REN21 Renewable Energy Policy Network for the 21st Century

RENEWABLES 2011
GLOBAL STATUS REPORT

2011

REN21 STEERING COMMITTEE

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.

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Report Citation
REN21. 2011. *Renewables 2011 Global Status Report*
(Paris: REN21 Secretariat).

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THE REN21 RENEWABLES GLOBAL STATUS REPORT AND RENEWABLES INTERACTIVE MAP

REN21 was established in 2005 to convene international leadership and a variety of stakeholders to enable a rapid global transition to renewable energy. REN21's **Renewables Global Status Report (GSR)** was first released later that year; it grew out of an effort to comprehensively capture, for the first time, the full status of renewable energy worldwide. The report also aimed to align perceptions with the reality that renewables were playing a growing role in mainstream energy markets and in economic development.

Over the years, the GSR has expanded in scope and depth, in parallel with tremendous advances in renewable energy markets and industries. The report has become a major production that involves the amalgamation of thousands of data points, hundreds of reports and other documents, and personal communications with experts from around the world. Initially researched and written in its entirety by Eric Martinot, with input from many international contributors, the report has become a true collaborative effort among several authors, REN21 Secretariat staff and Steering Committee members, regional research partners, and more than 100 individual contributors and reviewers.

The increasing need to optimize the process of GSR data collection led to the launch in 2010 of REN21's **Renewables Interactive Map**. Today, it is a streamlined tool for gathering and sharing information online about developments related to renewable energy. With interactive features that allow access to regularly updated policy and market overviews by country, region, technology, and sector, the map makes relevant information more accessible and dynamic. It also offers GSR researchers and readers the possibility to contribute on an ongoing basis while connecting with the broader renewable energy community. The Renewables Interactive Map can be found at **www.map.ren21.net**.

FOREWORD

Since the last *Renewables Global Status Report* was released one year ago, the world has seen many significant developments that have had an impact – both direct and indirect – on renewable energy.

The global economic recession entered a new phase in 2010, marked by massive public finance crises – felt most acutely in Europe – that led several governments to announce incentive cuts for solar energy. Natural gas prices remained low due to advances in technology for extracting gas from shale rock, temporarily reducing the competitiveness of renewable energy.

At the same time, worldwide developments have highlighted the security, economic, and human costs of relying so heavily on fossil and nuclear energy. The three-month long BP oil spill in the Gulf of Mexico caused extensive damage and continues to affect the economy and welfare of people in the region. The "Arab Spring" of popular unrest has triggered oil-price volatility and added instability to energy markets, while at the same time the global demand for oil is outpacing the capacity for production. And Japan's Fukushima nuclear catastrophe has led many countries to rethink the role of nuclear energy in providing low-carbon electricity.

Average global surface temperatures in 2010 tied those in 2005 as the warmest on record. Despite the economic recession, greenhouse gas emissions increased more than ever before during 2010, making the international goal to limit the rise in global temperatures to 2° C above preindustrial levels even harder to reach.

A positive constant amid this turbulence has been the global performance of renewable energy. Renewable sources have grown to supply an estimated 20% of global final energy consumption in 2010. By year's end, renewables comprised one-quarter of global power capacity from all sources and delivered close to one-fifth of the world's power supply. Most technologies held their own, despite the challenges faced, while solar PV surged with more than twice the capacity installed as the year before. No technology has benefited more than solar from the dramatic drop in costs.

Despite the recession, total global investment in renewable energy broke a new record in 2010. Investment in renewable power and fuels reached $211 billion, up 32% from $160 billion the previous year. As shown in the recently released UNEP report *Global Trends in Renewable Energy Investment 2011*, the GSR's companion publication, developing country investments in renewable energy companies and utility-scale generation and biofuel projects exceeded those of developed countries, with China attracting more than a third of the global total.

Beyond China and the other big economies of India and Brazil, major developments were seen elsewhere in the developing world in terms of policies, investments, market trends, and manufacturing. Of the 119 countries that now have renewable energy policy targets or support policies, at least half of them are in the developing world.

The increased activity in developing countries is a highlight of this year's report. It is an encouraging trend, since most of the future growth in energy demand is expected to occur in developing countries. Further, the spread of renewables to more regions and countries helps more of the world's people gain access to energy services not only to meet their basic needs, but also to enable them to develop economically.

Today, more people than ever before derive energy from renewables as capacity continues to grow, prices continue to fall, and shares of global energy from renewable energy continue to increase. This year's *Renewables Global Status Report* again has brought all the data together to provide a clear picture of the global momentum.

On behalf of the REN21 Steering Committee, I would like to thank all those who have contributed to the successful production of the *Renewables 2011 Global Status Report*. These include lead author/research director Janet L. Sawin, author and expert advisor Eric Martinot, project manager Rana Adib and the team at the REN21 Secretariat headed by Virginia Sonntag-O'Brien, as well as the growing network of authors, researchers, contributors, and reviewers who participate in the GSR process. Special thanks go to the German and Indian governments for their financial support, and to the Deutsche Gesellschaft für Internationale Zusammenarbeit and the United Nations Environment Programme, hosts of the REN21 Secretariat, for their administrative support.

We hope you will find this year's report more comprehensive and inspiring than ever, and we look forward to receiving your feedback.

Mohamed El-Ashry

Chairman, REN21

ACKNOWLEDGMENTS

This report was commissioned by REN21 and produced in collaboration with a global network of research partners. Financing was provided by the German Federal Ministry for Economic Cooperation and Development (BMZ), the German Federal Ministry for Environment, Nature Protection and Nuclear Safety (BMU), the Indian Ministry of New and Renewable Energy, and the Asian Development Bank. A large share of the research for this report was conducted on a voluntary basis.

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EXECUTIVE SUMMARY

Renewable energy continued to grow strongly in all end-use sectors, and global investment reached new highs. As policies spread, the geography of renewables is also expanding.

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 2011. The report covers both current status and key trends; by design, it does not provide analysis or forecast the future.

Global energy consumption rebounded in 2010 after an overall downturn in 2009. Renewable energy, which experienced no downturn in 2009, continued to grow strongly in all end-use sectors – power, heat and transport – and supplied an estimated 16% of global final energy consumption. Renewable energy accounted for approximately half of the estimated 194 gigawatts (GW) of new electric capacity added globally during the year. Renewables delivered close to 20% of global electricity supply in 2010, and by early 2011 they comprised one-quarter of global power capacity from all sources.

In several countries, renewables represent a rapidly growing share of total energy supply, including heat and transport. For example:

- In the United States, renewable energy accounted for about 10.9% of domestic primary energy production (compared with nuclear's 11.3%), an increase of 5.6% relative to 2009.
- China added an estimated 29 GW of grid-connected renewable capacity, for a total of 263 GW, an increase of 12% compared with 2009. Renewables accounted for about 26% of China's total installed electric capacity, 18% of generation, and more than 9% of final energy consumption in 2010.
- Germany met 11% of its total final energy consumption with renewable sources, which accounted for 16.8% of electricity consumption, 9.8% of heat production (mostly from biomass), and 5.8% of transport fuel consumption. Wind power accounted for nearly 36% of renewable generation, followed by biomass, hydropower, and solar photovoltaics (PV).
- Several countries met higher shares of their electricity demand with wind power in 2010, including Denmark (22%), Portugal (21%), Spain (15.4%), and Ireland (10.1%).

Trends reflect strong growth and investment across all market sectors. During the period from the end of 2005 through 2010, total global capacity of many renewable energy technologies – including solar PV, wind power, concentrating solar thermal power (CSP), solar water heating systems, and biofuels – grew at average rates ranging from around 15% to nearly 50% annually. Biomass and geothermal for power and heat also grew strongly. Wind power added the most new capacity, followed by hydropower and solar PV.

Across most technologies, 2010 saw further growth in equipment manufacturing, sales, and installation. Technology cost reductions in solar PV in particular meant high growth rates in manufacturing. Cost reductions in wind turbines and biofuel processing technologies also contributed to growth. At the same time, there was further industry consolidation, notably in the biomass and biofuels industries, as traditional energy companies moved more strongly into the renewable energy space, and as manufacturing firms continued to move into project development.

By early 2011, at least 119 countries had some type of policy target or renewable support policy at the national level, up from 55 countries in early 2005. There is also a large diversity of policies in place at state/provincial and local levels. Developing countries, which now represent more than half of all countries with policy targets and half of all countries with renewable support policies, are playing an increasingly important role in advancing renewable energy.

As policies spread to more and more countries, the geography of renewable energy use is also changing. For example, commercial wind power existed in just a handful of countries in the 1990s but now exists in at least 83 countries. Solar PV capacity was added in more than 100 countries during 2010. Outside of Europe and the United States, developed countries like Australia, Canada, and Japan are experiencing gains and broader technology diversification, while (collectively) developing countries have more than half of global renewable power capacity.

China now leads in several indicators of market growth: in 2010, it was the top installer of wind turbines and solar thermal systems and was the top hydropower producer. 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 hydropower, biomass, and wind power plants, as well as solar heating systems.

At least 20 countries in the Middle East, North Africa, and sub-Saharan Africa have active renewable energy markets. Manufacturing leadership continues to shift from Europe to Asia as countries like China, India, and South Korea increase their commitments to renewable energy. The increasing geographic diversity in markets and manufacturing is boosting confidence that renewables are less vulnerable to policy or market dislocations in any specific country.

One of the forces propelling renewable energy policies and development is the potential to create new industries and generate new jobs. Jobs from renewables number in the hundreds of thousands in several countries. Globally, there are more than 3.5 million direct jobs in renewable energy industries, about half of them in the biofuels industry, with additional indirect jobs well beyond this figure.

Also driving renewables development are state-owned multilateral and bilateral development banks, which have been pillars of investment in renewable energy during recent, troubled years for the world economy. More public money went to the renewable energy sector through development banks than through government stimulus packages during 2010.

Total investment in renewable energy reached $211 billion in 2010, up from $160 billion in 2009, continuing the steady annual increase seen since tracking first began in 2004. Including the unreported $15 billion (estimated) invested in solar hot water collectors, total investment exceeded $226 billion. An additional $40–45 billion was invested in large hydropower.

Asset finance of new utility-scale projects (wind farms, solar parks, and biofuel and solar thermal plants) accounted for almost 60% of the total and was the largest investment asset class. Investment in small-scale distributed generation projects (mainly solar PV) amounted to $60 billion and accounted for more than 25% of total investment in renewable energy. For the first time, investment in renewable energy companies and utility-scale generation and biofuel projects in developing countries surpassed that in developed economies. China attracted more than a third of global investment during 2010, making it the leader for the second year in a row.

2010 Market and Industry Highlights and Ongoing Trends

WIND POWER. The market maintained its 2009 level, with 38 GW added for a total of about 198 GW. For the first time, the majority of new wind power capacity was added in developing countries and emerging markets, driven primarily by China, which accounted for half the global market. Trends include continued offshore development, the growing popularity of community-based projects and distributed, small-scale grid-connected turbines, and the development of wind projects in a wider variety of geographical locations. Average turbine sizes continued to increase in 2010, with some manufacturers launching 5 MW and larger machines, and direct-drive turbine designs captured 18% of the global market.

SOLAR PHOTOVOLTAICS (PV). The PV industry had an extraordinary year, with global production and markets more than doubling in 2010. An estimated 17 GW of capacity was added worldwide (compared with just under 7.3 GW in 2009), bringing the global total to about 40 GW – more than seven times the capacity in place five years earlier. The EU dominated the global PV market, led by Italy and particularly Germany, which installed more PV in 2010 than the entire world did the previous year. The trend toward utility-scale PV plants continued, with the number of such systems exceeding 5,000 and accounting for almost 25% of total global PV capacity. Cell manufacturing continued its shift to Asia, with 10 of the top 15 manufacturers located in the region. Industry responded to price declines and rapidly changing market conditions by consolidating, scaling up, and moving into project development.

CONCENTRATING SOLAR THERMAL POWER (CSP). After years of inactivity, the CSP market has come back to life with nearly 740 MW added between 2007 and the end of 2010. More than half of this capacity was installed during 2010. Parabolic trough plants continued to dominate the market. Dramatic reductions in PV costs are challenging the growing market for CSP, at least in the United States, where several planned projects were redesigned to use utility-scale PV technologies. At the same time, project development is moving beyond the U.S. southwest and Spain to other regions and countries, particularly the MENA region.

SOLAR HOT WATER/HEATING. Solar heating capacity increased by an estimated 25 GW_{th} in 2010 to reach approximately 185 GW_{th}, excluding unglazed swimming pool heating. China continues to dominate the world market for solar hot water collectors. Europe's market shrank during 2010 due to the economic recession, despite the emergence of some new players, but it continued to rank a distant second. While virtually all installations in China are for hot water only, there is a trend in Europe toward larger combined systems that provide both water and space heating. A number of solar industrial process heat installations came online during 2009 and 2010 in China, Europe, the United States, and elsewhere.

BIOMASS POWER AND HEAT. Biomass supplies an increasing share of electricity and heat and continues to provide the majority of heating produced with renewable sources. An estimated 62 GW of biomass power capacity was in operation by the end of 2010. Biomass heat markets are expanding steadily, particularly in Europe but also in the United States, China, India, and elsewhere. Trends include increasing consumption of solid biomass pellets (for heat and power) and use of biomass in combined heat and power (CHP) plants and in centralized district heating systems. China leads the world in the number of household biogas plants, and gasifiers are used increasingly for heat applications in small and large enterprises in India and elsewhere. Biomethane (purified biogas) is increasingly injected into pipelines (particularly in Europe) to replace natural gas in power and CHP plants.

BIOFUELS. Liquid biofuels provided about 2.7% of global road transport fuels in 2010. The global ethanol industry recovered in response to rising oil prices, with production increasing 17% in 2010, and some previously bankrupt firms returned to the market. The United States and Brazil accounted for 88% of global ethanol production; after several years as a net importer, the United States overtook Brazil to become the world's leading ethanol exporter. The EU remained the center of biodiesel production, but due to increased competition with relatively cheap imports, growth in the region continued to slow. The diversity of players in the advanced biofuels industry continued to increase with the participation of young, rapidly growing firms, major aviation companies, and traditional oil companies.

GEOTHERMAL POWER AND HEAT. Geothermal power plants operated in at least 24 countries in 2010, and geothermal energy was used directly for heat in at least 78 countries. Although power development slowed in 2010, with global capacity reaching just over 11 GW, a significant acceleration in the rate of deployment is expected as advanced technologies allow for development in new countries. Heat output from geothermal sources increased by an average rate of almost 9% annually over the past decade, due mainly to rapid growth in the use of ground-source heat pumps. Use of geothermal energy for combined heat and power is also on the rise.

HYDROPOWER. Global hydropower production represented about 16% of global electricity production in 2010. An estimated 30 GW of capacity was added during the year, with existing global capacity reaching an estimated 1,010 GW. Asia (led by China) and Latin America (led by Brazil) are the most active regions for new hydro development.

OCEAN ENERGY. At least 25 countries are involved in ocean energy development, and wave and tidal technologies saw significant progress toward commercial generation during 2010. At year's end, an estimated total of 6 MW of wave (2 MW) and tidal stream (4 MW) capacity had been installed, with most of this capacity in Europe.

Continued strong growth is expected in all renewable energy sectors in the coming years, with projects at various stages of development around the world. China alone plans to install more than 30 GW of wind power capacity during 2011 and 2012, and significant additional capacity is under construction in India, the United States, nited Kingdom, and other countries. At least 5.4 GW of solar PV capacity was under contract in the United States by the end of 2010. Globally, nearly 2.6 GW of additional CSP capacity was under construction by year's end, with all plants expected to be operational by 2014. Significant geothermal power capacity (and CHP) was in project pipelines around the globe by year-end, with 46 countries forecast to have new geothermal capacity installed within the next five years. Major developments are under way for hydropower, ocean energy, and other renewable technologies as well.

For more 2010 data and country rankings, see the Selected Indicators and Top Five Countries tables on page 15.

A Dynamic Policy Landscape

Renewable energy support policies continued to be a driving force behind the increasing shares of renewable energy, despite some setbacks due to the lack of long-term policy certainty and stability around the world in 2010.

National targets now exist in at least 98 countries. These targets represent commitments to shares of electricity production (typically 10–30%), total primary or final energy, heat supply, installed capacities of specific technologies, and shares of biofuels in road transport fuels. Many targets also exist at the state, provincial, and local levels. Although some targets were not met or were scaled back, many countries achieved or exceeded their targets set for 2010; two countries – Finland and Sweden – passed their targets for 2020. Existing targets were raised in a number of countries including Finland, Germany, Spain, and Taiwan, and entirely new targets were adopted in South Africa, Guatemala, and India, among others.

Renewable power generation policies have been implemented in 95 countries and represent the most common type of renewables support policy. The feed-in tariff (FIT) remains the most widely implemented policy, in place in at least 61 countries and 26 states/provinces worldwide. Most FIT-related activity in 2010 focused on revisions to existing policies in response to strong markets that exceeded expectations, particularly in the case of PV. New FIT policies were implemented in several developing/transition countries in 2010 and early 2011. Renewable portfolio standard (RPS)/quota policies have been enacted at the national level in 10 countries and in at least 50 other jurisdictions, including 30 U.S. states (plus Washington, D.C.) and the Canadian province of British Columbia, which requires that 93% of new power capacity be renewable.

Many additional types of policies are being implemented to support renewable power generation, including direct capital investment subsidies, grants, or rebates; tax incentives; energy production payments or credits; and public financing. Net metering, or "net billing," policies exist in at least 14 countries, including Italy, Japan, Jordan, and Mexico, and in almost all U.S. states. Green energy purchasing and labeling programs are growing with more than 6 million green power consumers in Europe, the United States, Australia, Japan, and Canada.

Although enacted less aggressively than policies to promote renewable electricity or biofuels, many policies to support renewable heating and cooling have emerged in recent years. New policies introduced since the beginning of 2010 include the United Kingdom's innovative Renewable Heat Incentive and a grant program in South Africa. Governments have traditionally relied on direct capital grants and tax credits to spur investment in renewable heating systems, but new policies providing public budget neutrality have been gaining favor. Solar hot water mandates for new construction projects represent a growing trend at both national and local levels.

Mandates for blending biofuels exist in 31 countries at the national level and in 29 states/provinces. Subsidies and tax exemptions are also used to promote biofuels. Finland, Ethiopia, Thailand, and Spain all revised existing biofuels policy legislation in 2010, and South Korea and Jamaica implemented new blending mandates.

City and local governments continue to become increasingly important players in promoting the local generation and use of renewable energy. Local support policies include renewable energy targets; urban planning that incorporates renewable energy; building codes that mandate or promote renewable energy; tax credits and exemptions; investment in renewable energy for municipal buildings and transit; subsidies, grants, or loans; as well as a variety of informal, voluntary actions to promote renewable energy at the community level.

Rural Renewable Energy

In even the most remote areas, renewable energy is increasing access to basic energy services – including lighting and communications, cooking, heating and cooling, and water pumping – and generating economic growth. PV household systems, wind turbines, micro-hydro powered or hybrid mini-grids, biomass-based systems or solar pumps, and other renewable technologies are being employed in homes, schools, hospitals, agriculture, and small industry in rural and off-grid areas of the developing world.

The number of rural households served by renewable energy is difficult to estimate as the sector becomes driven increasingly by individual project promoters or private companies, but it runs into the hundreds of millions. Small solar PV systems provide power to a few million households, and micro-hydro configured into village- or county-scale mini-grids serves many more. Over 44 million households use biogas made in household-scale digesters for lighting and/or cooking, and more than 166 million households now rely on a new generation of more-efficient biomass cookstoves.

Off-grid renewable solutions are increasingly acknowledged to be the cheapest and most sustainable options for rural areas in much of the developing world. This will have an impact on market development in the long term, especially if the barriers to accessing information and financing products are addressed.

SELECTED INDICATORS AND TOP FIVE COUNTRIES

SELECTED INDICATORS

		2008	→	2009	→	2010
Global new investment in renewable energy (annual)	*billion USD*	130	→	160	→	**211**
Renewables power capacity (existing, not including hydro)	*GW*	200	→	250	→	**312**
Renewables power capacity (existing, including hydro)	*GW*	1,150	→	1,230	→	**1,320**
Hydropower capacity (existing)	*GW*	950	→	980	→	**1,010**
Wind power capacity (existing)	*GW*	121	→	159	→	**198**
Solar PV capacity (existing)	*GW*	16	→	23	→	**40**
Solar PV cell production (annual)	*GW*	6.9	→	11	→	**24**
Solar hot water capacity (existing)	GW_{th}	130	→	160	→	**185**
Ethanol production (annual)	*billion liters*	67	→	76	→	**86**
Biodiesel production (annual)	*billion liters*	12	→	17	→	**19**
Countries with policy targets	#	79	→	89	→	**98**
States/provinces/countries with feed-in policies[1]	#	71	→	82	→	**87**
States/provinces/countries with RPS/quota policies	#	60	→	61	→	**63**
States/provinces/countries with biofuels mandates	#	55	→	57	→	**60**

TOP FIVE COUNTRIES – Annual additions in 2010

	New capacity investment	Wind power	Solar PV	Solar hot water/heat[2]	Ethanol production	Biodiesel production
1	China	China	Germany	China	United States	Germany
2	Germany	United States	Italy	Germany	Brazil	Brazil
3	United States	Spain	Czech Republic	Turkey	China	Argentina
4	Italy	Germany	Japan	India	Canada	France
5	Brazil	India	United States	Australia	France	United States

TOP FIVE COUNTRIES – Existing capacity as of end-2010

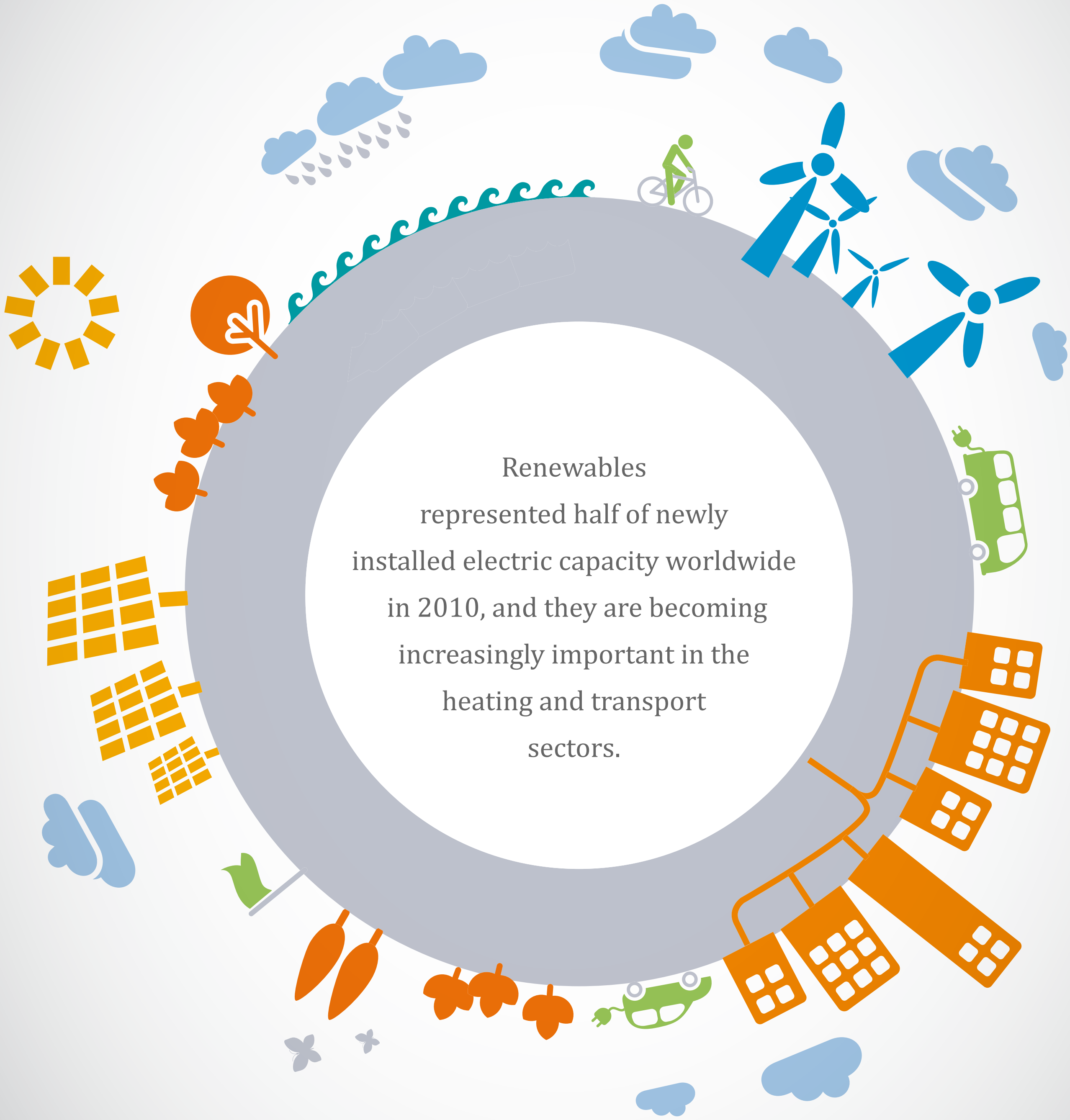
	Renewables power capacity (not including hydro)	Renewables power capacity (including hydro)	Wind power	Biomass power	Geothermal power	Solar PV	Solar hot water/heat[2]
1	United States	China	China	United States	United States	Germany	China
2	China	United States	United States	Brazil	Philippines	Spain	Turkey
3	Germany	Canada	Germany	Germany	Indonesia	Japan	Germany
4	Spain	Brazil	Spain	China	Mexico	Italy	Japan
5	India	Germany/ India	India	Sweden	Italy	United States	Greece

Notes: Rankings are based on absolute amounts of power generation capacity or biofuels production; per capita rankings would be quite different for many categories. Country rankings for hydropower would be different if power generation (TWh) were considered rather than power capacity (GW) because some countries rely on hydropower for baseload supply while others use it more to follow the electric load and match peaks.

1 Feed-in policies total for 2010 also includes early 2011.

2 Solar hot water/heating numbers are for 2009. 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.

01 GLOBAL MARKET OVERVIEW



Renewables represented half of newly installed electric capacity worldwide in 2010, and they are becoming increasingly important in the heating and transport sectors.

01 GLOBAL MARKET OVERVIEW

Global energy consumption rebounded strongly in 2010 after an overall downturn in 2009, with annual growth of 5.4%, well above the historical average.[1]* Renewable energy, which had no downturn in 2009, continued its strong growth in 2010 as well.

In 2009, renewable energy supplied an estimated 16% of global final energy consumption[I] – counting traditional biomass, hydropower, wind, solar, geothermal, modern biomass, and biofuels.[2] (See Figure 1.) Traditional biomass, which is used primarily for cooking and heating in rural areas of developing countries, accounted for approximately 10% of the total renewable energy share. Hydropower represented 3.4% and is growing modestly but from a large base. All other renewables accounted for approximately 2.8% in 2009 and are growing very rapidly in many developed countries as well as in some developing countries.

Renewable energy replaces fossil and nuclear fuels in four distinct markets: power generation, heating and cooling, transport fuels, and rural/off-grid energy services. This section provides an overview of recent developments in the first three markets; rural/off-grid energy in developing countries is covered in the Rural Renewable Energy section.

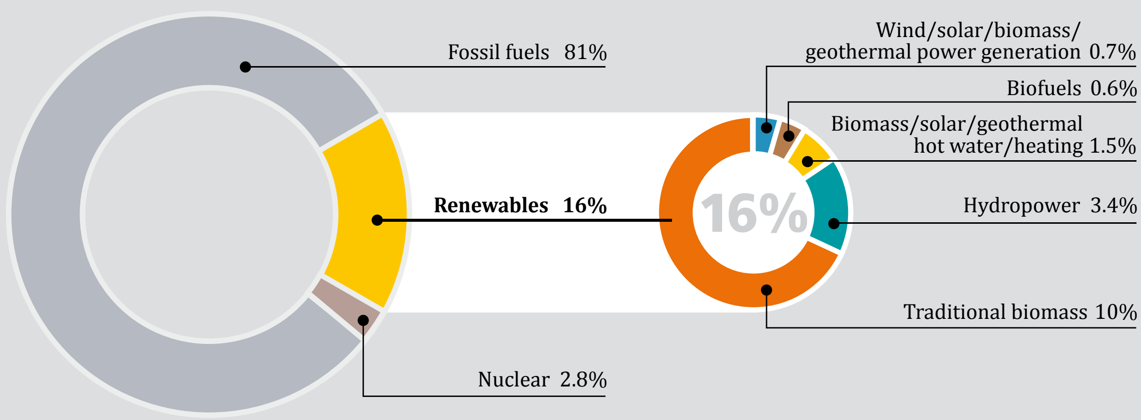
During the period from the end of 2005 through 2010, total global capacity[II] of many renewable energy technologies – including solar photovoltaics (PV), wind, concentrating solar power (CSP), solar water heating systems, and biofuels – grew at average rates ranging from around 15% to nearly 50% annually. Solar PV[III] increased the fastest of all renewables technologies during this period, followed by biodiesel and wind. For solar power technologies, growth accelerated during 2010 relative to the previous four years. At the same time, growth in total capacity of wind power held steady in 2010, and the growth rates of biofuels have declined in recent years, although ethanol was up again in 2010.[3] (See Figure 2, page 18.)

Hydropower, biomass power and heat, and geothermal heat and power are growing at more ordinary rates of 3–9% per year, making them more comparable with global growth rates for fossil fuels (1–4%, although higher in some developing countries).[4] In several countries, however, the growth in these renewable technologies far exceeds the global average. (See Table 1 for a summary of the main renewable energy technologies and their characteristics and costs.)

POWER GENERATION MARKETS

Renewable energy accounted for approximately half of the estimated 194 GW of new electric capacity added globally during 2010. Existing renewable power capacity worldwide reached an estimated 1,320 gigawatts (GW) in 2010, up almost 8% from 2009.[5] Renewable capacity

Figure 1. Renewable Energy Share of Global Final Energy Consumption, 2009



Source: See Endnote 2 for this section

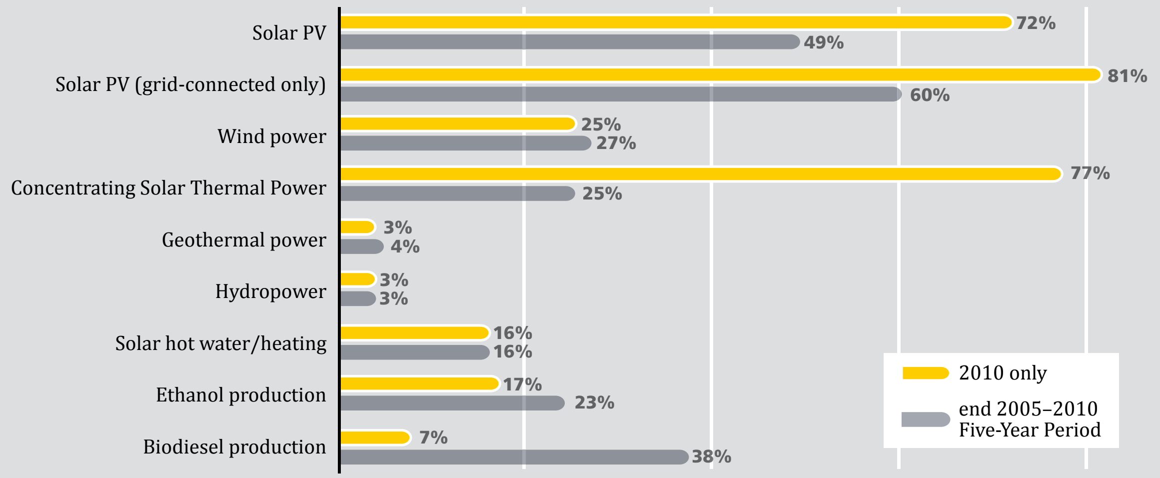
* Endnotes are grouped by section and begin on page 96.

I) Note that the 16% figure is the share of final energy consumption, which is a different but equally valid indicator compared to the more traditional indicator for share of primary energy consumption used in many statistical sources. The European Union uses share of final energy consumption for its 2020 targets. The *Renewables Global Status Report (GSR)* has used share of final energy consumption consistently since 2007; see Sidebar 1 of the 2007 edition for further explanation. Note also that the 2011 IPCC *Special Report on Renewable Energy Sources and Climate Change Mitigation* provides a figure of 13% global share from renewables, but that is for share of primary energy. Further, the IPCC figure of 13% is based on the "direct equivalent" method for calculating share of primary energy; if the "substitution" method were used, the IPCC figure also would be 16% (as given in Table A.II.1 in Annex II of the IPCC report).

II) This section includes energy data where possible but focuses mainly on installed capacity data. See Note on Accounting and Reporting of Installed Capacities on page 94.

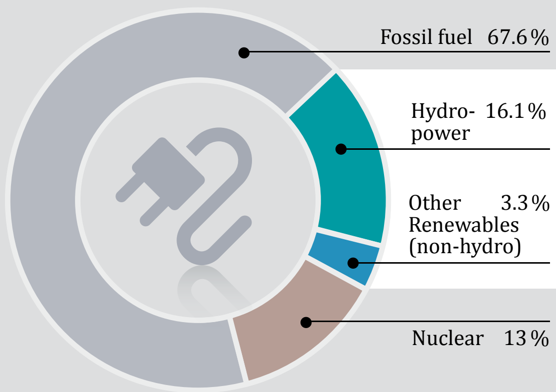
III) Starting with this edition, the *Renewables Global Status Report* covers all PV (on- and off-grid) together rather than focusing primarily on grid-connected PV. Figure 2 includes both all PV and grid-connected-only PV to demonstrate the impact of this change on average annual growth rates. See Note on Accounting and Reporting of Installed Capacities for more on PV coverage.

Figure 2. Average Annual Growth Rates of Renewable Energy Capacity and Biofuels Production, 2005–2010



Source: See Endnote 3 for this section

Figure 3. Renewable Energy Share of Global Electricity Production, 2010



Source: See Endnote 6 for this section

now comprises about a quarter of total global power-generating capacity (estimated at 4,950 GW in 2010) and supplies close to 20% of global electricity, with most of this provided by hydropower.[6/I] (See Figure 3.) When hydropower is not included, renewables reached a total of 312 GW, a 25% increase over 2009 (250 GW).[7] (See Table R4.) Among all renewables, global wind power capacity increased the most in 2010, by 39 GW. Hydropower capacity increased by about 30 GW during 2010, and solar PV capacity increased by almost 17 GW.

The top five countries for non-hydro renewable power capacity were the United States, China, Germany, Spain, and India. Including hydropower, China, the United States, Canada, Brazil, and India tied with Germany, were the top countries for total installed renewable energy capacity by the end of 2010.[8] (See Top Five Table on page 15 for other rankings; see also Figure 4.) Data are not readily available to provide a global ranking for categories such as increased share of electricity from renewables or per capita consumption, although these would be valuable measurements of progress.

In the United States, renewable energy accounted for an estimated 25% of electric capacity additions in 2010 and 11.6% of existing electric capacity at year's end; during the year, renewables provided just over 10.3% of total domestic electricity.[9] Further, renewables accounted for about 10.9% of U.S. domestic primary energy production (compared with nuclear's 11.3% share), an increase of 5.6% relative to 2009.[10]

China led the world in the installation of wind turbines and solar thermal systems and was the top hydropower producer in 2010. The country added an estimated 29 GW of grid-connected renewable capacity, for a total of 263 GW, an increase of 12% compared with 2009.[11] Renewables accounted for about 26% of China's total installed electric capacity in 2010, 18% of generation, and more than 9% of final energy consumption.[12]

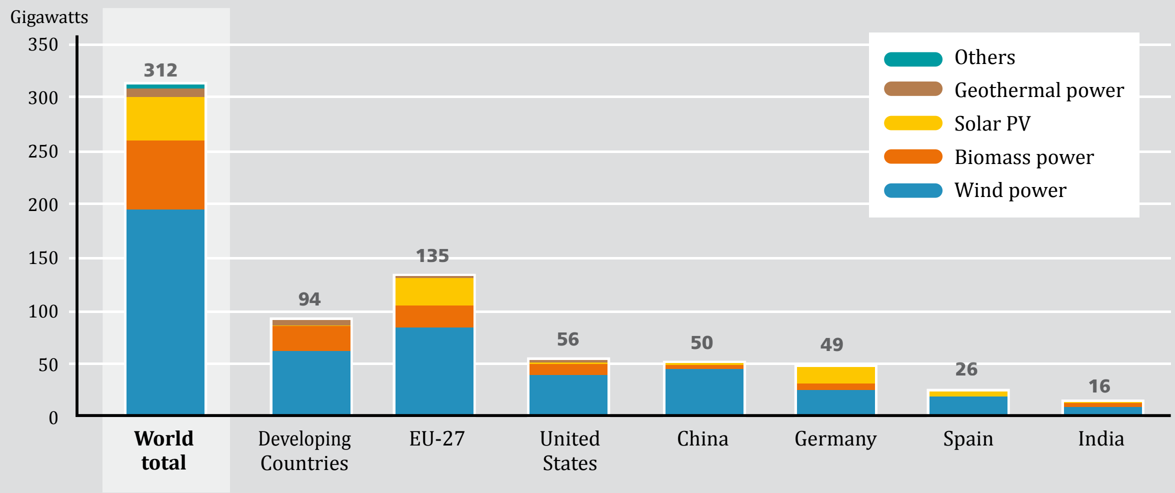
In the European Union[II], renewables accounted for an estimated 41% of newly installed electric capacity in 2010, with PV accounting for more than half of the total.[13] Although the share was significantly lower than the more than 60% of total capacity added in 2009, more renewable power capacity was added in Europe than ever before (22.6 GW), with total installations up 31% over the previous year (17.5 GW).[14] Renewable energy's share of total electricity generation in the EU was nearly 20% in 2009 (42% of which was non-hydropower); the share of total gross inland energy consumption increased from 5.4% in 1999 to 9% in 2009.[15]

In 2010, Germany met 11% of its total final energy consumption with renewable sources, which accounted for

I) These data include pumped storage, currently at about 136 GW globally, as part of hydropower capacity. This practice will be revisited with the *Renewables 2012 Global Status Report*. Although pumped storage is not an energy source and is often used to store fossil or nuclear energy, it can play an important role in enabling the increased penetration of variable renewable sources for electricity generation.

II) The use of "European Union," or "EU" throughout refers specifically to the EU-27.

Figure 4. Renewable Power Capacities*, Developing World, EU, and Top Five Countries, 2010



*excluding hydropower

Source: See Endnote 8 for this section

16.8% of electricity consumption, 9.8% of heat production (mostly from biomass), and 5.8% of transport fuel consumption.[16] The share of electricity generation from renewables was up from 16.3% in 2009, despite a 4.3% increase in Germany's total electricity consumption in 2010. Wind power (102 terawatt-hours, TWh) accounted for nearly 36% of renewable generation, followed by biomass, hydropower, and PV.[17] In Spain, renewables accounted for 13.2% of final energy production and generated 32.3% of electricity, up from 9.3% and 26%, respectively, in 2009.[18]

India added an estimated 2.7 GW of grid-connected renewable power capacity during 2010 – mainly from wind but also from biomass, small hydropower, and solar capacity – for a total of nearly 19 GW by January 2011.[19] Significant off-grid renewable capacity was added as well.[20] Large hydropower generated about one-quarter of India's electricity in 2010, with other renewables accounting for just over 4% of generation.[21] (See Tables R7 and R8 for national shares of renewable energy.)

