REN21 Renewable Energy Policy Network for the 21st Century

RENEWABLES 2012
GLOBAL STATUS REPORT

2012

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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 energy in developing and developed economies. Open to a wide variety of dedicated stakeholders, REN21 connects governments, international institutions, nongovernmental organisations, industry associations, and other partnerships and initiatives. REN21 leverages their successes and strengthens their influence for the rapid expansion of renewable energy worldwide.

www.ren21.net

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2012 THE REN21 RENEWABLES GLOBAL STATUS REPORT, RENEWABLES INTERACTIVE MAP, AND RENEWABLES GLOBAL FUTURES REPORT

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. The report is a true collaborative effort of around 400 experts, several authors, REN21 Secretariat staff, Steering Committee members, regional research partners, and numerous individual contributors and reviewers. With the support of such a wide community, the GSR has become the most frequently referenced report on renewable energy business and policy, serving a wide range of audiences.

The REN21 **RENEWABLES INTERACTIVE MAP** is a research tool for tracking the development of renewable energy worldwide. The Map offers a streamlined method for gathering and sharing information on economic development and policy frameworks in the field of renewable energy. The Renewables Interactive Map furthers the perspectives provided in the GSR by facilitating in-depth, country-specific analysis, providing access to market and policy information that is constantly updated, as well as to detailed exportable databases. 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.

REN21 is currently in the process of developing the new REN21 **RENEWABLES GLOBAL FUTURES REPORT (GFR)**, due to be released in January 2013. This futures report is intended to complement the Renewables Global Status Report by reporting on the "status" of the collective thinking about the future of renewable energy. It is based on interviews with over 150 experts around the world, and on several consultation workshops, and explores the range of credible possibilities for renewable energy in the long term. This futures report should enable REN21 to continue to expand its global dialogue on renewable energy among a growing number of stakeholders.

FOREWORD

The United Nations General Assembly declared 2012 as the International Year of Sustainable Energy for All. UN Secretary-General Ban Ki-moon has supported the Year with his new global initiative, Sustainable Energy for All, which seeks to mobilise action on three interlinked objectives to be achieved by 2030: providing universal access to modern energy services, doubling the rate of improvement in energy efficiency, and doubling the share of renewable energy in the global energy mix. The REN21 *Renewables Global Status Report* provides a comprehensive and timely overview of renewable energy market, industry, and policy developments worldwide, providing a sound basis for measuring global progress in renewable energy deployment.

For a long time to come, 2011 will be recognized as the year of the Fukushima Daiichi nuclear disaster that followed the tragic March earthquake and tsunami in Japan. These events had an enormous impact on most aspects of life in Japan, particularly energy policy and politics.

Fukushima's impacts have reached far beyond Japan, triggering heated debate about the security of nuclear energy and the reorientation of future energy policy in many countries. In Germany, for example, Fukushima has led to a commitment to rapid exit from nuclear energy use by 2022 and complete reform of the nation's energy sector. The "Energiewende" (Energy Transition), which focuses on energy efficiency and renewable energy sources, together with massive energy infrastructure investments, is Germany's biggest infrastructure modernisation project, with beacon-like character for many other countries around the world.

The year 2011 was also one of continued insecurity on financial markets and uncertainty over future renewable energy policy support, particularly in Europe and the United States. Despite the uncertainties, global new investment in renewable power and fuels increased by 17%, to a new record of USD 257 billion. Including hydropower projects of over 50 megawatts, net investment in renewable power capacity exceeded that for fossil fuels.

Renewable energy continued to grow strongly in all end-use sectors—power, heating and cooling, as well as transport—and supplied an estimated 17% of global final energy consumption. As in previous years, about half of the new electricity capacity installed worldwide was renewable based. Despite the difficult economic times, the European Union installed more renewable energy capacity during 2011 than ever before, and, for the fourth year running, renewables accounted for more than half of all newly installed electric capacity in the region—more than 71% of total additions.

Renewable energy support policies continued to be a driving force behind the increasing shares of renewable energy. At least 118 countries, more than half of which are developing countries, now have renewable energy targets in place, and 109 countries have policies to support renewables in the power sector.

A main driver propelling renewable energy policies is their potential to create jobs. Globally, an estimated 5 million people work directly or indirectly in renewable energy industries. More and more governments around the world acknowledge the benefits of energy efficiency and renewable energy as central elements of any green economy strategy.

Renewables are also increasingly viewed as critical for providing access to energy, particularly in rural areas of the developing world. For the first time, the *Renewables 2012 Global Status Report* features an overview of rural energy developments and trends by region, based largely on input from numerous international experts. Renewable energy is seen as a means for providing millions of people with a better quality of life.

Although there is still a long way to go to provide energy access for all, 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 renewables continue to increase.

On behalf of the REN21 Steering Committee, I would like to thank all those who have contributed to the successful production of the 2012 *Renewables Global Status Report*. These include lead author/research director Janet L. Sawin together with all section authors, GSR project manager Rana Adib, and the entire team at the REN21 Secretariat, under the leadership of Christine Lins. Special thanks go to the ever-growing network of more than 400 authors, researchers, contributors, and reviewers who participated in this year's process and helped make the GSR a truly international and collaborative effort.

We are indebted 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.

I hope this year's REN21 *Renewables Global Status Report* provides again a useful tool towards a rapid global transition to renewable energy.

Mohamed El-Ashry

Mohamed El-Ashry

Chairman of REN21

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2012 INTERNATIONAL YEAR OF
SUSTAINABLE ENERGY
FOR ALL

The UN Secretary-General's initiative **Sustainable Energy for All** (see Sidebar 9) aims at mobilising global action to achieve universal access to modern energy services, improved rates of energy efficiency, and expanded use of renewable energy sources by 2030. To support this initiative, REN21's *Renewables 2012 Global Status Report* includes a special focus on rural renewable energy, based on input from local experts working around the world. The report showcases how renewables can provide access to energy for millions of people, contributing to a better quality of life through use of modern cooking, heating/cooling, and electricity technologies. This year's report also addresses the systematic linking of energy efficiency and renewable energy in the policy arena.

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The **Global Trends in Renewable Energy Investment report (GTR)**, formerly Global Trends in Sustainable Energy Investment, was first published by the Frankfurt School—UNEP Collaborating Centre for Climate & Sustainable Energy Finance in 2011. This annual report was produced previously (starting in 2007) under UNEP's Sustainable Energy Finance Initiative (SEFI). It grew out of efforts to track and publish comprehensive information about international investments in renewable energy according to type of economy, technology, and investment.

The GTR is produced jointly with Bloomberg New Energy Finance and is the sister publication to the REN21 *Renewables Global Status Report* (GSR). The latest edition was released in June 2012 and is available for download at www.fs-unep-centre.org.

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EXECUTIVE SUMMARY

Renewable energy continued to grow strongly, and global investment reached new highs. Despite policy uncertainty in some countries, the geography of renewables is expanding as prices fall and policies spread.

EXECUTIVE SUMMARY

Renewable energy markets and policy frameworks have evolved rapidly in recent years. This report provides a comprehensive and timely overview of renewable energy market, industry, investment, and policy developments worldwide. It relies on the most recent data available, provided by a network of more than 400 contributors and researchers from around the world, all of which is brought together by a multi-disciplinary authoring team. The report covers recent developments, current status, and key trends; by design, it does not provide analysis or forecast the future.

As such, this report and subsequent editions will serve as a benchmark for measuring global progress in the deployment of renewable energy, which is of particular interest in this International Year of Sustainable Energy for All. UN Secretary-General Ban Ki-moon has marked the occasion with a new global initiative, Sustainable Energy for All, which seeks to mobilise global action on three interlinked objectives to be achieved by 2030: universal access to modern energy services, improved rates of energy efficiency, and expanded use of renewable energy sources.

RENEWABLE ENERGY GROWTH IN ALL END-USE SECTORS

Renewable energy sources have grown to supply an estimated 16.7% of global final energy consumption in 2010. Of this total, modern renewable energy accounted for an estimated 8.2%, a share that has increased in recent years, while the share from traditional biomass has declined slightly to an estimated 8.5%. During 2011, modern renewables continued to grow strongly in all end-use sectors: power, heating and cooling, and transport.

In the power sector, renewables accounted for almost half of the estimated 208 gigawatts (GW) of electric capacity added globally during 2011. Wind and solar photovoltaics (PV) accounted for almost 40% and 30% of new renewable capacity, respectively, followed by hydropower (nearly 25%). By the end of 2011, total renewable power capacity worldwide exceeded 1,360 GW, up 8% over 2010; renewables comprised more than 25% of total global power-generating capacity (estimated at 5,360 GW in 2011) and supplied an estimated 20.3% of global electricity. Non-hydropower renewables exceeded 390 GW, a 24% capacity increase over 2010.

The heating and cooling sector offers an immense yet mostly untapped potential for renewable energy deployment. Heat from biomass, solar, and geothermal sources already represents a significant portion of the energy derived from renewables, and the sector is slowly evolving as countries (particularly in the European Union) are starting to enact supporting policies and to track the share of heat derived from renewable sources. Trends in the heating (and cooling) sector include an increase in system size, expanding use of combined heat and power (CHP), the feeding of renewable heating and cooling into district networks, and the use of renewable heat for industrial purposes.

Renewable energy is used in the transport sector in the form of gaseous and liquid biofuels; liquid biofuels provided about 3% of global road transport fuels in 2011, more than any other renewable energy source in the transport sector. Electricity powers trains, subways, and a small but growing number of passenger cars and motorised cycles, and there are limited but increasing initiatives to link electric transport with renewable energy.

Solar PV grew the fastest of all renewable technologies during the period from end-2006 through 2011, with operating capacity increasing by an average of 58% annually, followed by concentrating solar thermal power (CSP), which increased almost 37% annually over this period from a small base, and wind power (26%). Demand is also growing rapidly for solar thermal heat systems, geothermal ground-source heat pumps, and some solid biomass fuels, such as wood pellets. The development of liquid biofuels has been mixed in recent years, with biodiesel production expanding in 2011 and ethanol production stable or down slightly compared with 2010. Hydropower and geothermal power are growing globally at rates averaging 2–3% per year. In several countries, however, the growth in these and other renewable technologies far exceeds the global average.

Renewables represent a rapidly growing share of energy supply in a number of countries and regions:

- In the European Union, renewables accounted for more than 71% of total electric capacity additions in 2011, bringing renewable energy's share of total electric capacity to 31.1%. Solar PV alone represented almost 47% of new capacity that came into operation. The renewable share of consumption is rising in parallel (although not as rapidly since much of the capacity is variable solar and wind). In 2010 (latest available data), the renewable share of total electricity consumption was 19.8% (up from 18.2% in 2009), and renewables represented 12.4% of gross final energy consumption (compared to 11.5% in 2009).
- Germany continues to lead in Europe and to be in the forefront globally, remaining among the top users of many renewable technologies for power, heating, and transport. In 2011, renewables provided 12.2% of Germany's final energy consumption, 20% of electricity consumption (up from 11.6% in 2006), 10.4% of heating demand (up from 6.2%), and 5.6% of transport fuel (excluding air traffic).

- In the United States, renewable energy made up an estimated 39% of national electric capacity additions in 2011. The share of U.S. net electricity generation from non-hydropower renewables has increased from 3.7% in 2009 to 4.7% in 2011. Nine states generated more than 10% of their electricity with non-hydro renewables in 2011, up from two states a decade ago. All renewables accounted for about 11.8% of U.S. primary energy production in 2011, up from 10.9% in 2010.
- China ended 2011 with more renewable power capacity than any other nation, with an estimated 282 GW; one-quarter of this total (70 GW) was non-hydro. Of the 90 GW of electric capacity newly installed during the year, renewables accounted for more than one-third, and non-hydro renewables were more than one-fifth.
- Several countries and states met higher shares of their electricity demand with wind power in 2011 than in 2010, including Denmark, where wind provided nearly 26% of electricity demand, Spain (15.9%), and Portugal (15.6%); four German states met more than 46% of their electricity needs with wind; the state of South Australia generated 20% of its demand from wind; and the U.S. states of South Dakota and Iowa produced 22% and 19% of their power from wind, respectively.

The top seven countries for non-hydro renewable electric capacity—China, the United States, Germany, Spain, Italy, India, and Japan—accounted for about 70% of total capacity worldwide. The ranking was quite different on a per-person basis, with Germany in the lead followed by Spain, Italy, the United States, Japan, China, and India. By region, the EU was home to nearly 44% of global non-hydro renewable capacity at the end of 2011, and the BRICS[i] nations accounted for almost 26%; their share has been increasing in recent years, but virtually all of this capacity is in China, India, and Brazil.

Even so, renewable technologies are expanding into new markets. In 2011, around 50 countries installed wind power capacity, and solar PV capacity is moving rapidly into new regions and countries. Interest in geothermal power has taken hold in East Africa's Rift Valley and elsewhere, and solar hot water collectors are used by more than 200 million households, as well as in many public and commercial buildings the world over. Interest in geothermal heating and cooling is on the rise in countries around the world, and the use of modern biomass for energy purposes is expanding in all regions of the globe.

Across most technologies, renewable energy industries saw continued growth in equipment manufacturing, sales, and installation during 2011. Solar PV and onshore wind power experienced dramatic price reductions resulting from declining costs due to economies of scale and technology advances, but also due to reductions or uncertainties in policy support. At the same time, some renewable energy industries—particularly solar PV manufacturing—have been challenged by falling prices, declining policy support, the international financial crisis, and tensions in international trade. Continuing economic challenges (especially in traditional renewable energy markets) and changing policy environments in many countries contributed to some industry uncertainties or negative outlooks, and over the course of the year there was a steady decline in new projects proposed for development.

A DYNAMIC POLICY LANDSCAPE

At least 118 countries, more than half of which are developing countries, had renewable energy targets in place by early 2012, up from 109 as of early 2010. Renewable energy targets and support policies continued to be a driving force behind increasing markets for renewable energy, despite some setbacks resulting from a lack of long-term policy certainty and stability in many countries.

The number of official renewable energy targets and policies in place to support investments in renewable energy continued to increase in 2011 and early 2012, but at a slower adoption rate relative to previous years. Several countries undertook significant policy overhauls that have resulted in reduced support; some changes were intended to improve existing instruments and achieve more targeted results as renewable energy technologies mature, while others were part of the trend towards austerity measures.

Renewable power generation policies remain the most common type of support policy; at least 109 countries had some type of renewable power policy by early 2012, up from the 96 countries reported in the *GSR 2011*. Feed-in-tariffs (FITs) and renewable portfolio standards (RPS) are the most commonly used policies in this sector. FIT policies were in place in at least 65 countries and 27 states by early 2012. While a number of new FITs were enacted, most related policy activities involved revisions to existing laws, at times under controversy and involving legal disputes. Quotas or Renewable Portfolio Standards (RPS) were in use in 18 countries and at least 53 other jurisdictions, with two new countries having enacted such policies in 2011 and early 2012.

