 | 1,150 | 1,230 GW |
| Hydropower capacity (existing, all sizes) | 920 | 950 | 980 GW |
| Wind power capacity (existing) | 94 | 121 | 159 GW |
| Solar PV capacity, grid-connected (existing) | 7.6 | 13.5 | 21 GW |
| Solar PV production (annual) | 3.7 | 6.9 | 10.7 GW |
| Solar hot water capacity (existing) | 125 | 149 | 180 GWth |
| Ethanol production (annual) | 53 | 69 | 76 billion liters |
| Biodiesel production (annual) | 10 | 15 | 17 billion liters |
| Countries with policy targets | 68 | 75 | 85 |
| States/provinces/countries with feed-in policies[2] | 51 | 64 | 75 |
| States/provinces/countries with RPS policies | 50 | 55 | 56 |
| States/provinces/countries with biofuels mandates | 53 | 55 | 65 |

| TOP FIVE COUNTRIES | #1 | #2 | #3 | #4 | #5 |
|---|---|---|---|---|---|
| **Annual amounts for 2009** | | | | | |
| New capacity investment | Germany | China | United States | Italy | Spain |
| Wind power added | China | United States | Spain | Germany | India |
| Solar PV added (grid-connected) | Germany | Italy | Japan | United States | Czech Republic |
| Solar hot water/heat added[3] | China | Germany | Turkey | Brazil | India |
| Ethanol production | United States | Brazil | China | Canada | France |
| Biodiesel production | France/Germany | | United States | Brazil | Argentina |
| **Existing capacity as of end-2009** | | | | | |
| Renewables power capacity (including only small hydro) | China | United States | Germany | Spain | India |
| Renewables power capacity (including all hydro) | China | United States | Canada | Brazil | Japan |
| Wind power | United States | China | Germany | Spain | India |
| Biomass power | United States | Brazil | Germany | China | Sweden |
| Geothermal power | United States | Philippines | Indonesia | Mexico | Italy |
| Solar PV (grid-connected) | Germany | Spain | Japan | United States | Italy |
| Solar hot water/heat[3] | China | Turkey | Germany | Japan | Greece |

*Notes*: Rankings are based on absolute capacities and production; per-capita rankings would be quite different for many categories. [1]Renewables power capacity figures rounded to nearest 5 GW. Renewables power capacity (including only small hydro) counts small hydro < 10 MW; this is a change from prior versions of this report. Capacity figures would be higher for other definitions of small hydro with higher limits. Excluding small hydro entirely, rounded capacity figures would be 160 GW, 195 GW, and 245 GW, for years 2007 through 2009, respectively. [2]Feed-in policies total for 2009 also includes early 2010. [3]Solar hot water/heating numbers are for 2008. Many figures in the above table and throughout the report are rounded to two significant digits, so some totals may not exactly reflect underlying data due to rounding.

## 1. GLOBAL MARKET OVERVIEW

Renewable energy supplies 19 percent of global final energy consumption, counting traditional biomass, large hydropower, and "new" renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels).[1] (See Figure 1.) Of this 19 percent, traditional biomass, used primarily for cooking and heating, accounts for approximately 13 percent and is growing slowly or even declining in some regions as biomass is used more efficiently or is replaced by more modern energy forms. Hydropower represents 3.2 percent and is growing modestly but from a large base.*[2] Other renewables account for 2.6 percent and are growing very rapidly in developed countries and in some developing countries.

Renewable energy replaces conventional fuels in four distinct markets: power generation, hot water and space heating, transport fuels, and rural (off-grid) energy services. This section provides an overview of recent developments in the first three markets; rural energy is covered in Section 5 of the report.

Global renewable energy capacity grew at rates of 10–60 percent annually for many technologies during the five-year period from the end of 2004 through 2009. For many renewable technologies, such as wind power, growth accelerated in 2009 relative to the previous four years.[3] (See Figure 2.) More wind power capacity was added during 2009 than any other renewable technology. Grid-connected solar photovoltaic (PV), however, increased the fastest of all renewables technologies, with a 60-percent annual average growth rate for the five-year period. Biofuels also grew rapidly, at a 20-percent annual average rate for ethanol and a 51-percent annual average for biodiesel (reflecting its lower production levels), although growth rates began declining later in the period.

Other technologies—including hydropower, biomass power and heat, and geothermal power—are growing at more ordinary rates of 3–6 percent, making them comparable with global growth rates for fossil fuels (3–5 percent, although higher in some developing countries). In several countries, however, the growth in these other renewables technologies far exceeds the global average. (For a summary of the main renewable energy technologies and their characteristics and costs, see Table 1 on page 26.)

Figure 2. Average Annual Growth Rates of Renewable Energy Capacity, end-2004 to 2009

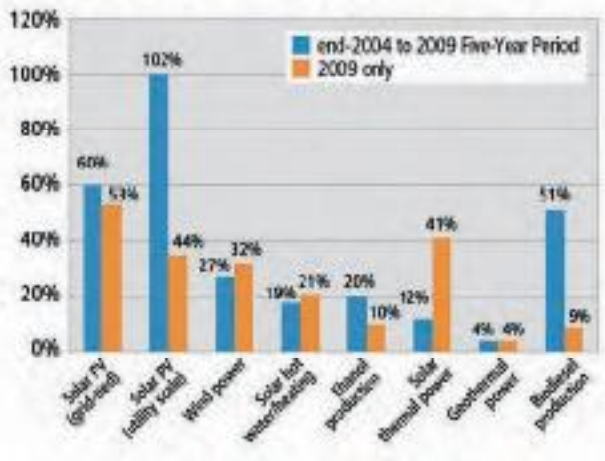
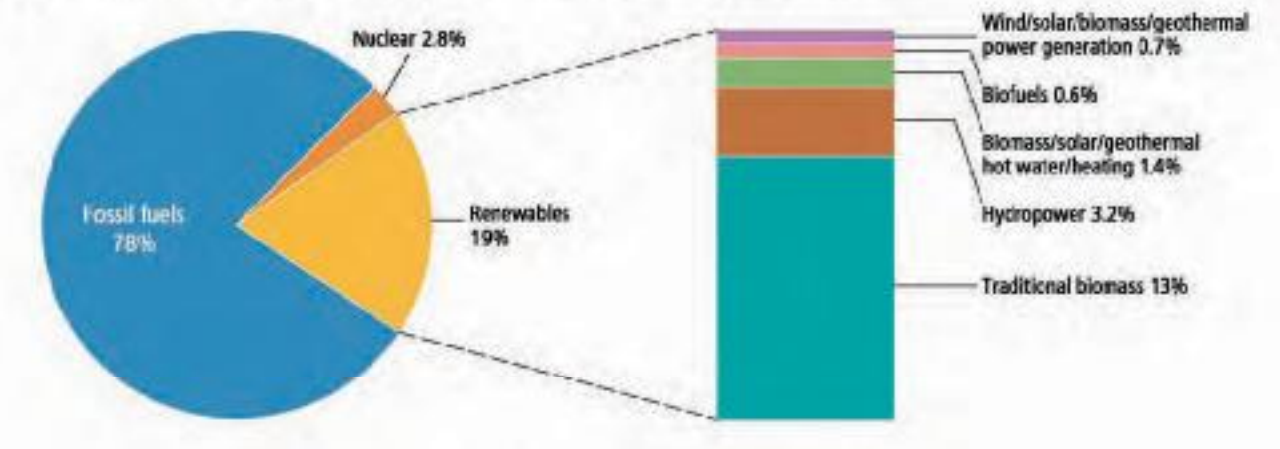



Figure 1. Renewable Energy Share of Global Final Energy Consumption, 2008




* In this report, global small hydropower data include plants of less than 10 MW in size. For further information on the treatment of hydropower in this report, see Endnote 2.

## Power Generation Markets

Existing renewable power capacity worldwide reached an estimated 1,230 gigawatts (GW) in 2009, up 7 percent from 2008. Renewable energy now comprises about a quarter of global power-generating capacity (estimated at 4,800 GW in 2009) and supplies some 18 percent of global electricity production.[4] (See Figure 3.) When large-scale hydropower is not included, renewables reached a total of 305 GW, a 22-percent increase over 2008.[5] (See Figure 4 and Table R4.) Among all renewables, global wind power capacity increased the most in 2009, by 38 GW. Hydropower has been growing annually by about 30 GW in recent years, and solar PV capacity increased by more than 7 GW in 2009.

Figure 3. Share of Global Electricity from Renewable Energy, 2008

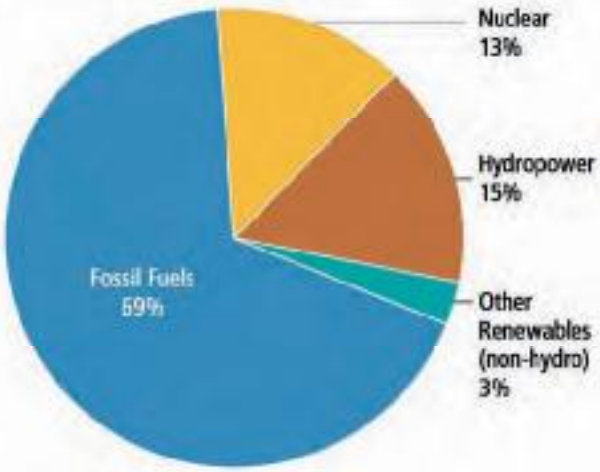
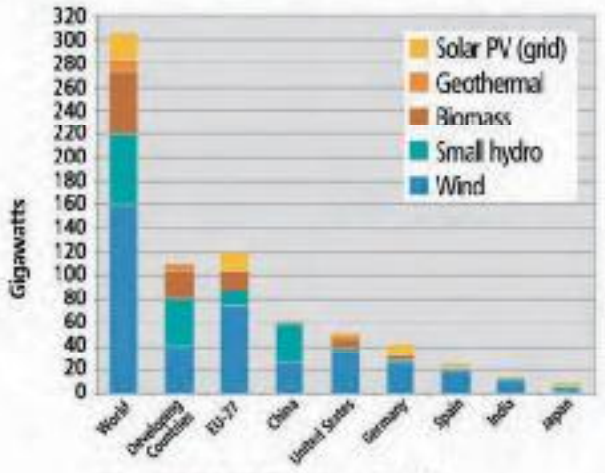



Figure 4. Renewable Power Capacities: Developing World, EU, and Top Six Countries, 2009




The top five countries for renewable power capacity in 2009, including small hydropower, were China, the United States, Germany, Spain, and India. When all scales of hydro are included, the top countries for total existing capacity were China, the United States, Canada, Brazil, and Japan. In the European Union, renewables accounted for more than 60 percent of newly installed capacity during 2009, and in the United States, wind power alone was the largest source of new capacity additions.[6] China added an estimated 37 GW of grid-connected renewable capacity in 2009, for a total of 226 GW.[7]

## Wind Power

Despite the global economic crisis, new wind power capacity installations in 2009 reached a record high of 38 GW. This represented a 41-percent increase over 2008 and brought the global total to 159 GW.[8] (See Figure 5 and Table R2.) Over the five-year period end-2004 to 2009, annual growth rates for cumulative wind power capacity averaged 27 percent. The capacity installed in 2009 is equivalent to nearly a quarter of total global installations, and cumulative capacity has doubled in less than three years.

China was the top installer in 2009, representing more than one-third of the world market.[9] (See Figure 6.) By comparison, China accounted for only about 2 percent of the market in 2004, when annual global installations were just over 8 GW.[10] China's wind power capacity surpassed the country's installed nuclear capacity in 2009, with just over 13.8 GW added to reach a total of 25.8 GW.[11] This means that China doubled its existing wind power capacity for the fifth year running in 2009.[12]

The United States added just over 10 GW of wind power capacity in 2009, enabling it to maintain its lead in existing capacity with a total of 35 GW.[13] As of the end of 2009, 14 U.S. states had more than 1 GW each of installed capacity.[14] Texas remained the leader with nearly 10 GW of cumulative capacity, enabling the state to reach its 2025 renewable energy target 15 years early.[15]

Germany continued to lead in Europe in existing capacity, adding 1.9 GW and ending the year slightly behind China with a total installed capacity just under 25.8 GW. But Spain topped the European market for new installations, adding 2.5 GW. Other major European players included Italy, France, and the United Kingdom, all installing more than 1 GW each.[16] India added 1.3 GW to maintain its fifth place position for existing capacity.[17]

Canada experienced a record year, adding 950 megawatts (MW), and for the first time all provinces (although not all territories) were generating electricity from wind.[18]

Figure 5. Wind Power, Existing World Capacity, 1996–2009

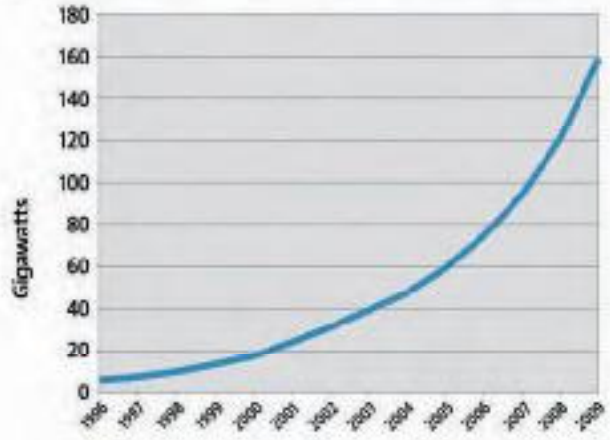
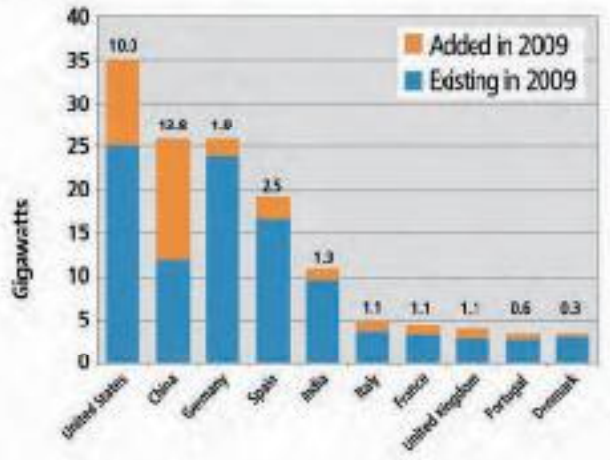



Figure 6. Wind Power Capacity, Top 10 Countries, 2009




Elsewhere, some of the most vibrant wind power markets were in Latin America and Africa, which saw significant growth rates, albeit relatively low capacity levels.[19] Both Kenya (5 MW added) and Nicaragua (40 MW added) joined the list of countries with commercial-scale wind power development. In all, at least 49 countries added capacity during 2009 and at least 82 countries now use wind energy on a commercial basis.[20]

The offshore wind industry is picking up speed, driven greatly by the declining availability of good onshore sites. The industry added 641 MW of capacity in 2009, representing a 72-percent increase over 2008 and bringing total existing offshore capacity to just over 2 GW.[21] Eleven countries had offshore wind farms by year-end. The vast majority of capacity remains in Europe, where the United Kingdom (883 MW) and Denmark (639 MW) retained the two top spots.[22] (The U.K. surpassed the 1 GW mark in April 2010 after two additional wind farms went on line.[23])

China installed the first major offshore wind project outside of Europe in 2009, adding 63 MW by year-end for a project that reached 102 MW upon completion in early 2010.[24] Japan added 1 MW in 2009.[25] In Europe, another 1 GW could be completed during 2010, a further 2.5 GW was under construction by early in the year, and an additional 16 GW had achieved full approval.[26] Although the United States began no new offshore wind projects during 2009, more than 10 were at various stages of development, and the 420 MW Cape Wind project off the Massachusetts coast won final approval in April 2010.[27]

Another trend is the growing market for small-scale wind systems*—not only systems off the grid, which have been popular from the United States to China in years past, but also distributed grid-connected projects. Although global sales in 2009 were relatively low from a capacity perspective, small, grid-connected turbines are increasingly popular in Europe. The United Kingdom has historically been the second largest market after the United States, representing 20–25 percent of global demand.[28] The U.K. added an estimated 4,500 small wind turbines in 2009, for a total of some 15,000.[29] There is also rising interest in Italy, where small turbines are seen as offering "made in Italy" potential.[30] Driven largely by residential demand, the U.S. market grew 15 percent in 2009, with 20 MW added through an estimated 10,000 units (comprising at least 10 percent of all small turbines and 20 percent of capacity installed since 1980).[31] China remained the largest market for small wind turbines, reportedly adding about 50,000 in 2009 for a total of some 400,000 installed by year-end.[32]

In both Europe and the United States, wind power accounted for 39 percent of all new electric generating capacity in 2009—more than any other generating technology for the second year in a row.[33] Several countries now meet a significant share of their electricity demand with the wind, including Denmark (20 percent); Spain (14.3 percent, where wind overtook coal for the first time in 2009); Portugal (11.4 percent in 2008); Ireland (9.3 percent in 2008); and Germany (6.5 percent in 2009).[34] In addition, four German states generated well over 30 percent of their power needs with wind in 2009.[35] The state of Iowa led in the United States, obtaining 14 percent of its electricity from wind power, and Texas exceeded the 5 percent mark.[36]

Wind power will likely continue to expand at a brisk pace. There is new interest in Africa, with a 300 MW project

* Small-scale wind systems are generally considered to include turbines that produce enough power for a single home, farm, or small business. The American Wind Energy Association, for example, defines "small-scale" as less than 100 kW, but size can vary according to needs and/or laws of a country or state.

currently under construction in Kenya and wind projects in advanced stages in Ethiopia and Tanzania.[37] Projects are also under way in North Africa and the Middle East, and hundreds of additional megawatts of capacity are under construction in Argentina, Peru, and Uruguay.[38] Development is accelerating in India as well.[39] In China's Gansu province, construction began in 2009 on the first so-called "wind power base"; such projects are planned for six provinces and will total some 120 GW when completed.[40] According to the American Wind Energy Association, another 300 GW of new capacity is on hold in the United States due to transmission limitations.[41]

## Biomass Power

Biomass, derived from forestry, agricultural, and municipal residues as well as from a small share of crops grown specifically as fuel, is available in solid (e.g., straw or wood chips), liquid (e.g., vegetable oils and animal slurries that can be converted to biogas), and gaseous (biogas) forms. It is commonly used to generate both power and heat, generally through combustion, and some biomass can be converted to biofuels for transport (see later sections on Heating and Cooling Markets and Transport Fuel Markets). Biogas, a byproduct of fermenting solid and liquid biomass, can be converted by a combustion engine to heat, power, and transport.

Recent increases in biomass use for power production have been seen in a number of European countries and in some developing countries, including China and India. Globally, an estimated 54 GW of biomass power capacity was in place by the end of 2009.[42]

As of 2007, the United States accounted for more than 34 percent of electricity from solid biomass generated in OECD countries, with a total of 42 Terawatt-hours (TWh). Japan was the OECD's second largest producer, at 16 TWh, and Germany ranked third, with 10 TWh.[43] Although the U.S. market is less developed than Europe's, by late 2009 some 80 operating biomass projects in 20 states provided approximately 8.5 GW of power capacity, making the United States the leading country for total capacity.[44] Many U.S. coal- and gas-fired power plants are undergoing partial or even full conversion to biomass by "co-firing" fuels in conventional power plants.[45]

Germany and the United Kingdom also generate increasing amounts of electricity with solid biomass through co-firing, and the capacity of biomass-only plants is rising rapidly across Europe.[46] The region's gross electricity production from solid biomass has tripled since 2001.[47] By early 2010, some 800 solid biomass power plants were operating in Europe—burning wood, black liquor, or other biomass to generate electricity—representing an estimated 7 GW of capacity.[48] The largest scale and number of such plants are in the heavily wooded countries of Scandinavia, but Germany and Austria have also experienced significant growth in recent years.[49] Most of this increase in biomass capacity has resulted from the development of combined heat-and-power (CHP) plants.[50]

Just over half of the electricity produced in the European Union from solid biomass in 2008 was generated in Germany, Finland, and Sweden. Biomass accounts for about 20 percent of Finland's electricity consumption, and Germany is Europe's top producer.[51] Germany increased its generation of electricity with solid biomass 20-fold between 2002 and 2008, to 10 TWh, and had about 1,200 MW installed by the end of 2008.[52] By early 2010, bioenergy accounted for 5.3 percent of Germany's electricity consumption, making it the country's second largest renewable generating source after wind power.[53]

Biomass power has also grown significantly in several developing countries, including Brazil, Costa Rica, India, Mexico, Tanzania, Thailand, and Uruguay.[54] China's capacity rose 14 percent in 2009 to 3.2 GW, and the country plans to install up to 30 GW by 2020.[55] India generated 1.9 TWh of electricity with solid biomass in 2008.[56] By the end of 2009, it had installed 835 MW of solid biomass capacity fueled by agricultural residues (up about 130 MW in 2009) and more than 1.5 GW of bagasse cogeneration plants (up nearly 300 MW in 2009, including off-grid and distributed systems); it aimed for 1.7 GW of capacity by 2012.[57] Brazil has over 4.8 GW of biomass cogeneration plants at sugar mills, which generated more than 14 TWh of electricity in 2009; nearly 6 TWh of this total was excess that was fed into the grid.[58]

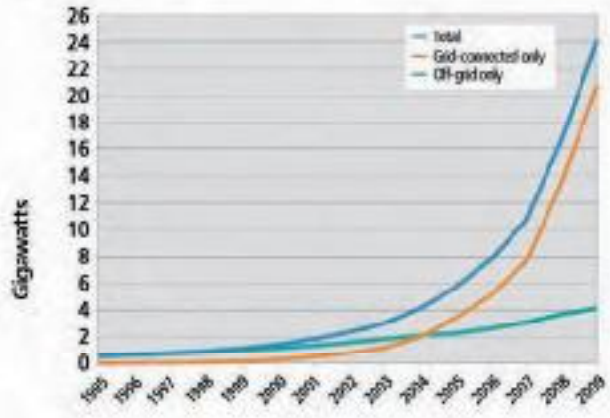
The use of biogas to generate electricity is on the rise as well, with production increasing an estimated 7 percent during 2008.[59] Biogas is used for electricity generation mainly in OECD countries, with some 30 TWh produced in the OECD in 2008.[60] But a number of developing countries also produce electricity with biogas, including Thailand, which nearly doubled its capacity in 2009 to 51 MW, and Malaysia, which is also seeing significant biogas power expansion.[61]

Germany passed the United States in biogas-generated electricity in 2007 and remained the largest producer in 2009; it is also the world's largest generator of electricity from liquid biomass, at 2.9 TWh in 2007.[62] The number of German biogas plants increased by 570 in 2009, to nearly 4,700, and associated capacity rose by 280 MW to 1.7 GW; total domestic production was an estimated 9–12 TWh of electricity.[63] In 2008, the most recent year for which data are available, the United States generated some 7 TWh with biogas, followed by the United Kingdom at 6 TWh and Italy at 2 TWh.[64]

## Solar Photovoltaic Power

Solar PV generates electricity in well over 100 countries and continues to be the fastest growing power-generation technology in the world. Between 2004 and 2009, grid-connected PV capacity increased at an annual average rate of 60 percent.[65] An estimated 7 GW of grid-tied capacity was added in 2009, increasing the existing total by 53 percent to some 21 GW (off-grid PV accounts for an additional 3–4 GW).[66] (See Figure 7 and Table R3.) This was the largest volume of solar PV ever added in one year and came despite a precipitous decline in the Spanish market relative to 2008. Solar PV accounted for about 16 percent of all new electric power capacity additions in Europe in 2009.[67]

Figure 7. Solar PV, Existing World Capacity, 1995–2009

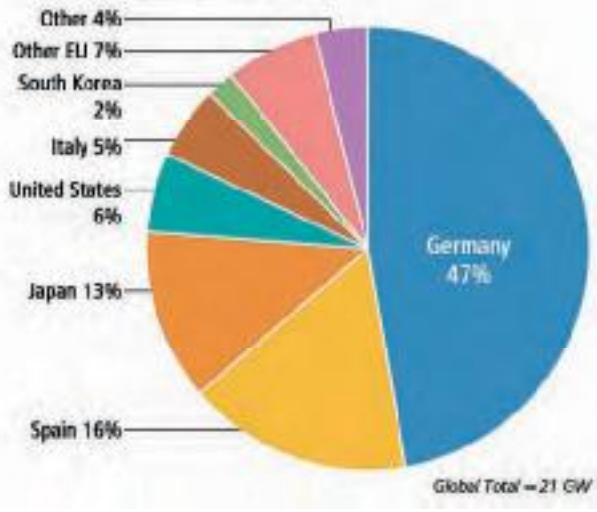



Cumulative global PV installations are now nearly six times what they were at the end of 2004. Analysts expect even higher growth in the next four to five years.[68] Thin film's share of the global market increased from 14 percent in 2008 to 19 percent in 2009 for cells, and from 16 to 22 percent for modules.[69]

Germany again became the primary driver of PV installations, more than making up for the Spanish gap with 3.8 GW added—about 54 percent of the global market. This was far above Spain's prior record-breaking addition of 2.4 GW in 2008, and brought Germany's capacity to 9.8 GW by the end of 2009, amounting to 47 percent of existing global solar PV capacity.[70] (See Figure 8.) While Germany has played a major role in advancing PV and driving down costs, its importance will decline as other countries step up their demand and reduce the industry's reliance on a single market.[71]

After its record-breaking year in 2008, the Spanish PV market plummeted to an estimated 70 MW added in 2009, due to a cap on subsidies after the national solar target was

Figure 8. Solar PV Existing Capacity, Top Six Countries, 2009




exceeded.[72] But there were other sunny spots in Europe. Italy came in a distant second after Germany, installing 710 MW and more than doubling its 2008 additions due to high feed-in tariffs and a good national solar resource; such strong growth is expected to continue.[73] Japan reemerged as a serious player, coming in third with 485 MW installed after reinstating residential rebates and introducing a buy-back program for residential rooftop systems.[74]

The United States added an estimated 470 MW of solar PV in 2009, including 40 MW of off-grid PV, bringing cumulative capacity above the 1 GW mark. California accounted for about half of the total, followed by New Jersey with 57 MW added; several other states are expected to pass the 50 MW per year mark in the near future.[75] Residential installations came to 156 MW, a doubling from 2008 thanks in part to removal of the $2,000 cap on the federal Investment Tax Credit and to a 10 percent drop in installed costs relative to 2008.[76]

Other strong markets included the Czech Republic, which saw a ninefold increase in total capacity relative to 2008—to 411 MW—thanks to generous feed-in tariffs for solar PV, although they are not likely to remain that high.[77] The country installed more new PV per capita than any other country except Germany.[78] It was followed by Belgium (292 MW), France (185 MW, with another 100 MW not grid-connected by year-end), and China (160 MW).[79]

The trend toward large-scale (greater than 200 kilowatt) PV plants continued around the globe, with the number of such plants exceeding 3,200 in 2009, up from roughly 2,450 the previous year. These facilities totaled some 5.8 GW of capacity, more than five times the 2007 capacity, and

accounted for more than a quarter of existing global PV capacity by year-end. The majority of these plants are operating in Spain, Germany, and the United States, although an increasing number are being installed in Asia and elsewhere.[80] A 950 kW system in Cagayan de Oro City in the Philippines is reportedly the largest in any developing country.[81] And a 250 kW system outside of Kigali in Rwanda is the largest grid-connected PV system in sub-Saharan Africa.[82] In the Middle East, installation of Saudi Arabia's first and largest PV system (2 MW) on the roof of King Abdullah University of Science and Technology was completed in May 2010.[83]

Even as the average size of PV projects increases, there is growing interest in very small-scale, off-grid systems, particularly in developing countries. These systems account for only some 5 percent of the global market, but sales and total capacity have increased steadily since the early 1980s.[84] In Africa, Asia, and Latin America, the hunger for modern energy is driving the use of PV for mini-grid or gridless systems, which in many instances are already at price parity with fossil fuels.[85] (See Section 5 on Rural Renewable Energy.) Several hundred megawatts of off-grid PV continue to be added globally every year, in both developed and developing countries.[86]

## Geothermal Power

Geothermal resources provide energy in the form of direct heat (see section on Heating and Cooling Markets) and electricity. Since 2004, significant additions of electric capacity have occurred in Indonesia, Iceland, New Zealand, the United States, and Turkey, with Turkey and Iceland each experiencing growth of more than 200 percent. Global capacity has increased 1.8 GW since 2004.[87] During 2009, the United States saw six new plants come on line—increasing domestic capacity by an estimated 181 MW, or 6 percent—followed by Indonesia (137 MW), Turkey (47 MW), and Italy (40 MW), for a total of at least 405 MW added.[88] While this was less than the 456 MW added in 2008, it was considerably larger than the 2007 market of 315 MW.[89] In addition, in the U.S. states of Louisiana and Mississippi, two projects were initiated to generate geothermal power with hot water produced by oil and gas wells.[90]

By the end of 2009, geothermal power plants operated in 24 countries and totaled approximately 10.7 GW of capacity, generating more than 67 TWh of electricity annually.[91] Nearly 88 percent of that capacity is located in seven countries: the United States (3,150 MW), the Philippines (2,030 MW), Indonesia (1,200 MW), Mexico (960 MW), Italy (840 MW), New Zealand (630 MW), and Iceland (at 580 MW, the leader on a per capita basis).[92] Iceland generates about 25 percent of its electricity with geothermal power, and the Philippines approximately 18 percent.[93]

As the geothermal market continues to broaden, a significant acceleration in installations is expected, with advanced technologies allowing for development of geothermal power projects in new countries.[94] As of early 2010, nearly 200 projects were under way in 15 U.S. states—which could result in at least 7.8 GW of new capacity—and much more capacity is in project pipelines around the globe.[95] As many as 70 nations had projects under development as of May 2010.[96] At least 11 countries that did not have operating geothermal power plants by early 2010—all in Europe and the Americas—are projected to add capacity by 2015, with the global total reaching 18.5 GW.[97] Additional projects are being planned or are under way in East Africa's Rift Valley in Kenya and in Eritrea, Ethiopia, Tanzania, and Uganda; the Geothermal Energy Association notes that 11 African countries are now working to produce geothermal power.[98]

## Concentrating Solar Thermal Power

After experiencing a stagnant market beyond the early 1990s, investments in new, commercial-scale concentrating solar thermal power (CSP) plants resumed in 2005. Global capacity—all in the United States and Spain—increased more than 70 percent between 2005 and the end of 2009, from 354 MW (all in the U.S. state of California) to about 610 MW, and had nearly doubled by March 2010 to 662 MW. Although the United States still accounted for 65 percent of total installations by early 2010, the Spanish market has driven most of the growth over the past few years. From March 2009 to March 2010, Spain added 220 MW of new CSP, for a total of 231 MW in operation, while the U.S. market grew only 7 MW, for a total of 431 MW.[99]

Dramatic changes are expected, however, and the United States will likely soon lead the global marketplace once again. At least two new U.S. facilities are expected to come on line in 2010, totaling more than 200 MW. And more than 8 GW of additional capacity is expected in six states, with most to be operational by 2014.[100] Worldwide, another 2.4 GW of capacity was being built or was under contract by early 2010; Spain accounted for the vast majority of this additional capacity.[101]

CSP is entering new markets as well. Small plants and research projects are currently under way in France, Germany, and elsewhere in Europe, and Italy could have 200 MW online by 2012.[102] A 100 MW commercial plant is planned in Abu Dhabi in the United Arab Emirates, and plants are under construction in Algeria, Egypt, and Morocco (20 MW each, all parabolic trough hybrid plants with natural gas) in connection with the Mediterranean Solar Plan.[103] In late 2009, financing was approved to help fund nearly 1 GW of capacity and associated transmission infrastructure in North Africa by 2020, and the Moroccan government announced plans to build 2 GW of CSP by

2020.[104] In early 2010, a deal was signed for at least 2 GW to be constructed in China by 2020, with installation of the first 92 MW to begin in 2010.[105]

The vast majority of CSP plants in operation rely on parabolic trough technology. But two power-tower plants went on line in 2009—a 20 MW plant in Spain, in addition to a previously existing 11 MW plant, and a 5 MW plant in California—and a 1.5 MW dish/engine plant began operating in Arizona in early 2010. Nearly half of the capacity in construction or under contract will use linear Fresnel, dish/engine, or power-tower technology. Storage technologies are also advancing. During 2009, the Andosol-I and Andosol-II trough plants in Spain both began operation with seven hours of thermal energy storage, which allow continued power generation after sundown, and Abengoa Solar's thermal energy storage test facility was operational.[106]

## Ocean Energy

Ocean energy is the least mature of the renewable energy technologies considered in this report, but interest is growing in a wide range of possible technologies. Ocean energy technologies for generating electricity include wave, tidal (barrages and turbines), and ocean thermal energy conversion (OTEC) systems. No commercial OTEC plants are currently in operation.