Wind Power

New wind power capacity added during 2010 reached 39 GW, more than any other renewable technology and over three times the 11.5 GW of wind added worldwide just five years earlier.[22] (See Figure 5.) As a result, existing capacity increased more than 24% relative to 2009, with total global capacity nearing 198 GW by year's end.[23] At least 52 countries increased their total existing capacity during 2010, and 83 countries now use wind power on a commercial basis.[24] Over the period from end-2005 to end-2010, annual growth rates of cumulative wind power capacity averaged 27%.[25]

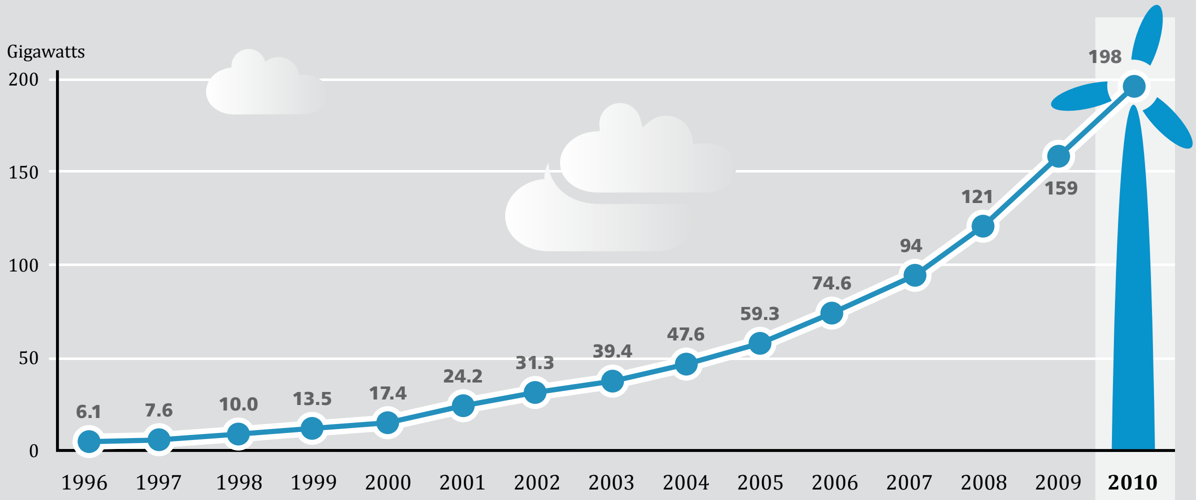
Nevertheless, the annual global wind power market held steady in 2010, just slightly above 2009 capacity additions, due to slower growth in the United States and Europe brought on by policy uncertainty in key countries (e.g., the U.S. and Spain), by the continuing economic crisis that reduced access to financing, and by depressed electricity demand in many developed countries.[26] As a result, for the first time, the majority of new turbine capacity was added in developing countries and emerging markets rather than in wind's traditional markets.[27]

This growth was driven primarily by China, which accounted for 50% of global capacity additions in 2010, up from 4.4% in 2005.[28] (See Figure 6.) China added 18.9 GW of new wind capacity, a 37% increase over the 2009 market, bringing the country into the global lead with a total of 44.7 GW.[29] However, about 13 GW of this total capacity had not yet been commercially certified by year-end, although all but 2 GW was in fact already feeding electricity into the grid. The process of finalizing the test phase and getting a commercial contract with the system operator takes somewhat longer, accounting for the delays in reporting.[30] More than 30% of China's installed capacity was in the Inner Mongolia Autonomous Region, followed by Gansu (10%), Hebei (10%) and Liaoning (9%) provinces.[31]

The United States added just over 5 GW in 2010, compared with more than 10 GW the previous year, bringing total wind power capacity to 40.2 GW, a 15% increase over 2009.[32] By year-end, wind accounted for 2.3% of electricity generation (up from 1.8% in 2009), enough to supply electricity for more than 10 million U.S. homes.[33] The state of Texas, with 10.1 GW, had more than one-quarter of existing U.S. capacity at the end of 2010, but 14 of the 38 states with utility-scale wind projects had more than 1 GW each installed.[34] The United States and Canada together accounted for about 15% of the global market.[35]

The European Union installed nearly 9.5 GW in 2010, down slightly compared with the 2009 market but bringing the total to about 84 GW.[36] For the first year since 2007, wind power did not account for the largest share of new electric capacity additions and came in third behind natural gas and solar PV.[37]

Figure 5. Wind Power, Existing World Capacity, 1996–2010



Source: GWEC, WWEA, EWEA, AWEA, MNRE, BMU, BTM Consult, IDAE, CREIA, CWEA

Germany maintained the lead in Europe with a total of 27.2 GW operating at the end of 2010, generating 36.5 TWh of electricity during the year.[38] Nevertheless, the annual addition of 1.6 GW represented a 19% reduction in new capacity relative to 2009 and the smallest annual German wind market since 1999; if dismantled systems are accounted for, net capacity additions totaled 1.5 GW.[39]

Spain again led Europe in new installations, adding nearly 1.8 GW for a total of more than 20.7 GW, making it the world's third largest market for new wind.[40] Although above the government target for the 2005–10 period, Spain saw its slowest growth since 2003 in absolute terms.[41] Despite having less capacity in operation than Germany did, Spain produced more electricity with wind (43 TWh) in 2010, due largely to high winds in Spain and to more-advanced turbines.[42] France (1.1 GW), Italy (0.9 GW), and the United Kingdom (adding just under 0.9 GW) were the other top markets in Europe.[43] Emerging-market EU countries helped to offset the decline in mature EU markets, with significant growth in Bulgaria, Lithuania, Poland, and Romania; in addition, Cyprus installed its first wind turbines (0.08 GW).[44]

India was also one of the top markets in 2010, adding 1.4 GW to reach nearly 13.2 GW of capacity and maintaining its fifth-place ranking for total capacity.[45]

Other markets around the world are starting to take off. In Latin America and the Caribbean, total installed capacity rose 54% during 2010, with Brazil and Mexico each adding about 0.3 GW.[46] However, Latin America still accounts for a very small share of global wind power capacity. The same is true in Africa and the Middle East, although at least 11 countries in the region had commercial wind installations by the end of 2010.[47] Egypt added 0.1 GW for a total of 550 megawatts (MW), the most of any African country, and Morocco inaugurated the Dahr Saadane wind project (140 MW).[48] Iran did not add capacity during 2010, but it remains the only country in the Middle East with large-scale wind projects (0.9 GW total).[49]

Figure 6. Wind Power Capacity, Top 10 Countries, 2010

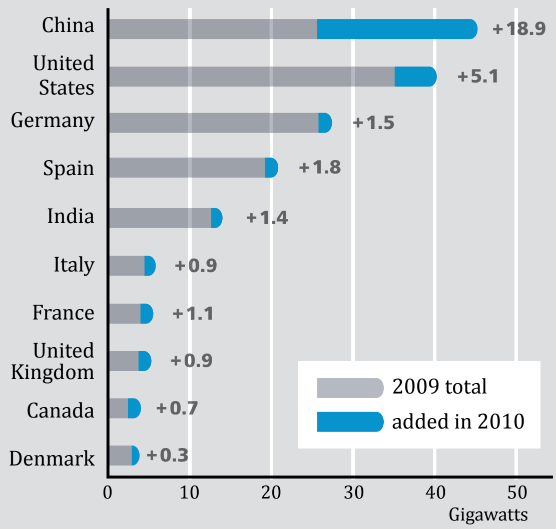


Figure 6. Source: GWEC, WWEA, EWEA, AWEA, MNRE, BMU, BTM Consult, IDAE, CREIA, CWEA

Although its share of total wind capacity remains small, the offshore wind industry continued to pick up speed, increasing by 1.2 GW to 3.1 GW at the end of 2010, with most of this capacity in Europe and the rest in China (0.1 GW) and Japan (0.02 GW).[50] The European offshore market grew more than 50% during 2010, bringing total capacity to 3 GW.[51] The U.K. led the world by adding almost 0.7 GW, ending the year with more than 1.2 GW; it was followed by Denmark, with nearly 0.9 GW of total offshore capacity, and the Netherlands, with 0.2 GW.[52]

I) The Global Wind Energy Council (GWEC) reported that India added 2.1 GW in 2010, for a total of 13.1 GW. If this (higher) GWEC number is used, India's ranking changes to third for capacity added in 2010.

The first major offshore wind farm outside of Europe, China's 0.1 GW Donghai Bridge near Shanghai, officially began operation in July 2010; three months later, China began construction of four projects off the coast of Jiangsu, totaling 1 GW and due to be completed by 2014.[53] Elsewhere, the Cape Wind project (nearly 0.5 GW) off the U.S. east coast, first proposed in 2001, completed its federal permitting process.[54]

There is a trend toward increasing the size of individual wind projects, both offshore and onshore, driven mainly by cost considerations (including infrastructure such as substations or grid connection points as well as licensing and permitting costs). By the end of 2010, the world's largest operating onshore wind farm (almost 0.8 GW) was located in the United States, as was the biggest then under construction.[55]

At the same time, interest in community wind power projects is on the rise in countries such as Canada. The use of small-scale[I] turbines is also increasing, driven by the need for electricity in rural areas, the development of lower-cost grid-connected inverters, and government incentives.[56] The United States added an estimated 0.02 GW of small-scale wind turbine capacity during 2010, while the U.K. small-scale turbine market increased 65% compared with 2009, for a total of almost 0.04 GW.[57] As of 2009, China's small-scale turbines were providing electricity to an estimated 1.5 million people.[58]

Total existing wind power capacity by the end of 2010 was enough to meet an estimated 2.0–2.5% of global electricity consumption.[59] Existing wind capacity installed in the EU by year-end could meet 5.3% of the region's electricity consumption in a normal wind year (up from 4.8% in 2009).[60] Several countries met higher shares of their electricity demand with wind power in 2010, including Denmark (22%), Portugal (21%), Spain (15.4%), Ireland (10.1 %), and Germany (6%).[61] In addition, four German states met well over 40% of their electricity needs with wind in 2010.[62]

The state of Iowa led in the United States, meeting more than 15% of electricity needs with wind power during 2010; in the territory of the Electric Reliability Council of Texas, which covers 85% of the state's electric load, wind generated 7.8% of electricity in 2010.[63] China generated 1% of its electricity with wind (nearly twice the production of the previous year), although wind's share was far higher in several provinces including Inner Mongolia Autonomous Region (12%) as well as Jilin and Heilongjiang provinces and Xinjiang Autonomous Region (4% each).[64]

A significant number of projects were at various stages of development by year's end. China alone planned to install more than 30 GW during 2011 and 2012; by early 2011, significant additional capacity was also under construction in the United States (5.6 GW) and U.K. (1.9 GW).[65] New European players include Bosnia (planning its first wind farm) and Romania, which in 2010 began constructing what will be Europe's largest onshore wind farm.[66] There are also encouraging signs from Latin America (particularly in Argentina, Brazil, Chile, Costa Rica, Mexico, Nicaragua, and Uruguay) and Africa, where projects are planned or under way in Egypt, Ethiopia, Kenya, Morocco, Nigeria, Tunisia, and Tanzania – including Kenya's 0.3 GW Lake Turkana project and 0.7 GW of capacity under construction in Morocco.[67]

Biomass Power

Biomass is commonly used to produce power and/or heat, and some is transformed into liquid biofuel for transportation. (See later sections on Heating and Cooling Markets, including heat from combined heat and power plants, and on Transport Fuel Markets.) Technologies for generating electricity from biomass include direct firing or co-firing (with coal or natural gas) of solid biomass, municipal organic waste[II], biogas[III], and liquid biofuels. Significant increases in biomass use for power production were seen during 2010 in a number of European countries, the United States, and in China, India, and several other developing countries. Globally, an estimated 62 GW of biomass power capacity was in place by the end of 2010.[68]

The United States continued to lead the world for total biomass power generation in 2010. Other significant producers included the EU, led by Germany, Sweden, and the United Kingdom, and Brazil, China, and Japan.[69] Less than 0.3 GW of biomass power capacity was added in the United States during 2010, bringing the total to 10.4 GW (excluding municipal organic waste), and it generated about 48 TWh during 2010.[70] Most U.S. biomass electricity is derived from wood and agricultural residues and black liquor burned as fuel for cogeneration in the industrial sector.[71] An increasing amount is derived from landfill gas, which accounted for 8 TWh in 2010; as of mid-April 2011, more than 550 plants were fueled with landfill gas, totaling 1.7 GW capacity (up from 1.4 GW in 2008).[72]

The European Union's gross electricity production from biomass increased nearly 10.2% between 2008 and 2009, from 79.3 TWh to 87.4 TWh.[73] Solid biomass accounted for 62.2 TWh – about 71% – and biogas

I) 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 (AWEA), 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.

II) Note that municipal organic waste (the organic/biogenic share of municipal solid waste) that is incinerated is not including in GSR data or in Tables R1 and R4. See Note on Accounting and Reporting of Installed Capacities for more on this topic and the challenges of reporting on global biomass energy developments.

III) Biogas can be produced from methane capture at landfills (landfill gas) or by anaerobic digestion of urban wastewater and effluent treatment plants (sewage gas) and of slurry, crop residues, food processing waste, household, and/or green waste.

accounted for the remainder. About half of Europe's biomass power production came from electric-only facilities and half came from combined heat and power (CHP) plants, but the breakdown varies by country.[74]

Although biogas experienced the most significant increase in the EU (up almost 18%), generation from all biomass sources has increased rapidly in the region.[75] For example, EU electricity production from solid biomass tripled between 2001 and 2009, and by early 2010 some 800 solid biomass power plants (an estimated 7.1 GW) were operating in Europe.[76] Growth of biomass for power and heat in the EU has been driven greatly by supportive policies, which in many countries are coupled with taxes on fossil fuels or carbon dioxide emissions, as well as EU regulations that require reductions in landfilling of organic waste.[77]

The top three countries in Europe – Germany, Sweden, and the United Kingdom – accounted for nearly 50% of the region's electricity production from biomass in 2009; Germany alone accounted for about 50% of the EU's biogas generation and almost 30% of total EU electricity generation from biomass.[78] Other significant biomass power producers included Finland, Poland, Italy, and the Netherlands; future high growth, particularly in biogas use, is expected in Italy, France, Spain, and the U.K., and new markets are emerging in the Czech Republic, Hungary, and Slovakia.[79] Although Denmark is not one of the top producers, its share of generation from biomass has increased rapidly, from 3.1% of total electricity generation in 2000 to 8.1% in 2009.[80]

Germany's total power output from biomass increased by an annual average of more than 22% during the past decade, to an estimated 28.7 TWh with a total of 4.9 GW capacity in 2010.[81] By the end of 2010, bioenergy accounted for 5.5% of Germany's total electricity consumption, making it the country's second largest renewable generating source after wind power.[82] Most biomass power in Germany comes from biogas, with capacity increasing more than 20% during 2010, and generating enough electricity for 4.3 million households.[83] Germany generated about 13.8 TWh with biogas in 2010, followed by the U.K. (6.8 TWh) and Italy (2.1 TWh).[84]

Brazil's biomass power capacity, nearly all cogeneration, has also been increasing steadily. Capacity reached 7.8 GW by the end of 2010, generating a total 28 TWh of electricity.[85] Most generation is from CHP plants at sugar mills using sugarcane bagasse as feedstock. During the 2010 sugar harvesting season, sugarcane bagasse generated 18.5 TWh of electricity, including 8.8 TWh of excess electricity that was exported into the grid.[86] Biomass power has also grown significantly in several other Latin American countries, including Costa Rica, Mexico, and Uruguay.[87]

Japan generated an estimated 10 TWh with biomass in 2010, excluding co-firing with coal.[88] Elsewhere in Asia, China's capacity rose about 25% in 2010 to 4 GW of capacity using a combination of sugarcane bagasse, solid biomass, organic waste, and biogas (including from livestock wastes).[89] In India, biomass resources are used for power generation through three general applications, including grid-connected biomass power plants, off-grid distributed biomass power applications, and cogeneration via sugar mills and other industries.[90] India added about 0.3 GW of biomass power capacity in 2010 for a total of 3 GW at year-end.[91] Thailand added only 0.003 GW of solid biomass capacity in 2010, ending the year with a total of 1.3 GW, but it nearly doubled its biogas capacity in 2009 to 0.05 GW and increased it a further 37% in 2010 to 0.07 GW.[92] Malaysia also is seeing significant biogas power expansion.[93]

There is increasing interest in Africa and the Middle East as well, where several countries – including Cameroon, Kenya, Tanzania, and Uganda – have existing biomass power capacity or plans for future development.[94] Construction of biogas projects (particularly landfill gas) in South Africa, Egypt, Tunisia, and Jordan, among others, has been driven in part by the Kyoto Protocol's Clean Development Mechanism.[95]

In addition to facilities that operate on 100% biomass, many existing coal- and gas-fired power plants are undergoing conversion to "co-firing" biomass with fossil fuels.[96] In 2010, the United States had about 40 such plants and Australia had around 10.[97] Japan had several coal plants that were demonstrating co-firing with biomass.[98] Germany and the United Kingdom also generate increasing amounts of electricity with solid biomass through co-firing, and an estimated 100 co-firing plants operated throughout Europe in 2010.[99]

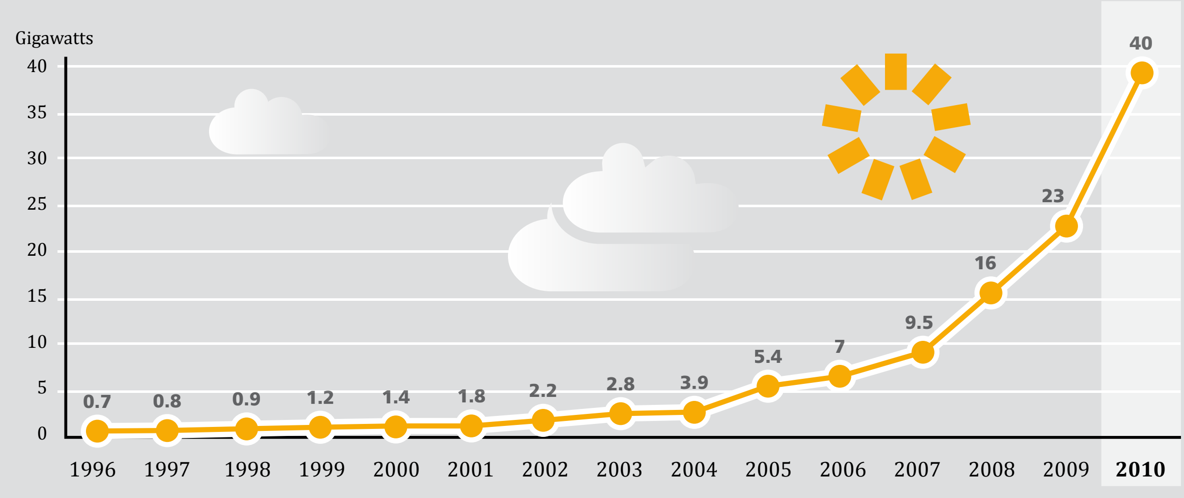
Solar Photovoltaic Power

Solar photovoltaic (PV) capacity was added in more than 100 countries during 2010, ensuring that PV remained the world's fastest growing power-generation technology.[100] An estimated 17 GW of PV capacity was added worldwide in 2010 (compared with just under 7.3 GW in 2009), bringing the global total to about 40 GW – more than seven times the capacity in operation five years earlier.[101/I] (See Figure 7.)

Total existing capacity of all PV grew 72% relative to 2009, with the average annual growth rate over the 2005 to 2010 period exceeding 49% (for grid-connected only, corresponding growth rates were 81% and 60%). For the first time since 2005, thin film's share of the market declined, from 17% in 2009 to 13% in 2010, although sales continued to increase.[102] The PV market was driven by falling costs (see Industry section), new applications, strong investor interest, and continued strong policy

I) Starting with this edition of the GSR, PV data include both on- and off-grid statistics unless otherwise noted.

Figure 7. Solar PV, Existing World Capacity, 1995–2010



Source: PV News, EPIA

support, but also by accelerated tariff digressions in some countries.[103]

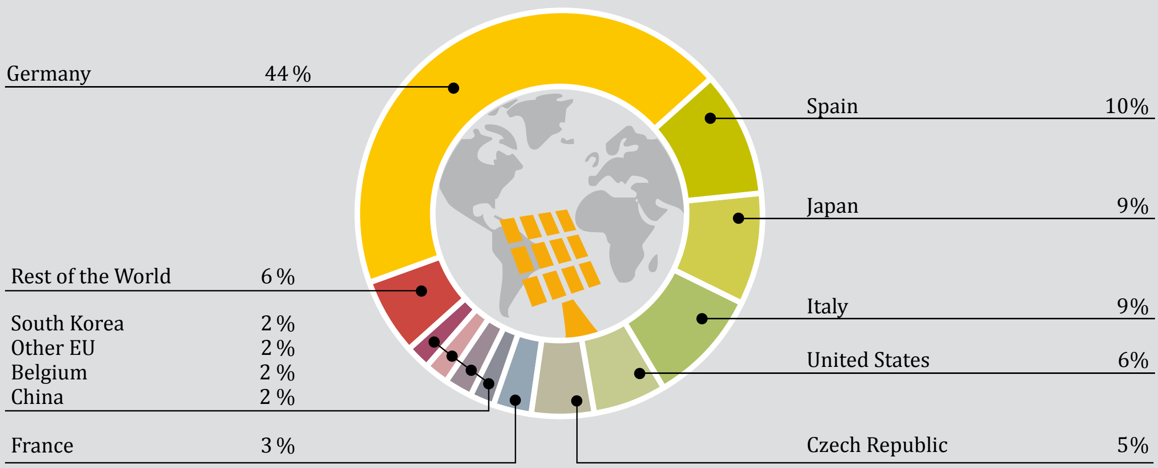
The EU dominated the global PV market, accounting for 80% of the world total with about 13.2 GW newly installed – enough to meet the electricity consumption of some 10 million European households.[104] (See Figure 8.) For the first time ever, Europe added more PV than wind capacity during 2010, led by Germany and Italy.[105] Germany added more PV (7.4 GW) in 2010 than the entire world did the previous year, ending 2010 with 17.3 GW of existing capacity.[106] During the first quarter of 2011, Germany generated 2.75 TWh of electricity with PV, an increase of 87% over the same period in 2010.[107]

Italy added an estimated 2.3 GW of new PV capacity to the grid by the end of the year, bringing the official total to nearly 3.5 GW.[108] Actual installations may have been higher, however; by the beginning of June 2011, total capacity officially connected under the nation's feed-in tariff (FIT) totaled 5.8 GW, some of which may have been installed in 2010.[109] In the Czech Republic, the combination of high FIT rates and the reduction in PV equipment costs led to a second strong year (1.5 GW), lifting the country from virtually zero capacity in 2008 to nearly 2 GW of existing capacity by the end of 2010.[110]

Other major European installers in 2010 included France (adding 0.7 GW), which more than tripled its additions relative to 2009, followed by Belgium (0.4 GW) and Greece (almost 0.2 GW), which more than quadrupled its 2009 additions.[111] Spain saw a second consecutive year with installations well below the 2008 peak as a result of a cap on ground-mounted systems and uncertainties associated with the new regulatory framework; less than 0.4 GW were added in 2010, bringing total PV capacity to 3.8 GW.[112]

Beyond Europe, the largest PV markets were Japan (nearly 1 GW), the United States (0.9 GW), and China (0.6 GW).[113] The Japanese and U.S. PV markets almost doubled relative to 2009, with Japan's total existing

Figure 8. Solar PV Capacity, Top 10 Countries, 2010



Source: EPIA, BMU, IDAE, GSE, KOPIA, CREIA capacity reaching 3.6 GW and the United States passing the 2.5 GW mark.[114] More than one-fourth of capacity added in the United States was in utility-scale projects, and electric utilities are becoming a key driver of future growth in the country.[115] At least 5.4 GW of additional U.S. capacity was under contract by year-end.[116] California still leads the nation with 30% of the market (down from 80% in 2004/05).[117] South Korea's market (0.1 GW) declined for the second year in a row, but Australia's market (0.3 GW) grew fourfold relative to 2009.[118]

The trend toward utility-scale[I] PV plants continued, with the number of such systems exceeding 5,000 in 2010, up from just over 3,200 in 2009.[119] These facilities totaled some 9.7 GW of capacity by the end of 2010, an increase of more than 3 GW during the year, and accounted for almost 25% of total global PV capacity.[120] The EU continued to lead with 84% of the global total by year's end, with Germany alone accounting for about one-third of global additions.[121] By year-end, Spain had 32% of total installed utility-scale capacity, followed by Germany (26%), Italy (16%), the United States (7%), and the Czech Republic (6%).[122]

Other countries with utility-scale facilities by early 2011 included Bulgaria, China, Egypt, India, Israel, Mali, Thailand, and the United Arab Emirates (Abu Dhabi) – or a total of at least 30 countries.[123] As with wind power, the trend is toward increasing project size, with nine of the world's 15 largest PV plants completed in 2010.[124] At the end of 2010, the world's largest PV plant in operation was the 0.08 GW Sarnia facility in Ontario, Canada, which is expected to power 12,800 homes.[125]

Interest in concentrating PV (CPV) is also on the rise, with as much as 0.02 GW connected to the grid worldwide during 2010 and early 2011, including projects or demonstrations in the U.S. state of California and in several countries, including Australia, Egypt, France, Italy, Jordan, Mexico, Spain, and South Africa.[126] A number of large U.S. projects were announced in 2010, and power purchase agreements were signed for 0.3 GW with the utility Southern California Electric.[127] Interest in building-integrated PV (BIPV) also increased in 2010 and extended beyond the traditional markets of France and Germany, with the largest BIPV project to-date commissioned in China.[128]

The vast majority of installed PV capacity today is grid-connected, with the off-grid sector accounting for a declining share with each passing year.[129] Yet there is growing interest in off-grid and mostly small-scale systems, particularly in developing countries but also in developed countries. In Australia, an estimated 70% of solar PV is off-grid at remote homes, farms, and other locations, including the country's largest PV tracker system, installed in 2010 as part of a hybrid solar/diesel power station in Western Australia.[130]

Geothermal Power

Geothermal resources provide energy in the form of direct heat (see section on Heating and Cooling Markets) and electricity. Since 2005, significant additions of electric capacity have occurred in Iceland, Indonesia, New Zealand, the United States, and Turkey, and global electricity production from geothermal has increased more than 20%.[131] Countries with lower capacity levels but high growth rates during this period include El Salvador (35%), Guatemala (58%), Papua New Guinea (more than 800%), and Portugal (81%).[132]

By the end of 2010, total global installations came to just over 11 GW, up an estimated 240 MW from 2009, and geothermal plants generated about 67.2 TWh of electricity during the year.[133] Although geothermal developments slowed in 2010 relative to 2009, the lull was expected to be temporary.[134] The lack of available drilling rigs (due to competition with the oil and gas industry) has hindered geothermal developers worldwide, while the lack of a qualified workforce has presented challenges in Kenya and elsewhere; it has been projected that by 2013, the need for drilling rigs in the United States alone will rise almost 150%.[135]

The three largest plants commissioned in 2010 were in New Zealand (the largest single-shaft turbine project ever developed, at 0.1 GW), Italy (0.04 GW), and Kenya (just under 0.04 GW).[136] The addition in Kenya increased the plant's capacity to 0.1 GW, making it the largest in Africa, and brought the country's total installations above 0.2 GW.[137] The United States added less than 0.2 GW of utility-scale geothermal power in 2010, down slightly compared with 2009.[138] Turkey and Mexico also added capacity during the year.[139]

By the beginning of 2011, geothermal power plants were operating in at least 24 countries, but the vast majority of global capacity was located in eight countries: the United States (3.1 GW), the Philippines (1.9 GW), Indonesia (1.2 GW), Mexico (just under 1 GW), Italy (0.9 GW), New Zealand (nearly 0.8 GW), Iceland (0.6 GW), and Japan (0.5 GW).[140] Iceland, the leader on a per capita basis, generated about 26% of its electricity with geothermal

I) Utility-scale PV plants are defined as larger than 200 kilowatts (kW).

power in 2010, and the Philippines generated approximately 18%.[141]

As the geothermal power market continues to broaden, a significant acceleration in the rate of deployment is expected, with advanced technologies allowing for development of geothermal power projects in new countries.[142] As of early 2011, nearly 0.8 GW of new capacity was in the drilling or construction phase in the United States and was expected to be generating by 2015; a total of 123 confirmed projects (accounting for up to 1.4 GW of resources) in 15 U.S. states were at some stage of development.[143]

Iceland expects to add nearly 0.1 GW to an existing plant in 2011, and much more capacity is in project pipelines around the globe, with 46 countries forecast to have new geothermal capacity installed within the next five years.[144] By late 2010, Germany had an estimated 150 projects in the pipeline, and projects were under development in Chile (0.2 GW), Costa Rica (0.4 GW), India (nearly 0.3 GW), and the U.K. (0.01 GW), among others.[145]

Concentrating Solar Thermal Power

After years of inactivity, the concentrating solar thermal power (CSP) market has come back to life with about 740 MW added between 2007 and end-2010.[146] More than half of this capacity (approximately 478 MW) was installed during 2010, bringing the global total to 1,095 MW.[147] The global market was dominated by parabolic trough plants, which account for 90% of CSP plants and for nearly all of the existing capacity in operation.[148]

In response to a Royal Decree that provided an attractive price premium for solar energy, Spanish firms focused on CSP development, and significant capacity began to come on line in 2009. Spain added another 400 MW in 2010, taking the global lead with a total of 632 MW in operation.[149]

The United States ended the year with 509 MW of total capacity after adding 78 MW, including two hybrid plants – a 2 MW add-on to a coal plant and a 75 MW add-on to an integrated-gas combined cycle power plant (the first in the state of Florida).[150]

In early 2011, an additional 50 MW plant (Extresol-2) was officially inaugurated in Spain, a 20 MW CSP/natural gas hybrid plant began operating in Morocco, and the 20 MW CSP El Kuraymat hybrid plant in Egypt began partial operation.[151]

CSP growth is expected to continue at a rapid pace. As of April 2011, another 946 MW were under construction in Spain with total new capacity of 1,789 MW expected to be in operation by the end of 2013.[152] In the United States, a further 1.5 GW of parabolic trough and power-tower plants were under construction as of early 2011, and contracts had been signed for at least another 6.2 GW of capacity, stimulated in great part by federal loan guarantees, permits for use of federal lands, and state renewable energy mandates (see Policy Landscape section).[153]

Interest is also notable in North Africa and the Middle East, where at least 1.2 GW capacity is in the pipeline, including plants under construction in the United Arab Emirates and planned in Algeria, Egypt, Jordan, Tunisia, and Morocco, which aims to have 2 GW of solar power by 2010.[154] Several CSP projects are under construction in India, and China has indicated intentions to install CSP plants – including cogeneration designs to provide electricity and space heat and/or process heat.[155] Australia, South Africa, Mexico, and Italy also have initiated new projects or MW-sized pilot plants with announced intentions to proceed further.[156] Globally, nearly 2.6 GW of additional CSP capacity (most of this in the United States and Spain) was under construction by late 2010, with all plants expected to be operational by 2014.[157]

At the same time, dramatic reductions in PV costs are challenging the growing CSP market, at least in the United States. During 2010, several planned projects in the country were redesigned to use utility-scale PV technologies rather than CSP.[158] Such substitutions toward PV may represent a growing trend, according to some experts, while others expect that the ability to provide thermal storage and enable dispatchability will remain an attractive attribute to utilities and thereby justify a moderately higher price for CSP.[159]

Hydropower

Hydropower is currently in use in some 150 countries.[160] Global hydropower production increased more than 5% in 2010, due greatly to new capacity and wet weather in China, and represented about 16% of global electricity production.[161] An estimated 30 GW of capacity was added during 2010, with existing global capacity reaching an estimated 1,010 GW.[162]

The top countries for hydro capacity are China, Brazil, the United States, Canada, and Russia, which account for 52% of total installed capacity.[163] Ranked by generation, the order is China, Canada, Brazil, the United States, and Russia, because some countries (e.g., Canada) rely on hydropower for baseload supply whereas others (e.g., the United States) use it more to follow the electric load and match peaks.[164] By region, Asia leads for share of installed global capacity, followed by Europe then North and South America, with Africa at a distant fifth.[165]

China added 16 GW during 2010 to reach an estimated 213 GW of total hydro capacity, a significant increase over the 117 GW in operation at the end of 2005.[166] Brazil brought about 5 GW into operation, bringing its existing capacity to 80.7 GW, with a further 8.9 GW under construction.[167] Canada generated about 348 TWh of electricity with hydropower in 2010, and added 500 MW of capacity to end the year with 75.6 GW.[168] More than

11 GW of new projects were under construction across Canada by early 2011, with an estimated 1.3 GW due to become operational before the end of 2012.[169]

Development in the United States has slowed recently due to the economic recession, but just over 0.02 GW of new hydro began operating in 2010 for a total of 78 GW (plus 20.5 GW of pumped storage), producing 257 TWh during the year (up from 233.6 TWh in 2009).[170] Russia has an estimated 55 GW, which represents about one-fifth of the country's total electric capacity.[171]

Brazil and Canada generate roughly 80% and 61%, respectively, of their electricity with hydropower.[172] Many countries in Africa produce close to 100% of their grid-based electricity with hydro, as does Norway.[173] Norway, Iceland, and New Zealand lead the world in per capita generation of hydropower.[174]

The largest projects completed in 2010 included the 1.1 GW Nam Theun 2 hydropower plant in Laos, China's 2.4 GW Jin'anqiao plant, Brazil's 0.9 GW Foz do Chapeco plant, and two facilities (0.5 and 0.3 GW) in Ethiopia.[175] Vietnam began partial operation of what will eventually be Southeast Asia's largest hydro station (2.4 GW.)[176]

Many other countries continue to develop hydropower on large to small scales.[177] During 2010, projects were completed in Ecuador (0.2 GW), Turkey (0.02 GW), and Uzbekistan (0.05 GW).[178] Operation began at Australia's first hydropower plant to use treated sewage water; this plant, in New South Wales, captures the potential energy as water falls down a 60-meter shaft.[179]

India, which ranks sixth worldwide for total hydro capacity, with an existing capacity of more than 40 GW (including 37.4 GW of large-scale), added about 0.3 GW of small-scale[I] hydro in 2010 for a cumulative small-scale hydro capacity of 2.9 GW at year-end; another 0.9 GW of small-scale hydro were under construction as of early 2011.[180] Brazil had 53 small-scale hydro projects (0.7 GW) under construction by early 2011, and 149 additional plants (2.1 GW) had been authorized.[181] Canada, Iran, Kazakhstan, and Switzerland also had significant amounts of small-scale hydropower under construction or in the planning stages.[182] Rwanda aimed to have 0.04 GW of small-scale hydro capacity by 2015.[183]

Asia (led by China) and Latin America (led by Brazil) are the most active regions for new hydro development.[184] An additional 140 GW are planned for construction in China over the next five years.[185] In collaboration with Iran, China also plans to build the world's tallest dam – a 1.5 GW project in Iran's Zagros Mountains.[186] Brazil plans two major projects in the Amazon region, including a 3.2 GW reservoir project due for completion in late 2011.[187] North America and Europe, also constructing new plants, are the main centers for modernization of existing plants and for the application of pumped storage.[188]

Pumped storage entails pumping water from a lower to a higher reservoir to store energy for later use; it involves conversion losses and is not a source of energy. Interest in pumped storage is increasing, particularly in regions and countries where variable renewable resources are achieving relatively high penetration.[189] Pumped storage is also used to capture higher power prices during times of peak demand. The vast majority of pumped storage capacity is in Europe, Japan, and the United States.[190] About 4 GW of capacity was added globally in 2010 – including facilities in China, Germany, Slovenia, and the Ukraine – with approximately 136 GW operating worldwide by year's end, up from 98 GW in 2005.[191] By early 2011, a further 5 GW of capacity was under contract, and the market was expected to rise 60% over the next five years. [192]

Ocean Energy

Ocean energy is the least mature of the technologies considered in this report, but interest is growing in a wide range of possible technologies.[193] (See Sidebar 1.) Ocean energy technologies for generating electricity include wave, tidal (barrages and turbines), osmotic power, and ocean thermal energy conversion (OTEC) systems.

The 240 MW La Rance tidal barrage began generating power off the French coast in 1966 and continues to produce about 600 GWh annually.[194] Additional tidal projects came on line over the years in Canada, Russia, and China, with an estimated 262 MW of capacity in operation by 2001.[195] Otherwise, ocean energy saw little further development until recently. By the end of 2010, only tidal barrage systems had achieved commercial scale, and they accounted for most of the world's installed ocean energy capacity.[196]

However, in 2010 there were a handful of pre-commercial projects generating power with a range of technologies. Although existing capacity remained low relative to other renewable technologies, numerous projects were in development or under contract, and at least 25

I) Note that small-scale hydropower is generally defined as less than 10 MW, but there are a number of exceptions including India (up to 25 MW) and Brazil (less than 30 MW). See Glossary for more information, and see Note on Accounting and Reporting of Installed Capacities for treatment of hydropower in this report.

countries were involved in ocean energy development activities.[197] At year's end, an estimated total of 6 MW of wave (2 MW) and tidal stream (4 MW) capacity had been installed by the 18 member countries of the International Energy Agency (IEA) Implementing Agreement on Ocean Energy Systems.[198] Most of these projects were in Europe, with the majority operating off the coasts of Portugal and the United Kingdom for short-term testing and demonstration, and a few prototypes were initiating first steps toward commercialization.[199]

Also during 2010, the first commercial-scale grid-connected wave generator (0.25 MW) marked its tenth year of operation, having fed electricity into the grid for around 60,000 hours and achieving an average annual availability of 98%.[200] In addition, the world's first commercial-scale tidal turbine (1.2 MW) passed the milestone of providing 2 GWh of electricity to the U.K. electricity grid from the waters off Northern Ireland.[201]

Ocean energy advances in 2010 included the launch of at least 0.04 MW of wave demonstration projects in Sweden and continued development of 5 MW in Western Australia.[202] In Norway, the 1.5 MW Morild II floating tidal plant opened in November.[203] Elsewhere, a 0.075 MW Pelamis wave device began tests with the German utility company E.ON.[204] Although a California utility abandoned three separate wave sites during 2008–10 due to site or cost concerns, wave energy is advancing elsewhere in the United States.[205] In 2010, a 0.04 MW wave converter was connected to a power grid on a U.S. marine base in Hawaii, and construction began on what could eventually be a utility-scale wave project off the Oregon coast.[206]

For the future, projects are planned in a number of countries around the globe. In the United Kingdom, a total of 7.4 MW of prototypes were in the advanced stages of planning and manufacture for deployment during 2011, with another 11 MW of projects awarded consents and a further 23 MW in the U.K. planning system.[207] Plans are under way for wave power off the Turkish coast and various ocean energy projects in Indonesia, Italy, and La Reunion in the Indian Ocean.[208]

Construction of Asia's first commercial tidal current power plant could start in 2011: an initial 50 MW will be built off the coast of the Indian state of Gujarat, with a future total of 250 MW planned.[209] In South Korea, several small projects are under way, and construction of the 254 MW Sihwa tidal barrage power plant, expected to be operational in 2011, will increase global existing tidal barrage capacity to nearly 520 MW.[210] Other countries assessing technologies include Australia, Canada, France, Ireland, Japan, New Zealand, Portugal, Spain, and the United States.[211]

Sidebar 1. OCEAN ENERGY TECHNOLOGY AND COMMERCIALIZATION

Commercial application of ocean energy technologies remains limited, but activities leading to future markets increased in 2010. The year saw more than 100 ocean energy projects – exceeding 1 GW in cumulative capacity – reach various phases of development; meanwhile, rising financial and political support accelerated the development of infrastructure required to test new prototypes. In 2010, offshore testing facilities were deployed in the United Kingdom, Denmark, Sweden, and Canada. By early 2011, new facilities were under development in Portugal, Spain, Norway, Ireland, and the United States.

The relative immaturity of ocean energy technology has prompted a wide range of exploratory R&D activities, with various devices racing to reach commercial readiness. This diversity of concepts is clearest in the wave energy sector. Companies in the United Kingdom, Australia, and the United States have tested prototypes of "point absorber" systems, which are typically small relative to wave size and are designed to absorb energy in all directions.

"Linear absorbers" – typically larger relative to wave size and operating in parallel with wave direction – also have been tested at sea. Other concepts under development include wave "terminators," which focus and absorb or "terminate" incoming waves, and "oscillating water columns," which use wave action to compress air and drive generator units.

Similar variety exists in the tidal energy sphere. In the past four years, horizontal axis turbines have been launched by several companies in Europe and North America, and an "oscillating hydrofoil" prototype was tested in 2009. Vertical axis (or cross-axis) turbines have reached the operational testing phase.

These developments have been strongly backed by public R&D funding, particularly in Europe, North America, and South Korea. Governments in these regions are contributing grants and funding, typically in the range of $10–100 million per project or program, for testing facilities, demonstration projects, and basic research. Recent investments have been made by Belgium, Canada, Denmark, Ireland, Portugal, South Korea, and the United States.

As wave and tidal technologies progress, other ocean energy technologies – including those tapping energy from thermal and salinity gradients – are gaining prominence on national research agendas. In general, ocean energy technologies remain in an emerging phase of development. While the sector is 15–25 years behind wind energy, it is poised to follow a similar path to wider commercialization.

Source: See Endnote 193 for this section

HEATING AND COOLING MARKETS

Modern biomass, solar, and geothermal energy currently supply hot water and heat for tens of millions of buildings worldwide. Solar hot water collectors alone are used by more than 70 million households (most of them in China), as well as in many schools, hospitals, hotels, government, and commercial buildings. There is also a growing trend to use solar resources to generate process heat in industry, and interest is increasing in the use of solar energy for cooling purposes. Biomass and geothermal energy supply heat for industry, homes, and agriculture as well. Passive solar building designs provide a significant amount of heat (and light), and their numbers are also on the rise; due to lack of global data, however, they are not included here.

Biomass Heating

Globally, modern biomass continues to provide the majority of heating produced with renewable sources. This includes heat derived from burning solid, liquid, and gaseous biomass for purposes ranging from cooking, to heating of water and space, to process heat. Applications range from individual residential-scale units to large district-heating systems, including combined heat and power (CHP) plants. Worldwide use of modern biomass for heat production totaled 11,600 petajoules (PJ) in 2008, the most recent year for which global data are available.[212]

An estimated 234.5 PJ (5.6 mtoe) of heat from solid biomass and biogas were sold into district heat markets in Europe during 2009, with 97% using solid biomass. Heat is produced from a combination of CHP (64%) and heat-only plants (36%), with the mix varying by country depending on resource availability, the current energy supply system, and supporting policies. Domestic heating, whether through individual household systems (e.g., wood stoves) or district heat systems, accounts for the majority of solid biomass sold in Europe. [213] Biomass heat markets are expanding steadily in Europe, with Hungary, Poland, and the Netherlands seeing the highest growth rates in 2009.[214]

Sweden, Finland, and Denmark lead the European biomass heating market, together producing almost 70% of all biomass heat sold into district networks in the EU. Finland leads Europe for per capita heat production from solid biomass.[215] However, total heat production declined slightly in Sweden and Finland during 2009, particularly in Finland where output continued to drop as the economic crisis caused further contraction in the wood product and paper pulp industries.[216]

In Sweden, biomass became the primary energy source for household heating in 2008, used either directly in heating appliances or via connections to district heating schemes. Although total heat sales to district networks were down in 2009, solid biomass sales continued to rise and, for the first time, biomass's share (32%) of Sweden's total energy supply (heat, power, and transport) exceeded that of oil (31%).[217] Denmark generates an estimated 10% of its power and a significant share of its heat from biomass in CHP plants.[218]

Biomethane (purified biogas) has been used for power and heat in Europe for decades. It is injected into the natural gas grid and used primarily in gas-powered cogeneration plants. This application is growing in several countries, including Austria, the Netherlands, Sweden, and Switzerland.[219] The top producers of heat with biogas are Germany, the Netherlands, France, Poland, and Denmark.[220] Germany did not begin developing biomethane until 2006 but is now far ahead of the rest of Europe. The number of projects has grown rapidly, driven greatly by a national feed-in tariff. By November 2010, 44 plants were injecting into the gas grid, with a total of 60 plants expected to be connected by year's end, providing total production of 40,000 cubic meters per hour.[221]

Biomass pellets are also becoming an increasingly common fuel in the EU. Whereas they are used primarily for electricity generation in Belgium and the Netherlands, in Sweden and Denmark pellets are burned mainly in CHP plants; elsewhere, they are used widely to heat residential and commercial buildings. The EU consumed more than 11 million tonnes of wood pellets in 2010, an increase of 7% over 2009.[222] Sweden was the largest consumer in 2010 at 2 million tonnes, and Germany consumed almost 1 million tonnes.[223] As a result, wood pellet exports to Europe from Canada (1 million tonnes in 2010) and the United States (0.6 million tonnes) doubled between 2008 and 2010.[224]

Domestic firewood for heating is becoming increasingly popular as well. In the United States, the number of homes using firewood or pellets for heat increased in several states by 50% or more between 2000 and 2010. An estimated 12 million wood and pellet stoves and inserts were installed by early 2011, meaning that about one in every ten U.S. households had a biomass stove. Between 2.1 million and 2.6 million homes used wood as their primary or sole heat source.[225]

Among developing countries, it is common to produce small- to large-scale power and heat from agricultural residues such as rice or coconut husks.[226] The use of bagasse for power and heat production is significant in developed and developing countries that have a large sugarcane industry, including Argentina, Australia, Brazil, China, Colombia, Cuba, Guatemala, India, Kenya, Mauritius, the Philippines, Tanzania, Thailand, and Uganda.[227] For example, most of Thailand's solid biomass capacity (see Biomass Power section) is from bagasse used for CHP.[228]

The use of small-scale biogas plants is on the rise as well. China, where an estimated 50 million households use biogas, leads the world in the number of plants.[229] India added more than 60,000 small biogas plants during 2010 for a total of 4.3 million plants nationwide that are used to meet energy needs for cooking.[230] Biomass gasifiers are used increasingly for heat applications in micro, small, and medium enterprises, and mixed-feed plants to produce biogas and bottle it or distribute it via pipelines are also becoming popular, with the residual digested solids used for soil fertilizers.[231]

Solar Heating and Cooling

Solar water heating technologies are becoming widespread and contribute significantly to hot water production in several countries. China, Germany, Turkey, India, and Australia led the market for newly installed capacity during 2009, with China, Turkey, Germany, Japan, and Greece taking the top spots for total installations by the end of that year.[232] (See Figures 9 and 10, and Table R5.)