Policies to promote renewable heating and cooling continue to be enacted less aggressively than those in other sectors, but their use has expanded in recent years. By early 2012, at least 19 countries had specific renewable heating/cooling targets in place and at least 17 countries and states had obligations/mandates to promote renewable heat. Numerous local governments also support renewable heating systems through building codes and other measures. The focus of this sector is still primarily in Europe, but interest is expanding to other regions.

i Brazil, Russia, India, China, and South Africa.

Regulatory policies supporting biofuels existed in at least 46 countries at the national level and in 26 states and provinces by early 2012, with three countries enacting new mandates during 2011 and at least six increasing existing mandates. Transport fuel-tax exemptions and biofuel production subsidies also existed in at least 19 countries. At the same time, Brazil's mandated ethanol blend level was reduced, partly in response to low sugar-cane yields, while long-term ethanol support policies in the United States were allowed to expire at year's end.

Thousands of cities and local governments around the world also have active policies, plans, or targets for renewable energy and climate change mitigation. Almost two-thirds of the world's largest cities had adopted climate change action plans by the end of 2011, with more than half of them planning to increase their uptake of renewable energy. Many of the institutions encouraging co-operation among cities in local renewable energy deployment saw increased membership and activities in 2011, including the EU Covenant of Mayors (with over 3,000 member cities). Most activity has occurred in North American and European cities, although 100 demonstration cities exist in China, and cities in Argentina, Australia, Brazil, India, Mexico, South Africa, South Korea, and elsewhere undertook initiatives to support renewable energy deployment in 2011.

Policymakers are increasingly aware of renewable energy's wide range of benefits—including energy security, reduced import dependency, reduction of greenhouse gas (GHG) emissions, prevention of biodiversity loss, improved health, job creation, rural development, and energy access—leading to closer integration in some countries of renewable energy with policies in other economic sectors. Globally there are more than 5 million jobs in renewable energy industries, and the potential for job creation continues to be a main driver for renewable energy policies. During 2011, policy development and implementation were also stimulated in some countries by the Fukushima nuclear catastrophe in Japan and by the UN Secretary-General's announced goal to double the share of renewables in the energy mix by 2030.

There has been little systematic linking of energy efficiency and renewable energy in the policy arena to date, but countries are beginning to wake up to the importance of tapping their potential synergies. Efficiency and renewables can be considered the "twin pillars" of a sustainable energy future. Improving the efficiency of energy services is advantageous irrespective of the primary energy source, but there is a special synergy between energy efficiency and renewable energy sources. The more efficiently energy services are delivered, the faster renewable energy can become an effective and significant contributor of primary energy; and the more energy obtained from renewable sources, the less primary energy required to provide the same energy services.

In the EU, the United States, and elsewhere, countries are beginning to link the two through targets and policies; at the global level, the UN Secretary-General's initiative on Sustainable Energy for All highlights the interlinkages among energy access, energy efficiency improvements, and renewable energy deployment. Policies have also begun to address the efficiency of renewable energy systems themselves.

INVESTMENT TRENDS

Global new investment in renewables rose 17% to a record USD 257 billion in 2011. This was more than six times the figure for 2004 and almost twice the total investment in 2007, the last year before the acute phase of the recent global financial crisis. This increase took place at a time when the cost of renewable power equipment was falling rapidly and when there was uncertainty over economic growth and policy priorities in developed countries. Including large hydropower, net investment in renewable power capacity was some USD 40 billion higher than net investment in fossil fuel capacity.

One of the highlights of 2011 was the strong performance of solar power, which blew past wind power, the biggest single sector for investment in recent years (although total wind power capacity added in 2011 was higher than for solar). Another highlight was the performance of the United States, where investment increased by 57% relative to 2010, mainly as the result of developers rushing to take advantage of federal support policies that were coming to an end.

The top five countries for total investment were China, which led the world for the third year running, followed closely by the United States, and by Germany, Italy, and India. India displayed the fastest expansion in investment of any large renewables market in the world, with 62% growth. Developing countries saw their relative share of total global investment slip back after several years of consistent increases; developing countries accounted for USD 89 billion of new investment in 2011, compared with USD 168 billion in developed countries.

RURAL RENEWABLE ENERGY: SPECIAL FOCUS

Significant technological innovation and cost reductions of renewable energy technologies, along with improved business and financing models, are increasingly creating clean and affordable renewable energy solutions for individuals and communities in developing countries. For a majority of very remote and dispersed users, decentralised off-grid renewable electricity is less expensive than extending the power grid. At the same time, developing countries have begun deploying more and more grid-connected renewable capacity, which is in turn expanding markets and further reducing prices, potentially improving the outlook for rural renewable energy developments.

Rural renewable energy markets in developing countries differ significantly across regions: for example, Africa has by far the lowest rates of access to modern energy services, while Asia presents significant gaps among countries, and Latin America's rate of electrification is quite high. In addition, active players in this sector are numerous, and participants differ from one region to the next. The rural renewable energy market is highly dynamic and constantly evolving; it is also challenged by the lack of structured frameworks and of consolidated data sets.

In addition to a focus on technologies and systems, most developing countries have started to identify and implement programmes and policies to improve the ongoing operational structures governing rural energy markets. Most countries are developing targets for electrification that include renewable off-grid options and/or renewably powered mini-grids; there is also some use of grid-connected renewable electricity. In the rural cooking and heating market, advanced cookstoves fueled by renewable sources are gaining ground as reliable and sustainable alternatives to traditional biomass cookstoves. Such developments are increasing the attractiveness of rural energy markets and developing economies for potential investors.

After many years of relatively slow political, technical, financial, industrial, and related developments, the impressive deployment of all renewable energy technologies and notable cost reductions point to a brighter future. However, further efforts will be necessary to reach the outlined objectives: the International Energy Agency estimates that annual investment in the rural energy sector needs to increase more than fivefold to provide universal access to modern energy by 2030.

2011 MARKET AND INDUSTRY HIGHLIGHTS AND ONGOING TRENDS

WIND POWER. Wind power capacity increased by 20% in 2011 to approximately 238 GW by year-end, seeing the greatest capacity additions of any renewable technology. As in 2010, more new capacity was added in developing countries and emerging markets than in OECD countries. China accounted for almost 44% of the global market (adding slightly less capacity than it did in 2010), followed by the United States and India; Germany remained the largest market in Europe. Although its market share remained relatively small, the offshore wind sector continued to expand, with the use of larger turbines and movement into deeper water, farther from shore. The trend towards increasing the size of individual wind projects and larger wind turbines continued; at the same time, the use of small-scale turbines is increasing, and interest in community wind power projects is on the rise in several countries.

SOLAR PHOTOVOLTAICS (PV). Solar PV saw another year of extraordinary market growth. Almost 30 GW of operating capacity was added, increasing total global capacity by 74% to almost 70 GW. The trend towards very large-scale ground-mounted systems continued, while rooftop and small-scale systems continued to play an important role. For the first time ever, solar PV accounted for more capacity additions in the EU than any other technology. While the EU again dominated the global market, led by Italy and Germany, markets expanded in other regions, and China has rapidly emerged as the dominant player in Asia. Although 2011 was a good year for consumers and installers, manufacturers struggled to make profits or even survive amidst excess inventory and falling prices, declining government support, slower market growth for much of the year, and significant industry consolidation. Module manufacturing continued its marked shift to Asia, mainly at the expense of European firms.

BIOMASS FOR HEAT, POWER, AND TRANSPORT. The growing use of biomass for heat, electricity, and transport fuels has resulted in increasing international trade in biomass fuels in recent years; wood pellets, biodiesel, and ethanol are the main fuels traded internationally. Biomass, in the form of both solid and gaseous fuels, continues to provide the majority of heating produced with renewable energy sources. Markets are expanding rapidly, particularly in Europe where biomass is used increasingly in district heat systems. Another growing trend, also taking place largely in Europe, is the use of biomethane (purified biogas) that can be injected directly into the natural gas network and used to produce heat and power and to fuel vehicles. Biogas produced from domestic-scale digesters is used increasingly for cooking, and to a smaller extent for heating and lighting, in China, India, and elsewhere.

2012 SELECTED INDICATORS

		2009	→	2010	→	2011
Investment in new renewable capacity (annual)[1]	billion USD	161	→	220	→	257
Renewable power capacity (total, not including hydro)	GW	250	→	315	→	390
Renewable power capacity (total, including hydro)[2]	GW	1,170	→	1,260	→	1,360
Hydropower capacity (total)[2]	GW	915	→	945	→	970
Solar PV capacity (total)	GW	23	→	40	→	70
Concentrating solar thermal power (total)	GW	0.7	→	1.3	→	1.8
Wind power capacity (total)	GW	159	→	198	→	238
Solar hot water/heat capacity (total)[3]	GW_{th}	153	→	182	→	232
Ethanol production (annual)	billion litres	73.1	→	86.5	→	86.1
Biodiesel production (annual)	billion litres	17.8	→	18.5	→	21.4
Countries with policy targets	#	89	→	109	→	118
States/provinces/countries with feed-in policies[4]	#	82	→	86	→	92
States/provinces/countries with RPS/quota policies[4]	#	66	→	69	→	71
States/provinces/countries with biofuels mandates[5]	#	57	→	71	→	72

Note: Numbers are rounded. Renewable power capacity (including and not including hydropower) is rounded to nearest 10 GW; renewable capacity not including hydropower, and hydropower capacity data are rounded to nearest 5 GW; other capacity numbers are rounded to nearest 1 GW except for very small numbers and biofuels, which are rounded to one decimal point.

1 Investment data are from Bloomberg New Energy Finance and include all biomass, geothermal, and wind power projects of more than 1 MW, all hydropower projects between 1 MW and 50 MW, all solar projects, with those less than 1 MW estimated separately and referred to as small-scale projects, or small distributed capacity, all ocean energy projects, and all biofuel projects with a capacity of 1 million litres or more per year.

2 Hydropower data and, therefore, also renewable power capacity including hydro, are lower relative to past editions of the GSR due to the fact that pure pumped storage capacity is not included as part of the hydropower data. For more information, see Note on Reporting and Accounting on page 167.

3 Solar heat data include glazed capacity but not capacity of unglazed systems for swimming pool heating.

4 Feed-in and RPS/quota policy totals for 2011 also include early 2012.

5 Biofuel policies for 2010 and 2011 include policies listed under both the biofuels obligation/mandate column in Table 3, Renewable Energy Support Policies, and those listed in Reference Table R14, National and State/Provincial Biofuel Blend Mandates, whereas data for 2009 and earlier have included only the latter.

Biomass power capacity increased from about 66 GW in 2010 to almost 72 GW at the end of 2011. The United States leads the world in biomass-based power generation, with other significant producers in the EU in addition to Brazil, China, India, and Japan. Most sugar-producing countries in Africa generate power and heat with bagasse-based combined heat and power (CHP) plants. Improvements in the logistics of biomass collection, transport, and storage over the past decade, and growing international trade (particularly in pellets), have helped to remove constraints on plant size, and the size of facilities in some countries is increasing as a result.

Ethanol and biodiesel are the primary renewable fuels in the transport sector. During 2011, ethanol production remained stable or declined slightly for the first time in more than a decade, but biodiesel production continued to rise globally. Several airlines began to operate commercial flights using various biofuels blends, and interest in advanced biofuels continued to increase, although production levels remain relatively low. Limited but growing quantities of gaseous biofuels (mainly biomethane) are fuelling trains, buses, and other vehicles, particularly in Europe.

SOLAR THERMAL HEATING AND COOLING. Solar heating capacity increased by an estimated 27% in 2011 to reach approximately 232 GW_{th}, excluding unglazed swimming pool heating. China again led the world for solar thermal installations, with Europe a distant second. Most solar thermal is used for water heating, but solar space heating and cooling are gaining ground, particularly in Europe. The year 2011 was difficult for parts of the solar thermal industry due to the economic situation in northern Mediterranean countries and the general negative outlook across much of Europe. China remained dominant in the global solar heating industry, a position that it has held for several years, and export of Chinese products has increased considerably in recent years.

CONCENTRATING SOLAR THERMAL POWER (CSP). More than 450 megawatts (MW) of CSP was installed in 2011, bringing global capacity to almost 1,760 MW. Spain accounted for the vast majority of capacity additions, while several developing countries launched their first CSP plants and industry activity expanded its attention from Spain and the United States to new regions. Parabolic trough plants continued to dominate the market, but new central receiver and Fresnel plants were commissioned during 2011 and others were under construction. Although CSP faced challenges associated with rapidly falling PV prices and the Arab Spring, which slowed development in the Middle East and North Africa region, significant capacity was under construction by year's end.

GEOTHERMAL HEAT AND POWER. Geothermal energy provided an estimated 205 TWh (736 PJ) in 2011, one-third in the form of electricity (with an estimated 11.2 GW of capacity) and the remaining two-thirds in the form of heat. At least 78 countries used direct geothermal energy in 2011. Most of the growth in direct use was associated with ground-source heat pumps (GHP), which can provide heating and cooling and have experienced growth rates averaging 20% annually. Geothermal electricity saw only modest expansion in 2011, but the rate of deployment is expected to accelerate with projects under development in traditional markets and the movement into new markets in East Africa and elsewhere.

While expansion in the geothermal power industry is hampered by high risk inherent in the development of new resources and lack of awareness, geothermal power is advancing due to the development of new technologies, such as binary-cycle plants and hydraulic enhancement (EGS), which are expanding the range of producible resources and improving the economy of existing plants.

HYDROPOWER. An estimated 25 GW of new capacity came on line in 2011, increasing global installed capacity by nearly 2.7% to approximately 970 GW. Hydropower continues to generate more electricity than any other renewable resource, with an estimated 3,400 TWh produced during 2011. Asia was the most active region for new projects, while more mature markets focused on retrofits of existing facilities for improved output and efficiency. Hydropower is increasingly providing balancing services, including through expansion of pumped storage capacity, in part to accommodate the increased use of variable solar and wind resources. Companies reported increased sales in 2011, and large manufacturers have been investing in new plants and acquiring smaller firms to address billions of dollars in backlogs.

OCEAN ENERGY. After years that saw development of only small pilot projects, global ocean power capacity almost doubled in 2011. The launch of a 254 MW tidal power plant in South Korea and a 0.3 MW wave energy plant in Spain brought total global capacity to 527 MW. A number of additional projects—small pilot-scale and utility-scale—were under development in 2011, designed to test and demonstrate various technologies for full commercial applications in the near future. Continued investment and strategic partnerships are coalescing around several key wave and tidal technologies that look poised for deployment on a large scale in coming years.

For more 2011 data and country rankings, see the Selected Indicators and Top Five Countries tables on pages 17 and 19.