The 240 MW La Rance tidal barrage began generating power off the French coast in 1966, but ocean energy saw little further development for decades. Today, a handful of modern commercial projects are generating power, and numerous other projects are in development or under contract, from the coast of Ireland to Australia. An estimated 6 MW is operational or being tested in European waters (off the coasts of Denmark, Italy, the Netherlands, Norway, Spain, and the United Kingdom), with additional projects off the shores of Canada, India, Japan, South Korea, the United States, and elsewhere.[107] At least 25 countries are involved in ocean energy development activities.[108]

A 2.5 MW commercial wave plant was installed in Portuguese waters in 2008, with plans to expand total capacity up to 250 MW by 2020; an area has been set aside for future development of ocean energy in order to facilitate licensing.[109] During 2009, South Korea completed a 1 MW tidal-current plant and began construction of a 260 MW tidal plant.[110] Europe added at least 0.4 MW of ocean power capacity.[111] The United Kingdom is currently in the lead with at least 0.5 MW of wave capacity, 1.5 MW of tidal stream capacity, and a 1.2 MW tidal-current plant—the world's first commercial-scale tidal turbine to generate electricity for the grid, producing enough to power about 1,000 U.K. homes.[112] By late in the year, 58 MW of commercial-scale projects were being developed in U.K. waters, 27 MW of which had obtained planning permission.[113]

## Hydropower

Hydropower supplied 16 percent of global electricity production in 2008.[114] An estimated 31 GW was added in 2008, and a further 31 GW was added during 2009—an increase in capacity that was second only to wind power.[115] Global hydropower capacity reached an estimated 980 GW by the end of 2009, including 60 GW of small hydro.[116]

China has seen the greatest growth, nearly doubling its hydropower capacity during the five-year period of 2004–2009. The country added 23 GW in 2009 to end the year with 197 GW.[117] By late 2009, the United States had some 81 GW of hydro capacity, including 10 GW of small-scale plants, plus 19 GW of pumped storage.[118] Brazil had approximately 76 GW of capacity by early 2010.[119] Canada had more than 74 GW of hydropower capacity at the end of 2008 and about 4 GW of additional capacity under construction by early 2010.[120]

In Europe during 2009, conventional projects entered commercial operation in Norway (270 MW), the United Kingdom (100 MW), and Slovenia (43 MW), and Austria added 525 MW of pumped storage.[121] The 300 MW Tekezé dam in Ethiopia, Africa's tallest concrete arch dam (and taller than the Three Gorges dam in China) also began operation in 2009.[122] Many other developing countries continue to actively develop hydropower on large and small scales.[123] In un-electrified rural areas, small hydro is often used in autonomous or semiautonomous applications to replace diesel generators or other small-scale power plants.

Significant increases in hydropower capacity are in the project pipeline for 2011. Much new hydro development appears to be concentrated in Brazil, China, India, Malaysia, Russia, Turkey, and Vietnam.[124] India added nearly 130 MW of hydropower in 2009, for a total of more than 2.5 GW of small hydro, and total domestic hydropower capacity approached 37 GW by early 2010.[125] In Brazil, significant expansion is under way, with 8.8 GW under construction; most new capacity will come from large-scale projects, but a dramatic increase in smaller-scale projects is also expected.[126]

Hydropower expansion is expected in developed countries as well. In the United States, 10 GW of new capacity is proposed as a result of favorable policies, and the industry is reportedly planning to add up to 60 GW in coming years, mostly through repowering improvements and new technologies.[127] Supportive policies are also spurring growth in Canada.[128] And many utilities in Europe are upgrading existing facilities, with more pumped storage under

construction.[129] Worldwide, at least 15 pumped storage projects under construction in nine countries will add 8.8 GW of new capacity.[130] India expects to bring 400 MW of pumped storage capacity on line by 2012, and Eskom in South Africa is constructing a 1,350 MW pumped storage facility to be operational by 2013.[131]

## Heating and Cooling Markets

Biomass, solar, and geothermal energy currently supply hot water and space heating for tens of millions of buildings worldwide. Solar hot water collectors alone are used by more than 70 million households worldwide, most of them in China, as well as by many schools, hospitals, government, and commercial buildings.[132] There is also a growing trend to use renewable heating for process heat in industry. Biomass and geothermal energy supply heat for industry, homes, and agriculture, and interest in the use of solar energy for cooling purposes is increasing.

### Biomass Heating

Globally, biomass continues to provide the majority of heating produced with renewable sources. This includes heat derived from the burning of solid, liquid, and gaseous biomass for purposes ranging from cooking to heating water and space. Applications range from individual residential-scale units to large district-heating systems, including combined heat-and-power (CHP) plants.

Biomass heating markets are expanding steadily in Europe, particularly in Austria, Finland, Germany, the Netherlands, and Sweden, where energy requirements for heat are large. Expansion is driven greatly by concerns about fossil fuel prices and the security of supply.[133] Sweden, Finland, and Denmark lead the European biomass heating market, together producing more than two-thirds of all biomass heating sold in the region.[134] In Sweden, biomass is now the primary energy source for the district heat sector, in addition to being used for power generation and transportation; in 2009, for the first time, biomass's share of energy production in Sweden exceeded that of oil, 32 to 31 percent.[135]

Domestic heating, whether through small appliances or district heat systems, now accounts for the majority of solid biomass sold in Europe.[136] And the use of biomass for district heating and CHP provides about 67 percent of all biomass heat sold in Europe.[137] CHP has been increasing in Austria, the Czech Republic, France, Germany, Latvia, and Sweden, among others, and Denmark generates an estimated 10 percent of its power and a large share of its heat from biomass in CHP plants.[138]

Biomass pellets are becoming an increasingly common fuel, with about 7.5 million tons consumed in Europe in 2008—up 25 percent since 2005.[139] In Belgium and the Netherlands, pellets are used mainly for electricity generation; in Sweden and Denmark, they are burned mostly for CHP; elsewhere, they are used widely to heat residential and commercial buildings. Italy, Germany, and France are experiencing some of the fastest annual growth rates in pellet use for heating (20–27 percent), with a rapid rise in sales of pellet-burning heating appliances.[140] Household wood heating is also increasingly popular beyond Europe. In the United States, an estimated 800,000 households use wood as their primary heat source.[141]

Among developing countries, it is common to produce small-scale power and heat from agricultural waste such as rice or coconut husks.[142] The use of bagasse (sugar cane after juice extraction) for power and heat production is significant in countries that have a large sugar industry, including Argentina, Australia, Brazil, China, Colombia, Cuba, Guatemala, India, Kenya, Mauritius, the Philippines, Tanzania, Thailand, and Uganda.[143]

### Solar Heating and Cooling

Solar hot water technologies are becoming widespread and contribute significantly to hot water production in several countries. China, Germany, Turkey, Brazil and India led the market for newly installed capacity during 2008, and China, Turkey, Germany, Japan, and Greece led total installations by the end of that year.[144] (See Figures 9 and 10, and Table R5.)

Figure 9. Solar Hot Water/Heating Existing Capacity, Top 10 Countries/Regions, 2008

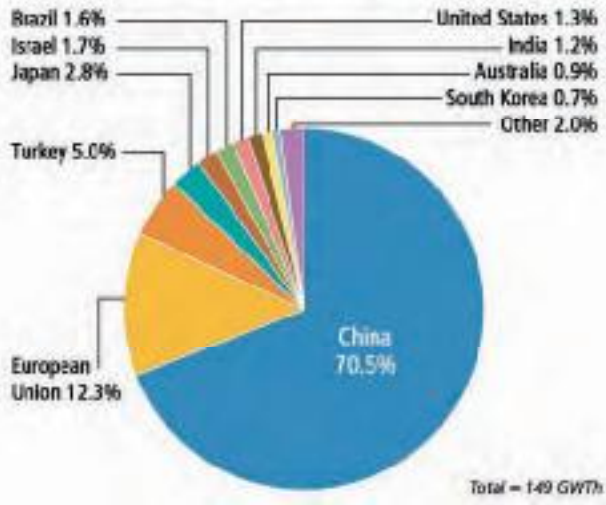
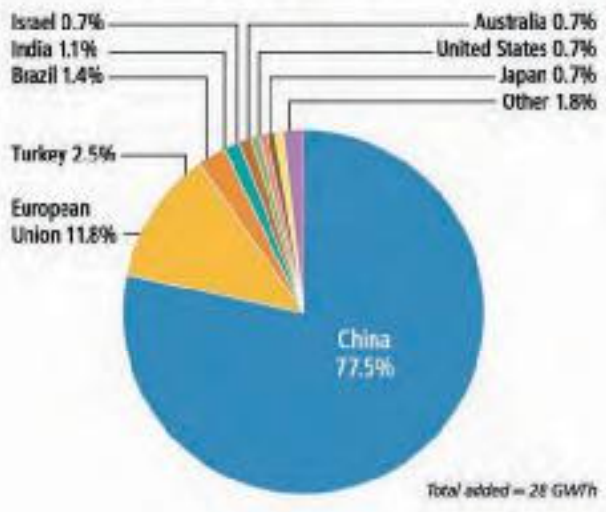


Figure 10. Solar Hot Water/Heating Capacity Added, Top 10 Countries/Regions, 2008




In 2009, existing solar water and space heating capacity increased by an estimated 21 percent to reach about 180 gigawatts-thermal (GWth) globally, excluding unglazed swimming pool heating.[145] China alone added more than 29 GWth, or about 42 million square meters—an increase of 34 percent over its 2008 additions and representing more than 80 percent of the global market. Chinese demand was driven in large part by the central government's program of "home appliances going to the countryside," which accounted for about 58 percent of newly installed capacity.[146]

The European Union accounted for most of the remaining global added capacity, installing an estimated 2.9 GWth (about 4 million square meters) in 2009. Although the European market was stronger than in any year prior to 2008, it was down 12 percent in 2009.[147] Germany's new installations were slightly lower in 2009, after a record year in 2008, at an estimated 1.1 GWth (1.6 million square meters. This brought its total domestic capacity to about 9 GWth (12.6 million square meters), with annual solar heat output increasing by 14 percent to 4.7 gigawatt-hours (GWh).[148] Markets also declined in France, Greece, Italy, and Spain relative to 2008 due to the economic crisis, but many smaller markets experienced significant growth in 2009. And while Germany remains Europe's largest installer, its importance is declining as others step up installations and as new markets emerge due in large part to supportive policies in an increasing number of countries.[149]

There is some evidence that the Turkish solar heating market is shrinking due to lack of government support, a VAT tax on solar thermal systems, and the introduction of new natural gas pipelines.[150] At the same time, use of solar thermal in remote villages in Turkey is increasing rapidly thanks to zero-interest government loans.[151] In India, an estimated 20,000 solar hot water systems are installed each year.[152] Brazil's capacity increased 14 percent in 2009, bringing total existing capacity to nearly 3.7 GWth (5.2 million square meters).[153] The U.S. market for solar hot water systems (excluding unglazed swimming pool heating) is still relatively small but is gaining ground—especially in California—and total capacity increased 10 percent in 2009 to some 2.1 GWth.[154] Interest is also up in Africa, with markets expanding in Ethiopia, Kenya, South Africa, Tunisia, and Zimbabwe, among others.[155]

On a per capita basis, Cyprus remained the world solar heating leader as of the end of 2008, with 527 kilowatts-thermal (kWth) per 1,000 inhabitants, followed by Israel (371 kWth), where more than 80 percent of households heat their water with the sun.[156] Austria, which had 285 kWth per 1,000 inhabitants in 2008, remains the leader in continental Europe.[157] Palestine has the highest installed capacity across the Middle East and North Africa region: about 68 percent of all households use solar water heaters, which are routinely installed on new buildings.[158]

Solar space heating is gaining ground as well. In Europe, about 50 percent of the solar collector area added annually now serves space heating applications as well as water heating. The focus is on larger systems for multi-family dwellings, hotels, and district heating, with the largest system in Denmark at 12.5 megawatts-thermal (MWth), or 18,000 square meters.[159] In contrast, fewer than 5 percent of systems in China provide space heating in addition to hot water.[160]

The market for solar-assisted cooling remains small to date but is growing quite rapidly, particularly in Europe where demand has risen 50–100 percent annually over the past five years. By the end of 2008, an estimated 450–500 systems were in operation worldwide, most of them in Europe.[161] An increase in sales of small-sized systems has been observed in recent years, mostly in Spain and other southern European countries. In general, data on such systems are limited.[162]

## Geothermal Direct Use

Direct use of geothermal energy continued to grow faster than geothermal power, with average annual growth rates exceeding 12 percent since 2005. Global capacity reached an estimated 51 GWth at the end of 2009.[163] Since 2005, heat output has increased by just below 10 percent annually on average, reaching 122 GWh in 2009.* Ground-source heat pumps, at 35 GWth, accounted for some 70

* Output per unit of capacity is declining as the share of heat pumps (which have a relatively low capacity factor) rises. This is due to the fact that heat pumps generally have fewer load hours than other uses. Heat use is estimated with a coefficient of performance of 3.5.

percent of global capacity and nearly 50 percent of direct heat use in 2009. Almost 25 percent of geothermal direct heat was used for bathing and swimming, more than 14 percent for heating (primarily district heat), and the remainder for greenhouses, industrial purposes, aquaculture pond heating, agricultural drying, snow melting, cooling, and other uses.[164]

At least 78 countries used direct geothermal energy by early 2010, up from 72 in 2005 and 58 in 2000. The United States leads the world for installed capacity, with just under 13 GWth, followed by China (9 GWth), Sweden (4.5 GWth), Germany (4.2 GWth, including 4.1 GWth from heat pumps and 0.1 GWth deep geothermal for district and building heat), and Norway (3.3 GWth).[165] These five countries account for 60 percent of global capacity. Due to the high share of heat pumps in the United States, China leads in actual annual energy production at 21 TWh, followed by the United States (16 TWh), Sweden (13 TWh), Turkey (10 TWh), and Japan (7 TWh). However, when average annual energy use per person is considered, Iceland, Sweden, Norway, New Zealand, and Switzerland lead the way.[166] About 90 percent of Iceland's heating is derived from geothermal resources.[167]

Installed heat pump capacity has more than doubled since 2005, with use increasing from 33 countries in 2005 to 43 in 2009.* Most installations are in the United States, China, and Europe.[168] The United Kingdom, the Netherlands, South Korea, Norway, and Ireland have seen the largest increases in installed capacity of direct-use geothermal since 2005, with heat pumps accounting for all additions.[169]

## Transport Fuel Markets

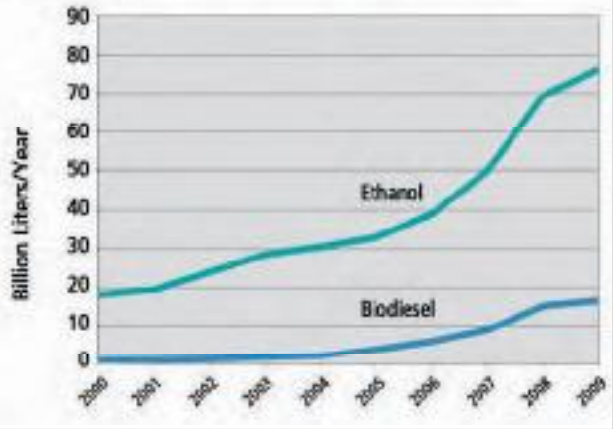
Biofuels for transport include ethanol, made primarily from corn and sugar cane, and biodiesel, produced from vegetable oils. Corn accounts for more than half of global ethanol production, and sugar cane for more than one-third. Almost all global production to date has been first-generation biofuels.† Biogas is also being used in very limited quantities for transportation in Sweden and elsewhere to fuel trains, buses, and other vehicles.[170]

Biofuels make small but growing contributions to fuel usage in some countries and a very large contribution in Brazil, where ethanol from sugar cane replaces 50 percent of gasoline for transport.[171] The United States is the world's largest producer of biofuels, followed by Brazil and the European Union.‡[172] Despite continued increases in production, growth rates for both ethanol and biodiesel have slowed considerably in 2009.

### Ethanol

In 2009, production of fuel ethanol reached an estimated 76 billion liters, an increase of 10 percent over 2008.[173] (See Figure 11 and Table R6.) The United States and Brazil accounted for 88 percent of global ethanol production in 2009. Most of the increased production occurred in the United States, with significant increases also in Canada, Germany, and France; production in Brazil declined. Both Belgium (up 230 percent) and the United Kingdom (up 160 percent) saw significant expansions, although their totals (120 million liters and 110 million liters, respectively) remained relatively low. Other countries that produce sizable volumes of fuel ethanol include Australia, Belgium, China, Colombia, India, Spain, and Thailand.[174]

Figure 11. Ethanol and Biodiesel Production, 2000–2009




After a significant downturn in the U.S. fuel ethanol market in 2008, U.S. production rose 16 percent to about 41 billion liters in 2009, accounting for approximately 54 percent of global ethanol production.[175] According to one estimate, U.S. ethanol (which is mostly corn-based) displaced more than 360 million barrels of imported oil for gasoline production.[176]

The highest sugar prices in years, combined with adverse weather conditions in a major producing region, resulted in a drop in Brazil's ethanol production from 27.1 billion liters in 2008 to 26.3 billion liters in 2009.[177] Almost all ethanol produced in Brazil is from sugar cane, with a very small

* Some of this increase could be due to better reporting of statistics.
† The environmental, social, and other costs of biofuels, including lifecycle greenhouse gas emissions, can be significant without safeguards, and vary according to several factors including feedstock, land use changes, and refining processes. In general, ethanol made from corn has higher associated environmental impacts than that made from cane sugar. For more information and efforts to improve the sustainability of biofuels production and use, see Sidebar 7.
‡ Note that there is a difference between production of biofuels (or any bioenergy) feedstock and the fuel itself. Some countries produce a significant amount of biofuel but import much of the feedstock from elsewhere.

amount from corn. All fueling stations in Brazil sell both pure ethanol and gasohol, a 25 percent ethanol/75 percent gasoline blend. Flex-fuel cars, which can use pure ethanol, gasoline, or any blend of the two, provide the flexibility to choose fuel based on price at the pump. They have been widely embraced by drivers and represent more than 95 percent of all new cars sold in Brazil.[178]

In recent years, significant global trade in fuel ethanol has emerged, with Brazil being the leading exporter. However, Brazilian ethanol export declined by almost 31 percent in 2009.[179] International demand declined in great part because of the global economic crisis.[180]

## Biodiesel

Biodiesel production increased 9 percent in 2009, to 16.6 billion liters globally; this compares to a five-year average (end-2004 through 2009) of 51 percent. Biodiesel production is far less concentrated than ethanol, with the top 10 countries accounting for just under 77 percent of total production in 2009.[181]

The European Union remained the center of biodiesel production worldwide, representing nearly 50 percent of total output in 2009, and biodiesel still accounted for the vast majority of biofuels consumed in Europe. But growth in the region has slowed considerably over the past few years. Production increased less than 6 percent in 2009, down from 65 percent growth in 2005 and 54 percent in 2006; at least half of existing plants remained idle during 2008/09.[182]

France countered this trend, increasing its production by 34 percent during 2009 to surpass Germany as both the European and world leader. France produced more than 2.6 billion liters, or 16 percent of global biodiesel. Production in Germany declined by 19 percent to just under 2.6 billion liters.[183] Among the top countries, biodiesel production was also down in the United States, Italy, and Belgium. In contrast, significant expansion in percentage terms occurred in Argentina, Austria, Colombia, Indonesia, Spain, and the United Kingdom, with growth rates of 50 percent or more. India, which ranked sixteenth in 2009, increased production more than 100-fold to over 130 million liters. Other biodiesel producers in the top 15 include Brazil, China, Malaysia, and Thailand.[184]

## Table 1. Status of Renewables Technologies, Characteristics and Costs

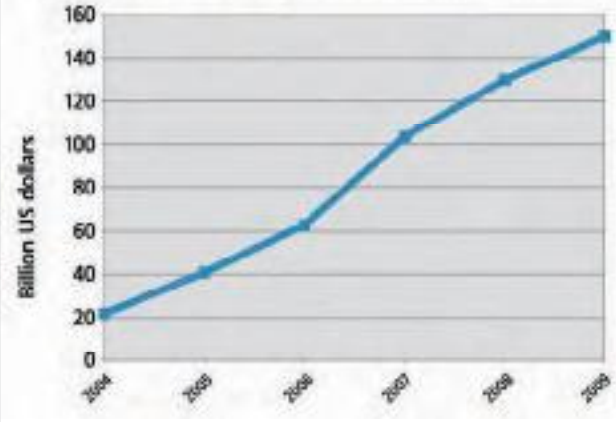
| Technology | Typical Characteristics | Typical Energy Costs (U.S. cents/kilowatt-hour unless indicated otherwise) |
|---|---|---|
| **Power Generation** | | |
| Large hydro | *Plant size*: 10 megawatts (MW)–18,000 MW | 3–5 |
| Small hydro | *Plant size*: 1–10 MW | 5–12 |
| On-shore wind | *Turbine size*: 1.5–3.5 MW<br>*Blade diameter*: 60–100 meters | 5–9 |
| Off shore wind | *Turbine size*: 1.5–5 MW<br>*Blade diameter*: 70–125 meters | 10–14 |
| Biomass power | *Plant size*: 1–20 MW | 5–12 |
| Geothermal power | *Plant size*: 1–100 MW;<br>*Types*: binary, single- and double-flash, natural steam | 4–7 |
| Solar PV (module) | *Cell type and efficiency*: crystalline 12–18%;<br>thin film 7–10% | ––– |
| Rooftop solar PV | *Peak capacity*: 2–5 kilowatts-peak | 20–50 |
| Utility-scale solar PV | *Peak capacity*: 200 kW to 100 MW | 15–30 |
| Concentrating solar thermal power (CSP) | *Plant size*: 50–500 MW (trough), 10–20 MW (tower); *Types*: trough, tower, dish | 14–18 (trough) |
| **Hot Water/Heating/Cooling** | | |
| 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)<br>1–15 (medium)<br>1–8 (large) |
| Geothermal heating/cooling | *Plant capacity*: 1–10 MW;<br>*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) | 30–50 cents/liter (sugar)<br>60–80 cents/liter (corn)<br>(gasoline equivalent) |
| Biodiesel | *Feedstocks*: soy, rapeseed, mustard seed, palm, jatropha, and waste vegetable oils | 40–80 cents/liter (diesel equivalent) |
| **Rural Energy** | | |
| Mini-hydro | *Plant capacity*: 100–1,000 kilowatts (kW) | 5–12 |
| Micro-hydro | *Plant capacity*: 1–100 kW | 7–30 |
| 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 indicative economic costs, levelized, 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 such as diesel backup and battery storage. Costs for solar PV vary by latitude and amount of solar insolation. *Source*: Data compiled from a variety of sources, including U.S. National Renewable Energy Laboratory, World Bank, International Energy Agency (IEA), and various IEA 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 equivalent Table 1 in the *Renewables 2007 Global Status Report* reflect a combination of refined estimates, technology changes, and commercial market changes. For further costs reference, see World Bank/ESMAP, *Technical and Economic Assessment: Off Grid, Mini-Grid and Grid Electrification Technologies*, ESMAP Technical Paper 121/07 (Washington, DC: 2007); and IEA, *Deploying Renewables: Principles for Effective Policies* (Paris: OECD, 2008).

## 2. INVESTMENT FLOWS

Total investment in renewable energy capacity (excluding large hydro) was about $150 billion in 2009.* This is up from the revised $130 billion in 2008.† (See Figure 12.) Investment in utility-scale renewable energy additions dropped 6 percent in 2009 from the 2008 level, despite "green stimulus" efforts by many of the world's major economies and increased investments from development banks in Europe, Asia, and South America. (See Sidebar 1.) All told, the world invested $101 billion in new utility-scale renewable energy development (including biofuels refineries but excluding large hydro) in 2009, compared with $108 billion in 2008. There was also investment of some $50 billion worldwide in 2009 in small-scale projects such as rooftop solar PV and solar hot water.‡ An additional $40–45 billion was invested in large hydropower.

Figure 12. Annual Investment in New Renewable Energy Capacity, 2004–2009




Other important types of investment activity also occurred. Renewable energy companies invested billions of dollars in plants and equipment to manufacture solar modules, wind turbines, and other generating devices. Venture capital and private equity investment in clean energy companies totaled $4.5 billion, down from $9.5 billion in 2008, while public markets investment in quoted clean energy firms reached $12.8 billion, up from $11.8 billion. Government and corporate research, development, and deployment spending on clean energy technology in 2009 is estimated at $24.6 billion, up $0.4 billion (2 percent) from 2008, the bulk of which ($16.8 billion, or 68 percent) went to energy efficiency technologies.

**Sidebar 1. "Green Stimulus" Packages**

Since the climax of the world financial crisis in autumn 2008, the world's major governments have made "green stimulus" programs one of their main instruments for supporting the economic recovery. Some $188 billion in green stimulus funding had been allocated to renewable energy and energy efficiency. Of that, only around 9 percent had actually been spent at the end of 2009. The delay reflects the time it takes for money to get through administrative processes, some of which were brought in only after the programs were announced. Greater parts of the overall clean energy stimuli are expected to be spent in 2010, and in 2011.

Germany and China were the investment leaders in 2009, each spending roughly $25–30 billion on new renewables capacity, including small hydro. The United States was third, with more than $15 billion in investment. Italy and Spain followed with roughly $4–5 billion each.

A detailed look at the 2009 investment in utility-scale assets (generating plants and biofuels refineries) shows that the wind energy sector continued to be the hands-down leader, receiving 62 percent of the global total. Total investment in wind assets grew to $62.7 billion in 2009, up from $55.5 billion the year before. Most of the growth was due to China's rapid expansion of capacity, increased investment activity in wind in Latin America, and a handful of large utility-backed offshore wind deals in the United Kingdom. The wind energy sector's significant gains, however, were offset by a $5.6 billion drop in solar power asset investment, to $17.1 billion in 2009, and a deep slide in biofuels spending, down to $5.6 billion from $15.4 billion in 2008.

There are several reasons for the lower investment in PV in 2009. One was the behavior of prices along the PV module value chain, with PV module prices falling by some 50 percent, bringing the dollar value of financial investment down with them. Other factors holding back solar in 2009 were the Spanish government's cap on PV project development at the end of the boom associated with the pre-September 2008 tariff, and the shortage of debt finance for utility-scale

* The figures in this section, with the exception of the investment data from public sector banks and development assistance agencies, are based on the output of the Desktop database of Bloomberg New Energy Finance (BNEF). These data reflect financial transactions. Where deal values are not disclosed, BNEF assigns an estimated value based on comparable transactions. The following renewable energy projects are included: all biomass, geothermal, and wind generation projects of more than 1 MW, all hydro projects of between 0.5 MW and 50 MW, all solar projects of more than 0.3 MW, all ocean energy projects, and all biofuel projects with a capacity of 1 million liters or more per year.
† All dollar and cent figures in this report are in U.S. dollars unless otherwise noted.
‡ The small-scale project investment number reported here is considerably higher than the $18 billion small-scale project number reported by Bloomberg New Energy Finance. There are two main reasons: (1) global investment in solar hot water ($13 billion) is included in the number here but not in the BNEF number; and (2) balance-of-plant costs for distributed grid-connected solar PV (not utility-scale projects) are included in the number here, which has been the traditional methodology for this report since 2005, while BNEF includes only PV module costs. (Total installed costs for distributed solar PV were estimated at $7/watt in recent years, although a reasonable estimate for 2009 is probably $6/watt.)

projects in Europe and the United States (which also affected wind farms). There were concerns about cuts in feed-in tariff support in countries such as Germany, but these spurred on developers rather than holding them back. Indeed, Germany witnessed a spectacular end-of-2009 spurt in small-scale PV project construction.

An oversupply in U.S. ethanol continued to smother investment in the biofuels sector in 2009. Biofuels had commanded 22 percent of global asset finance in 2007, with investment totaling $19.6 billion. However, the sector slipped to $15.4 billion in spending in 2008 and just $5.6 billion in 2009, representing only 5 percent of global project investment. Things may soon turn around, however. Both Brazil and the United States continue to follow ambitious biofuels targets, Brazil's state-owned oil company Petrobras has moved into the ethanol sector, and U.S. plants bought under bankruptcy auctions in 2008 and 2009 have begun slowly to resume operation.

The decline in asset investment in biofuels relegated the sector to fourth place among the renewable energy sectors in 2009. Stepping up to third place, after wind and solar, was biomass (including waste-to-energy), with a rise in investment to $10.4 billion, from $9 billion in 2008.

Among the smaller sectors, small hydropower had a more subdued year after a rush of development in 2008.[185] Asset investment in small hydro slipped to $3.8 billion in 2009 from $4.1 billion in 2008, reflecting the difficulties and expense in securing project debt. There were, however, some projects worth more than $200 million financed in countries such as Albania, Austria, Brazil, and Turkey.

Geothermal was more exposed to the credit squeeze than small hydro, reflecting its geographic concentration in places such as the United States, Iceland, and Indonesia, and its higher average upfront capital cost per megawatt. Geothermal asset investment worldwide dropped by roughly a third from $1.7 billion to $1 billion.

Ocean energy is the most immature of the renewable power sectors, and asset investment has remained much less important than venture capital support for the dozens of young companies that are developing wave and tidal devices. Nevertheless, asset finance in ocean energy rose from virtually nothing in 2008 to $0.2 billion in 2009, although most activity still consists of pilot and demonstration plants.

In terms of geographical shares, a milestone was reached in 2009 as the Asia/Oceania region displaced the Americas as the second most important region in global investment, behind the combined rest-of-world (Europe, Middle East, and Africa). The Asia/Oceania total was $34.4 billion, compared with $24.7 billion for the Americas and $41.8 billion for Europe/Middle East/Africa.