In 2010, existing solar water and space heating capacity increased by an estimated 25 gigawatts-thermal (GW_{th}), or about 16%, to reach approximately 185 GW_{th}, excluding unglazed swimming pool heating.[233] China added an estimated 17.5 GW_{th} (25 million m^2 of collectors) for a total of just under 118 GW_{th} (168 million m^2).[234]

The European Union accounted for most of the remaining global added capacity. However, due to the economic recession, new installations continued to decline in some key European markets, including Austria, Germany, and France. The Greek and Italian markets increased slightly, while Spain's market held constant in 2010 after increasing about 21% the previous year.[235] Growth in developing European markets – including the Czech Republic, Denmark, Poland, Portugal, Switzerland, and the U.K. – did not make up for the decrease in larger markets. Total EU additions in 2010 came to 2.6 GW_{th}, down 10% relative to 2009 and nearly 19% below the 2008 market, bringing existing capacity to 25.1 GW_{th}.[236]

Germany remained Europe's largest installer, accounting for nearly one-third of EU additions, but new installations declined for the second year in a row (off 26% relative to 2009) due greatly to the temporary halt and restructuring of the national rebate program, and to decreasing natural gas market prices.[237] Germany added about 0.8 GW_{th} for an existing capacity of 9.8 GW_{th} by year's end.[238] The share of combination systems for both water and space heating increased to about two-thirds of the market.[239] Austria (3.2 GW_{th}) and Greece (2.9 GW_{th}) continue to rank second and third, respectively, for total installed capacity.[240]

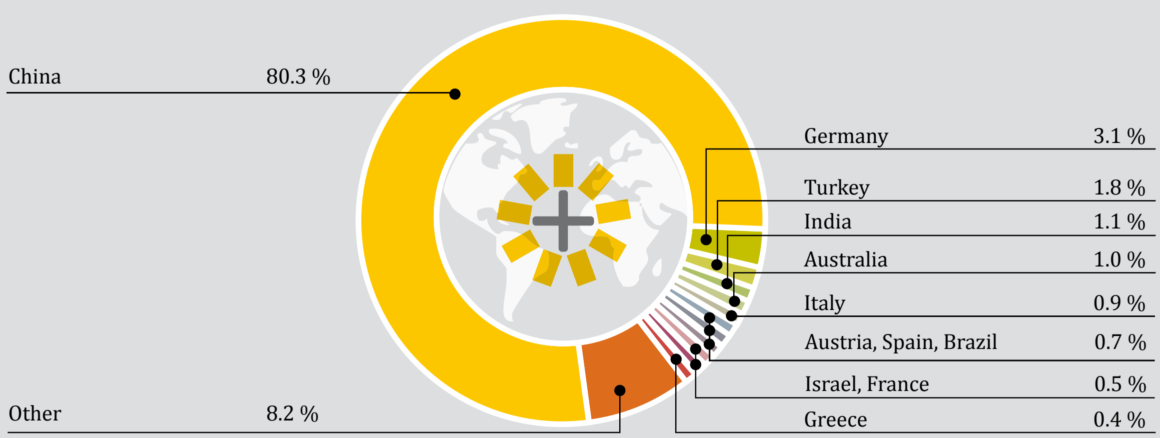
Brazil added about 0.6 GW_{th} in 2010.[241] The Brazilian market has been increasingly rapidly in recent years, with most of the installations in the southeastern states.[242] Elsewhere in Latin America there are very small but growing markets, including in Chile and Uruguay.[243]

Outside of China, Japan and India represent the largest markets in Asia. During 2010–11, India added about 0.35 GW_{th} (0.5 million m^2) of solar heat capacity for an estimated total of 2.8 GW_{th} (3.97 million m^2) at the end of January 2011.[244]

The U.S. market (excluding unglazed swimming pool heating) is still relatively small but is gaining ground. California appears to have overtaken Hawaii's lead, and these states are followed by Florida and Arizona.[245] An estimated 35,500 systems (nearly 0.2 GW_{th}) were installed nationally in 2010, representing 5% market growth and bringing total capacity close to 2.3 GW_{th}.[246] The slower rate of growth relative to 2009 was due to the economic crisis and to the low cost of competing home-heating fuels, which extended the payback period for solar heat systems.[247]

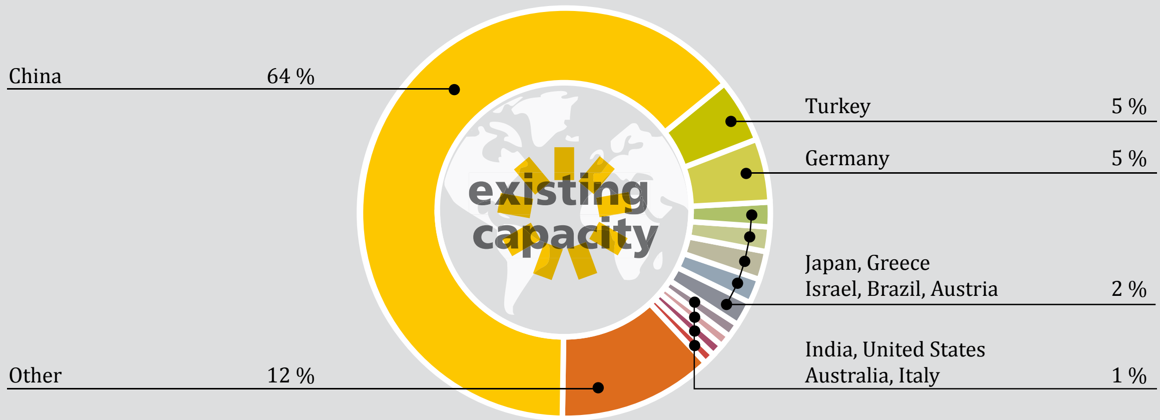
In Africa, markets were expanding in Egypt, Ethiopia, Kenya, Morocco, Namibia, South Africa, Tunisia, and Zimbabwe, among others.[248] For example, Egypt had an estimated 1 GW_{th} (700,000 m^2) of solar thermal systems by the end of 2010, and Morocco's collectors totaled an estimated 0.2 GW_{th} (280,000 m^2).[249]

Figure 9. Solar Heating Added Capacity, Top 12 Countries, 2009



Source: Weiss and Mauthner, 2011

Figure 10. Solar Heating Existing Capacity, Top 12 Countries, 2009



Source: Weiss and Mauthner, 2011

Although it ranked 18th overall, Cyprus remained the world solar heating leader on a per capita basis at the end of 2009, with 554 kilowatts-thermal (kW_{th}) per 1,000 inhabitants, followed by Israel (391 kW_{th}).[250] Austria, which had 315 kWth per 1,000 inhabitants in 2009, remained the leader in continental Europe, followed by Greece (266 kW_{th}) and Germany (102 kW_{th}).[251]

Solar space heating and cooling are gaining ground as well, particularly in Europe. The most advanced solar thermal markets are in Austria, Germany, and Spain, where applications include water and space heating for dwellings of all sizes, hotels, and large-scale plants for district heating, air conditioning, and cooling.[252] An estimated 115 solar supported heating networks and 11 solar cooling systems were operating in Europe by the end of 2009.[253]

Canada and Saudi Arabia also had significant systems installed. A 0.03 GW_{th} system commissioned in Riyadh in early 2011 to provide hot water and space heat for 40,000 university students overtook an installation in Marstal, Denmark, to become the world's largest.[254] What may become the world's largest solar cooling plant (3,900 m^2, or 0.003 GW_{th}) was under construction in Singapore in early 2011.[255]

Solar heat and steam can be used for various industrial processes as well, although this is the least developed solar thermal technology. A number of solar industrial process heat installations came on line during 2009 and 2010, but only about 100 projects are operational worldwide.[256] Temperatures below 100°C can be produced with typical flat plate or vacuum tube collectors such as those used in smaller systems that are often mounted on rooftops.[257] Higher temperatures require parabolic trough or linear Fresnel collectors and good solar resources comparable to CSP, but generally with smaller systems that are often mounted on rooftops and that require lower operating temperatures.[258] By early 2011, the biggest solar process-heat application was believed to be operating in Hangzhou, China; other plants also were operating in China and plans were under way to install systems in South Africa and elsewhere.[259]

Geothermal Direct Use

Global direct use of geothermal energy continued to rise in 2010, with capacity reaching an estimated 51 GW_{th} by year end.[260] Over the past decade, heat output from geothermal sources increased by an average rate of almost 9% (4% if heat pumps are not included), reaching about 439 petajoules (PJ) annually.[261] Most of this increase is associated with ground-source heat pumps, which have grown an average of 25% annually over the past decade.[262]

In 2010, ground-source heat pumps, at 35.5 GW_{th}, accounted for some 70% of global direct geothermal capacity and nearly 50% of direct heat use (214.8 PJ).[263/I] Almost 25% of geothermal direct heat was used for bathing and swimming applications; more than 14% for heating (primarily district heat); and the remainder for greenhouses, industrial purposes, aquaculture pond heating, agricultural drying, snow melting, cooling, and other uses.[264]

At least 78 countries used direct geothermal energy in 2010, up from 72 in 2005 and 58 in 2000.[265] The United States led the world for installed capacity, with just over 12.6 GW_{th}, followed by China (9 GW_{th}), Sweden (4.5 GW_{th}), Germany (2.5 GW_{th}, including 2.2 GW_{th} from heat pumps and 0.1 GW_{th} deep geothermal for district and building heat), and Japan (2.1 GW_{th}).[266] These five countries accounted for 64% of total global capacity in 2010.[267]

I) The share of heat use is lower than the share of capacity for heat pumps because they have a relatively low capacity factor. This is due to the fact that heat pumps generally have fewer load hours than other uses. As the share of heat pumps rises, output per unit of geothermal heat capacity is declining. Heat use is estimated with a coefficient of performance of 3.5.

China led in actual annual energy production at 21 TWh, followed by the United States (15.7 TWh), Sweden (12.6 TWh), Turkey (10.2 TWh), Japan (7.1 TWh), and Iceland (6.8 TWh).[268] Accounting for the average annual energy use per person, Iceland, Sweden, Norway, New Zealand, and Denmark led the way.[269] About 90% of Iceland's heating demand was derived from geothermal resources in 2010.[270]

Installed heat pump capacity has more than doubled since 2005, with use increasing from 33 countries in 2005 to 43 in 2010.[271] An estimated 2.9 million ground-source heat pumps were operating worldwide during 2010, with most installations in the United States, China, and Europe.[272] The United Kingdom, South Korea, Ireland, Spain, and the Netherlands saw large increases in installed capacity of direct-use geothermal between 2005 and 2010, with heat pumps accounting for all additions.[273]

Use of geothermal energy for CHP is also on the rise. In late 2010, 130 MWth of heat capacity began operating at Iceland's Hellisheiði power plant near Reykjavik (eventually it will be one of the world's largest, with 300 MW electric and 400 MW of thermal capacity).[274] Other geothermal CHP plants under construction by early 2011 included the first commercial geothermal plant in Cornwall, England, and a 10 MW German facility in Bavaria, which will provide electricity and district heat.[275]

TRANSPORT FUEL MARKETS

Renewable energy is used in the transport sector in the form of electricity, renewably produced hydrogen, biogas, and liquid biofuels.

Electricity is used to power trains, subways, and a small but growing number of electric passenger cars and bicycles. The EU Renewable Energy Directive, which includes renewable electricity in the 10% transportation target, will help drive this sector forward. As the number of electric vehicles increases and the share of electricity from renewables rises, renewable energy's role in the transport sector will increase as well; electric vehicles also can enable increased penetration of variable renewables by helping to balance demand and supply. (See Sidebar 7 on grid integration.) However, due to the small scale and lack of data, renewable electricity is not included in this section. Hydrogen is not included for the same reason.

Limited but growing quantities of biogas are fueling trains, buses, and other vehicles.[276] In Austria, France, Germany, Sweden, and Switzerland, biomethane is being used primarily in bus and car fleets.[277] In 2010, biogas made up 11% (on an energy basis) of the total 5.7% biofuels share of transport fuels in Sweden.[278]

Liquid biofuels make a small but growing contribution to fuel usage worldwide, providing about 2.7% of global road transport fuels in 2010.[279] They accounted for higher shares in some countries (e.g., 4% in the United States) and regions (3% in the EU) and provided a very large contribution in Brazil, where ethanol from sugar cane accounted for 41.5%[I] of light duty transport fuel during 2010.[280] The United States was the world's largest producer of biofuels, followed by Brazil and the European Union.[280/II] Despite continued increases in production, growth rates for biodiesel slowed again in 2010, whereas ethanol production growth picked up new momentum.[282] (See Figure 11.)

This section focuses on biofuels for transport, which include ethanol – made primarily from corn and sugar cane – and biodiesel, produced from virgin plant oils, waste vegetable oil, animal fats, fish oil, and algae (not yet produced on a commercial scale). Corn accounts for more than half of global ethanol production, mainly in the United States, and sugar cane accounts for more than one-third, mainly in Brazil.[III] Most biofuel is used for road transport, with a limited amount in the marine transport sector, and interest is growing in the use of biodiesel as a potential fuel for aviation (still at the pilot stage).[283]

Ethanol

In 2010, global production of fuel ethanol reached an estimated 86 billion liters, an increase of 17% over 2009.[284] (See Figure 11 and Table R6.) The United States and Brazil accounted for 88% of ethanol production in 2010, with the United States alone producing 57% of the world's total.[285]

The United States accounted for most of the increase, producing 8.4 billion more liters in 2010 than in 2009, for a total of 49 billion liters.[286] Well over 90% of U.S. gasoline was blended with ethanol.[287] Approximately 3% of the world's grain supply was used to produce this ethanol, with almost 32.5 million tonnes of animal feed as a co-product.[288] After several years as a net importer, the United States became a net exporter in 2010, sending a record 1.3 billion liters of fuel ethanol overseas, mainly to Canada, Jamaica, the Netherlands, the United Arab Emirates, and Brazil.[289]

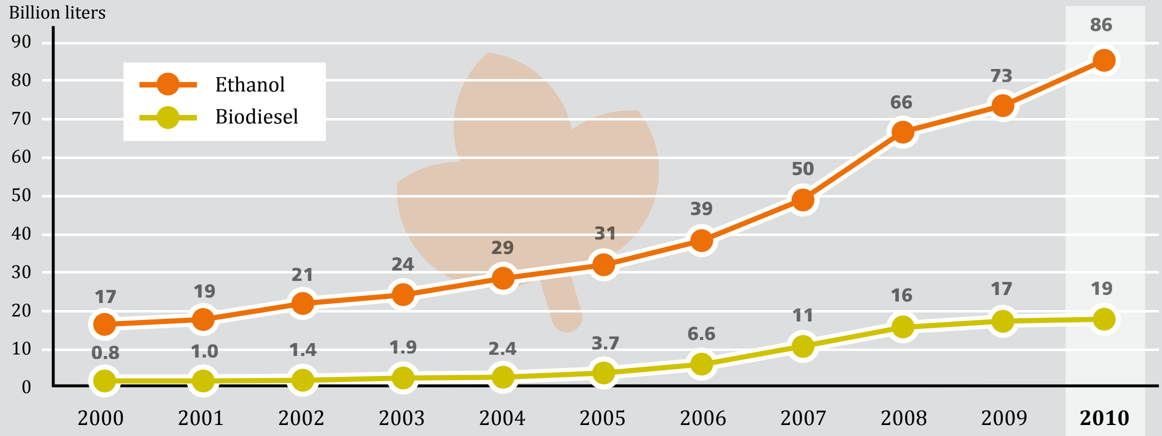
Long the world's leading ethanol exporter, Brazil continued to lose international market share to the United States, particularly in its traditional markets in Europe.[290]

I) These are energy-based values; in terms of volume, ethanol accounted for 48% of Brazilian light-duty transportation fuels.

II) Note that there is a difference between the production of biofuels and the source of biomass feedstock. Some countries produce large volumes of biofuels but import much of the raw biomass feedstock from elsewhere.

III) 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 sugar cane. For more information and efforts to improve the sustainability of biofuels production and use, see Sidebar 7 in the *Renewables 2010 Global Status Report*.

Figure 11. Ethanol and Biodiesel Production, 2000–2010



Source: F.O. Licht

Adverse weather conditions hampered global harvesting of sugar cane, pushing up prices.[291] As a result, U.S. corn-based ethanol became relatively cheaper in international markets (although it was subsidized, unlike Brazilian ethanol).[292] However, Brazil's ethanol production increased more than 7% in 2010, to 28 billion liters, and the country accounted for nearly one-third of the global total.[293]

China, at 2 billion liters, remained Asia's largest ethanol producer, followed by Thailand and India, which more than doubled its annual production to 0.4 billion liters.[294] In the European Union, the United Kingdom saw the largest increase with annual production rising about 325% to 0.32 billion liters.[295] France and Germany remained the largest European producers in 2010.[296] Other important producers included Canada, Colombia, Poland, and Spain.[297] Africa represents a tiny share of world production but saw continued rapid growth in production during 2010.[298]

Biodiesel

Global biodiesel production increased 7.5% in 2010, to nearly 19 billion liters, giving a five-year average (end-2005 through 2010) of 38% growth. Biodiesel production is far less concentrated than ethanol, with the top 10 countries accounting for just under 75% of total production in 2010.[299]

The European Union remained the center of global biodiesel production, with more than 10 billion liters and representing nearly 53% of total output in 2010.[300] Biodiesel accounted for the vast majority of biofuels consumed in the EU, but growth in the region continued to slow, with production increasing only 2% in 2010, down from a 19% growth rate in 2009 (and 65% growth rate in 2005).[301]

The slowdown in many countries was due to increased competition with relatively cheap imports from outside the EU (including Canada, Argentina, and increasingly Indonesia). This trend is leading to plant closures from reduced domestic production requirements, an expansion of tariffs on imports, and increases in some blending mandates.[302] Biodiesel production declined in several EU countries, including Belgium, Slovakia, Spain, and the United Kingdom; France held level with its 2009 output.[303]

Germany remains the world's top biodiesel producer at 2.9 billion liters in 2010, followed by Brazil, Argentina, France, and the United States.[304] Consumption in Germany has declined significantly since the elimination of Germany's biodiesel tax credit. The greatest drop in demand has been in pure vegetable oil and B100 (100% unblended biodiesel). In contrast, the use of blended biodiesel has increased during this period due to the national blending quota, and total production rose in 2010.[305]

The greatest production increase was seen in Brazil (up 46% to 2.3 billion liters) and in Argentina, which continued its rapid growth with production up 57% over 2009 to 2.1 billion liters, three-quarters of which was exported.[306] In the United States, biodiesel production fell more than 40%, the second year of decline.[307] Almost 12% of biodiesel production occurred in Asia (up from 10% in 2009), with most of this from palm oil in Indonesia and Thailand.[308]

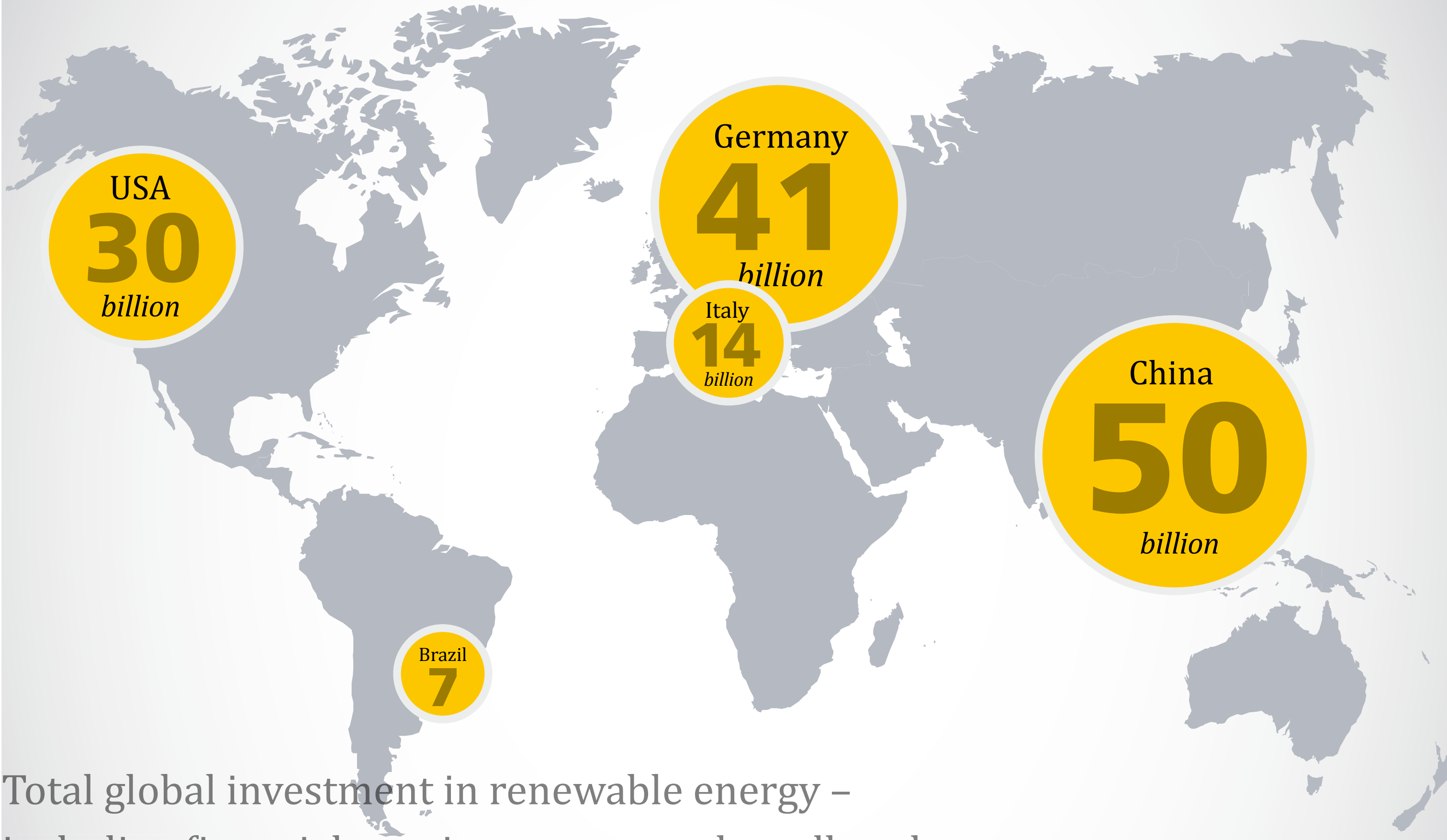
Table 1. Status of Renewable Energy Technologies: Characteristics and Costs

Technology	Typical Characteristics		Typical Energy Costs (U.S. cents/kilowatt-hour)
Power Generation			
Large hydro	Plant size:	10 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; Rotor diameter: 60–100 meters	5–9
Off-shore wind	Turbine size:	1.5–5 MW; Rotor diameter: 70–125 meters	10–20
Biomass power	Plant size:	1–20 MW	5–12
Geothermal power	Plant size: Types:	1–100 MW; binary, single- and double-flash, natural steam	4–7
Solar PV (module)	Efficiency:	crystalline 12–19%; thin film 4–13%	–
Solar PV (concentrating)	Efficiency:	25%	–
Rooftop solar PV	Peak capacity:	2–5 kW_{peak}	17–34
Utility-scale solar PV	Peak capacity:	200 kW to 100 MW	15–30
Concentrating solar thermal power (CSP)	Plant size: Types:	50–500 MW (trough), 10–20 MW (tower) trough, tower, dish	14–18 (trough)
Hot Water/Heating/Cooling			
Biomass heating	Plant size:	1–20 MW_{th}	1–6
Solar hot water/heating	Size: Types:	2–5 m^2 (household); 20–200 m^2 (medium/multi-family); 0.5–2 MW_{th} (large/district heating); evacuated tube, flat-plate	2–20 (household) 1–15 (medium) 1–8 (large)
Geothermal heating	Plant capacity: Types:	1–10 MW_{th} heat pumps, cooling, 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) 60–80 cents/liter (corn) (gasoline equivalent)
Biodiesel	Feedstocks:	soy, rapeseed, mustard seed, palm, jatropha, waste vegetable oils, and animal fats	40–80 cents/liter (diesel equivalent)
Rural Energy			
Mini-hydro	Plant capacity:	100–1,000 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 m^3	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 W	40–60

Notes: Data are unchanged from 2010 report edition with the exception of solar PV costs, which have been updated per EPIA to reflect recent trends in solar PV costs and characteristics in Europe. A full update of all costs was not done for the 2011 edition but will be done in 2012. In particular, a number of new publications in 2011 provide new cost data, which will be synthesized with expert estimation for the next edition. All costs in this table are indicative economic costs, levelized, and 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 that employ 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. Costs for biomass power depend on type of biomass resource.

Source: Data compiled from a variety of sources, including NREL, World Bank, IEA, and various IEA implementing agreements. Many current estimates are unpublished. Historically, no single published source has provided a comprehensive or authoritative view on the costs of all technologies, although recent sources in 2011 are more comprehensive. For further cost references, see *IPCC, Special Report on Renewable Energy Sources and Climate Change Mitigation*, May 2011, at http://srren.ipcc-wg3.de/; World Bank/ESMAP, *Technical and Economic Assessment: Off Grid, Mini-Grid and Grid Electrification Technologies* (Washington, DC: 2007); and *IEA, Deploying Renewables: Principles for Effective Policies* (Paris: 2008). PV costs data from Gaëtan Masson, European Photovoltaic Industry Association (EPIA), personal communication with REN21, 5 April 2011.

02 INVESTMENT FLOWS



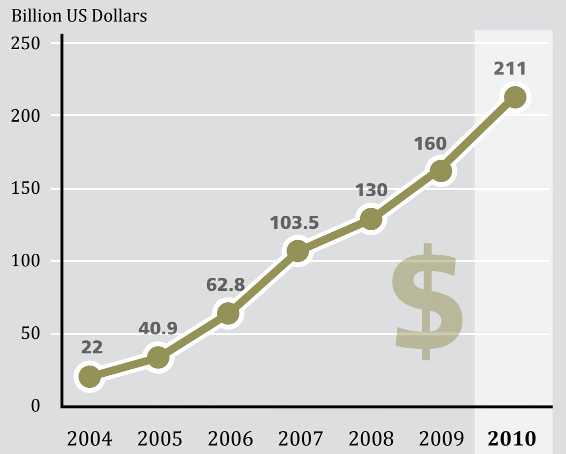
Total global investment in renewable energy – including financial new investment and small-scale investment – jumped in 2010 to a record $211 billion. China attracted nearly $50 billion, making it the leader for the second year in a row.

02 INVESTMENT FLOWS

Total investment in renewable energy reached $211 billion in 2010,[I] up from $160 billion in 2009,[II] including reported asset finance, venture capital, private equity investment, public markets (stock purchases), and corporate and government research and development. (See Figure 12.) If the unreported $15 billion (estimated) invested in solar hot water collectors is included, then total investment exceeded $226 billion. An additional $40–45 billion was invested in large hydropower.

If only total investment in new renewable energy capacity (excluding large hydro) is counted, the total comes to $203 billion. This $203 billion includes utility-scale asset finance (large wind farms, solar parks, and biofuel plants), distributed generation capacity (mostly rooftop solar PV less than 1 MW in size), and hot water/heating capacity. Within the overall figure, financial new investment, which consists of money invested in renewable energy companies and utility-scale generation and biofuel projects, rose 17% in 2010 to $143 billion.

Figure 12. Global New Investment in Renewable Energy, 2004–2010



Investment by Region

The top countries for total investment in 2010 were China, Germany, the United States, Italy, and Brazil. For the first time, financial new investment in renewable energy in developing countries surpassed that in developed economies. (Note that in the two areas not included in the financial new investment measure, namely small-scale projects and R&D, developed countries remain well ahead.) Financial new investment rose $17 billion to more than $72 billion, while in OECD countries it increased less than $4 billion to $70.5 billion. China attracted $49 billion (up 28% over 2009), which was more than two-thirds of developing country investment and more than a third of global investment in renewable energy during 2010, making China the leader for the second year in a row. The United States ranked second for financial new investment, with just over $25 billion, an increase of 58% over 2009. Germany enjoyed financial new investment of $6.7 billion in 2010, but this was dwarfed by its $34.3 billion in small-scale projects, mainly rooftop solar PV.

Although total financial new investment was higher in developing countries, growth rates in a number of developed countries exceeded those in some major developing economies. For example, Belgium saw an increase in investment of 40%, Canada 47%, Italy 248 %, and the United States 58%, whereas growth rates in India and Brazil were 25% and minus 5%, respectively. Italy moved from ninth to third place in global renewable energy investment as asset finance in solar PV surged on the back of generous feed-in tariffs.

Increases in developing countries, as well as in the United States, were due to an increase in asset finance, dominated by wind, for which global asset finance rose by $23 billion to $90 billion.

China's lead was due mainly to the growth in wind power capacity in 2010. China continued to benefit from a $46 billion "green" stimulus package, which had been announced at the height of the financial crisis in 2008. By the end of 2010, 70% of the funds had been spent, although data about the details are unclear. China also dominated public markets, with $5.9 billion (out of the total $49 billion) in new investment in renewables.

India ranked eighth in the world for renewable energy investment. Investment rose 25% to $3.8 billion, dominated by wind power projects ($2.3 billion), followed by $400 million each for solar and biomass power (including waste-to-energy).[III]

In Brazil, new investment dropped 5% to $7 billion. This seemingly weak performance can be explained by the fact that the focus was on consolidating the biofuel sector, so that most money went into mergers and acquisitions, which does not count as new investment. Latin America (excluding Brazil) saw the biggest absolute increase in renewable energy investment among the regions of the developing world. The largest gain within Latin America was achieved by Mexico (348%). This

I) This section is derived from UNEP, *Global Trends* in *Renewable Energy Investment 2011* (Paris, 2011), the sister publication to the GSR. The figures are based on the output of Bloomberg New Energy Finance's (BNEF) database unless otherwise noted. 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 and 50 MW, all solar power 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. BNEF defines utility-scale solar parks as greater than 500 kW in capacity. For more detail, please refer to the UNEP *Global Trends* report. Note that all dollar and cents figures in this report are in U.S. dollars unless otherwise indicated.

II) Revised upward from $150 billion as reported in the *Renewables 2010 Global Status Report*.

III) In this section, waste-to-energy includes all waste-to-power technologies, but not waste-to-gas.

growth was a result of the successful financing of large wind projects and one geothermal project following the government's 2009 announcement that it was increasing its renewables target from 3.3% to 7.6 % by 2012. Argentina saw investment increase by 568%, to $740 million; Peru's investment doubled to $480 million; and Chile saw a 21% increase to $960 million.

Africa achieved the largest percent increase in renewable energy investment among developing country regions apart from China, India, and Brazil. Total investment rose from $750 million to $3.6 billion, largely as a result of strong performances in Egypt and Kenya.

Investment by Type

Asset finance of new utility-scale renewable energy projects (wind farms, solar parks, biofuel and solar thermal plants), the largest investment asset class, reached a record $128 billion in 2010, or almost 60% of the total. This represents an increase of 20% over 2009, which had seen a drop of 6% compared to 2008.

The resumption of utility-scale asset finance growth in 2010 is due mainly to the Asia and Oceania region, which accounted for about 44% of the total new-build asset finance during the year. China in particular took first place in new-build clean energy in 2010, with asset finance of $43.8 billion, the largest for any single country. The United States was second on the list, with $19.6 billion in asset finance, or less than half that of China.

China and the United States together accounted for more than half of the total new-build asset finance in 2010. Several European countries, led by Germany, Italy, and Spain, were among the top 15 countries. So were Brazil, Canada, India, and Mexico. Asset finance for the 3rd- to 15th-ranked countries ranged from $1.4 billion (Poland) to $6.9 billion (Brazil).

Wind power dominated the utility-scale asset finance sector (70%), with $90 billion invested in projects, a 33% rise over 2009. Large-scale solar power plants represented the second largest sector under utility-scale asset financing, at $19 billion in 2010. This was about 5% higher than the financing secured in 2009, although still below the 2008 record of $23 billion due to the sharp decline in PV panel prices.

Geothermal also saw an increase in asset finance in 2010 compared to 2009. Financing for biomass (including waste-to-energy), biofuels, small hydro, and ocean power in 2010 was lower than it was the previous year. Asset financing for biomass (including waste-to-energy) was down 10% to $10.2 billion in 2010. The sector continued to be plagued by feedstock supply challenges and uncertainty over future feedstock prices.

The biofuel sector saw a 19% drop in asset finance, to $4.7 billion. This was one quarter of the $20 billion of asset financing that the sector secured in 2007, and less than one third of the 2008 amount ($16 billion). The downward trend was driven by lower crude oil prices in 2010 and by uncertainty over feedstock supplies.

Financing for small-scale hydropower was down 43%, to $2 billion, hit by a post-financial crisis lull, regulatory restrictions in Europe, and concerns about the risk of rainfall variations affecting the performance of some projects.

Ocean energy continued to be at an immature stage of development, managing just $40 million of asset financing. However, ambitious plans emerged during 2010 for multi-MW projects off the coasts of countries such as the U.K. and Portugal.

Other types of investment activities in 2010 were notable as well. Venture capital and private equity investment in renewable energy companies increased 19% over 2009, to $5.5 billion, despite a significant drop in the third quarter of the year. All of the growth was in venture capital (both early and late stage), while private equity expansion capital continued to drop, following the trend in 2009. Early-stage venture capital rose 41% to $930 million, and late-stage venture capital increased 71% to $1.5 billion. Early-stage venture capital was still 38% below its 2008 peak, but late-stage established a new record high, almost 9% above its 2008 level.

Meanwhile, investment of private equity expansion capital dropped by $20 million, to $3.1 billion, following the decline in 2009, and was less than half the value of its 2008 peak. Private equity continued to face challenges over fundraising, valuations, and exits in 2010. The regional leader in venture capital and private equity investment was North America. In terms of technology, most investment went into solar.

Renewable energy investment in public markets increased 23% in 2010, to $15.4 billion, an increase over the previous year. Research and development (R&D) on renewable energy rose to $9 billion in 2010, with most R&D worldwide going into solar ($3.6 billion) followed by biofuels ($2.3 billion). For the first time, governments spent more on R&D for renewables ($5 billion, up from $2 billion in 2009) than the private sector did ($3 billion, down from $4 billion in 2009). This is because green stimulus money was still being spent during 2010, most strongly in Asia and Oceania (excluding China and India), where government R&D investment in renewable energy increased 27-fold spurred by national stimulus packages in Australia, Japan, and South Korea.

In 2010, $60 billion was invested in small-scale distributed generation projects, accounting for more than 25% of total investment in renewable energy. This small-scale investment was largely solar PV, which is benefiting from generous support programs, falling prices for solar modules, and a growing base of installers that are marketing to consumers. Bloomberg New Energy Finance (BNEF) estimates that 86% of the investment in small-scale solar took place in countries that have introduced feed-in tariffs. Germany, which continues to have the world's largest solar PV market, took the lead with a 57% global investment share. Counting both utility-scale solar and small-scale solar, total solar power investment in 2010 grew to $79 billion, driven largely by distributed generation projects in Europe.

There are no reliable figures for the value of investment in solar water heaters worldwide[I], but on the basis of installation, investment can be estimated at around $15 billion.

Development and National Bank Finance

State-owned multilateral and bilateral development banks have been pillars of investment in renewable energy during recent, troubled years for the world economy. In 2010, more public money went to the renewable energy sector through development banks than through government stimulus packages.

Data compiled by BNEF show that 13 development banks worldwide provided $13.5 billion of finance for renewable energy projects in 2010, up from $8.9 billion in 2009, $11 billion in 2008, and just $4.5 billion[II] in 2007. Almost all of this funding took the form of loans, although there were also a few equity finance deals, notably in Eastern Europe by the European Bank for Reconstruction and Development (EBRD).

The three leading development banks, in terms of financing of renewables projects in 2010, were the European Investment Bank ($5.4 billion), Brazil's BNDES ($3.1 billion), and Germany's KfW ($1.5 billion). The EIB's contribution grew almost fivefold between 2007 and 2010. BNDES's activity in 2010 was double its 2007 level, but the bank's contribution actually peaked at $6.2 billion in 2008, when Brazil's ethanol investment boom was at its height. KfW's project finance footprint doubled as well between 2007 and 2010.

The Asian Development Bank (ADB) invested $819 million in renewable energy projects in 2010. The World Bank Group committed $748 million in direct renewable energy project finance, with over two-thirds of this coming from loans from the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA). Roughly a third came from the International Finance Corporation (IFC), much of it to energy efficiency projects (which are not covered in this report).

One uncertainty relates to the China Development Bank, which in 2010 announced some $36 billion in credit lines to Chinese clean energy manufacturers. However, CDB shows up as the confirmed lender to only some $600 million of renewable energy projects. It is likely that the bank's contribution to projects is much larger than has been revealed as of publication of this report.

The Global Environment Facility (GEF), which was not included in the BNEF analysis, approved funding in 2010 for 25 renewable energy projects, with a total direct GEF contribution of $40.4 million. Total co-financing for these projects from all sources was $382.1 million.

Sidebar 2. INVESTMENT TRENDS IN EARLY 2011

Given the rush to complete a number of big investment transactions in the closing weeks of 2010 – in some cases to "catch" attractive subsidy deals before they expired – it was little surprise that activity in the first quarter of 2011 was relatively subdued. Financial new investment in renewable energy totaled $31 billion, down from $44 billion in the fourth quarter of 2010 and below the $32 billion figure for the first quarter of 2010.

In asset finance, the biggest reductions in terms of absolute dollars came in U.S. wind power and European solar power. The brightest spots of January–March 2011 were wind power in China, up 25% relative to the same quarter in 2010, and in Brazil, which saw investment double from a year earlier.

Key wind power projects going ahead included the 211 MW IMPSA Ceara wind auction portfolio and the 195 MW Renova Bahia portfolio, both in Brazil, and the 200 MW Hebei Weichang Yudaokou village wind farm in China. In Europe, there were several large offshore wind infrastructure commitments, including the Dan Tysk project off the coast of Germany, the Skagerrak 4 project off Denmark, and the Randstad project off the Netherlands.

In public market investment, transactions included a $1.4 billion share sale by Sinovel Wind and a $220 million offering by solar manufacturer Shandong Jinjing Science & Technology – both in China. In venture capital and private equity investment, the largest transaction of the first quarter of 2011 was a $143 million expansion capital round for U.S. biomass and waste-to-energy specialist Plasma Energy.

March 2011 brought a series of tragic events with potentially far-reaching consequences for energy, including renewable energy. The Japanese earthquake and tsunami, and the ensuing crisis at the reactors at Fukushima Daiichi, cast into doubt the future of nuclear power in Japan and also in other countries such as Germany. Initially, the result was a sharp rise in the share prices of renewable energy companies. But natural gas-fired generation, rather than renewable power, could prove to be the primary, short-term beneficiary of nuclear energy's problems.

I) Solar water heaters are not included in BNEF's overall data for investment in small-scale renewable energy projects.

II) These data are based on a combination of deals recorded on BNEF Desktop, deal-specific disclosures in the annual reports, and communication with the related organizations. According to BNEF's revised methodology, the data cover only development banks' project finance loans and equity contributions. Excluded are loans from commercial lenders to the same projects, equity provided by other investors, as well as development banks' investment in renewable energy companies. Development banks made significant contributions to large hydro projects, which are not included in the investment figures.

03 INDUSTRY TRENDS

Strong growth continued in manufacturing, sales, and installation despite a changing policy landscape in many countries, while consolidation and internationalization continued.

03 INDUSTRY TRENDS

Across most renewable energy technologies, renewables industries saw continued growth in equipment manufacturing, sales, and installation during 2010. Technology cost reductions in solar PV in particular meant high growth rates in solar PV manufacturing. Cost reductions in wind turbines and biofuel processing technologies also contributed to growth.

At the same time, industry consolidation continued, notably in the biomass and biofuels industries, as traditional energy companies moved more strongly into the renewable energy space. The year 2010 saw the emergence of increasingly vertically integrated supply chains. And the trend continued for manufacturing firms to move into project development.

Longstanding trends in internationalization of the industry also continued. Global wind turbine manufacturers focused their attention on the Chinese market, and solar PV manufacturers in China also sold more products in Europe than ever before. At the same time, a changing policy landscape in many countries (see Policy Landscape section) contributed to some industry uncertainties or negative outlooks, for example with biodiesel production in the United States and solar PV installations in Spain.[1]

Wind Power Industry

Although the wind power industry saw manufacturing volumes remain constant at their 2009 levels, manufacturing capacity increased substantially during 2010.[2] Project developers were challenged by competition with natural gas prices at three-year lows (leading to reduced sales), the continued challenge of obtaining project finance, and access to transmission. Industry leaders Vestas, Gamesa, Hansen Transmissions, and GE Wind all lowered sales forecasts during 2010.

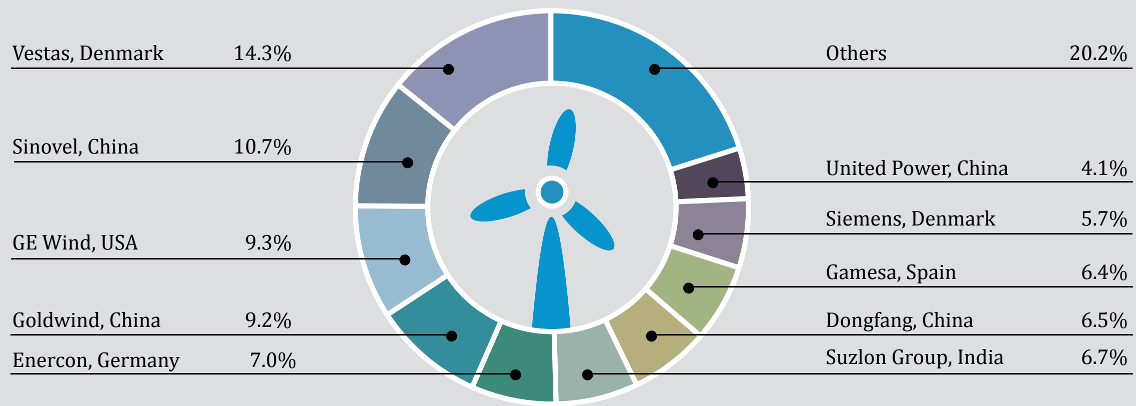
Growth opportunities were focused mainly on China and other emerging markets as GE Wind supplied turbines to Brazil; Gamesa planned to triple investments in China by 2012; and Repower and Suzlon signed contracts in Turkey and Bulgaria.[3] Among the top 10 global manufacturing firms, Vestas of Denmark easily retained its number-one ranking, but Sinovel of China edged ahead of GE Wind in 2010 to take second place.[4] (See Figure 13.)