2012 TOP FIVE COUNTRIES

ANNUAL ADDITIONS/PRODUCTION IN 2011

	New capacity investment	Hydropower capacity	Solar PV capacity	Wind power capacity	Solar hot water/heat capacity[1]	Biodiesel production	Ethanol production
1	China	China	Italy	China	China	United States	United States
2	United States	Vietnam	Germany	United States	Turkey	Germany	Brazil
3	Germany	Brazil	China	India	Germany	Argentina	China
4	Italy	India	United States	Germany	India	Brazil	Canada
5	India	Canada	France	U.K./ Canada	Italy	France	France

TOTAL CAPACITY AS OF END-2011

	Renewable power capacity (incl. hydro)	Renewable power capacity (not incl. hydro)	Renewable power capacity per capita (not incl. hydro)[2]	Biomass power capacity	Geothermal power capacity	Hydropower capacity
1	China	China	Germany	United States	United States	China
2	United States	United States	Spain	Brazil	Philippines	Brazil
3	Brazil	Germany	Italy	Germany	Indonesia	United States
4	Canada	Spain	United States	China	Mexico	Canada
5	Germany	Italy	Japan	Sweden	Italy	Russia

	Solar PV capacity	Solar PV capacity per capita	Wind power capacity	Solar hot water/heat capacity[1]	Solar hot water/heat capacity per capita[1]	Geothermal heat installed capacity	Geothermal direct heat use[3]
1	Germany	Germany	China	China	Cyprus	United States	China
2	Italy	Italy	United States	Turkey	Israel	China	United States
3	Japan	Czech Rep.	Germany	Germany	Austria	Sweden	Sweden
4	Spain	Belgium	Spain	Japan	Barbados	Germany	Turkey
5	United States	Spain	India	Brazil	Greece	Japan	Japan

Note: Most rankings are based on absolute amounts of investment, power generation capacity, or biofuels production; per capita rankings would be quite different for many categories (as seen with per capita rankings for renewable power, solar PV, and solar hot water/heat capacity). 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 whereas others use it more to follow the electric load and match peaks.

1 Solar hot water/heat rankings are for 2010. Based on capacity of glazed systems (excluding unglazed systems for swimming pool heating).

2 Per capita renewable power capacity ranking considers only those countries that rank among the top seven for total installed capacity, not including hydro.

3 In some countries, ground-source heat pumps make up a significant share of geothermal direct-use capacity; the share of heat use is lower than the share of capacity for heat pumps because they have a relatively low capacity factor. Rankings are based on 2010 data.

GLOBAL MARKET AND INDUSTRY OVERVIEW

Renewables generated an estimated 20.3% of global electricity by the end of 2011. In 2010, renewable energy supplied an estimated 16.7% of global final energy consumption, with 8.2% from modern renewable energy.

01

01 GLOBAL MARKET AND INDUSTRY OVERVIEW

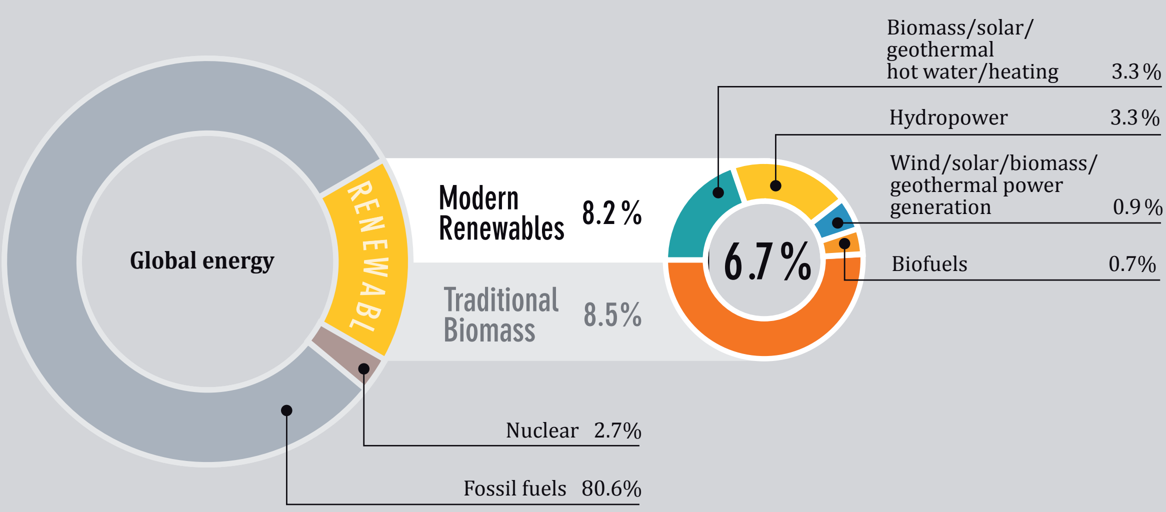
Renewable energy in 2010 supplied an estimated 16.7% of global final energy consumption. Of this total, an estimated 8.2% came from modern renewable energy—counting hydropower, wind, solar, geothermal, biofuels, and modern biomass.[1i] (See Figure 1.) Traditional biomass, which is used primarily for cooking and heating in rural areas of developing countries, and could be considered renewable,[ii] accounted for approximately 8.5% of total final energy. (See Rural Renewable Energy section for more on traditional biomass.) Hydropower supplied about 3.3% of global final energy consumption, and hydro capacity is growing steadily from a large base. All other modern renewables provided approximately 4.9% of final energy consumption in 2010, and have been experiencing rapid growth in many developed and developing countries alike.

Modern renewable energy can substitute for fossil 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 market and industry developments in the first three sectors; rural/off-grid energy in developing countries is covered in the Rural Renewable Energy section. The section that follows provides more detailed coverage of market and industry developments and trends by technology.

During the period from end-2006 through 2011, total global installed capacity[iii] of many renewable energy technologies grew at very rapid rates. Solar photovoltaics (PV) grew the fastest of all renewable technologies during this period, with operating capacity increasing an average of 58% annually. It was followed by concentrating solar thermal power (CSP), which increased almost 37%, growing from a small base, and wind power, which increased 26%.[2] (See Figure 2.) For the first time ever, in 2011 solar PV accounted for more new electric generating capacity in the European Union[iv] than did any other technology.[3]

Demand is also increasing rapidly for solar thermal heat systems, geothermal ground-source heat pumps, and some biomass fuels.[4] The growth of liquid biofuels has been mixed in recent years, with biodiesel production expanding in 2011, and ethanol stable or down slightly compared with 2010.[5] Hydropower and geothermal power are growing globally at rates of 2–3% per year, making them more comparable with global growth rates for fossil fuels.[6] In several countries, however, the growth

FIGURE 1. RENEWABLE ENERGY SHARE OF GLOBAL FINAL ENERGY CONSUMPTION, 2010



Source: See Endnote 1 for this section.

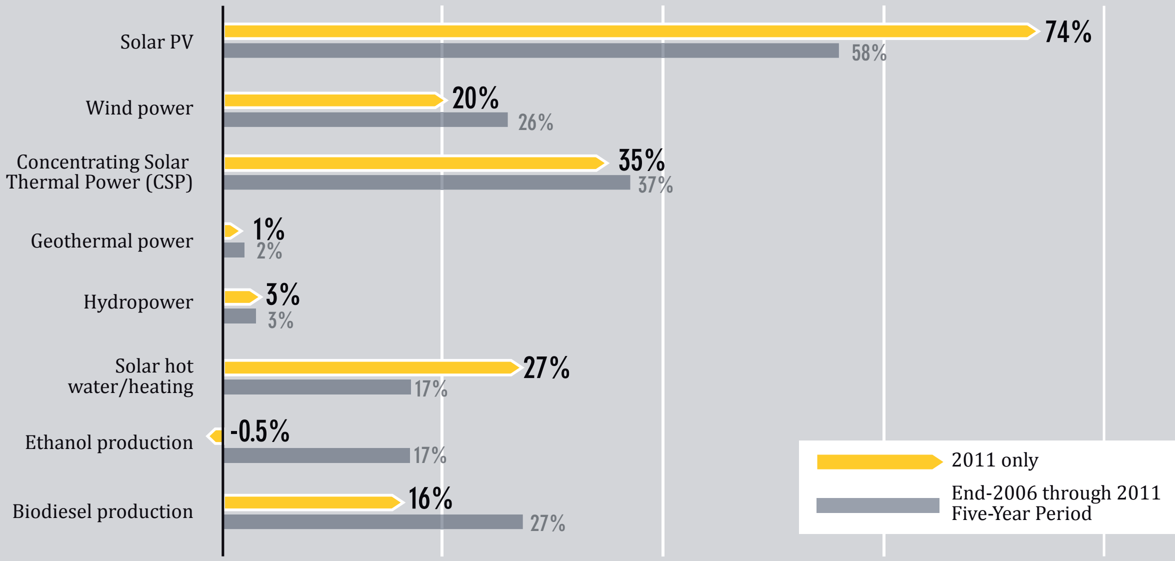
i - Endnotes are numbered by section and begin on page 135.

ii - Biomass plays a critical role in meeting rural energy demand in much of the developing world. There is debate about the sustainability of traditional biomass, and some people (although they may be in the minority) do not consider it to be renewable. For information about the environmental and health impacts of traditional biomass, see H. Chum et al., "Bioenergy," in Intergovernmental Panel on Climate Change, (IPCC), *Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K.: Cambridge University Press, 2011), and John P. Holdren et al., "Energy, the Environment, and Health," in *World Energy Assessment: Energy and the Challenge of Sustainability* (New York: United Nations Development Programme, 2000).

iii - The following sections include energy data where possible but focus mainly on installed and operating capacity data. See Note on Accounting and Reporting on page 167.

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

FIGURE 2. AVERAGE ANNUAL GROWTH RATES OF RENEWABLE ENERGY CAPACITY AND BIOFUELS PRODUCTION, 2006–2011



Source: See Endnote 2 for this section.

in these and other renewable technologies far exceeds the global average.

Across most technologies, renewable energy industries saw continued growth in equipment manufacturing, sales, and installation during 2011. Solar PV and onshore wind power experienced dramatic price reductions during the course of the year resulting from declining costs due to economies of scale, technology advances, and other factors, but also due to reductions or uncertainties in policy support.

At the same time, some renewable energy industries—particularly solar PV manufacturing—have been challenged by these falling prices, declining policy support, the international financial crisis, and tensions in international trade.[7] Continuing economic challenges, especially in traditional renewable energy markets, and changing policy environments in many countries (see Policy Landscape section) contributed to some industry uncertainties or negative outlooks, and over the course of the year there was a steady decline in new projects proposed for development.[8] Impacts on jobs in the renewable energy sector have been mixed, but global employment numbers have continued to rise.[9] (See Sidebar 1, page 26.)

Industry consolidation continued among players both large and small, most notably in the solar PV, wind power, and biofuel industries.[10] The emergence of increasingly vertically integrated supply chains continued in 2011, as well as the movement of manufacturing firms into project development. Across the board, from wind and solar power to solar thermal to biofuels, traditional energy and technology companies continue to play important roles in production and project development.[11]

Longstanding trends in internationalisation of markets and industries also continued, with all renewable technologies expanding into new markets as traditional markets become relatively less important. In part this has been the result of oversupply pushing players towards emerging market niches in new countries and regions. Leadership in both markets and manufacturing continued to shift towards developing countries, with China and India playing an increasingly significant role, and with new players emerging elsewhere in Asia as well as in Latin America and the Middle East and North Africa (MENA) region.

POWER SECTOR

Renewables accounted for almost half of the estimated 208 GW of new electric capacity installed globally in 2011.[12] In fact, non-hydro renewables have accounted for a larger and larger share of new electric capacity over the past several years, rising from 10% in 2004 to about 37% in 2011, while their share of total global generating capacity has more than doubled during this period.[13] Total renewable power capacity worldwide exceeded 1,360 GW in 2011, up about 8% from 2010.[14] Non-hydro renewables exceeded 390 GW, a 24% capacity increase over 2010.[15] Globally, wind and solar PV accounted for almost 40% and 30% of new renewable capacity, respectively, followed by hydropower (nearly 25%).[16] (See Reference Table R1.)

By the end of 2011, operating renewable capacity comprised more than 25% of total global power generating capacity (estimated at 5,360 GW by end-2011) and supplied an estimated 20.3% of global electricity, with most of this provided by hydropower.[17 i] (See Figure 3.) While renewable capacity rises at a rapid rate from year to year, renewable energy's share of total generation is increasing more slowly because much of the renewable capacity relies on variable sources, such as wind and solar energy, and because many countries continue to add significant fossil fuel capacity.[18] At the same time, in some countries the electricity generation from variable resources has reached impressive record peaks, meeting high shares of national power demand and positively affecting spot market prices via the merit order effect.[19]

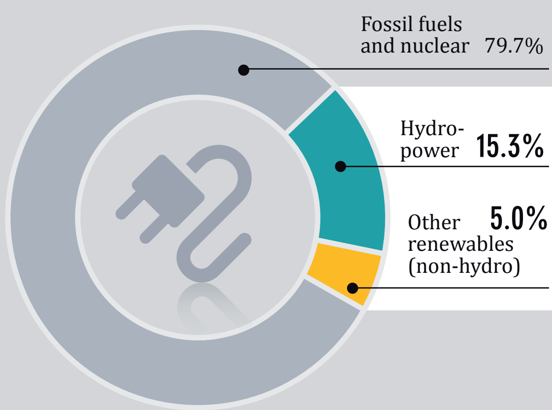
Including hydropower, China, the United States, Brazil, Canada, and Germany (followed closely by India) were the top countries for total installed renewable electric capacity by the end of 2011. The top countries for non-hydro renewable power capacity were China, the United States, Germany, Spain, and Italy, followed closely by India, with Japan a distant seventh.[20] Among these countries, the ranking on a per-person basis put Germany first, followed by Spain, Italy, the United States, Japan, China, and India.[21] (See Top Five Table on page 19 for other rankings; see also Figure 4, page 25, and Reference Table R2.) By region, the EU was home to approximately 44% of global non-hydro renewable capacity at the end of 2011, and the BRICS nations accounted for almost 26%; their share has been increasing in recent years, but virtually all of this capacity is in China, India, and Brazil.