China saw asset finance of $29.2 billion in 2009, up from $22 billion in 2008, on the back of a surge in wind investment. Some of this went into the country's wind "mega bases," such as the planned 3.8 GW development at Jiuquan in Gansu Province. By contrast, U.S. asset investment slipped to $10.7 billion in 2009, down from $19.7 billion in 2008. A key reason was the drying-up of the tax equity market.[186] The Obama administration promised a system of grants to help make up for the shortage of tax equity, but this money only started to flow relatively slowly toward the end of 2009. In Europe, asset investment fell by 4 percent in 2009, with weaker figures for solar and biofuels more than offsetting stronger ones for wind and biomass. Non-recourse debt finance from banks had helped to finance 80 percent of the capital cost of many wind and solar PV plants in 2007 and 2008, often at low margins over market interest rates. The credit crunch put an end to that.

The brightest feature for project investors during 2009 in Europe, and also in Brazil and elsewhere, was the expanded role of public sector banks. The European Investment Bank (EIB) raised its lending to renewable energy from a then-record €2.2 billion ($2.9 billion) in 2008 to €4.2 billion ($5.6 billion) in 2009, including the provision of €300 million ($400 million) toward the financing of the first (165 MW) phase of the Belwind offshore wind project in Belgium.* Germany's KfW Banking Group increased its lending to renewable energy from €5.4 billion in 2008 to €6.3 billion in 2009. The European Bank for Reconstruction and Development was an active provider of project finance as well, albeit not on the scale of the EIB and KfW.

In Brazil, the Brazilian National Bank of Economic and Social Development (BNDES) was once again the dominant provider of debt, backing large projects such as the 680 MW Impsa Santa Catarina wind portfolio and the Bevap Vale do Paracatu bioethanol plant (with production capacity of 260 million liters per year). Overall, BNDES's lending to the sector slipped from $7 billion in 2008 to $6.4 billion in 2009, but remained far above 2007's $2.4 billion.

This strong contribution by the public sector was all the more needed, because many commercial banks found it impossible to sustain the 2008 level of lending to renewable energy projects. The Royal Bank of Scotland, the leading provider of project finance debt in Europe in 2007, had to scale back its activities drastically in 2009, although it remains committed to the sector, particularly in its home country. Rival bank HBOS, a big lender to solar projects in

* All euro amounts in this report are converted to U.S. dollars at a $1.33 rate of exchange.

2008, became part of the Lloyds Banking Group in early 2009 but was unable to extend as many loans as before. Several of the German Landesbanken, important providers of debt for wind and solar in many European countries and even the United States until 2008, also had to retrench in 2009. In the United States, one of the leading providers of tax equity finance up to 2008 was Lehman Brothers, the most celebrated casualty of the financial crisis. Another provider was GE Energy Financial Services, which came through the crisis intact but found its scope to invest in renewable energy tax equity more restricted in 2009. (For early 2010 trends, see Sidebar 2.[187])

Development assistance for renewables in developing countries jumped by a large margin in 2009, exceeding $5 billion (compared with some $2 billion in 2008). The World Bank Group, including the International Finance Corporation and the Multilateral Investment Guarantee Agency (MIGA), saw the largest increase in finance compared to previous years. Finance rose fivefold in 2009 as the World Bank Group committed $1.38 billion to new renewables (solar, wind, geothermal, biomass, and hydro below 10 MW) and another $177 million for large hydropower. (These figures exclude Global Environment Facility (GEF) funds and carbon finance.) Germany's KfW committed €284 million ($381 million) to new renewables and an additional €20 million ($27 million) to large hydropower. It also committed €819 million ($1.1 billion) at the governmental level for renewable energy through its Special Facility for Renewable Energies and Energy Efficiency.

Many other development assistance agencies committed large funds to renewables in 2009. The Inter-American Development Bank committed more than $1 billion in loans for renewable energy, including $941 million for hydropower and another $9 million in technical assistance grants. The Asian Development Bank invested approximately $933 million in renewables, including $238 million in large hydropower. The GEF funded 13 renewable energy projects with a total direct GEF contribution of $51.2 million and with associated co-finance from other sources of $386.8 million (some of the co-finance may already be included in figures mentioned above, for example, KfW and World Bank). Agence Française de Développement (AFD) committed €220 million ($293 million) to renewable energy through direct financing, and around €350 million ($465 million) through lines of credit to local banks. The Japan International Corporation Agency provided 110 billion JPY ($1.2 billion). The Netherlands Development Finance Company committed €276 million ($370 million). Other official development assistance (ODA) figures from a variety of bilateral and multilateral development agencies suggest additional flows to renewables on the order of $100–200 million per year.

**Sidebar 2. Renewables Investment Trends in Early 2010**

The first quarter of 2010 found the renewable energy sector largely out of the limelight, following the inconclusive Copenhagen climate change conference in December 2009. However, investment continued at a level significantly above that of a year earlier.

Investment in clean energy assets (not including large hydro) was $29.5 billion in the first quarter of the year, some 63 percent above that in the same period of 2009. It was up from $26 billion in the fourth quarter of 2009, a strong result given the continuing uncertainties in the world economy and the financial markets and the impact of the Northern Hemisphere winter on project progress.

The highlights of the first quarter included a healthier figure for asset finance in the United States, at $3.5 billion from $2.3 billion in the fourth quarter of 2009, helped by a $394 million construction debt package for a California wind farm and another big number for China, $6.5 billion, reflecting its investment in wind "mega bases" and smaller projects.

The quarter was also notable for a continuation of the recovery in venture capital and private equity investment in clean energy. This reached $2.9 billion, up from $1.7 billion in the fourth quarter of 2009 and $1.5 billion in the first quarter of 2009.

*Source:* See Endnote 187.

## 3. INDUSTRY TRENDS

Almost all renewable energy industries experienced growth in 2009 despite the continuing global economic crisis. A number of industries saw further consolidation as well as a scaling up in manufacturing capacity. China continued to increase its importance as a manufacturer of renewable technologies, particularly wind turbines, solar PV, and solar hot water systems. At the same time, declining costs combined with greater government support through stimulus packages and other policies increased utility interest in renewable energy.

### Wind Power Industry

China continued its emergence as a global manufacturer of wind turbines as three firms—Sinovel, Goldwind, and Dongfang—ranked among the top 10 manufacturers in 2009, all up in ranking significantly relative to 2008. Building on its strong domestic market for wind power, China saw a new trend of increasing exports of turbines and spare parts, for example by Sinovel to India and by Goldwind to the United States. Chinese firms also announced plans to open manufacturing plants abroad, particularly in the United States.

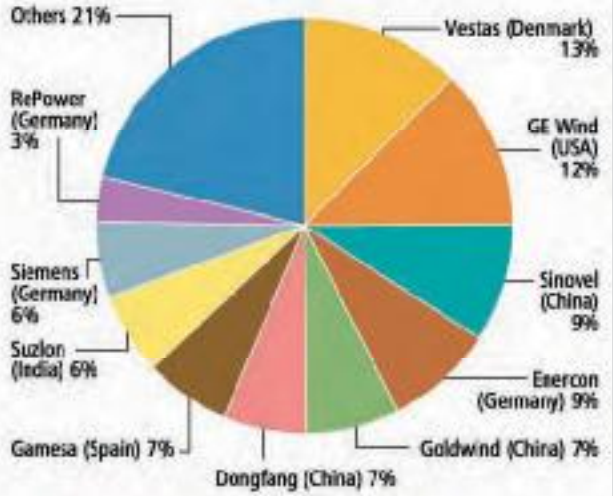
For European manufacturers and developers, clear targets set by the EU Directive for a 20-percent final energy share by 2020 are driving new projects across the region. The year 2009 was characterized by the growth of offshore wind farm development and further geographic diversification, with new projects in Scandinavia and Eastern Europe. The industry is working in concert with EU authorities to streamline consent processes and improve permitting timelines, paving the way to deliver future installations at a lower cost.

EU manufacturers continued to develop offshore wind turbine technologies. The industry also saw the launch of the gearless Goldwind Vensys 1.5 MW turbine and the completion of prototypes of other gearless turbines, such as the Siemens 3.6 MW machine. Gearless turbines made up less than 10 percent of production in 2009 but are growing in popularity. The average utility-scale wind turbine installed during 2009 was 1.6 MW, while the largest turbine installed overall was the 7.5 MW Enercon gearless turbine.[188]

In the United States, following substantial decline of the tax equity market that had provided a key incentive for new project development, the wind industry was boosted by national stimulus funding.[189] During 2009, the U.S. industry expanded with 38 new manufacturing facilities either brought on line, enlarged, or announced.[190] Controversy surrounding one U.S. Senator's charge that 85 percent of the first $1 billion in Department of Energy/Treasury grants was awarded to projects owned by companies with foreign parent corporations resulted in announcements by several Chinese firms that they planned to open manufacturing plants in the United States.

In 2009, European and Chinese firms clearly dominated the wind turbine manufacturing sector. Among individual companies, Danish company Vestas retained its top spot in 2009 compared to 2008, while GE Wind of the United States remained in second place. Suzlon of India also featured among the top 10 global manufacturers.[191] (See Figure 13.)

Figure 13. Market Shares of Top 10 Wind Turbine Manufacturers, 2009




### Biomass Power and Heat Industries

Biomass power and heat facilities burn solid biomass, wood, wood waste, and plant and animal matter and waste for electricity as well as cogeneration. This baseload form of power ranges from private or merchant industrial generation in the paper and forestry industries to combined heat-and-power (CHP) generation in municipalities.

In Europe, the solid biomass industry grew more than 2 percent from 2007 to 2008, providing 5.6 TWh of electricity, for an increase of 10.8 percent during this period.[192] A subsection of the industry, the wood pellet market, strengthened in 2009 following a fall in shipping costs, which can account for as much as 50 percent of the pellet supply expense. This was accompanied by an increased demand for co-firing by Europe's coal-fired power plants. These developments led a growing number of firms to develop new projects for biomass power and heat.

If lower shipping costs persist, biomass power producers may consider burning lower-density fuels, such as wood chips, nut shells, and plant husks, as a substitute for pellets.[193] German industry currently has more than 90 contractors for ready-to-use biogas plants and 170 companies in development and manufacturing.[194] In China, developers installed 3 million biogas digesters and 400 MW of biomass for power generation in 2009.[195] Internationally, there is strong utility interest in biomass electric power generation for co-firing with coal, repowering coal-fired plants to biomass, and CHP. Key challenges facing developers and facility operators as the industry grows include sourcing, transportation, and the storage and handling of feedstock.

## Solar PV Industry

The solar PV industry saw major declines in module prices in 2009, by some estimates dropping over 50–60 percent from highs averaging $3.50 per watt in the summer of 2008. By December 2009, prices were falling below $2.00 per watt in some instances.[196] Perhaps counter-intuitively, the price decline resulted in a purchasing lag: as prices continued to drop, many buyers waited until late in the year to place orders. Many firms were caught with high-priced contracts for material supplies and found it difficult to reduce costs.

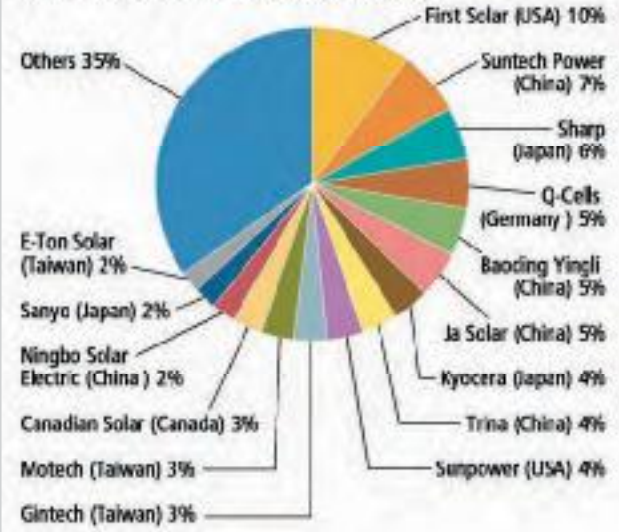
To retain competitiveness, firms focused on increasing efficiency, reducing operating costs, and increasing capacity utilization at factories. Low-cost, high-quality manufacturing and the ability to respond to rapidly changing market conditions became the markings of resilient and profitable industry players. Consolidation and scale-up also emerged as major responses.[197] In the United States, for example, 2009 saw the closing of BP Solar's PV manufacturing facility in Frederick, Maryland. Simultaneously, the top 10 manufacturers were looking to grow from 6.9 GW of manufacturing capacity in 2009 to 10.6 GW in 2010. China's Jiangsu and Zhenjiang provinces, where more than 300 manufacturers compete for contracts, are representative of the intense competition.

Many manufacturers responded to softening demand by broadening their market positions into project development as well as manufacturing. A new project subsidiary of Q-Cells, for example, had 100 MW of projects under construction in Germany and Italy by the end of 2009, generating demand equivalent to 18 percent of Q-Cells' annual module production. Suntech of China acquired an 86 percent stake in Global Solar Equity Funds, an entity created to provide equity to PV projects. And First Solar signed a memorandum of understanding (MOU) to build a 2 GW project in China, the first 30 MW of which is scheduled for completion in 2010.[198] As many manufacturers grow and buy their way into the project development business, new business models are being created for project development and financing, based on regional and local incentives and regulations. These models often look more like real estate development than manufacturing or power-project development businesses.

Thin-film PV manufacturing maintained its 25 percent production share in 2009, despite losing its historical cost advantage over crystalline PV module prices. Of the roughly 150 thin-film manufacturing firms that existed in 2008, only about half (70) were estimated to be active by early 2010, and only a handful continued to produce at full capacity. First Solar led the industry, becoming the first PV manufacturer to produce more than 1 GW in a single year (1.1 GW in 2009). The rest of the thin-film industry, notably Sharp and Showa Shell, produced a combined 500 MW in 2009. The majority of thin-film firms purchase their production lines from market leaders Applied Materials and Oerlikon Solar.

The top 15 solar cell manufacturers produced 65 percent of the 10.7 GW of cells manufactured in 2009. (See Figure 14.) Firms in mainland China and Taiwan produced nearly half (49 percent) of the global total, followed by Europe (18 percent), Japan (14 percent), and the United States (6 percent).[199]

Figure 14. Market Shares of Top 15 Solar PV Manufacturers, 2009



## Concentrating Solar Power (CSP) Industry

CSP manufacturers and developers focused predominantly on opportunities in the United States and Spain in 2009. More and more projects are expected to obtain utility power purchase agreements (PPAs) at competitive prices as CSP is increasingly valued as a hedge against carbon pricing and as a source of peaking, intermediate, or baseload generating capacity (when paired with thermal storage or natural gas generation).[200] (See Sidebar 3.) In the U.S. market in particular, renewable portfolio standard (RPS) requirements for utilities have spurred new project development opportunities for industry firms and utilities, first capitalized on by Acciona's 64 MW Nevada Solar One in 2007.

Globally, no single technology has yet emerged as a CSP leader. Commercially mature parabolic troughs are employed in 50 percent of planned installations, power towers in 30 percent, and dish/engines in 20 percent, representing most of the remaining projects in the pipeline. Leading firms in CSP include Brightsource, eSolar, Siemens, Schott, SolarMillenium, Abengoa Solar, Nextera Energy, Infinity, Tessera, and Acciona, with dozens of other manufacturers and developers active in the market.

## Ocean Energy Industry

Wave and tidal technology development has benefited from government grants and private investment, most notably in the United Kingdom, Ireland, Portugal, Denmark, France, Australia, South Korea, Canada, and the United States. Twenty firms are currently developing marine technologies in the United Kingdom and Ireland—ocean energy's largest markets—with most development expected to happen in Scotland.[201] Leading manufacturers in ocean energy include Aquamarine Power, Pelamis Wave Power, Marine Current Turbines, Open Hydro, and Ocean Power Technologies; noted developers are SSE Renewables and Scottish Power Renewables. Beyond the United Kingdom and Ireland, many of these firms are landing contracts to build generation facilities in Australia, Brazil, Canada, South Korea, Spain, and Sweden.[202]

## Hydropower Industry

Given its long history and large scale, hydropower is the most mature of the renewables industries. In developed markets such as the European Union, United States, Canada, and Japan, where many hydropower plants were built 30–40 years ago, the industry is focused on relicensing and repowering as well as adding hydro generation to existing dams. In developing nations such as China, Brazil, Ethiopia, India, Malaysia, Turkey, and Vietnam, utilities and developers are focused on new hydro construction. There has been extensive development of Chinese hydro resources, and recently utilities and grid operators have moved actively to purchase assets from private owners.[203]

Leading equipment manufacturers for hydropower include Voith, Alstom, Andritz, Impsa, BHEL, Hitachi, and Makamidi. While hydro equipment orders were down in 2009 and 2010 relative to 2008, the years 2007–2010 overall represented levels of business not experienced previously in the hydro sector. With the support of many new government hydropower targets (see Section 4), pre-orders placed for 2011 and beyond are high, leading to industry expectations that average orders for the 2010s will be higher than for the 2000s.[204]

### Sidebar 3. Electric Utility Companies Look to Renewables

During 2009, electric utility companies became more engaged in renewable energy development than ever before. This was driven by a mix of regulatory incentives, the need for a hedge against potential carbon regulation and rising fossil fuel prices, and a need for both baseload and peaking power capacity with short installation timelines.

Utilities continued to buy development firms and their project pipelines, increasingly embracing development as an in-house function. Technologies such as biomass power and CSP can provide baseload power, and others such as utility-scale PV can provide cost-effective peaking. One example of utilities' foray into large-scale project development in 2009 was involvement in "Desertec," a proposed initiative of 12 large European industry, finance, and utilities players envisioned to provide 15 percent of Europe's electricity by 2050 from renewable energy projects in the North African desert.

In the United States, electric utilities are playing an increasing role in the PV marketplace as a result of regulatory pressure, a newfound ability to access the investment tax credit, declining PV costs, and the potential for rapid deployment. During 2009, utilities accounted for about 15 percent of new grid-connected capacity. Most of these are in California, but utilities in Arizona, Colorado, Florida, and New Jersey are following their lead. By April 2010, the United States had 102 MW of utility-driven PV projects in operation, 67 MW under construction, and 11.7 GW under development.

*Source:* See Endnote 200.

## Solar Hot Water and Heating Industry

China continues to dominate the global solar hot water industry. Chinese companies manufactured 28 million square meters of systems in 2009, representing 80 percent of global solar hot water/heating output. China's manufacturing sector comprises more than 5,000 producers and distributors; many of these operate only locally, but some 100 compete in the broader domestic marketplace, and 25 have been accredited under a new Chinese labeling standard.[205] The dominant manufacturer is Himin Solar Energy, based in Shandong province.

A major issue for Chinese manufacturers is the need for systematic increases in quality and product standardization. Nearly all Chinese production is installed domestically, but in 2009 China began to export low-cost solar hot water systems to developing countries in Africa and Central and South America—regions with warmer climates where thermo-siphon systems can be sold.[206] Chinese-made systems have also begun to enter the European market through joint ventures such as the German-Chinese Linuo-Paradigma initiative.[207]

The European solar hot water/heating industry has been marked by acquisitions and mergers among leading players, solid average growth of more than 12 percent annually during 2001–07, and a shift toward increased use of systems for space heating in addition to hot water. Leading manufacturers in the region include Alanod, Almeco-TiNOX, Bosch, Bluetec, GreenOneTec, the Ritter Group, and Solvis. Israel's market is dominated by Chromagen, and Australia's by Solahart-Rheem. In the United States, firms report a much stronger market than five years ago, particularly in California.[208]

## Ethanol Industry

The ethanol industry faced multiple challenges in 2009, both for corn ethanol and for ethanol produced from sugar cane. This resulted in limited additions to production capacity and to widespread consolidation as the assets of many former market leaders stagnated or were acquired, and as investors and policymakers focused increasingly on second-generation biofuels.[209]

Most of the world's corn ethanol is produced in the United States, where existing production capacity was not fully utilized in 2009 due to unfavorable market conditions. Producers faced large fluctuations in natural gas, corn, and ethanol prices, along with the inability to raise new financing from both debt and credit markets. The corn ethanol industry commissioned only 19 new facilities in 2009, compared to 59 in 2008 and 30 in 2007. Several independent players filed for bankruptcy protection, including VeraSun, Hereford Biofuels, Cascade Grain, Northeast Biofuels, Aventine Renewable Energy and Renew Energy, White Energy, and Pacific Ethanol.[210]

By the end of 2009, however, the industry outlook was fundamentally improved, with lower corn prices and higher crude oil prices than in the autumn.[211] By early 2010, an additional 11 plants remained under construction in 26 U.S. states.[212]

In Brazil, the world's largest producer of sugarcane ethanol, the credit crunch hit the industry hard in 2009. The Brazilian National Development Bank (BNDES) stepped in to cover the funding breach as the 9th and 10th ranked Brazilian ethanol producers, CBAA and Santa Fany, filed for bankruptcy protection in November.[213] Meanwhile, the Louis Dreyfus and Santelisas Brazilians mills were consolidated under the umbrella corporation LDC-SEV, creating a new firm that will be capable of crushing 40 million tons of sugar a year, second only to Cosan's 60-million-ton crushing capacity. Cosan, the world's 4th largest producer with 10.5 percent of the Brazilian sugarcane market, is the only fully vertically integrated producer globally.[214]

Brazil's ethanol exports became less competitive abroad during 2009 as sugar prices increased and as the nation's currency underwent revaluation. In the longer term, the outlook for Brazilian firms is bright, with the government aiming to double national production by 2017, to 63 billion liters annually.[215] The U.S. market remains difficult for foreign ethanol producers to sell into profitably, with an import tariff combined with the Volumetric Ethanol Excise Tax Credit (VEETC), giving a roughly 60 cents/gallon cost advantage to domestic U.S. producers.[216]

## Biodiesel Industry

Europe remains the world's top biodiesel producer. It is currently home to almost 280 production facilities across 27 member states, with an estimated annual production capacity of nearly 24 billion liters—most of it in Germany, Spain, France, the Netherlands, and Italy. However, the European biodiesel industry continued to stagnate in 2009, with low levels of capacity utilization.[217]

Nevertheless, construction of new plants continued during 2009. For example, Neste Oil began construction in the Netherlands of what will be the EU's largest biodiesel plant, with a capacity of 900 million liters per year.[218] Industry leaders include Renova, ECOFUEL Argentina, LDC Argentina, Unitec Bio, and Explora. Other countries that began biodiesel production in 2009 include Colombia, Ecuador, and Peru.

The U.S. biodiesel industry suffered from EU regulations imposed in 2009 that limit the flow of biodiesel imports to the European Union, historically the leading destination for U.S. production. The U.S. biodiesel industry's key tax credit, valued at $1.00/gallon, expired at the end of 2009, was subsequently reinstated and then delayed, and was ultimately retroactively extended in May 2010.[219]

## Second-Generation Biofuels Industry

Second-generation biofuels are not yet being produced commercially, but the European Union, United States, and Canada, along with China, Brazil, India, and Thailand, are investing in research and pilot production projects.[220] In particular, the European Commission research program on bio-refineries, which focuses on second-generation biofuels, reflects the shift under way in the EU toward second-generation fuels and integrated systems that combine electricity, fuels, and commodities.[221] European firms such as Novozymes are also investing outside of the region, establishing second-generation pilot plants in Brazil and China.[222] Novozymes reached benchmark enzyme costs of $1/gallon in March 2009 and is targeting 50 cents/gallon in 2010.

The U.S. Department of Energy has granted up to $564 million in stimulus grants for 19 pilot demonstration and commercial-scale second-generation biofuels projects. The United States is currently home to 12 pilot and small-scale demonstration plants with 15 million liters/year of production capacity, and Canada has three producers with almost 19 million liters/year in combined capacity.[223] The algae-based fuels industry made news in November 2009 with the announcement by the U.S. Defense Advanced Research Projects Agency (DARPA) that it has produced algae fuel for $2/gallon and is targeting $1/gallon by 2013.[224]

The second-generation biofuels industry continues to face challenges related to developing infrastructure, growing to commercial scale, acquiring reliable feedstock supply, and lowering enzyme costs. However, the synergies and sustainability in second-generation development in concert with other renewables, particularly in bio-refinery constructs, has driven substantial government support internationally, which is likely to continue.[225]

Accounting for all industries discussed above, jobs from renewable energy continue to grow into the millions.[226] (See Sidebar 4.)

### Sidebar 4. Jobs from Renewable Energy

Worldwide, jobs in renewable energy industries exceeded 3 million in 2009. A 2008 report by the United Nations Environment Programme on jobs from renewable energy observes that while developed economies have shown the most technological leadership in developing viable renewable energy, developing countries are playing a growing role and this is reflected in employment. China and Brazil account for a large share of global total employment, having strong roles in solar hot water and biofuels industries. Many of these jobs are in installation, operations, and maintenance, as well as in biofuels feedstocks. Jobs are expected to grow apace with industry and market growth. Some countries keep track of total jobs from renewable energy; for example, the German government estimates 300,000 jobs currently and expects this to increase to 400,000 by 2020.

| Industry | Estimated jobs worldwide | Selected national estimates |
|---|---|---|
| Biofuels | > 1,500,000 | Brazil 730,000 for sugar cane and ethanol production |
| Wind power | > 500,000 | Germany 100,000; United States 85,000; Spain 42,000; Denmark 22,000; India 10,000 |
| Solar hot water | ~ 300,000 | China 250,000 |
| Solar PV | ~ 300,000 | Germany 70,000; Spain 26,000; United States 7,000 |
| Biomass power | – | Germany 110,000; United States 66,000; Spain 5,000 |
| Hydropower | – | Europe 20,000; United States 8,000; Spain 7,000 |
| Geothermal | – | Germany 9,000; United States 9,000 |
| Solar thermal power | ~ 2,000 | Spain 1,000; United States 1,000 |
| Total | > 3,000,000 | |

*Sources:* See Endnote 226 for further information on data sources behind these numbers and on analytic methods for estimating jobs using employment factors.

## 4. POLICY LANDSCAPE

Policies to promote renewable energy existed in a few countries in the 1980s and early 1990s but began to emerge in many more countries, states, provinces, and cities during the period 1998–2005, and especially during the period 2005–2010. The number of countries with some type of policy target and/or promotion policy related to renewable energy almost doubled during this five-year period, from 55 in early 2005 to more than 100 by early 2010.[227]

Many of these policies have exerted substantial influence on the market, investment, and industry developments reviewed in the previous sections. It is beyond the scope of this report to provide analysis of policy impacts and lessons; however, 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 literature also shows that market growth often results from combinations of policies, rather than single policies; that not all policies are effective or efficient; that longevity and predictability of policy support is important; that local and state/provincial authority and involvement are important; and that policy mechanisms are evolving as countries gain experience.

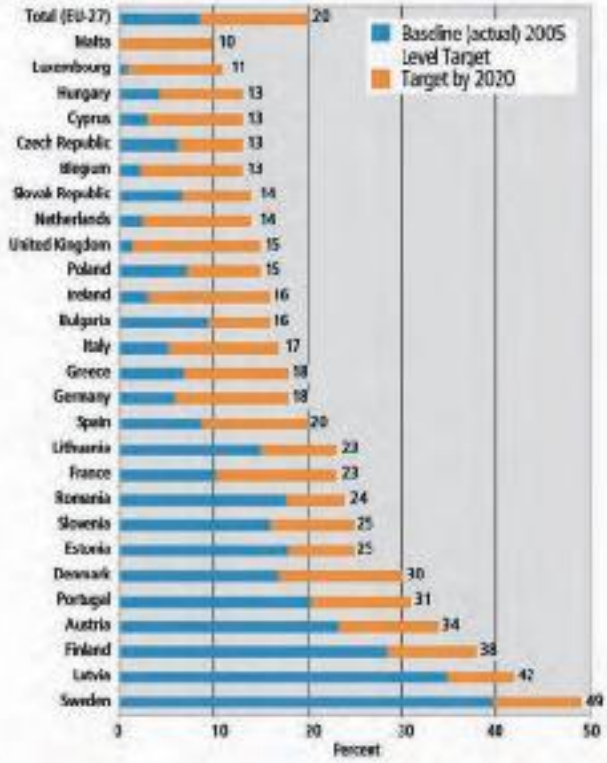
This section examines the existing policy targets for renewables and then reviews policies to promote renewable power generation, solar hot water/heating, and biofuels. It also discusses green power and municipal policies.

### Policy Targets for Renewable Energy

By early 2010, policy targets for renewable energy at the national level existed in at least 85 countries worldwide, including all 27 European Union member states.[228] (See Tables R7–R9.) Many national targets are for shares of electricity production, typically 5–30 percent, but range from 2 percent to 90 percent. Other targets are for shares of total primary or final energy supply, specific installed capacities of various technologies, or total amounts of energy production from renewables, including heat. Targets also exist for biofuels in many countries. (See Biofuels Policies later in this section.)

Many historical targets have aimed for the 2010–2012 timeframe, although targets aiming for 2020 and beyond have emerged in increasing numbers in recent years. In 2008, all 27 EU countries confirmed national targets for 2020, following a 2007 EU-wide target of 20 percent of final energy by 2020. (See Figure 15.) By early 2010, more than two-thirds of the 85 countries with existing national targets were aiming for 2020 or beyond in some manner.

Figure 15. EU Renewable Energy Targets: Share of Final Energy by 2020




Examples of new national targets among developed countries include Australia (20 percent of electricity by 2020), Ireland (500 MW of ocean power by 2020), Japan (14 GW of solar PV by 2020), and South Korea (11 percent of primary energy by 2030).

An increasing number of developing countries have targets and as a group now account for over half the countries worldwide with targets. The *Renewables 2007 Global Status Report* counted 22 developing countries with targets, and this figure expanded to 45 countries by early 2010.[229] Developing-country plans also reflect increasing ambition in targeted amounts. China aims for 15 percent of final energy consumption from renewables by 2020, even as total energy demand continues to grow at nearly double-digit annual rates.[230] (China already met its 2010 renewables target for 10 percent of primary energy two years early, in 2008.) The country's most recent draft development plan targets 300 GW of hydro, 150 GW of wind, 30 GW of biomass, and 20 GW of solar PV by 2020.[231]

India's current five-year plan targets 12.5 GW of added renewables by 2012 (including wind, small hydro, and bio-

mass power), and in 2009 the country adopted targets for solar power of 1 GW by 2013 and 20 GW by 2022 (including 1 GW of off-grid solar PV by 2017). Brazil aims to maintain or increase its existing shares of total energy (48 percent) and electricity (85 percent) from renewables through 2030. Thailand increased its primary energy target to 20 percent by 2022. The Philippines's national plan calls for 4.5 GW of new renewables capacity during the period 2003–2013. Egypt targets 20 percent of electricity by 2020, including 12 percent from wind power. Kenya plans 4 GW of geothermal by 2030. Other developing countries that added new national targets during 2009 include Ghana, Ethiopia, Jordan, Kuwait, Morocco, and Tuvalu.

In addition to these national-level targets, sub-national targets exist in a number of countries at the state, provincial, regional, city, or other levels. In the United States, 36 states (and the District of Columbia) have targets based on renewable portfolio standards (see next section) or policy goals.[232] Nine Canadian provinces and eight Indian states similarly have targets based on RPS or policy goals. The most recent additions include the Indian state of Karnataka, which adopted a policy goal of 6 GW of renewables by 2015, and the Chinese province of Jiangsu, which adopted a policy goal of 400 MW of solar PV by 2011. Other sub-national jurisdictions with electricity targets include Abu Dhabi (7 percent by 2020), Scotland (50 percent by 2020), South Australia (33 percent by 2020), Taiwan (10 percent by

**Sidebar 5. Delhi International Renewable Energy Conference (DIREC) 2010**

The Delhi International Renewable Energy Conference (DIREC 2010) will take place in New Delhi, India, from 27 to 29 October 2010. It is the fourth global ministerial-level conference on renewable energy, following previous events in Washington, D.C. in 2008, Beijing in 2005, and Bonn in 2004. With the main theme on "upscaling and mainstreaming renewables for energy security, climate change, and economic development," DIREC will provide an international platform for government, private sector, and civil society leaders to jointly address the goal of advancing renewable energy through policy development.