In China, firms Sinovel, Goldwind, Dongfang, and United Power saw strong growth driven by continued political and regulatory support and lower labor and manufacturing costs. Continued technology development at these firms also meant a smaller and closing gap in technological parity with overseas firms. Sinovel, for example, launched a 5 MW turbine model in 2010.[5] It appeared that industry consolidation might be on the horizon in China as a draft government policy called for narrowing the industry to far fewer than the existing 100-plus firms. The major developers of wind projects in China remained predominately state-owned enterprises: Longyuan, Datang, Huaneng, Huadian, CPI, and Guohua.[6]

In Europe, industry activity focused increasingly on offshore technologies and on project development in Eastern Europe. The largest turbine to be financed so far, RePower's 6 MW model, was deployed in C-Power's 300 MW Thornton Bank project in Belgium, one of nine offshore wind farms developed in 2010.[7] And Transpower's high-voltage cable transmission infrastructure is being installed in the North Sea, laying the base for German offshore connectivity by 2013. Project developers became more aggressive in Eastern Europe, for example in Ukraine, where at least 10 project developers were active in 2010 due to a new feed-in tariff.[8]

In the United States, 14 new turbine manufacturing plants were established in 2010[9]. The U.S. industry was hampered, however, by late extension by the U.S. Congress

Figure 13. Market Shares of Top 10 Wind Turbine Manufacturers, 2010



Source: BTM Consult ApS - a part of Navigant Consulting of the Investment Tax Credit (ITC), low natural gas and electricity prices, and transmission access issues, so that project developers managed only half the number of projects they did in 2009. Leading owners of wind power projects in the United States include NextEra, Iberdrola Renewables, Horizon-EDPR, MidAmerican/PacifiCorp, and E.ON Climate & Renewables.[10]

Direct-drive turbine designs captured 18% of the global market, led by Enercon (Germany), Goldwind (China), and Hara XEMC (China). Preferred turbine sizes were 2.5 MW in the U.K., 1.4 MW in China, and 1.2 MW in India. Globally, the average turbine size increased to 1.6 MW, up from 1.4 MW in 2007.[11] Vestas launched the largest commercial turbine thus far, the dedicated offshore V164 7 MW turbine, targeting North Sea opportunities.[12]

The small-scale wind industry continued its expansion in 2010. The Nordic Folkecenter has identified 106 companies in 29 countries that are manufacturing wind turbines of 50 kW and smaller.[13] In the United States, an estimated 95 manufacturers were producing turbines of 100 kW and smaller (up from 60 active firms in 2001), with half of the firms still developing prototype turbines.[14] In China, 80 manufacturers were reported to be active in 2010, selling turbines within China and exporting to Mongolia.[15] With strong incentives for small wind in the U.K., installations grew 65% to 3,280 systems deployed in 2009 with over 20 domestic manufacturers and a number of foreign manufacturers active in the market. Roughly 55% of small wind turbines produced in the U.K. are exported, and 45% are used domestically.[16]

Biomass Power and Heat Industry

The biomass power and heat industry supplies and uses solid, liquid, and gaseous fuels from forestry, agricultural, and municipal residues. Much of this diverse industry is centered in Europe where, despite fiscal austerity, manufacturing and project-development firms saw modest growth in 2010, reflecting the continued push from EU targets and national action plans for renewables. Leading biomass conversion equipment manufacturers are located primarily in Sweden, Finland, Denmark, Austria, Poland, and Germany. Europe has the largest wood pellet production industry in the world, with 670 pellet plants under operation, producing 10 million tonnes in 2009.[17]

The growth of wood pellet production facilities, in particular, continues to be a notable trend in the biomass industry. Significant developments during 2010 include a new deal agreed by Brazilian pellet producer Suzano to supply eucalyptus pellets to U.K. developer MGT Power; Biowood Norway's launch of wood pellet exports from its 450,000 tonne/year facility; and an announcement by the Finnish-Swedish venture Stora Enso of a EUR10 million investment in a 100,000 tonne/year plant in Estonia.

By early 2011, Vyborgskaya Cellulose planned to start operations at its 900,000 tonne/year plant in Russia, the world's largest, targeting pellet sales to Scandinavia.[18] In the United States, Point Bio Energy was constructing a 400,000 tonne/year pellet plant in Louisiana, targeting European markets starting in 2012.[19]

The production of biogas is also increasing. Historically a fuel produced in small quantities at the household, farm, or community level in rural agricultural areas of developing countries (see section on Rural Renewable Energy), biogas has become a mainstream commercial fuel produced from passive methane capture at landfills, from urban wastewater and effluent treatment plants, and from energy conversion methanization plants fed with slurry, crop residues, food processing waste, and household and green waste.[20]

The biogas industry has been moving beyond its historic focus on waste treatment and management into energy generation, including the use of purpose-grown green energy crops in some countries. German firms have led in manufacturing and project development, driven by strong domestic demand and a feed-in tariff for biogas. By the end of 2010, there were roughly 6,800 biogas production plants in Germany.[21] Leading biogas manufacturing firms include Axpo Kompogas (Switzerland), Organic Waste Systems (Belgium), Strabag Umweltanlagen (Austria), and Agroferm Group, MIT-Energie, Biotechnische Abfallvertungen, Biogas Nord, Weltec BioPower, Envitec Biogas, and Schmack Biogas, all in Germany.[22]

Leading producers of biomass boilers for homes and small businesses (4.5–1,000 kW capacity) include Froeling (Austria), HDG Bavaria (Germany), ETA Heizteknik (Austria), and KWB (Austria). Industrial and municipal-scale plants and boilers (250 kW to 45 MW capacity) are manufactured by Compte-R (France), Weiss France (France), MW Power Oy (Finland), Foster Wheeler AG (Switzerland), and Babcock & Wilcox (USA), among others. Many electric utility companies, such as E.ON, Dalkia, and GDF Suez, also continued to increase their investments in biomass power plants during 2010.

Solar PV Industry

The solar PV industry had an extraordinary year in 2010, with global cell and module production more than doubling over 2009 levels. An estimated 23.9 GW of cells and 20 GW of modules were produced in 2010. The large PV cost reductions seen in 2009 continued in 2010, with module prices falling a further 14% in 2010 according to some sources (following a reported 38% drop in 2009), into the the $1.30–1.80/$W_{peak}$ range.[23] Price reductions were aided by a sufficient supply of polysilicon and wafers due to rapid expansion of manufacturing capacity in China and elsewhere. The fact that manufacturers were sold out a full quarter in advance, from June to December of 2010, indicated that the supply of cells and modules tightened in the second half of 2010.[24]

Although crystalline silicon production continued to dominate the market, and thin film's market share declined to 13%, production of thin-film increased in 2010 by a record 63% to reach 3.2 GW. Thin-film production became more diversified as well, being spread among a larger number of firms beyond the traditional thin-film industry leader First Solar.[25]

The top 15 solar cell manufacturers produced 55% of the 23.9 GW of global production.[26] (See Figure 14.) Cell manufacturing continued its marked shift to Asia, and by 2010, ten of the top 15 manufacturers were located there.[27] Firms in mainland China and Taiwan alone accounted for 59% of global production in 2010, up from 50% in 2009. Europe's share dropped to 13% in 2010 and Japan's share dropped to 9%. The North American share was 5%, although North America produced a disproportionally large share of thin-film products. Almost half of North American production was thin-film, compared to the global average of 13%.

Suntech of China moved into first place among all manufacturers, up from second place in 2009, and JA Solar of China moved to second place, up from sixth. The U.S. firm First Solar dropped from first place to third place, even though its annual production continued to increase.[28]

Expansion of manufacturing capacity dominated industry attention in 2010. By year's end, capacity stood at roughly 27 GW. Nearly 50% of this capacity was in China, followed by Taiwan (15%), the EU (10%), and Japan and the United States (both less than 10%).[29] Given the high growth rates alongside continued market uncertainty, many Chinese manufacturers took unusual steps that included the preemptive construction of manufacturing factory buildings without installing the production equipment itself.

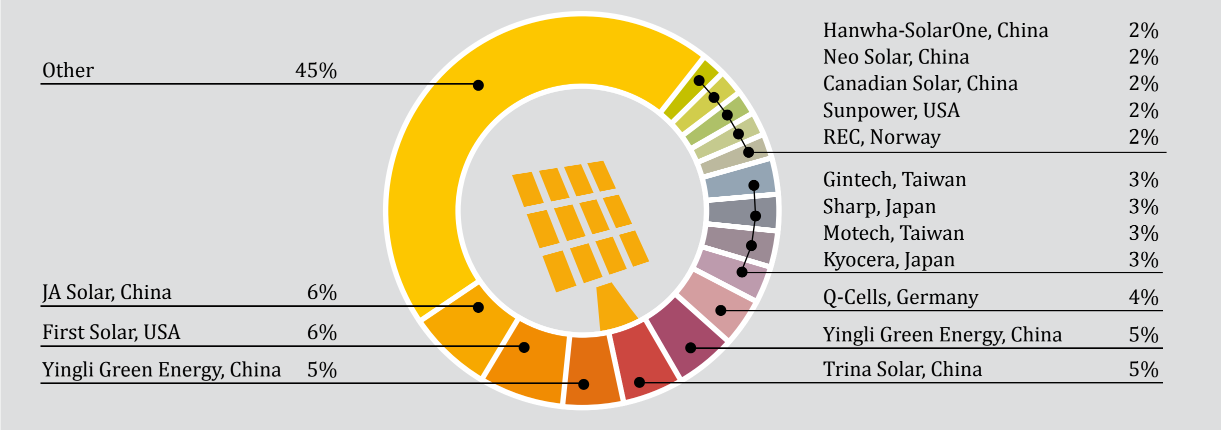
In the United States, growth rates for the manufacture of PV components and materials were 97% for wafers (to 624 MW), 81% for cells (to 1,058 MW), and 62% for modules (to 1,205 MW).[30] New U.S. plants are under construction in Tennessee (Wacker Chemie's polysilicon), California (Flextronic's module), and Mississippi (Stion's CIGS); however, some facilities were closed during 2010, including a BP plant in Maryland, a Spectrawatt plant in New York, and an Evergreen Solar plant in Massachusetts.[31]

The year 2010 also saw diversification of manufacturing to new regions and new partners. For example, Germany's SolarWorld announced a joint venture with Qatar's government to invest $500 million in a 3,600 tonnes/year polysilicon facility that is expected to start production in 2012.[32] South Korea's Hanwha Corporation acquired a 49% stake in Chinese Solarfun, and the Korean corporations Samsung, LG, Hyundai, and STX all expanded their cell manufacturing capacity.

Chinese leader Suntech acquired 100% of Japan's MSK Corporation and became the first Chinese firm to establish a U.S. manufacturing presence, with the opening of a 30 MW manufacturing facility in Arizona in October.[33] The emergence of new thin-film producers reduced First Solar's dominance to a 44% global market share in 2010, its lowest since 2006. Japan's Solar Frontier opened the world's largest thin-film plant, with 1 GW/year capacity.[34]

Many solar PV manufacturing firms continued their vertical integration in 2010 by expanding into project

Figure 14. Market Shares of Top 15 Solar PV Cell Manufacturers, 2010



Source: PV News

Sidebar 3. SUSTAINABILITY SPOTLIGHT: RARE-EARTH MINERALS AND PV RECYCLING

As renewable energy markets and industries continue to expand, so does their use of raw materials. The U.S. Department of Energy estimates that clean energy technologies (which include PV cells, wind turbines, electric vehicles, and fluorescent lighting) now account for approximately 20% of the global consumption of "critical materials," including the rare-earth elements[I] and other key elements such as indium, gallium, tellurium, cobalt, and lithium.

Rising demand has exposed uncertainties in the supply chains of these materials, which are critical in the manufacture of both PV films as well as the permanent magnets and batteries used in wind turbines and electric vehicles. China, which possesses roughly 36% of the world's rare-earth deposits, currently produces around 97% of the global supply. It is projected to fall short of meeting the annual 10–15% growth in rare-earth demand within two to three years.

China also is implementing more stringent controls over its formerly under-regulated rare-earths industry, exacerbating uncertainties in global supplies. Citing concerns over environmental impacts and overexpansion, the government cut rare-earth exports 72% in early 2010 and a further 11% in the first half of 2011. It also introduced tough pollution controls in late 2010 that are likely to further restrict rare-earth extraction and processing.

As a result, 2010 saw price increases of 300–700% for various rare-earth elements. Policymakers have responded with a variety of measures aimed at stabilizing the rare-earth risk. Some countries, such as Japan, are actively supporting the expansion of rare earth mining activities beyond their own borders while also investing in stockpiles of strategic minerals. Others are developing their own reserves: in Canada alone, 26 companies are involved in exploration, and rare-earth mines are expected to come on line soon in Australia, the United States, Canada, South Africa, and Kazakhstan.

The U.S. government has allocated $15 million for R&D on rare-earth elements and for the development of substitutes for rare-earth magnets. These efforts have been echoed in the European Union, South Korea, and Japan, as well as in private industry, where a number of firms are developing ferrite magnets to replace magnets based on rare-earths such as neodymium. In addition, the U.S. government is investing $35 million in the development of batteries free of rare-earth elements, with similar programs under way in Japan, the EU, and South Korea. In the long term, public and private nanotechnology research programs are looking to use nano-composites to reduce the rare-earth content of permanent magnets.

At the other end of the product life-cycle, burgeoning production, operation, and decommissioning processes have highlighted growing environmental and materials issues. In the solar PV sector in particular, questions about material and energy flows, environmental impacts, and the reprocessing of used components have become increasingly central. With total installed global solar PV capacity increasing by seven times between 2005 and 2010, these practices have come under greater scrutiny, driving innovations in efficient manufacturing, new production equipment, recycling of process-water and other resources, and the on-site generation of renewable process energy.

Of growing importance is the recycling of solar panels that have reached the end of their service life. While current quantities of disused PV modules remain too small to fully support an extensive recycling operation, it is predicted that around 130,000 tonnes of end-of-life PV panels will be ready for disposal in Europe by 2030.

In anticipation of this, the PV industry has launched initiatives such as the "Solar Scorecard" operated by the nonprofit Silicon Valley Toxics Coalition, which ranks the overall environmental impact of numerous solar manufacturers. In Europe, a network of recycling depots and collectors for end-of-life solar PV panels has been established by the organization PV Cycle. By March 2011, the group had recorded the collection of around 150 tonnes of end-of-life PV modules, many of which are now in various stages of the recycling process.

Source: See Endnote 37 for this section.

I) The "rare earths" are a group of 17 elements that exhibit unique catalytic, magnetic and optical properties. They include scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium.

development, a trend first noted in 2008. In Japan, manufacturers have become involved in direct retailing, installation, and after-sale service. Some traditional energy companies have diversified by expanding their operations into renewable energy: Saudi Arabian energy firm KA-CARE announced a 10 MW PV plant for desalination in 2010, and oil company Saudi Aramco is co-developing a 1–2 MW power plant with Solar Frontier.[35]

In response to India's National Solar Mission, with its ambitious target of 20 GW of solar power installed nationwide by 2022, India's domestic solar manufacturing industry saw new growth in 2010. Indian firms include Bharat Heavy Industries, Central Electronics, HHV Solar Technologies, Indosolar, KSK Surya Photovoltaic, Moser Baer, Tata BP, Websol Energy Systems, XL Telecom & Energy, Jupiter Solar Power, and Bhaskar Silicon. Moser Baer India led in new project installations during 2010, including the commissioning of a 1 MW thin-film power plant in Maharashtra.[36]

Concentrating Solar Thermal Power (CSP) Industry

The year 2010 saw some notable trends in the CSP industry. Although industry activity continued to focus in the two leading markets of Spain and the United States, the industry expanded its attention to other markets in Algeria, Australia, Egypt, Morocco, and even China. Still, most industry expansion took place in Europe and the United States. For example, Schott of Germany doubled its production of receiver tubes in its facility in Seville, Spain. Rio Glass of Spain, a relatively new company that has become a major producer in recent years, was building a manufacturing plant in the United States and also planning for plants in India and China.[38]

The industry also saw several acquisitions by major energy players seeking to enter the CSP market. Siemens bought Solel (Israel), ABB bought Novatech, GE bought E-Solar, and Ariva bought Ausra. Alstrom also entered into a joint venture with Bright Source. The industry remained vertically integrated, with individual companies involved in many parts of the value chain, but this was expected to change as markets expand and as companies specialize in specific parts of the value chain.[39]

Firms also began to expand their technology development efforts to include molten salt technology. Examples are Bass and Yara of Spain. Development of new designs for molten salt towers and even trough systems was continuing in expectation of new Spanish policy for CSP beyond 2012. Such new policy would allow for new designs and technologies, in contrast to the existing but limited feed-in tariff, which applies only to already-planned and designed projects.[40]

The Spanish industry leads the world in CSP plant design and operation with over 80 active firms.[41] Leading project development firms worldwide include Abengoa (Spain), Acciona (Spain), BrightSource (United States), Schott (Germany), and Siemens (Germany).[42] Leading mirror manufacturers include Saint-Gobain (France), Flabeg (Germany), and Rio Glass (Spain). Other notable CSP firms include Areva (Spain), eSolar (USA), Solar Millennium (Germany), and Solar Reserve (USA).[43]

Geothermal Heat and Power Industry

Geothermal power technologies include conventional "hydrothermal," enhanced geothermal systems (hot rocks, EGS), and co-production or geopressure systems. Plants are typically 50–200 MW and take 5–7 years to develop from discovery to commercial development. The risk to developers is similar to oil or mining projects where the size of the resource is unconfirmed until drilling takes place.

The U.S. industry is the global leader, developing approximately one-third of the world's new projects, all in its domestic market. Japanese firms Mitsubishi, Toshiba, and Fuji Electric supply 70% of the steam turbines at geothermal plants worldwide. Leading firms in conventional geothermal include Borealis Geopower, Calpine, CalEnergy, Chevron, Enel SpA, GeoGlobal, Gradient Resources, Magma Energy Corp., Mighty River Power, Nevada Geothermal Power, Ormat Technologies, Oski Energy, POWER Engineers, Ram Power, Terra-Gen Power, ThermaSource, and U.S. Geothermal. Leaders in EGS Geothermal include AltaRock Energy, EGS Energy, Geox, Geodynamics, and Potter Drilling.[44]

Hydropower Industry

The most mature of the renewables industries, the hydropower industry in developed markets such as the United States, the EU, Russia, Canada, and Japan is characterized by a focus on repowering, relicensing, and pumped storage development to complement increasing shares of variable renewable electricity. Elsewhere, particularly in emerging markets, the focus is on construction of new hydropower capacity.

During 2010 in Brazil, developers like PCH Brasil put projects on hold in response to rates of return below 12–14%.[45] The small hydro industry suffered in the EU, where conflicting national-level implementation demands associated with the Renewable Energy Directive and Water Framework Directive resulted in delays and permitting difficulties.[46]

The largest active hydropower industry is in China, where there are hundreds of small entrepreneurs and municipal governments, as well as a number of large players. India has a wide manufacturing base for small-scale hydropower equipment, with 20 active domestic manufacturers with equipment manufacturing total capacity of 300 MW per year. In addition, there are about five manufacturers producing equipment for micro-hydro and watermills.[47]

Alstom, Andritz, IMPSA, and Voith lead in the manufacture of hydropower equipment, accounting for approximately 40–50% of the global market. The remaining 50–60% market share is controlled by regional players, including American Hydro (North America), Bharat Heavy Electrical (India), CKD Blansko Holding (former Eastern Bloc), Energomashexport (Russian Federation and former Eastern bloc), and Hitachi and Toshiba (Japan and North America). Chinese equipment manufacturers Harbin Electric Machinery and Zhejiang Machinery & Equipment are also emerging as global players.[48]

Ocean Energy Industry

Wave and tidal technologies saw significant progress toward commercial generation in 2010, benefiting from a mix of government policies and financial grants and new entrants. Industry development in the U.K. led this nascent industry, with development also occurring in the United States and Canada. The focus continues to be on the design and evaluation of demonstration prototypes.

Manufacturers of wave energy devices include Pelamis Wave Power, Wave Dragon, Voith Hydro Wavegen, Ocean Energy Ltd., AWS II BV, Fred Olsen, Ocean Power Technologies, Aquamarine, and Wello Oy. Manufacturers of tidal current energy technologies include Hammerfest Strom, Verdant Power, Voith Hydro Ocean Current Technologies, Marine Current Turbines, Clean Current Power Systems, Ponte di Archimede, Open Hydro, Atlantis Resources, Minesto, Pulse Tidal, Tidal Energy, Tidal Generation, TidalStream, and VerdErg Renewable Energy.[49] At least 32 companies are active in the development and evaluation of prototype wave projects funded by the U.K. government, with the industry's long-term outlook growing following the auctioning of leases by the Crown Estate. The U.S. industry currently has more than 50 active companies.[50]

In 2010, a number of traditional hydropower firms joined the industry, including Andritz Hydro, Alstom Hydro, and Voith Hydro in 2010. Utilities that joined include Iberdrola-ScottishPower, Vattenfall, RWE, E.ON, Scottish & Southern Energy Renewables, and Scottish Power Renewables.[51]

Solar Heating and Cooling Industry

China has dominated the world market for solar water heating for several years and is also the world leader in manufacturing. Chinese manufacturers of solar water heaters produced 49 million m^2 of collector area in 2010. More than 5,000 firms were active in the Chinese industry, with most of them operating at the regional and/or national levels; however, approximately 20 of these firms were active internationally.[53] The largest Chinese firms include Himin, Linuo, Sunrain, and Sangle.

A major issue for Chinese manufacturers continues to be the need for systematic improvements in quality and product standardization. Most Chinese production is installed domestically, but increasingly China has been exporting to developing countries in Africa and Central and South America, regions with warmer climates where thermo-siphon systems can be sold. Chinese-made systems have also begun to enter the European market.[54]

In Europe, the solar hot water/heating industry has been marked by acquisitions and mergers among leading players, solid annual growth, and a shift toward increased use of systems for space heating in addition to hot water. Leading manufacturers include Alanod, Almeco-TiNOX, Bosch, Bluetec, GreenOneTec, the Ritter Group, and Solvis.

In 2010, leading manufacturers in Germany, Italy, Austria, and Spain began looking increasingly beyond domestic/regional markets to the emerging markets of India and Brazil. Leading European systems suppliers in 2010 included GreenOneTec, Viessman, Schueco, Thermosolar, Solvis, Ritter Solar, Wolf, Kingspan Solar, Vaillant, KBB Kollektobau, Riello Group, Ezinc, and Bosch Thermoteknik. As a result of a 26% drop in system sales in Germany during 2010, due to a temporary suspension of rebates, a number of firms in Germany declared bankruptcy and closed facilities.[55]

European installed system prices have not declined in the past 10 years, although tank and collector prices have decreased slightly.[56] By contrast, in Brazil the installation cost is typically only 10% of the total system price, reflecting the lower labor costs relative to the EU.[57]

Brazilian firms are emerging as major manufacturers of solar hot water systems. In 2010, Brazilian production of solar collectors reached almost 1 million m^2, an increase of 20% over the previous year.[58] In 2010, the industry consisted of 200 manufacturers and approximately 1,000 installers.[59]

In South Africa, following the doubling of the solar hot water subsidy in response to rising electricity rates, the market is booming and the industry has expanded as a result. Eskom, the South African national utility, recorded that 108 accredited suppliers, 245 registered distributors, and 124 registered independent installers participated in the incentive program during 2010, up from eight registered suppliers in 2008 when the subsidy scheme was first launched. The national association SESSA has grown from 200 to 500 corporate members, primarily installers, in two years.[60]

Ethanol Industry

The global ethanol industry recovered in 2010 in response to rising oil prices. Some previously bankrupt firms returned to the market, and there were a number of acquisitions as large traditional oil companies entered the industry.[61]

The corn ethanol industry continued to grow in the United States. Ethanol manufacturers in 29 U.S. states operated a total of 204 plants with a capacity of 51 billion liters, and 10 of these plants were undergoing expansion to increase capacity by 2 billion liters.[62]

The line between biofuel innovators and traditional oil players was blurred in 2010 with a number of prominent acquisitions. U.S. oil refiner Valero Energy established itself as one of the largest ethanol firms in the United States, acquiring 4.2 billion liters of production capacity at the conclusion of a process that began in 2009. By year's end, Valero Energy operated 10 ethanol plants, nine of which previously belonged to Verasun.

In addition, refiner Flint Hills acquired 830 million liters of production capacity from Hawkeye's plants in Kansas; Sunoco acquired Northeast Biofuels' 379 million liter ethanol plant in New York; and Murphy Oil acquired a 416 million liter North Dakota facility from Verasun. Producer Pacific Ethanol returned from bankruptcy in 2010, reopening four plants.[63] POET, the integrated biorefiner, operated 26 plants and produced more than 6 billion liters of ethanol (about 12% of the national total) and 4 million tonnes of animal feed in 2010.[64]

In Brazil during 2010, multiple vertically integrated sugarcane groups emerged in the ethanol space that was previously occupied only by market leader Cosan during 2010. Shell launched a joint venture with Cosan to generate electricity and produce ethanol and advanced biofuels, and thereby became Brazil's largest ethanol producer, with 23 mills producing sugar and ethanol. In addition, Shell and Cosan began jointly developing second-generation fuels with Iogen Energy of Canada. Bunge acquired Moema's five crushing plants, and Louis Dreyfus acquired Brazil's second largest sugarcane group, Santelisa Vale.[65]

By the end of 2010, sugar prices rose to the point that Brazilian ethanol could no longer be exported economically to the United States. Around 44% (up from 42% in 2008–09) of the sugarcane harvest was allocated to sugar production, leaving only 55% for ethanol production.[66] In response to strong demand and the need for increased production, Brazil approved a plan in 2010 to invest over $400 billon in the industry in order to meet domestic demand while also targeting a future tripling of ethanol exports to 9.9 billion liters/year.[67]

Biodiesel Industry

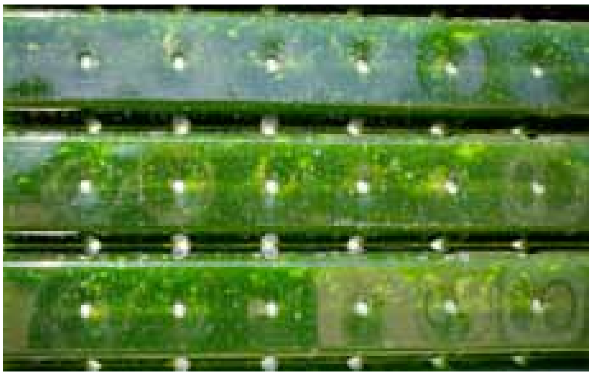
Producers in the EU continued to lead the biodiesel industry in 2010. However, affected negatively by rising rapeseed oil costs and cheaper imports, many EU producers operated at an average of 50% capacity or lower, similar to their 2009 levels. The 245 biodiesel plants in the EU-27 had 25 billion liters (21.9 million tonnes) of capacity, but produced only 10 billion liters of biodiesel in 2010.[68] Palm oil imports from Indonesia stood at 135 million liters (120,000 tonnes) in 2010, and were expected to rise to 565 million liters (500,000 tons) in 2011; further pressure comes from recycled oil, which is taking a share of the market from biodiesel refiners.

Following complaints that low-cost U.S. B99 biodiesel was being sold through Canada and Singapore to the EU starting in late 2006, the European Commission initiated a probe in August of 2010.[69] Consolidation in the sector continued in the EU, with deals such as Glencore's GLEN.UL takeover of Biopetrol.[70]

In Brazil, biodiesel production increased 50% over 2010, mostly in response to a domestic biodiesel blending mandate of 5% that was established in January 2010. By the end of 2010, there were 68 biodiesel plants operating in Brazil.[71] The country's largest firms are Granol, Brasil Ecodiesel, Caramuru, Petrobras, and ADM Brasil.[72]

In November 2010, Nestle Oil opened the world's largest renewable diesel plant so far, in Singapore. The company's vegetable oil-based NExBTL process plant will produce about 900 million liters (800,000 metric tonnes) of fuel per year.[73]

One of the fastest growing biodiesel industries is found in Argentina, where 23 biodiesel suppliers have responded to the increased national blending requirement for B7 (up from B5 in September).[74] The industry's growth was driven by the depreciation of the peso and by a strong soybean harvest. Argentina's largest firms are YPF, Shell, Eso, and Petrobras.[75]



Advanced Biofuels Industry

Although advanced biofuels were not yet being produced commercially at scale during 2010, the diversity of players in the advanced biofuels industry continued to increase. Participants included traditional oil companies, major aviation companies, and young, rapidly growing firms.

The aviation industry, which has committed almost exclusively to advanced biofuels, made major strides in 2010. Commercial airlines such as Lufthansa, Virgin Atlantic, Quantas, KLM, and Alaska Airlines, as well as the Royal Dutch Air Force and the U.S. Air Force, launched bio-ethanol initiatives or test flights. British Airways and Quantas launched a joint venture with Solena Fuels to support commercial biofuels refineries that convert wood and agricultural wastes to aviation fuels. In Brazil, a coalition led by developer Curcas launched the world's largest aviation bio-kerosene plant jointly with BP, Airbus, TAM Airlines, and Brasil EcoDiesel.[76] Producers of advanced biofuels including Amyris, ClearFuels, Sapphire Energy, Solazyme, and Solena Fuels have all made aviation fuels a focus.[77]

The companies Algenol, Martek, Solix, BioArchitecture, Accelergy, and Synthetic Genomics were also actively developing algae-based fuels during 2010. Overall, approximately 25 of the estimated 100 firms active in the algae space have made the transition from the laboratory to the pilot phase during the recession.[78] Pilot and demonstration plants operating in 2010 included Solix's 28,000 liter plant and Sapphire Energy's 2.6 million liter facility. The current cost estimate for photosynthetic microalgael biofuel production is $7 per liter.[79]

Traditional oil companies have begun to enter the algae industry. ExxonMobil has arranged a deal with Synthetic Genomics, and Shell with Cellana; Conoco Philips, Petrobras, and Neste Oil are supporting academic research or conducting internal studies.[80] Choren and Neste Oil both made advanced-biofuels investments in Europe prior to 2010, and Abengoa Bioenergy's 480 million liter facility in Rotterdam opened in April 2010.[81]

Sidebar 4. JOBS IN RENEWABLE ENERGY

Worldwide, jobs in renewable energy industries exceeded 3.5 million in 2010. (See Table.) A 2008 report by UNEP on jobs in renewable energy observes that while developed economies have shown the most technological leadership in renewable energy, developing countries are playing a growing role and this is reflected in employment.

China, Brazil, and India account for a large share of global total employment in renewables, having strong roles in the wind power, solar hot water, and/or biofuels industries. In addition to manufacturing, many of these jobs are in installations, operations, and maintenance, as well as in biofuels feedstocks. Jobs are expected to grow apace with industry and market growth, although increasing automation of manufacturing and economies of scale in installation services may moderate the rate of jobs growth below that of market growth.

Some countries keep track of total jobs from renewable energy. For example, the German government estimates 370,000 jobs currently, and the Spanish government estimates more than 70,000 jobs currently.

Industry	Estimated jobs worldwide	Selected national estimates
Biofuels	> 1,500,000	Brazil 730,000 for sugarcane and ethanol production
Wind power	~ 630,000	China 150,000 / Germany 100,000 / United States 85,000 / Spain 40,000 / Italy 28,000 / Denmark 24,000 / Brazil 14,000 / India 10,000
Solar hot water	~ 300,000	China 250,000 / Spain 7,000
Solar PV	~ 350,000	China 120,000 / Germany 120,000 / Japan 26,000 / United States 17,000 / Spain 14,000
Biomass power	-	Germany 120,000 / United States 66,000 / Spain 5,000
Hydropower	-	Europe 20,000 / United States 8,000 / Spain 7,000
Geothermal	-	Germany 13,000 / United States 9,000
Biogas	-	Germany 20,000
Solar thermal power	~ 15,000	Spain 1,000 / United States 1,000
Total estimated	**> 3,500,000**	

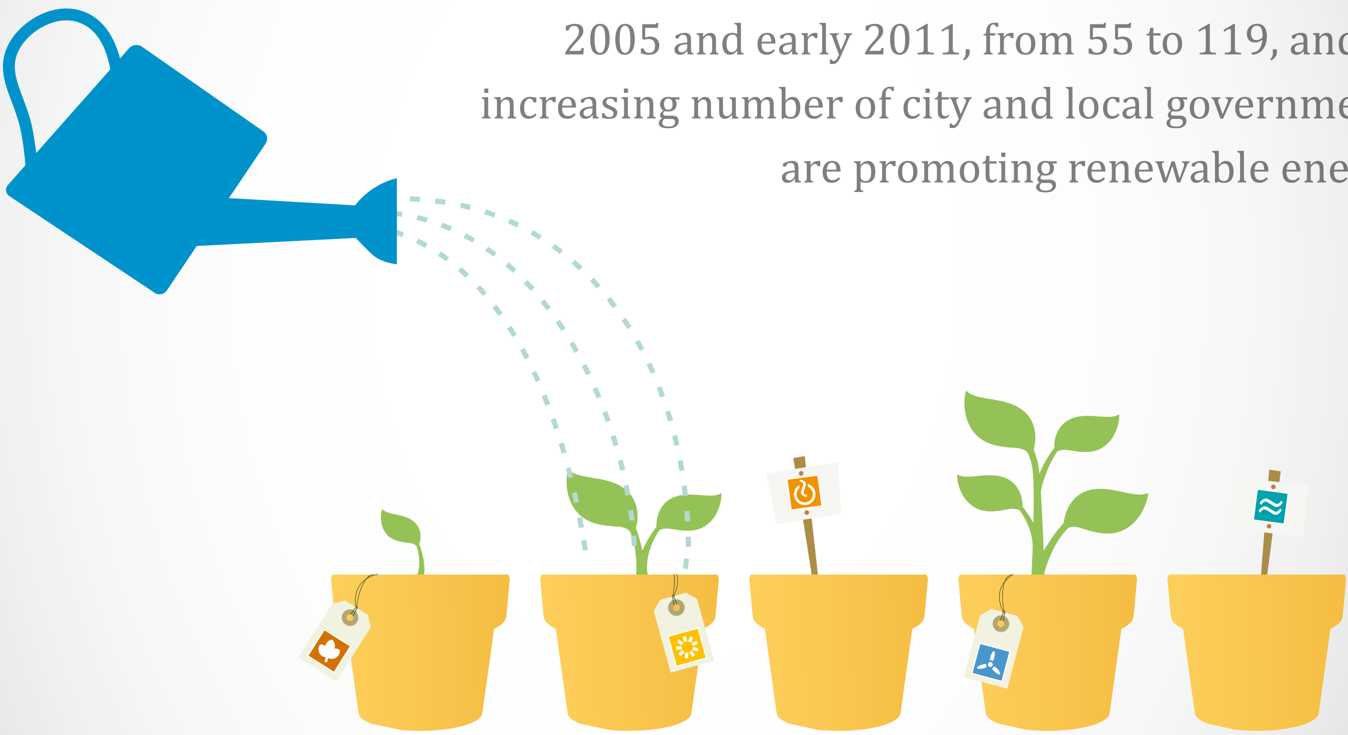
Note: Figures are rounded to nearest 1,000 or 10,000 as all numbers are rough estimates and not exact.

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 European Wind Energy Association (2009). Similar estimates for the solar PV sector are 38 person-years per MW produced and 0.4 jobs per MW existing, according to the European Photovoltaics Industry Association. 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).

Source: See Endnote 82 for this section.

04 POLICY LANDSCAPE

The number of countries with renewable targets or support policies more than doubled between 2005 and early 2011, from 55 to 119, and an increasing number of city and local governments are promoting renewable energy.



04 POLICY LANDSCAPE

Policies to support renewable energy investments continued to increase in number during 2010 and early 2011.[1] Only a few countries had renewable energy support policies in the 1980s and early 1990s, but many more countries, states, provinces, and cities began to adopt such policies during the period 1998–2005, and especially during the period 2005–2011. The number of countries with some type of policy target and/or support policy related to renewable energy more than doubled during this latter period, from an estimated 55 in early 2005 to 119 by early 2011.[2]

At the national, state/provincial, and local/municipal levels, policies have played a major role in driving renewable energy markets, investments, and industry developments. However, not all policies have been equally effective in supporting these developments.[3] The success of such efforts depends not only on policy choice, but also on policy design and implementation. (For further discussion of policy design and effectiveness, see the IPCC *Special Report on Renewable Energy Sources* discussed in Sidebar 5.) Consequently, governments continue to update and revise policies in response to design and implementation challenges and in response to advances in technologies and changes in the marketplace.

In addition, each year the synergies between policies that promote renewable energy and those that encourage energy efficiency improvements become clearer. One example of such synergy is the potential for reductions in energy supply as the energy demand in buildings is reduced.[4] Policies for building renovations and new construction standards are increasingly integrating on-site renewable energy and energy efficiency.

In 2010, the lack of long-term policy certainty and stability in many places around the world became a stronger factor for renewable energy markets. In response to continuing cost reductions for several technologies (particularly solar PV) and the global financial crisis that began in late 2008, many governments undertook reductions in tax and financial incentives for renewables, and others were contemplating significant policy overhauls. As a result, several national- and state-level renewable energy support mechanisms saw funding cuts in 2010, including in France, Germany, Spain, Italy, the Czech Republic, and the United Kingdom.[5]

Nevertheless, supporting policies continued to exert substantial influence on the rate of increase of the shares of renewables in the electricity, heat, and transport markets. The renewable energy industry, along with many other players, continued to push for stable, long-term policies and effective policy mixes. In many instances, a combination of policies (such as offering an incentive in parallel with running a related education program) has proved more successful than taking a single approach (such as simply providing a tax credit). In general, the global renewable energy market remains in a state of flux as policymakers continue to be challenged to set realistic and achievable targets and to link them with appropriate long-term policy mechanisms.

This section surveys the landscape of existing renewable energy targets and policies, including new and amended policies at the national, state/provincial, and local levels. For a fuller history of renewable energy policies enacted since 2005, refer to past editions of this *Renewables Global Status Report*.

POLICY TARGETS

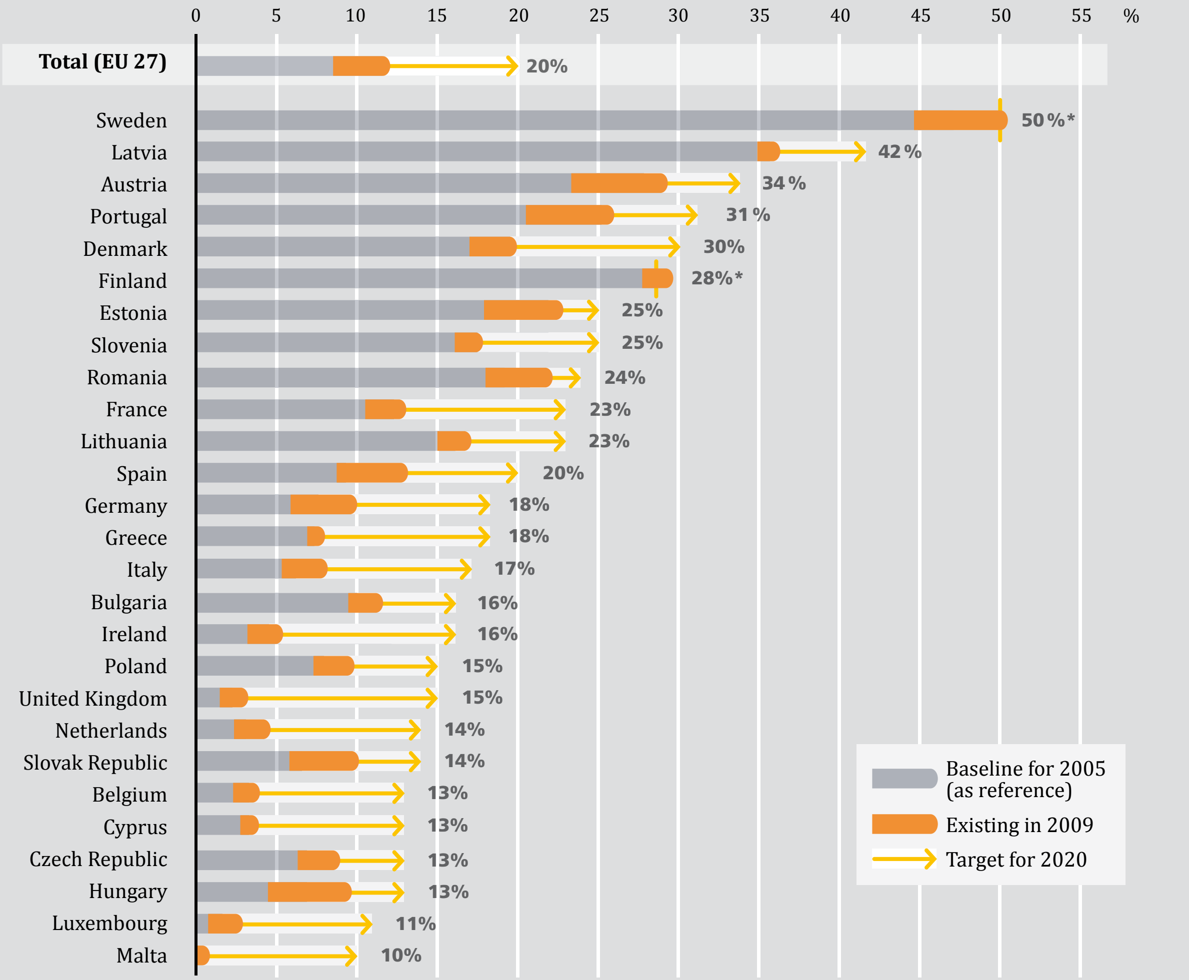
Policy targets for various penetration levels of renewable energy as part of the future energy supply continue to grow in number.[6] Targets now exist in at least 98 countries, more than half of which are developing countries. (See Reference Tables R7–R9.) Most targets are for shares of electricity and typically aim at 10–30% of total electricity within the next 1–2 decades. Other types of targets include renewable energy shares of total primary or final energy, share of heat supply, installed capacities of specific technologies, and shares of biofuels in road transport fuels.[7] Targets typically apply to a specific future year, although some apply to a range of years.

Many targets existed for 2010 and, although some data for that year were still not available by mid-2011, it appears that many countries and states met their 2010 targets. In other cases, targets either were missed or were scaled back. However, because some targets are more ambitious than others, and because the supporting policies needed to help achieve them are not always implemented strongly or consistently, caution is needed when judging the "success" of policy targets.