China ended 2011 with more renewable power capacity than any other nation, or about one-fifth of the world's total, passing the United States for total installed non-hydropower capacity. China had an estimated 70 GW not including hydropower (mostly wind power), and 282 GW with hydropower. Of the 90 GW of electric capacity newly installed during the year, all renewables accounted for more than one-third, and non-hydro renewables for more than one-fifth.[22] China again led the world in the installation of wind turbines and was the top hydropower producer and leading manufacturer of solar PV modules in 2011. Hydropower generation declined by 3.5% relative to 2010, but wind power generation increased by 48.2% during the year.[23]

In the United States, renewables accounted for 12.7% of net electricity generation in 2011 (up from 10.4% in 2010), with the largest share from hydropower. Non-hydro renewables generated 4.7% of total net electricity, up from 4% in 2010 and 3.7% in 2009.[24] Renewable energy made up an estimated 39% of national electric capacity additions in 2011, with most of this from wind power, and 11.6% of cumulative electric capacity at year's end.[25] Further, all renewables accounted for about 11.8% of U.S. primary energy production (compared with nuclear's 10.6% share), up from 10.9% in 2010.[26] The number of U.S. states that generate more than 10% of their electricity from non-hydro renewable energy has increased from two to nine over the past decade.[27]

In Germany, all renewable sources met about 12.2% of total final energy consumption and accounted for 20% of electricity consumption (up from 17.2% in 2010 and 16.4% in 2009), generating more electricity than nuclear, hard coal, or gas-fired power plants.[28] Of the nearly 122 TWh generated with renewable sources during 2011, wind energy accounted for the largest share (38.1%), followed by biomass (30.3%), hydropower (16%), and solar PV (15.6%).[29]

FIGURE 3. ESTIMATED RENEWABLE ENERGY SHARE OF GLOBAL ELECTRICITY PRODUCTION, 2011



Note: Based on renewable generating capacity in operation at year-end 2011.

Source: See Endnote 17 for this section.

i - Global hydropower data and thus total renewable energy statistics in this report reflect an effort to remove capacity of pure pumped storage from the totals. For more information, see Note on Accounting and Reporting on page 167.

Spain has experienced a slowdown in renewable capacity additions in response to the economic recession and policy uncertainties. However, globally it still ranks fourth after Germany for non-hydro renewable power capacity, with an estimated 28.1 GW in operation. Renewable energy provided about one-third of Spain's electricity needs in 2011, with wind contributing nearly half of the renewable share.[30] Italy moved into fifth place during the year, in great part because of the large increase in operating solar PV capacity, which accounted for more than half (57%) of the country's non-hydro renewable electric capacity (22.4 GW) by the end of 2011. Including hydropower, Italy's year-end renewable power capacity was about 40 GW.[31]

India added about 4 GW of grid-connected non-hydro renewable power capacity during 2011, mainly from wind but also from biomass and solar capacity to give a total of more than 20 GW by year-end.[32] Japan's wind, solar, biomass, and geothermal power capacity totalled 11.3 GW by the end of 2011, with PV accounting for the largest share (estimated at 43%), followed by biomass, wind, and geothermal power.[33] In total, these top seven countries accounted for more than 70% of total non-hydro renewable capacity worldwide.[34]

By region, the European Union has the most non-hydro capacity, totalling an estimated 174 GW. All renewables accounted for more than half of all newly installed electric capacity in the EU for the fourth year in a row, representing an estimated record share of 71.3% of total additions; solar PV alone made up 46.7% of total electric capacity that came into operation during 2011, and wind accounted for 21.4%.[35] As a result, renewable energy's share of total electric generating capacity in the region, including hydropower, increased to 31.1%.[36] The renewable share of consumption is rising in parallel, although not as rapidly since much of the capacity is variable solar and wind. In 2010 (latest available data), the renewable share of total electricity consumption was 19.8% (up from 18.2% in 2009), and renewables represented 12.4% of gross final energy consumption (compared to 11.5% in 2009).[37]

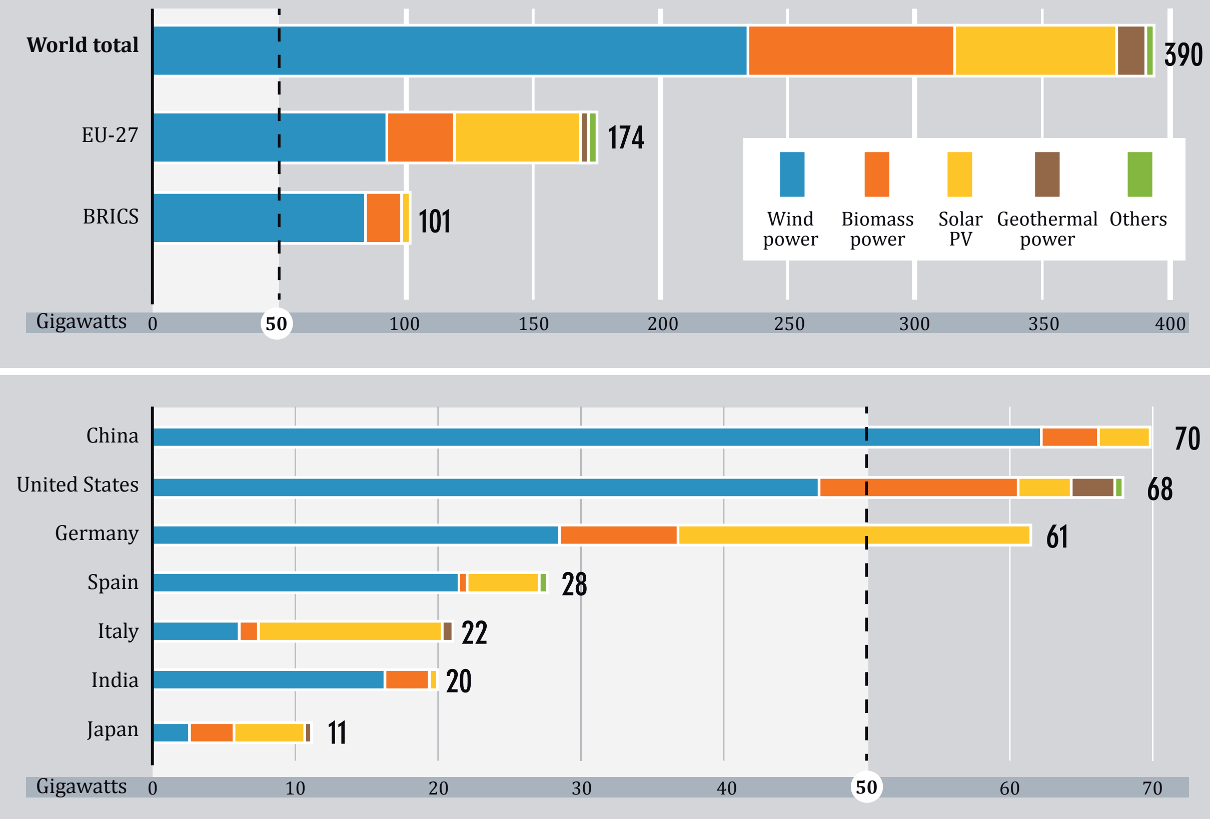
Around the world and across technologies, there have been varying trends in system sizes, due greatly to policy drivers. Many countries are seeing wind, solar, and biomass power projects of growing scale, while there is also rising interest in small-scale, distributed, and community-owned projects. In some countries, such as India, where urban blackouts occur frequently, interest in renewable energy deployment is increasing as a means to ensure more stable access to electricity services.[38]

Voluntary purchases of renewable energy are also on the rise; they are possible for renewable heat and transport biofuels, but are most common for renewable electricity. Germany has become one of the world's green power leaders, with a market that grew from 0.8 million residential customers in 2006 to 3.2 million in 2010.[39] Reportedly, the number of customers doubled during 2011 in direct response to the Fukushima accident in Japan.[40] Other major European green power markets include Austria, Finland, Italy, Sweden, Switzerland, and the United Kingdom (U.K.), although the market share in these countries is less than 5%.[41]

In the United States, more than half of U.S. customers have the option to purchase green power directly from a retail electricity provider. During 2010, voluntary green power market sales totalled about 35.6 TWh, up 10% over 2009 and representing more than 1% of total U.S. electricity sales. More than 1.8 million consumers purchased green power products in 2010, a 25% increase in participation over 2009.[42] Innovative green power purchasing models are emerging in the United States, and the first consumer label for companies and products using wind power (WindMade) was launched during 2011.[43]

Green power markets also exist in Australia, Canada, and Japan, and at least one company offers green power to retail customers in South Africa.[44] Major companies are also playing an increasingly important role in the renewable power sector purchasing green power, installing renewable energy systems, and purchasing Renewable Energy Credits (RECs).[45]

FIGURE 4. RENEWABLE POWER CAPACITIES[1], EU 27, BRICS, AND TOP SEVEN COUNTRIES, 2011



1 - excluding hydropower

Source: See Endnote 21 for this section.

HEATING AND COOLING SECTOR

Modern biomass, solar thermal, and geothermal energy currently supply hot water and space heating and cooling for tens of millions of domestic and commercial buildings worldwide. These resources are also used to supply process heat for industrial and agricultural applications. Modern biomass accounts for the vast majority of renewable heating worldwide and is increasingly replacing traditional biomass for cooking purposes in many developing countries. (See Rural Renewable Energy section.)

Solar hot water collectors are used by more than 200 million households (over half of them in China), as well as in schools, hospitals, hotels, and government and commercial buildings, and there is a growing trend to use solar resources to generate process heat for industry.[46] Solar, geothermal, and biomass resources all offer cooling services 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 in this report.

Use of modern renewable energy technologies for heating and cooling is still limited relative to their potential for meeting global demand. But interest is on the rise, and countries (particularly in the EU) are starting to enact supporting policies and to track the share of heat derived from renewable sources. For example, renewable energy met 10.4% of Germany's heating demand (mostly with biomass) in 2011, up from 10.2% in 2010 and 8.9% in 2009.[47]

Trends in the heating (and cooling) sector include the use of larger systems, increasing use of combined heat and power (CHP), the feeding of renewable heating and cooling in district schemes, and use of renewable heat for industrial purposes.

TRANSPORT SECTOR

Renewable energy is used in the transport sector in the form of liquid and gaseous biofuels, as well as electricity, and it offers the potential to power fuel cell vehicles through renewably produced hydrogen.

Liquid biofuels make a small but growing contribution to fuel usage worldwide. They provided about 3% of global road transport fuels in 2011, and they account for the largest share of transport fuels derived from renewable energy sources.[48] Global ethanol production was stable or down slightly in 2011 for the first time in more than a decade, but biodiesel production continued to rise. Several airlines around the world began to operate commercial flights using various biofuels blends, and interest in advanced biofuels continued to increase, although production levels remain relatively low.[49]

Limited but growing quantities of gaseous biofuels (mainly biomethane from purified biogas) are fuelling trains, buses, and other vehicles.[50] In Austria, France, Germany, Sweden, and Switzerland, biomethane is being used primarily in bus and car fleets.[51] In 2010, for example, biomethane made up 11% (on an energy basis) of the total 5.7% biofuels share of transport fuels in Sweden.[52]

Electricity is used to power trains, subways, and a small but growing number of electric passenger cars and motorised cycles, and there are limited but increasing initiatives to link electric transport with renewable energy. As the number of electric vehicles increases and the share of electricity generated from renewables rises, the role of renewable electricity in the transport sector will increase.

In some locations, electric transport is being tied directly to renewable electricity through specific projects and policies. (See the City and Local Government Policies sub-section.) For example, Germany's Deutsche Bahn, one of Europe's largest electricity consumers, announced plans in 2011 to increase the share of renewables used to power its trains from 20% in 2011 to 28% in 2014; local railways in some cities already run on 100% renewable energy.[53] Electric light-duty vehicles also can enable increased penetration of variable renewables by helping to balance demand and supply of grid-based electricity.

The EU Renewable Energy Directive, which includes renewable electricity in the 10% renewable energy target for the transport sector, is expected to help drive this sector forward. However, due to the small scale and lack of data, renewably powered electric vehicles are not addressed in detail in this report; renewable hydrogen is not included for the same reason.

See Table 2 on pages 28–29 for a summary of the main renewable energy technologies and their characteristics and costs [54].

SIDEBAR 1. JOBS IN RENEWABLE ENERGY

Recent estimates indicate that about 5 million people worldwide work either directly or indirectly in the renewable energy industries. (See Table 1.) Direct jobs are those related to a sector's core activities, such as manufacturing, equipment distribution, and site preparation and installation, whereas indirect jobs are those that supply the industry—for example, in copper smelting plants whose outputs may be used for manufacturing solar hot water equipment. It should be noted that global data are incomplete and of uneven quality, and the use of different methodologies makes simple aggregation or comparison difficult.

Although total renewable energy employment numbers continue to increase, some countries have experienced a decrease in the rate of growth, due mainly to the global recession and policy changes. For example, Germany's growth rate fell from about 16% in 2008 to 8% in 2010, and it halved again in 2011. Spain actually suffered the loss of about 20,000 jobs between 2008 and 2010. Worldwide, employment trends will be affected both by overcapacities in the wind and solar supply chains and by an ongoing geographical shift in wind turbine and solar PV manufacturing towards Asia. In the United States, jobs in the wind industry may be reduced by half (by 37,000) should the government fail to extend the current tax credit policy.

The majority of renewables jobs worldwide are located in a handful of major economies, namely China, Brazil, the United States, and the European Union, in particular Germany. In the EU alone, the renewable energy sector contributes 1.1 million jobs.

Globally, renewable energy jobs are clustered primarily in the bioenergy and solar hot water industries. Growing, harvesting, and distributing bioenergy feedstock is very labour intensive, and these processes account for the bulk of bioenergy-related jobs. (The quality of biomass and biofuels jobs estimates is very uneven and requires additional scrutiny.) For other technologies, the equipment manufacturing, installation, and project operation phases of the value chain are more important for job creation. In Germany, equipment manufacturing accounted for 63.7% of renewables jobs in 2010, operations and maintenance for 19.1%, and bioenergy fuel preparation for 15.2%.

Increasingly, developing countries are also tracking job creation related to renewable energy. India, for instance, estimated 350,000 jobs in 2009. Although there is no distinction between urban and rural jobs, technologies such as off-grid solar, biogas, and small-scale hydro, principally relevant in a rural context, account for more than 190,000 of India's renewables jobs.

To have a complete picture of job creation in the renewable energy sector, more studies are needed in the off-grid context. Case-study evidence from developing countries shows significant potential for off-grid projects to create jobs and enhance local economic productivity, particularly in the sales, installations, and operations and maintenance stages of the value chain. As of December 2011, Bangladesh had installed 1.2 million rural solar home systems, creating an estimated 60,000 jobs in the solar sector. A United Nations Development Programme initiative in Nepal has since 1998 supported the construction of 323 micro-hydro plants, leading to the equivalent of 3,850 full-time jobs. There are many other examples.

Renewable energy offers significant potential for job creation. While future estimates vary greatly depending on the models used, the largest growth is expected in offshore wind and solar thermal heating. The number will depend on many factors, including policy decisions.