Through interactive, moderated discussions, DIREC 2010 will enable participants to acquire a deeper understanding of the policy efforts needed to encourage and enable major scale up of renewables; the measures to mobilize finance for renewable energy innovation, deployment, and end use; and the benefits of collaboration, synergies, and knowledge-sharing at the international level. DIREC will continue the International Action Programme, begun in Bonn, which promotes voluntary pledges (and policy targets) for concrete and innovative actions to advance renewables.

The Indian government, host of DIREC 2010, has demonstrated its commitment to scaling up renewable energy. India ranks fifth worldwide in installed renewable power capacity (not counting large hydro), with 10.9 GW of wind power, 2 GW of small hydro, and 1.5 GW of biomass power. India also had 110 MW of rural biomass gasifiers operating and was making extensive use of many other forms renewables in rural areas (see Section 5 on Rural Renewable Energy). The ambitious Jawaharlal Nehru National Solar Mission (JNNSM) aims to install 20 GW of solar power capacity by 2022, which will result in further technological development in India's solar sector, allow solar energy to attain grid parity at a much faster speed, and bring in additional job opportunities. In May 2010, the Indian government also reported plans for a new renewable energy certificate scheme designed to drive investment in low-carbon energy projects.

*Source:* See Endnote 233.

**Sidebar 6. International Renewable Energy Agency (IRENA)**

The International Renewable Energy Agency (IRENA) was founded in 2009 to promote the international uptake and sustainable use of renewable energies. By mid-2010, more than 140 countries and the European Union had signed the agency's statute, including countries in Africa (48), the Americas (15), Asia (34), Australia/Oceania (9), and Europe (38). The required number of 25 signatories had ratified the statute by June 2010, and it entered into force on 8 July 2010. The agency's interim headquarters were established in Abu Dhabi in the United Arab Emirates, and two other centers are also being established: the Centre of Innovation and Technology in Bonn, Germany, and a Liaison Office for Cooperation with other Organizations in Vienna, Austria.

IRENA will provide advice and support to governments worldwide on renewable energy policy, capacity building, and technology transfer. IRENA will also improve the flow of financing and know-how and collaborate with existing renewable energy organizations. IRENA's goal is ultimately to increase the share of renewable energy worldwide. IRENA's founding reflects a growing consensus among governments around the world on the need to actively support the expansion of renewable energy.

*Source:* See Endnote 234.

2010), and Wales (7 TWh/year by 2020). Many city-level targets also exist; see "City and Local Government Policies" later in this section and also Table R13.

It appears that many countries won't meet their 2010 targets by the end of the year, although this won't be known immediately due to data lags. For example, the EU's total share of electricity from renewables in 2008 was an estimated 16.7 percent, still short of the EU-wide target of 21 percent by 2010, although some EU countries were close to or had already achieved various types of national 2010 targets, including France, Germany, Latvia, Spain, and Sweden. A series of global ministerial-level conferences dating back to 2004 have allowed countries to report progress and announce new targets.[233] (See Sidebar 5.) In addition, support for setting targets and implementing policies will be one of the roles of IRENA, the new International Renewable Energy Agency.[234] (See Sidebar 6.)

## Power Generation Promotion Policies

At least 83 countries—41 developed/transition countries and 42 developing countries—have some type of policy to promote renewable power generation. The 10 most common policy types are feed-in tariffs, renewable portfolio standards, capital subsidies or grants, investment tax credits, sales tax or VAT exemptions, green certificate trading, direct energy production payments or tax credits, net metering, direct public investment or financing, and public competitive bidding.[235] (See Table 2.)

The most common policy of all is the feed-in tariff, which has been enacted in many new countries and regions in recent years.* By early 2010, at least 50 countries and 25 states/provinces had adopted feed-in tariffs over the years, more than half of which have been enacted since 2005.[236] (See Table R10.) The policies have spurred innovation and increased interest and investment in many countries. They have had the largest effect on wind power but have also influenced solar PV, biomass, and small hydro development.[237]

Strong momentum for feed-in tariffs continues around the world as countries enact new policies or revise existing ones. Many changes and additions were made during 2009. China updated feed-in tariffs for wind power based on bidding and project development experience of recent years, and set uniform tariffs for different regions depending on wind resource geography. It also established a modest feed-in tariff (RMB 1.09/kWh) for utility-scale solar PV (multi-MW scale), although it was not clear which projects would be eligible.

France adopted a tariff for building-integrated PV that was also among the highest in the world (EUR 42–58 cents/kWh). Greece added a new feed-in tariff for solar PV (EUR 55 cents/ kWh) as part of a comprehensive policy to support rooftop solar PV for homes and small business. Ireland added new feed-in tariffs for ocean power (as have several other countries in recent years). Japan adopted its first-ever feed-in tariff, for residential solar PV only (JPY 48/kWh), and was considering others. Kenya added feed-in tariffs for solar PV and biogas in addition to the existing wind, geothermal, and biomass tariffs. Other countries that adopted or updated feed-in tariffs included the Czech Republic, Germany, India, Kenia, Slovenia, South Africa, Taiwan, Thailand, Ukraine, and the United Kingdom. In some countries, tariffs were reduced in response to technology cost reductions, market slowdowns, and concerns about foreign manufacturer market share; reductions were more prevalent in 2009 and early 2010 than in previous years.

States and provinces have been adopting and updating feed-in tariff policies in increasing numbers as well. This is particularly true in the United States, where several states have adopted some form of feed-in policy in recent years, including California, Hawaii, Vermont, and Washington (although all of these are limited in scope).[238] California recently amended its solar PV feed-in tariff to allow larger-scale plants of up to 3 MW to qualify. Beyond the United States, the Canadian province of Ontario announced feed-in tariff provisions implementing its original 2006 Green Energy Act, including offshore wind power tariffs, and solar PV tariffs that are among the highest in the world (CAD 80 cents/kWh). The Australian state of New South Wales added a new feed-in tariff for solar PV (AUD 60 cents/kWh on gross generation). And the Indian state of Uttar Pradesh adopted a new feed-in tariff for bagasse power generation.

Several other countries and sub-national jurisdictions continue to debate and formulate feed-in policies for the future. Countries considering new feed-in policies include Israel, Japan, Malaysia, Vietnam, and Yemen. 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, payment for net versus gross generation, limitations based on type of ownership, and differential treatment of technology sub-classes.

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 ten countries: Australia, Chile, China, Italy, Japan, the Philippines, Poland, Romania, Sweden, and the United Kingdom.[239] (See Table R11.) Globally, 56 states,

* For a definition of "feed-in tariff" and other policies covered in this chapter, see the Glossary.

## Table 2. Renewable Energy Promotion Policies

| Country | Feed-in tariff | Renewable Portfolio Standard/quota | Capital subsidies, grants, rebates | Investment or other tax credits | Sales tax, energy tax, excise tax, or VAT reduction | Tradable RE certificates | Energy production payments or tax credits | Net metering | Public investment, loans, or financing | Public competitive bidding |
|---|---|---|---|---|---|---|---|---|---|---|
| **EU-27** | | | | | | | | | | |
| Austria | X | | X | X | | X | | | X | |
| Belgium | | (*) | X | X | X | X | | X | | |
| Bulgaria | X | | X | | | | | | X | |
| Cyprus | X | | X | | | | | | | |
| Czech Republic | X | | X | X | X | X | | X | | |
| Denmark | X | | X | X | X | X | | X | X | X |
| Estonia | X | | X | | X | | X | | | |
| Finland | X | | X | | X | X | X | | | |
| France | X | | X | X | X | X | | | X | X |
| Germany | X | | X | X | X | | | X | X | |
| Greece | X | | X | X | | | | X | X | |
| Hungary | X | | X | X | X | | | | X | X |
| Ireland | X | | X | X | | X | | | | X |
| Italy | X | X | X | X | X | X | | X | X | |
| Latvia | X | | | | X | | | | X | X |
| Lithuania | X | | X | X | X | | | | X | |
| Luxembourg | X | | X | X | X | | | | | |
| Malta | | | X | | X | | | X | | |
| Netherlands | | | X | X | X | X | X | | | |
| Poland | | X | X | | X | X | | | X | X |
| Portugal | X | | X | X | X | | | | X | X |
| Romania | | X | | | X | X | | | X | |
| Slovakia | X | | | X | X | | | | X | |
| Slovenia | X | | X | X | X | X | | | X | X |
| Spain | X | | X | X | X | X | | | X | |
| Sweden | | X | X | X | X | X | X | | X | |
| United Kingdom | X | X | X | | X | X | | | X | |
| **Other Developed/Transition Countries** | | | | | | | | | | |
| Australia | (*) | X | X | | | X | | | X | |
| Belarus | | | | | | | | | X | |
| Canada | (*) | (*) | X | X | X | | | X | X | X |
| Israel | X | | | | X | | | | | X |
| Japan | X | X | X | X | | X | | X | X | |
| Macedonia | X | | | | | | | | | |
| New Zealand | | | X | | | | | | X | |
| Norway | | | X | | X | X | | | X | |
| Russia | | | X | | | X | | | | |
| Serbia | X | | | | | | | | | |
| South Korea | X | | X | X | X | | | | X | |
| Switzerland | X | | X | | X | | | | | |
| Ukraine | X | | | | | | | | | |
| United States | (*) | (*) | X | X | (*) | (*) | X | (*) | (*) | (*) |

## Table 2. Renewable Energy Promotion Policies (continued)

| Country | Feed-in tariff | Renewable Portfolio Standard/quota | Capital subsidies, grants, rebates | Investment or other tax credits | Sales tax, energy tax, excise tax, or VAT reduction | Tradable RE certificates | Energy production payments or tax credits | Net metering | Public investment, loans, or financing | Public competitive bidding |
|---|---|---|---|---|---|---|---|---|---|---|
| **Developing Countries** | | | | | | | | | | |
| Algeria | X | | | X | X | | | | | |
| Argentina | X | | X | (*) | X | | X | | X | X |
| Bolivia | | | | | X | | | | | |
| Brazil | | | | X | | | | | X | X |
| Chile | | X | X | X | X | | | | X | X |
| China | X | X | X | X | X | | X | | X | X |
| Costa Rica | | | | | | | X | | | |
| Dominican Republic | X | | X | X | X | | | | | |
| Ecuador | X | | | X | | | | | | |
| Egypt | | | | | X | | | | | X |
| El Salvador | | | | X | X | | | | X | |
| Ethiopia | | | | | X | | | | | |
| Ghana | | | X | | X | | | | X | |
| Guatemala | | | | X | X | | | | | |
| India | (*) | (*) | X | X | X | X | X | | X | |
| Indonesia | X | | | X | X | | | | | |
| Iran | | | | X | | | X | | | |
| Jordan | | | | | X | | | X | X | |
| Kenya | X | | | X | | | | | | |
| Malaysia | | | | | | | | | X | |
| Mauritius | | | X | | | | | | | |
| Mexico | | | | X | | | | X | X | X |
| Mongolia | X | | | | | | | | | X |
| Morocco | | | | X | X | | | | X | |
| Nicaragua | X | | | X | X | | | | | |
| Pakistan | X | | | | | | | X | | |
| Palestinian Territories | | | | | X | | | | | |
| Panama | | | | | | | X | | | |
| Peru | | | | X | X | | X | | | X |
| Philippines | X | X | X | X | X | | X | X | X | X |
| Rwanda | | | | | | | | | X | |
| South Africa | X | | X | | X | | | | X | X |
| Sri Lanka | X | | | | | | | | | |
| Tanzania | X | | X | | X | | | | | |
| Thailand | X | | | | X | | | | X | |
| Tunisia | | | X | | X | | | | X | |
| Turkey | X | | X | | | | | | | |
| Uganda | X | | X | | X | | | | X | |
| Uruguay | | X | | | | | | | | X |
| Zambia | | | | | X | | | | | |

*Notes*: 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. *Sources*: See Endnote 235.

provinces, or countries had RPS policies by early 2010. 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 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, one new state enacted an RPS policy during 2009 (Kansas, 20 percent by 2020), bringing the total number of U.S. states with such policies to 29 plus the District of Columbia. (There are also seven U.S. states with non-RPS policy goals; West Virginia was the most recent to enact a policy goal, in 2009, for 25 percent by 2025.[240]) In addition, four U.S. states revised existing RPS targets. California revised its RPS mandate of 20 percent by 2010 to a new mandate of 33 percent by 2020. (It appeared California would fall well short of the 2010 mandate, at less than 15 percent.) Colorado increased its RPS to 30 percent by 2020, Maine increased incentives for community-based projects, and Nevada extended its existing RPS to 25 percent by 2025. RPS policies by U.S. states increasingly emphasize solar PV as well; of the 11 states that modified their RPS policies in some manner in 2009, 7 of these modifications included new provisions specific to solar PV. Beyond the United States, Canada has three provinces with RPS policies and seven more with some form of planning targets, India has at least 12 states with RPS policies, and two Belgian regions have RPS policies.[241]

Some type of direct capital investment subsidy, grant, or rebate is offered in at least 45 countries. Investment tax credits, import duty reductions, and/or other tax incentives are also common means for providing financial support at the national level in many countries, and also at the state level in the United States, Canada, and Australia. Many tax credits apply to a broad range of renewable energy technologies, such as Indonesia's new 5 percent tax credit adopted in early 2010, and a new 2009 policy in the Philippines for seven-year income tax exemptions and zero-VAT rates for renewable energy projects. Some are technology-specific, such as India's accelerated depreciation and 10-year income-tax exemption for wind power projects. Many countries have reduced import duties for renewable energy equipment, such as South Korea's 50 percent duty reduction announced in 2009.

Capital subsidies and tax credits have been particularly instrumental in supporting solar PV markets. Capital subsidies for solar PV have become common at the national, state, local, and utility levels, typically for 30–50 percent of installed costs.[242] More than half of all U.S. states had such subsidy programs (or tax-credit policies), either statewide or for specific utilities, with many programs added or modified in at least 20 states during 2009 alone. California's solar PV subsidy programs have existed the longest, and the state's "Solar Initiative" calls for 3 GW of solar PV by 2018. South 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 tax credit for solar PV (through 2016 in the United States).[243] France provides a 50-percent income tax credit. Australia provides rebates up to AUD 8/watt.

New solar PV rooftop programs featuring subsidies and tax credits were announced in 2009 in several countries. Notable are China's new solar PV subsidies, which provide roughly 50 percent of capital cost for building-based solar PV over 50 kW and for other on-grid projects over 300 kW in size. China also provides 70-percent capital-cost subsidies for off-grid projects. (The policy requires that utilities purchase surplus power from solar generators who primarily supply their own needs, and establishes a government-financed 500 MW solar PV project pipeline through 2012.) India established a new solar PV program that provides a variety of incentives including tax credits and subsidies. Japan, five years after discontinuing its original national solar PV subsidy program that began in the 1990s, re-instated national subsides for residential installations, equivalent to 25–35 percent of installation costs.

Energy production payments or credits, sometimes called "premiums," exist in a handful of countries. These are typically a fixed price per kilowatt-hour, or may be a percentage of other utility tariffs or baselines. In early 2009, the United States extended the production tax credit (PTC) through 2012 for wind power, and through 2013 for biomass, geothermal, hydro, and ocean technologies. The PTC was originally established in 1992 at 1.5 cents/kWh and increased through inflation adjustments to 2.1 cents/kWh by 2009. In a new trend, many U.S. states are establishing so-called "performance-based incentives" to support solar PV, enacting or considering various forms of energy production payments. India provides an INR 0.50/kWh production payment for wind power. Other countries with energy production payments or premiums now include Argentina, Estonia, Finland, Honduras, Luxembourg, the Netherlands, Panama, Peru, the Philippines, and Sweden.

A variety 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. In 2009, several such funds were announced, many connected to economic stimulus bills. Canada launched a CAD 1 billion clean energy fund for demonstration projects and research and development. China plans a $440 billion (equivalent) fund that targets clean power, including renewables. The Philippines established a $2 billion (equivalent) fund in 2009 and was supporting more than 65

renewable energy projects across all renewables technologies. Other countries that established new funds in 2009 include Bangladesh (BDT 2 billion or $29 million, by the central bank) and Jordan. In early 2010, India proposed to start a national renewable energy fund.

Countries have adopted public competitive bidding for fixed quantities of renewable power capacity at various times over the past two decades, and new competitive bidding policies continue to appear. Following the United Kingdom's NFFO policy in the 1990s, China's wind power "concession" policy during 2003–07 was one of the longest-running examples, with annual bidding rounds for five years running that resulted in 3.4 GW added, but was subsequently eclipsed by the growing use of feed-in tariffs to support projects instead. Brazil also conducted bidding for small hydro, wind, and biomass power as part of its PROINFA program, which completed a first phase in 2008 with 3.3 GW installed and was beginning its second phase in 2009. Uruguay was among a new group of countries to launch competitive bidding in 2009, with the state-owned utility bidding for 60 MW of wind, biomass, and small hydro. Argentina's state-run utility likewise bid for 1 GW of renewables. New bidding in the Philippines totaled 1.3 GW. And Peru resolved in 2009 to bid for 500 MW of renewables by 2012.

Net metering (also called "net billing") is an important policy for rooftop solar PV (as well as other renewables) that allows self-generated power to offset electricity purchases. Net metering laws now exist in at least 10 countries and in 43 U.S. states.[244] Most net metering is only for small installations, but a growing number of regulations allow larger-sized installations to qualify. At least 20 U.S. states now allow net metering up to 1 MW for at least one customer type. Some net metering provisions cap total installations allowed to qualify for net metering, although caps may change over time. For example, California in 2010 increased the total capacity eligible for net metering to 5 percent of peak system power demand, after the previous cap of 2.5 percent was about to be reached. Net metering exists in a growing number of developing countries, for example Tanzania and Thailand. Net metering laws continue to evolve and become more sophisticated as new provisions address issues such as net excess generation, renewable energy credit ownership, and community-owned systems.

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). Several U.S. states have mandates as well. California's "Solar Homes Partnership" requires home builders to offer solar as a standard feature in new developments of 50 buildings or more starting in 2011. New 2009 building codes in Colorado and New Jersey require builders to make homes PV-ready or to give purchasers the option of installing solar PV. More examples of building code requirements at the city level appear in Table R13.

## Solar and Other Renewable Hot Water and Heating Policies

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 in new construction and renovation. Solar hot water must meet 30–70 percent of hot water energy needs, depending on dimatic zone, consumption level, and back-up fuel. Now many other countries have followed suit. India's nationwide energy conservation codes requires at least 20 percent of water heating capacity from solar for residential buildings, hotels, and hospitals with centralized hot water systems.[245] South Korea's new 2010 mandate requires on-site renewable energy to contribute at least 5 percent of total energy consumption for new public buildings larger than 1,000 square meters. Uruguay mandates solar hot water for some types of commercial buildings with high hot water requirements like hotels and sports clubs. China is planning to mandate solar hot water in certain types of new construction nationwide.[246] In 2009, Hawaii became the first U.S. state to mandate solar hot water in new single-family homes.

Municipal governments have been enacting solar hot water mandates as well. Ordinances by more than 70 municipalities throughout Spain preceded the country'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 Lianyungang, Rizhao, and Shenzhen, which mandate solar hot water in all new residential buildings (up to 12 stories in height in Lianyungan and Shenzhen) and in new construction and renovation of hotels and commercial buildings (Lianyungang only). In India, the cities of Nagpur and Rajkot require solar hot water in new residential buildings (larger than 150 square meters in Rajkot and greater than 1,500 square meters in Nagpur). Nagpur also provides a 10-percent property tax rebate as an added incentive. Brazil's largest city, São Paulo, requires solar hot water in new buildings larger than 800 square meters.[247] In 2009, other cities were working on solar hot water policies as well, including Rome, Italy, which would require 30–50 percent of hot water energy from solar for new buildings.

In Europe, a new crop of policies supporting renewable heating has emerged in recent years. Germany's Renewable Energies Heating Law, effective in 2009, requires all new residential buildings to obtain at least 20 percent of household heating and hot water energy from renewables, including solar, biomass, and geothermal.[248] At least one German state also mandates renewables for existing buildings during building retrofits. Germany's overall goal is for 14 percent of total heating energy to come from renewables by 2020, including district-heating systems. Lithuania has a similar goal for a 23 percent share of heating from renewables by 2020, including 70 percent of central district heating from biomass by 2020. Scotland and the United Kingdom have been providing tens of millions of British pounds in grants for biomass heating. And in late 2009 and early 2010, the European Parliament was working on a directive to require high "energy performance" in newly constructed buildings throughout Europe starting in 2020, including renewable energy sources for building energy needs. The directive also aimed to mandate retrofits of existing buildings and to target the public-sector ownership/leasing of such buildings.

For some years, China was one of the only countries 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. (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. Beyond China, other countries with solar hot water targets include India (20 million square meters by 2022), Morocco (1.7 million square meters by 2020), and Tunisia (740,000 square meters by 2012).

Capital subsidies for solar hot water are now a common policy in many states and countries. At least 20 countries, and probably several more, provide capital grants, rebates, VAT exemptions, or investment tax credits for solar hot water/heating investments, including Australia, Austria, Belgium, Canada, Chile, Cyprus, Finland, France, Germany, Greece, Hungary, Japan, the Netherlands, New Zealand, Portugal, Spain, Sweden, the United Kingdom, the United States, and Uruguay. Capital grants or tax credits are typically 20–40 percent of system cost. The United States provides a 30-percent federal tax credit (through 2016) in addition to many state-level rebates and credits. German incentives for large-scale installations include low-interest loans and 30- percent subsidies for large systems (less than 40 square meters) for heating, cooling, and industrial process heat. Many U.S. states and some Canadian provinces also offer capital subsidies. 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 is considering 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). Several countries in North Africa and the Middle East are continuing to develop solar hot water policies, building codes, and/or promotion programs, including Egypt, Jordan, Morocco, Syria, and Tunisia.

## Biofuels Policies

Mandates for blending biofuels into vehicle fuels have been enacted in at least 41 states/provinces and 24 countries at the national level. (See Table R12.) Most mandates require blending 10–15 percent ethanol with gasoline or blending 2–5 percent biodiesel with diesel fuel. Mandates can now be found in at least 13 Indian states/territories, 9 Chinese provinces, 9 U.S. states, 5 Canadian provinces, 2 Australian states, and at least 14 developing countries at the national level. Many jurisdictions, including several U.S. states, are also starting to mandate biofuels use in government vehicles.

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 a legally mandated range of 20–25 percent. All fueling 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 and tax preferences for vehicles (both "flex-fuel" vehicles and those that run on pure ethanol). Brazil also began to mandate B2–B3 biodiesel blending in 2008, and increased the blending mandate to B5 in early 2010.

In addition to mandated blending, several biofuels targets and plans define future levels of biofuels use. The 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. The United Kingdom has a similar renewable fuels obligation, targeting 5 percent by 2010. Japan's strategy for long-term ethanol production targets 6 billion liters/year by 2030, representing 5 percent of transport energy. China targets the equivalent of 13 billion liters of ethanol and 2.3 billion liters of biodiesel per year by 2020. South Africa's strategy targets 2 percent biofuels.

Targets in the EU for share of transport energy from renewables include Belgium (5.75 percent by 2010), Croatia (5.75 percent by 2010), France (10 percent by 2015), and Portugal (7 percent biodiesel by 2010). These are in addition to the

### Sidebar 7. Sustainability Spotlight: Biofuels and Biomass

As the scale of investment and visibility of renewables soared during the period 2005–10, the sustainability of various renewable energy technologies emerged as a prominent issue. High-profile topics that have captured public and policymaker attention include land use and biodiversity, deforestation, noise and visual aesthetics, toxic byproducts from manufacturing, impacts on food security and markets, and mineral resource constraints. Sustainability concerns often focus on lifecycle (net) greenhouse gas emissions and/or lifecycle (net) energy production. While these issues are receiving increased scrutiny for all technologies, the sustainability of bioenergy received particular policy attention during the 2008–10 period.

Recent policy attention has focused on bioenergy sustainability because the environmental, economic, and social costs of bioenergy can be quite high if sustainability safeguards are omitted. That is, policy measures for sustainability can have a large influence. This is especially true for lifecycle (net) greenhouse gas emissions, biodiversity impacts associated with crop production, impacts on food security, and land rights infringements on local populations. Policies are affecting bioenergy sustainability by influencing the types of feedstocks/crops used, the locations and types of land where bioenergy is grown/produced, and the technical means of energy conversion. International trade policies are also affecting sustainability by influencing which bioenergy forms are traded.

For example, liquid biofuels for transportation are now one of the most prominent forms of bioenergy. In recent years, several countries and regions have enacted policies or adopted standards to promote sustainable liquid biofuels production and use, most prominently the European Union and the United States. The 2009 EU Renewable Energy Directive, which requires 10 percent of transportation energy from renewables by 2020, is the most comprehensive mandatory sustainability standard in place today. The Directive requires that the lifecycle (net) greenhouse gas emissions of biofuels consumed be at least 50 percent less than the equivalent emissions from gasoline or diesel by 2017 (and 35 percent less starting in 2011). In addition, the feedstocks for biofuels should not be harvested from lands with high biodiversity value, from carbon-rich or forested land, or from wetlands. And although social requirements are not included in the Directive, reporting obligations on social impacts (for example, food security and land rights) have been established for all EU member countries.

Like the EU, the U.S. Renewable Fuel Standard (RFS) and the California Low Carbon Fuel Standard (LCFS) both require specific levels of lifecycle (net) greenhouse gas reductions compared to equivalent fossil fuel consumption. The U.S. RFS requires that at least half of the biofuels production mandated by 2022 should reduce lifecycle emissions by 50 percent. The California LCFS is a performance standard that calls for a minimum of 10 percent emissions reduction per unit of transport energy by 2020. Both the U.S. and California standards currently address only greenhouse gas emissions, but California plans to expand its policy to address other sustainability issues associated with liquid biofuels in the future. Brazil also adopted new sustainability policies in 2009 for sugarcane ethanol, including zoning regulation of sugarcane expansion and social protocols.

In addition to mandatory policies for sustainability, several voluntary initiatives exist around the world. One of the most comprehensive is the Roundtable on Sustainable Biofuels, which released the first version of its standard in 2009 after extensive consultations. The Roundtable is conducting pilot applications and convening expert groups to detail sustainability requirements. Another global initiative is the Global Bioenergy Partnership (GBEP) among 32 countries, international organizations, and industry associations. Other initiatives are oriented to sustainability of specific feedstocks, such as the Roundtable on Sustainable Palm Oil (RSPO), the Better Sugarcane Initiative (BSI), the Roundtable on Responsible Soy (RTRS), and the Forest Stewardship Council (FSC). These initiatives represent collaborations of stakeholders involved in specific supply chains to establish sustainability requirements. Most voluntary initiatives incorporate independent verification to demonstrate compliance.

Other forms of bioenergy, such as gaseous and solid biomass for electricity and heat, have not been subject to as much scrutiny in terms of sustainability, but this is also changing as these forms of bioenergy are used in increasing quantities. For example, many countries, both developed and developing, as well as prominent international agencies, participate in the Global Bio-Energy Partnership, an intergovernmental body established by the G8 in 2005. The partnership is compiling sustainability standards and criteria for all forms of bioenergy and is aiming for an agreed list by 2011, to serve as a basis for voluntary country-by-country implementation. The International Organization for Standardization (ISO) also started work on a voluntary sustainability standard for bioenergy in 2010, but results are not expected for several years.

*Source:* See Endnote 250.

EU-wide target of 10 percent of transport energy by 2020 that covers both sustainable biofuels and electric vehicles.[249] The EU-wide target incorporates a newly adopted definition of sustainability, which adds to a growing number of biofuels sustainability standards.[250] (See Sidebar 7.)

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 45 cents/gallon (13 cents/liter) tax credit for ethanol blending through 2010. There is also a U.S. tax credit of $1.00/gallon (28 cents/liter) for biodiesel. A number of U.S. states also offer production incentives and sales tax reductions or exemptions. Canada provides federal biofuels production subsidies of CAD 10 cents/liter for ethanol and CAD 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. Five Canadian provinces also provide producer incentives and/or tax exemptions of CAD 9–20 cents/liter. Other countries with tax incentives for production include Argentina, Bolivia, Colombia, Paraguay, and Portugal.

Biofuels tax exemptions exist in at least 10 EU countries, including Belgium, France, Greece, Ireland, Italy, Lithuania, Slovenia, Spain, Sweden, and the United Kingdom. Other OECD countries with fuel-tax exemptions include Canada and Australia. Fuel-tax exemptions also exist in several 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 6 million green power consumers in Europe, the United States, Australia, Japan, and Canada.[251] 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.[252] As markets expand, the price premiums for green power over conventional power have generally declined.

Green power purchasing and utility green pricing have existed in some countries since the late 1990s. In most European countries, the market share of green power is still small, less than 5 percent. The Netherlands was the leader in green power consumers during the period 2005–20008, due in part to large fossil-fuel electricity taxes combined with tax exemptions for green power. At the peak, there were more than 3 million green power consumers in the Netherlands, although this had declined to an estimated 2.3 million by 2007 once the tax and exemption were rescinded.

Germany has now eclipsed the Netherlands as the green power leader in Europe. In 2008, the country was home to an estimated 2.2 million green power residential customers (6.2 TWh purchased) and an estimated 150,000 business customers (4.8 TWh purchased). Germany's market has shown the fastest growth in recent years, up from 750,000 customers in 2006. Other major green power markets in Europe include Austria, Finland, Italy, Sweden, Switzerland (600,000 customers in 2007), and the United Kingdom. In some European countries, green power labels have been introduced to strengthen consumer confidence, such as "grüner strom" and "ok-power" in Germany and "nature-made star" in Switzerland.

Eighteen European countries are members of the European Energy Certificate System (EECS), a framework 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). A total of 209 TWh of certificates were issued during 2009, triple the 67 TWh of issuance during 2006. Hydropower has dominated certificate trading, accounting for 91 percent of certificates in 2009. (Norway, a major hydro producer, issued 62 percent of all certificates under the EECS in 2009.) A growing volume of certificates (150 TWh in 2009) is being used to provide guarantee-of-origin disclosure as more countries and issuers are registered.

In the United States, more than 1 million green power consumers purchased 24 TWh in 2008, up from 18 TWh in 2007 and double the 12 TWh purchased in 2006. Retail green power premiums for residential and small commercial consumers are typically 1–3 cents/kWh, with some premiums now below 1 cent/kWh. Currently, more than 850 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. The U.S. Environmental Protection Agency's "Green Power Partnership" grew to more than 1,200 corporate and institutional partners, who were collectively purchasing more than 17 TWh of green power annually by the end of 2009. (The company Intel remains the largest single purchaser of green power, at 1.4 TWh in 2009.)