The European Union's 2010 targets for wind power (40 GW), solar PV (3 GW_{peak}), CSP (1 GW), and heating/heat pumps (5 GW_{th}), were all surpassed.[8] By the end of 2010, wind power capacity had reached 86 GW and solar PV exceeded 29 GW.[9] These strong growth trends are expected to continue and mean that the EU could well surpass its 2020 target of having 20% of energy come from renewables.[10] (See Figure 15, next page.) However, neither the Renewable Electricity Directive nor the Biofuels Directive targets for 2010 were fully met (targets were 21% and 5.75% shares of electricity and transport fuels, respectively).[11]

Within the EU, many individual countries met their targets for 2010 or were about to do so. Two countries – Finland and Sweden – even passed their 2020 targets by 2010. Scotland is on track to exceed its target, set in 2007, for 31% of total electricity generation coming from renewables by 2011.[12] Consequently, the Scottish government raised its 2020 target for the renewable

Figure 15. EU Renewable Shares of Final Energy, 2005 and 2009, with Targets for 2020



* Both Sweden and Finland in 2009 exceeded their targets, achieving 50.2% and 29.8% respectively.

Source: EC and EurObserv'ER

share of total electricity generation from 50% to 80%. In Germany, the 2010 target of 3.5 GWp for newly installed solar PV capacity under the Renewable Energy Act (EEG) was easily exceeded.[13] This led to an agreement with the PV industry for an annual reduction in feed-in-tariffs (FITs) if a cap of 3.5 GW is surpassed.[14]

Australia met its original 2010 target of 9.5 TWh for renewable electricity well before 2010.[15] A consequent revision of the scheme, legislated in June 2010 as a result of separate state targets encouraging many small projects, resulted in a new 45 TWh target by 2020. This target will be met in part through a Small Renewable Energy Scheme (SRES) with uncapped fixed-price certificates bought and sold in a national certificate market. That scheme will help support an overall target for annual electricity generation to reach 10.4 TWh by 2011 and then increase to 41 TWh by 2020. (An additional 4 TWh of the total target is to come from the SRES.)

In China, favorable government policies have resulted in a significant increase in installed wind power capacity every year since 2005.[16] Wind power in China reached nearly 45 GW in 2010 (although not all was operating; see Global Market Overview section).[17] This was well above the former national targets for wind (5 GW by 2010 and 30 GW by 2020), as issued by the National Development and Reform Commission in 2007. A new target for wind power of 130 GW by 2015 was set in the 12th Five-Year Plan (2011–15), with a further unofficial target of 150–200 GW by 2020.[18] China's previous target for a 10% share of total primary energy from renewables by 2010 was almost met, as the share exceeded 9%, but attention has shifted to the new target for 2020, a 15% share of non-fossil (renewables and nuclear) final energy by 2020 (a metric that appeared to reach about 9.1% renewables and 0.4% nuclear in 2010).[19]

Some countries did not achieve their 2010 targets. For example, India missed its target for 2 GW of added wind power in 2010.[20] And some countries have scaled back their existing targets for a variety of reasons. For example, the U.S. Environmental Protection Agency reduced its mandate for about 950 million liters of advanced cellulosic biofuels by 2011 (as originally envisioned in the Energy Independence and Security Act of 2007) to just around 25 million liters, citing the difficulty of securing sufficient finance to set up commercial production facilities.[21] Spain has reduced its goal for 8.3 GW of solar PV cumulative total capacity for 2020 down to 6.7 GW.[22] Both Chile and Israel have reduced their 2020 electricity targets from 10% down to 8% and 7% respectively.

On the other hand, several governments have raised existing targets. Finland increased its existing target for transport biofuels, which was for up to 6% by 2014, to 20% by 2020.[23] Spain increased its minimum biofuel blend level from 5.8% in 2010 to 6.2% in 2011, and 6.5% in 2012.[24] Germany introduced a goal in 2010 to achieve 35% renewable electricity in 2020 as part of a new "Energy Concept" that would extend the still-official policy target of 30% by 2020, as established in 2008.[25] Taiwan is now aiming for a 16% renewable electricity share by 2025 compared with the previous 15.1% target.[26] And Jordan's 2020 target for total share of renewable energy was increased from the previous 1% to 10% based around individual technology targets such as 30% of solar for water heating, 1,000 MW of wind power, and 300–600 MW of solar thermal electricity.[27]

New targets introduced by countries, states, and territories (see Tables R7, R8, and R9) include South Africa's 1 million new SWH installations by 2014[28]; Guatemala offering tax breaks on equipment to project developers in its aim to generate 60% of total electricity from hydro and geothermal by 2022[29]; India aiming to increase its 2013 target for 10 MW of grid-connected renewable capacity to 1,000 MW of solar power (from both PV and concentrating solar power (CSP) equally) and by 2020 to 20,000 MW through a number of incentives[30]; the U.S. state of Oklahoma setting a target for 15% of total electricity generation capacity to be derived from renewable sources, including hydropower, by 2015[31]; the U.S. territory of Puerto Rico's renewable electricity target of 12% of total power generation for 2015–19 ramping up to 20% by 2035[32]; the Cook Islands, following its Pacific Island neighbor Tonga, aiming for 50% renewable electricity by 2015 and 100% by 2020, supported by a a feed-in tariff (FIT)[33]; and the United Arab Emirates targeting 5% of energy by 2030.[34] In India, the recent Jawaharlal Nehru National Solar Mission was responsible for the increased 2013 and 2020 targets for PV and CSP.[35]

At the regional level, a handful of targets exist, such as the EU 2009 Renewables Directive and the Mediterranean Solar Plan (which would add 20 GW of renewables by 2020), but no new regional targets were adopted in 2010.[36]

POWER GENERATION POLICIES

At least 95 countries now have some type of policy to support renewable power generation. More than half of these countries are developing countries or those considered "emerging economies." Such policies are the most common type of renewables policy support, although many other policy types exist to support renewable energy for heating, cooling, and transport. [37] (See Table 2 and following sections.)

Sidebar 5. IPCC SPECIAL REPORT ON RENEWABLE ENERGY SOURCES

The UN Intergovernmental Panel on Climate Change (IPCC) published a *Special Report on Renewable Energy Sources and Climate Change Mitigation* in mid-2011 after over two years of effort by more than 100 authors, including some of the authors of this *Renewables Global Status Report*. The IPCC special report provides broader coverage of renewable energy than was included in the IPCC's latest climate change assessment report (in 2007), as well as stronger policy linkages and more substantial information for policymakers. In addition to comprehensive technical coverage, the special report assesses existing policy experience and policies needed for further progress in developing renewables.

The report notes that government policies play a crucial role in accelerating the deployment of renewable technologies. Under most conditions, increasing the share of renewable energy in the energy mix will require policies to stimulate changes in the energy system. There is no one-size-fits-all policy, and the details of design and implementation are critical in determining a policy's effectiveness and efficiency.

Systematic development of policy frameworks that are transparent and sustained in order to reduce risks, and that enable attractive returns over a timeframe relevant to the investment, can facilitate deployment of renewable energy and the evolution of low-cost applications. The existence of an "enabling" environment in parallel can increase the efficiency and effectiveness of policies to promote renewable energy deployment.

The report is expected to create a more informed and broader-based policy dialogue on support for renewable energy, as well as a better understanding of the role of renewables in climate change mitigation and overall energy system development. The report will contribute to international climate change debates and agreements and represents a milestone in access to understanding of renewable energy matters for many types of stakeholders.

The full IPCC report and the policymaker and technical summaries can be downloaded from www.ipcc.ch or http://srren.ipcc-wg3.de/.

Table 2. Renewable Energy Support Policies

▲ Some states/provinces within these countries have state/provincial-level policies but there is no national-level policy.

	REGULATORY POLICIES						FISCAL INCENTIVES				PUBLIC FINANCING	
	Feed-in tariff (incl. premium payment)	Electric utility quota obligation/ RPS	Net metering	Biofuels obligation/ mandate	Heat obligation/ mandate	Tradable REC	Capital subsidy, grant, or rebate	Investment or production tax credits	Reductions in sales, energy, CO_2, VAT, or other taxes	Energy production payment	Public investment, loans, or grants	Public competitive bidding
HIGH-INCOME COUNTRIES												
Australia	▲			▲		●	●				●	
Austria	●			●		●	●	●			●	
Belgium		▲	●	●		●	●	●	●			
Canada	▲	▲	●	●			●	●	●		●	●
Croatia	●						●				●	
Cyprus	●						●					
Czech Republic	●			●		●	●	●	●			
Denmark	●		●	●		●	●	●	●		●	●
Estonia	●			●			●		●	●		
Finland	●			●		●	●		●	●		
France	●			●		●	●	●	●		●	●
Germany	●			●	●		●	●	●		●	
Greece	●		●				●	●			●	
Hungary	●			●			●		●		●	
Ireland	●				▲	●						●
Israel	●				●				●			●
Italy	●	●	●	●	●	●	●	●	●		●	●
Japan	●	●	●			●	●				●	
Latvia	●			●					●		●	●
Luxembourg	●						●					
Malta			●				●		●			
Netherlands				●		●	●	●	●	●		
New Zealand							●					
Norway				●		●	●		●		●	
Poland		●		●		●	●		●		●	●
Portugal	●	●	●	●	●		●	●	●		●	●
Singapore											●	
Slovakia	●						●					
Slovenia	●					●	●	●	●		●	●
South Korea[1]		●		●		●	●	●	●		●	
Spain[2]	●			●	●		▲	●	●		●	
Sweden		●		●		●	●	●	●	●		
Switzerland	●						●		●			
Trinidad & Tobago							●	●	●			
United Kingdom	●	●		●		●			●	●	●	
United States	▲	▲	▲	●	▲	●	●	●	●	●	●	●

Table 2. Renewable Energy Support Policies (continued)

	REGULATORY POLICIES						FISCAL INCENTIVES				PUBLIC FINANCING	
	Feed-in tariff (incl. premium payment)	Electric utility quota obligation/ RPS	Net metering	Biofuels obligation/ mandate	Heat obligation/ mandate	Tradable REC	Capital subsidy, grant, or rebate	Investment or production tax credits	Reductions in sales, energy, CO_2, VAT, or other taxes	Energy production payment	Public investment, loans, or grants	Public competitive bidding
UPPER-MIDDLE INCOME COUNTRIES												
Algeria	●											
Argentina	●			●			●	●	●	●	●	●
Belarus									●		●	
Bosnia & Herzegovina	●											●
Botswana									●			
Brazil				●					●		●	●
Bulgaria	●			●			●		●		●	
Chile		●					●		●		●	
Colombia				●			●					
Costa Rica	●			●								
Dominican Rep.	●						●	●	●			
Iran								●		●		
Kazakhstan	●					●						
Lithuania	●										●	
Macedonia	●										●	
Malaysia	●										●	
Mauritius							●					
Mexico			●					●			●	●
Panama	●									●		●
Peru	●			●				●	●	●		●
Romania		●		●		●			●		●	
Russia						●	●					
Serbia	●											
South Africa	●					●	●					●
Turkey	●											
Uruguay		●		●					●			●

Note: Countries are organized according to per capita income level as follows: "high" is $12,196 or more, "upper-middle" is $3,946 to $12,195, "lower-middle" is $996 to $3,945, and "low" is $995 or less. Per capita income levels from World Bank, 2010. 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.

1 In South Korea, the current feed-in tariff will be replaced by an RPS policy in 2012.

2 In Spain, the Value Added Tax (VAT) reduction is for the period 2010–12 as part of a stimulus package.

3 In Mozambique, the biofuel blend mandate approved but not yet specified.

Source: See Endnote 37 for this section.

Table 2. Renewable Energy Support Policies (continued)

▲ Some states/provinces within these countries have state/provincial-level policies but there is no national-level policy.

* The Palestinian Territories are not included in the World Bank country classification, they have been placed using the 2008 "Occupied Palestinian Territory" GNI per-capita provided by the UN ($1,595)

	REGULATORY POLICIES						FISCAL INCENTIVES				PUBLIC FINANCING	
	Feed-in tariff (incl. premium payment)	Electric utility quota obligation/RPS	Net metering	Biofuels obligation/mandate	Heat obligation/mandate	Tradable REC	Capital subsidy, grant, or rebate	Investment or production tax credits	Reductions in sales, energy, CO_2, VAT, or other taxes	Energy production payment	Public investment, loans, or grants	Public competitive bidding
LOWER-MIDDLE INCOME COUNTRIES												
Armenia	●											
Bolivia									●			
China	●	●		●	●		●			●	●	●
Ecuador	●											
Egypt							●		●		●	●
El Salvador								●	●	●	●	●
Guatemala			●					●	●			●
Honduras	●							●	●			●
India	●	●		●		●	●	●	●		●	●
Indonesia	●						●	●	●		●	●
Jordan			●						●			
Marshall Islands									●			
Moldova	●								●		●	
Mongolia	●											●
Morocco											●	
Nicaragua	●							●	●			
Pakistan			●				▲				●	
Palestinian Ter.*									●			
Philippines	●	●	●	●			●	●	●	●	●	●
Sri Lanka	●											
Thailand	●			●							●	
Tunisia							●		●		●	
Ukraine	●											
Vietnam							●	●	●			
LOW INCOME COUNTRIES												
Bangladesh							●				●	
Ethiopia				●					●		●	
Gambia									●			
Ghana						●			●			
Kenya	●								●			
Kyrgyzstan		●					●		●			
Mali									●			
Mozambique[3]				●							●	
Nepal							●	●	●		●	●
Rwanda									●		●	
Tanzania	●						●		●			
Uganda	●						●		●			
Zambia									●			

Of all the policies employed by governments, feed-in tariffs (also called premium payments, advanced renewable tariffs, and minimum price standards) remain the most common. By early 2011, at least 61 countries and 26 states/provinces had FITs, more than half of which had been enacted since 2005.[38] (See Table R10.)

There are many variations of FITs, and no single definition applies.[39] (See Sidebar 6.) In one variation of a new FIT, the U.S. State of Louisiana's Public Utility Commission announced in 2010 that electric utilities would be required to implement a limited "standard offer tariff" that is undifferentiated by project size, technology, or resource intensity. This type of tariff represents the utility's "avoided cost" of generation plus an "environment" premium fixed at U.S. 3 cents/kWh. The tariff also sets total floor and ceiling prices of 6 cents/kWh and 12 cents/kWh, caps total capacity at 30 MW per utility, and applies to projects between 25 kW and 5 MW.[40] The additional costs are passed on to ratepayers through a fuel adjustment clause, an approach normally used to cover increases in the cost of fossil fuels.[41]

Several of the existing FIT policies around the world are presently under review. In particular, many countries are revising solar PV FITs to dampen the booming rate of installations, which in many cases are far exceeding expectations due to the unprecedented price reductions in solar PV that occurred in 2009 and 2010. In late 2010, the Czech Republic passed new legislation to slow the rate of PV installations as total capacity increased from 65 MW at the end of 2008 to nearly 2 GW by the end of 2010 – in part out of concern for the impact of the FIT on average electricity prices.[42] Effective from March 2011, the country cut all FIT rates for ground-mounted PV installations that were not yet interconnected with the grid. In May 2011, Italy cut tariffs for solar PV by 22–30% for 2011, by 23–45% for 2012, and by 10–45% for 2013 (ranges apply to different scales of installation). A project ceiling of 1 MW on rooftops and 0.2 MW for ground-mounted systems was also imposed to limit the total cost to EUR 6–7 billion by the end of 2016, when roughly 23 GW are expected to be installed.[43]

Many other FIT changes took place in 2010. In Spain, the EUR 0.42/kWh FIT level for solar PV, as set in 2007, still remains, but new legislation now caps the annual hours rewarded by the FIT, and some uncertainty arose regarding retroactive cuts to existing systems.[44] Greece's financial problems led to the government blocking a backlog of project applications for support incentives worth over EUR 2 billion, but the restriction was lifted in September 2010 and new projects continued. The United Kingdom decided in 2010 to replace its existing quota policy with a FIT, starting in 2013, for "low carbon generation."[45] Bulgaria, through its new Renewable Energy Act of June 2011, put an annual cap on new projects receiving the FIT prices by applying a quota.[46] And Turkey enacted a long-awaited renewable energy law that replaces the existing single-rate FIT with technology-specific FIT rates over a 10-year term for wind, geothermal, biomass, biogas, and solar, with bonus payments if hardware components are made in Turkey.

In Australia, the federal government in December 2010 adjusted the solar rooftop PV credit scheme in order to wind it down faster than was originally planned due to the impact on electricity prices, continuing strong industry growth, and the resulting lower demand for other clean energy technologies such as solar water heaters.[47] In May 2011, it reduced the AUD 1.5 billion Solar Flagship program, which aims for four grid-connected power stations, by AUD 220 million.[48] New South Wales reduced its solar PV FIT incentive by a third, to AUD 0.40/kWh, and cut the scheme for new participants because the measure had cost the state some AUD 1.9 billion since its inception in 2009.[49] Conversely, the Australian Capital Territory (ACT) expanded the existing FIT for rooftop solar PV so it also applies to 30–200 kW grid-connected generation systems, up to a total installed capacity cap of 240 MW.[50]

Although most policy activity in developed countries involves revisions to existing FITs, at least three new FIT policies were introduced or implemented in developing countries in 2010 and early 2011. Malaysia's policy aims to meet a 3,000 MW renewables target by 2020, with one-third of that expected from solar PV and another third from bioenergy.[51] Ecuador adopted a new system of FITs in early 2011, following an earlier FIT policy from 2005.[52] And Uganda began implementation of its existing FIT in early 2011 for 11 separate technologies.[53] Many other developing countries saw increasing capacity of renewables from previously enacted FIT policies.[54]

Another common policy in some jurisdictions, particularly at the state/provincial level in the United States, Canada, India, Australia, and a growing number of other regions, is the "quota" or "renewable portfolio standard" (RPS). A quota/RPS is an obligation (mandated and not voluntary) placed by a government on a utility company, group of companies, or consumers to provide or use a predetermined minimum share from renewables of either installed capacity, electricity generated, or electricity sold.[55] A penalty may or may not exist for non-compliance.

Sidebar 6. WHAT IS A FEED-IN TARIFF?

A basic feed-in tariff (FIT) is a renewables promotion policy that pays a guaranteed price for power generated from a renewable energy source, most commonly for each unit of electricity fed into the grid by a producer, and usually over a fixed long-term period (typically 20 years). A FIT also can be developed for units of heat supplied from biomass, solar thermal, or geothermal energy sources.

The FIT payment is usually administered by the utility company or grid operator and is derived from an additional per-kWh charge for electricity (or other energy source, such as heat) that is imposed on national or regional customers, often spread equally to minimize the costs to individuals. Tariffs may be differentiated by technology type, size, and location, and they usually decline over time. The basic FIT has been popularized in its "modern" form by Germany, which serves as a reference point for all similar policies. It could be called a "market-independent" mechanism.

Another variation of a FIT policy is a "premium FIT," a market-dependent mechanism developed principally by Spain and emulated elsewhere. Here, two remuneration components exist instead of one: a reduced FIT payment, plus the hourly market price for electricity. To ensure that the combination of the two does not pay producers either too little or too much, the Spanish version uses a lower floor and upper cap.

The policy community broadly agrees that a "true" FIT includes three key provisions: 1) guaranteed grid access, 2) long-term contracts for the electricity (or heat) produced, and 3) prices based on the cost of generation plus a reasonable rate of return. However, formulating a definition that is broad enough to encompass all of the instruments claimed to be FITs by their legislative creators is difficult. The range of policies and their provisions vary widely year-by-year. Moreover, experts may disagree about whether or not a given policy should be called a "true" FIT, based on price levels, capacity limits, administrative provisions, or other factors.

For the purposes of this report, policies are classified as FITs if they are defined as such by the jurisdictions enacting them, rather than relying on an absolute set of criteria that would be difficult to apply in practice.

Quota/RPS policies are also known as "renewable electricity standards," "renewable obligations," and "mandated market shares," depending on the jurisdiction. Quota/RPS policies can be linked with certificate schemes to add flexibility by enabling mandated entities (utilities) to meet their obligations through trading. By early 2011, quota/RPS policies existed in 10 countries at the national level and in at least 50 other jurisdictions at the state, provincial, or regional level. (See Table R11.)

In the United States, 30 states (plus Washington, D.C.) have RPS policies, and six more have non-binding policy goals.[56] U.S. RPS policies continue to evolve and expand actively each year. For example, in early 2010, the New York Public Service Commission expanded the state's RPS requirement for investor-owned utilities from 24% by 2013 to 29% by 2015.[57] In California, utilities will probably reach their 20% RPS target in 2012, four years early. After some years of debate, California enacted a new RPS target in early 2011 for 33% of electricity by 2020.[58] The California Public Utilities Commission (CPUC) also authorized the use of tradable renewable energy credits (TRECs) for RPS compliance.[59] Delaware amended its RPS in 2010 to require municipal utilities within the state, as well as the major investor-owned utility, the Delaware Electric Cooperative, to purchase a 25% share by 2026 from in-state sources, including 3.5% from solar PV systems.[63] And Iowa adopted new interconnection rules that mandate that renewable energy standards apply to distributed generation facilities of up to 10 MW.[64]

Elsewhere, quota/RPS policies continued to emerge and evolve in 2010. In South Korea, the government announced that by 2012 the existing FITs for wind and solar PV will be replaced with a quota system. The quota will mandate that 14 utilities generate 4% of electricity from renewables in 2015, increasing to 10% by 2020.[65] The new policy mandates 350 MW per year of additional renewable capacity up to 2016, and thereafter 700 MW per year through 2022.[66] As part of the policy, renewable energy projects will receive a 5% tax credit and local governments will receive capital subsidies up to 60% and low-interest loans. And in Canada, British Columbia's clean energy requirement of 93%, enacted in 2007, was legislated under the Clean Energy Act of 2010.[67]

Developing countries are a growing part of the policy landscape for policies beyond FITs and quota/RPS policies. In recent years, many developing countries have established comprehensive national laws and frameworks for renewable energy, as noted in past editions of this *Renewables Global Status Report*. In 2010, Jordan became one of the recent entries in this category when it established a renewable energy support fund and passed a new law to accelerate the development of both renewable energies and energy efficiency and to allow investors to present unsolicited proposals for grid-connected renewable energy investments.[68] In Malaysia, targets were adopted for solar PV and biomass, while Zambia relaxed tax policies in mining areas to stimulate investment in power capacity, with a preference for renewable energy technologies including hydro and solar.[69] Trinidad and Tobago also adopted measures for the promotion of renewable energy, introducing a variety of tax credits, exemptions and allowances for wind turbines, solar PV and solar hot water systems.[70]

Across the policy landscape, many other types of policies are promoting renewable power generation. (See Table 2.) At least 52 countries offer some type of direct capital investment subsidy, grant, or rebate. 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. 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. 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 quality or performance standards.

Countries continue to employ public competitive bidding for fixed quantities of renewable power capacity, in a variety of formats and levels. 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 14 countries and almost all U.S. states. And finally, new forms of electric utility regulation and planning are emerging that target the integration of renewables into power grids at increasing levels of penetration.[71] (See Sidebar 7.)

GREEN ENERGY PURCHASING AND LABELING

There are currently more than 6 million green power consumers in Europe, the United States, Australia, Japan, and Canada.[72] 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.[73]

Germany has become the world's green power leader, with a market that grew from 0.8 million residential customers in 2006 to 2.6 million in 2009.[74] These consumers purchased 7 TWh of green electricity in 2009 (6% of the nation's total electricity consumption). In addition to residential consumers, 150,000 business and other customers purchased over 10 TWh in 2009 (9.5% of total electricity consumption). Other major European green power markets are Austria, Finland, Italy, Sweden, Switzerland, and the United Kingdom, although the market share of green power in these countries is less than 5%.

Australia's 900,000 residential and 34,000 business consumers collectively purchased 1.8 TWh of green power in 2008. In Japan, the green power certificate market grew to 227 GWh in 2009 with more than 50 sellers.[75] The Green Heat Certificate Program began in 2010 for solar thermal, with biomass joining in 2011.[76] In South Africa, at least one company offers green power to retail customers using renewable electricity produced from bagasse combustion in sugar mills.

Some governments require that utilities offer green energy options to their consumers. In the United States, where green pricing programs are offered by more than 850 utilities, regulations in several states require utilities or electricity suppliers to offer green power products.[77] More than 1.4 million U.S. consumers purchased 30 TWh

Sidebar 7. GRID INTEGRATION AND COMPLEMENTARY INFRASTRUCTURE

As the share of renewable power increases in electricity grids around the world, the technologies and policies for grid integration – to handle the variability of some renewables – are advancing as well. On some national power grids, non-hydro renewables already make up large shares of total generation, for example 21% of Spain's electricity and nearly 14% of Germany's. (See the Global Market Overview section of this report.) Variable renewable sources – particularly wind and solar – are growing rapidly in these countries, as well as in Denmark, Portugal, Ireland, some U.S. states, and many other places.

Traditionally, electric power supply systems have provided enough flexibility to meet variable power demands, which can differ significantly by time of day and season of year. Conventional power plants offer some flexibility to adjust their output, on a response scale that ranges from minutes for natural gas and hydro plants (including pumped hydro storage) to hours for coal plants. Nuclear plants offer the least flexibility.

The existing flexibility of power grids offers some capability for integrating variable renewables up to a certain level of penetration. This level depends on the strength of the transmission grid, the degree and capacity of interconnection, the amount of existing reservoir or pumped hydro capacity, and the amount of generation that can be run on a flexible basis. The share of renewable generation that can be accommodated from this existing flexibility may vary from just a few percent on weak, inflexible grids to 30% or more on strong, flexible grids.

Power dispatch models that incorporate day-ahead weather forecasts for wind speeds and solar insolation have also become standard power system tools for handling more variable renewables. Beyond these standard tools, Spain in 2007 established a pioneering example of a separate power control center (CECRE) dedicated to renewable energy, which allows the transmission operator Red Eléctrica to monitor and control, in real time, renewable power generation around the country.

Smart grid controls and intelligent load management (also called "demand response" or "load control") have begun to extend the level of flexibility of power systems in ways that make higher shares of renewable energy possible at competitive economic cost. Such complementary technologies and practices support renewable energy development, especially in the presence of facilitating regulations and policies, although they can go only so far in extending the flexibility of traditional power grids.

In the longer term, advanced technologies and practices such as grid-connected energy storage (batteries or other forms of storage) and electric vehicles with "vehicle to grid" capability that functions as a form of storage, may allow even higher levels of renewable penetration, although some experts are convinced that intelligent load control by itself could provide enough additional flexibility without the need for more advanced storage technologies.

Geographic distribution of renewable energy project sites can also help to reduce variability by increasing resource diversity. Policies that influence the location and siting of wind and solar resources can explicitly enhance this diversity, as can policies for transmission grid planning and strengthening. In addition, having a diverse portfolio of renewable technologies that naturally balance each other, and including dispatchable renewables like hydro and biomass, can enable higher penetration levels.

Source: See Endnote 71 for this section.

of green power in 2009, up from 18 TWh in 2007.[78] The U.S. Environmental Protection Agency's Green Power Partnership grew to more than 1,300 corporate and institutional partners that purchased more than 19 TWh of electricity by the end of 2010.[79] The largest consumer, Intel, nearly doubled its purchases in 2010, to 2.5 TWh. Other innovative green power purchasing models are emerging in the United States. For example, some utilities enable customers to purchase shares in a community solar project and then obtain a credit on their utility bill equivalent to their share of the project output.[80]

The European Energy Certificate System (EECS) framework has 18 member countries and allows the issue, transfer, and redemption of voluntary renewable energy certificates (RECs). It also provides "guarantee-of-origin" certificates in combination with RECs to enable renewable electricity generators to confirm origin. During 2009, 209 TWh of certificates were issued, more than triple the number in 2006.[81] Norway, a major hydropower producer, issued 62% of all certificates under the EECS, virtually all of which were hydropower. In other European countries, green power labels such as "Grüner strom" and "Ok-power" in Germany and "Naturemade star" in Switzerland have been introduced to strengthen consumer confidence.

Price premiums for green power over conventional electricity tariffs have tended to decline in recent years.[82] For example, retail green power premiums for residential and small commercial consumers in the United States were typically U.S. 1–3 cents/kWh over the past several years, but recently some premiums have fallen below 1 cent/kWh.[83] Disclosure of renewable energy shares on consumer bills is used in Italy and elsewhere to help drive demand.[84] In general, green labeling programs provide information to consumers about energy products. They are either government mandated or voluntary guarantees that the products meet pre-determined sustainability criteria, including specified shares of renewable energy content. Labeling can therefore facilitate voluntary decisions for green energy purchasing. However, having several different labels can cause confusion for electricity consumers.[85]

Voluntary purchases of "green" energy by consumers are most commonly made for renewable electricity, but they also are possible for renewable heat and transport biofuels. For example, in New Zealand one independent transport fuel company, to distinguish itself commercially from the major oil companies in the market, offers a 10% ethanol blend and a 5% biodiesel blend.[86] These fuels were initially sold at a higher "green" price, but with recent oil price increases they have actually become a cheaper option. The 2009 New Zealand Biodiesel Grant scheme and Emission Trading Scheme have also helped to promote green energy purchases.[87]

HEATING AND COOLING POLICIES

Renewable energy heating and cooling policies are not being enacted as aggressively, nor implemented as rapidly, as policies for electricity or transport biofuels. Still, many more policies for heating and cooling have emerged in recent years, reflecting the significant potential for heating from modern biomass, direct geothermal, and solar hot water/heating. Already the energy from these forms of heating exceeds, in total final energy terms, the energy from all non-hydro renewable electricity as well as all biofuels.[89] (See Figure 1.)

Heat is supplied through district heating systems in a number of countries, but for most buildings and industries it is supplied on-site using a wide range of individual appliances and fuels.[90] Recent policies for renewable heating and cooling have favored regulatory approaches that mandate energy shares or equipment requirements, although policy approaches based on quotas are gaining momentum. Governments have traditionally relied on direct capital grants and tax credits for purchasing and installing renewable heating technologies, but new policies that provide public budget neutrality have been gaining favor.[91]

In particular, mandates for solar hot water in new construction represent a strong and growing trend at both the 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. Many other countries have followed suit. India's nationwide energy conservation code requires at least 20% of water heating capacity from solar for residential buildings, hotels, and hospitals with centralized hot water systems.[92] South Korea's new 2010 mandate requires on-site renewable energy to contribute at least 5% 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. In 2009, Hawaii became the first U.S. state to mandate solar hot water in new single-family homes, a policy that entered into force in 2010.

One example of a recent new policy is the 2010 solar hot water/heating National Strategic Reference Framework (QREN) in Portugal.[93] The QREN is a protocol established with several commercial banks to facilitate investment in solar hot water/heating for residential installations and also installations by small (45% non-refundable grant) and medium-sized (40% grant) enterprises. Another example is the Brazilian program "Minha casa, minha vida" (My House, My Life), which is targeting 300,000–400,000 solar water heaters in social housing projects.[94] The Brazil program targets 15 million m^2 of total solar collector area by 2015, up from 6 million m^2 in 2010. In Spain, in addition to the national solar hot water mandates mentioned earlier, the "Biomcasa" program, which is promoting the use of biomass for heat in buildings, provided EUR 5 million to certified energy service companies to offer a biomass alternative and ensure that building occupants receive a 10% minimum decrease in their heat bill.[95]

Balancing policy costs against policy effectiveness has led to the re-evaluation of some heating support measures in recent years. For example, in 2010 the German Ministry of Finance initially did not approve continued funding for a market incentive program to support solar hot water/heating, biomass heating, and efficient heat pumps.[96] After some months of public campaigning, however, the suspension was lifted.[97]

New policies introduced since the beginning of 2010 include the United Kingdom's innovative Renewable Heat Incentive (RHI), which started in June 2011 and will continue to 2014–15. The total program investment budget of GBP 850 million was retained, against the trend of wider government budget cuts.[98] Householders will receive a grant upon installing a renewable heating appliance, with long-term tariff support to be introduced in 2012. Businesses will receive Renewable Heat Premium payments quarterly over a 20-year period with exact support levels yet to be announced. Technologies include injection of biomethane into natural gas pipelines for heat applications.[99] The government aims to obtain 12% of U.K. heating from renewable sources by 2020, compared with about 2% at present, although the country's 4 pence/kWh biomethane tariff is lower than other key European biomethane heat markets such as Germany and France.[100] Germany rejected an approach similar to the U.K.'s in favor of a heat obligation, in part because heat metering costs are relatively high for smaller applications.[101]

Another example of new policies, the newly implemented Irish guaranteed support price, ranging from EUR 8.5 cents/kWh to 15 cents/kWh depending on the technology deployed, includes heating from anaerobic digestion, combined heat and power (CHP), biomass CHP, and biomass heat, including provision for 30% co-firing of biomass in the three existing peat-fired power stations that are operating.[102] In Hungary, the National Renewable Energy Action Plan has a target of 4.4% share of heating and cooling from renewables by 2020.[103] This includes providing subsidies to help promote geothermal and biomass heat projects as well as for the installation of solar thermal systems.[104] The South African Department of Energy announced in 2010 its intention to offer 200,000 individual grants for a mass roll-out of the national solar water heating program under the Industrial Policy Action Plan.[105] Solar water heating is also gaining support in India where a 30% capital subsidy and/or loan at 5% has been made available.[106]

TRANSPORT POLICIES

Policies continue to support liquid biofuel production and blending for use as transportation fuel. Common policies include biofuel subsidies, tax exemptions, or blending mandates. Blending mandates now exist in 31 countries at the national level and in 29 states/provinces around the world. (See Table R12.) Fuel-tax exemptions and production subsidies exist in at least 19 countries, including 10 EU countries and four developing countries.[107] However, in some countries, recent reductions of support schemes has resulted in the closure of some biofuel production plants. Recent years have also seen increased attention to biofuels sustainability and environmental standards, most notably under the EU Renewable Energy Directive.[108]

Countries that have recently introduced biofuels blending mandates include South Korea (2% biodiesel and fuel-tax exemption incentives from 2012) and Jamaica (supporting policies for the development and expansion of bioethanol from sugar cane and biodiesel).[109] Several countries also enacted amendments to existing biofuel policy legislation in 2010. Finland increased the current mandated E4 biofuel blend (4% ethanol) to E6 for 2011–14, and then to E20 by 2020.[110] Ethiopia boosted the E5 blend to E10 in March 2011.[111] Thailand increased its subsidy on B3 and B5 diesel fuels to keep retail prices below THB 30 per liter.[112] And Spain increased the minimum biofuel blend for 2011 and mandated biodiesel blending to increase from the previous B3.9 to B6 in 2011 and then to B7 in 2012.[113]

In addition to mandated blending, several biofuels targets and plans define future levels of biofuels use. The EU is targeting 10% of transport energy from renewables by 2020, counting both sustainable biofuels and electric vehicles. 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.[114] 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% biofuels.

In the United States, tax-cut legislation at the end of 2010 extended tax credits for the blending of ethanol and biodiesel through 2011. Those credits provide a 45 cents/gallon (13 cents/liter) subsidy for ethanol blending and a $1.00/gallon (28 cents/liter) subsidy for biodiesel. The legislation also extended federal cash grants providing up to 30% of the capital cost of new large-scale renewable biofuel production facilities. In other developments from the United States, the U.S. Air Force now aims to have its entire fleet certified to fly on biofuels by 2011, and the U.S. Navy has mandated that all its aircraft and ships be powered by a 50-50 biofuel/gasoline blend by 2020.[115]

Policies to support electric vehicle deployment are also starting to appear, although such policies do not necessarily require or imply that the electricity used will be renewable. Several countries have announced targets that together would result in over 20 million electric battery vehicles (EVs) operating by 2020, equating to around 2% of light-duty vehicle stocks.[116] EVs could become part of a future smart grid with integrated storage from their batteries enabling higher shares of electricity from variable renewable sources.[117] (See Sidebar 7.)

Several cities, at times supported by national and state funding, have anticipated the expanding use of EVs (including both two- and four-wheel designs and plug-in hybrids) by providing public recharging infrastructure.[118] And some cities are mandating that the electricity supplying these recharging stations be provided through green power purchases, a first step toward linking renewable electricity with EVs.

London boroughs have received support from Transport for London to provide on- and off-street recharging.[119] Owners of electric vehicles are exempted from paying the London congestion charge and, from January 2011, purchasers of EVs can receive a GBP 5,000 U.K. government subsidy.[120] The government is committed to mandating a national recharging network for EVs and further investment in research and development activities supporting advanced vehicle technologies.[121] In Paris, more than 110 recharging points already exist.[122]

Israel is aggressively promoting EVs and aims to become independent of oil by 2020.[123] Israel has invested in a recharging grid and battery-swap stations and will reduce the 90% purchase tax on conventional vehicles down to 10% for EVs purchased by early adopters including fleet owners.[124] The governments of Ireland, Portugal, and Denmark are developing similar policies.[125]

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. National governments are progressively taking note that multiple local and decentralized actions can effectively pool efforts toward national energy security, albeit still at a small scale at this stage.[126]

More and more local governments are setting targets for increasing the generation and use of renewable energy, whether within wider programs and city cooperation projects or as individual council decisions. Interest in aiming for 100% local renewables is growing, mainly among smaller communities that face a simpler transition process. This is influenced by unstable energy prices, the need for secure and safe energy, and the recognition among leaders that their communities have green development potential. The role of cities and local governments in international climate policy has also strengthened in recent years. In 2010, local governments received official recognition for the first time in international climate negotiations, where they are now designated as "governmental stakeholders."

Local government commitments continued strongly in 2010. For example, the Mexico City Climate Pact was launched in November 2010 and was subsequently signed by over 180 local governments representing 300 million people.[127] Signatories voluntarily commit to a 10-point action plan to implement low-carbon programs and register emissions inventories in a measurable, reportable, and verifiable manner. The Pact reflects the increasing role of cities in combating climate change globally and the value of city-to-city cooperation. One provision of the Pact envisages that signatories report

their climate commitments, performance, and actions regularly through a new "Carbon Cities Climate Registry," established in 2010 to serve as a central data collection point.[128]

In Europe, the Covenant of Mayors has seen tremendous growth, with more than 2,000 signatories committing to go beyond the EU 2020 target of a 20% reduction in carbon dioxide (CO_2) and at least a 20% share of renewables in local energy supply.[129] Cities and towns in the Covenant agree to create and implement action plans to achieve these reductions. This initiative provides a practical framework for commitment and reporting, with cities and towns obtaining practical assistance, such as from national energy agencies, sub-national governments, and city networks. The Covenant of Mayors underlines the strong interest from the European Commission in seeing energy and climate change addressed at the local level in substantial ways.

A 2011 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 210 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.

Almost all cities working to promote renewable energy at the local level have established some type of renewable energy or CO_2 emissions reduction target. Of the cities and local governments surveyed, at least 140 have some type of future target for CO_2 and/or renewable energy. CO_2 emissions-reduction goals are typically a 10–20% reduction over a baseline level (usually 1990 levels) by 2010–12, 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% 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 indicator.

There are several types of renewable energy-specific targets. One is for the renewable share of total electricity consumption, with several cities in the range of 10–30%. 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% to 100%. 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 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 water heating 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 cities and local governments surveyed, at least 35 have some type of building code or permitting policy that incorporates renewable energy.

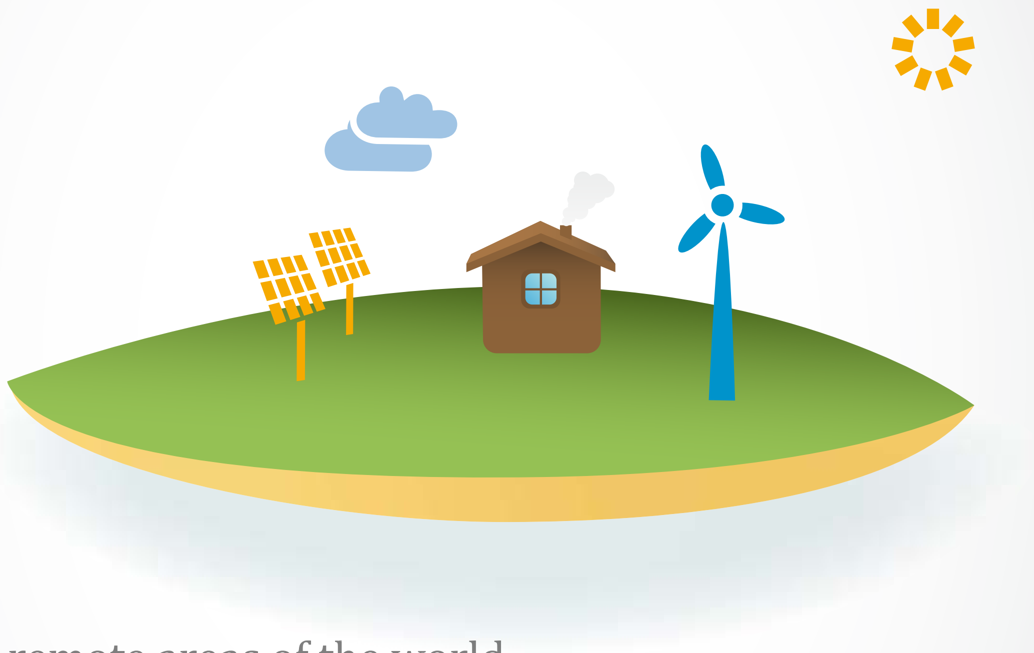
Many other regulatory measures for renewable energy are being adopted. Where cities have regulatory authority over some type of taxation, tax credits and exemptions for renewable energy at the local level are possible, although these do not appear to be common. Of the cities and local governments surveyed, 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; a feed-in tariff for solar PV in Gainsville, Florida (USA), and a Tokyo, Japan, mandate for a carbon cap-and-trade system on large businesses within city jurisdiction.

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. 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.

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 cities and local governments surveyed, at least 50 have some type of subsidies, grants, or loans. Other voluntary actions include government investment funds and a variety of ways to support or facilitate private and community initiatives.

Many other initiatives at national, regional, and global levels have been supporting cities to work together for renewable energy. Examples are the U.S. Mayors’ Climate Protection Agreement involving more than 700 U.S. cities, 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 Communities Program, the China Low Carbon City Program, the Japanese Eco-Model City Project, the ICLEI Local Renewables Model Communities Initiative, and the ICLEI Cities for Climate Protection campaign.[130] For many of these initiatives and associations, the number of participating cities continues to increase year by year. For example, the India Solar Cities Program started with 20 cities in 2008 and by early 2011 it had expanded to 48 cities, with a further target of 60 cities by 2012.[131]

05 RURAL RENEWABLE ENERGY



Even in the most remote areas of the world, renewable technologies are providing access to energy services and fostering economic development.

05 RURAL RENEWABLE ENERGY

Renewable energy can play an important role in providing modern energy services to the billions of people who depend on traditional sources of energy. Globally, some 1.5 billion people still lack access to electricity, often relying on kerosene lamps or candles for lighting and on expensive dry-cell batteries to power radios for communications.[1] Approximately 3 billion people – more than a third of the world's population – cook their food and warm themselves on open fires fueled by wood, straw, charcoal, coal, or dung, which are very inefficient and damaging to health.[2]

In many rural areas of developing countries, connections to electric grids are economically prohibitive and/or may take decades to materialize. Today, there exists a wide array of viable and cost-competitive alternatives to traditional biomass energy and to grid electricity and carbon-based fuels that can provide reliable and sustainable energy services. Renewable energy systems offer an unprecedented opportunity to accelerate the transition to modern energy services in remote and rural areas.