TABLE 1. ESTIMATED JOBS IN RENEWABLE ENERGY WORLDWIDE, BY INDUSTRY

TECHNOLOGIES	**Global**	China	India	Brazil	USA	EU[7]	Germany	Spain	Others
	Thousand jobs								
Biomass[1]	750	266	58		152	273	51	14	2[8]
Biofuels	1,500			889[6]	47–160	151	23	2	194[9]
Biogas	230	90	85			53	51	1.4	
Geothermal[1]	90				10	53	14	0.6	
Hydropower (Small[2])	40		12		8	16	7	1.6	1[8]
Solar PV	820[4]	300[5]	112		82	268	111	28	60[10]
CSP	40				9		2	24	
Solar Heating/ Cooling	900	800	41		9	50	12	10	1[8]
Wind Power	670[4]	150	42	14	75	253	101	55	33[11]
Total[3]	**5,000**	**1,606**	**350**	**889**	**392-505**	**1,117**	**372**	**137**	**291**

Note: Data are for 2011 or earlier and were compiled in cooperation with IRENA and the International Labour Organization's green jobs programme.

1 Power and heat applications. 2 Employment information for large-scale hydropower is incomplete, and therefore focuses on small hydro. Although 10 MW is often used as a threshold, definitions are inconsistent across countries. For example, India considers small-scale hydro to be ≤25 MW, and the United States <30 MW. 3 Rounded; derived from the totals of each renewable energy source (given data gaps, the national/regional totals do not add up to the same grand total). 4 Bloomberg New Energy Finance estimates 675,000 solar PV jobs and 517,000 wind jobs worldwide, reflecting a different calculation methodology. 5 Some estimates are substantially higher, but overcapacity problems may generate considerable fluctuations in the actual number of people working in the industry. 6 Includes 200,000 indirect jobs in manufacturing the equipment needed to harvest and refine sugar cane into biofuels. 7 EU data include Germany and Spain, but are derived from different sources. 8 Australia. 9 APEC member economies (Australia, Brunei, Canada, Chile, China, Hong Kong, Indonesia, Japan, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, the Philippines, Russia, Singapore, South Korea, Taiwan, Thailand, and Vietnam), excluding USA. 10 Bangladesh. 11 Various.

Source: See Endnote 9 for this section.

TABLE 2. STATUS OF RENEWABLE ENERGY TECHNOLOGIES: CHARACTERISTICS AND COSTS

RURAL ENERGY	Typical Characteristics	Typical Energy Costs (US cents/kWh)
Biogas digester	Digester size: 6–8 m^3	n/a
Biomass gasifier	Size: 20–5,000 kW	8–12
Solar home system	System size: 20–100 W	40–60
Household wind turbine	Turbine size: 0.1–3 kW	15–35
Village-scale mini-grid	System size: 10–1,000 kW	25–100

POWER GENERATION	Typical Characteristics	Capital Costs (USD/kW)	Typical Energy Costs (US cents/kWh)
Biomass Power Stoker boiler/steam turbine Circulating fluidised bed	Plant size: 25–100 MW Conversion efficiency: 27% Capacity factor: 70–80%	3,030–4,660	7.9–17.6
Geothermal Power	Plant size: 1–100 MW Types: binary cycle, single-and double-flash, natural steam Capacity factor: 60–90%	condensing flash: 2,100–4,200 binary: 2,470–6,100	condensing flash: 5.7–8.4 binary: 6.2–10.7
Hydropower (grid-based)	Plant size: 1 MW–18,000+ MW Plant type: reservoir, run-of-river Capacity factor: 30–60%	Projects >300 MW: <2,000 Projects <300 MW: 2,000–4,000	5–10
Hydropower (off-grid/rural)	Plant capacity: 0.1–1,000 kW Plant type: run-of-river, hydrokinetic, diurnal storage	1,175–3,500	5–40
Ocean Power (tidal range)	Plant size: <1 to >250 MW Capacity factor: 23–29%	5,290–5,870	21–28
Solar PV (rooftop)	Peak capacity: 3–5 kW (residential); 100 kW (commercial); 500 kW (industrial) Conversion efficiency: 12–20%	2,480–3,270	22–44 (Europe)
Solar PV (ground-mounted utility-scale)	Peak capacity: 2.5–100 MW Conversion efficiency: 15–27%	1,830–2,350	20–37 (Europe)
Concentrating Solar Thermal Power (CSP)	Types: trough, tower, dish Plant size: 50–500 MW (trough), 50–300 MW (tower); Capacity factor: 20–25% (trough); 40–50% (trough with six hours storage); 40–80% (solar tower with 6–15 hours storage)	Trough without storage: 4,500; Trough with six hours storage: 7,100–9,000; Solar tower with 6–18 hours storage: 6,300–10,500	18.8–29
Wind Power (onshore)	Turbine size: 1.5–3.5 MW Rotor diameter: 60–110+ meters Capacity factor: 20–40%	1,410–2,475	5.2–16.5
Wind Power (offshore)	Turbine size: 1.5–7.5 MW Rotor diameter: 70–125 meters Capacity factor: 35–45%	3,760–5,870	11.4–22.4
Wind Power (small-scale)	Turbine size: up to 100 kW	3,000–6,000 (USA); 1,580 (China)	15–20 (USA)

TABLE 2. STATUS OF RENEWABLE ENERGY TECHNOLOGIES: CHARACTERISTICS AND COSTS (CONTINUED)

HOT WATER/ HEATING/COOLING		Typical Characteristics	Capital Costs (USD/kW_{th})	Typical Energy Costs (USD/GJ)
BIOMASS HEAT	Biomass steam turbine CHP	Plant size: 12–14 MW_{th} Capacity factor: ~69% Conversion efficiency: 25%	430–1,170	13–80
BIOMASS HEAT	Biogas CHP	Plant size: 0.5–5 MW_{th} Capacity factor: ~80% Conversion efficiency: 25%	200–1,170	11.8–35.2
BIOMASS HEAT	Domestic pellet heating	Plant size: 5–100 kW_{th} Capacity factor: 13–29% Conversion efficiency: 86–95%	360–1,410	18.8–100
GEOTHERMAL DIRECT USE	Space heating (buildings)	Plant size: 0.1–1 MW_{th} Capacity factor: 25–30%	1,865–4,595	28–76
GEOTHERMAL DIRECT USE	Space heating (district)	Plant size: 3.8–35 MW_{th} Capacity factor: 25–30%	665–1,830	16–36
GEOTHERMAL DIRECT USE	Ground-source heat pumps	Plant size: 10–350 kW_{th} Capacity factor: 25–30%	1,095–4,370	20–65
SOLAR THERMAL	Domestic hot water systems	Collector type: flat-plate, evacuated tube Plant size: 2.1–4.2 kW_{th} (3–6 m^2); 35 kW_{th} (50 m^2)	China: 147–634 Small-scale: 1,670–1,730 Large-scale: 1,020–1,060	4.2–79 (China)
SOLAR THERMAL	Domestic heat and hot water systems	Collector type: flat-plate, evacuated tube Plant size: 4.2–11.2 kW_{th} (6–16 m^2; small-scale); 35 kW_{th} (50 m^2; medium-scale); 70–3,500 kW_{th} (100–5,000 m^2; district heating); >3,500 kW_{th} (>5,000 m^2; district heat with seasonal storage)	620–2,115 In Europe: Small-scale: 1,390–1,490 Medium-scale: 870–1,020 District heat: 460-780; with storage: 1,060	14–200

TRANSPORT FUELS	Typical Characteristics	Estimated Production Costs (US cents/Litre)	
Biodiesel	Feedstocks: soy, rapeseed, mustard seed, palm, jatropha, waste vegetable oils, and animal fats	Range: 16.5–177	Argentina (soy): 42–91; USA (soy): 55–82; Indonesia/Malaysia/ Thailand/Peru (palm oil): 24–100
Ethanol	Feedstocks: sugar cane, sugar beets, corn, cassava, sorghum, wheat (and cellulose in the future)	Range: 20–102	Brazilian sugar cane: 68 (2011) U.S. corn ethanol (dry mill): 40 (2010)

See Endnote 54 for this section.

Notes: Costs are indicative economic costs, levelised, and exclusive of subsidies or policy incentives. Typical energy costs are generally under best conditions, including system design, siting, and resource availability. Optimal conditions can yield lower costs, and less favourable conditions can yield substantially higher costs. Data for rural energy are unchanged from GSR 2011; off-grid hydro data were combined and moved. Costs of off-grid hybrid power systems employing renewables depend strongly on system size, location, and associated items such as diesel backup and battery storage. Costs for solar PV vary by latitude and amount of solar insolation and are rapidly changing. Costs for biomass power and heat as well as biomass transport fuels depend on type and cost of biomass feedstock.

MARKET AND INDUSTRY TRENDS BY TECHNOLOGY

Renewable energy accounted for more than 71% of total electric capacity additions in the EU during 2011, while markets and industries expanded into new countries and regions. All end-use sectors experienced significant growth.

02

02 MARKET AND INDUSTRY TRENDS BY TECHNOLOGY

BIOMASS ENERGY

In addition to being a source of food, fibre, and feed for livestock, biomass accounts for over 10% of global primary energy supply and is the world's fourth largest source of energy (following oil, coal, and natural gas). Biomass demand grew at an annual average rate of 1.4% during the period 2002–2009.[1] Biomass feedstocks come in solid, gaseous, and liquid forms and can be converted through a variety of technologies to provide heat, electricity, and transport fuels.[2] (See Sidebar 2.)

The present global demand for biomass for energy purposes is estimated to be 53 EJ.[3] About 86% of this amount is used to produce heating (and cooling), for cooking, and for industrial applications; of this, nearly three-fourths is "traditional" biomass energy, burned directly and usually in very inefficient devices. Of the remaining 14%, nearly three-fourths is used for electricity generation and combined heat and power (CHP), and the rest is used to produce liquid biofuels for road transport.[4]

This section focuses on the modern uses of biomass for energy purposes, which has been growing rapidly. For example, over the past five years, liquid biofuels production increased at an average annual rate of 17% for ethanol and 27% for biodiesel.[5] The solid biomass industry also has been expanding rapidly, producing an increasing quantity and variety of biomass fuels as well as appliances for converting them to useful energy.

BIOMASS MARKETS

Demands for biomass fuels and related equipment and appliances have been increasing in response to policies to reduce GHG emissions and diversify energy sources. The growing use of biomass for heat, electricity, and transport fuels has resulted in increasing international trade of biomass fuels in order to supplement local supply. Wood pellets, biodiesel, and ethanol are the main fuels traded internationally, although others include methane (still insignificant but likely to increase in the future), fuelwood, charcoal, and agricultural residues.[6] (See Figure 6, page 34, and Table R3.)

In 2010, trade of solid biomass fuels (excluding charcoal) amounted to 18 million tonnes (300 PJ); more than 90% of this total consisted of pellets (120 PJ), wood waste (77 PJ), and fuelwood (76 PJ).[7] Net trade of fuel ethanol and biodiesel reached about 20 million barrels of oil equivalent (120–130 PJ) in 2009, with energy content on the same scale as pellets.[8]

Wood pellets represent a very small share of modern biomass energy, but they have experienced rapid growth since the mid-1990s, with some estimates showing production more than doubling since 2008.[9] Demand for wood pellets is increasing quickly due to their convenience, affordability, and ease of shipping over long distances. Their high density and small, uniform shapes make wood pellets ideal for use in automated combustion systems. About 65% of the total production is used in small heat plants and 35% in larger power plants.[10] Pellets have made biomass-fired, auger-fed automatic combustion possible, as well as a new generation of super-clean pellet-fired stoves.

The leading global markets for biomass energy are diverse and vary depending on fuel type. Europe consumes about 85% of the pellets produced globally each year, with Sweden alone consuming nearly 20%.[11] Although the pellet market has been limited primarily to Europe, North America, and Russia so far, a number of countries in South America and Asia, including Argentina, Brazil, and Chile in South America, and China, India, Japan, and Korea in Asia, as well as New Zealand, are getting involved in pellet consumption and production.[12]

The major biogas market is also in Europe, where Germany accounted for around 61% of total primary biogas energy consumption in 2010.[13] For liquid biofuels in the transportation sector, the top ethanol-consuming region in 2011 was North America, followed by Latin America, with Europe consuming the highest share of biodiesel.

BIOMASS HEATING (AND COOLING) MARKETS

An estimated 10 GW_{th} of modern biomass heating capacity was added in 2011, bringing the global total to 290 GW_{th}. Heat derived from burning solid, liquid, and gaseous biomass is used for industrial and agricultural processes, for cooking, and for heating water and space. Applications range from individual residential-scale units to large district heating systems, including combined heat and power (CHP) plants.

Globally, modern biomass used in the building and industry sectors for heat production in 2008 was 3.4 EJ, about 7.5 times the total of geothermal and solar heat.[14] Biomass is used for industrial heat predominantly in the food and tobacco, paper, pulp, and wood processing sectors. In Brazil, biomass accounts for 34% of final energy consumption in the cement industry and for 40% in the iron and steel industries, but this high share has not been replicated elsewhere.[15]

Solid biomass fuels provide a significant and growing amount of heat worldwide. The best data available are for markets in Europe. During 2010, solid biomass, excluding renewable municipal solid waste[i] (MSW), provided a total 2.8 EJ of heat in Europe; around half of

i - Renewable MSW refers to the portion of MSW that consists only of its biogenic constituents, e.g., paper, food wastes, wood, leather, and garden residues. For more on the treatment of renewable MSW, see Note on Accounting and Reporting, page 167.

SIDEBAR 2. BIOENERGY: COMPLEXITIES AND DATA COLLECTION CHALLENGES

The primary biomass feedstocks usually exist in solid form and include residues from forestry and agricultural harvesting, residues from food and fibre processing, organic components of municipal solid waste (MSW), and animal manures. Feedstocks can also come in liquid form, such as waste water.

Biomass feedstock can be processed into biomass fuels that are solid (e.g., wood pellets or chips), gaseous (e.g., biogas, biomethane, synthesis gas), and/or liquid (e.g., ethanol, biodiesel). Using a wide variety of technologies, these fuels are then converted into end-use energy as heat, electricity, or transport fuels and are used to provide useful energy services such as space heating, food chilling, light, and mobility. The pathways for converting biomass to energy services are many and complex. (See Figure 5.)

In addition, competition for biomass resources can exist for non-energy biomass uses such as animal feeds, bio-chemicals, and bio-materials. Bio-refineries exist that produce a range of products from biomass resources for both energy and non-energy purposes.