Other countries have also seen gains in green power purchasing. Australia had 900,000 green power residential consumers and 34,000 business consumers who collectively purchased 1.8 TWh in 2008. 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. Several Japanese electric utilities offer a Green Power Fund that allows customers to contribute voluntarily to support green power investments; some 35,000 customers were doing so in 2007. In Canada, about a dozen organizations, including utilities and independent marketers, offer green power options to consumers. In South Africa, at least one company offers green power to retail customers, using bagasse power from sugar mills.

## City and Local Government Policies

City and local governments around the world continue to enact policies to reduce greenhouse gas emissions and promote renewable energy. Their motives are multi-faceted, including climate protection, improved air quality, energy security, and sustainable local development. And these governments can play multiple roles: as decision-makers, planning authorities, managers of municipal infrastructure, and role models for citizens and businesses.

A 2009 companion report from REN21, the *Global Status Report on Local Renewable Energy Policies*, provides an overview of municipal policies and activities to promote renewable energy, surveying 180 cities and local governments in Europe, the United States, Latin America, Australia, New Zealand, China, South Korea, and Japan. It considers local policies in five main categories: target setting; regulation based on legal responsibility and jurisdiction; operation of municipal infrastructure; voluntary actions and government serving as a role model; and information, promotion, and raising awareness. Some of the main findings in these five categories are summarized below. The report also gives many specific examples of these policies, some of which are summarized in Table R13.[253]

Almost all cities working to promote renewable energy at the local level have established some type of renewable energy or carbon emissions ($CO_2$) reduction target. Of the 180 cities and local governments surveyed, at least 140 have some type of future target for renewable energy and/or $CO_2$. $CO_2$ emissions-reduction goals are typically a 10–20 percent reduction over a baseline level (usually 1990 levels) by 2010–2012, consistent with the form of Kyoto Protocol targets. $CO_2$ targets for 2020 and beyond have appeared in recent years and are typically for 20–40 percent reductions by 2020, with some $CO_2$ targets now even extending to 2050. Other cities have targets to become fully or partially "carbon neutral" (zero net emissions) by a future year. One novel type of $CO_2$ target is emissions per capita, with several cities targeting future reductions in this indictor.[254]

There are several types of renewable energy-specific targets. One type is for the renewable share of total electricity consumption, with several cities in the range of 10–30 percent. Some cities target the share of electricity consumed by the government itself, for its own buildings, vehicle fleets, and operations. Such "own-use" targets can range from 10 percent to 100 percent. Another type of target is total share of energy from renewables (e.g., including transport and heating, not just electricity), or share of energy just for a specific sector such as buildings. Some targets are for total amounts of installed renewable energy capacity, such as megawatts of solar PV or wind power, or the number or total surface area of solar hot water collectors.

Regulation related to municipal responsibility and jurisdiction can take many forms. One common aspect is urban planning that incorporates renewable energy. Most plans call for integrating renewable energy in some systematic and long-term fashion into city development. Some plans are relatively short term, for example five years or less, while many others extend to 2020, 2030, or even 2050. Of the 180 cities and local governments surveyed, at least half have some type of urban planning that incorporates renewable energy.

Another type of regulatory policy emerging in recent years is incorporation of renewable energy in building codes or permitting. Some policies mandate solar hot water in all new construction above a certain size threshold. Other types of mandates are for design reviews prior to construction that reveal the opportunities for integrating solar into building designs, or for building designs to include "stub-outs" or other features that permit easy future installation of renewables. Of the 180 cities and local governments surveyed, at least 35 have some type of building code or permitting policy that incorporates renewable energy.

Many other regulatory measures for renewable energy are being adopted. Where cities have regulatory authority over some type of taxation, tax credits and exemptions for renewable energy at the local level are possible, although these do not appear to be common. Of the 180 cities and local governments surveyed, only 12 were found to have some form of these policies. Property tax credits or abatement for residential installations appear to be the most common. Other unique examples of regulatory measures include a Portland, Oregon (USA), mandate for blending biofuels with all gasoline and/or diesel fuel sold within city limits; a Betim, Brazil, mandate that all taxis use biofuels; and a Tokyo, Japan, mandate for a carbon cap-and-trade system on large businesses within city jurisdiction.

Related to regulatory measures are cases where local governments have established city departments or public market-facilitation agencies that are planning, regulating, and/or promoting renewable energy. These agencies may have a regulatory function, or they may be "market facilitation" agencies that provide information, training, finance, stakeholder convening, public outreach, etc. Often, government departments or agencies tasked with promoting renewable energy take both roles.

Incorporation of renewable energy into municipal infrastructure and operations takes many forms. Some cities have decided to purchase green power for municipal buildings and operations. Others are purchasing biofuels for municipal fleet vehicles and/or public transit vehicles. Associated with these biofuels purchases may be investment in alternative-fuel vehicles that are able to use richer mixtures of biofuels than conventional vehicles. Many cities also invest in renewable energy installations for municipal buildings, schools, hospitals, recreation facilities, and other public facilities. Cities with community- or district-scale heating systems may also invest in renewable heating infrastructure, for example biomass cogeneration plants. Of the 180 cities and local governments surveyed, at least half have some type of policy related to municipal infrastructure and operations.

For electric utility operations, very few local governments worldwide have direct jurisdiction over the electric utility that serves their populations. But in cases where full or partial jurisdiction exists, or where local regulation can be achieved indirectly through regional or state government, electric utility policies for renewable energy are possible. These include feed-in tariffs, renewable portfolio standards, net metering, a carbon tax on fossil-fuel electricity purchases, and green power sales by the utility. Feed-in tariffs are very common around the world at national levels and in a few cases at state/provincial levels, but not at local levels. However, some cities and local governments are beginning to consider electric utility feed-in policies and to explore how to implement these policies. The first city to adopt a local feed-in tariff in the United States was Gainesville, Florida, in 2008; Sacramento, California, began a feed-in tariff in 2010.[255]

Beyond their formal regulatory roles, many cities undertake additional voluntary actions to promote renewable energy or to serve as a role model for the private sector and other groups. Demonstration projects are very common. Subsidies, grants, and loans for end-users to install renewable energy are common in some specific countries or regions; of the 180 cities and local governments surveyed, at least 50 have some type of subsidies, grants, or loans.

Other voluntary actions include government investment funds that often solicit proposals and invest in public or private projects, and a wide variety of ways to support or facilitate private and community initiatives. A growing trend in this category is for cities to offer low-interest loans for renewable energy investments by homeowners and businesses, paid back through the property tax/assessment system. Berkeley, California, was one of the early cities to enact this type of program, and in 2009, 13 U.S. states enacted so-called "PACE" (Property-Assessed Clean Energy) financing authorization to enable local governments to create such programs. Also in the category of voluntary actions, a few cities provide municipal land or building rooftops for projects, or sell land with sustainability conditions for its development. Finally, some cities choose to subsidize public-access biofuels stations, including conversion costs for conventional tanks and pumps, and also biofuels production and distribution.

Voluntary information and promotion activities are very diverse. Activities among many of the 180 cities and local governments surveyed include public media campaigns and programs; recognition activities and awards; organization of stakeholders; forums and working groups; training programs; enabling access to finance by local stakeholders; enabling stakeholder-owned projects; removing barriers to community participation; energy audits and GIS databases; analysis of renewable energy potentials; information centers; and initiation and support for demonstration projects.

Municipal governments are joining forces to share resources and make joint commitments through associations or support networks. The European "Covenant of Mayors" was launched in 2008 and by early 2010 had grown to more than 1,600 cities and towns, mostly in Europe.[256] Cities and towns in the Covenant agree to a reduction in $CO_2$ emissions of 20 percent by 2020 and agree to create and implement action plans to achieve the reductions. In December 2007 at the United Nations Climate Change Conference in Bali, Indonesia, the World Mayors and Local Governments Climate Protection Agreement was launched, in which signatories agree to measure and report on annual reductions of greenhouse gas emissions and effect emissions reductions, including renewable energy. 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 India Solar Cities Program, the U.S. Solar America Partnership, the International Solar Cities Initiative, the ICLEI Local Renewables Model Communities Initiative, and the ICLEI Cities for Climate Protection campaign.[257]



## 5. RURAL RENEWABLE ENERGY

Renewable energy has an important role in providing modern energy access to the billions of people that continue to depend on more traditional sources of energy. Some 1.5 billion people worldwide still lack access to electricity, and approximately 2.6 billion are reliant on wood, straw, charcoal, or dung for cooking their daily meals.[258] Many heat their food on open fires that are very inefficient in providing heat; more than one-third of the world's people are cooking almost as they were hundreds or even thousands of years ago. For lighting, households without electricity generally rely on kerosene lamps that are very poor in transforming energy into light. Communications is limited to radios powered by expensive dry cell batteries.

In many rural areas of developing countries, connections to electric grids may take decades or may be economically prohibitive. Today, there are good alternatives to grid electricity and carbon-based fuels that do not have to wait for the expansion of grid electricity systems. These include a wide array of new and renewable energy systems that can provide for both specific end uses and general rural energy services. Thus, there is a possibility to speed up the transition to modern energy services through the acceleration of off-grid renewable energy systems.

### Rural Transition to New and Renewable Energy Systems

A rural transition from traditional to more modern forms of energy is clearly under way in households and small industries in many countries. "Traditional" and "modern" refer both to the type of fuel and the technologies that use it. Wood, for example, can be burned very inefficiently

**Table 3. Transitions to Renewable Energy in Rural (Off-Grid) Areas**

| Rural Energy Service | Existing Off-Grid Rural Energy Sources | Examples of New and Renewable Energy Sources |
|---|---|---|
| Lighting and other small electric needs (homes, schools, street lighting, telecom, hand tools, vaccine storage) | Candles, kerosene, batteries, central battery recharging by carting batteries to grid | • Hydropower (pico-scale, micro-scale, small-scale)<br>• Biogas from household-scale digester<br>• Small-scale biomass gasifier with gas engine<br>• Village-scale mini-grids and solar/wind hybrid systems<br>• Solar home systems |
| Communications (televisions, radios, cell phones) | Dry cell batteries, central battery recharging by carting batteries to grid | • Hydropower (pico-scale, micro-scale, small-scale)<br>• Biogas from household-scale digester<br>• Small-scale biomass gasifier with gas engine<br>• Village-scale mini-grids and solar/wind hybrid systems<br>• Solar home systems |
| Cooking (homes, commercial stoves and ovens) | Burning wood, dung, or straw in open fire at about 15 percent efficiency | • Improved cooking stoves (fuel wood, crop wastes) with efficiencies above 25 percent<br>• Biogas from household-scale digester<br>• Solar cookers |
| Heating and cooling (crop drying and other agricultural processing, hot water) | Mostly open fire from wood, dung, and straw | • Improved heating stoves<br>• Biogas from small- and medium-scale digesters<br>• Solar crop dryers<br>• Solar water heaters<br>• Ice making for food preservation<br>• Fans from small grid renewable system |
| Process motive power (small industry) | Diesel engines and generators | • Small electricity grid systems from microhydro, gasifiers, direct combustion, and large biodigesters |
| Water pumping (agriculture and drinking water) | Diesel pumps and generators | • Mechanical wind pumps<br>• Solar PV pumps<br>• Small electricity grid systems from microhydro, gasifiers, direct combustion, and large biodigesters |

in a traditional open fire with high levels of pollutants, or wood chips can be gasified and burned as a high-quality "modern" cooking fuel, with high combustion efficiency and very little pollution. In the case of household lighting, kerosene is a traditional form of lighting, offering poor light and low efficiency, whereas electric lamps (for example powered by solar) give off 100 times more light compared to kerosene lamps or candles.[259] Electric light enables households to read, socialize, and be more productive during the evening and also has been associated with greater school attendance by children.[260]

In even the remotest areas, many renewable energy sources such as PV household systems, micro-hydro powered mini-grids, and solar pumps can provide some of the basic necessities of modern life, including quality lighting, communications, motive power, and heating and cooling. More recently, there have been encouraging developments with biofuels-based generating systems. The rural services that can be provided in more modern ways are described in Table 3.

Unfortunately, statistics on renewable energy use in rural areas of developing countries are not being collected systematically by any international organization. As a consequence, it is generally difficult to detail the progress of renewable energy in off-grid areas for all developing countries. However, there are statistics available for many individual programs and countries. The following sections review trends for some of the more common renewable energy technologies that have been promoted and adopted in remote areas of developing countries.

## Household Lighting and Communications

Household lighting is one of the most important benefits of rural electricity.[261] Many renewable energy technologies are appropriate for delivering high-quality lighting to rural households. These include solar home systems, pico- and micro- hydropower systems, biogas from household-scale digesters, small-scale biomass gasifiers with gas engines, solar/wind hybrid village mini-grids, and others. There are also some new micro-lighting systems being developed under programs such as Lighting Africa. Household lighting requires very little power, especially with new lighting technologies available today.

The renewable energy technologies most directly connected with improving household lighting are a wide variety of solar PV systems including whole-home systems and lanterns. Worldwide achievements are somewhat difficult to estimate, but there have been some significant accomplishments. In Bangladesh during the last eight years, close to half a million solar home systems have been installed—most between 50 and 75 Watts-peak—and a new program aims to expand this to 1.3 million by 2012.[262] Under China's Renewable Energy Development project, which ended in mid-2008, more than 400,000 solar home systems were sold in northwestern China—most of them to herders who transported the systems on the backs of their animals as they moved to new pastures.[263] India's Ministry of New and Renewable Energy estimates that as of 2009, close to 500,000 solar home systems and 700,000 solar lanterns had been purchased nationwide.[264] And in Sri Lanka, some 60,000 systems had been purchased as of 2007, most during the last decade.

In Africa, the rise in solar home systems has been slower. But by 2007, the continent still had more than 500,000 systems in use, with more than half of these in Kenya and South Africa.[265] As of 2005, Kenya was home to just over 150,000 solar systems with a median size of 25 watts, and reports suggest that coverage has since reached some 300,000 households.[266] Outside these two countries, the number of solar home systems installations in rural Africa is relatively small.

Bangladesh, where the power grid reaches only about one-third of the rural population, has applied one successful approach to the sale of solar home systems. In the early 2000s, the government and donors established a rural energy fund that has enabled a group of 16 participating sales and service companies to install about half a million systems. A key part of this program has been to ensure that the systems meet high quality standards and to provide guarantees for the technology and after-sales service. Participants have included Grameen Shakti and several other microfinance organizations. These and other non-governmental organizations facilitate sales and guarantee the quality of the systems.

Another illustrative project is Sri Lanka's Renewable Energy for Rural Economic Development Project, which also employs consumer credit and a network of microfinance institutions and solar companies. Through their dealer networks, solar companies sell solar home systems and offer operation and maintenance services. The business model is based on a memorandum of understanding between the microfinance institution and the solar company, key features of which are a buyback scheme and identification of the consumer-service responsibilities of the two parties. Applying this model, the Sarvodaya Economic Enterprises Development Services—the project's key partner in solar home system financing and a recognized leader in off-grid energy services delivery in remote rural areas—financed more than 70,000 systems during 2002–06.[267]

Similar to household lighting, communications require a small amount of power that is easily handled by solar household systems. In China, the main use of larger, 50-

watt solar household systems, after lighting, is for viewing television—and retailers actually market the systems for this purpose.[268] Many battery systems in developing countries are used extensively for television viewing, and more recently mobile phone charging has been added as an option as communication towers become available.

## Cooking and Heating

In rural areas of developing countries, most energy used for cooking is "renewable energy" in the form of wood, straw, and dung. Unfortunately, the stoves used are often quite primitive and have poor combustion efficiency. In some cases, this has resulted in excessive biomass use and unsustainable forest management practices that have contributed to declining biomass stocks in many developing countries.

Today, a new generation of improved biomass stoves is being manufactured in factories or workshops, sometimes backed by large international companies.[269] These stoves generally are made of durable materials that will last for 5 to 10 years or even longer, and many are sold with guarantees. The market potential for biomass stoves in developing countries is large. The goal of marketing the stoves is to improve the energy efficiency of cooking, lower indoor air pollution, and reduce labor or cash expenses for the poorest half of the world's population.

Estimates of the number of improved cookstoves vary, but the World Health Organization and United Nations Development Programme recently surveyed 140 countries with a combined population of 3 billion people who rely on solid fuels such as wood, straw, dung, and coal for cooking.[270] The study found that approximately 830 million people—slightly less than one-third of the population using solid fuels—are using improved cookstoves (defined as a closed stove with a chimney or an open fire with a hood). This amounts to about 166 million households, including 116 million in China and more than 13 million in the rest of East Asia, 20 million in South Asia, 7 million in sub-Saharan Africa, and over 8 million in Latin America.

The use of factory manufactured improved stoves still lags considerably behind that of locally produced stoves, but most companies have been in business for only the last five years. The combustion efficiency of these stoves appears to be superior to the locally made stoves, and they operate much longer. Even though most have not been marketed until the last several years, approximately half a million of these stoves have sold to date, with major programs in India, South Africa, Uganda, Honduras, and Guatemala.[271] Despite growing experience in implementing successful programs, however, this does not lessen the challenging nature of such initiatives.[272]

In addition to these new varieties of manufactured or locally produced stoves, smaller niche cooking technologies such as biogas systems and solar cookers can play a significant role in improving cooking practices.[273] The introduction of biogas for cooking has been a slow and steady process in developing countries, in part because the manure feedstock limits the market for household biogas systems to animal owners. But the technology itself is undergoing a bit of a rebirth after roughly 25 years of design experimentation.

China now has some 25 million biogas systems, with an estimated 3 million added during 2009.[274] India is home to some 4 million systems, according to recent figures from the Ministry of New and Renewable Energy.[275] Vietnam has more than 150,000 systems.[276] And Nepal's Biogas Support Programme, which combines the participation of the private sector, microfinance organizations, community groups, and non-governmental organizations, has resulted in a steady increase in biogas systems during the last decade, with close to 200,000 adopted.[277]

## Motive Power, Irrigation, and Village-Scale Systems

Generally, the use of energy for motive purposes requires more power than is possible with household-sized systems. Although household systems can be scaled up to almost any size, the expense of having enough PV cells or installing larger biogas plants or micro-hydro systems is often financially prohibitive. The larger amounts of power necessary to drive machinery for productive use of energy often requires a larger system that is shared by others in the community to achieve economies of scale that make the energy affordable. This might include small electricity grid systems from micro-hydro, gasification and direct combustion of biomass, and larger scale biogas digesters coupled to engines and electric generators. Water pumping for drinking water or irrigation can be achieved using mechanical wind pumps and solar PV pumps.

In India today there are approximately 7,000 solar-powered pumps for irrigation.[278] These systems are not as numerous as the technologies used for lighting, communication, or cooking, but they can be important for increasing income in rural areas. In the early days of China's rural electrification program, both small- and micro-hydro systems were promoted to provide energy self sufficiency to isolated local communities. But today, as the country's electricity grid expands, many small-hydro stations now provide power to the grid system. As of 2007, some 50 GW of small hydro was installed in China, only about 3 GW of which was not connected to the existing grid system.[279]

One example of village small grids is the Nepal Village Micro Hydro Program, which has benefited from more than 30 years of low-cost technology development and from the evolution of community-managed administration systems. The program has expanded steadily and now covers about 40,000 households in 40 of 51 districts that have been identified as having potential for this type of power generation.[280] The main obstacles to promoting such systems are the relatively high costs and the need for villagers to support the project as a whole community. Nepal's program works with communities to overcome these obstacles and sets up financing mechanisms to help cope with the initial capital costs.

Brazil has reached what some have called the "last mile" for grid rural electrification. Although the national grid currently reaches over 95 percent of households, the Luz Para Todos program continues to expand access to rural areas both through the extension of grid electricity and by means of off-grid community and household systems. By 2010, the program had reached about 11 million people with isolated grid systems of various types.[281] This amounts to over 2 million households, most of which are in northeast Brazil.

## Trends in Financing Off-Grid Renewable Energy

In recent years, many governments have realized that providing subsidies for grid extension is not the only way to expand electricity or other energy services. Increasingly, the trend has been to integrate both electricity grid extensions and off-grid renewable energy into one project. In the past, the main problem for financing renewable energy has been the relatively small project size, which led financial institutions to resist providing loans. Private investors have faced challenges as well, due to problematic legal frameworks, poor tax or subsidy structures, and the dearth of local groups or retailers to develop local markets. This is less of a problem for grid-based electricity systems because the financing needs tend to be larger and loans can be made directly with a dedicated electricity company.

For off-grid electricity projects, the trend during the last 10 years has been to provide larger amounts of financing to local private or public banks that are committed to financing rural energy projects. Typically, such banks or funds develop a portfolio of possible rural and renewable energy projects, although they also can react to requests for new lines of financing by reviewing project proposals. And they do not actually provide financing to households directly; rather it is up to the private companies, concessionaires, non-governmental organizations, and microfinance groups to organize the demand for the energy service and to apply for project funding after developing a sound business plan to serve rural consumers.

This successful model has been implemented in many countries, including Bangladesh, Mali, Senegal, and Sri Lanka. (See Sidebar 8.) As a result, renewable household systems, improved biomass stoves, and village or community small grids systems can all be serviced by the same financing agency. In practice, many of these funds initially specialize in a single technology, such as solar home systems, but increasingly they are expanding to other renewable energy systems as well as to non-renewable energy access.

### Sidebar 8. Mali's Rural Energy Fund

Mali's household energy and rural electrification agency, AMADER, promotes both standard designs and self-initiated forms of rural electrification. The agency has succeeded in attracting local private sector operators to provide electricity services in rural areas, offering these operators services that include direct and indirect grants and advisory assistance on engineering, project management, project feasibility studies, and master plans. AMADER uses a competitive bidding process to serve a small to medium geographic area, specifying the grant per connected household and allowing bidders to bid on the basis of lowest tariff.

Self-initiated electrification projects tend to be smaller, spontaneous projects that serve individual villages. Currently, AMADER will finance up to 80 percent of the capital costs, and it uses a local commercial bank to handle disbursement of its grants. The agency is the de facto regulator for the grant recipients, setting a maximum allowed price as a condition for receiving a grant. This price is based on a cost-of-service financial model developed by AMADER. AMADER also establishes quality of service standards.

Mali is not the only country with rural energy funds, which appear to be a growing trend in developing countries. IDCOL in Bangladesh manages a rural energy fund that has been successful in promoting nearly 500,000 solar home systems and now is expanding into other services such as biogas and improved biomass stoves. In Tanzania, a new $25 million program for off-grid rural electrification has been established and is now under implementation. A Rural Energy Agency was created to coordinate overall implementation of the rural/renewable energy credit line, with responsibilities that include program oversight, facilitation of new projects, and monitoring and evaluation.

Many other types of financing exist as well. Technical assistance grant funds are becoming very common to support market development for solar home systems and sustainable access to other modern energy services, thus reducing the costs for the private sector to sell energy products to more remote areas.[282] A variety of output-based aid grant funds is available to finance both technical assistance and part of the costs of delivering rural off-grid energy services.[283] Some initiatives have helped finance innovative pilot projects that have the potential to be scaled up in the future.[284] And private sector development funds have supported private involvement in off-grid energy services. Recently, large established appliance manufacturing firms have developed innovative rural energy appliances such as stoves and lighting systems as part of their corporate outreach programs.

One financing approach used in Latin America has been to include renewable energy options in programs that provide social and community block grants—as was the case in Guatemala with World Bank funding for improved biomass stoves. Because these social investment funds provide assistance to whole communities, they can lead to very equitable approaches in promoting off-grid renewable energy services.

In many cases, the high initial capital costs of renewable energy systems relative to household incomes have resulted in the slow adoption of renewables in off-grid rural areas. To make these systems more affordable, non-governmental organizations and prominent microfinance groups such as Grameen Shakti have been developing lines of credit, contributing to the rising success of recent programs. This is a welcome trend that should continue to grow over the coming years.

Finally, many private carbon funds are actively providing carbon credits to off-grid energy projects. International agencies involved in the Clean Development Mechanism (CDM), in particular the World Bank's Community Development Carbon Fund, have supported solar home systems and recently expanded their interest to biogas systems, improved cookstoves, micro-hydro development, and other technologies. This is especially relevant following the 2008 UN climate change conference in Bali, Indonesia, where it was decided that improved stoves could be considered for CDM projects. However, small programs face significant obstacles to receiving carbon funding, and it may be necessary to streamline procedures that do not violate some of the basic CDM methodologies. With greater facilitation, the many groups that are currently developing financing for off-grid renewable energy systems could achieve the dual goals of alleviating poverty and reducing carbon emissions.

## LAST WORD: RENEWABLE ENERGY AT THE TIPPING POINT

*By Christopher Flavin, Worldwatch Institute*

This report has captured the essence of global renewable energy trends annually since 2005. The 2010 edition conveys a powerful story: renewable energy is hitting a tipping point, with far-reaching implications for the global economy and for the environment. Buoyed by hundreds of new government energy policies, accelerating private investment, and myriad technology advances over the past five years, renewable energy is breaking into the mainstream of energy markets.[285]

Understanding the scale and patterns of renewable energy development has, more than ever, become essential to any full analysis of energy investment figures, of the market for fossil fuels, and of emissions of carbon dioxide.

Steady advances in policy, technology, and investment have become mutually reinforcing; together, they have created a "critical mass," to borrow a phrase from the nuclear industry. The trends elaborated in the Market Overview section of this report make this abundantly clear. Continued progress in the face of a steep global recession that has reduced annual world energy use for the first time in three decades suggests that renewable energy now has tremendous forward momentum that is likely to yield continued progress and many surprises in the years immediately ahead.

One of the new forces propelling renewable energy development is the potential to create new industries and generate millions of new jobs. Jobs from renewables now number in the hundreds of thousands in several countries. (See the Industry Trends section of this report and Sidebar 4, page 34.) Germany, which has led renewable energy development for more than a decade, had more than 300,000 people employed in renewables industries in 2009, almost equaling the number of jobs in the country's largest manufacturing sector, automobiles.[286] In the United States, President Obama made "green jobs" a centerpiece of his 2008 election campaign, and many state governors have done the same. Proponents of new climate and energy legislation in the U.S. Congress now rarely mention the word "climate" in political debates but frequently note the potential for job creation.

Most of the large fiscal stimulus packages launched since late 2008 to combat the global recession have included significant funding for renewable energy. This has prevented a more pronounced economic downturn in the United States and has created a new industry almost from scratch in South Korea, which devoted four-fifths of its fiscal stimulus to the green economy. In total, nearly $200 million in green stimulus funding has been allocated to renewables and energy efficiency. (See Sidebar 1, page 27.)

The geography of renewable energy is changing in ways that suggest we are entering a new era—with the growing geographic diversity boosting confidence that renewables are no longer vulnerable to political shifts in just a few countries. It is also clear that leadership is shifting decisively from Europe to Asia, with China, India, and South Korea among the countries that have stepped up their commitments to renewable energy. (See the Policy Landscape section and Tables R7–R9, pages 57–61, for examples.)

This transition reflects a growing recognition within Asia itself that these oil- and gas-short countries have much to gain from the development of renewable energy in economic, environmental, and security terms. For the world as a whole, this is a momentous development, since Asian nations now lead the growth in carbon emissions. Given East Asia's dominance of low-cost global manufacturing, the region's commitment to renewable energy will almost certainly drive down the price of many renewable energy devices in the coming years.

Among recent Asian developments, China's move to leadership in the manufacturing of wind turbines and solar photovoltaics is the most consequential, reflecting the government's commitment to renewable energy through a series of new laws and financial support measures. Despite early hiccups, it is now clear that the important reforms included in China's 2005 Renewable Energy Law have been implemented with a speed and effectiveness that most countries can only envy. China has meanwhile stepped up its research and development efforts with the aim of becoming a leading innovator as well as producer of renewable technologies. Already, China is leading the world in clean technology patents and IPOs.

Beyond the rise of East Asia, the geographical spread of renewable energy is creating huge synergies as countries learn from each other—in policy as well as technology—and find ways to improve on the many success stories. Ireland, Japan, Kenya, and South Africa are among the countries that appear to have made great strides in the past two years. The almost organic diffusion of policy ideas is seen in the dramatic rise in electricity feed-in laws, which were found in just 15 states and nations in 2001 and have risen to more than 70 in 2010. (See Table R10, page 62.)

The 1,230 gigawatts (GW) of renewable power generating capacity in place at the end of 2009 now constitutes just over 25 percent of total generating capacity worldwide. This is over three times nuclear generating capacity and roughly 38 percent of the capacity of fossil fuel-burning power plants worldwide.[287] (See Figure 16.)

Figure 16. World Generating Capacity by Source, 2009

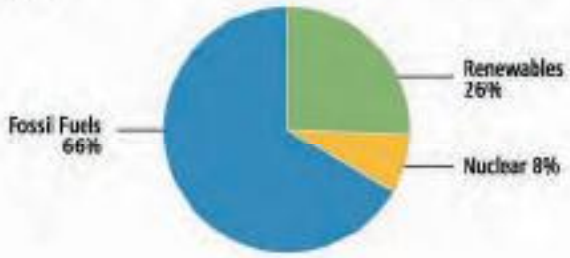
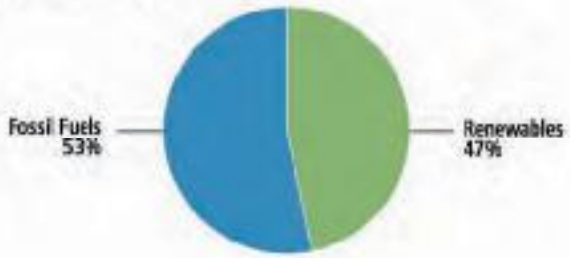



Figure 17. New Power Capacity Added Worldwide by Source, 2008–2009




For power plant developers, renewable energy is hard to ignore. Of the roughly 300 GW of new generating capacity of all types added to the world's grids over the past two years, the 140 GW of renewable capacity makes up 47 percent of the total.[288] (See Figure 17.)

About 45 percent of the new renewable generating capacity added between 2008 and 2009 was hydropower, which means that non-hydro renewables (dominated by wind power) made up a majority of renewable capacity additions during those years. If the growth rates documented in this report continue, non-hydro renewables will dominate the new power plant business globally by the middle of this decade. According to a 2010 forecast by McKinsey & Company, renewable technologies will dominate global power plant construction in the decade from 2010 to 2020, exceeding the totals for coal, oil, natural gas, and nuclear power combined.[289]

Renewable energy provides 18 percent of total net electricity generation worldwide. (See Figure 3, page 16.) Renewable energy generators are spread across the globe, and wind power alone already provides a significant share of electricity in some regions: for example, 14 percent in the U.S. state of Iowa, 40 percent in the northern German state of Schleswig-Holstein, and 20 percent in the nation of Denmark. Some countries get most of their power from renewables, including Iceland (100 percent), Brazil (85 percent), Austria (62 percent), New Zealand (65 percent), and Sweden (54 percent). (See Table R8, page 59, for shares.)

Solar hot water provides an important contribution to meeting hot water needs in many countries, most importantly in China, which now has fully 70 percent of the global total (180 GWth). Most of these systems are installed on multi-family apartment buildings and meet a portion of the hot water needs of an estimated 50–60 million households in China, or more than 150 million people.[290] Worldwide, total installed solar water heating systems meet a portion of the water heating needs of over 70 million households.[291] The use of biomass for heating continues to grow as well. Notable is Sweden, where national use of biomass energy has surpassed that of oil. Direct geothermal for heating is also growing rapidly.