Rural Transition to New and Renewable Energy Systems

A rural transition from traditional to more modern forms of energy is possible in households, communities, and small industries in most developing countries. "Traditional" and "modern" refer both to the type of fuel and to the technologies that use it. Wood, for example, can be burned very inefficiently in a "traditional" open fire that emits 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. Candles and kerosene are traditional forms of lighting that offer poor quality light and low efficiency; by contrast, electric lamps (powered by solar or other sources) give off up to 100 times more light.[3]

In even the most remote areas, renewable energy technologies such as household PV systems, micro-hydro powered mini-grids, biomass-based systems, and solar pumps can provide sustainable energy services ranging from basic necessities – including quality lighting, communications, and heating and cooling – to services such as motive power that generate economic growth.[4] Table 3 describes many of the rural services that can be provided in more modern ways through renewable technologies.

Unfortunately, statistics on renewable energy use in rural areas of developing countries are not being collected systematically. For many years, public programs were the primary stakeholders responsible for rural electrification; today, however, many initiatives are driven by individual project promoters or private companies, making these efforts more dispersed. In addition, a large portion of the market for small-scale renewable systems is paid in cash, even in the most remote areas.

As a consequence, it is difficult to detail the progress of renewable energy in off-grid areas for all developing countries; however, statistics are available for many individual programs and countries. This section reviews trends in some of the more critical energy service sectors.

Household Lighting and Communications

Household lighting is one of the most important benefits of rural electricity.[5] Many small and affordable renewable energy technologies are available to deliver high-quality lighting to households that lack access to grid electricity. These technologies are evolving toward smaller, cheaper, and more efficient systems that are better adapted to end users in developing countries. Such advances are due in part to programs such as Lighting Africa (see Sidebar 8) but are also the result of private sector efforts in this field.

Household lighting requires very little power, especially with new lighting technologies such as light emitting diodes (LEDs). However, recent field studies by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) suggest that although there is clearly a vector of progress, many of the solar lamp systems available on the market and/or offered in some programs do not provide enough light or are not robust enough to provide the level of lighting desired by rural households.[6]

The renewable energy technology that is connected most directly with improving household lighting is solar PV, including whole-home systems and solar lamps. Although worldwide achievements are difficult to estimate, there have been many significant accomplishments.

In Africa, more than 500,000 solar PV systems were in use in 2007, with more than half of these in South Africa and Kenya.[8] As of 2005, Kenya was home to just over 150,000 solar PV systems, with a median size of 25 W_{peak}, and coverage had reached a reported 300,000 households.[9] Beyond these two countries, most African solar home system (SHS) or pico-PV system projects are relatively small, although there are encouraging developments.

In Tanzania, recent World Bank activity has focused in part on the promotion of renewable energy off-grid electricity solutions, particularly mini-hydropower generation, biomass cogeneration, and solar energy. The Bank has invested some $22.5 million for support of a Rural Energy Agency, established in 2007, that will test new off-grid electrification approaches that are expected to be scaled up in the future.[10]

Several African rural electrification programs launched since the early 2000s have involved large concessions of SHS, especially in western Africa (Mali, Senegal, and

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

Rural Energy Service	Existing Off-Grid Rural Energy Sources	Examples of New and Renewable Energy Technologies
Lighting and other small electric needs (homes, schools, street lighting, phone charging, hand tools, vaccine storage, refrigeration)	Candles, kerosene, batteries, small diesel generators, central battery recharging by carting batteries to grid	• Hydropower (pico-scale, micro-scale, small-scale) • Biogas from household-scale digester • Small-scale biomass gasifier with gas engine • Village-scale mini-grids and solar/wind/hydro hybrid systems • Solar home systems • Pico-scale PV System, including solar lamps
Communications (televisions, radios, mobile phones)	Dry cell batteries, small diesel generators, central battery recharging by carting batteries to grid	• Hydropower (pico-scale, micro-scale, small-scale) • Biogas from household-scale digester • Small-scale biomass gasifier with gas engine • Village-scale mini-grids and solar/wind/hydro hybrid systems • Solar home systems • Pico-scale PV System
Cooking (domestic, 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 • Biogas from household-scale digester and biogas stove • Solar cookers
Heating and cooling (crop drying and other agricultural processing, hot water)	Mostly open fire from wood, dung, and straw	• Improved heating stoves • Biogas from small- and medium-scale digesters • Solar crop dryers • Solar thermal for heating and cooling • Fans from small grid renewable systems
Process motive power (small industry)	Diesel engines and generators	• Small and large solar home systems • Small wind turbine • Mini-grid with hybrid system (e.g., combination of microhydro, gasifiers, direct combustion, large biodigesters, and other renewables)
Water pumping (agriculture and drinking water)	Diesel pumps and generators	• Mechanical wind pumps • Solar PV pumps • Mini-grid with hybrid system

Sidebar 8. LIGHTING AFRICA: LESSONS IN MARKET AND TECHNOLOGY INNOVATION

The Lighting Africa program, implemented jointly by the International Finance Corporation (IFC) and the World Bank, provides small technical-assistance grants to promote private sector innovation and new lighting technologies. It aims to facilitate the commercialization of environmentally friendly, affordable, high-quality lighting for off-grid rural households across Africa. The program promotes solar-charged, battery-operated light emitting diode (LED), and fluorescent lighting devices by building an enabling environment and market infrastructure, without providing product subsidies.

There are striking parallels between the issues that Lighting Africa has tackled and those faced by other efforts to develop and market improved or advanced biomass stoves. Through its interaction with leaders in the lighting industry, for example, Lighting Africa revealed that major manufacturers lacked information about African markets and that an enabling environment was important. To improve this environment, the program has provided "intelligence" to the industry by facilitating business linkages through its interactive business-to-business website and by organizing international and domestic conferences, trade fairs, and workshops.

Together with GIZ, Lighting Africa has helped create initial testing methods and standards for lighting devices, and it is in the process of developing a publicly recognized certification label. In addition, Lighting Africa has conducted consumer awareness and information campaigns in various countries. It also has provided grant funds for innovations in technology development, marketing, and implementation strategies.

Recognizing the important role of finance, Lighting Africa is working to meet financing needs by assisting in the development of market-appropriate solutions and financial products. For example, it is providing trade finance and working capital to small and medium-sized distributors of off-grid lighting products.

Source: See Endnote 7 for this section.

Mauritania). Whether through fee-for-service programs or household-based schemes (micro-finance or cash), the SHS market in Africa is continuing to take off.[11]

Progress in Asia is also notable. Under China's Renewable Energy Development project, which ended in mid-2008, more than 400,000 SHS were sold to residents of northwestern China, most of them herders who transported the systems by animal back as they moved to new pastures.[12] In India, the Ministry of New and Renewable Energy estimates that nearly 600,000 solar home systems and 800,000 solar lamps had been purchased nationwide as of 2010.[13] This amounts to an increase that year of some 37,000 new home lighting systems, more than 3,500 solar lamps, and around 1,500 solar street lighting systems.[14] In Sri Lanka, some 60,000 SHS had been purchased as of 2007, most during the previous decade; by 2010, that number had increased to more than 125,000.[15]

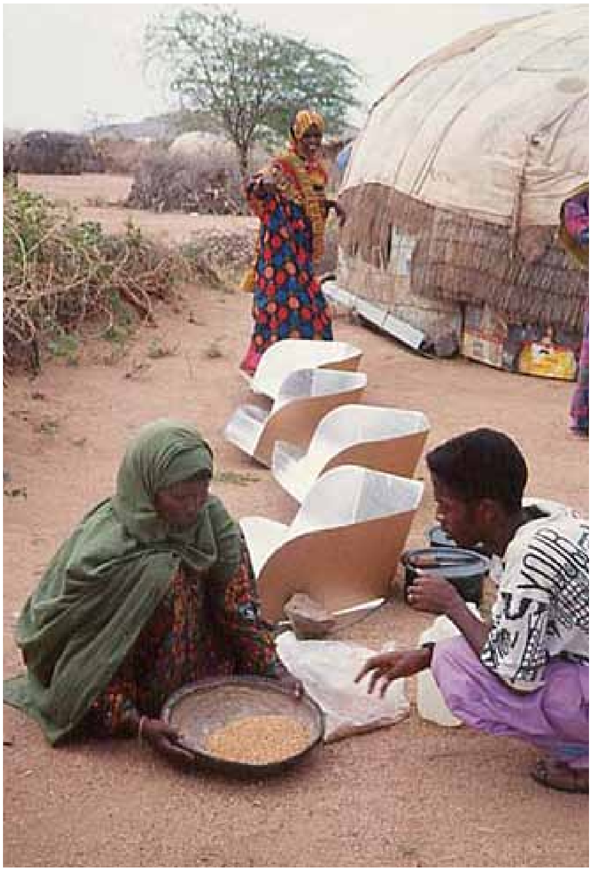
In Bangladesh, an estimated 30,000 solar home systems are being sold each month nationwide. In the early 2000s, the Bangladeshi government and international banks and bilateral donors established a rural energy fund, implemented by the Infrastructure Development Company Limited (IDCOL), that has enabled a group of 30 participating sales and service companies to install some 750,000 SHS – most of them 50–75 W_{peak}.[16] A third of these systems were installed in 2010 alone, and the number of participating organizations has doubled in the last few years.

Key to the program's success have been high-quality system standards and guarantees, combined with after-sales service, and the active participation of microfinance organizations such as Grameen Shakti and BRAC, which have facilitated sales and have guaranteed system quality. Since its inception in 2002, the program has expanded to include a national biogas initiative, solar micro-grids, solar pump irrigation, and biomass based power. The program illustrates the benefit of having a dedicated organization (IDCOL) to coordinate outreach for renewable energy in rural areas.

Other Asian countries, such as Cambodia and Laos, are developing ambitious rural electrification programs based on SHS concessions. They also are embracing community electrification schemes that utilize hybrid systems or hydropower plants.[17]

Sri Lanka's Renewable Energy for Rural Economic Development (RERED) project relies on consumer credit and a network of microfinance institutions and solar companies. Solar companies sell solar home systems and offer operation and maintenance services through dealer networks. A memorandum of understanding between the microfinance institution and the solar company outlines the buyback scheme and the consumer/service responsibilities of the two parties. Applying this model, Sarvodaya Economic Enterprises Development Services – RERED's partner in SHS financing – had financed nearly 130,000 systems by 2010, an increase of more than 100,000 since 2002.[18] This multi-stakeholder approach, based on well-conceived public-private partnerships and supported by a grant from the Global Environment Facility (GEF), also has been used to develop a village mini-grid network using a small hydropower plant.[19]

Similar to household lighting, communication technologies require small amounts of power that can be covered by household and individual solar systems. Traditionally, these needs were covered by costly, inefficient, and unsustainable automotive batteries that were charged either on village generators or directly on the national grid. With the expansion of the global communications network, mobile phone charging also is becoming an increasingly important need (and recurrent business) in developing countries. It has become a driver for the purchase of many solar PV systems, some of which integrate mobile charging.



Cooking and Heating

In rural areas of developing countries, most of the energy used for cooking is in the form of wood, straw, and dung that is burned in stoves that are often basic and inefficient. Emissions from such cooking practices cause serious health problems and, in some cases, collection of the fuel results in unsustainable harvesting of biomass.

Estimates of the prevalence of improved cookstoves – defined as a closed stove with a chimney or an open fire with a hood – vary. The World Health Organization and United Nations Development Programme (2009) compiled information from surveys in 140 countries and estimated that 3 billion people rely on solid fuels such as wood, straw, dung, and coal for cooking.[20] The study found that approximately 830 million people are using improved cookstoves. This amounts to some 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.[21]

These figures do not include the newer stoves that are now being developed and manufactured, in some cases with the backing of large international companies.[22] These new stoves are designed with the goals of improving the energy efficiency of cooking, reducing indoor air pollution, and reducing the labor or cash requirements for the world's poorest people. Generally, these stoves are made of durable materials that will last 5–10 years or even longer, and many are sold at affordable prices with guarantees.[23] The market potential for biomass stoves in developing countries is large.

Significant developments have been made in promoting improved stoves in developing countries. In 2010, the United Nations Foundation launched the Global Alliance for Clean Cookstoves (GACC), which advocates for implementing programs to improve biomass cookstoves for developing countries.[24] The GACC is dealing with issues related to standards and testing methods; encouraging stove adoption; developing financing techniques to spread out the upfront costs of stoves; and raising awareness – with the goal of helping to promote more than 100 million stoves by 2020.[25]

GACC will complement existing efforts such as the Energising Development program sponsored by the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Directorate-General for International Cooperation (DGIS) of the Dutch Ministry of Foreign Affairs. This program, which works to establish sustainable markets for energy-efficient cookstoves, focuses primarily on providing grants to develop the technology and create markets for better stoves, rather than on subsidizing the purchase of the stoves themselves. Interventions have been implemented in 12 countries worldwide, with a focus on Africa. By the end of 2010, nearly 7.2 million people had gained access to modern cooking technologies through the program.[26]

In 2010, India announced a large initiative for advanced biomass cookstoves that could potentially reach millions of people who currently use traditional biomass cooking methods.[27] The program will focus on five key areas: technical issues, including research and development related to testing and standards; delivery procedures; potential programs for fuel processing and supply; an innovation contest for next-generation cookstoves; and a study on what can be accomplished with community cookstoves.

The use of factory-manufactured improved stoves still lags considerably behind the use of locally produced stoves, and most factory stove manufacturers have been in business for less than five years. The combustion efficiency and lifetime of factory stoves appears to be superior to locally made ones. Although marketing of factory stoves began only recently, approximately half a million units have been sold to date, with major programs in India, South Africa, Uganda, Honduras, and Guatemala.[28]

Since 1994, Groupe Energies Renouvelables, Environnement et Solidarités (GERES) has been working in Cambodia to develop energy-efficient solutions to preserve the environment and improve living conditions. Between 2003 and 2010, sales of the New Lao stove exceeded 1 million units, with some 200,000 units sold in 2010.[29]

In addition to these new varieties of stoves, smaller niche cooking technologies such as biogas systems and solar cookers can play a significant role in improving cooking practices.[30] 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 rebirth after roughly 25 years of design experimentation.

As the result of renewed efforts through the Ministry of Agriculture, China added an estimated 22 million biogas systems between 2006 and 2010 – to reach a total of some 40 million systems in early 2011.[31] India is home to some 4 million systems, and Vietnam has installed some 20,000 systems annually in recent years, to reach more than 100,000 by 2010.[32] Cambodia, Laos, and Indonesia have smaller programs, each adding some 1,000 systems in 2010.[33]

Nepal's Biogas Support Programme, which involves the private sector, microfinance organizations, community groups, and NGOs, has resulted in a steady increase in biogas systems during the last decade. Some 25,000 systems were adopted in 2010, bringing the nationwide total to nearly 225,000.[34]

Motive Power, Irrigation, and Village-Scale Systems

Larger applications, such as motive power and village electrification, require tailor made power systems that generate much higher output than household or small individual systems. For power generation, an example of a larger system is a small electricity grid that is supplied by a hybrid power system using PV, wind, hydro, and/or biomass, usually with a battery bank and a diesel generator as backup.[35] Larger individual systems that use PV, small-scale wind, small-scale hydropower, or biomass also exist for providing motive power, pumping water, and for desalination.

Such applications, whether used for business enterprises or for supplying communities, raise different financial issues than smaller applications and require specific business and banking models.[36] Even so, the lifetime system costs are still generally cheaper than the traditional alternatives – such as grid extension and diesel generators – and can be very quickly compensated in the case of business applications (hotels, telecommunication stations, fisheries, etc.). The main financial barrier is the upfront investment cost.

Nepal's Village Micro Hydro Program 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 some 41,000 households in 40 of the 51 districts that were identified as having potential for this type of power generation.[37] The main obstacles to promoting such systems are the relatively high costs and the need for community-level support. Nepal's program works with communities to overcome these obstacles and helps villagers cope with the initial capital costs via financing mechanisms.

Brazil has reached what some have called the "last mile" for rural electrification. Although the national grid currently reaches more than 95% of households, the Luz Para Todos program continues to expand access to rural areas both by extending grid power and by using off-grid community and household systems. By 2010, the program had reached about 13 million people (more than 2.6 million households) with isolated grid systems of various types, mostly in northeast Brazil.[38]

Trends in Financing Off-Grid Renewable Energy

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. Historically, the main problem for financing such projects has been the small project size, which has discouraged financial institutions from providing loans. Problematic legal frameworks, poor tax or subsidy structures, and the dearth of local groups or retailers to develop local markets have deterred private investors as well. Grid-based electricity systems generally do not face such barriers because their financing needs tend to be larger, and loans can be provided directly to dedicated electricity companies.

Many governments have come to realize that such challenges can be addressed in ways other than simply providing subsidies for grid extension. Increasingly, the trend has been to integrate grid extensions and off-grid renewable energy into the same project.

With regard to the financing of off-grid and mini-grid power projects, the trend during the past decade has been to provide large amounts of funding to local private or public financing institutions that are committed (or trained) to support rural and renewable energy projects. Typically, such banks or funds develop a portfolio of possible projects, although they also can react to requests for new lines of financing by reviewing project proposals. They do not provide financing to households directly; rather it is up to the private companies, concessionaires, NGOs, 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. As a result, renewable household systems, improved biomass stoves, and village or community small-grid systems can all be serviced by the same financing agency. In practice, many of these funds specialize initially in a single technology, such as solar home systems, but they are expanding increasingly to other renewable energy systems as well as to non-renewable energy access.

Another emerging option involves utility financing of solar home systems. In Peru, with the support of the government, electricity distribution companies have initiated a new program to reach out to remote residents by providing SHS at no initial cost; instead, households pay a monthly fee.[39] The fee-for-service approach has been used in many other countries, including extensively in Africa.[40]

Argentina, meanwhile, has introduced a nationally regulated tariff for solar PV systems in certain provinces, making it the first Latin American country to do so. The government estimates that 300,000 isolated rural households cannot be reached by extending the electricity grid and will need to be served by renewable energy.[41] With support from the project, distribution companies that own individual PV systems will provide regulated electricity service to the country's most isolated consumers, who will in turn pay a tariff for this service. Other countries in Latin America are considering similar financing models.

Carbon credits are another growing source of project finance. One such project, initiated in China in late 2008, involves the promotion of biogas digesters to produce energy for domestic heating, lighting, and cooking using animal waste.[42] More than 33,000 households in low-income rural communities (or approximately 165,000 people) are benefiting from the installation of domestic digesters, displacing carbon-intensive domestic fuels such as coal and coke.[43]

Grants and other forms of technical assistance are becoming a common means for supporting rural solar home systems markets and sustainable access to other modern energy services.[44] A variety of grant sources are available to public agencies and private firms to cover items such as training, delivery networks, business model development, product development, and pilot projects.[45] Another form of grant – social and community block grants – provides assistance to entire communities, which can lead to more equitable and socially-appropriate approaches to off-grid renewable energy services. Lines of credit from microfinance organizations are often enhancing these approaches.

In summary, several key trends have emerged in off-grid and rural renewable energy markets. The first is that off-grid renewable solutions are increasingly acknowledged to be the cheapest and most sustainable options for rural areas. This will have an impact on market development in the long term, especially if the barriers to accessing information and financing products are addressed. Second is the broadening of the focus of energy access to include "enhanced" access (targeting beyond the most simple electricity needs) and "sustainable" access (addressing the problem of security of diesel supply). Third, it is clear that the increasing diversity of support programs and their more-dispersed nature will further complicate the process of monitoring, documenting, and learning from these experiences.

REFERENCE TABLES

Table R1. Renewable Energy Added and Existing Capacities, 2010

		Added during 2010	Existing at end of 2010
Power generation (GW)			
Wind power	+	39	198
Biomass power	+	2–4	62
Solar PV	+	17	40
Geothermal power	+	0.2	11
Concentrating solar thermal power (CSP)	+	0.5	1.1
Hydropower	+	30	1,010
Ocean power	+	> 0	0.3
Hot water/heating (GWth)			
Biomass heating (modern)		n/a	280
Solar collectors for hot water/space heating	+	30	185
Geothermal heating		n/a	~ 51
Transport fuels (billion liters/year)			
Ethanol production	+	12	86
Biodiesel production	+	1.5	19

Note: Numbers are rounded; for more precise data, see Global Market Overview section and relevant endnotes.
Source: See sources for Tables R2–R6 and relevant endnotes in Global Market Overview section.

Table R2. Added and Existing Wind Power, Top 10 Countries, 2010

Country	Cumulative at end of 2009 (GW)		Added in 2010 (GW)	Cumulative at end of 2010 (GW)
China[1]	17/25.8	+	14/18.9	31/44.7
United States	35.1	+	5.1	40.2
Germany	25.7	+	1.5	27.2
Spain	18.9	+	1.8	20.7
India[2]	11.8	+	1.4	13.2
Italy	4.8	+	0.9	5.8
France	4.6	+	1.1	5.7
United Kingdom	4.4	+	0.9	5.3
Canada	3.3	+	0.7	4.0
Denmark	3.5	+	0.3	3.8
World Total	**159**	+	**39**	**198**

Note: Country data are rounded to nearest 0.1 GW; world data are rounded to nearest GW. Rounding is to account for uncertainties and inconsistencies in available data; where totals do not add up, the difference is due to rounding. Figures reflect a variety of sources, some of which differ to small degrees, reflecting variations in accounting or methodology.

1 For China, the lower figure is the amount classified as operational by the end of 2010; the higher is the total installed capacity. See Global Market Overview section and relevant endnotes for further elaboration of these categories.

2 The Global Wind Energy Council (GWEC) reported that India added 2.1 GW in 2010, for a total of 13.1 GW. If this (higher) GWEC number is used, India's ranking changes to third for capacity added in 2010; India's ranking for cumulative capacity at year end remains unchanged.

Source: GWEC; WWEA; CREIA; CWEA; EWEA; AWEA; BMU; IDAE; MNRE; GSE; DECC; BTM Consult – A part of Navigant Consulting. For specific sources and notes on data points, see relevant endnotes in Global Market Overview section.

Table R3. Solar PV Additions and Existing Capacity, 2006–2010

	Added					Existing				
	2006	2007	2008	2009	**2010**	2006	2007	2008	2009	**2010**
	MW					GW				
Germany	845	1,270	1,950	3,795	**7,405**	2.9	4.2	6.1	9.9	**17.3**
Spain	90	560	2,600	145	**370**	0.2	0.7	3.3	3.4	**3.8**
Japan	290	210	230	480	**990**	1.7	1.9	2.1	2.6	**3.6**
Italy	10	70	340	715	**2,320** [1]	0.05	0.1	0.5	1.2	**3.5** [1]
United States	145	205	340	475	**880**	0.6	0.8	1.2	1.6	**2.5**
Czech Republic	–	3	60	400	**1,490**	–	–	0.07	0.5	**2**
France	10	10	45	220	**720**	0.03	0.04	0.09	0.3	**1**
China	10	20	40	160	**550**	0.08	0.1	0.2	0.3	**0.9**
Belgium	2	20	70	285	**425**	–	0.02	0.09	0.4	**0.8**
South Korea	25	45	275	170	**130**	0.03	0.08	0.4	0.5	**0.7**
Other EU	20	35	100	180	**515**	0.2	0.2	0.3	0.5	**1**
Other World	130	80	145	285	**865**	1.2	1.3	1.4	1.7	**2.6**
Total Added	1,580	2,510	6,170	7,260	**16,630**					
World Total						7	9.5	16	23	**40**

Note: Added capacities are rounded to nearest 5 MW (with a few exceptions for very low totals), existing capacities are rounded to nearest 0.1 GW, and world totals for 2008–2010 are rounded to nearest 1 GW. This is to reflect uncertainties and inconsistencies in available data (see Global Market Overview section and related endnotes for more specific data and differences in reported statistics). Added and existing figures may be slightly inconsistent due to rounding and reporting differences from year-to-year. Where totals do not add up, the difference is due to rounding. Starting with this edition of the GSR, data for solar PV include both on- and off-grid capacity; all columns above reflect this change, including retroactive changing of 2006–2009 data, which thus differ from data in previous editions of this report. See Note on Reporting and Accounting of Installed Capacities for more information.

1 For Italy, actual installations in 2010 and year-end capacity may have been higher. See Global Market Overview section and related endnotes for more information.

Source: All data are derived from EPIA with the exception of national data for Germany (BMU), Spain (IDAE), Italy 2010 (GSE), and China (CREIA). For specific sources and notes on data points, see relevant endnotes in Global Market Overview section.

Table R4. Renewable Electric Power Capacity, Existing at End of 2010

Technology	World Total	Developing Countries	EU-27	United States	China	Germany	Spain	India
	GW							
Wind power	198	61	84	40	45	27	21	13
Biomass power	62	27	20	10	4	5	0.5	3
Solar PV	40	n/a	29	2.5	0.9	17.3	3.8	~ 0
Geothermal power	11	5	1	3.1	~ 0	0	0	0
Solar thermal power (CSP)	1.1	0	0.6	0.5	0	0	0.6	0
Ocean (tidal) power	0.3	0	0.3	0	0	0	0	0
Total renewable power capacity (not including hydropower)	312	94	135	56	50	49	26	16
Hydropower	1,010 [1]	n/a	130	78 [2]	213	5 [2]	16	40 [2]
Total renewable power capacity (including hydropower)	1,320 [1]	n/a	265	134	263	54	42	56

Note: Small amounts, on the order of a few MW, are designated by "~ 0." 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 to actual capacity changes. World total reflects other countries not shown; countries shown reflect the top five countries by total renewable power capacity (excluding hydropower). Biomass power figures do not include waste-to-energy capacity (MSW)—see Note on Accounting and Report of Installed Capacities for explanation. Biomass power figures are adjusted from 2009 to reflect updated IEA data for biogas and solid biomass power statistics from individual country submissions to this report. Hydropower added in 2010 was 27 GW (large-scale only) according to BNEF and 29–35 GW according to IHA; the total here reflects the 2009 total of 980 GW and roughly 30 GW added for 2010. The world hydro total and some national hydro data include some amount of pumped storage capacity because country-by-country hydro statistics are not consistent in stating whether pumped hydro is part of the country total or not. There was an estimated 136 GW of pumped storage capacity in 2010, according to IHA, although the meaning of this figure is not clear because some pumped storage capacity is counted as capacity of conventional hydro facilities that include pumped storage, and some as standalone pumping capacity only. Further investigation is planned for next year's edition of this report. Note that the *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (2011) reported 926 GW of conventional hydropower in 2009 from the *International Journal on Hydropower and Dams, World Atlas & Industry Guide* (Wallington, Surrey, UK: 2010). If the estimated 30 GW is added to this, the global total for conventional hydro for 2010 becomes about 956 GW. This is 55 GW lower than our estimate, which is based on IHA data for 2009 and 2010, and reflects the middle of the range of 2010 capacity (970–1,060 GW) estimated by the IHA. Pumped storage capacity could account for much of this difference.

1 Data rounded to nearest 10 GW.

2 Data for the United States, Germany, and India reflect only conventional hydropower capacity.

Source: Sources cited in Tables R2–R3 and in the Global Market Overview section; *IEA, Renewables Information 2010* (for OECD biomass power capacity) and Electricity Information 2010; WEC*, Survey of Energy Resources 2009*; submissions from report contributors; historical databases going back to 2005 report edition as maintained by Eric Martinot.

Table R5. Solar Hot Water Installed Capacity, Top 12 Countries/EU and World Total, 2009

Country/EU	Additions 2009	Existing 2009
	GW$_{th}$	
China [1]	+ 29	102
Turkey	+ 0.7	8.4
Germany	+ 1.1	8.4
Japan	+ 0.1	4.0
Greece	+ 0.1	2.9
Israel	+ 0.2	2.8
Brazil	+ 0.3	2.8
Austria	+ 0.3	2.6
India	+ 0.4	2.2
United States	+ 0.1	1.9
Australia	+ 0.4	1.8
Italy	+ 0.3	1.4
Rest of World	+ ~ 3.0	~ 19
World Total	**+ 37**	**160**
EU-27	**+ 2.9**	**21.2**

Note: Figures do not include swimming pool heating (unglazed collectors). World additions are gross capacity added; existing figures include allowances for retirements; China and world data are rounded to nearest GW$_{th}$. Weiss and Mauthner estimate that their survey covers 85–90% of the global market. The world total and other figures above take this into account, adding a conservative 5% to the global total capacity. Note that Brazil had an estimated 3.7 GW$_{th}$ at the end of 2009 per Renata Grisoli, CENBIO, Brazil, personal communication with REN21, February 2011. However, Weiss and Mauthner data have been used in the above table to ensure consistency across all numbers. By accepted convention, 1 million square meters = 0.7 GW$_{th}$.

1 Numbers for China were revised downward in 2010 relative to those reported in previous report editions due to past accounting for a large number of systems installed in recent years that are no longer operational. In previous editions, data for China accounted only for cumulative added capacity and did not account for systems becoming non-operational. (Note that this is different than system retirements in other countries due to aging; in China, relatively new systems are becoming non-operational well before their design lifetimes.) In addition, there were some past discrepancies in terms of systems manufactured in China and exported versus those installed in China. These discrepancies and corrections significantly affect the global solar hot water picture for past report editions and mean that the figures in this edition should not be compared with figures in previous editions.

Note for 2010 estimate of total global capacity used elsewhere in report (e.g., Global Market Overview section; Table R1): Solar collector capacity of 185 GW$_{th}$ for 2010 is estimated from Weiss and Mauthner, which provides a 2010 year-end total of 196 GWth for all collectors. Subtracting an estimated 10–11% market share for unglazed collectors brings the total to 176 GW$_{th}$, adjusted upward by 5% to 185 GW$_{th}$ to account for those countries not included in the Weiss and Mauthner survey. The gross added capacity during 2010 of 30 GWth is estimated based on the difference between 2009 and 2010 existing unglazed totals in the Weiss and Mauthner survey (25 GW$_{th}$), and on the assumption that 5 GW$_{th}$ were retired globally during 2010 (5% annual retirement rate for systems outside of China, and 2 GW$_{th}$ becoming non-operational in China during 2010).

Source: Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contributions to Energy Supply 2009* (Paris: IEA Solar Heating and Cooling Programme, May 2011).

Table R6. Biofuels Production, Top 15 Countries and EU Total, 2010

Country	Fuel ethanol	Biodiesel	Total
	billion liters		
1. United States	49	1.2	50.2
2. Brazil	28	2.3	30.3
3. Germany	1.5	2.9	4.4
4. France	1.1	2.0	3.1
5. China	2.1	0.2	2.3
6. Argentina	0.1	2.1	2.3
7. Spain	0.6	1.1	1.7
8. Canada	1.4	0.2	1.6
9. Thailand	0.4	0.6	1.0
10. Italy	0.1	0.8	0.9
11. Indonesia	0.1	0.7	0.8
12. Belgium	0.3	0.4	0.7
13. Poland	0.2	0.5	0.7
14. United Kingdom	0.3	0.4	0.7
15. Colombia	0.4	0.3	0.7
World Total	**86**	**19**	**105**
EU Total	**4.5**	**10**	**14.5**

Note: 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. Where reported in tonnes, figures were converted to liters using factors 1,260 liters/tonne ethanol and 1,130 liters/tonne biodiesel; where reported in cubic meters, ethanol data were converted to liters using 1,000 liters/cubic meter.

Source: F.O. Licht, March 2011; IEA, *Medium Term Oil and Gas Markets 2011* (Paris: June 2011). Brazil ethanol data from Brazilian Ministry of Agriculture, Livestock and Supply (MAPA), provided by Renewable Fuels Department, Brazilian Ministry of Mines and Energy, communication with REN21, 28 April 2011; Germany ethanol and biodiesel data from BMU, *Renewable Energy Sources 2010*, provisional data as of 23 March 2010. F.O. Licht and IEA reported that Brazil produced 26 billion liters of ethanol, and that Germany produced 0.9 billion liters of ethanol and 2.7 (F.O. Licht)/2.9 (IEA) billion liters of biodiesel. In the 2010 edition of this report, data for this table came from the IEA, whereas F.O. Licht was the primary source for the current edition; small discrepancies of 0.1 billion liters or less may be noted between these two sources, with the exception of the following from IEA: United States (50.1 billion liters ethanol, 1.0 billion liters biodiesel); France (0.7 billion liters ethanol, 2.6 billion liters biodiesel); China (2.3 billion liters ethanol, 0.4 billion liters biodiesel); Spain (0.4 billion liters ethanol); Poland (0.3 billion liters biodiesel); Indonesia (0.4 liters biodiesel). Note that the IEA ranks Indonesia after Belgium, Poland, United Kindom. and Colombia. For total ethanol production, F.O. Licht reported 85.6 billion liters and IEA 86.3; for total biodiesel production, F.O. Licht reported 18.7 billion liters and IEA 19.3.

Table R7. Share of Primary and Final Energy from Renewables, Existing in 2008/2009 and Targets

Country/Region	Existing Share (2008/2009)[1]	Future Target	Existing Share (2009)	Future Target[2]
	Primary Energy		Final Energy	
EU-27	8.2%		11.6%	→ 20% by 2020
Albania		→ 18% by 2020		
Austria	29%		29%	→ 34% by 2020
Belgium	3.0%		3.8%	→ 13% by 2020
Botswana				→ 1% by 2016
Bulgaria	5.1%		12%	→ 16% by 2020
Burundi				→ 2.1% by 2020
China[3]			9.1%	→ 15% by 2020
Cyprus	2.1%		3.8%	→ 13% by 2020
Czech Republic	5.3%		8.5%	→ 13% by 2020
Denmark[2]	18%		20%	→ 30% by 2020 → 20% by 2011
Egypt		→ 14% by 2020		
Estonia	11%		23%	→ 25% by 2020
Fiji				→ 100% by 2013
Finland	25%		30%	→ 38% by 2020
France	7.5%		12%	→ 23% by 2020
Gabon				→ 80% by 2020
Germany[2]	8.9%		9.7%	→ 18% by 2020 → 30% by 2030 → 45% by 2040 → 60% by 2050
Greece	5.1%		7.9%	→ 18% by 2020
Hungary[2]	5.8%		9.5%	→ 14.7% by 2020 → 13% by 2020
Indonesia	5.0%	→ 17% by 2025		
Ireland	3.8%		5.1%	→ 16% by 2020
Israel				→ 50% by 2020
Italy	12%		7.8%	→ 17% by 2020
Jamaica	30%	→ 20% by 2030		
Japan	6.0%	→ 10% by 2020		
Jordan		→ 7% by 2015 → 10% by 2020		
Latvia	35%		37%	→ 40% by 2020
Lebanon				→ 12% by 2020
Lithuania	10%	→ 20% by 2025	17%	→ 23% by 2020
Luxembourg	3.6%		2.8%	→ 11% by 2020
Madagascar				→ 54% by 2020
Malawi		→ 7% by 2020		
Mali		→ 15% by 2020		
Malta	0.5%		0.7%	→ 10% by 2020

Table R7. Share of Primary and Final Energy from Renewables, Existing in 2008/2009 and Targets (continued)

Country/Region	Existing Share (2008/2009)[1]	Future Target	Existing Share (2009)	Future Target[2]
	Primary Energy		Final Energy	
Mauritius	18%	→ 35% by 2025		
Moldova	2.7%	→ 20% by 2020		
Morocco		→ 8% by 2012		→ 10% by 2012
Netherlands	3.4%		4.2%	→ 14% by 2020
Niger		→ 10% by 2020		
Palestinian Territories				→ 20% by 2012
Poland	5.7%	→ 14% by 2020	9.4%	→ 15% by 2020
Portugal	20%		26%	→ 31% by 2020
Romania	14%		22%	→ 24% by 2020
Senegal		→ 15% by 2025		
Slovakia	5.2%		10%	→ 14% by 2020
Slovenia	12%		18%	→ 25% by 2020
South Korea	2.5%	→ 4.3% by 2015 → 6.1% by 2020 → 11% by 2030		
Spain	9.3%		13%	→ 20% by 2020
Sweden	32%		50%	→ 50% by 2020
Switzerland	16%	→ 24% by 2020	17%	
Syria		→ 4.3% by 2011		
Thailand	6.4%	→ 20% by 2022		
Tonga				→ 100% by 2013
Uganda		→ 61% by 2017		
United Arab Emirates				→ 5% by 2030
United Kingdom	3.1%		2.9%	→ 15% by 2020
Vietnam		→ 5% by 2020 → 8% by 2025 → 11% by 2050		

Note: Actual percentages rounded to nearest whole decimal for figures over 10%. Many existing shares and targets shown exclude traditional biomass. In general, existing shares are indicative and not intended to be a fully reliable reference. 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 are not directly comparable or consistent across countries. IEA *Renewables Information* (2010) 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 26.9% while the REN21 database reports 29%; the difference could stem from calculations using different (and equally valid) methods.

1 Primary energy share figures are given for end 2009, except for the following cases where share figures refer to end 2008: EU-27, Austria, Belgium, Bulgaria, China, Cyprus, Denmark, Finland, France, Greece, Indonesia, Ireland, Japan, Lithuania, Luxembourg, Malta, Mauritius, Netherlands, Romania, Slovakia, Slovenia, Sweden, Switzerland, and Thailand.

2 Final energy targets for all EU-27 countries are set under EU Directive 2009/28/EC. The governments of Denmark and Hungary have set additional targets that are shown above the EU targets. The German targets for 2030, 2040, and 2050 are also additional targets set by the German government, and are not mandatory.

3 China's target changed in 2007 from a 15% share of primary energy from renewables to a 15% share of final energy from renewables and nuclear combined; however, there remains some question as to whether the target now represents final or primary share of energy. The 9.1% actual share of final energy is for 2010.

Source: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER, *The State of Renewable Energies in Europe*, 10th EurObserv'ER Report (Paris: 2011). For online updates, see the "Renewables Interactive Map" at www.ren21.net.

Table R7 Annex. Primary Energy Shares of Countries without Primary or Final Energy Targets

Country	Existing Share (2009)
Argentina	9.1%
Australia	5.1%
Barbados	66%
Belarus	9.3%
Bolivia	23%
Bosnia & Herzegovina	9.5%
Brazil	47%
Canada	17%
Chile	81%
Colombia	23%
Costa Rica	86%
Croatia	9.3%
Cuba	11%
Dominican Republic	30%
Ecuador	14%
El Salvador	73%
Grenada	100%
Guatemala	95%
Guyana	100%
Haiti	100%
Honduras	97%
Iceland	83%
Macedonia[1]	11%
Mexico	8.3%
Montenegro[2]	10%
New Zealand	37%
Nicaragua	63%
Norway	46%
Panama	100%
Paraguay	100%
Peru	22%
Serbia[2]	10%
Suriname	27%
Trinidad & Tobago	0.1%
Turkey	11%
United States	11%
Uruguay	43%
Venezuela	8.2%

Note: See previous page for relevant notes.

1 All shares for primary energy production at end 2009, except for Macedonia where the number refers to final energy consumption at end 2009.

2 Including both Serbia and Montenegro.

Source: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER, *The State of Renewable Energies in Europe*, 10th EurObserv'ER Report (Paris: 2011). For online updates, see the "Renewables Interactive Map" at www.ren21.net.

Table R8. Share of Electricity from Renewables, Existing in 2009, and Targets

Country/Region	Existing Share (end 2009)	Future Target
Global[1]	18%	—
EU-27[1]	20%	→ 21% by 2010
Algeria	0.8%	→ 5% by 2017 → 20% by 2030
Argentina[3]	29%	→ 40% by 2015
Australia	7.2%	→ 20% by 2020
Bangladesh	–	→ 5% by 2015 → 10% by 2020
Brazil[2]	6.0%	→ 16% by 2020
Cape Verde	–	→ 50% by 2020
Chile[2]	6%	→ 8% by 2020
China[2]	0.8%	→ 3% by 2020
Czech Republic	6.3%	→ 16–17% by 2030
Dominican Republic[1]	10%	→ 10% by 2015 → 25% by 2020
Egypt	12%	→ 20% by 2020
Estonia	2.6%	→ 8% by 2015
Germany	16%	→ 35% by 2020 → 50% by 2030 → 65% by 2040 → 80% by 2050
Ghana	–	→ 10% by 2020
India[4]	14%	→ 10% by 2012
Israel	0.1%	→ 5% by 2016 → 7% by 2020
Italy	21%	→ 26.4% by 2020
Jamaica[1]	3.0%	→ 15% by 2020
Japan[2]	2.2%	→ 1.63% by 2014
Kuwait	–	→ 5% by 2020
Libya	0%	→ 10% by 2020 → 30% by 2030
Madagascar	64%	→ 75% by 2020
Mauritius	37%	→ 65% by 2028
Mongolia	3.0%	→ 20–25% by 2020
Morocco[5]	16%	→ 20% by 2020 → 42% by 2020
New Zealand[6]	73%	→ 90% by 2025
Nicaragua	29%	→ 38% by 2011
Nigeria[2]	~ 0%	→ 7% by 2025
Pakistan[2]	~ 0%	→ 10% by 2012
Palestinian Territories	–	→ 10% by 2020
Philippines	33%	→ 40% by 2020
Portugal	44%	→ 55–60% by 2020
Romania	27%	→ 35% in 2015 → 38% by 2020
Russia[2]	0.1%	→ 2.5% by 2015 → 4.5% by 2020
Rwanda	–	→ 90% by 2012
South Africa	1.7%	→ 4% by 2013 → 13% by 2020 → 14% by 2050
Spain	26%	→ 40% by 2020
Sri Lanka[2]	0.1%	→ 10% by 2017 → 14.1% by 2022
Thailand	8.1%	→ 10.6% by 2011 → 14.1% by 2022
Tonga	–	→ 50% by 2012
Tunisia	1.0%	→ 11% by 2016 → 25% by 2030
Turkey	20%	→ 30% by 2023
United Arab Emirates	–	→ 7% by 2020
United Kingdom	7.0%	→ 10.4% by 2010/11 → 15.4% by 2015/16
Scotland		→ 100% by 2020
Vietnam	–	→ 5% by 2020

Source: REN21 database; submissions by report contributors; various industry reports; Observ'ER, *Worldwide Electricity Production from Renewable Energy Sources: Stats and Figures Series*. Twelfth Inventory – Edition 2010 (Paris: 2010). For online updates, see the "Renewables Interactive Map" at www.ren21.net.

Note: Actual percentages are rounded to nearest whole decimal for figures over 10%. The United States and Canada have de-facto state- or provincial-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 Policy Landscape section for more information about sub-national targets. Existing shares are indicative and are not intended to be a fully reliable reference. Share of electricity can be calculated using different methods. Reported figures often do not specify which method is used to calculate them, so the figures in this table for share of electricity are likely a mixture of the different methods and thus not directly comparable or consistent across countries. In particular, certain shares sourced from Observ'ER are different from those provided to REN21 by Bariloche Foundation (for example, Observ'ER lists the shares for Argentina and Cuba as 29% and 3%, respectively, while Bariloche Foundation lists these shares as 36% and 9%, respectively). The difference likely stems from calculations using different (and equally valid) methods.