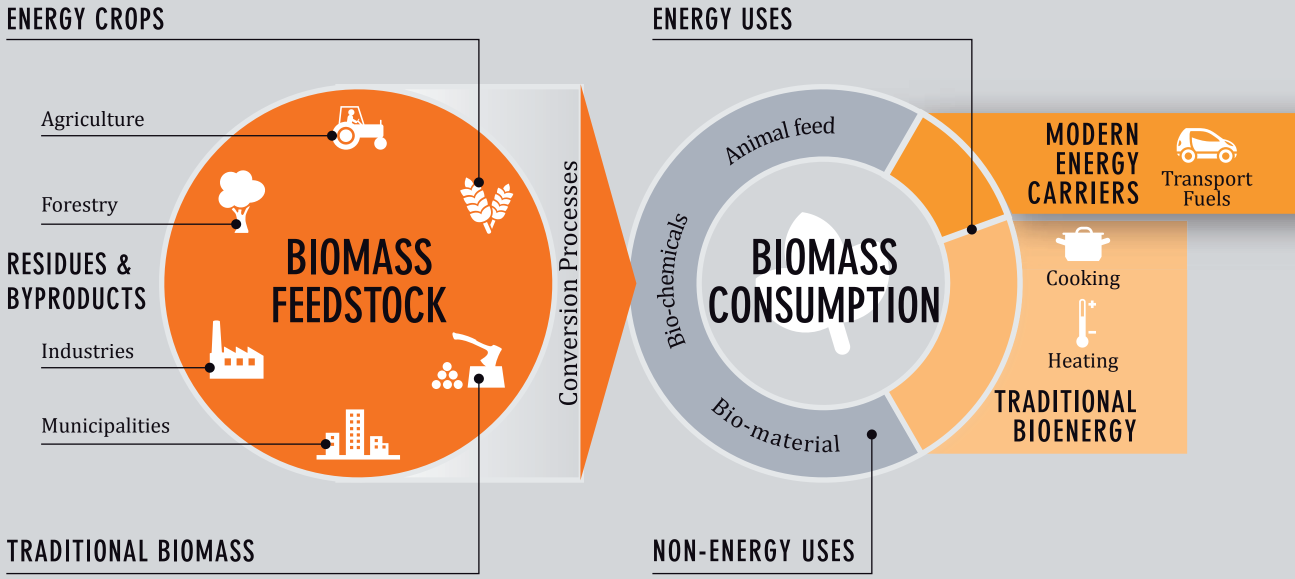
Bioenergy has the benefit of being easily integrated with conventional energy, by co-firing wood chips or pellets with coal, injecting biomethane into natural gas pipelines, and adding liquid biofuels to gasoline, diesel, or aviation fuels. Biomass is commonly used in power plants or combined heat and power (CHP) plants, either as gaseous fuels (typically at scales of 10 kW–5 MW or as solid biomass fuels (up to several hundred MW).

Source: See Endnote 2 for this section.

The diversity of biomass feedstocks and conversion pathways, as well as the disperse structure of the bioenergy sector, results in a lack of consolidated data at the supra-regional and especially global levels. Yet having a consolidated overview of the production, consumption, and trade of biomass feedstock, together with its processing and end-uses, is critical for sound energy planning. These data are also necessary for monitoring trends and sustainability impacts over time on a national and regional level. (The Global Bioenergy Partnership, for example, has developed indicators to monitor the sustainability of bioenergy on a national level.)

The bioenergy data challenge differs for internationally traded biomass versus non-traded fuels (i.e., biomass that is predominantly used locally). Systematic collection of data appears to be possible for traded goods, although it varies for the different biomass fuels traded. The viability of biomass trade depends on the monetary value of the commodity, its energy and bulk density, its homogeneity, and its flow properties. Commodity prices for biomass fuels have also been influenced greatly by national support policies for renewable energy. The most prominent examples for traded biomass fuels include

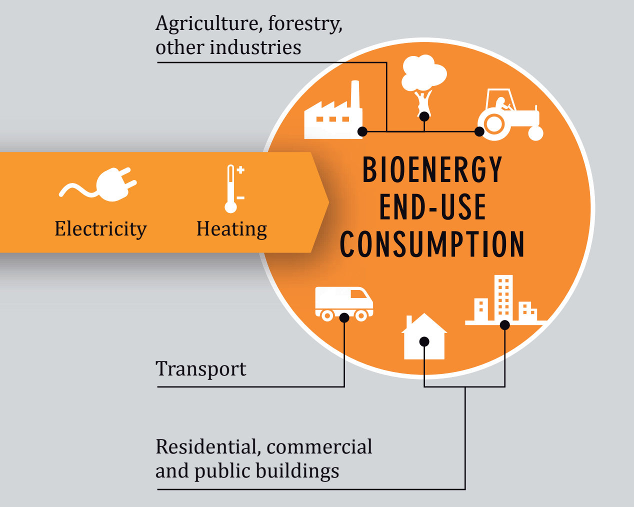
FIGURE 5. BIOMASS TO ENERGY PATHWAYS



biodiesel derived from vegetable oil, ethanol derived from sugar or starch, and wood pellets, all of which have seen an exponential increase in trade over the past decade.

In contrast to wood pellets, trade streams for biodiesel and ethanol have varied annually in both their volume and their routes of trade. This is directly related to the fact that customs duties or preferences (and sometimes additional taxes) are imposed on liquid biofuels but currently not on wood pellets or other forms of woody biomass. Research on biomass fuel trade indicates that, historically, the level of import duties has influenced the volume of trade, whereas tariff preferences (typically tariff exemptions) have defined the routes of trade.

Although biomass trade statistics can provide a systematic way of collecting and comparing global data, they should be considered with caution because, at the international level, trade codes are not harmonised to a sufficient degree of detail. Ultimately, the use of harmonised and specific biomass codes would significantly improve the availability and homogeneity of international biomass trade data, bearing in mind that these data do not provide a comprehensive picture of bioenergy worldwide.



Different pieces of circles do not represent relative shares.

this total was consumed in France, Germany, Sweden, and Finland.[16] District heating accounted for almost 11% of this total, mainly in Sweden, Finland, Denmark and Austria.[17] Heat delivered by district heating systems increased by 23.7% in 2010, to 300 PJ, with CHP units delivering two-thirds of this total. Heat produced through the combustion of renewable MSW accounted for only about 3% of the total heat generated from all solid biomass in 2010.

Biogas is also being used increasingly for heat production. In developed countries, it is used primarily in CHP plants, with relatively small amounts used in heat-only plants. Total heat consumption from biogas in Europe was 63 PJ in 2010. In the United States in 2011, 576 operational landfill methane-capture projects produced useful heat (along with electricity) to meet the heat demand of almost 750,000 homes, for a total of 62 PJ.[18] As of early 2012, about 186 U.S. biogas plants were operating at commercial livestock farms, with 168 of these generating around 0.2 PJ/year of useful heat energy (excluding gas flaring).[19] Biomethane (purified biogas) is produced in 11 European countries, and in nine[ii] of them it is injected into the natural gas network.[20] Its use in CHP plants along with other applications is well established in these countries, led by Germany.

In developing countries, biogas produced from domestic-scale digesters is used for cooking and to a smaller extent for water heating and lighting. China and India have the largest numbers of domestic digesters in the world, with 43 million and 4.4 million domestic biogas digesters, respectively, in 2011.[21] Nepal and Vietnam also have them in significant numbers, while several other countries in Asia and Africa have initiated digester programmes. (See Rural Renewable Energy section.)

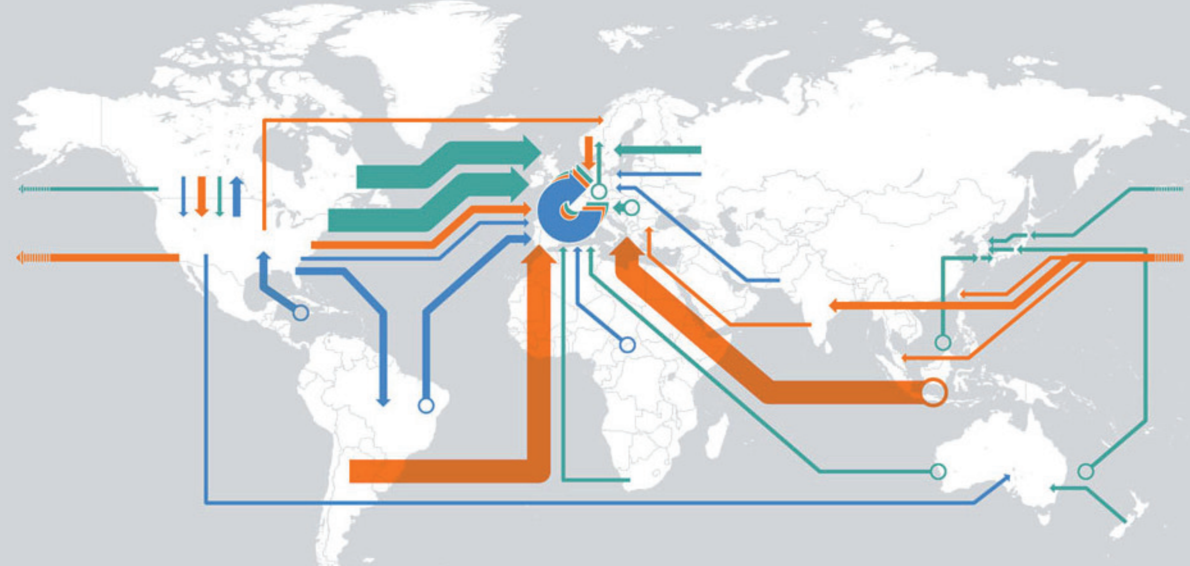
Although used primarily as a transport fuel, pure or blended biodiesel also is being used increasingly for space heating in response to the prevailing high price of heating oil.[22] In 2011, liquid biofuels were used for heating in several European countries, including Germany, Portugal, and Sweden, and their use is poised to grow further as an increasing number of U.S. states require that all heating oil sold must contain a blend of biodiesel.[23]

Markets for biomass heat appliances have enjoyed healthy growth in recent years, particularly in Europe. Appliances range from small-scale stoves for room heating, to small boilers for heating of houses, to multi-megawatt boilers for industrial process heat and district heating. A recent advance in developing countries is the introduction of gasifier stoves for cooking. These highly efficient modern stoves, fired by pellets or wood chips, are commercially available in a few developing countries, particularly China, India, Sri Lanka, and the Philippines.[24]

Domestic biomass-fired boilers and stoves are used widely for heating and continue to gain in popularity. In Germany, for example, the number of installed wood pellet combustion units rose from 3,000 in 2000 to 155,000 in 2011.[25]

ii - The nine countries are Austria, France, Germany, Luxembourg, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.

FIGURE 6. NET TRADE STREAMS OF WOOD PELLETS, BIODIESEL, AND ETHANOL, 2011



Bioethanol:	Biodiesel:	Pellets:		Energy Content:
> 1000 Ml/yr	> 600 Ml/yr	> 1000 kt/yr	=	> 20 PJ/yr
501-1000 Ml/yr	301-600 Ml/yr	501-1000 kt/yr	=	10-20 PJ/yr
101-500 Ml/yr	61-300 Ml/yr	101-500 kt/yr	=	2-10 PJ/yr
10-100 Ml/yr	6-60 Ml/yr	10-100 kt/yr	=	0,2-2 PJ/yr

Source is more than one country

Ml = Million litres; kt = Thousand tons

Source: See Endnote 6 for this section.

Note: The map shows net fuel ethanol, biodiesel, and wood pellets trade flows between countries/regions in 2011. Individual flows were derived as net volumes and are depicted in ranges to allow a broader picture and a comparison among commodities; arrow widths show energy content, so all are comparable across fuels. Only trade flows to markets with national renewable energy policy frameworks that stimulate the use of the respective traded commodity are included. The map does not contain all reported trade (the minimum energy content per trade stream was set to 200 TJ); nor does it contain non-energy related trade. Since production and consumption data were not available for the EU-27 region for 2011, 2010 values were used as an approximation to derive the fuel ethanol share of 2011 imports.

Wood-burning stoves made a comeback in Greece in 2011, and the number of pellet stoves installed in Italy increased nearly 14% that year to more than 1.56 million.[26]

In the United States, between 2000 and 2010, household heating from woody biomass combustion grew 34%, faster than any other heating fuel. It now constitutes the country's fourth leading residential heat source. Approximately 12 million wood and pellet stoves had been installed in the United States by early 2011, and an estimated 2.1–2.6 million homes use wood as their sole source of space heating.[27]

Heat can also be used to produce a cooling effect using the absorption refrigeration cycle. Although absorption chillers are well-established technologies, the use of biomass to fuel them is not yet common. Only a limited number of large centralised systems exist; for example, there is at least one biomass-fuelled absorption chiller in Spain.[28] Small-scale biomass-powered cooling systems are not commercially available at present.[29]

BIOMASS POWER MARKETS

Almost 72 GW of biomass power generation capacity was in place worldwide by the end of 2011, up from an estimated 66 GW in 2010.[30] Electricity is generated from biomass through direct firing or co-firing (with coal or natural gas) of solid biomass, renewable MSW, biogas, and liquid biofuels in electricity-only and CHP plants.

About 88.3% of biomass power is generated with solid biomass fuels.[31] The United States continues to lead the world in terms of total solid biomass-based power generation, with other significant bioenergy power producers in the EU (led by Germany, Sweden, and the U.K.), Brazil, China, India, and Japan.