Renewable biofuels are meanwhile making inroads in the transportation fuels market and are beginning to have a measurable impact on demand for petroleum fuels, contributing to a decline in oil consumption in the United States in particular starting in 2006.[292] Although the rapid growth of previous years has slowed, production of biofuels for transportation grew 58 percent between 2007 and 2009. The 93 billion liters of biofuels produced worldwide in 2009 displaced the equivalent of an estimated 68 billion liters of gasoline, equal to about 5 percent of world gasoline production.[293]

In financial markets, renewable energy now appears prominently on the computer screens of investors across the globe—symbolized by Bloomberg L.P.'s decision in December 2009 to purchase New Energy Finance, the world's leading renewable energy analysis firm. Worldwide renewable energy investment of $150 billion in 2009 represented nearly 40 percent of annual investment in the upstream oil and gas industry, which topped $380 billion.[294] (See the Investment Flows section of this report.) And renewables accounted for about 57 percent of global investment in power generation of all forms in 2009, estimated at $320 billion.[295]

At a time when the world's headlines are dominated by a deep-water oil spill in the Gulf of Mexico, coal mine accidents, and gyrating fuel prices, renewable energy is a rare good news story. The trends documented in this report point to a very different energy system that will begin to emerge over the next decade. To be sure, political leaders will need to continue enacting additional and effective policies, engineers and scientists will need to continue creating new technologies, and businesses will need to continue investing if this bright new future is to be realized. But for those who are paying attention to the trends, there is now good reason to be optimistic that hard work and dedication will be rewarded in the near future—and this knowledge will itself fuel further change.

## REFERENCE TABLES

### Table R1. Renewable Energy Added and Existing Capacities, 2009

| | Added during 2009 | Existing at end of 2009 |
|---|---|---|
| **Power generation (GW)** | | |
| Wind power | 38 | 159 |
| Small hydropower <10 MW | 2–4 | 60 |
| Biomass power | 2–4 | 54 |
| Solar PV, grid-connected | 7 | 21 |
| Geothermal power | 0.4 | 11 |
| Concentrating solar thermal power (CSP) | 0.2 | 0.6 |
| Ocean power | ~0 | 0.3 |
| Hydropower (all sizes) | 31 | 980 |
| **Hot water/heating (GWth)** | | |
| Biomass heating | n/a | ~270 |
| Solar collectors for hot water/space heating | 35 | 180 |
| Geothermal heating | n/a | ~60 |
| **Transport fuels (billion liters/year)** | | |
| Ethanol production | 9 | 76 |
| Biodiesel production | 5 | 17 |

*Sources*: See Endnotes and sources for Tables R2–R6.

### Table R2. Added and Existing Wind Power, Top 10 Countries, 2009

| Country | Added in 2009 (GW) | Cumulative at end of 2009 (GW) |
|---|---|---|
| United States | 10.0 | 35.1 |
| China | 13.8 | 25.8 |
| Germany | 1.9 | 25.8 |
| Spain | 2.5 | 19.2 |
| India | 1.3 | 10.9 |
| Italy | 1.1 | 4.9 |
| France | 1.1 | 4.5 |
| United Kingdom | 1.1 | 4.1 |
| Portugal | 0.6 | 3.6 |
| Denmark | 0.3 | 3.5 |

*Note*: Figures rounded to nearest 0.1 GW. *Sources*: GWEC 2010, WWEA 2010, AWEA, EWEA, Chinese Renewable Energy Industries Association, and Portugal DGEG/DSACIA.

## Table R3. Grid-Connected Solar PV, 2005–2009

| Country | Added 2005 | Added 2006 | Added 2007 | Added 2008 | Added 2009 | Existing 2006 | Existing 2007 | Existing 2008 | Existing 2009 |
|---|---|---|---|---|---|---|---|---|---|
| | | | MW | | | GW | | | |
| Germany | 900 | 830 | 1,170 | 2,020 | 3,800 | 2.8 | 4.0 | 6.0 | 9.8 |
| Spain | 23 | 90 | 560 | 2,430 | 70 | 0.2 | 0.7 | 3.3 | 3.4 |
| Japan | 310 | 290 | 240 | 240 | 480 | 1.5 | 1.7 | 2.0 | 2.6 |
| United States | 65 | 100 | 160 | 250 | 430 | 0.3 | 0.5 | 0.7 | 1.2 |
| Italy | – | 10 | 70 | 340 | 710 | <0.1 | 0.1 | 0.4 | 1.1 |
| South Korea | 5 | 20 | 60 | 250 | 70 | <0.1 | 0.1 | 0.4 | 0.4 |
| Other EU | 40 | 40 | 100 | 60 | 1,000 | 0.2 | 0.3 | 0.4 | 1.4 |
| Other World | >20 | >50 | >150 | >250 | >400 | >0.1 | >0.3 | >0.5 | >0.9 |
| Total Added | 1,350 | 1,400 | 2,500 | 5,900 | 7,000 | | | | |
| Cumulative | | | | | | 5.1 | 7.6 | 13.5 | 21 |

*Notes*: All added capacities rounded to nearest 10 MW and all existing capacities rounded to nearest 0.1 GW. Added and existing figures may be slightly inconsistent due to rounding and reporting differences from year-to-year. South Korea existing in 2008 and 2009 were 360 MW and 430 MW. "Other EU" is significantly higher in 2009 relative to previous years due to large 2009 additions by the Czech Republic (410 MW) and Belgium (290 MW), among others. German figures for 2005–08 are revised from previous editions of this table due to revisions by the German Federal Network Agency (Bundesnetzagentur) published in April 2010. Preliminary figure from IDAE for Spain is 100 MW added for 2009. Some figures in the table may include some amounts of off-grid PV, but these are considered small. Figures for the United States are only for on-grid totals. One estimate by Mints/Navigant for total global off-grid solar PV is 3.2 GW. EPIA estimates 22.9 GW of total global solar PV existing in 2009, but this may include off-grid. *Sources*: See Endnotes 66, 70, and 296. Figures in table reflect a variety of sources, some of which differ from each other to small degrees, reflecting differences in accounting or methodology.

## Table R4. Renewable Electric Power Capacity, Existing as of 2009

| Technology | World Total | Developing Countries | EU-27 | China | United States | Germany | Spain | India | Japan |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | GW | | | | |
| Wind power | 159 | 40 | 75 | 25.8 | 35.1 | 25.8 | 19.2 | 10.9 | 2.1 |
| Small hydropower <10 MW | 60 | 40 | 12 | 33 | 3 | 2 | 2 | 2 | 4 |
| Biomass power | 54 | 24 | 16 | 3.2 | 9 | 4 | 0.4 | 1.5 | 0.1 |
| Solar photovoltaic-grid | 21 | 0.5 | 16 | 0.4 | 1.2 | 9.8 | 3.4 | ~0 | 2.6 |
| Geothermal power | 11 | 5 | 0.8 | ~0 | 3.2 | 0 | 0 | 0 | 0.5 |
| Concentrating solar thermal power (CSP) | 0.7 | 0 | 0.2 | 0 | 0.5 | 0 | 0.2 | 0 | 0 |
| Ocean power | 0.3 | 0 | 0.3 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total renewable power capacity (including small hydropower)** | **305** | **110** | **120** | **62** | **52** | **42** | **25** | **14** | **9** |
| Total hydropower (all sizes) | 980 | 580 | 127 | 197 | 95 | 11 | 18 | 37 | 51 |
| **Total renewable power capacity (including hydropower of all sizes)** | **1,230** | **650** | **246** | **226** | **144** | **51** | **41** | **49** | **56** |

*Notes*: Small amounts, on the order of a few megawatts, are designated by "~0." World and developing country totals are rounded to the nearest 5 or 10 GW. Other totals are rounded to the nearest 1 GW. Figures should not be compared with prior versions of this table to obtain year-by-year increases, as some adjustments are due to improved or adjusted data rather than actual capacity changes. World total reflects other countries not shown; countries shown reflect the top 6 countries by total renewable power capacity (including small hydro). Developing countries total includes China. Biomass power figures do not include waste-to-energy capacity (MSW). Small hydro is less than 10 MW. For further discussion of hydropower, see Endnote 2. Small hydro figures in previous editions of this report are significantly higher because previous editions showed China capacity for all plants less than 50 MW, which is how the Chinese government defines and reports small hydro; this edition shows China capacity only for plants less than 10 MW, to make the global total more consistent. *Sources*: Sources cited in Tables R2–R3; International Energy Agency (IEA) *Renewables Information 2009* (for OECD biomass power capacity); submissions from report contributors; historical databases going back to 2005 report edition maintained by Eric Martinot (see Notes N3 through N7 of the *Renewables 2005 Global Status Report* and the notes associated with Table 4 in the 2006 Update and Endnote 11 in the *Renewables 2007 Global Status Report*).

## Table R5. Solar Hot Water Installed Capacity, Top 10 Countries/EU and World Total, 2008

| Country/EU | Additions 2008 | Existing 2008 |
|---|---|---|
| | GWth | |
| China | 21.7 | 105 |
| European Union | 3.3 | 18.3 |
| Turkey | 0.7 | 7.5 |
| Japan | 0.2 | 4.1 |
| Israel | 0.2 | 2.6 |
| Brazil | 0.4 | 2.4 |
| United States | 0.2 | 2.0 |
| India | 0.3 | 1.8 |
| Australia | 0.2 | 1.4 |
| South Korea | 0.04 | 1.0 |
| (other countries) | <0.5 | <3 |
| **World Total** | **28** | **149** |

*Notes:* Figures do not include swimming pool heating (unglazed collectors). World totals are rounded to the nearest 1 GWth. Existing figures include allowances for retirements. By accepted convention, 1 million square meters = 0.7 GWth. *Sources*: Werner Weiss and Franz Mauthner, and IEA Solar Heating and Cooling Programme, *Solar Heat Worldwide: Markets and Contributions to Energy Supply 2008*, May 2010, except for China. China data from Li Junfeng and Ma Lingjuan, Chinese Renewable Energy Industries Association (CREIA), personal communication with REN21, April 2010. China data differ significantly from Weiss and Mauthner, which give a 2008 world total existing of 132 GWth based on 87.5 GWth for China. Weiss and Mauthner figures are based on 53 countries and roughly 85–90 percent of global market. China added an estimated 29 GWth in 2009, according to CREIA, which, along with other estimates for 2009 additions in Brazil (0.5 GWth), the EU (2.9 GWth), and the United States (0.2 GWth), and extrapolating 2008 additions for other countries and estimating retirements, yields a 2009 world total estimate of 180 GWth. Additional sources for 2009 data: Brazil from National Solar Heating, Brazilian Association of Refrigeration, Air Conditioning, Ventilation and Heating, www.dasolabrava.org.br/dasol; EU from European Solar Thermal Industry Federation, "Solar Thermal Markets in Europe: Trends and Market Statistics 2009" (Brussels: June 2010); United States from U.S. Solar Energy Industries Association and from extrapolations derived from Weiss and Mauthner.

## Table R6. Biofuels Production, Top 15 Countries plus EU Total, 2009

| Country | Fuel Ethanol | Biodiesel |
|---|---|---|
| | billion liters | |
| 1. United States | 41 | 2.1 |
| 2. Brazil | 26 | 1.6 |
| 3. France | 0.9 | 2.6 |
| 4. Germany | 0.8 | 2.6 |
| 5. China | 2.1 | 0.4 |
| 6. Argentina | ~0 | 1.4 |
| 7. Canada | 1.1 | 0.1 |
| 8. Spain | 0.4 | 0.6 |
| 9. Thailand | 0.4 | 0.6 |
| 10. United Kingdom | 0.2 | 0.5 |
| 11. Colombia | 0.3 | 0.2 |
| 12. Italy | 0.1 | 0.4 |
| 13. Belgium | 0.2 | 0.3 |
| 14. India | 0.2 | 0.1 |
| 15. Austria | 0.1 | 0.2 |
| **EU Total** | **3.6** | **8.9** |
| **World Total** | **76** | **17** |

*Notes*: All figures are rounded to nearest 0.1 billion liters except world totals and U.S. and Brazil ethanol figures, which are rounded to nearest billion liters. Ethanol numbers are for fuel ethanol only. Table ranking is by total biofuels production. Figures are by volume, not energy content. *Sources*: Ethanol and biodiesel data from International Energy Agency, *Medium-Term Oil and Gas Markets: 2010* (Paris: IEA/OECD, 2010), and from F.O. Licht, 2010. Brazil ethanol data from DATAGRO, 2010, provided by Renata Grisoli, and from CENBIO, personal communication with REN21, May 2010, both of which give equivalent figures. Where reported in tons, figures are converted to liters using factors 1,260 liters/ton ethanol and 1,130 liters/ton biodiesel. In previous editions of this report, data for this table came exclusively from F.O. Licht, whereas the IEA was the primary source for this edition; small discrepancies of 0.1 billion liters or less may be noted between these two sources, with the exception of Brazil ethanol, where larger differences are noted (IEA 26.8 billion liters and F.O. Licht 23.9 billion liters). One other report by GlobalData put global biodiesel production at slightly less than 16 billion liters in 2009.



## Table R7. Share of Primary and Final Energy from Renewables, Existing in 2008 and Targets

| | Primary Energy | | Final Energy | |
|---|---|---|---|---|
| **Country/Region** | **Existing share (2008)[1]** | **Future target** | **Existing share (2008)** | **Future target** |
| World | | | 19% | |
| EU-27 | 8.2% | 12% by 2010 | 10.3% | 20% by 2020 |
| **EU Countries** | | | | |
| Austria | 29% | | 28.5% | 34% by 2020 |
| Belgium | 3.0% | | 3.3% | 13% by 2020 |
| Bulgaria | 5.1% | | 9.4% | 16% by 2020 |
| Cyprus | 2.1% | 9% by 2010 | 4.1% | 13% by 2020 |
| Czech Republic | 4.9% | 8.6–10% by 2020 | 7.2% | 13% by 2020 |
| Denmark | 18% | 20% by 2011<br>30% by 2025 | 18.8% | 30% by 2025 |
| Estonia | 12% | | 19.1% | 25% by 2020 |
| Finland | 25% | | 30.5% | 38% by 2020 |
| France | 7.5% | 7% by 2010 | 11.0% | 23% by 2020 |
| Germany | 8.1% | 4% by 2010<br>18% by 2020<br>50% by 2050 | 8.9% | 18% by 2020 |
| Greece | 5.1% | | 8.0% | 18% by 2020 |
| Hungary[2] | 6.1% | | 6.6% | 13% by 2020 |
| Ireland | 3.8% | | 3.8% | 16% by 2020 |
| Italy | 8.2% | | 6.8% | 17% by 2020 |
| Latvia | 28% | 6% by 2010 | 29.9% | 40% by 2020 |
| Lithuania | 10% | 12% by 2010<br>20% by 2025 | 15.3% | 23% by 2020 |
| Luxembourg | 3.6% | | 2.1% | 11% by 2020 |
| Malta | 0.5% | | 0.2% | 10% by 2020 |
| Netherlands | 3.4% | | 3.2% | 14% by 2020 |
| Poland | 5.8% | 14% by 2020 | 7.9% | 15% by 2020 |
| Portugal | 17.6% | | 23.2% | 31% by 2020 |
| Romania | 14% | | 20.4% | 24% by 2020 |
| Slovakia | 5.2% | | 8.4% | 14% by 2020 |
| Slovenia | 12% | | 15.1% | 25% by 2020 |
| Spain | | | 10.7% | 20% by 2020 |
| Sweden | 32% | | 44.4% | 49% by 2020 |
| United Kingdom | 2.6% | | 2.2% | 15% by 2020 |
| **Other Developed/OECD/Transition Countries** | | | | |
| Albania | | 18% by 2020 | | |
| Israel | | | | 10–20% by 2020 |
| South Korea | 2.4% | 4.3% by 2015<br>6.1% by 2020<br>11% by 2030 | | |
| Switzerland | 16% | 24% by 2020 | 18% | |

**Table R7. (continued)**

| | Primary Energy | | Final Energy | |
|---|---|---|---|---|
| **Country/Region** | **Existing share (2008)** | **Future target** | **Existing share (2008)** | **Future target** |
| **Developing Countries** | | | | |
| China[3] | 9.9% | 10% by 2010 | | 15% by 2020 |
| Egypt | | 14% by 2020 | | |
| Fiji | | | | 100% by 2013 |
| Indonesia | 5% | 17% by 2025 | | |
| Jordan | | 7% by 2015<br>10% by 2020 | | |
| Kuwait | | | | 5% by 2020 |
| Lebanon | | | | 12% by 2020 |
| Madagascar | | | | 54% by 2020 |
| Malawi | | 7% by 2020 | | |
| Mali | | 15% by 2020 | | |
| Morocco | | 8% by 2012 | | 10% by 2012 |
| Nigeria[4] | | 20% by 2012 | | |
| Pakistan | | 10% by 2012 | | |
| Palestine | | | | 20% by 2012 |
| Senegal | | 15% by 2025 | | |
| Syria | | 4.3% by 2011 | | |
| Thailand | | 20% by 2022 | | |
| Tonga | | | | 100% by 2013 |
| Tunisia | | 10% by 2011 | | 10% by 2011 |
| Uganda | | 61% by 2017 | | |
| Vietnam | | 3% by 2010<br>5% by 2020<br>11% by 2050 | | |

*Notes*: Actual percentages are rounded to nearest whole decimal for figures over 10 percent. Countries included in table are only those with targets. Energy shares for selected other countries without a target for share of energy include Argentina (7.7% primary), Bolivia (22% primary), Brazil (48% primary), Canada (16% primary; 20% final), Chile (31% primary), Colombia (24% primary), Cuba (12% primary), Dominican Republic (30% primary), Ecuador (17% primary), India (31% primary), Jamaica (33% primary), Japan (3.2% primary and final), Kenya (81% primary), Mexico (11% primary), Peru (28% primary), South Africa (11% primary), Turkey (9.5% final), United States (5.1% primary; 7.0% final), and Uruguay (37% primary). Many existing shares and targets shown exclude traditional biomass, including those for China, Morocco, and Thailand. In general, existing shares are indicative and not intended to be a fully reliable reference. [1]Share of primary energy can be calculated using different methods. See Sidebar 1 of *Renewables 2007 Global Status Report* for further discussion. In particular, the "physical energy content" and the "substitution/equivalent primary" methods will yield different results depending on the mix of renewables. Reported figures often do not specify which method is used to calculate them, so the figures in this table for share of primary energy are likely a mixture of the different methods and thus not directly comparable or consistent across countries. IEA *Renewables Information* (2009) gives primary energy shares for all OECD countries according to the physical energy content method, and these numbers are generally consistent with the primary energy shares reported here, although there are some differences, for example IEA gives Austria as 23.4 percent while the REN21 database reports 29 percent; the difference could stem from calculations using different (and equally valid) methods. [2]Hungary actual 2008 primary energy share includes municipal waste. [3]China changed its target in 2009 to 15 percent share of final energy by 2020, including energy from nuclear power. Previously, the target was 15 percent of primary energy by 2020, not including nuclear. [4]Nigeria's target is for off-grid energy share only. *Sources*: REN21 database and submissions from report contributors. Existing share of final energy for EU-27 (2008) from Nikos Roubanis, *Environment and energy: Data in focus 30/2010* (Brussels: Eurostat, 5 July 2010). The EU-27 shares are calculated on the basis of the methodology described in the Renewable Energy Directive 2009/28/EC. For online updates, see the "Renewables Interactive Map" at www.ren21.net.



## Table R8. Share of Electricity from Renewables, Existing in 2008 and Targets

| Country/Region | Existing share (2008) | Future target |
|---|---|---|
| World | 18% | |
| EU-27 | 16.7%‡ | 21% by 2010 |
| **EU Countries** | | |
| Austria | 62% | 78% by 2010 |
| Belgium | 5.3% | 6% by 2010 |
| Bulgaria | 7.4% | 11% by2010 |
| Cyprus | 0.3% | 6% by 2010 |
| Czech Republic | 5.2% | 8% by 2010<br>16.9% by 2030 |
| Denmark | 29% | 29% by 2010 |
| Estonia | 2% | 5.1% by 2010 |
| Finland | 31% | 31.5% by 2010 |
| France | 14% | 21% by 2010 |
| Germany | 15% | 12.5% by 2010<br>25–30% by 2020<br>50% by 2030 |
| Greece | 8.3% | 20.1% by 2010 |
| Hungary | 5.6% | 3.6% by 2010 |
| Ireland | 12% | 13.2% by 2010<br>40% by 2020 |
| Italy | 17% | 22.5% by 2010 |
| Latvia | 41% | 49.3% by 2010 |
| Lithuania | 4.6% | 7% by 2010 |
| Luxembourg | 4.1% | 5.7% by 2010 |
| Malta | | 5% by 2010 |
| Netherlands | 8.9% | 9% b 2010 |
| Poland | 4.3% | 7.5% by 2010 |
| Portugal | 27% | 39% by 2010<br>55–60% by 2020 |
| Romania | 28% | 33% by 2010 |
| Slovakia | 16% | 31% by 2010 |
| Slovenia | 29% | 33.6% by 2010 |
| Spain | 21% | 29.4% by 2010 |
| Sweden | 56% | 60% by 2010 |
| United Kingdom | 5.6% | 10.4% by 2010/11<br>15.4% by 2015/16 |
| **Other Developed/OECD/Transition Countries** | | |
| Israel | 17% | 5% by 2016<br>10% by 2020 |
| Japan[1,2] | 0.4% | 1.63% by 2014 |
| Switzerland | 16% | 24% by 2020 |
| Mexico | 3.9% | 4.5% by 2010 |
| New Zealand | 65% | 90% by 2025 |
| Russia | | 1.5% by 2010<br>4.5% by 2020 |
| **Developing Countries** | | |
| Algeria | 9.9% | 10% by 2010 |
| Argentina[3] | 35% | 40% by 2015 |
| Bangladesh | | 5% by 2015<br>10% by 2020 |
| Brazil | 85% | 75–85% by 2020 |
| Cameroon | | 50% by 2015<br>80% by 2020 |
| Cape Verde | | 50% by 2020 |
| Dominican Republic | 7% | 10% by 2015<br>25% by 2025 |
| Egypt | | 20% by 2020 |
| Ghana | | 10% by 2020 |
| India[2] | 4% | 25% by 2010 |
| Jamaica | 5% | 10% by 2010<br>15% by 2020 |
| Libya | | 10% by 2020<br>30% by 2030 |
| Madagascar | | 75% by 2020 |
| Mauritius | 37% | 65% by 2028 |
| Morocco | 4% | 20% by 2012 |
| Mongolia | 3% | 20–25% by 2020 |
| Nicaragua[4] | 27% | 38% by 2011 |
| Niger | | 10% by 2020 |
| Nigeria | | 7% by 2025 |
| Pakistan | | 10% by 2012 |
| Philippines | | 4.7% by 2013 |
| Rwanda | | 90% by 2012 |
| South Africa | <1% | 4% by 2013<br>13% by 2020 |
| Sri Lanka[5] | | 10% by 2017 |
| Thailand | | 10.6% by 2011<br>14.1% by 2022 |
| Tonga | | 50% by 2012 |

*Notes*: ‡EU-27 attained 19.9% share in 2009 per EC Joint Research Center, "Renewable Energy Snapshots" (Brussels, May 2010). For some countries percentages rounded to nearest 1 percent. Countries included in table are those with targets; share of electricity from renewables for selected other countries without a target for share of electricity include Australia (7%), Bolivia (39%), Canada (61%), Chile (51%), China (17%), Colombia (82%), Costa Rica (95%), Cuba (9%), Ecuador (62%), Honduras (60%), Kenya (58%), South Korea (1%), Mozambique (99%), Panama (64%), Peru (56%), Switzerland (56%), United States (8.8%), Uruguay (61%), and Zambia (99%). The United States and Canada have de-facto state- or province-level targets through existing RPS policies (see Table R11), but no national targets. Some countries shown also have other types of targets; see Tables R7 and R9. See text of Section 4 for more information about sub-national targets. Existing shares are indicative and are not intended to be a fully reliable reference. [1]Japan existing share does not include large hydro because the target excludes hydro; with hydro included, existing share is 9 percent. [2]These indicated countries' existing shares are for 2006, unchanged from the 2007 report edition. [3]Argentina also has a target for 8 percent of electricity by 2016 from sources excluding large hydropower. [4]Another estimate for Nicaragua gives a 44 percent existing share in 2008. [5]Sri Lanka 2017 target excludes large hydro. *Sources*: REN21 database and submissions by report contributors; existing country shares for EU and other OECD countries from IEA *Renewables Information 2009*. For online updates, see the "Renewables Interactive Map" at www.ren21.net.

## Table R9. Other Renewable Energy Targets

| Country | Targets |
|---|---|
| Algeria | Wind: 100 MW by 2015; solar thermal: 170 MW by 2015; solar PV: 5.1 MW by 2015; cogeneration: 450 MW by 2015; CSP: 500 MW by 2010 |
| Argentina | Renewable capacity: 1,000 MW by 2012, including 500 MW wind, 150 MW biofuels, 120 MW waste-to-energy, 100 MW biomass, 60 MW small hydro, 30 MW geothermal, 20 MW solar, and 20 MW biogas; 2,500 MW by 2016 |
| Australia | Renewable capacity: 20% by 2020; generation: 45 TWh by 2020 |
| Canada | Renewable generation: 14.3 TWh by 2020 |
| Cape Verde | Renewables in general: 100% on one island |
| China | Renewable capacity: 362 GW by 2020, including 300 GW hydro, 30 GW wind, 30 GW biomass, and 1.8 GW solar PV/CSP, although increased targets to 150 GW wind and 20 GW solar PV/CSP by 2020 exist as draft or unofficial targets; solar hot water: 150 million m² by 2010 and 300 m² by 2020 |
| Croatia | Wind: 400 MW by 2030 |
| Denmark | Offshore wind: 1.02 GW by 2012 |
| Dominican Republic | Wind: 500 MW by 2015 |
| Egypt | Renewable generation: 20% by 2020, including 12% from wind (about 7,200 MW) and 8% from hydro and solar PV |
| Ethiopia | Wind: 0.76 GW new installed capacity by 2013; geothermal: 0.45 GW new installed capacity by 2018; hydro: 5.6 GW new installed capacity by 2015 |
| France | Solar PV: 4.9 GW by 2020 |
| Germany | Renewable heating: 14% by 2020 |
| India | Renewable capacity: 12.5 GW added 2007–2012; 15% share of added power capacity 2002–2022<br>Solar PV and CSP: 1.1 GW by 2013, 10 GW by 2017, 20 GW by 2022<br>Wind power: 9 GW added 2007–2012<br>Small hydro: 1.4 GW added 2007–2012<br>Biomass/cogeneration: 1.7 GW added 2007–2012<br>Waste-to-energy: 0.4 GW added 2007–2012<br>Solar hot water: 15 million m² by 2017; 20 million m² by 2022<br>Rural lighting systems: 20 million by 2022 |
| Indonesia | Geothermal: 6 GW; biomass: 810 MW; wind power: 255 MW; solar PV: 80 MW (all by 2025) |
| Ireland | Ocean power: 500 MW by 2020 |
| Israel | Solar PV: 10–20% by 2020 |
| Italy | Solar PV: 3 GW by 2016 |
| Japan | Solar PV: 4.8 GW by 2010; 14 GW and 5.3 million homes by 2020; 53 GW by 2030 |
| Jordan | Wind: 600–1,000 MW; solar PV: 300–600 MW; waste-to-energy: 30–50 MW |
| Kenya | Renewable capacity: double installed capacity by 2012; geothermal power: 4 GW by 2030 |
| Libya | Wind: 280 MW by 2012 and 1,500 MW by 2030; CSP: 50 MW by 2012 and 800 MW by 2030; solar PV: 150 MW by 2030 |
| Lithuania | Biomass: 70% of centralized heating by 2020 |
| Mexico | Share of installed capacity: 7.6% by 2012, including wind power 4.34%, small hydro 0.77 %, geothermal 1.65%, and biogas/biomass 0.85%. |
| Morocco | Solar hot water: 400,000 m² by 2012 and 1.7 million m² by 2020; wind power: 1440 MW by 2015; small hydro: 400 MW by 2015 |
| Namibia | Non-hydro renewable capacity: 40 MW by 2011 |
| Nigeria | Renewable capacity: 16 GW by 2015 |
| Norway | Renewable generation: 30 TWh increased annual production from 2001 to 2016; bioenergy: 14 TWh by 2020 |
| Pakistan | Renewable capacity: 5% by 2030 |

**Table R9. (continued)**

| Country | Targets |
|---|---|
| Peru | Renewable share of power capacity: 5% by 2013 |
| Philippines | Renewable capacity: 4.5 GW added during 2003-2013<br>Biomass power: 76 MW by 2010, 94 MW by 2015, 267 MW by 2030 |
| Portugal | Wind: 5.1 GW by 2012 and 8.5 GW by 2020; hydro: 5.5 GW by 2010; biomass: 0.25 GW by 2010; solar: 0.15 GW by 2010 and 1.5 GW by 2020; geothermal: 0.25 GW by 2020; ocean: 0.25 GW by 2020 |
| Serbia | Renewable generation: increase by 7.4% (735 GWh) by 2012 (base 2007) |
| Singapore | Solar hot water: 50,000 m² by 2012 |
| South Africa | Renewable capacity: 3,100 MW by 2013, including 500 MW wind and 50 MW CSP |
| South Korea | Solar PV: 1.3 GW by 2012 |
| Sri Lanka | Share of rural off-grid households served by renewable energy: 6% by 2010 and 10% by 2016 |
| Spain | Wind: 20 GW by 2020; solar PV: 10 GW by 2020; CSP: 500 MW by 2010 |
| Sweden | Renewable generation: 10 TWh by 2015; wind: 30 TWh by 2020 (20 TWh on-shore and 10 TWh offshore) |
| Thailand | Solar PV: 0.055 GW by 2011, 0.095 GW by 2016, 0.500 GW by 2022<br>Wind: 0.115 GW by 2011, 0.375 GW by 2016, 0.800 GW by 2022<br>Hydro: 0.185 GW by 2011, 0.281 GW by 2016, 0.324 GW by 2022<br>Biomass: 2.8 GW by 2011, 3.22 GW by 2016, 3.7 GW by 2022<br>Biogas: 0.06 GW by 2011, 0.09 GW by 2016, 0.12 GW by 2022 |
| Tunisia | Wind: 330 MW; solar PV: 0.015 GW; solar hot water: 740,000 m² (all by 2011) |
| Turkey | Wind: 20 GW by 2023 |
| Uganda | Small hydro, biomass, and geothermal: 188 MW; solar hot water: 30,000 heaters;<br>biogas: 100,000 digesters (all by 2017) |

*Note*: Countries on this list may also have primary energy or electricity targets; see Tables R7 and R8. *Sources*: REN21 database compiled from all available policy references plus submissions from report contributors. For online updates, see the "Renewables Interactive Map" at www.ren21.net.