1 Global share is for end 2008. EU-27 2009 share is preliminary (19.9% per EC Joint Research Centre, Renewable Energy Snapshots (Brussels: May 2010). Dominican Republic (DR) and Jamaica shares are estimations from Bariloche Foundation, which, in some cases, used extrapolations of the previous year's data. It appears DR met its 2015 target, but this may be due the use of different methods in setting the target or calculating share value.

2 For certain countries, existing shares exclude large hydro, because corresponding targets exclude large hydro. With large hydro included, shares for these countries are: Brazil 89%, Chile 50%, China 16%, Japan 10%, Nigeria 28%, Pakistan 31%, Russia 17%, and Sri Lanka 42%. Shares excluding hydro have been calculated from data published by Observ'ER (source below).

3 Argentina also has a target of 8% of electricity by 2016 from sources excluding large hydro.

4 India has already reached this target.

5 Morocco's second target of 42% by 2020 refers to installed capacity.

6 New Zealand's target is not mandatory and is intended as a guide for government policy.

Table R8 Annex. Existing Renewables Share of Electricity Production in Countries without Targets

Country/ Region	Existing Share (end 2009)	Country/ Region	Existing Share (end 2009)	Country/ Region	Existing Share (end 2009)
Austria	73%	Haiti[1]	46%	Panama[1]	59%
Belarus	0.2%	Honduras[1]	63%	Papua New Guinea	35%
Belgium	7.1%	Hungary	8.0%	Paraguay[1]	100%
Bolivia[1]	29%	Iceland	100%	Peru	62%
Bosnia & Herzegovina	35%	Indonesia	12%	Poland	6.0%
Bulgaria	9.2%	Iran	3.6%	Senegal	11%
Canada	61%	Iraq	0.8%	Serbia[2]	29%
Chile	50%	Ireland	16%	Slovakia	20%
Columbia	68%	Jordan	0.5%	Slovenia	31%
Costa Rica	95%	Kazakhstan	7.0%	South Korea	1.1%
Côte d'Ivoire	36%	Kenya	58%	Sudan	62%
Croatia	55%	Latvia	64%	Suriname[1]	55%
Cuba	3.1%	Lithuania	8.9%	Sweden	60%
Cyprus	0.3%	Luxembourg	26%	Switzerland	57%
Denmark	27%	Malawi	94%	Taiwan	4.1%
Ecuador[1]	54%	Malta	0.1%	Trinidad & Tobago[1]	0.0%
El Salvador	60%	Mexico	13%	Ukraine	7.0%
Ethiopia	81%	Moldova	2.0%	United States	10%
Finland	31%	Montenegro[2]	27%	Uruguay	66%
France	14%	Mozambique[3]	100%	Uzbekistan	10%
Gabon	38%	Namibia[3]	97%	Venezuela	69%
Greece	15%	Nepal[4]	71%	Zambia	100%
Guatemala	62%	Netherlands	9.6%		
Guyana[1]	36%	Norway	97%		

Note: See previous page for relevant notes.

1 Shares for Bolivia, Ecuador, Guyana, Haiti, Honduras, Panama and Paraguay, Suriname, and Trinidad and Tobago are sourced from estimations from the Bariloche Foundation, which, in some cases, used rough extrapolations of the previous year's data.

2 Figure includes Montenegro and Serbia.

3 Renewable energy share of electricity in Mozambique and Namibia is derived entirely from large hydro.

4 Share value for Nepal refers to end-2010.

Source: REN21 database; submissions by report contributors; various industry reports; Observ'ER, *Worldwide Electricity Production from Renewable Energy Sources: Stats and Figures Series,* Twelfth Inventory – Edition 2010 (Paris: 2010). For online updates, see the "Renewables Interactive Map" at www.ren21.net.

Table R9. Other Renewable Energy Targets

Country/ Region	Targets	
EU-27	Transport	All EU-27 countries are required to meet 10% of final energy consumption in the transport sector with renewables by 2020
Algeria	Wind: CSP: Solar PV: Cogeneration:	100 MW by 2015 170 MW by 2015 5.1 MW by 2015 450 MW by 2015
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-scale hydro, 30 MW geothermal, 20 MW solar, and 20 MW biogas 2,500 MW by 2016
Australia	Renewable generation:	Additional 45 TWh per year from large-scale renewable power sources by 2020 (equal to 20% of generating capacity)
Austria	Renewable generation:	Annual generated hydropower to increase by 12.6 PJ (3,500 GWh) by 2015. Annual generated wind power to double by 2020 (an increase of 10 PJ or 2,778 GWh)
Bangladesh	Rural off-grid solar:	2.5 million units by 2015
Cambodia	Renewable generation:	15% of rural electricity supply from solar and small hydro by 2015
Canada	Wind:	4,600 MW by 2020 (Ontario); 4,000 MW by 2016 (Quebec); 1,200 MW by 2015 (Maritime Provinces); 1,000 MW by 2016 (Manitoba); 400 MW by 2016 (New Brunswick)
China[1]	Renewable capacity: Solar hot water:	362 GW by 2020, including 300 GW hydro, 30 GW wind, 30 GW biomass, and 1.8 GW solar PV/CSP 150 million m^2 (105 GW_{th}) by 2010; 300 million m^2 (210 GW_{th}) by 2020
Croatia	Wind:	400 MW by 2030
Denmark	Offshore wind: : Ocean	1,020 MW by 2012 500 MW by 2020
Dominican Republic	Wind:	500 MW by 2015
Egypt	Wind: Hydro: Other renewables:	12% by 2020 (or more than 7,200 MW) 6% by 2020 2% by 2020
Ethiopia	Wind: Hydro: Geothermal:	760 MW new installed capacity by 2013 5.6 GW new installed capacity by 2015 450 MW new installed capacity by 2018
Finland	Transport:	20% renewable energy share in transport by 2020
France	Ocean: Wind: Solar PV:	800 MW of ocean power by 2020 25 GW by 2020, including 6 GW offshore 4.9 GW by 2020
Germany	Renewable heating:	14% by 2020
India	Renewable capacity: Wind: Small hydro (< 25 MW): Biomass cogeneration: Waste-to-energy: Solar hot water: Solar PV: Rural lighting systems:	78.7 GW renewable capacity to be added during the period from 2007–2012 10.5 GW added 2007–2012 1,400 MW added 2007–2012 1,700 MW added 2007–2012 0.4 GW added 2007–2012 15 million m^2 (10.5 GW_{th}) by 2017; 20 million m^2 (14 GW_{th}) by 2022 12 GW by 2022, including 10 GW grid-connected and 2,000 MW off-grid 20 million by 2022
Indonesia	Wind: Geothermal: Biomass power: Solar: Hydro:	255 MW by 2025 9,500 MW by 2025 810 MW by 2025 870 MW by 2025 500 MW by 2025

Table R9. Other Renewable Energy Targets (continued)

Country/ Region	Targets	
Iran	Wind:	1,500 MW by 2013
Ireland	Ocean:	500 MW by 2020
Italy	Solar PV: Renewable heating:	23 GW by 2016 16% by 2020
Japan	Solar PV:	4.8 GW by 2010; 14 GW and 5.3 million homes by 2020; 53 GW by 2030
Jordan	Wind: Solar PV: Waste-to-energy:	600 MW by 2015, with a further 600 MW by 2020 300 MW by 2015, with a further 300 MW by 2020 30–50 MW
Kenya	Renewable capacity: Geothermal power:	Double installed capacity by 2012 4 GW by 2030
Libya	Wind:	1,000 MW by 2015
Lithuania	Biomass:	70% of centralized heating by 2020
Malaysia	Renewable capacity:	3,000 MW of new renewables by 2020, including 1,250 MW of solar PV and 1,065 MW from biomass
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	Small-scale hydro: Solar PV and CSP: Wind: Solar hot water:	400 MW by 2015 2,000 MW to provide 20% of electricity by 2020 1,440 MW by 2015; 2,000 MW by 2020 400,000 m^2 (0.28 GW_{th}) by 2012; 1.7 million m2 (1.2 GW_{th}) by 2020
Mozambique	Renewable capacity: Rural:	2,000 MW each from wind, solar, and hydro Installation of PV systems for lighting (50,000), refrigerators (5,000), TVs (2,000), water pumping (5,000). and community services (20,000); installation of 1,000 biodigesters; installation of 3,000 wind pumping systems; installation of 5,000 renewable-energy-based productive systems; installation of 100,000 solar heaters. Dates not specified for these targets.
Namibia	Non-hydro renewable capacity: 40 MW by 2011	
Nepal	Rural: Solar: Wind:	7% of rural electricity from renewables; electrification of 150,000 households using 15 MW of micro-hydropower; installation of 150 solar drinking water and micro-irrigation projects, 2,000 solar dryers/cookers, 90,000 domestic biogas plants, 50 community biogas plants, and 75 institutional biogas plants; installation or refurbishment of 4,500 water mills; installation of 300,000 improved stoves and other biomass systems in certain areas. All by 2012/2013. 3 MW by 2012/2013 1 MW by 2012/2013
Nigeria	Renewable capacity:	16 GW by 2015
Norway	Renewable generation: Biomass:	30 TWh of increased annual production of renewable energy by 2016 compared to 2001. 14 TWh annual production by 2020
Pakistan	Renewable capacity:	5% by 2030
Peru	Renewable share of power capacity: 5% by 2013	
Philippines	Renewable capacity: Transport biodiesel: Biomass power:	10.6 GW by 2030; 4.5 GW added during 2003–2013 1,885 million liters annually by 2030 76 MW by 2010; 94 MW by 2015; 267 MW by 2030
Portugal	Hydro: Renewable capacity: Ocean: Wind: Solar: Biomass: Geothermal: Energy efficiency:	9,548 MW by 2010 19.2 GW by 2020 250 MW by 2020 6,875 MW by 2020, including 75 MW of offshore wind power 1,500 MW by 2020 952 MW by 2020 75 MW by 2020 20% reduction of energy use by 2050

Table R9. Other Renewable Energy Targets (continued)

Country/ Region	Targets	
Rwanda	Small hydro:	42 MW by 2015
Serbia	Renewable generation:	increase by 7.4% (735 GWh) by 2012, from 2007 levels
Singapore	Solar hot water:	50,000 m^2 (0.035 GW_{th}) by 2012
South Africa	Renewable generation: CSP: Solar PV:	10,000 GWh, 3,100 MW by 2013, including 500 MW wind and 50 MW CSP 43 TWh annually by 2030 14% of generated electricity by 2050
South Korea	Onshore wind: Offshore wind: All wind: Solar PV:	2,390 MW to be built in 2012 100 MW by 2013; 1 GW by 2015; 2.5 GW by 2019 Cumulative capacity of 15.7 GW by 2022 1,300 MW by 2012
Spain	Ocean: Wind: Solar PV:	10 MW by 2016; 100 MW by 2020 38 GW by 2020, including 35 GW on-shore and 3 GW off-shore 10 GW by 2020
Sri-Lanka	Rural off-grid households served by renewable energy:	6% by 2010; 10% by 2016
Sweden	Renewable generation:	Additional 25 TWh annually by 2020 compared to 2002
Thailand	Wind: Solar PV: Hydro: Biomass:	115 MW by 2011; 375 MW by 2016; 800 MW by 2022 55 MW by 2011; 95 MW by 2016; 500 MW by 2022 185 MW by 2011; 281 MW by 2016; 324 MW by 2022 2,800 MW by 2011; 3,220 MW by 2016; 3,700 MW by 2022
Tunisia	Renewable capacity: Wind: Solar PV: Solar hot water:	1,000 MW by 2016; 4,700 MW by 2030 330 MW by 2011 15 MW by 2011 750,000 m^2 (0.5 GW_{th}) by 2011
Turkey	Wind:	20 GW by 2023
Uganda	Small hydro, biomass, and geothermal: Solar hot water: Biogas:	188 MW by 2017 30,000 heaters by 2017 100,000 digesters by 2017
Uruguay	Renewable capacity:	500 MW by 2015

Note: Countries on this list may also have primary energy or electricity targets (see Tables R7 and R8).

1 In China, increased targets of 150 GW wind and 2 GW solar exist as draft or unofficial targets.

Source: 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	9	Luxembourg, Spain, Greece
1997	10	Sri Lanka
1998	11	Sweden
1999	14	Portugal, Norway, Slovenia
2000	14	—
2001	17	Armenia, France, Latvia
2002	23	Algeria, Austria, Brazil, Czech Republic, Indonesia, Lithuania
2003	29	Cyprus, Estonia, Hungary, South Korea, Slovak Republic, Maharashtra (India)
2004	34	Israel, Nicaragua, Prince Edward Island (Canada), Andhra Pradesh and Madhya Pradesh (India)
2005	41	Karnataka, Uttaranchal, and Uttar Pradesh (India); China, Turkey, Ecuador, Ireland
2006	46	Ontario (Canada), Kerala (India), Argentina, Pakistan, Thailand
2007	56	South Australia (Australia), Albania, Bulgaria, Croatia, Dominican Republic, Finland, Macedonia, Moldova, Mongolia, Uganda
2008	69	Queensland (Australia); California (USA); Chattisgarh, Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu, and West Bengal (India); Kenya; the Philippines; Tanzania; Ukraine
2009	80	Australian Capital Territory, New South Wales and Victoria (Australia); Hawaii, Oregon, and Vermont (USA); Japan; Kazakhstan; Serbia; South Africa; Taiwan
2010	84	Bosnia and Herzegovina, Malaysia, Malta, United Kingdom
2011 (early)	85	Louisiana (USA)
Total existing	**87**	**See note below**

Note: "Cumulative number" refers to number of jurisdictions that had enacted feed-in policies as of the given year. "Total existing" discounts three countries that are known to have subsequently discontinued policies (Brazil, South Korea, and the United States) and adds five countries that are believed to have feed-in tariffs but with an unknown year of enactment (Costa Rica, Honduras, Mauritius, Peru, and Panama). See Endnote 236 of the *Renewables 2010 Global Status Report* for further details. Many policies have been revised or reformulated in years subsequent to the initial year shown for a given country. For example, India's national FIT from 1993 was substantially discontinued but a new national FIT was enacted in 2008.

Source: All available policy references, including the IEA online Global Renewable Energy Policies and Measures database, published sources as given in the endnotes for the Policy Landscape section of this report, and submissions from report contributors.

Table R11. Cumulative Number of Countries/States/Provinces Enacting RPS/Quota 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, and Nevada (USA)
1998	9	Connecticut, Pennsylvania, and Wisconsin (USA)
1999	12	New Jersey and 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, and Rhode Island (USA); Nova Scotia, Ontario, and Prince Edward Island (Canada); Andhra Pradesh, Karnataka, Madhya Pradesh, and Orissa (India); Poland
2005	38	District of Columbia, Delaware, and Montana (USA); Gujarat (India)
2006	39	Washington State (USA)
2007	44	Illinois, New Hampshire, North Carolina, and Oregon (USA); China
2008	50	Michigan, Missouri, and Ohio (USA); Chile; India; Philippines
2009	51	Kansas (USA)
2010	53	British Columbia (Canada); South Korea
Total existing	**63**	**See note below**

Note: "Cumulative number" refers to number of jurisdictions that had enacted RPS/Quota policies as of the given year. Jurisdictions are listed under year of first policy enactment; many policies shown have been revised or renewed in subsequent years, and some policies shown may have been repealed or lapsed. "Total existing" adds 10 jurisdictions believed to have RPS/Quota policies but whose year of enactment is not known (Kyrgyzstan, Portugal, Romania, Uruguay, and the Indian states of Haryana, Kerala, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal). In the United States, there are six additional states with policy goals that are not legally binding RPS policies (Alaska, North Dakota, Utah, Vermont, Virginia, and West Virginia). Three additional Canadian provinces also have non-binding policy goals (Alberta, Manitoba, and Quebec); see Endnote 241 of the *Renewables 2010 Global Status Report* for further details. The Netherlands is not listed in this table as utilities were implementing voluntary quota goals but no national quota policy exists.

Source: All available policy references, including the IEA online Global Renewable Energy Policies and Measures database, published sources as given in the endnotes for the Policy Landscape section of this report, and submissions from report contributors.

Source: All available references, including the IEA online Global Renewable Energy Policies and Measures database, published sources in the endnotes for the Policy Landscape section, and submissions from report contributors.

Table R12. Biofuels Blending Mandates

Country	Mandate
Argentina	E5 and B5
Australia	E6 in New South Wales
Belgium	As of mid-2009, all registered fossil fuel companies in Belgium must incorporate 4% of biofuels in fossil fuels that are made available in the Belgian market
Bolivia	B2.5 by 2007; B20 by 2015; E10
Brazil	B5 by 2013; E20–E25 currently
Canada	National: E5 by 2010 and B2 by 2012. Provincial: E5 and B3 currently, and B5 by 2012, in British Columbia; E5 and B2 in Alberta; E7.5 in Saskatchewan; E8.5 and B2 in Manitoba; E5 in Ontario
China	E10 in nine provinces
Colombia	B7; B20 by 2012; E8 by 2010
Costa Rica	B10 by 2012
Czech Republic	B3.5
Dominican Republic	E15 and B2 by 2015
Ethiopia	E10
Finland	Mandatory blending rate of 5.75%
Germany	Biofuels share of 6.75% by 2010 and 7.25% by 2012; biodiesel 4.4%; ethanol 2.8% increasing to 3.6% by 2015
India	B10 and E10 as of 2008; B20 and E20 by 2017
Italy	4% for 2011; 4.5% for 2012; 5% by 2014
Malaysia	B5 by 2008
Netherlands	Renewable fuel share 4%
Norway	B3.5
Pakistan	B5 by 2015; B10 by 2025
Panama	E2 by April 2013; E5 by April 2014; E7 by April 2015; E10 by April 2016
Paraguay	E18–E24; B5
Peru	B5 by 2011; E7.8 by 2010 in northern districts and by 2011 nationwide (except in five low-population density districts)
Philippines	B10 by 2011; E10 in August 2011
Portugal	Mandatory incorporation of biofuels for the years 2011–2020, growing up to 10% (in energy content) by 2020 and the mandatory incorporation of biofuel for substitute gasoline of 2.5% (minimum % in energy content) for the period 2015–2020; B7 by 2010
South Korea	B2 by 2012
Spain	Biofuels share of 6.2% currently; 6.5% for 2012; biodiesel 6% currently, increasing to 7% by 2012
Thailand	B3 and E10
Uruguay	B2 through 2011; B5 from 2012; E5 by end of 2014
United Kingdom	B3.25
United States	National biofuels blending mandate of 13.95 billion gallons (53 billion liters) for 2011 and 36 billion gallons (136 billion liters) annually by 2022. State-level mandates: B5 in Oregon; E10 in Iowa, Hawaii, Missouri, and Montana; E20 in Minnesota; B5 in New Mexico; E2 and B2 in Louisiana and Washington State; 0.9 billion gallons (3.4 billion liters) of biofuels annually by 2017 in Pennsylvania.

Note: "E" denotes ethanol, "B" denotes biodiesel; "E5" is a blend of 5% ethanol and 95% regular gasoline. Where no target date is provided, the mandate is already in place. Table shows binding obligations on fuel suppliers; there are other countries with future indicative targets that are not shown here; see Transport Policies in the Policy Landscape section, as well as the Biofuels obligation/mandate column in Table 2. Victoria province in Australia has an aspirational biofuels target of 5% for 2010, which includes biodiesel. Chile has voluntary guidelines for E5 and B5. Bolivia has an indicative mandate under the 2005 Biodiesel Act. Ecuador has instituted an E5 pilot program in the province of Guadalajara. South Africa has proposed mandates of B2 and E8 by 2013. Mozambique has an approved but unspecified blend mandate. Some entries from previous years were removed based on updated research, including 13 Indian provinces.

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

CO_2 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- equivalent. 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, South 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 by All Consumers

Beijing, China	4% of electric power capacity and 6% of heating by 2010
Calgary AB, Canada	30% of total energy by 2036
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 by All Consumers

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

Table R13. City and Local Renewable Energy Policies: Selected Examples (continued)

Targets for Installed Capacity of Renewable Energy

Adelaide, Australia	2 MW of solar PV on residential and commercial buildings
Barcelona, Spain	100,000 m^2 (0.07 GW_{th}) of solar hot water by 2010
Kunming, China	6 million m^2 surface area covered by solar PV and solar hot water, with at least 100 MW of 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 conventional energy use 15% 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% of own-use energy in public buildings; 8% of electricity for 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 electricity in buildings; 20% for street lamps
Toronto ON, Canada	25% of own-use electricity by 2012

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

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

Table R13. City and Local Renewable Energy Policies: Selected Examples (continued)

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	60% solar hot water in all new buildings and major renovations
Lianyangang, China	Solar hot water in all new residential buildings up to 12 stories and in new construction and renovation of hotels/commercial buildings
Rajkot, India	Solar hot water in new residential buildings larger than 150 m^2 and in hospitals and other public buildings
Rio de Janeiro, Brazil	Solar hot water for 40% of heating energy in all public buildings
San Francisco CA, USA	New buildings over 100,000 ft^2 (9,290 m^2) must supply 5% of energy from solar
Tokyo, Japan	Property developers must assess and consider possibilities for solar hot water and other renewables and report assessments to owners

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.

Table R13. City and Local Renewable Energy Policies: Selected Examples (continued)

Municipal 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 per kW for systems > 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	RMB13 billion ($2 billion) investment fund to achieve 4% energy target
Edinburgh, Scotland, UK	Climate Change Fund totaling GBP18.8 million
Kunming, China	Fund for solar PV industry development and solar PV projects
Montreal QC, Canada	CAD24 million energy fund over six 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: 2011).

LIST OF ABBREVIATIONS

BNEF	Bloomberg New Energy Finance
CHP	combined heat and power
CO_2	carbon dioxide
CSP	concentrating solar (thermal) power
EU	European Union (specifically the EU-27)
EV	electric vehicle
FIT	feed-in tariff
GACC	Global Alliance for Clean Cookstoves
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (formerly GTZ)
GJ	gigajoule
GSR	Renewables Global Status Report
GW/GWh	gigawatt / gigawatt-hour
IEA	International Energy Agency
IPCC	UN Intergovernmental Panel on Climate Change
kW/kWh	kilowatt / kilowatt-hour
m^2	square meters
mtoe	million tons of oil equivalent
MW/MWh	megawatt/ megawatt-hour
MSW	municipal solid waste
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
PJ	petajoule
PV	solar photovoltaics
REN21	Renewable Energy Policy Network for the 21st Century
RPS	renewable portfolio standard
SHS	solar home system
TWh	terawatt-hour
UNEP	United Nations Environment Programme

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Page 68, middle left: Mongolian Family Uses Solar Energy to Power Home

Page 68, bottom left: Solar Cooker in Kenya

GLOSSARY

Biodiesel
A fuel used in diesel engines installed in cars, trucks, buses, and other vehicles; and also used in stationary heat and power applications. Biodiesel is produced from oilseed crops such as soy, rapeseed (canola), and palm oil, and from other vegetable oil sources such as waste cooking oil and animal fats.

Biofuel
A wide range of liquid and gaseous fuels derived from biomass. Biofuels – including ethanol, biodiesel, and biogas – can be combusted in vehicle engines as transport fuels, in stationary engines for heat and electricity generation, and used for domestic heating and cooking (for example, as ethanol gels or di-methyl ether).

Biogas digester
A unit that converts animal and plant organic material into biogas, which is made up predominantly of methane. Biogas can be used as fuel for lighting, cooking, heating, electricity generation, and transport. It can also be upgraded to biomethane.

Biomass energy/bioenergy
Biomass is any material of biological origin, excluding material that is embedded in geological formations. Biomass energy (or bioenergy) can take many forms, including biofuels, biogas, biomethane (similar to natural gas and derived by removing impurities – including carbon dioxide, siloxanes, and hydrogen sulfides – from biogas), solid biomass from dedicated plantations, and biomass waste and residues from forestry, agriculture, industrial processes, and wet and solid municipal waste.

Capital subsidy, consumer grant, rebate
One-time payments by a government or utility to cover a percentage of the capital cost of an investment, such as a solar water heater or a solar PV system.

Combined heat and power (CHP)/Cogeneration Plants
Facilities that recover "waste heat" that is otherwise discarded from power generation processes that produce thermal energy. Biomass, geothermal, and solar thermal resources can be used in such plants.

Ethanol
A liquid fuel made from biomass (typically corn, sugar cane, or grains) that can replace ordinary gasoline in modest percentages for use in ordinary spark ignition engines (stationary or in vehicles), or that can be used at higher blend levels (usually up to 85% ethanol, or 100% in Brazil) in slightly modified engines such as those provided in "flex-fuel vehicles" that can run on various fuel blends or on 100% gasoline.

Feed-in tariff
A policy that: (a) sets a fixed, guaranteed price over a stated fixed-term period at which small or large generators can sell renewable power into the electricity network, and (b) usually guarantees grid access to renewable electricity generators. Some policies provide a fixed tariff whereas others provide fixed premium payments that are added to wholesale market- or cost-related tariffs. Other variations exist, and feed-in tariffs for heat are evolving.

Fiscal Incentive
An economic incentive that provides actors (individuals, households, companies) with a reduction in their contribution to the public treasury via income or other taxes, or with direct payments from the public treasury in the form of rebates or grants.

Geothermal
Heat energy emitted from within Earth's crust, usually in the form of hot water or steam, which can be used to produce electricity or as direct heat for buildings, industry, and agriculture. In addition, ground-source heat pumps use shallow geothermal heat (up to around 20 meters depth but that can also be deemed to be stored solar heat) to heat and cool water and space.

Gigajoule/Petajoule
A unit of energy that is equal to 1 billion (10^9) joules. Approximately six gigajoules represent the amount of potential chemical energy in a barrel of oil, when combusted. A petajoule is 10^{15} joules.

Green energy purchase
Voluntary purchase of renewable energy, usually electricity, by residential, commercial, government, or industrial consumers, either directly from a utility company, from a third-party renewable energy generator, or through the trading of renewable energy certificates (RECs).

Hydropower
Electricity that is derived from the energy of water moving from higher to lower elevations. Categories of hydropower projects include run-of-river, storage (reservoir)-based capacity, and low-head in-stream technology (the least developed). Pumped storage plants pump water from a lower reservoir to a higher storage basin using surplus electricity, and reverse the flow to generate electricity when needed; they are not energy sources but means of energy storage. Hydropower covers a continuum in project scale from large (usually defined as more than 10 MW installed capacity, but the definition varies by country) to small-, mini-, micro-, and pico.

Investment
In this report, total investment includes venture capital, corporate and government research and development, private equity, public markets new equity, re-invested investment, asset finance, and small-scale distributed capacity. It excludes mergers and acquisitions, which are based on previously invested money changing hands. Financial new investment includes venture capital and private equity investment (VC/PE), public markets investment, and asset finance of utility-scale projects;

these categories are highlighted because data are available in greater detail in the BNEF database, quarter-by-quarter.

Investment tax credit
A taxation measure that allows investments in renewable energy to be fully or partially deducted from the tax obligations or income of a project developer, industry, building owner, etc.

Mandate/obligation
A measure that requires designated parties (consumers, suppliers, generators) to meet a minimum, and often gradually increasing, target for renewable energy such as a percentage of total supply or a stated amount of capacity. Costs are generally borne by consumers. In addition to electricity mandates through renewable portfolio standards/quotas, mandates can include building codes or obligations that require the installation of renewable heat or power technologies (often in combination with energy efficiency investments); renewable heat purchase mandates; and requirements for blending biofuels into transportation fuel.

Modern biomass energy
Heat, electricity, and/or transport fuels that are produced from biomass-fueled technologies other than those using "traditional biomass." Technologies include combustion, gasification, pyrolysis, cogeneration of power and heat, and anaerobic digestion to produce biogas and landfill gas. Liquid biofuel also is a form of modern biomass.

Net metering
A power supply arrangement that allows a two-way flow of electricity between the electricity distribution grid and customers that have their own generation system. The customer pays only for the net electricity delivered from the utility (total consumption minus self-production). A variation that employs two meters with differing tariffs for purchasing electricity or exporting excess electricity off-site is called "net billing."

Production tax credit
A taxation measure that provides the investor or owner of a qualifying property or facility with an annual tax credit based on the amount of renewable energy (electricity, heat, or biofuel) generated by that facility.

Public Competitive Bidding
An approach under which public authorities organize tenders for a given quota of renewable supplies or capacity, and remunerate winning bids at prices that are typically above standard market levels.

Regulatory policy
A rule to guide or control the conduct of those to whom it applies. In the renewable energy context, examples include mandates or quotas such as renewable portfolio standards, feed-in tariffs, biofuel blending mandates, and renewable heat obligations.

Renewable energy target
An official commitment, plan, or goal by a government (at local, state, national or regional level) to achieve a certain amount 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 renewable obligation or quota).
A measure requiring that a minimum percentage of total electricity or heat sold, or generation capacity installed, be provided using renewable energy sources. Obligated utilities are required to ensure that the target is met; if it is not, a fine is usually levied.

Solar home system (SHS)
A small solar PV panel, battery, and charge controller that can provide modest amounts of electricity to homes, usually in rural or remote regions that are not connected to the electricity grid.

Solar water heating
Solar collectors, usually rooftop mounted but also on-ground at a larger scale, that heat water and store it in a tank for later use as hot water or for circulation to provide space or process heating.

Solar photovoltaic (PV)
A PV cell is the basic manufactured unit that converts sunlight into electricity. Cells can be used in isolation (such as on a wristwatch or garden light) or combined and manufactured into modules and panels that are suitable for easy installation on buildings. Thin-film solar PV materials can be applied as films over existing surfaces or integrated with building components such as roof tiles. Some materials can be used for building-integrated PV (BIPV) by replacing conventional materials in parts of a building envelope, such as the roof or façade. A pico PV system is a small solar home system – such as a solar lamp or an information and communication technology (ICT) appliance – with a power output of 1–10 W_{peak}.

Renewable energy certificate (REC)
A certificate that is awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat). Certificates can be accumulated to meet renewable energy obligations and also provide a tool for trading among consumers and/or producers. They also are a means of enabling purchases of voluntary green energy.

Traditional biomass
Unprocessed solid biomass, including agricultural residues, animal dung, forest products, and gathered fuel wood, that is combusted in stoves, furnaces, or open fires to provide heat energy for cooking, comfort, and small-scale agricultural and industrial processing, typically in rural areas of developing countries.

NOTE ON ACCOUNTING AND REPORTING OF INSTALLED CAPACITIES

A number of issues arise when accounting for and reporting installed capacities of renewable energy. Five of these issues are elaborated below, along with some justification for the approaches chosen in this report.

1. Capacity vs. energy data.

The Global Market Overview section includes energy (i.e., GWh) data where possible but focuses mainly on capacity (i.e., GW) data for three reasons. First, capacity data are generally more readily available and, in countries where updated annual data are not available, capacity expansion is easier to extrapolate from year-to-year than energy production. Second, capacity is less prone to seasonal and annual variations that are common for many forms of renewable energy. Third, capacity data better mimic investment trends over time. (For a better sense of potential energy production, see capacity factors in Table 1.) For heating, output is provided in Joules where production data are available; otherwise, capacity data are given in Watts-thermal (Wth). Biofuels data are consistently provided as annual volumes (billion liters/year) produced.

2. Constructed capacity vs. connected capacity and operational capacity.

In 2009 and 2010, the solar PV and wind markets saw increasing amounts of constructed capacity that was not yet connected to the grid, or capacity that was connected but not yet deemed officially operational. This phenomenon is particularly prominent with wind power in China but also became evident with PV during 2010, notably in Italy (see text). Differences among constructed, connected, and operational capacities are due to the inability of public administrators, utilities, and others to keep up with the pace of construction, for example in terms of technical interconnection, testing, approval, contracting, and certification. This situation will likely persist in future years if high rates of installation continue. Where feasible, this report focuses on constructed capacity because it best correlates with actual flows of capital investment during the year.

3. Complexities of biomass energy.

Biomass energy is derived from organic residues and waste from forestry, agriculture, and industry; the biogenic portion of municipal waste; and energy crops grown specifically as fuel. Biomass cuts across all energy end-use sectors – providing power, heat, and transport – as well as many other sectors, including food and agriculture, forestry, industry, and waste. There exist numerous bioenergy "routes," or pathways from feedstock to final energy. Biomass can be transformed into energy through direct combustion or it can be used to produce a combustible liquid or gaseous fuel, such as ethanol, methanol, biogas, biomethane (a substitute for natural gas), or synthetic gas. Increasingly, facilities that process biomass are integrating the production of electricity, heat, and (depending on the pathway) even fuels. Much of the bioenergy used around the world, especially for heat, is highly decentralized and difficult to track comprehensively. As a result, statistics for many countries do not exist or are incomplete, dispersed, and difficult to obtain and consolidate. This report strives to provide the best available data regarding biomass energy developments given these complexities and constraints. Note that energy derived from incineration of the biogenic, or organic, share of municipal solid waste (MSW) is not included in the main text and tables of this report (although where official data are specified, they are included in the Endnotes). Explicit data on the organic vs. non-organic waste shares are unavailable for many countries, and thus it is not possible to track capacity or output on a global scale. Even where the share of organic feedstock is known, there is no clear or universally accepted methodology for calculating the energy output (which varies depending on waste composition) derived from the organic component of waste. As biogas and landfill gas are derived exclusively from the organic component of waste, these energy carriers and the energy produced are included in GSR statistics, where available.

4. Total PV vs. grid-connected and off-grid PV.

Grid-connected and off-grid PV were reported separately in past editions of this report, with the focus being on grid-connected capacity. Initially, the purpose of this practice was to highlight the dynamic shift from off-grid to grid-connected PV that took place after 2005. Until 2005, off-grid PV accounted for most of the global market, but by 2010 the market share of grid-connected had risen above an estimated 90–95%. Starting with this edition of the report, only total PV data will be reported in tables; where available and of possible interest, data and information regarding off-grid installations will continue to be provided in the text. The reasons for this change are two-fold: (1) as with small-scale hydropower (see below), it is becoming increasingly difficult to track global off-grid developments; and (2) it seems logical to report on statistics for the total PV market rather than just one (although the most significant) segment of it. It is important to note that this change affects the reported growth rates for PV because the total PV market has not grown as quickly over the past five years as the grid-connected market has, as seen in Figure 2. The change also retroactively affects data for years prior to 2010, particularly in Table R3.

5. Total hydro vs. small- and large-scale hydro.

In past editions of this report, small-scale hydro data were reported separately from total hydro in reference tables for a variety of reasons: (1) the relatively large scale of large hydropower significantly exceeds all other renewable capacity combined and would mask the dynamic growth in capacity of small-scale hydro and other renewables if all were counted together; (2) small-scale hydro is reported separately by a number of countries and is sometimes treated differently in terms of planning or national support policies; and (3) the technical, economic, social, and environmental challenges often differ by scale. As a result, small-scale hydro was reported separately in the interest of capturing as rich a picture as possible of renewables development. Since 2005, however, small-scale hydro reporting has suffered from lack of statistics which, combined with inconsistent definitions across countries (for example, "small-scale" in Sweden is ≤ 1.5 MW; Norway ≤ 10 MW; India ≤ 25 MW; Brazil and the United States < 30 MW; Canada and China ≤ 50 MW), makes it difficult to derive reliable global data. Thus, global data for small-scale hydro are no longer reported separately in this report, although where available, national data are included in the text. Dynamic growth of non-hydro renewables is shown by presenting data with and without all hydropower, but where appropriate we continue to highlight where policy frameworks and other developments distinguish between small- and large-scale hydro. Hydropower statistics are not provided according to category of plant (run-of-river, reservoir, in-stream) due to lack of data.

NOTE ON FURTHER INFORMATION AND SOURCES OF DATA

This 2011 report edition follows five previous editions in 2005, 2006, 2007, 2009, and 2010. 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.

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. Each edition draws from hundreds of published references, plus a variety of electronic newsletters, numerous unpublished submissions from contributors, personal communications, and Web sites.

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 water heating, and biofuels. 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. More precise annual increments to capacity are generally available only for wind, solar PV, and solar hot water.

GLOBAL MARKET OVERVIEW

1 BP, *Statistical Review of World Energy*, June 2011.

2 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). Figure 1 is based on the following data for 2009: (a) global final energy consumption of 8,340 Mtoe including traditional biomass, which is derived from the 8,428 Mtoe for 2008 from International Energy Agency (IEA), *Key World Energy Statistics 2010* (Paris: IEA/OECD, 2010), and then adjusted (downward) for 2009 using the -1.1% growth rate in global primary energy for 2009 found in BP, *Statistical Review of World Energy 2010* (London: June 2010); (b) traditional biomass final consumption of 800 Mtoe, which is based on the 746 Mtoe (2008) in the residential sector of developing countries per IEA, *World Energy Outlook 2010* (Paris, 2010), p. 342, which likely undercounts traditional biomass because much of this use is in the informal or non-commerical sector, adjusted upward for final consumption of charcoal in the informal sector as given in Chapter 8 of IPCC, *Special Report on Renewable Energy Sources and Climate Change Mitigation (2011)*; this 800 Mtoe of traditional biomass final consumption is less than previously estimated in previous editions of the *Renewables Global Status Report* from other sources;; (c) hydropower of 3,272 TWh and 282 Mtoe for 2009 from BP, op. cit. this note; (d) nuclear of 2,698 TWh and 233 Mtoe from BP, op. cit. this note; (e) non-hydro renewables for 2009 from BP *Statistical Review of World Energy* 2011 for non-hydro power generation (607 TWh) and for biofuels (52 Mtoe); and from REN21 *Renewables 2007 Global Status Report* figures using capacity increases and additional industry data. Figures estimated for 2009 are: biomass power 190 TWh, wind power 370 TWh, geothermal power 70 TWh, solar and other power 40 TWh, solar hot water 390 petajoules (PJ), geothermal heat 330 PJ, biomass heat 4,600 PJ, ethanol 1,660 PJ, and biodiesel 460 PJ. So total non-hydro renewable power generation for 2009 is calculated as 670 TWh (an estimate which is slightly higher than the BP figure of 607 TWh, but which makes no difference in terms of final shares), and total final energy from non-hydro renewables is calculated as 236 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.

3 Growth rates and Figure 2 based on the following sources: historical PV data from Paul Maycoc k, *PV News*, various editions, and from REN21, *Renewables 2005 Global Status Report* (Washington, DC: Worldwatch Institute, 2005) current data from European Photovoltaic Industry Association (EPIA), *Global Market Outlook for Photovoltaics Until 2015* (Brussels: 2011); Global Wind Energy Council (GWEC), *Global Wind Report: Annual Market Update 2010* (Brussels: 2011); BTM Consult – A part of Navigant Consulting, *World Market Update 2010* (Ringkøbing, Denmark: March 2011; World Wind Energy Association (WWEA), *World Wind Energy Report 2010* (Bonn: April 2011); Ma Lingjuan, Chinese Renewable Energy Industries Association (CREIA), Beijing, personal communications with REN21, May and June 2011; Indian Ministry of New and Renewable Energy (MNRE), *Annual Report 2010–11* (Delhi: 2011); Morse Associates, provided by Fred Morse and Kurt Klunder, personal communications with REN21, March, April, and May 2011; Ruggero Bertani, Enel Green Power, S.p.A, personal communication with REN21, 21 April 2011; International Journal on Hydropower and Dams (Wallington, Surrey, U.K.: various editions); Bloomberg New Energy Finance (BNEF), "Clean Energy - Analyst Reaction, Investment in Large-hydro - How Large?" Table 1, 12 January 2011; Lau Saili, International Hydropower Association (IHA), London, personal communication with REN21, March 2011; Werner Weiss, Irene Bergmann, and Gerhard Faninger, *Solar Heat Worldwide 2007: Markets and Contribution to the Energy Supply 2005* (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme, May 2007); Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2009* (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme, March 2011); F.O. Licht, 2011; IEA, *Medium Term Oil and Gas Markets 2011* (Paris: June 2011).

4 The low end of this range is for hydropower and geothermal power, although it should be noted that hydropower is growing from a relatively large base; the high end is for geothermal direct heat. Fossil fuel consumption growth rates are for period 2005 through 2010, with average annual growth rates over this period for oil at 0.8%, natural gas 2.6% and coal 3.4%, based on data from BP, op. cit. note 1. Note that single-year growth rates in 2010 were higher, with oil at 3.1%, natural gas 7.4%, and coal 7.6%.

5 Half and 194 GW based on 92 GW of fossil capacity added, and 5 GW of nuclear capacity added from UNEP, *Global Trends in Renewable Energy* Investment (Nairobi: 2011), p. 25, and on renewable energy data noted in this report. See Table R4; data based on the following: sources provided in note 3; IEA, *Renewables Information 2010* (Paris: 2010) (for OECD biomass power capacity); IEA, *Electricity Information 2010* (Paris: OECD, 2010); WEC, *Survey of Energy Resources 2009* (London: 2009); submissions from report contributors; historical databases going back to 2005 report edition as maintained by Eric Martinot.

6 Figure 3 from BP 2011, op. cit. note 1, Excel supplementary data tables. Global electricity production according to BP was 21,325 TWh in 2010; hydro was 3,428 TWh; nuclear was 2,767 TWh; and other (non-hydro) renewables were 701 TWh. Global power capacity estimate of 4,950 GW is based on IEA's 4,500 GW installed in 2007, adjusted for an average growth rate of 3% for 2008–2010, per IEA, *World Energy Outlook 2009* (Paris: IEA/OECD, 2009), p. 102. World electricity generation estimated at 20,700 TWh in 2009, based on 2008 generation of 20,269 TWh from IEA, *Electricity Information 2010* , op. cit. note 5, adjusted by 2.1% growth for 2009 (assuming same growth rate as 2008). Hydropower accounts for an estimated 16% of global electricity generation (and other renewables 2%), from IHA, *Advancing Sustainable Hydropower, 2011 Activity Report* (London: 2011).

7 See Table R4 for 2010 data; increase over 2009 based on data for total renewable electric capacity including small hydropower in 2009, less the small-scale hydro total, from REN21, *Renewables 2010 Global Status Report* (Paris: 2010), Table R4, with adjustments for restated solar PV and biomass data for 2009.

8 Figure 4 based on data in Table R4; see sources for Figure 2, op. cit. note 3; also based on IEA, *Renewables Information 2010* (for OECD biomass power capacity) and *Electricity Information 2010*, both op. cit. note 5; WEC, op. cit. note 5; submissions from report contributors; historical databases going back to 2005 report edition as maintained by Martinot.