At the end of 2011, total installed capacity of bioenergy power plants in the United States, including renewable MSW, was nearly 13.7 GW, up about 3% over 2010 (13.3 GW).[32] U.S. net generation of electricity from solid biomass increased from 56.1 TWh in 2010 to 56.7 TWh in 2011.[33]

In the EU, where the installed capacity was 26.2 GW at the end of 2011, gross electricity production from solid biomass (excluding MSW) increased by 12.2% in 2010 to 69.9 TWh, with 25.3 TWh (36%) of this total coming from electricity-only plants, and the remainder from CHP plants. Electricity generation based on renewable MSW in 2010 was 17.3 TWh, up 13.5% over 2009. Around 46.3% of the total was generated by CHP plants and the remainder by electricity-only plants. The top five countries—Germany, Sweden, Finland, the U.K., and the Netherlands—accounted for almost two-thirds of EU electricity production from solid biomass (including MSW), with Germany accounting for the largest share (17.6%). Other major producers include Poland, Italy, Denmark, and Austria.[34]

Brazil's biomass power capacity has also been increasing steadily, reaching 8.9 GW by the end of 2011, up 14% from 7.8 GW in 2010.[35] The majority (7.3 GW) was based on cogeneration using bagasse. China, where the first biomass power plant came on line only in 2006, has seen remarkable growth with total installed capacity reaching 4.4 GW at the end of 2011, an increase of 10% over 2010.[36] India added about 0.6 GW of capacity during 2011 to reach 3.8 GW.[37] In 2011, Japan had 3.3 GW of generation capacity based on solid biomass, while Thailand's installed capacity reached 1.6 GW.[38]

In Africa, most sugar-producing countries generate power and heat with bagasse-based CHP plants. Grid-connected bagasse CHP plants exist in Kenya, Mauritius, Tanzania, Uganda, and Zimbabwe. However, despite Africa's enormous biomass resource potential, biomass power generation has remained extremely low until recently. Biomass power plants are now planned or under construction in Cameroon, Côte d'Ivoire, Ghana, Liberia, Nigeria, Rwanda, Senegal, Sierra Leone, and Sudan, and plans for an 11.5 MW biomass power plant in Kenya were announced in early 2012.[39]

A decade ago, the typical size of a bioenergy power facility was limited by the availability of sufficient biomass feedstock within a given radius. Thus, the average size of plant in the United States, for example, was constrained to about 20 MW. Improvements in the logistics of biomass collection, transport, and storage since then, and growing international trade (particularly in pellets), have helped to largely remove constraints on plant size. As a result, plant sizes are increasing. The world's largest biomass power plant (750 MW) is fuelled primarily with imported pellets. It became operational in the U.K. at the end of 2011 following conversion of a 1 GW coal-fired plant.[40] Also in 2011, construction began on two 100 MW plants in the United States after sufficient fuel (including pellets) was secured.[41]

Many existing coal- and gas-fired power plants are undergoing conversions to co-firing with biomass in order to reduce their GHG emissions per unit of electricity generated. By 2009, approximately 264 power plants worldwide had tested or demonstrated co-firing of biomass or were co-firing on a commercial basis. At the time, the leading countries were Finland (81 plants operational), the United States (40), Germany (27), the U.K. (18), and Sweden (15).[42]

Biogas is also increasingly being used to generate electricity. In the EU, gross electricity production from biogas was 30.3 TWh in 2010, up 20.9% relative to 2009. Around one-fifth of the total generation came from CHP plants.[43] In the United States during 2011, operational landfill methane capture projects produced 14.3 TWh of electricity, enough to provide power to more than 1 million homes.[44] In addition, biogas plants at commercial livestock farms generated more than 0.5 TWh of electricity.[45]

In developing countries, biogas produced in large digesters is generally used for power generation. In China, by the end of 2009, nearly 2,000 large and medium-scale biogas digesters had been installed at industrial enterprises. A further 22,570 digesters had been installed at livestock and poultry farms, and 630 in municipal waste and sludge treatment facilities.[46] By the end of 2010, China's total biogas power generating capacity stood at 800 MW.[47] India had 70 biogas plants based on urban and industrial wastes amounting to 91 MW of installed capacity as of 2010.[48]

Although liquid biofuels are used primarily in the transport sector, some are also used for stationary power and CHP generation applications. About 760 CHP plants (totaling 340 MW) fuelled with biofuels were in operation in Germany at the end of 2010.[49] The world's largest palm oil power station (about 100 MW) is located in Italy.[50] Brazil and Argentina also have power plants fuelled by ethanol and biodiesel, respectively.[51]

TRANSPORT BIOFUEL MARKETS

Liquid biofuels have made a small but growing contribution to transport fuel usage worldwide, currently providing about 3% of global road transport fuels.[52] Biofuels commonly used today include ethanol—produced primarily from corn and sugar cane—and biodiesel, which is made from virgin plant oils (such as soybean oil, oilseed rape, and palm oil), used cooking oil, animal fats, and fish oil.[i] A limited amount of biofuel is used by the marine transport sector, and interest is growing in the use of biofuels for aviation.

i - The environmental, social, and other costs of biofuels, including lifecycle GHG 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 ethanol made from sugar cane. For more information and efforts to improve the sustainability of biofuels production and use, see Sidebar 7 in GSR 2010.

Global production of fuel ethanol was stable or down slightly in 2011, for the first time since 2000, to an estimated 86.1 billion litres.[53] (See Figure 7 and Table R4.) In 2011, the United States and Brazil accounted for 63% and 24% of global ethanol production, respectively, compared with 60% and 30% in 2010.[54]

Although global production was down, in the United States, corn ethanol production reached a new high, exceeding 54 billion litres.[55] This country, which was a net biofuel importer until 2010, saw its exports rise nearly threefold from 1.5 billion litres in 2010 to 4.5 billion litres in 2011.[56] The United States continued to gain international market share from Brazil, which was the world's leading ethanol exporter for many years.

About one-third of U.S. exports flowed to Brazil, where ethanol production was down by almost 18% in 2011 relative to 2010, to 21 billion litres (down from about 25.5 billion litres).[57] Declining investment in new sugarcane assets and plantations since the 2008 financial crisis, combined with poor sugarcane harvests due to unfavourable weather and high world sugar prices, resulted in this significant decrease.[58] This decline led Brazil to announce new policies to stimulate sugar production and to reduce, in September 2011, the amount of anhydrous ethanol required in gasoline to 20% (from 25%).[59] (See Policy Landscape section.)

China was the world's third largest ethanol producer and Asia's largest in 2011, at 2.1 billion litres. It was followed by Canada (1.8 billion litres), France (1.1 billion), and Germany (0.8 billion). Africa accounted for only a tiny share of world production, but saw a slight increase during 2011 compared with 2010.[60]

In contrast to ethanol, global biodiesel production continued to expand, increasing by almost 16% to 21.4 billion litres in 2011, compared with 18.5 billion litres in 2010.[61] The United States saw a record year, with biodiesel production increasing by 159% to nearly 3.2 billion litres, mainly from soybeans.[62] As a result, the country passed the 2010 leaders, Germany, Brazil, Argentina, and France, to become the world's top producer. The dramatic increase in biodiesel production in the United States was due to a government mandate in mid-2010 that required refiners to blend 3.1 billion litres (800 million gallons) of biodiesel with diesel fuel in 2011 or face stiff daily fines.[63]

The EU remained the largest regional producer of biodiesel, but its total production declined by 6%, and the EU share of the world total was down from 53% in 2010 to 43% in 2011.[64] Germany dropped from first to second place globally, although its production increased by 18%, and, with 3.2 billion litres of biodiesel production, it was not far behind the United States.[65] It was followed by Argentina (2.8 billion litres), which saw an increase of 34% over 2010, and Brazil (2.7 billion litres), up 12%.[66] Production in France dropped from 1.9 billion litres in 2010 to 1.6 billion litres in 2011.[67]

Use of biomethane (purified biogas) is quite well established in the transport sector in the European countries where it is injected into the natural gas network. In 2010, out of 70,000 public natural gas-operated buses in Europe, 9,000 (13%) ran on biomethane, and approximately 39,000 gas vehicles in Sweden were operating on mixtures of biogas and natural gas (containing an average 60% biogas) at the end of 2011.[68]

Airlines around the world have shown growing interest and involvement in aviation biofuels as part of their effort to reduce fuel costs and GHG emissions.[69] During 2011, several airlines including Aeromexico, Finnair, KLM Royal Dutch Airlines, Lufthansa, Thai Airways, United Airlines, and Alaska Airlines began to operate commercial flights using various biofuel blends.[70]

Although commercial production of advanced biofuels remained low in 2011, interest in these fuels is increasing. In December, the U.S. Navy signed contracts to purchase around 1.7 million litres of advanced biofuels, and it plans to displace 50% of its fossil fuel demand with alternative fuels by 2020, amounting to 2.3 billion litres of biofuels annually.[71]

BIOMASS INDUSTRY

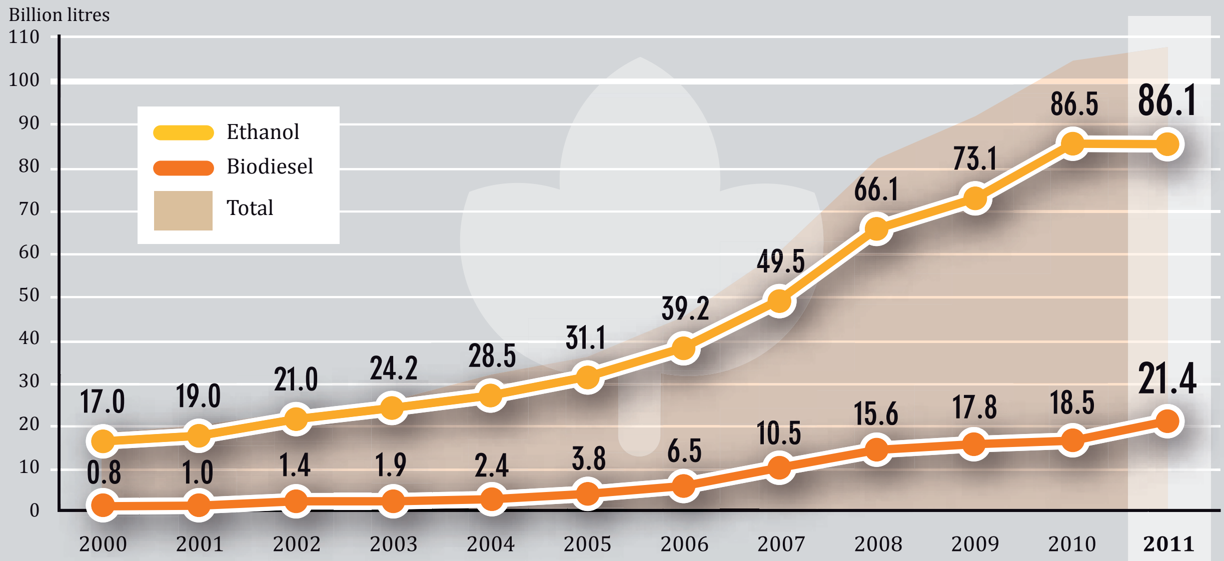
The biomass industry supplies and uses solid, liquid, and gaseous fuels produced from forest, agricultural, and municipal residues, and crops grown for energy purposes. The industry also produces appliances for using these fuels, such as biomass boilers for homes and small businesses, and industrial- and municipal-scale plants and boilers.

Overall, the bioenergy industry remained only slightly affected by global and regional economic turmoil, despite the fact that much of this diverse industry is centred in Europe. Due to rising interest in modern bioenergy, in Europe and elsewhere, local feedstock supplies are failing to keep pace with the rapidly rising demand in some countries. This trend is driving both an increase in international trade in biomass and the creation of large feedstock plantations in tropical and sub-tropical regions.[72] A growing number of large companies—including utilities, energy, and telecommunications companies (based primarily in Europe but also in Asia and elsewhere)—are investing in biomass plantations across Africa and, to a lesser extent, in Asia, Eastern Europe, and Latin America.[73]

Significant developments in the biomass industry during 2011 included the opening of biomass exchanges in the Netherlands and the U.S. city of Minneapolis to serve as platforms for encouraging trade in biomass resources.[74] They are expected to bring security and stability to this growing industry. Also in 2011, the biofuel industry continued its efforts to address concerns regarding sustainability issues through participation in several schemes and roundtables. An estimated 67 such schemes were operating or under development during the year, with the aim of promoting sustainable use of biomass through trading under an approved certification scheme.[75]

BIOMASS ENERGY

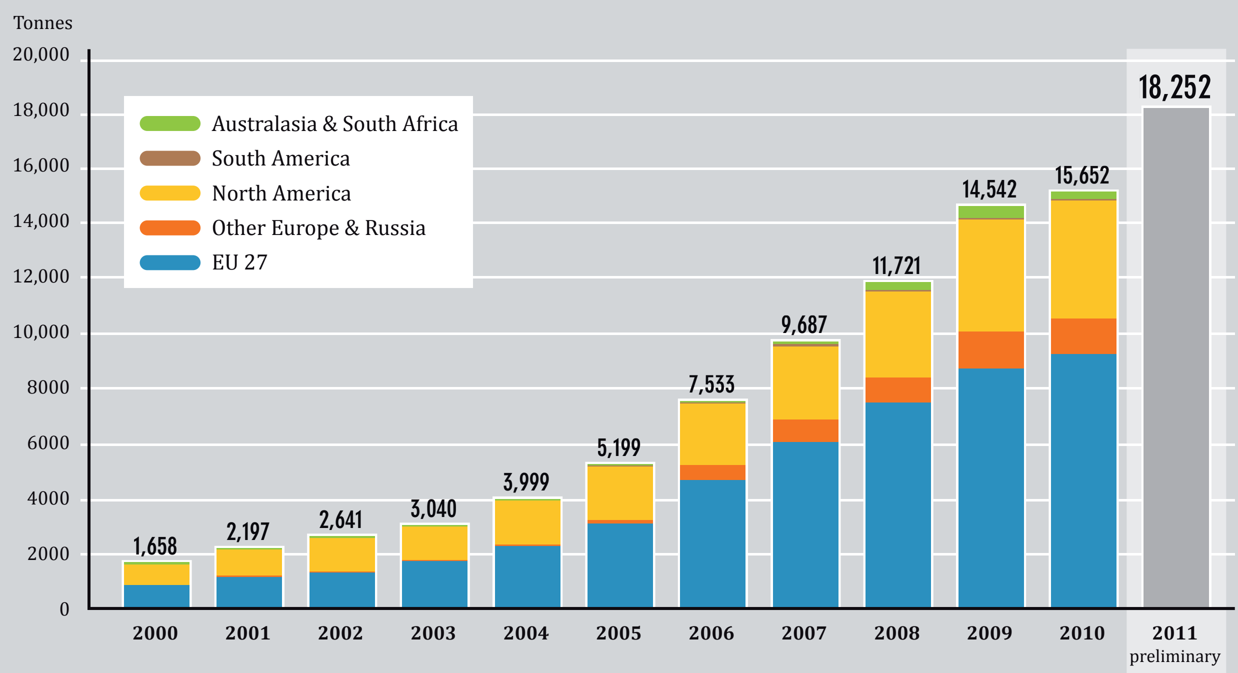
FIGURE 7. ETHANOL AND BIODIESEL PRODUCTION, 2000–2011



Source: See Endnote 53 for this section

BIOMASS MEETS AN ESTIMATED 53 EJ OF GLOBAL ENERGY DEMAND; ~35% IS FOR MODERN ENERGY USES.

FIGURE 8. GLOBAL WOOD PELLET PRODUCTION, 2000–2011



Source: See Endnote 80 for this section.