## 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 | 27 | Cyprus, Estonia, Hungary, South Korea, Slovak Republic, Maharashtra (India) |
| 2004 | 33 | Israel, Nicaragua, Prince Edward Island (Canada), Andhra Pradesh and Madhya Pradesh (India) |
| 2005 | 40 | Karnataka, Uttarakhand, and Uttar Pradesh (India); China, Turkey, Ecuador, Ireland |
| 2006 | 45 | Ontario (Canada), Kerala (India), Argentina, Pakistan, Thailand |
| 2007 | 54 | South Australia (Australia), Albania, Bulgaria, Croatia, Dominican Rep., Finland, Macedonia, Mongolia, Uganda |
| 2008 | 67 | Queensland (Australia); California (USA); Chattisgarh, Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu, and West Bengal (India); Kenya, the Philippines, Tanzania, Ukraine |
| 2009 | 77 | Australian Capital Territory, New South Wales, Victoria (Australia); Japan; Serbia; South Africa; Taiwan; Hawaii; Oregon and Vermont (USA) |
| 2010 (early) | 78 | United Kingdom |

*Note*: Cumulative number refers to number of jurisdictions that had enacted a feed-in policy by the given year; however, polices in some countries were subsequently discontinued so the number of existing policies cited in this report is 75. See Endnote 236 for details. Many policies have been revised or reformulated in years subsequent to the initial year shown for a given country. India's national feed-in tariff from 1993 was substantially discontinued but new national feed-in tariffs were enacted in 2008. *Sources*: All available policy references, including the IEA online 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 That Year |
|---|---|---|
| 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 |
| 2008 | 49 | Michigan, Ohio (USA); Chile; Philippines; Romania |
| 2009 | 50‡ | Kansas (USA) |

*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. ‡There are also six Indian states not shown because year is uncertain: Haryana, Kerala, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal. *Sources*: All available policy references, including the IEA online Global Renewable Energy Policies and Measures database, published sources as given in the endnotes and the 2007 report edition, and submissions from report contributors.

## Table R12. Biofuels Blending Mandates

| Country | Mandate |
|---|---|
| Argentina | B5 by 2010; E5 by 2010 |
| Australia | E2 in New South Wales, increasing to E10 by 2011; E5 in Queensland by 2010 |
| Bolivia | B2.5 by 2007 and B20 by 2015; E10 |
| Brazil | B5; E20–E25 currently |
| Canada | E5 by 2010 and B2 by 2012; E5 in Alberta; E7.5 in Saskatchewan; E8.5 in Manitoba; E5 in Ontario; Quebec 5% target by 2012 from advanced biofuels |
| China | E10 in 9 provinces |
| Colombia | B10 by 2010 and B20 by 2012; E8 by 2010 |
| Czech Republic | B3.5 |
| Dominican Republic | E15 and B2 by 2015 |
| Germany | Biofuels share 6.75% by 2010 and 7.25% by 2012; biodiesel 4.4% by 2009; ethanol 2.8% by 2009 and 3.6% by 2015 |
| India | E5 by 2008 and E20 by 2018; E10 in 13 states/territories |
| Italy | E3.5, B3.5 |
| Jamaica | E10 by 2009 |
| Kenya | B5 |
| Malaysia | B5 by 2008 |
| Mexico | E6.7 by 2010 in Guadalajara, by 2011 in Monterrey, by 2012 in Central Valley |
| Pakistan | B5 by 2015; B10 by 2025 |
| Paraguay | E18–E24; B5 |
| Peru | B5 by 2011; E7.8 by 2010 |
| Philippines | B2 and E10 by 2011 |
| Portugal | B7 by 2010 |
| South Korea | B3 by 2012 |
| Spain | B5.8 by 2010 |
| Thailand | B3 by 2010; E10 |
| United Kingdom | B3.25 |
| 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; 3.4 billion liters/year biofuels by 2017 (0.9 billion gallons) in Pennsylvania |
| Uruguay | B5 by 2012, less than E5 until 2015, then greater than E5 after 2015 |

*Notes*: 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. Chile had voluntary guidelines for E5 and B5. South Africa had proposed mandates of E8–E10 and B2–B5. Some mandates shown may be delayed by market issues. 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. *Sources*: All available policy references, including the IEA online Global Renewable Energy Policies and Measures database and submissions from report contributors.

## Table R13. City and Local Renewable Energy Policies: Selected Examples

### CO2 Emissions Reductions Targets

| | |
|---|---|
| Austin TX, USA | Zero net emissions ("carbon-neutral") by 2020 |
| Barcelona, Spain | Reduce per-capita emissions to 3.15 tons of $CO_2$-eq. by 2010 |
| Copenhagen, Denmark | Reduce 20% by 2015; zero net emissions by 2025 |
| Hamburg, Germany | Reduce 40% by 2020 and 80% by 2050 (base 1990) |
| Oslo, Norway | Reduce 50% by 2030 (base 1991) |
| San Francisco CA, USA | Reduce 20% by 2012 (base 1990) |
| Seoul, Korea | Reduce 25% by 2020 (base 1990) |
| Stockholm, Sweden | Reduce per-capita emissions to 3 tons of $CO_2$ by 2015 (base 5.5 tons 1990) |
| Sydney, Australia | Reduce 70% by 2030 (base 2006) |
| Tokyo, Japan | Reduce 25% by 2020 (base 2000) |

### Targets for Share of Renewable Energy

| | |
|---|---|
| Beijing, China | 4% of electric power capacity by 2010 and 6% of heating |
| Calgary AB, Canada | 30% of total energy by 2036 |
| Cape Town, South Africa | 10% of total energy by 2020 |
| Madrid, Spain | 20% reduction in fossil fuel use by 2020 |
| Münster, Germany | 20% of total energy by 2020 |
| Rajkot, India | 10% reduction in conventional energy by 2013 |
| Samsø, Denmark | 100% of total energy |
| Stockholm, Sweden | 80% of district heating from renewable sources |
| Tokyo, Japan | 20% of total energy by 2020 |
| Växjö, Sweden | 100% of total energy (fossil fuel-free) |

### Targets for Share of Renewable Electricity

| | |
|---|---|
| Austin TX, USA | 30% by 2020 |
| Adelaide, Australia | 15% by 2014 |
| Ann Arbor MI, USA | 20% by 2015 |
| Cape Town, South Africa | 10% by 2020 |
| Freiburg, Germany | 10% by 2010 |
| Taipei City, Taiwan | 12% by 2020 |
| Sydney, Australia | 25% by 2020 |

### Targets for Installed Capacity of Renewable Energy

| | |
|---|---|
| Adelaide, Australia | 2 MW of solar PV on residential and commercial buildings |
| Barcelona, Spain | 100,000 m² of solar hot water by 2010 |
| Kunming, China | 6 million m² surface area covered by of solar PV and solar hot water, with at least 100 MW solar PV |
| Leister, UK | 1,000 buildings with solar hot water by 2010 |
| Los Angeles CA, USA | 1.3 GW of solar PV by 2020: residential, commercial, city-owned facilities |
| San Francisco CA, USA | 50 MW of renewables by 2012, including 31 MW of solar PV |
| Shanghai, China | 200–300 MW of wind and 10 MW of solar PV by 2010 |
| Tokyo, Japan | 1 GW of added solar PV by 2010 |



### Targets for Government Own-Use Purchases of Renewable Energy

| | |
|---|---|
| Austin TX, USA | 100% of own-use electricity by 2012 |
| Bhubaneswar, India | Reduce by 15% own-use conventional energy by 2012 |
| Bristol, UK | 15% of own-use electricity (14% currently) |
| Calgary AB, Canada | 100% of own-use electricity by 2012 |
| Hepburn Shire, Australia | 100% for own-use in buildings, 8% public lighting |
| Houston TX, USA | 50% of own-use electricity (currently) |
| Portland OR, USA | 100% of own-use electricity by 2010 |
| Sydney, Australia | 100% of own-use energy |
| Toronto ON, Canada | 25% of own-use electricity by 2012 |
| Sydney, Australia | 100% own-use electricity in buildings; 20% for street lamps |

### Targets for Share of Buildings with Renewable Energy

| | |
|---|---|
| Cape Town, South Africa | 10% of homes with solar hot water by 2010 |
| Dezhou, China | 50% of buildings with solar hot water by 2010 |
| Iida City, Japan | 30% of homes with solar PV by 2010 |
| Kunming, China | 50% of buildings with solar hot water and/or solar PV by 2010; 90% of new construction |
| Oxford, UK | 10% of homes with solar hot water and/or solar PV by 2010 |

### Urban Planning

| | |
|---|---|
| Adelaide, Australia | "Adelaide City Development Plan" calls for green buildings and renewables |
| Berlin, Germany | "Berlin Energy Action Plan" |
| Göteborg, Sweden | "Göteborg 2050" envisions being fossil fuel-free |
| Hamburg, Germany | Wilhelmsburg model urban district with renewables |
| Porto Alegre, Brazil | "Program for Solar Energy in Buildings" |
| Shanghai, China | "Regulations of Renewable Energy Development in Shanghai" |
| Tokyo, Japan | "Tokyo Renewable Energy Strategy" (2006) |
| Toronto ON, Canada | "Sustainable Energy Action Plan" |
| Växjö, Sweden | "Fossil Fuel Free Växjö" targets per-capita $CO_2$ |
| Yokohama, Japan | "Yokohama Energy Vision" targets electric vehicles, solar, green power |

### Building Codes and Permitting

| | |
|---|---|
| Barcelona, Spain | Mandates 60% of hot water heating energy from solar in all new buildings and major renovations |
| Lianyungang, China | Requires solar hot water in all new residential buildings up to 12 stories, and in new construction and renovation of hotels and commercial buildings |
| Rajkot, India | Requires new residential buildings larger than 150 $m^2$ and hospitals and other public buildings to install solar hot water |
| Rio de Janeiro, Brazil | Requires all public buildings to use solar hot water for 40% of heating energy |
| San Francisco CA, USA | Requires new buildings over 100,000 $ft^2$ to supply 5% of energy from solar |
| Tokyo, Japan | Requires property developers to assess and consider possibilities for solar hot water and other renewables and to report assessments to owners |

### Tax Credits and Exemptions

| | |
|---|---|
| Belo Horizonte, Brazil | Tax credits for residential solar |
| Boulder CO, USA | Rebate of sales and use taxes for solar |
| Caledon ON, Canada | Property development fee discount of 5% if projects include renewables |
| Nagpur, India | Property tax credit of 10% for solar hot water in new residential buildings |
| New York NY, USA | Property tax abatement for solar PV |

| Transport Infrastructure and Fuels Mandates, Operation, Investment, and Subsidies | |
|---|---|
| Adelaide, Australia | Operate electric public buses charged with 100% solar electricity |
| Ann Arbor MI, USA | Subsidies for public-access biofuels stations |
| Betim, Brazil | Mandates for biofuels in public transport and taxis (plan through 2017); preference to flex-fuel vehicles for municipal vehicle fleet purchases |
| Calgary AB, Canada | B5 and B20 used in municipal fleet vehicles |
| Portland OR, USA | Mandate for biofuels blending B5 and E10 for all diesel and gasoline sold within city limits; biofuels investment fund to enhance production, storage, distribution; biofuels infrastructure grants; use of biofuels in municipal fleet |
| Stockholm, Sweden | Plan to have 50% of all public transit buses run on biogas or ethanol by 2011, and 100% of buses by 2025; metro and commuter trains run on green electricity; additional biofuels stations |

| Electric Utility Policies | |
|---|---|
| Austin TX, USA | Renewable portfolio standard 30% by 2020 |
| Boulder CO, USA | Carbon tax on fossil fuel electricity purchases |
| Gainesville FL, USA | Feed-in tariff for solar PV (32 cents/kWh for 20 years) |
| Mexico City, Mexico | Net metering for solar PV |
| Minneapolis MN, USA | Renewable portfolio standard 30% by 2020 (for Xcel Energy) |
| New York NY, USA | Net metering up to 2 MW capacity |
| Oakville ON, Canada | Local utility voluntary green power sales |
| Sacramento CA, USA | Feed-in tariff for eligible generation starting January 2010 (by SMUD) |

| Subsidies, Grants, and Loans | |
|---|---|
| Adelaide, Australia | Subsidy for solar PV (AUD1,000/watt for> 1kW) |
| Aspen CO, USA | Subsidies for solar PV ($1,500 for> 2kW) |
| Berkeley CA, USA | Loans to households repaid through property tax bills (up to $37,500) |
| Berlin, Germany | Subsidies for solar PV (40%) and solar hot water (30%) on apartment buildings |
| Boulder CO, USA | Small loan program ($3,000–5,000 loans) |
| Christchurch, New Zealand | Lower permit costs for solar hot water |
| Kawasaki, Japan | Subsidies for solar PV for households (JPY70,000/kW up to 3.5 kW) |
| Porto Alegre, Brazil | Grants for solar hot water in buildings |
| Rome, Italy | Subsidies for solar hot water (to 30%), solar PV (to 60%) |
| Toronto ON, Canada | Sustainable energy fund low interest loans |

| Government Funds and Investments | |
|---|---|
| Beijing, China | 13 billion RMB ($2 billion) investment fund to achieve 4% energy target |
| Edinburgh, Scotland, UK | Climate Change Fund totaling £18.8 million |
| Kunming, China | Fund for solar PV industry development and solar PV projects |
| Montreal QC, Canada | CAD24 million energy fund over 6 years |
| San Francisco CA, USA | Solar Energy Bond issue of $100 million |
| Toronto, Canada | CAD20 million Green Energy Fund to support renewable energy investments |

*Source*: REN21, Institute for Sustainable Energy Policies, and ICLEI Local Governments for Sustainability, *Global Status Report on Local Renewable Energy Policies* (Paris: September 2009).



## 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. Biodiesel is also used in non-vehicle engines.

**Biofuel.** A wide range of fuels derived from biomass, including ethanol, biodiesel, and biogas, which can be burned for transportation, heating, cooking, and electricity generation.

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

**Biomass power and heat.** Power and/or heat generation from solid biomass, which includes forest product waste, agricultural residue 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 for ordinary vehicles, or can be used at higher blend levels in specially modified vehicles.

**Feed-in tariff.** A policy that (a) guarantees grid access to renewable energy producers; and (b) 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, either directly from utility companies, from a third-party renewable energy generator, or through the trading of renewable energy certificates (RECs).

**Hydropower.** Electricity derived from the energy of water moving from higher to lower elevations. Hydropower can be "run-of-river" without a reservoir, or can include reservoir storage capacity. Large hydropower is usually defined as larger than 10 megawatts; the definition can vary by country. Smaller-scale installations are called small-, mini-, micro-, or pico-hydropower, depending on the scale.

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

**Modern biomass.** Biomass-utilization technologies other than those defined for traditional biomass, such as biomass cogeneration 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 delivered from the utility (total consumption minus self-production). A variation employing two meters is called "net billing."

**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.

**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. The PV cell is the basic building block, which is then manufactured into modules and panels for installation. Thin-film solar PV materials can also be applied as films over existing surfaces or integrated with building components (so-called BIPV).

**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.

## FURTHER INFORMATION AND SOURCES OF DATA

This 2010 report edition follows four previous editions in 2005, 2006, 2007, and 2009 (*Renewables 2005 Global Status Report, Renewables Global Status Report 2006 Update, Renewables 2007 Global Status Report*, and *Renewables Global Status Report 2009 Update*). The knowledge base of information used to produce these reports continues to expand, and readers are directed to the previous report editions for historical details and elaborations that have formed the foundation for the present report. Relevant information can be found in the endnotes and reference lists of the 2006, 2007, and 2009 editions, and in 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*. 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. Subsequent editions have added 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 ethanol. 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 are generally more available for developing countries than energy production.) Exact annual increments to capacity are generally available only for wind, solar PV, and solar hot water.

## ENDNOTES

1 Figure 1 shows shares of final energy consumption, which is different than shares of primary energy consumption. For an explanation of the differences, see Sidebar 1 on page 21 of REN21, *Renewables 2007 Global Status Report* (Paris: 2007), available at www.ren21.net. Figure 1 is based on the following data for 2008: (a) global final energy consumption of 8,400 Mtoe including traditional biomass, which is derived from the 8,286 Mtoe for 2007 from International Energy Agency (IEA) *Key World Energy Statistics 2009* (Paris: IEA/OECD, 2009), and then adjusted to 2008 using the 1.4% growth rate in global primary energy for 2008 found in BP, *Statistical Review of World Energy 2009* (London: June 2009); (b) traditional biomass of 1,100 Mtoe (adjusted by 2 percent/year growth from 2001 estimate in J. Goldemberg and T.B. Johansson, eds., *World Energy Assessment Overview: 2004 Update* (New York: United Nations Development Programme, United Nations Department of Economic and Social Affairs, and World Energy Council, 2004), although there are no consistent global estimates for growth of traditional biomass); (c) hydropower of 3,170 Terawatt-hours (TWh) and 270 Mtoe for 2008 from BP, op. cit. this note; (d) nuclear of 2,739 TWh and 235 Mtoe from BP, op. cit. this note; (e) renewables for 2008 adjusted from REN21 *Renewables 2007 Global Status Report* figures (which are 2006 figures) using capacity increases and additional industry data; figures calculated for 2008 are: biomass power 270 TWh, wind power 260 TWh, geothermal power 70 TWh, solar and other power 15 TWh, solar hot water 350 petajoules (PJ), geothermal heat 310 PJ, biomass heat 4,400 PJ, ethanol 1,470 PJ, and biodiesel 410 PJ. So total non-hydro renewable power generation for 2008 is calculated as 615 TWh, and total final energy from non-hydro renewables is calculated as 219 Mtoe. 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. The IEA gives 4,000 PJ heat from modern bioenergy, per IEA, *Renewables for Heating and Cooling* (Paris: IEA/OECD, 2007), and Johansson and Turkemburg give 730 TWh(th), or 2,600 PJ final heat in 2001, per T. Johansson and W. Turkemburg, "Policies for Renewable Energy in the European Union and Its Member States: An Overview," *Energy for Sustainable Development*, vol. 8, no. 1 (2004), pp. 5–24. Figures from the 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 renewable heating/hot water could be higher than shown in Figure 1. Further discussion of the different methods for calculating share of energy from renewables can be found in Eric Martinot et al., "Renewable Energy Futures: Targets, Scenarios and Pathways," *Annual Review of Environment and Resources*, vol. 32 (2007), pp. 205–39.

2 Note on treatment of hydropower: past editions of this report, starting with the original 2005 edition, have reported separate figures for large and small hydropower and generally treated large hydropower as separate from "new renewables," which includes small hydropower. In the past, global data for "small hydropower" have been determined by reporting standards or definitions of individual countries, which vary by country. The most notable exceptions are China (less than 50 MW), Brazil and the United States (less than 30 MW), and India (up to 25 MW). In this edition, small hydropower is defined as less than 10 MW. Small hydro has been differentiated from large for several reasons. Small hydro is counted, reported, and tracked separately from large hydro in a variety of policy and market contexts around the world, for example, as an

eligible technology for Renewable Portfolio Standards, feed-in tariffs, tax credits, and in portfolio tracking by financiers and development assistance agencies. Some policy targets (see Section 4) count only small hydro in calculating share of electricity from renewable and exclude large hydro from policy targets. In addition, many countries separate small and large hydro when tracking renewables development. Further, because it represents such a large portion of total renewable energy capacity on a global basis and in many individual countries, large (or total) hydropower masks the dynamic growth and features of ongoing markets for wind, biomass, solar, and other "new renewables" if it is not separated out. At the same time, this approach to hydropower has not been without problems, particularly as the definition of small hydro is not globally consistent. The International Hydropower Association (IHA) maintains that hydro, of whatever size, should not be differentiated from other renewables and that this separation is contrary to the spirit of a global transition to renewable energy. Hydropower technology is fundamentally the same regardless of scale, and other distinctions in hydro technology (e.g., technology types such as storage hydro versus run-of-river) are potentially more relevant to a discussion of renewable energy and provide a scientifically based distinction. Unfortunately, a lack of data makes it impossible to provide details regarding developments by specific hydro technology.

3 Figure 2 based on data provided later in this section and in the reference tables. For full source information see: note 66 for solar PV (grid-connected), note 80 for solar PV (utility scale), note 8 for wind power, note 145 for solar hot water/heating, note 99 for solar thermal power, note 87 for geothermal power, and note 173 for ethanol and biodiesel production. In addition, some data are based on 2004 statistics that can be found in REN21, *Renewables 2005 Global Status Report* (Washington, DC: Worldwatch Institute, 2005).

4 For Figure 3 sources, see reference notes for Figure 1, op. cit. note 1. Global power capacity estimate of 4,800 GW is based on IEA's 4,500 GW installed in 2007, adjusted for an average growth rate of 3 percent for 2008 and 2009, per IEA, *World Energy Outlook 2009* (Paris: IEA/OECD, 2009), p. 102. World electricity generation estimated at 20,700 TWh in 2008, based on 2007 generation of 19,845 TWh from International Energy Agency, *Electricity Information 2009*, (Paris: OECD, 2009), adjusted by 4.4% growth for 2008 (assuming same growth rate as 2007).

5 Figure 4 and 305 GW based on data in Table R4. See Table R4 for sources, as well as endnotes throughout this section that provide references for specific national and global statistics.

6 Europe from Global Wind Energy Council (GWEC), "More Wind Power Capacity Installed Last Year in the EU Than Any Other Power Technology," press release (Brussels: 2 February 2010); United States from American Wind Energy Association (AWEA), *AWEA U.S. Wind Industry Annual Market Report Year Ending 2009* (Washington, DC: April 2010).

7 Li Junfeng, Chinese Renewable Energy Industries Association (CREIA), personal communication with REN21, May 2010.

8 Figure 5 and Table R2 derived from the following primary yearbooks for wind power: GWEC, *Global Wind 2009 Report* (Brussels: 2010) and World Wind Energy Association (WWEA), *Wind Energy International 2007/2008* and *World Wind Energy Report 2009* (Bonn: 2010). Other important sources include the European Wind Energy Association (EWEA), AWEA, and Chinese Wind Energy Association (CWEA).

9 China and Figure 6 from Shi Pengfei, CWEA, personal communication with REN21, May 2010, and from sources provided in Endnote 8.

10 Based on just under 200 MW installed in 2004, per Shi, op. cit. note 9; 8 GW from GWEC, op. cit. note 8.

11 Total of 25.8 GW is completed installations, per CWEA and based on data provided by manufacturers and cross-checked with project developers. About 3 GW was installed but not yet connected at end of 2009 due to normal testing and certification delays, but still counted in China's operating base for 2009. Number based on total installations and on grid-connected capacity from Hydrochina Corporation (official recognized by China's National Energy Administration), available at www.windpower.org.cn/news/news.jsp?id=335 and provided by Shi, op. cit. note 9. China's installed nuclear generating capacity at the end of 2009 was 21.9 GW, per "China's Nuclear Power Capacity over 21 Million KW," *People's Daily Online*, 7 January 2010.

12 Based on data from Shi, op. cit. note 9, and from Li Junfeng and Ma Lingjuan, CREIA, personal communication with REN21, April 2010. Note that the 2005 market did not quite double total installed capacity but came close (from 764 MW at end 2004 to 1,260 MW at end 2005.)

13 AWEA, op. cit. note 6.

14 AWEA, "AWEA Releases U.S. Wind Industry Annual Market Report," press release (Washington, DC: 8 April 2010).

15 Electric Reliability Council of Texas (ERCOT), "Texas Posts Record Increase in Voluntary Renewable Energy Credits: State Exceeds Legislature's 2025 Goal 15 Years Early," press release (Austin, TX: 14 May 2010).

16 Germany from Thomas Nieder, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), Germany, personal communication with REN21, May 2010; Spain from Asociación Empresarial Eólica, 25 March 2010, at www.aeeolica.es/en; other Europe from EWEA, *Wind in Power—2009 European Statistics* (Brussels: February 2010).

17 GWEC, op. cit. note 8; WWEA, op. cit. note 8. Note that the Indian Ministry of New and Renewable Energy estimates that 1,565 MW were installed during 2009 through 31 March 2010, with cumulative capacity exceeding 11,800 MW by the end of March 2010, per Government of India, Ministry of New and Renewable Energy, "New and Renewable Energy – Cumulative Achievements as on 31.03.2010," www.mnre.gov.in, updated 30 April 2010.

18 José Etcheverry, York University, Toronto, Canada, personal communication with REN21, April 2010; Canadian Wind Energy Association, "Canadian Wind Farms," www.canwea.ca/farms/index_e.php, viewed 13 June 2010.

19 Brazil, for example, increased its installed capacity in the range of 70 percent over 2008 levels, with capacity rising from 414 MW in 2008 to 717 MW in 2009, per Marlon Arraes Jardin Leal, Ministry of Mines and Energy, Brazil, personal communication with REN21, May 2010; 2009 year-end capacity reached 766 MW, per National Electric Energy Agency, Generation Data Bank, www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.asp, viewed May 2010, and provided by Renata Grisoli, CENBIO, personal communication with REN21, May 2010. In addition, significant capacity was added in Chile (60 MW added for a total of 78 MW) and Costa Rica (49.5 MW added for total of 120 MW), per ECLAC, *Istmo Centroamericano: Estadísticas Del Subsector Eléctrico*, April 2010.

20 WWEA, *World Wind Energy Report 2009*, op. cit. note 8. Note that the WWEA data do not include Kenya and some smaller players, such as Thailand, that installed wind capacity during 2009. This brings the number of countries above 82. In addition, several countries—including Ethiopia, Ghana, and Uganda in Africa—have small off-grid wind systems in operation. Africa from Mark Hankins, independent consultant and solar project developer, Kenya, personal communication with REN21, May 2010; Thailand from Chris Greacen, Palang Thai, personal communication with REN21, February 2010; Nicaragua from Organización Latinoamericana de Energía (OLADE, http://www.olade.org/siee.html), provided by Gonzalo Bravo, Bariloche Foundation (Argentina), personal communication with REN21, March 2010.

21 Additions calculated using 577 MW added in Europe from EWEA, *The European Offshore Wind Industry—Key Trends and Statistics 2009* (Brussels: January 2010); 63 MW in China from Pengfei, op. cit. note 9, and from Steve Sawyer, GWEC, personal communication with REN21, May 2010; 1 MW in Japan from WWEA, *World Wind Energy Report 2009,* op. cit. note 8; 72 percent assumes the 373 MW installed in Europe was the only offshore capacity added in 2008; 373 MW in 2008 from EWEA, op. cit. this note.

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23 "UK Offshore Wind Reaches 1 GW," RenewableEnergyFocus.com, 28 April 2010.
24 Sawyer, op. cit. note 21. All 34 turbines to make up the 102 MW Donghai Bridge project were installed by February 2010.
25 Japan from WWEA, *World Wind Energy Report 2009*, op. cit. note 8.
26 EWEA, op. cit. note 21.
27 Graham Jesmer, "US Offshore Wind Project Updates," RenewableEnergyWorld.com, 16 December 2009; Graham Jesmer, "Approved! Cape Wind Gets Green Light," RenewableEnergyWorld.com, 28 April 2010.
28 Nao Nakanishi, "UK Small Wind Blows Strong Despite Recession," *Reuters*, 20 November 2009.
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30 Daniele Guidi and Stephanie Cunningham, Ecosoluzione, personal communication with REN21, March 2010.
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32 China data presented at 1st World Wind Energy Association, World Summit for Small Wind, op. cit. note 29.
33 Europe from GWEC, op. cit. note 6, and from EWEA, op. cit. note 16; United States from AWEA, op. cit. note 6.
34 Denmark from WWEA, op. cit. note 8; Spain from Asociación Empresarial Eólica, op. cit. note 16; Germany from Nieder, op. cit. note 16; Portugal and Ireland from Sawyer, op. cit. note 21.
35 Germany from B. Neddermann, "Status de Windenergienutzung in Deutschland–Stand 31.12.2009," German Wind Energy Institute (DEWI GmbH).
36 Iowa and Texas from AWEA, op. cit. note 14, and from Peter Behr, "Renewable Energy: Is Texas Writing the Book on Wind Power?" *E&E News*, 8 April 2010.
37 Kenya from Hankins, op. cit. note 20; Ethiopia and Tanzania from Sawyer, op. cit. note 21, from "Ethiopia, French Firm Sign 210m-Euro Wind-Powered Electricity Project," *Ethiopian Review, 9* October 2009, and from Daniel Dickinson, "Wind of Change Blows in Tanzania," *BBC News Online*, 21 April 2008.
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40 J. Matthew Roney, "China Challenging the United States for World Wind Leadership," *Earth Policy Release*, 10 December 2009, www.earthpolicy.org/index.php?/indicators/C49; Christian Zeppezauer and Connie Carnabuci, "A New Revolution: China Hikes Wind and Solar Power Targets," *Renewable Energy World Magazine*, September/October 2009.
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43 IEA, "Development of Renewables and Waste in OECD Countries," in *Renewables Information*, op. cit. note 42.
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50 EurObserv'ER, op. cit. note 47.
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53 Nieder, op. cit. note 16.
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63 Figure of 9 TWh from Offermann, Witt, and Kaltschmitt, op. cit. note 55; estimate of German plants and 11.7 TWh from German Biomass Research Centre, op. cit. note 56.
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130 Elizabeth A. Ingram, "Development Activity Snapshots," HydroWorld.com, December 2009. Note that another source says that 10 projects are under way in Europe, including a 178 MW project in Slovenia, two projects in Austria totaling 1,020 MW, and one in Switzerland with 141 MW, per Barnes, op. cit. note 21.
131 India from Arun Kumar, The Energy and Resource Institute (TERI), India, personal communication with REN21, May 2010; South Africa from Max Edkins, Energy Research Centre (ERC), South Africa, personal communication with REN21, May 2010.
132 Figure of 70 million households with solar hot water is a rough estimate based on 260 million m² of installed collector area worldwide, assuming that 80% of that collector area serves residential households with 3 m² per household. The 3 m² per household figure is higher than the average residential system in China (per available information). Since China has two-thirds of the world's solar hot water capacity, and a lower average system size would mean an even higher number of households, the figure of 70 million households is probably too low.
133 Fritsche, op. cit. note 46.
134 Growth rates calculated with data from EurObserv'ER, op. cit. note 47, p. 8; largest markets are 2008 data from idem, p. 10.
135 "Biomass Generates 32% of All Energy in Sweden," RenewableEnergyWorld.com, 2 June 2010.
136 Figure of EurObserv'ER, op. cit. note 47.
137 67 percent is 2008 data from EurObserv'ER, op. cit. note 47, p. 10.
138 Danish Energy Agency, cited in Pernick et al,, op. cit. note 45.
139 2008 data from EurObserv'ER, op. cit. note 47; 2005 consumption was 6 million tons, per REN21, op. cit. note 1.
140 EurObserv'ER, op. cit. note 47.
141 Jeremy van Loon, "Wood Is New Coal as Polluters Use Carbon-Eating Trees (Update1)," *Bloomberg*, 2 June 2009.
142 REN21, op. cit. note 1.
143 Australia, Brazil, China, Colombia, Cuba, India, and the Philippines from REN21, op. cit. note 1; Guatemala and Argentina from Bravo, op. cit. note 38; Mauritius from Stephen Karekezi et al., "Scaling up Bio-energy in Africa," presentation for International Conference on Renewable Energy in Africa, Dakar, Senegal, 16–18 April 2008; Kenya, Tanzania, and Uganda from Godefroy Hakizimana et al., *Renewable Energies in East Africa Regional Report on Potentials and Markets–5 Country Analyses*, prepared for Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH on behalf of Federal Ministry for Economic Cooperation and Development (BMZ) (Eschborn, Germany: 2009).
144 China from Li and Ma, op. cit. note 12; others from Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2008*, prepared for Solar Heating and Cooling Programme, IEA (Gleisdorf, Austria: May 2010). Figures 9 and 10, and Table R5 based on idem, except for China. China data differ significantly from Weiss and Mauthner, which give a 2008 world total existing of 132 GWth based on 87.5 GWth for China. Weiss and Mauthner figures based on 53 countries and roughly 85–90 percent of global market.
145 Estimate for 2009 based on China data from Li and Ma, op. cit. note 12, which, along with other estimates for 2009 additions in Brazil (0.5 GWth), the EU (2.9 GWth), and the United States (0.2 GWth), and extrapolating 2008 additions for other countries and estimating retirements (3–4 percent annually), yields a 2009 world total estimate of 180 GWth. Brazil from National Solar Heating, Brazilian Association of Refrigeration, Air Conditioning, Ventilation and Heating, www.dasolabrava.org.br/dasol; EU from European Solar Thermal Industry Federation (ESTIF), "Solar Thermal Markets in Europe: Trends and Market Statistics 2009" (Brussels: June 2010); United States based on 10 percent market growth relative to 2008 per SEIA, op. cit. note 66, and 2008 U.S. data from Weiss and Mauthner, op. cit. note 144; additional extrapolations derived from Weiss and Mauthner, op. cit. note 144.
146 Li and Ma, op. cit. note 12. Share of market derived from estimates for gross additions in 2009. See note 145.
147 Over 4 million m2 of solar thermal panels were sold in the EU during 2009, per ESTIF, op. cit. note 145.
148 Growth in the German market from German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Development of Renewable Energy Sources in Germany 2009" (Berlin: 18 March 2010). There are two estimates for Germany's total capacity by end 2009: 9.2 GWth from Nieder, op. cit. note 16; and 8.9 GWth from ESTIF, op. cit. note 145. Heat output from Nieder, op. cit. note 16.
149 ESTIF, op. cit. note 145.
150 Based on 2009 survey by Gunder, the Turkish division of the International Solar Energy Society, cited in Baerbel Epp, "Lack of Support: Turkish Market Decreasing," 17 April 2009, at www.solarthermalworld.org/node/527.
151 According to 2009 statistics from the General Directorate of Forest and Village Relations, Turkey, and cited in Baerbel Epp, "40,000 'Forest Villagers' in Turkey Heat Water with the Sun," 21 April 2009, at www.solarthermalworld.org/node/530.
152 India Development Gateway, "Rural Energy," www.indg.in/rural-energy/technologies-under-rural-energy/energy-production/faqs-domestic-solar-water-heating, updated May 2010.
153 National Solar Heating, Brazilian Association of Refrigeration, Air Conditioning, Ventilation and Heating, www.dasolabrava.org.br/dasol, provided by Grisoli, op. cit. note 19.
154 California from Werner Weiss, Arbeitsgemeinschaft Erneuerbare Energie - Institut für Nachhaltige Technologien (AEE INTEC), Austria, personal communication with REN21, March 2010. U.S. additions and total based on 10 percent market increase, per SEIA, op. cit. note 66, and on 158 MWth added in 2008 for total existing capacity of 1.9 GWth in 2008, per Weiss and Mauthner, op. cit. note 144.
155 South Africa's annual market has tripled, to 30,000 m² in 2008, bringing the total above 100,000 m² in 2008, per Edkins, op. cit. note 131; Ethiopia and Kenya from Hankins, op. cit. note 20; Tunisia and Zimbabwe from Weiss and Mauthner, op. cit. note 144.