9 Capacity shares based on 2009 nameplate capacity from U.S. Energy Information Administration (EIA), "Annual Electric Generator Report," Generator Y09 File, "Exist" tab, EIA Form 860, www.eia.doe.gov/cneaf/electricity/page/eia860.html, viewed 13 June 2011; proposed additions (total, biomass without MSW and hydro without pumped storage) for 2010 from EIA, "Annual Electric Generator Report," Generator Y09 File, "Proposed" tab, EIA Form 860, 2010; 2010 geothermal additions from Geothermal Energy Association (GEA), *Annual U.S. Geothermal Power Production and Development Report* (Washington, DC: April 2011); wind additions from American Wind Energy Association (AWEA), "U.S. Wind Energy Industry Finishes 2010 with Half the

Installations of 2009, Activity Up in 2011, Now Cost-competitive with Natural Gas," press release (Washington, DC: 24 January 2011); solar PV additions from EPIA, op. cit. note 3, and from U.S. Solar Energy Industries Association (SEIA), U.S. *Solar Market Insight: 2010 Year in Review,* Executive Summary (Washington, DC: 9 March 2011); CSP additions from Morse Associates, op. cit. note 3, and from SEIA, op. cit. this note. Note that wind and solar accounted for an estimated 96% of renewable capacity added in 2010; hydro accounted for almost 59% of total existing renewable capacity at the end of 2010. Share of generation based on data from EIA, *Monthly Energy Review,* March 2011, pp. 15, 105. In absolute numbers, renewable energy output increased from 7.751 quad Btu in 2009 to 8.182 quad Btu in 2010.

10 Based on data from U.S. EIA, *Monthly Energy Review,* March 2011, pp. 15, 105. In absolute numbers, renewables increased from 7.751 quadrillion Btu in 2009 to 8.182 quadrillion Btu in 2010.

11 Ma Lingjuan, CREIA, Beijing, personal communication with REN21, 21 June 2011.

12 Ibid.

13 Figure of 41% from European Wind Energy Association (EWEA), "Offshore and Eastern Europe New Growth Drivers for Wind Power in Europe," www.ewea.org; and from EWEA, *Wind in Power: 2010 European Statistics* (Brussels: February 2011). This was the fifth consecutive year in which renewable share of EU annual power capacity additions exceeded 40%; wind accounted for nearly 17% of new electric capacity and solar PV for 21.7%, from EWEA, *Wind in Power...*, op. cit. this note; PV accounted for 21% according to EPIA, cited in Jackie Jones, "Italy Overhauls its PV Incentives." RenewableEnergyWorld.com, 19 May 2011.

14 EWEA, "Offshore and Eastern Europe...," op. cit. note 13; EWEA, *Wind in Power,* op. cit. note 13.

15 Share of electricity generation in 2009 from Hans Bloem et al., *Renewable Energy Snapshots 2010* (Ispra, Italy: European Commission, DG Joint Research Centre, Institute for Energy, June 2010); 1999 and 2009 share of gross inland consumption from "Renewable Energy Contribution to the EU27 Energy Supply Almost Doubled Over the Last Decade," *Newsletter* EnergyMarketPrice.com, 12 April 2011.

16 Renewables' share of total final energy consumption is up from 10.4% in 2009. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)/ Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Renewable Energy Sources 2010*, provisional data as of 23 March 2011, www.erneuerbare-energien.de/files/english/pdf/application/pdf/ee_in_zahlen_2010_en_bf.pdf.

17 Biomass (33%, including solid and liquid biomass, biogas, landfill and sewage gas, biogenic share of waste), hydropower (19%), and PV (12%); renewables' share of electricity generation increased in 2010 despite a decline in wind output relative to 2009, from 38.6 billion kWh (2009) to 37.5 billion kWh (2010); PV output was up 82% relative to 2009; all from Ibid. Renewables accounted for 55.7 GW of capacity at the end of 2010: 4.8 GW hydro; 27.2 GW wind; 4.9 GW biomass; 1.5 GW biogenenic share of waste; 17.3 PV GW; 7.5 MW geothermal. According to the Bundesverband der Energie- und Wasserwirtschaft e.V., renewables represented 32.9% of Germany's electric capacity in 2010. Data provided by the office of Hans-Josef Fell, Berlin, personal communication with REN21, June 2011.

18 Spain's 2010 primary energy and electricity shares from Alfonso Beltrán García-Echániz, Director General of Instituto para la Diversificacion y Ahorro de la Energía (IDAE), "Balance energético 2010 y Perspectivas 2011: Energías Renovables y Eficiencia Energética," presentation in Madrid, 28 March 2011. Note that wind provided 15.4% of Spain's 2010 electricity and solar PV 2.5%, per Ibid; 2009 share of final energy from Eurostat, "Share of Renewable in the EU27 Energy Supply Almost Doubled between 1999 and 2009," press release (Luxembourg: 11 April 2011); 2009 share of electricity from Observ'ER, *Worldwide Electricity Production from Renewable Energy Sources: Stats and Figures Series*, Twelfth Inventory - Edition 2010 (Paris: 2010), at www.energies-renouvelables.org/observ-er/html/inventaire/Eng/sommaire.asp#chapitre3.

19 This was up from 3.5 GW of renewable capacity (not including large hydropower) installed in April 2002, per MNRE, op. cit. note 3.

20 Ibid. 142 MW of off-grid capacity (about half from non-bagasse biomass CHP, and 23% from PV) were installed by 31 March 2011, per MNRE, www.mnre.gov.in/achievements.htm.

21 MNRE, op. cit. note 3. Note that large hydro came to 37.4 GW and other renewable energy grid-connected capacity came to 18.8 GW; total power capacity was 172.3 GW.

22 Figure of 39 GW based on 37.6 GW from WWEA, op. cit. note 3; 38.3 GW from GWEC, CREIA and CWEA, "China Adds 18.9 GW of New Wind Power Capacity in 2010," press release (Beijing/Brussels: 6 April 2011); 39.4 GW from BTM Consult – A part of Navigant Consulting, op. cit. note 3; 11.5 GW in 2005 from GWEC, op. cit. note 3. Figure 5 based on sources in this note and on data from previous editions of this report.

23 There are a range of estimates of added wind capacity and total installations, based on when data are collected, what new capacity is included (e.g., capacity once it begins feeding into the grid or once it is officially 'operational'), and other possible factors and assumptions. Data here are based on 196.6 GW from WWEA, op. cit. note 3, and from GWEC, provided by Steve Sawyer, GWEC, Brussels, review comment, May 2011; on 199.5 GW from BTM Consult – A part of Navigant Consulting, op. cit. note 3; and on national data from sources provided elsewhere in this section.

24 Estimates of 52 and 83 from WWEA, op. cit. note 3.

25 Based on 59 GW at end of 2005, per GWEC, op. cit. note 3.

26 U.S. from GWEC, "Global Wind Capacity Increases by 22% in 2010 – Asia Leads Growth," press release (Brussels: 2 February 2011), and from Jesse Gilbert and John Catillaz, "SNL Energy Analysis: Wind Industry Q3'10 Update," RenewableEnergyWorld.com, 23 November 2010; Spain from "Wind Power Installed Capacity in Spain Increased by 1,516 MW in 2010, Slowest Rhythm in Seven Years," 3 February 2011, www.aeeolica.es/en; causes of depressed demand from GWEC, "op. cit. note 26; Gilbert and Catillaz, op. cit. note 26; GWEC, op. cit. note 3; IEA, *Clean Energy Progress Report* (Paris: OECD, 2011).

27 GWEC, op. cit. note 3; WWEA, op. cit. note 3.

28 Figure of 4.4% based on REN21 and Worldwatch Institute, *Renewables 2006 Global Status Report* (Paris and Washington, DC: 2006). Note that the 2004 share was 2% based on just below 200 MW added that year, per Shi Pengfei, CWEA, personal communication with REN21, May 2010. Figure 6 based on multiple sources cited in these notes.

29 Additions and total from Li Junfeng, CREIA, communication with REN21, June 2011; Shi Pengfei, CWEA, communication with REN21, 17 March 2011, and from GWEC, CREIA and CWEA, "China Adds 18.9 GW of New Wind Power Capacity in 2010," press release (Beijing/Brussels: 6 April 2011); percent increase based on 13.8 GW added in 2009 from Shi Pengfei, CWEA, personal communication with REN21, May 2010.

30 Ma Lingjuan, CREIA, personal communication with REN21, May 2011. Note that China had 25.8 GW installed at the end of 2009, but only 17 GW were then considered officially operational; 44.7 GW were installed and 31.1 GW of capacity were officially operational the end of 2010, according to China Electricity Council, data provided by Shi Pengfei, CWEA, personal communication with REN21, 17 March 2011; and also State Grid Corporation of China, white paper, cited in "China Grids to Connect 90 m kW of Wind Power by 2015," *China Daily,* 16 April 2011. The difference is explained by the fact that there are three prevailing statistics in China: installed capacity (turbines installed according to commercial contracts); construction capacity (constructed and connected to grid for testing); and operational capacity (connected, tested, and receiving tariff for electricity produced). At the end of 2010, operational capacity was 31 GW, construction capacity was 40 GW, and installed capacity was 44.7 GW according to Li Junfeng, CREIA, personal communication with REN21, 3 June 2011.

31 China Electricity Council, data provided by Shi Pengfei, CWEA, personal communication with REN21, 17 March 2011.

32 Based on 5,115 MW added in 2010, per AWEA, op. cit. note 9.

33 Amount of generation from Debra Preikis-Jones, AWEA, Washington, DC, personal communication with REN21, 8 June 2011; number of homes from AWEA, "The Report is Out: US Wind Industry Continues Growth, Despite Slow Economy and Unpredictable Policies," *Wind Energy Weekly,* 8 April 2011.

34 AWEA, op. cit. note 9.

35 Estimate of 15% based on Canada additions of 690 MW in 2010, for a total of just over 4,000 MW from WWEA, op. cit. note 3, and from GWEC, op. cit. note 3.

36 Data based on the following sources: 9,259 MW added and 84,074 MW total from EWEA, *Wind in Power..*, op. cit. note 13, and from GWEC, op. cit. note 3; 9,970 added for a total of 85,983 MW from WWEA, op. cit. note 3; 10,980 MW added in 2010 from BTM Consult – A part of Navigant Consulting, op. cit. note 3. WWEA and BTM both cover Europe more broadly (e.g., they include Turkey, which added an estimated 528 MW during 2010 according to BTM). The reduction relative to 2009 varies from negligible from BTM Consult to 5% from WWEA, to 8% from EWEA.

37 EWEA, "Offshore and Eastern Europe ...," op. cit. note 13; natural gas accounted for 51% of added capacity in 2010, followed by solar PV (21.7%) and wind (16.7%), per EWEA, *Wind in Power...*, op. cit. note 13.

38 Germany added 1.49 GW net in 2010 for a total of 27,204 MW, per BMU/AGEE-Stat, op. cit. note 16; 2009 data in Table R2 from idem. Germany 2010 total also from J.P. Molly, "Status der Windenergienutzung in Deutschland – Stand 31.12.2010," DEWI, www.dewi.de; generation data from BMU/AGEE-Stat, op. cit. note 16.

39 BMU/AGEE-Stat, op. cit. note 16.

40 Spain added 1,752 MW in 2010, ending the year with 20,744 MW, per Beltrán García-Echániz, op. cit. note 18. Note that Spain added 1,516 MW in 2010, for a total approaching 20.7 GW, according to GWEC, "Global Installed Wind Power Capacity (MW) – Regional Distribution" (Brussels: February 2011), and EWEA, *Wind in Power...*, op. cit. note 13. Capacity added was 1,094 MW according to Red Eléctrica de España, cited in AE Eolica, "Spain Becomes the First European Wind Energy Producer after Overcoming Germany for the First Time," 25 April 2011, www.aeeolica.es/en. The 2009 data in Table R2 are based on 2010 additions and total capacity.

41 AE Eolica, op. cit. note 40. Government target set in the 2005–2010 Renewable Energies Plan was 20,155 MW, whereas estimated capacity at year-end 2010 was 20,676 MW.

42 Generation from the Spanish Wind Energy Association (Asociación Empresarial Eólica, AEE), per John Blau, "Spanish Wind Generated More Power than German Wind in 2010," RenewableEnergyWorld.com, 15 April 2011.

43 France added 1,108 MW in 2010 for a total of 5,729 MW by February 2011, per Miriam Sperlich, Bureau de coordination énergies renouvelables/Koordinierungsstelle Erneuerbare Energien e.V., "Wind Energy in France after Grenelle II –Future Developments and Regional Planning Rules," presentation in Hannover, 6 April 2011, slide 3, www.enr-ee.com/fileadmin/user_upload/Downloads/Messen/Praesentation_Hannover_Messe_2011.pdf. Note that France added 1,086 MW, for a total of 5,660 MW, per EWEA, *Wind in Power...*, op. cit. note 13, GWEC, op. cit. note 3, and WWEA, op. cit. note 3. Italy added an estimated 948 MW, per Gestore Servizi Energetici (GSE), "Incentivazione delle fonti rinnovabili: Certificati Verdi e Tariffe Onnicomprensive. Bollettino aggiornato al 31 dicembre 2010" (Rome: April 2011); the year-end total was 5,797 MW per EWEA, *Wind in Power...*, op. cit. note 13 (GWEC and WWEA provided the same data). Note that cumulative, incentivized GW at end 2010 was 4.7 GW, per GSE, at www.gse.it/attivita/Incentivazioni%20Fonti%20Rinnovabili/Pubblicazioni%20informative/Bollettino%20energia%20da%20fonti%20rinnovabili%20-%20anno%202010.pdf. The U.K. added 400 MW offshore and 476 MW onshore, for a total of 5,300 MW, per Energy Statistics Team, U.K. Department of Energy and Climate Change (DECC), London, personal communication with REN21, 6 June 2011. Note that additions were 1,192 MW per Nick Medic, BWEA/RenewableUK, London, personal communication with REN21, 6 June 2011. Both DECC and RenewableUK estimated almost the same existing capacity at year-end, so the difference in additions is likely due to when a site is classified as operational, per Energy Statistics Team, DECC, personal communication with REN21, 8 June 2011. In addition, Denmark, which is included in Table R2, added 323 MW net for a total of 3,805 MW from Energinet.dk, from Danish Energy Agency, and BTM Consult – A part of Navigant Consulting, all provided by Birger Madsen, Ringkøbing, Denmark, personal communication with REN21, 7 June 2011.

44 Bulgaria more than doubled its capacity to 375 MW; total capacity increased more than 50% in Lithuania (154 MW) and Poland (1,107 MW); Romania increased installations 33-fold (to 462 MW) or 40-fold to 591 MW, depending on the source. All from EWEA, *Wind in Power..*, op. cit. note 13 except for Romania 40-fold increase, which is from WWEA, op. cit. note 3. Belgium also increased capacity more than 50%, to 911 MW, per EWEA, *Wind in Power..*, op. cit. note 13, or to 886 MW per WWEA, op. cit. note 3.

45 Figure of 1,377 MW added for total installed capacity of 13,184 MW from MNRE, "Wind Energy Programme," in *Annual Report 2010-2011*, op. cit. note 3; 2009 total in Table R2 derived by subtracting additions from 2010 total. Note that India added 1,259 MW, for total of 13.1 GW, per WWEA, op. cit. note 3; and added 2,139 MW for total of 13,065 MW per GWEC, op. cit. note 3.

46 Latin America and Caribbean from GWEC, op. cit. note 40; Brazil added 325 MW per ANEEL - National Electric Energy Agency of Brazil (ANEEL), Generation Data Bank, January 2011, at www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.asp; 326 MW per GWEC, op. cit. note 40; and 320 MW per WWEA, op. cit. note 3. Mexico from Secretaría de Energía, *Prospectiva del Sector Eléctrico 2010-2025,* Dirección General de Planeación Energética, Editor (Mexico DF: 2011), p. 227. Note that Mexico added 316 MW per GWEC, op. cit. note 3; and added 104 MW per WWEA, op. cit. note 3.

47 GWEC, op. cit. note 40.

48 Egypt from WWEA, op. cit. note 3; Morocco from Sahara Wind Project, "Current Wind Farms Operating in North Africa," www.saharawind.com/index.php?Itemid=55&id=38&option=com_content&task=view&lang=en, viewed 15 June 2011, and from Gamesa, "Inauguration of a 140 MW Wind Farm Equipped with Gamesa Turbines," press release (Vizcaya, Spain: 28 June 2010). Note that Morocco added only 33 MW for a total of 286 MW in 2010, per WWEA, op. cit. note 3 and GWEC, op. cit. note 3. The total appears to be consistent with other data found.

49 GWEC, op. cit. note 3.

50 Offshore capacity increased by 1,162 MW to a total of 3,118 MW, from WWEA, op. cit. note 3, and from Stefan Gsänger, "World Wind Outlook: Down But Not Out," RenewableEnergyWorld.com, 25 May 2011. Note that Japan's year-end total installed wind capacity was 2.3 GW, per GWEC, op. cit. note 3.

51 Figure of 2,978 MW from WWEA, op. cit. note 3; the total was more than 2.9 GW according to EWEA, *Wind in Power...*, op. cit. note 13; 3.05 GW from EurObserv'ER, *Wind Barometer* (Paris: February 2011).

52 U.K. additions from Nick Medic, BWEA/RenewableUK, London, communication with REN21, 6 June 2011 (additions were 652.8 MW for total of 1,192.3 MW); existing totals from "Europe Close to 3 GW Offshore Wind Power," RenewableEnergyFocus.com, 20 January 2011.

53 Donghai Bridge from Ivan Tong and Ben Warren, "Quick Look: Renewable Energy Development in China," RenewableEnergyWorld.com, 14 December 2010; four projects from "China's Goldwind Plans to Invest More in Offshore Turbine Production," *Xinghua*, 17 April 2011.

54 AWEA, "EPA Permit in Hand, Cape Wind Turns to Financing," *Wind Energy Weekly*, 14 January 2011.

55 "The Big List: 2010's Biggest Renewable Energy Projects," RenewableEnergyWorld.com, 28 December 2010; Franz Alt, "World's Largest Wind Project Is Underway," sonnenseite.com, 6 August 2010.

56 Community wind projects from Stefan Gsänger, WWEA, Bonn, personal communication with REN21, May 2011; Canada from WWEA, op. cit. note 3; small-scale turbines from Andrew Kruse, Southwest Windpower Inc., personal communication with REN21, 21 May 2011.

57 About 24 MW were added in the U.S. from AWEA data provided by Kruse, op. cit. note 56; 8.6 MW were added in the U.K., from RenewableUK, "Summarized Statistics," in *Small Wind Systems UK Market Report 2011* (London: April 2011).

58 Katie Christensen, *Catalogue of Small Wind Turbines 2010* (Hurup Thy, Denmark and Beijing: Nordic Folkecenter for Renewable Energy and CWEA, May 2010). Small-scale wind turbines are also being used in many countries for water pumping, as in India, where there were 1,351 installed at the end of January 2011, per MNRE, op. cit. note 3, Table 5.6, 2011. Note that there exists only limited data available for small-scale wind turbine markets

and other developments, so it is not possible to provide global statistics here.
59 Estimate of 1.92% from BTM Consult – A Part of Navigant Consulting, provided by Birger Madsen, personal communication with REN21, May 2011; 2.5% from WWEA, op. cit. note 3.
60 EWEA, "Offshore and Eastern Europe...," op. cit. note 13.
61 Denmark from energinet.dk and Danish Energy Agency, provided by Birger Madsen, communication with REN21, 7 June 2011. Note that 2010 was an 84% wind year; in a normal wind year, the coverage would have been 26%. Portugal from Luísa Silvério, Directorate General for Energy and Geology (DGEG), personal communication with REN21, April 2011; Spain from Beltrán García-Echániz, op. cit. note 18; 16.4% in Spain from AE Eolica, op. cit. note 40. Note that wind power covered 43% of Spain's national electricity demand on 9 November 2011, per Red Eléctrica de España (REE), *The Spanish Electricity System: Preliminary Report 2010* (Madrid: December 2010); Ireland from EWEA, *Wind in Power...*, op. cit. note 13; Germany from BMUAGEE-Stat, op. cit. note 16. EWEA says wind's share in Germany was 9.3%.
62 J.P. Molly, "Status der Windenergienutzung in Deutschland – Stand 31.12.2010," DEWI, www.dewi.de.
63 Iowa leads the U.S. with 15.4% of all electricity generated from wind (8,799 MWh of 57,135 MWh total) in 2010, based on EIA, *Monthly Energy Review,* March 2011, at www.eia.doe.gov/pub/electricity/epm0311.zip. Note that wind's share is up to 20% according to George C. Ford, "Iowa Wind Energy Industry Expected to See Slow Recovery," *Eastern Iowa Business*, 30 January 2011; Texas from "About ERCOT," www.ercot.com/about/; AWEA, *U.S. Wind Industry Year-End 2010 Market Report* (Washington, DC: January 2011).
64 Figure of 1% from IEA, op. cit. note 26, p. 44; nearly twice the production is based on 27.6 TWh generated in 2009 and 50.1 TWh in 2010, from China Electricity Council, data provided by Shi Pengfei, CWEA, personal communication with REN21, 17 March 2011; provincial data from Shi Pengfei, CWEA, personal communication with REN21, May 2011. According to another source, in 2010 China' s wind turbines operated for 2,097 hours on average and constituted 21.1% of local power consumption in the eastern part of Inner Mongolia, 8.7% in the western part of Inner Mongolia, 5.6% in Jilin Province, and 4.6% in Heilongjiang Province, per State Grid Corporation of China, as cited in "China Grids to Connect 90 m kW of Wind Power by 2015," *China Daily*, 16 April 2011.
65 China from Shi Pengfei, CWEA, China country report, in WWEA, *Wind Energy International 2011/2012* (Bonn: May 2011); United States from AWEA, "U.S. Wind Industry Continues Growth, Despite Slow Economy and Unpredictable Policies," press release (Washington, DC: 7 April 2011); the UK also had 3.3 GW with consent and awaiting construction, but there is no guarantee this will be built, per Energy Statistics Team, U.K. Department of Energy and Climate Change (DECC), London, 6 June 2011.
66 Energy & Enviro Finland, "Bosnia to Kick Off Hydro, Wind Projects," www.energy-enviro.fi/index.php?PAGE=3&NODE_ID=5&LANG=1&ID=3456, 31 December 2010; Romania from Andrew Lee, "Country Profile: Romania Opens Up to Green Energy," RenewableEnergyWorld.com, 5 October 2010.
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68 Biomass power figures do not include waste-to-energy capacity (MSW) – see Note on Accounting and Report of Installed Capacities for explanation. Biomass power figures are adjusted from 2009 to reflect updated IEA data for biogas and solid biomass power statistics from individual country submissions to this report.
69 IEA, op. cit. note 26, p. 52. Due to lack of available data it is not possible to rank countries according to newly installed capacity.
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72 Generation from EIA, "2010 December EIA-923 Monthly Time Series," op. cit. note 70; 2010 data from EPA, Landfill Methane Outreach Program, "National and State lists of landfills and energy projects," www.epa.gov/lmop/projects-candidates/index.html#map-area, updated 12 April 2011; 2008 data from EIA, "Table 1.12 U.S. Electric Net Summer Capacity, 2004–2008," in *Renewable Energy Trends in Consumption and Electricity 2008* (Washington, DC: 2009), at www.eia.doe.gov/cneaf/solar.renewables/page/trends/trends.pdf.
73 Not including municipal organic waste. EurObserv'ER, *Solid Biomass Barometer* (Paris: November 2010), pp. 125, 127; EurObserv'ER, *Biogas Barometer* (Paris: November 2010), p. 108.
74 Further, about 63% of solid biomass power was from CHP, whereas the vast majority (81%) of biogas-derived power was from electric-only plants. Ibid.
75 Solid biomass generated 62.2 TWh, biogas 25.2 TWh and the renewable share of MSW 15.4 TWh in 2009, Ibid and EurObserv'ER, *Renewable Municipal Waste Barometer* (Paris: November 2010), p. 94.
76 Production increased from 20.8 TWh in 2001 to more than 62 TWh in 2009, per EurObserv'ER, *Solid Biomass Barometer,* op. cit. note 73; 800 plants from Ecoprog and Fraunhofer Umsicht survey reports, cited in idem.
77 EurObserv'ER, ibid and EurObserv'ER, *Biogas Barometer,* op. cit. note 73, p. 107.
78 Data exclude MSW, per EurObserv'ER, *Solid Biomass Barometer*, op. cit. note 73, p. 125, and EurObserv'ER, *Biogas Barometer,* op. cit. note 73, p. 108. Germany is also the top biogas producer in Europe, both in total and in per capita production, per EurObserv'ER, idem, p. 111.
79 Data exclude MSW. Future growth and new markets from EurObserv'ER, *Biogas Barometer*, op. cit. note 73, p. 115.
80 Danish Energy Agency, *Energistatistik 2009* (Copenhagen: September 2010).
81 Figure of 28.7 TWh provided by Thomas Nieder, Centre for Solar Energy and Hydrogen Research Baden-Württenberg (Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg ZSW), affiliated with BMU/AGEE-Stat, personal communication with REN21, 6 April 2011; 22% annually from IEA, op. cit. note 26, p. 52; Germany 2010 data exclude organic domestic waste and green waste, per BMU/AGEE-Stat, *Zeitreihen zur Entwicklung der erneuerbaren Energien in Deutschland* (Berin: March 2011).

Of this 4.9 GW total, 2.1 GW was solid biomass, 330 MW was liquid, 2.1 GW was biogas, 200 MW sewage gas, and 160 MW landfill gas. (Including power output of biogenic share of waste, biomass power capacity was 6.4 GW, generating 33.5 TWh or 5.5% of total electricity consumption, per BMU/AGEE-Stat, op. cit. note 16.

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84 Ramanauskaite, op. cit. note 83.

85 Capacity from IEA, op. cit. note 26, p. 52; generation from Issao Hirata, Brazilian Ministry of Mines and Energy, personal communication with REN21, May 2011; 7.8 from Renata Grisoli, CENBIO, personal communication with REN21, February 2011.

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103 EPIA, cited in Isabella Kaminski, "Solar PV Leads Renewable Growth in Europe," RenewableEnergyFocus.com, 24 February 2011.

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109 GSE, Atlasole Web site, http://atlasole.gse.it/atlasole, viewed 2 June 2011. Note that approximately 13 MW of PV were being connected daily under Italy's FIT as of early June 2011. This is because many installments readied in 2010 or earlier were re-considered and determined to qualify under the FIT by law 129-2010, and were connected in early 2011, together with new systems, per GSE, www.gse.it/attivita/ContoEnergiaF/servizi/Pagine/Legge129-2010.aspx.
110 Amount of 1,490 MW added in 2010 for total of 1,953 MW, and all data in Table R3, from EPIA, op. cit. note 3.
111 France and Belgium data in Table R3; all data sourced from Ibid.
112 Figure of 369 MW added and 3,787 MW total from Beltrán García-Echániz, op. cit. note 18. An estimated 371 MW of PV capacity was installed in 2010, per Asociación Empresarial Fotovoltaica, cited in www.europapress.es/castilla-lamancha/noticia-energia-fotovoltaica-produjo-57-mas-2010-siendo-lm-mayor-potencia-853-mw-20110407161241.html. Spain data in Table R3 from the following: 2009 additions from IDAE, *La industria fotovoltaica española en el contexto europeo* (Madrid: 2010); 2009 existing from Ministerio de Industria Turismo y Comercio, "La Energía en España 2009," Table 8.5, p. 207, at www.mityc.es/energia/balances/Balances/LibrosEnergia/Energia_2009.pdf; 2008 from Ministerio de Industria Turismo y Comercio, "La Energía en España 2008," Table 8.6, p. 198, at www.mityc.es/energia/balances/Balances/LibrosEnergia/ENERGIA_2008.pdf; 2005–07 data from past editions of this report. See Table R3 for additional data. Note that EPIA data vary from IDAE data by only a few MW, with the exception of 2006 (EPIA reports 102 MW added; 148 MW total), 2007 (EPIA reports 542 MW added); 2008 (EPIA reports 2,708 MW added; 3,398 MW total), and 2009 (EPIA reports only 17 MW added).
113 Japan and U.S. from EPIA, op. cit. note 3; U.S. also from SEIA, op. cit. note 9. Another source put the U.S. total at 937 MW, per Henning Wicht, "Photovoltaic Market in Europe to Account for 70 Percent of World Total in 2011," isuppli.com, 14 March 2011; 550 MW for China (includes additions of 525 MW grid-connected and 25 MW off-grid, making a total of 861 MW PV) from Ma Lingjuan, CREIA, communication with REN21, May 2011. Note that other sources say 0.4 GW for China, per Greentech Media (Greentech Solar), *PV News*, Vol. 30, No. 2 (2011); and 520 MW added for total of 893 MW from EPIA, op. cit. note 3. China added 9 MW off-grid in 2006; 18 MW off-grid in 2007; 19 MW off- and 20 MW on-grid in 2008; 18 MW off- and 140 MW on-grid in 2009; and 25 MW off- and 525 MW on-grid in 2010. Cumulative capacity was 60 MW in 2006, 114 MW in 2007, 153 MW in 2008, 311 MW in 2009, and 861 MW in 2010. Data differ from EPIA by no more than a few MW, with the exception of 2008 (EPIA reports 145 MW total), 2009 (EPIA reports 228 MW added; 373 MW total), and 2010 (EPIA reports 520 MW added).
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116 United States from "The Future of the Utility Scale PV in the U.S.," GreentechMedia.com, 1 December 2010. As of 15 April 2011, just shy of 7.5 GW of utility scale PV were under contract, per "Utility-scale project pipeline (as of April 15, 2011)," *PV News*, May 2011.
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118 EPIA, op. cit. note 3. Note that EPIA data only very slightly from 2009 and 2010 data from KOPIA, op. cit. note 104.
119 Data for 2009 and 2010 from Denis Lenardic, pvresources.com, personal communications with REN21, 31 March 2011 and April and May 2010. Note that it is not possible to estimate the exact number of power plants because many of the large-scale PV power plants consist of several small (very often MW-ranged) PV power plants.
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121 Lenardic, 26 February 2011, op. cit. note 120.
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124 The other six were completed in 2008 and 2009. Denis Lenardic and Rolf Hug, "Große Photovoltaik-Kraftwerke: 2010 mehr als 3 GW neu an das Netz angeschlossen," www.solarserver.de, 16 February 2011.
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127 Prior, op. cit. note 126. In March 2011, California-based utility San Diego Gas and Electric signed a PPA for a 150 MW CPV project scheduled for completion in 2015, per "Concentrating Photovoltaics: Soitec Announces 150 MW Solar Power Project in Southern California," *Solar Magazine*, 10 March 2011.

128 BIPV project of 6.7 MW from GTM Research, cited in "BIPV on the Upswing," RenewableEnergyFocus.com, 3 August 2010.

129 The off-grid sector accounted for approximately 6% of demand in 2008, falling to 5% in 2009 and an estimated 3% in 2010, per Paula Mints, "Solar PV Market Analysis: Unstable Boom Times Continue for PV Market," *Renewable Energy World International Magazine*, July-August 2010.

130 Figure of 70% from Jackie Jones, "Country Profile: Australia," RenewableEnergyWorld.com, 20 December 2010. Largest tracker system is 0.5 MW in Western Australia, per idem.

131 Ruggero Bertani, "Geothermal Power Generation in the World 2005-2010 Update Report," Proceedings World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010; more than 20% based on data for 2005 (55.7 GWh) and 2010 from Bertani, op. cit. note 3.

132 El Salvador's capacity increased from 151 MW in 2005 to 204 MW in 2010, Guatemala from 33 MW to 52 MW, Papua New Guinea from 6 MW to 56 MW, and Portugal from 16 MW to 29 MW, from Bertani, op. cit. note 3.

133 Figure of 240 MW derived from estimate of 340 MW global additions from Bertani, op. cit. note 131, minus 100 MW for Iceland that were not added during 2010. This compares with at least 405 MW added in 2009, 456 MW in 2008, and 315 MW in 2007, per Bertani.

134 Stephen Lacey, "U.S. Installs Only One Geothermal Plant in 2010," RenewableEnergyWorld.com, 3 February 2011.

135 Projection made by Islandsbanki. All information from Stephen Lacey, "East Africa Sees a Flurry of Geothermal Activity," RenewableEnergyWorld.com, 1 February 2011.

136 New Zealand (134 MW), Italy, and Kenya from Bertani, op. cit. note 131; New Zealand additions of 132 MW (and same data for Italy and Kenya) from Lacey, op. cit. note 134; "The Big List…," op. cit. note 155.

137 "The Big List…,"op. cit. note 155; more than 250 MW from Lacey, op. cit. note 135. Kenya total was an estimated 202 MW per Bertani, op. cit. note 131.

138 Figure of 15 MW from Geothermal Energy Association, *Annual U.S. Geothermal Power Production and Development Report* (Washington, DC: April 2011).

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140 Twenty-four countries, United States (3,098 MW), Philippines, Italy, New Zealand, and Japan from Bertani, op. cit. note 131. Indonesia based on 1,189 MW from "Indonesia to Lure More Geothermal investments: Firm," *Jakarta Post*, 9 February 2011; on Directorate General of New, Renewable Energy and Energy Conservation, MEMR "Geothermal Development in Indonesia," 18 November 2010; on 1,197 MW according to Íslandsbanki, "Geothermal Power: Top 10 Countries, Installed Capacity in MW, 1990-2010," http://datamarket.com/data/set/1c7w/#ds=1c7w|qy2&display=table, viewed March 2011; and on Bertani, op. cit. note 131. Mexico from Íslandsbanki, op. cit. this note; from Organización Latinoamericana de Energía, http://siee.olade.org/siee/default.asp, provided by Gonzalo Bravo, Bariloche Foundation, Argentina, communication with REN21, May 2011; and from United Nations –Mexico, per Anne Elliot, "Mexico Leads in Geothermal Energy," *Latin Daily Financial News*, 24 April 2011. Note that other U.S. estimates include 3.1 from Geothermal Energy Association (GEA), *Annual U.S. Geothermal Power Production and Development Report* (Washington, DC: April 2011), and 3.3 GW derived from Ventyx Global LLC, Velocity Suite, cited in FERC, "Office and Energy Projects, Energy Infrastructure Update for December 2010," www.ferc.gov/legal/staff-reports/01-19-11-energy-infrastructure.pdf, viewed March 2011. Note that Mexico's total was 965 MW per Bertani, op. cit. note 131; Italy's total was 863 MW per Íslandsbanki, op. cit. this note; Iceland from Orkustefna fyrir Ísland, Drög Til Umsagnar, Reykjavik, 12 January 2011, p. 5. Japan's total was 536 MW per Íslandsbanki, op. cit. this note.

141 Iceland data is estimated for 2009, from Orkustofnun, *Ársskýrsla Orkustofnunar 2010*, Reykjavik, March 2011; Philippines from Alison Holm et al., *Geothermal Energy: International Market Update* (Washington, DC: GEA, May 2010).

142 Holm et al., op. cit. note 141.

143 Expected resources from confirmed projects ranges from 1,377 to 1,393 MW; when accounting for unconfirmed projects the range of planned capacity additions in development is 1,613–1,664 MW, per GEA, op. cit. note 140.

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145 Germany and U.K. (with 10 MW) from "Drilling to Begin for Cornwall Geothermal Power Plant in 2011," *The Guardian*, 16 August 2010; and from "Bavaria Builds 10 MW Geothermal Power Plant," RenewableEnergyFocus.com, 23 November 2010; Chile and U.K. from Bertani, op. cit. note 131; Costa Rica from Istmo Centroamericano: Estadísticas Del Subsector Eléctrico, ECLAC, April 2010; India from "India's First Geothermal Power Plant…," op. cit. note 144. Note that a 30 MW plant is also under development in Argentina (per Bertani), but while a company has won the public bidding for developing the project, it is at a standstill due to legal claims by future potential neighbors, according to Gonzalo Bravo, Bariloche Foundation, Argentina, personal communication with REN21, May 2011.

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147 Additions in 2010 based on 78 MW added in U.S. and 400 MW in Spain, per Morse Associates, op. cit. note 3, and Beltrán García-Echániz, op. cit. note 18. Global year-end total based on 739 MW added between end-2005 and end-2010, plus 356 MW installed earlier (including 354 MW of SEGs plants installed in the U.S. during 1985–1991; 1 MW installed in Arizona, U.S., during 2006; 1 MW installed in Australia, during 2004). Data from Morse Associates, op. cit. note 3.

148 Based on data from Morse Associates, op. cit. note 3.

149 Beltrán García-Echániz, op. cit. note 18; 632 MW also from IEA, op. cit. note 26, p. 46.

150 Morse Associates, op. cit. note 3; 78 MW and Florida also from SEIA, op. cit. note 9.

151 Extresol-2 from NREL, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=11, updated 30 March 2011; Morocco based on data from Morse Associates, op. cit. note 3. El Kuraymat is a total of 140 MW Integrated Solar Combined Cycle, with 20 MW of solar. Partial operation from Egyptian New and Renewable Energy Authority (NREA), provided by Maged Mahmoud, RCREEE, personal communication with REN21, May 2011.

152 Based on 996 MW under construction and 1,839 MW expected to come on line by end of 2013, per Beltrán García-Echániz, op. cit. note 18, and subtracting 50 MW that began operating in March 2011, per NREL, op. cit. note 151.

153 Capacity under construction and signed contracts from Morse Associates, op. cit. note 3. See also "Feds Surge Forward on Solar Projects in the Southwest," PoliticsDaily.com, 17 January 2011, and Sarah McBride, "Big Push Could Be Over For California Solar," *Reuters*, 29 December 2010. Note that at the end of 2010 there were 6.5 GW under contract in the United States; that had declined to 6.238 GW as projects shifted from CSP to PV. The main hurdles remaining for these projects are permitting and financing, per Morse Associates, op. cit. note 3. There are 10,918 MW of CSP projects under construction or development ("in the pipeline") in the United States, per GTM Research, "Concentrating Solar Power 2011: Technology, Costs and Markets," www.gtmresearch.com, 12 January 2011.

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155 Morse Associates, op. cit. note 3; CHP in China from "Israeli Solar Combined Heat and Power Provider Signs Landmark Agreement with Chinese Government," RenewableEnergyWorld.com, 22 February 2011.

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161 Increase in 2010 from BP, op. cit. note 1; 16% from IHA, *Advancing Sustainable Hydropower, 2011 Activity Report* (London: 2011).

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167 National Electric Energy Agency of Brazil (ANEEL), Generation Data Bank, www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.asp, January 2011.

168 Canadian Hydropower Association, Ottawa, personal communication with REN21, 27 April 2011.

169 Ibid.

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HydroWorld.com, 9 December 2010; China from BNEF, op. cit. note 162; Brazil and Ethiopia from "The Big List...," op. cit. note 155; "One Unit of Beles Hydropower Project in Ethiopia Begins Generating Power," HydroWorld.com, 10 May 2010; also Tana Beles plant (460 MW), per IHA, op. cit. note 161.

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POLICY LANDSCAPE

1 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 International Energy Agency (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.

2 Policy statistics in this section are the result of considerable and careful analysis based on many sources of published and unpublished information, in an attempt to ensure that the statistics and comparative data are as accurate as possible. However, the evaluation of renewable energy policies is a complex process. Accounting methods used to assess primary and final consumer energy vary but are poorly understood and often confused or ignored in the literature. Definitions of specific renewable energy policies differ widely, and this can be exacerbated by the varying interpretations used when presenting information in the databases and literature upon which this section is based. As one simple example, 30 U.S. states are listed by the U.S. Department of Energy as having a "Renewable Portfolio Standard," a quota imposed on their electricity utilities. However, a further six states have voluntary standards that are not strictly within the normally accepted definition of a quota policy. In addition, the definition of "renewable energy" varies among these states with, for example, most but not all excluding new large hydropower projects and only around half including biogas produced from anaerobic digestion plants.

3 Policy impacts and lessons learned have been discussed in Chapter 11 of the IPCC *Special Report on Renewable Energy Sources* and also in a forthcoming IEA report *Deploying Renewables: Worldwide Prospects and Challenges.*

4 Database of State Incentives for Renewable Energy (DSIRE), www.dsire.org; D. Gold, "Renewable Energy Standards, Savvy or Silly?" RenewableEnergyWorld.com, 22 March 2011.

5 In December 2010, France suspended solar PV projects of less than 3 kW for three months to evaluate subsidy cuts and measures to limit industry growth following a boom. The PV capacity installed at the end of 2010 will cost EUR 560 million a year for 20 years in subsidies paid for through a tax to electricity consumers. France is targeting 5,400 MW of solar PV capacity by 2020, per "French Government Plans Solar Energy Tender, Modifiable Rates, Besson Says," http://budurl.com/mercomftmr; J. Jones, "Italy Overhauls Its PV Incentives," RenewableEnergyWorld.com, 20 May 2011; E. Hughes, "Cuts Conundrum – Investigating Likely Feed-in Tariffs Worldwide," *PV Tech*, 25 August 2010.

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7 Actual country primary energy shares from renewable energy in recent years are listed in the annual IEA report *Renewables Information*, www.iea.org/publications/free_new_Desc.asp?PUBS_ID=2037, viewed 15 March 2011. A detailed description and comparison of the different methods of calculating the share of primary energy is contained in the IPCC *Special Report on Renewable Energy Sources and Climate Change Mitigation* (May 2011) which, after detailed deliberations, chose to use the *direct equivalent method* commonly used in IPCC long-term scenarios rather than the *physical accounting method* as used by the IEA or the *substitution method* as used by BP in their *Energy Outlook* and the U.S. Energy Information Administration; see also Sidebar 7 of the *Renewables 2007 Global Status Report*.

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36 Resources and Logistics, *Identification Mission for the Mediterranean Solar Plan*, Final report, January 2010, http://ec.europa.eu/energy/international/international_cooperation/doc/2010_01_solar_plan_report.pdf.

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38 Some question the inclusion of the United States (1978) in Table R10. The U.S. national feed-in law was the Public Utility Regulatory Policy Act (PURPA) of 1978, 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. Some jurisdictions are not listed in Table R10 due to the limited scope of their policies – for example, the U.S. state of Washington, which has enacted limited FITs for solar PV but restricts the amount of capacity that can be installed and is capped at $5,000/year per project. Other policies are listed even though they are limited also: California's FIT is limited to 750 MW; Oregon and Vermont's FITs are limited to 25 MW and 50 MW, respectively, and are considered pilot programs. In addition, some utilities in the U.S. states of Michigan and Wisconsin offer limited FITs but there is no state-level policy. The Australian Northern Territory had a limited FIT for a small number of systems in Alice Springs.

39 There remain significant differences of opinion among experts as to what constitutes a feed-in tariff. For Table 2, the Netherlands MEP policy is considered a premium and is classified as an energy production payment, rather than a feed-in policy. Costa Rica, Panama, Peru, and Iran may be the same, although some claim these countries have FITs. FITs shown for some other countries might better be classified as energy production payments as well. Indonesia's 2002 FIT covers generators less than 10 MW (revised from 1 MW in 2006) but at low tariff levels and is thus not considered by some to be a true FIT. India's national FIT from 1993 was substantially discontinued but new national FITs were enacted in 2008.

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56 Federal Energy Regulatory Commission (FERC), "Renewable Power & Energy Efficiency Market: Renewable Portfolio Standards," www.ferc.gov/market-oversight/othr-mkts/renew/othr-rnw-rps.pdf. For states with non-binding policy goals, see references for Table R11.

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GLOBAL STATUS REPORT

Version 1.1 | 07/2011

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