156 Per person data from Weiss and Mauthner, op. cit. note 144; 80 percent in Israel from David Appleyard, "Solar Heating Industry Review 2009," RenewableEnergyWorld.com, 21 September 2009. Cyprus had 646 GWth per person in 2009, per ESTIF, op. cit. note 145.
157 Weiss and Mauthner, op. cit. note 144. Austria had 301 GWth per person in 2009, per ESTIF, op. cit. note 145.
158 Palestine from Basel Yaseen, Palestinian Energy and Environment Research Center, personal communication with REN21, February 2010.
159 Weiss and Mauthner, op. cit. note 144.
160 REN21, op. cit. note 1.
161 David Appleyard, "Chilling Out in the Sun: Solar Cooling," *Renewable Energy World International Magazine,* May/June 2010; Edo Wiemken, "Market Review and Analysis of Small and Medium Sized Solar Air Conditioning Applications: Survey of Available Technical Solutions and Successful Running Systems–Cross Country Analysis" (Munich: Fraunhofer ISE, December 2009).
162 Wiemken, op. cit. note 161.
163 John W. Lund, Derek H. Freeston, and Tonya L. Boyd, "Direct Utilization of Geothermal Energy 2010 Worldwide Review, Proceedings" World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010.
164 Ibid.
165 Ibid.; Germany from Nieder, op. cit. note 16.
166 Lund, Freeston, and Boyd, op. cit. note 163.
167 Holm et al., op. cit. note 91.
168 Lund, Freeston, and Boyd, op. cit. note 163.
169 Ibid.
170 See, for example, Nicolaj Stenkjaer, "Biogas for Transport," Nordic Folkecenter for Renewable Energy, November 2008, at www.folkecenter.net/gb/rd/transport/biogas_for_transport/.
171 UNICA - Sugarcane Industry Association, 2010, data provided by Grisoli, op. cit. note 19.
172 Anselm Eisentraut, *Sustainable Production of Second Generation Biofuels: Potential and Perspectives in Major Economies and Developing Countries* (Paris: IEA, 2010), p. 21; IEA, *Medium-Term Oil and Gas Markets: 2010* (Paris: IEA/OECD, 2010).
173 Figure 11 and Table R6 derived from the following: ethanol and biodiesel data from IEA, *Medium-Term Oil and Gas Markets*, op. cit. note 172, and from Claus Keller, F.O. Licht, personal communication with REN21, May 2010. Brazil ethanol data from DATAGRO, 2010, provided by Grisoli, op. cit. note 19. Where reported in tons, figures converted to liters using factors 1,260 liters/ton ethanol and 1,130 liters/ton biodiesel.
174 IEA, *Medium-Term Oil and Gas Markets*, op. cit. note 172. Note that IEA biofuels data are expressed in volumetric terms, not in terms of energy content.
175 Ibid.
176 Citing John Urbanchuk, in "Ethanol Production Impacts U.S. Economy," *NAFB News Service*, 15 February 2010.
177 Causes from Arraes Jardim Leal, op. cit. note 19, and from Grisoli, op. cit. note 19; 2008 data from Brazilian Ministry of Mines and Energy, "Brazilian Energy Balance," 2009, at https://www.ben.epe.gov.br/downloads/Resultados_Pre_BEN_2009.pdf; 2009 from DATAGRO, 2010, provided by Grisoli, op. cit. note 19.
178 J. Goldemberg, "The Brazilian Experience with Biofuels," *Innovations* (MIT Press), Fall 2009, pp. 91–107; Denise Luna, "Brazil Opens World's First ethanol-fired Power Plant," *Reuters,* 20 January 2010.
179 Brazilian Supply Company (CONAB), Brazilian Ministry of Agriculture Livestock and Supply, December 2009, data provided by Grisoli, op. cit. note 19. Europe accounted for the vast majority of this decline. Exports to Europe totaled 1.061 billion liters in 2009, down from 1.484 billion liters in 2008, per Arraes Jardim Leal, op. cit. note 19.
180 Arraes Jardim Leal, op. cit. note 19.
181 IEA, *Medium-Term Oil and Gas Markets*, op. cit. note 172.
182 Growth in 2009 from ibid; other data from European Biodiesel Board, "2008–2009: EU Biodiesel Industry Shows Resilience Amid Unfair International Competition and Degraded Market Conditions," press release (Brussels: 15 July 2009).
183 IEA, *Medium-Term Oil and Gas Markets*, op. cit. note 172.
184 Ibid. Note that Malaysia is not included in Table R6 because its combined total for ethanol and biodiesel does not place it in the top 15 for biofuels production.
185 Investment figure for small hydro counts projects less than 50 MW. For purposes of calculating annual investment numbers, Bloomberg New Energy Finance defines small hydropower projects as those less than 50 MW in size. Elsewhere in this report, small hydro is defined as less than 10 MW; see Endnote 2.
186 Tax equity involves banks investing in renewable energy projects in exchange for the project developer's tax credit, which they then use to offset their tax burden. These investments were typically made by large banks or corporations with significant tax exposure. Many of them took major losses due to the financial crisis of 2008 and were no longer able to commit to tax equity investments. This meant that renewable energy project developers and owners could no longer 'monetize', i.e., make use of, the Production Tax Credit (PTC), which is the support instrument at federal level in the United States.
187 Sidebar 2 from early 2010 unpublished data by Bloomberg New Energy Finance.
188 BTM Consult, *World Market Update 2008*, interim report (Ringkøbing, Denmark: March 2009); Stefan Gsänger, WWEA, personal communication with REN21, February 2009. The Enercon turbine blades are delivered in two parts and assembled on site, indicating the potential for future large-scale turbines.
189 The decline is estimated at 80 percent.
190 AWEA, *AWEA Year End 2009 Market Report* (Washington, DC: January 2010).
191 Figure 13 data from BTM Consult, op. cit. note 188, and from BTM Consult, *World Market Update 2009*, interim report (Ringkøbing, Denmark: March 2010). Latin America's market, although historically small, has grow with investment from Argentine groups such as Pescarmona's IMPSA, which holds 533 MW of wind energy in Brazil and 405 MW in Argentina.
192 EurObserv'ER, op. cit. note 47.
193 Pellet exports to Europe are approximately 1 million tons a year from western Canada.
194 German Biomass Research Centre, op. cit. note 56.
195 Li and Ma, op. cit. note 12.
196 Jenny Chase, Bloomberg New Energy Finance, personal communication with REN21, April 2010.

197 German Sunfilm announced a merger with NorSun in April of 2009. NorSun had merged with Sontor, a Q-Cells subsidiary, in 2006.
198 "Sector Round-Up," *New Energy Finance Monthly*, December 2009, p. 4.
199 Figure 14 and national production shares from *PV News*, May 2010 (Cambridge, MA: Greentech Media).
200 Sidebar 3 from the following sources: U.S. data from SEIA, op. cit. note 66; Desertec Web site, www.desertec.org.
201 Entec and BWEA, op. cit. note 109.
202 Brito-Melo and Huckerby, op. cit. note 107.
203 Li and Ma, op. cit. note 12.
204 Taylor, op. cit. note 124. This development encompasses developed and new developing markets, such as Sudan in 2009.
205 The Gold Star Labeling Standard in China.
206 A thermo-siphon hot water circulating system relies on the principle that hot water rises, and does not rely on a pump. In such a system, the water heater must be below system fixtures in order to work.
207 Werner Weiss, Arbeitsgemeinschaft Erneuerbare Energie - Institut für Nachhaltige Technologien (AEE INTEC), Austria, personal communication with REN21, April 2010; Matthias Fawer and Magyar Balzas, "Solar Industry - The First Green Shoots of Recovery" (Basel: Bank Sarasin, November 2009).
208 Weiss, op. cit. note 207.
209 The ethanol industry is driven by security, sustainability, and economic concerns, and the industry in different regions of the world has very different lifecycle energy balances and greenhouse gas emissions profiles.
210 "Sector Round-Up," *New Energy Finance Monthly,* June 2009, p. 8.
211 NAFB News Service, 2010, viewed 15 February 2010, at www.hoosieragtoday.com.
212 Renewable Fuels Association, "Statistics," www.ethanolrfa.org/pages/statistics, viewed 15 April 2010.
213 "Sector Round-Up," *New Energy Finance Monthly*, March 2009, pp. 13–14.
214 "Sector Round-Up," op. cit. note 198, p. 9.
215 Several countries began ethanol production for the first time in 2009, including Sudan.
216 The VEETC is currently $0.45/gallon, but the tariff is a 2.5% tax plus $0.54/gallon. The total tariff is approximately $0.60/gallon. Robert Rapier," The Energy Source," http://blogs.forbes.com/energysource/author/rrapier/.
217 European Biodiesel Board, "Statistics," www.ebb-eu.org/stats.php, viewed 15 April 2010.
218 Neste Oil, "Neste Oil Builds Europe's Largest Renewable Diesel Plant in Rotterdam," press release (Espoo, Finland: 26 May 2009).
219 The tax credit was extended retroactively for one year on March 10, 2010, per "House Passes Legislation to Extend Biodiesel Tax Credit," *Bloomberg News*, 28 May 2010.
220 Anselm Eisentraut, "Sustainable Production of Second-Generation Biofuels" (Paris: IEA, February 2010).
221 Fritsche, op. cit. note 46.
222 Anselm Eisentraut, IEA, personal communication with REN21, March 2010.
223 Ibid.; IEA Bioenergy Task 39, Commercializing 1st and 2nd Generation Liquid Biofuels from Biomass Web site, http://biofuels.abc-energy.at/demo-plants/projects/mapindex, viewed 24 April 2010.
224 "DARPA Official Says Teams at $2 Per Gallon Algal Fuel, Headed for $1; Commencing Commercial Scale by 2013," *Biofuels Digest*, 15 February 2010; Suzanne Goldenberg, "Algae to Solve the Pentagon's Jet Fuel Problem, *The Guardian* (UK), 13 February 2010. A major driver for DARPA's research and production are prices of $431/gallon for jet fuel in forward military areas.
225 The sustainability criteria are driving biofuels production, and particularly second-generation biofuels production. Some experts have raised concerns about policies not supporting production facilities that are most sustainable and are in favor of greater consideration of greenhouse gas balance, land and water use, and endemic species selection.
226 Sidebar 4 based on the following sources: estimates by UNEP 2008 (1.7 million global total) and Sven Teske and Greenpeace International 2009 (1.9 million global total), not including biofuels and solar hot water, adjusted by data from report contributors and other sources, along with estimates for biofuels and solar hot water by Eric Martinot. These various authors used a variety of national sources for jobs in specific industries, including CREIA 2009; Clean Edge 2009; Danish Wind Industry Association; German BMU 2010; GWEC 2010; WWEA 2009; Greenpeace International 2009; Martinot and Li 2007; Navigant 2009; Nieto 2007; REN21 2005 and 2008; Suzlon 2007; UNEP 2008; U.S. Geotherm al Industry Association 2009; SEIA 2009; and interviews with industry experts. Brazil ethanol estimate from Labor Market Research and Extension Group (GEMT, ESALQ/USP). Solar hot water employment estimate uses the figure of 150,000 for China in 2007 cited in Eric Martinot and Li Junfeng, *Powering China's Development: The Role of Renewable Energy* (Washington, DC: Worldwatch Institute, 2007), adjusted for growth in 2008–2009, and assuming employment in other countries is in proportion to China's global market share (80%). There are significant uncertainties associated with most of the numbers presented here, related to such issues as accounting methods, industry definition and scope, direct vs. indirect jobs, and displaced jobs from other industries (net vs. gross job creation). The greatest uncertainties occur in biofuels jobs estimates, where the distinction between direct and indirect jobs can be interpreted and analyzed using different methods and definitions; Renner, Sweeny, and Kubit (2008) estimated 1.2 million jobs from biofuels, including indirect jobs. See also Kammen, Kapadia, and Fripp 2004 for general discussion of jobs estimates. In addition, it is possible to estimate the number of direct jobs associated with a specific technology through the use of "employment factors." For example, jobs associated with the on-shore wind industry are 15 person-years in construction and manufacturing per MW produced, and 0.4 jobs in operations and maintenance per MW existing, according to the EWEA (2009). Similar estimates for the solar PV sector are 38 person-years per MW produced and 0.4 jobs per MW existing, according to EPIA. These factors do not account for indirect jobs. The "employment factors" method was employed in analyses done specifically for the 2005 and 2007 editions of this report, which estimated 1.7 million jobs in 2004 (including 0.9 million jobs in biofuels production) and 2.4 million jobs in 2006 (including 1.1 million jobs in biofuels production).
227 This section is intended only to be indicative of the overall landscape of policy activity and is not a definitive reference. 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. 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. Information on policies comes from a wide variety of sources, including the IEA Renewable Energy Policies and Measures Database, the U.S. DSIRE database, RenewableEnergyWorld.com, press reports, submissions from country-specific contributors to this report, and a wide range of unpublished data. Much of the information presented here and further details on specific countries appear on the "Renewables Interactive Map" at www.ren21.net. It is unrealistic to be able to provide detailed references to all sources here.

228 The term "target" is used rather loosely in this section and encompasses many different types of policy processes, such as legislative mandates, executive or ministerial statements and programs, other types of announced goals and plans, and pledges made as part of international action programs (from Bonn Renewables 2004, Beijing International Renewable Energy Conference 2005, and Washington International Renewable Energy Conference 2008 (WIREC)). It is very difficult to conclusively separate and categorize targets by type across all countries.

229 Targets noted in Tables R7–R9 for Brazil, Cape Verde, Jamaica, Kenya, Magagascar, Nicaragua, Rwanda, and Tunisia are pledges made publically at WIREC in March 2008, or afterward, but not necessarily backed by specific legislation.

230 In 2009, China modified its target for share of energy. The old target was for 15 percent share of primary energy from renewables by 2020. The new target is for 15 percent share of final energy from "non-fossil-fuel" sources by 2020, which includes nuclear power. Nuclear power was 0.3 percent share of final energy in China in 2009, but is expected to grow. A 15 percent share of final energy implies more total renewables than a 15 percent share of primary energy, so even including nuclear, the new target is likely to result in more renewables than the old target.

231 The official targets for China, based on the 2007 "Medium and Long-Term Plan for Renewable Energy Development in China," are still 300 GW hydro, 30 GW wind, 30 GW biomass, and 1.8 GW solar PV. The higher numbers given in the text are draft (provisional) targets not yet formally adopted. China plans 100 GW of wind power development in five regional "bases" in Gansu, Hami, Xinjiang, and Jiangsu provinces and eastern and western Inner Mongolia. There were also provincial targets in China emerging, for example a 2007 target in Hainan Province for 400 MW of wind capacity by 2015 and 600 MW by 2020.

232 Neither the United States nor Canada has a national-level policy target.

233 Sidebar 5 data from Table R4 and Section 1. See also DIREC Web site, www.direc2010.gov.in.

234 Sidebar 6 adapted from from IRENA Web site, www.irena.org.

235 Table 2 from sources listed in note 227.

236 A few feed-in policies shown in Table R10 have been discontinued so the current number of active policies is less than the number reported here; see notes to Table R10. There is now a large literature on feed-in tariffs with many sources of information; see, for example, Miguel Mendonca, *Feed-In Tariffs: Accelerating the Deployment of Renewable Energy* (London: Earthscan, 2007) and Paul Gipe's extensive data at www.wind-works.org. The current report takes a broad definition of feed-in tariff, but also excludes some policies that are considered minor or capped at very low levels of capacity (such as enabling just a few hundred small generators, as was the case for the 2008 feed-in tariff for solar PV in Wisconsin in the United States), as one of the defining characteristics of a feed-in tariff is guaranteed purchasing of power from all renewable generators. There remain significant differences of opinion among experts as to what constitutes a feed-in tariff. The Netherlands MEP policy is considered a premium and classified as an energy production payment in Table 2. Costa Rica, Panama, Peru, and Iran may be the same, although some claim these countries have feed-in tariffs. Feed-in tariffs shown for some other countries might better be classified as energy production payments as well. Indonesia's 2002 feed-in tariff covers generators less than 10 MW (revised from 1 MW in 2006) but at low tariff levels and is not considered by some a true feed-in tariff. At least three countries shown in Table R10, and possibly others, discontinued their policies subsequent to enactment: Brazil (ending in 2010), South Korea, and United States (original 1978 PURPA). The total number of countries with feed-in tariffs existing as of early 2010 reflects the cumulative total in Table R10 minus these three discontinuations. India's national feed-in tariff from 1993 was substantially discontinued but new national feed-in tariffs were enacted in 2008.

237 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, op. cit. note 236). 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.

238 The U.S. state of Washington has enacted limited feed-in tariffs for solar PV but restricts the amount of capacity that can be installed and is capped at $5,000/year per project. California's feed-in tariff is limited to 750 MW. Oregon's feed-in tariff is limited to 25 MW is considered a pilot program. Vermont's feed-in tariff is limited to 50 MW and is also considered a pilot program. In addition, some utilities in the U.S. states of Michigan and Wisconsin offer limited feed-in tariffs, but there is no state-level policy. The Australian Northern Territory had a limited feed-in tariff for a small number of systems in Alice Springs.

239 Some RPS policies in Table R11 may have been repealed or lapsed. Australia's policy was renewed in 2009. India had at least 12 states with RPS policies, and possibly as many as 16 states. Uruguay's RPS policy shown in Table 2 is unconfirmed and not counted in global total.

240 In the United States, there are seven additional states with policy goals that are not legally binding renewable portfolio standards: Alaska, Missouri, North Dakota, Utah, Vermont, Virginia, and West Virginia. Alaska enacted the most recent goal, 25 percent of electricity from renewables by 2025, in mid-2010. U.S. state policies from North Carolina Solar Center, Database of State Incentives for Renewables and Efficiency (DSIRE), electronic database, available at www.dsireusa.org; and data from the Interstate Renewable Energy Council and press reports.

241 Colorado's revision occurred in 2010. 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; and Prince Edward Island targets 15 percent by 2010 (achieved) and 100 percent by 2015. Nova Scotia, in addition to its RPS, also enacted in early 2009 a new non-RPS target of 25 percent share of energy by 2020. There is no target in Newfoundland/Labrador.

242 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.

243 Prior to 2009, the U.S. solar PV tax credit was capped at $2,000 per system but this cap was removed in 2009.

244 In addition to 43 U.S. states, net metering also exists in the District of Columbia and Puerto Rico.

245 India's national codes are initially voluntary, but will later become mandatory.

246 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, op. cit. note 226.

247 São Paulo's solar collector mandate applies to all new residences with more than three bathrooms and all industrial and commercial buildings.
248 For more on the German Renewable Energies Heat Act, see Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, "Heat from Renewable Energies: What Will the New Heat Act Achieve?" (Berlin: July 2008).
249 From 2017 onward, the greenhouse gas emission savings of biofuels produced in existing production plants must be at least 50 percent compared to fossil fuels. The greenhouse gas emissions of biofuels produced in new installations will have to be at least 60 percent lower than those from fossil fuels.
250 In June 2010, the European Commission adopted a new certification scheme for sustainable biofuels, per European Commission, "Commission Sets Up System for Certifying Sustainable Biofuels," press release (Brussels: 10 June 2010). Sidebar 7 based on the following sources: Jinke van Dam et al., *Update: Initiatives in the Field of Biomass and Bioenergy Certification* (IEA Bioenergy Task 40, April 2010), at www.bioenergytrade.org/downloads/overviewcertificationsystemsfinalapril2010.pdf; K. Hennenberg et al., "The Power of Bioenergy-Related Standards to Protect Biodiversity," *Conservation Biology*, 16 December 2009; Roundtable on Sustainable Biofuels Web site, www.rsb.org; Global Bioenergy Partnership Web site, www.globalbioenergy.org
251 No published sources report comprehensively on green power globally, so all information must be compiled country-by-country based on submissions from report contributors.
252 Renewable energy certificates in some countries may also enable utilities and other firms subject to quotas to meet their obligations; this is a role distinct from voluntary trading.
253 Most of the information in this section comes from REN21, Institute for Sustainable Energy Policies, and ICLEI Local Governments for Sustainability, "Global Status Report on Local Renewable Energy Policies," (Paris: September 2009). The report provides preliminary policy information, some of which remains unverified. Subsequent versions are expected. A good general source of information about local policies is the Local Renewables Web Portal, http://local-renewables.org. For further examples and in-depth discussion see IEA, *Cities, Towns and Renewable Energy* (Paris: OECD, 2009).
254 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.
255 Gainesville's feed-in tariff is only for solar PV and only up to a maximum limit of 4 MW across all subscribers. Sacramento's feed-in tariff applies to all forms of renewables up to a maximum of 100 MW. Reportedly, Sacramento's 100 MW limit was already fully subscribed soon after the policy began in early 2010.
256 See Covenant of Mayors Web site, www.eumayors.eu.
257 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.
258 World Health Organization (WHO) and United Nations Development Programme (UNDP), *The Energy Access Situation in Developing Countries: A Review Focusing on the Least Developed Countries and Sub-Saharan Africa* (New York and Geneva: 2009).
259 See Kyran O'Sullivan and Douglas F. Barnes, *Energy Policies and Multitopic Household Surveys: Guidelines for Questionnaire Design in Living Standards Measurement Studies*, World Bank Working Paper No. 90 (Washington, DC: World Bank, 2006). The original source for much of this work on lighting is the background study F. Nieuwenhout, P. Van de Rijt, and E. Wiggelinkhuizen, "Rural Lighting Services," paper prepared for the World Bank (Petten: Netherlands Energy Research Foundation, 1998).
260 Shahid Khandker, Douglas F. Barnes, and Hussain Samad, *The Welfare Impact of Rural Electrification: Evidence from Vietnam*, DEC Policy Research Working Paper No. 5057 (Washington, DC: World Bank, 2009); Shahid Khandker, Douglas F. Barnes, and Hussain Samad, *The Welfare Impact of Rural Electrification: A Case Study of Bangladesh*, DEC Policy Research Working Paper, (Washington, DC: World Bank, 2009).
261 World Bank, *Rural Electrification and Development in the Philippines: Valuing the Social and Economic Benefits, ESMAP Report* (Washington, DC: World Bank, 2002).
262 International Development Company Limited (IDCOL) (Dhaka, Bangladesh, 2010), at www.idcol.org.
263 World Bank, *Renewable Energy and Development Implementation Completion Report* (Washington, DC: World Bank, 2009).
264 Ministry of New and Renewable Energy, Government of India, "New and Renewable Energy Cumulative Achievements," fact sheet (New Delhi: 2009).
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271 Stove numbers from the following manufacturer Web sites: www.envirofit.org, www.stovetec.net/us, www.onilstove.com, and www.treeswaterpeople.org/stoves/programs/honduras.htm.
272 GTZ has developed a Cooking Energy Compendium summarizing the last 25 years of knowledge and experience with markets for improved cook stoves in developing countries, per GTZ, *Cooking Energy Compendium, 2009*, at www.hedon.info/GTZCookingEnergyCompendium.
273 Worldwide experiences with solar cookers summarized in GTZ, *Here Comes the Sun: Options for Using Solar Cookers in Developing Countries* (Eschborn: 2007). The use of solar cookers depends on the purpose and cultural habits of those cooking, and the cooking must generally be done during daytime hours. It is quite relevant for foods that require slow cooking.
274 Li and Ma, op. cit. note 12.
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282 The Dutch-German Partnership "Energising Development," EnDev, is an initiative to provide 6.1 million people in developing countries access to modern energy services by 2012.
283 See U.K. Department for International Development (DFID) Web site, www.dfid.gov.uk.
284 See Global Village Energy Partnership (GVEP) Web site, www.gvepinternational.org, and the Energy Strategy Management Assistance Program Biomass Energy Initiative in Africa, World Bank, Washington, DC.
285 Unless otherwise noted, the statistics and other data in this section are taken from other parts of this report. Please see other sections and associated endnotes for full references.
286 Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety, "Development of Renewable Energy Sources in Germany" (Berlin: 18 March 2010).
287 Shares and Figure 16 based on the following: see Endnote 4 for source of total power capacity; for renewable energy capacity see Table R4 and endnotes for specific renewable energy technologies in Section 1; nuclear capacity from International Atomic Energy Agency (IAEA), *Nuclear Power Reactors in the World* (Vienna: 2009), Table 7; fossil fuel capacity calculated by subtracting renewable and nuclear power capacity from total global power capacity.
288 Figure of 300 MW calculated by subtracting global power capacity in 2007 from estimated total for 2009; see Endnote 4. Renewable capacity additions for 2008 from REN21, *Renewables Global Status Report 2009 Update* (Paris: 2009), and for 2009 from Table R4 and endnotes for specific renewable energy technologies in Section 1. Figure 17 derived from ibid., and from IAEA, op. cit. note 287. Note that nuclear power capacity declined during 2008 and 2009 according to IAEA.
289 Stefan Heck, Director, McKinsey & Company, presentation at Cleantech Forum, Boston, MA, 10 June 2010.
290 China had roughly 134 GWth of solar hot water collectors in 2009, which equals 190 million square meters; see Table R5. If two-thirds of this capacity is for households, and each household has 2–2.5 square meters of collector area, this translates to roughly 50–60 million households. A 2 square meter collector can provide hot water to a 3–4 person family in China, per Ling Li, "China to Push Solar Hot Water," *China Watch* (Worldwatch Institute). See also note 132.
291 See note 132.
292 U.S. Energy Information Administration (EIA), *Monthly Energy Review*, June 2010.
293 World gasoline output of 21.3 million barrels/day in 2006 from U.S. Energy Information Administration, "International Energy Statistics," at http://tonto.eia.doe.gov, adjusted by 3 percent per year growth rate and converted to 1350 billion liters/year using 159 liters/barrel from Oak Ridge National Laboratory, "Bioenergy Conversion Factors," at http://bioenergy.ornl.gov. Figure of 68 billion liters/year gasoline equivalent energy of biofuels (76 billion liters/year ethanol and 17 billion liters/year biodiesel) using LHV conversion factors of 21 MJ/liter ethanol, 35 MJ/liter biodiesel, and 32 MJ/liter gasoline, from Oak Ridge National Laboratory, op. cit. this note.
294 IEA, op. cit. note 1, p. 43.
295 UNEP/Bloomberg New Energy Finance, *Clean Energy Investment Trends 2010.*
296 German data (2005-2009) from Nieder, op. cit. note 16; 2009 also from BMU, op. cit. note 66. Spain 2009 from EPIA, op. cit. note 66; note that preliminary data from IDAE put 2009 additions at 100 MW and existing at 3.5 GW; this is preliminary, to be finalized in July 2010. Japan 2009 data from EPIA. United States 2009 data from SEIA, op. cit. note 66; exdudes 40 MW of off-grid PV. Italy data for 2006-2008 from EPIA, op. cit. this note, and for 2009 from GSE, op. cit. note 66. Note that EPIA puts Italy's 2009 additions at 730 MW and existing at 1.2 GW; other estimates put 2009 additions significantly lower because they take only FIT systems into account, per Guidi, op. cit. note 66. South Korea 2008 existing capacity was 357 MW, per KEMCO, op. cit. note 66, with 73 MW added in 2009, per Ministry of Knowledge and Economy of Korea, op. cit. note 66, putting 2009 existing total at 430 MW. Other EU based on EPIA 2009 additions of 5.6 GW (difference between 2008 and 2009 existing) and existing total of 16 GW. Off-grid solar PV from Paula Mints of Navigant Consulting, who estimates that total off-grid PV capacity at the end of 2009 was 3.2 GW, with 360 MW added in 2009, per Mints, op. cit. note 66.

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**Row 2; from left to right:**
- *"Tidal energy,"* Fotopedia/London looks.
- *"Large parabolic solar dishes for community kitchens, Muni Seva Ashrams, India,"* GTZ/ Michael Netzhammer.
- "*Horse Hollow Wind Farm, USA,"* GWEC.

**Row 3; from left to right:**
- *"PV Cells"*
- *"Marsh Gas Producing through Wastewater Anaerobic Treatment of Luxin Jinhe Biochemical Co. Ltd.,"* Rizhao Municipal Government, China.

**Row 4; from left to right:**
- *"Solar barbershop in Kalabwe, Zambia,"* John Mulrow.
- *"Kutch Wind Farm, Gujarat/India,"* GWEC.
- *"Mini-hydro plant, Indonesia,"* GTZ.

**Row 5:**
- *"Solar Water Heaters Installed in the Roof of the Apartment,"* Rizhao Municipal Government, China.

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