Another trend of note is the rise of bio-refineries in Brazil, the United States, and elsewhere. Bio-refineries integrate biomass conversion processes and equipment to produce a multi-product range that could include transport biofuels, power, heat, lubricants, polymers, and other chemicals. This approach can take advantage of different components of biomass feedstocks, maximise the derived value, enhance profitability, and reduce GHG emissions.[76]

In 2011, 29 "bio-refinery" projects received Department of Energy funding support in the United States.[77] Some produce lignin and industrial chemical furfural as co-products with the ethanol; others generate heat and power for use on site as the associated co-products.[78] It is estimated that 300–600 processing plants will be required to meet existing U.S. biofuel blending mandates by 2022, but how many of these will be multi-product bio-refineries is not known.[79]

SOLID BIOMASS INDUSTRY

Among solid biomass fuels, the manufacture of wood pellets has experienced the most significant growth over the last 10 years. Between 2000 and 2011, global pellet production grew by an annual average of 25%, with production approaching 18.3 million tonnes in 2011.[80] (See Figure 8.) The world's largest producers were the United States, Canada, and Europe (led by Germany, Sweden, Austria, and Poland). Elsewhere, Russia and China are becoming sizable and growing producers and consumers of pellets, with production capacity of around 2 and 0.75 million tonnes, respectively, in 2011.[81] Other countries seeing increases included Japan, New Zealand, and South Korea.[82]

Significant industry developments during the year included completion of the world's two largest pellet production plants in Russia (0.9 million tonnes/year capacity) and the U.S. state of Georgia (0.75 million tonnes/year capacity).[83] The Brazilian group Suzano announced plans to establish three pellet production units with an annual output of 1 million tonnes each during the first phase of development.[84] Also in 2011, Enviva LP, a leading pellet manufacturer operating in the United States and Europe, partnered with ConocoPhillips to produce torrefied biomass fuels.[i]

Briquetting[ii] of loose biomass materials (for example, crop residues and sawdust) is well established in several countries. China produced roughly 0.5 million tonnes in 2010; other Asian countries producing briquettes include Japan, India, Malaysia, and Thailand.[85] Outside of Asia, total wood briquette production around the world is estimated to be 1.3 million tonnes.[86]

BIOGAS INDUSTRY

The biogas industry has been enjoying remarkable growth in some parts of the world. This is particularly true in Europe, where total primary energy production from biogas increased more than 31% in 2010 to 460 PJ.[87] Germany produces nearly 61% of the region's biogas and has experienced rapid growth.[88] The number of German production plants grew at an average annual rate exceeding 18% during the period 2001–2010.[89] In 2011, a large number of biogas upgrading plants, producing biomethane, were in operation in OECD countries.[90] Some of these were directly dispensing the gas as a vehicle fuel, and the others were injecting it into natural gas networks. In the United States, 40 landfill gas upgrading projects were operating at year's end.[91]

In Europe, the top five countries for biomethane-to-grid injection in 2011 were Germany, Sweden, Switzerland, the Netherlands, and Austria; together they had more than 170 plants in operation.[92] The technology has witnessed the most dramatic growth in Germany, where the first plant was established in 2006, and 84 plants were operating in 2011.[93]

LIQUID BIOFUELS INDUSTRY

Production capacity of biofuels continues to be centred primarily in the United States, Brazil, and Europe. As of January 2012, U.S. corn ethanol manufacturers operated 209 plants with a total nameplate annual capacity of over 56 billion litres. This represented an increase of 5.3 billion litres relative to the previous January.[94]

In Brazil, there were 440 plants with a capacity of 37 billion litres. The maximum cane milling capacity is around 620 million tonnes, whereas 492 million tonnes was produced and milled in 2011–12, implying that ethanol production could be increased by 30% over the current level using existing capacity. New plants are starting to operate, and Brazil's capacity is expected to expand further, although the investment has been relatively low over the past three years.[95]

Biodiesel production capacity is also expanding rapidly in the United States, where there were 190 biodiesel plants with a combined annual production capacity of 11 billion litres in 2011.[96] A further 14 plants, with a combined production capacity of 1.5 billion litres, were under construction by year's end.[97] In Europe, annual biodiesel production capacity rose slightly in 2011, to 25.1 billion litres up from 24.9 billion litres in 2010; about 22% of the total capacity was located in Germany and 20% of it in Spain.[98] Production capacity in Argentina in 2011 was estimated to be 3.8 billion litres, up almost 36% over 2010 (2.8 billion litres).[99] Although

i - Torrefied wood is produced by heating wood to 200–300 °C in restricted air, and it has useful characteristics for a fuel such as relatively high energy density, good grindability into pulverised fuel, and water repellency.

ii - Briquetting is the process of producing briquettes, which are similar to wood pellets but physically much larger with a diameter of 5–10 centimetres and a length of 6–15 centimetres. They can be substituted for fuelwood logs.

it produced less than Argentina, Brazil had far more biodiesel production capacity by the end of 2011: Brazil's capacity reached 6.5 billion litres, with 70 plants.[100]

Several major traditional oil and gas companies continue to be interested in the biofuels sector. For example, BP, which already had a 50% stake in Goias-based Tropical BioEnergia SA of Brazil, purchased the company's remaining shares in 2011.[101] Shell and Cosan, the third largest sugarcane producer in Brazil, formed a joint venture, Raízen, becoming the second largest ethanol distributor and retailer after BR (from Petrobras).[102]

Commercial production of advanced biofuels remained low in 2011, except for a handful of hydro-treated vegetable oil (HVO) plants in operation.[103] A few large cellulosic ethanol plants were under construction at year's end, including facilities in Italy and the United States.[104] In early 2012, Royal Dutch Shell announced that it had built an advanced biofuels pilot plant in Houston, Texas, to produce drop-in biofuels.[105i]

The advanced biofuels industry saw some ups and downs in 2011 and early 2012. For example, Range Fuels, which had received funding from the U.S. government, was unable to overcome technical and business hurdles involved in producing ethanol from wood, and closed its plant in Georgia.[106] Germany's Choren Industries GmbH declared insolvency, and the biomass-to-liquid (BTL) technology that it had developed was acquired by Linde Engineering Dresden, a subsidiary of the Linde Group.[107]

On the upside, shares of Solazyme Inc. began trading successfully on the Nasdaq, and the company completed a deal with Dow Chemicals to ship up to 200 million litres of its algae-based oil to be used in electrical transformers.[108] In another development, nine partners from six European countries and Israel joined a project, funded largely by the European Commission (EC), with the aim of integrating the entire value chain in the production of ethanol and biodiesel from algae.[109] In addition, the airline and biofuel industries, together with the EC, launched the initiative "European Advanced Biofuels Flightpath" to speed up the commercialisation of aviation biofuels.[110]

BIOMASS ENERGY SYSTEMS

Much of the manufacturing industry for biomass handling and combustion equipment is centred in the EU and the United States. However, systems for converting biomass to energy are varied, and are produced and used around the world

Boiler-steam turbine systems, which account for nearly 80% of global power generation, are used to produce power in capacities above 1 MW. These are well established and commercially available in developed countries as well as large developing countries such as China and India.

CHP systems that rely on solid biomass fuels are normally based on steam turbine systems; however, gasifier-engine systems, Organic Rankine Cycle (ORC), and Stirling engines are currently at initial stages of demonstration and commercialisation.[111] Gasifier-gas engine systems offer higher electrical efficiency compared with conventional boiler-steam turbine systems for output at scales less than 10 MW.[112] A number of advanced gasifier projects are currently operational in Europe.[113] ORC systems are commercially available in the electrical capacity range of 0.3–1.5 MW.[114] Stirling engines, with capacities of up to 75 kW, are currently being demonstrated.[115]

Biogas use for CHP is based mostly on reciprocating engines, gas turbines, and micro-turbines of capacities below 250 kW; micro-turbines are used primarily in North America.[116] Biogas-powered systems based on fuel cells are in the very early stages of commercialisation, but their use for power generation with biogas recently got a boost in 2011 when Spain's Abengoa SA announced plans to use them for projects to be developed in Europe and Latin America.[117] Biodiesel-fuelled CHP engines have long been commercial. Biogas- and vegetable oil-fuelled systems are offered by a number of manufacturers from Australia, Germany, the United States, and China.[118]

i - Drop-in biofuels are biofuels that can be used directly without requiring any engine modifications and that do not need to be blended with petroleum fuels..

GEOTHERMAL HEAT AND POWER

GEOTHERMAL MARKETS

Geothermal resources provide energy in the form of direct heat and electricity, totalling an estimated 205 TWh (738 PJ) in 2011. Two-thirds of this output was delivered as direct heat and the remaining one-third was delivered as electricity.

Global direct (heat) use of geothermal energy continued to rise in 2011, with capacity reaching an estimated 58 GW_{th} by year-end.[1] From 2005 through 2010, heat output from geothermal sources increased by an average rate of about 10% annually, and is estimated to have reached 489 PJ in 2011. Most of this increase is associated with ground-source heat pumps (GHP), which grew at an average rate of 20% annually from 2005 through 2010.[2]

At an estimated 42 GW_{th}, GHP accounted for some 72% of global direct geothermal capacity and nearly 53% of direct heat use (257 PJ) in 2011.[i] About one-quarter of geothermal direct heat is used for bathing and swimming applications, more than 13% for heating (primarily district heat), and the remainder for greenhouses, industrial purposes, aquaculture pond heating, agricultural drying, snow melting, cooling, and other uses.[3]

At least 78 countries used direct geothermal energy in 2011, up from 72 in 2005 and 58 in 2000.[4] The top five countries with geothermal heat capacity—the United States, China, Sweden, Germany, and Japan—accounted for about two-thirds of total global capacity.[5] China led in direct geothermal energy use in 2010 at 21 TWh, followed by the United States (18.4 TWh in 2011), Sweden (13.8 TWh), Turkey (10.2 TWh), Japan (7.1 TWh), and Iceland (7.0 TWh in 2011).[6] Iceland, Sweden, Norway, New Zealand, and Denmark were in the lead for average annual energy use per person.[7] About 90% of Iceland's heating demand was derived from geothermal resources in 2011.[8]

Installed heat pump capacity has more than doubled since 2005, with use increasing from 33 countries in 2005 to 43 in 2010.[9] Heat pumps can generate heating or cooling and can be used in conjunction with CHP plants.[10]

In the United States, heat pump shipments have grown steadily (with a dip due to the housing crisis) in response to government incentives and greater awareness.[11] Demand for heat pumps in China is growing at about 20% per year, but challenges include the lack of a regulated market and unified standards, as well as difficulties associated with maintenance and repair.[12]

Some key European GHP markets (Germany, France, Austria) have contracted in recent years due to the economic crisis and slow housing market, but expansion has continued in Northern Europe and interest is surging in southern European countries (from very low levels).[13] EU capacity rose 12% in 2010 to more than 12.6 GW_{th}, led by Sweden (>4 GW_{th}), Germany (2.6 GW_{th}), France (1.7 GW_{th}), and Finland and Switzerland (each with about 1 GW_{th}).[14]

It is estimated that geothermal electricity generation reached 69 TWh in 2011.[15] The global market for geothermal electric capacity saw very modest expansion in 2011. An estimated 136 MW of geothermal electricity generating capacity was added during 2011—in Iceland, Nicaragua, and the United States—bringing total global capacity to 11.2 GW.[16]

Most of the new capacity came on line in Iceland, where 90 MW was added to the Hellisheiði combined heat and power plant. Producing 303 MW of power and another 133 MW_{th} of space heating and hot water, this is one of the world's largest geothermal energy plants.[17] Nicaragua added 36 MW of capacity with an expansion of its San Jacinto-Tizate project; another 36 MW is expected to be added at a later stage.[18] After adding 15 MW in 2010, the United States brought on line another 10 MW in 2011, and a further 81 MW in the first quarter of 2012.[19] Growth is expected to pick up as the recession eases, with as much as 772 MW of new capacity in advanced stages of development.[20]

The Philippines added no capacity in 2011, but committed to six new projects.[21] In January 2012, Mexico launched the 50 MW Los Humeros Phase II.[22] Indonesia's plans for some 4 GW by 2014 have stalled, but new regulations are expected to reassure developers, and three additional plants (135 MW total) are due to come on line in 2012.[23] Multiple enhanced geothermal system (EGS) projects are also under development around the world; the first plant started operating in Germany in 2008.[24]

Geothermal power plants operate in at least 24 countries, with the vast majority of global capacity in eight countries: the United States (3.1 GW), the Philippines (1.9 GW), Indonesia (1.2 GW), Mexico (just under 1 GW), Italy (0.8 GW), Iceland (0.7 GW), New Zealand (nearly 0.6 GW), and Japan (0.5 GW).[25] Iceland, the leader on a per capita basis, generated about 26% of its electricity with geothermal power in 2010, and the Philippines generated approximately 18%.[26] While only 46 countries were considering geothermal power development in 2007, some 70 countries had projects under development or consideration by 2010.[27]

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 do 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.

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.[28] Drought in East Africa has renewed interest in geothermal electricity to improve reliability in a region dependent predominantly on hydropower.[29] The high cost of exploration has dampened the growth rate in the region, but plans are progressing for significant growth in the East African Rift Valley.[30] Kenya, which has about 200 MW of existing capacity, aims to meet 50% of its electricity needs with geothermal by 2018, while Djibouti, Eritrea, Rwanda, Tanzania, and Uganda are at varying stages of geothermal development.[31] There are also plans for new capacity under way in Latin America, including in Chile and Peru.

GEOTHERMAL INDUSTRY

A large number of GHP manufacturers operate in the United States and also in Europe.[32] Most European companies are in the main markets—Sweden, Germany, Austria, and France—where there are two distinct classes of companies: general heating companies and electric heating specialists; and manufacturers of heat pump systems. Significant investments by major European manufacturers in recent years have led to rapid increases in production capacities for heat pumps.[33] In China, due to a low market threshold, a large number of manufacturers have entered the market for direct geothermal energy, resulting in a vicious price war. Geothermal integrators and builders with mixed levels of expertise often face high operating costs, which can result in constructing units with weak heating or cooling.[34]

Company developments during 2011 include the Nibe Energy Systems (Sweden) takeover of Schulthess Group (Switzerland) and its 50% acquisition of ABK AS (Norway); the Viessmann Group (Germany) launch of Vitocal 350-G, a new highly efficient ground-to-water heat pump; and Bosch's announcement of a new line of high-efficiency residential ground-source heat pumps for the North American market.[35]

In the power sector, the five leading turbine manufacturers in terms of total capacity in operation are Mitsubishi (Japan), Toshiba (Japan), Fuji (Japan), Ansaldo/Tosi (Italy), and Ormat (Israel), which account for well over 80% of capacity currently in operation around the world.[36]

Geothermal power projects take 5–7 years to develop from resource discovery to commercial development, and, as with oil or mining projects, the size of the resource is unconfirmed until drilling takes place. Long development times and the upfront risk and exploration often force geothermal companies to fund the work required to prove the resource. Tight capital and policy uncertainties in some countries, such as the United States, have made it challenging for developers to attract project funding.[37] Moreover, no two project sites are the same, and each plant must be designed to project-specific conditions.[38]

Technology continued to advance in the power sector during 2011. Geothermal power is made more attractive by the flexibility afforded by new technologies such as marrying flash plants with binary bottoming cycles for increased efficiency, binary cycle plants expanding producible resources, and reservoir enhancements (EGS).[39]

Among notable recent demonstration projects is a new Kalina Cycle EcoGen unit that was completed by Wasabi Energy in Japan in early 2012. The novelty of this unit lies in the miniaturisation of the Kalina Cycle technology, incorporating next-generation micro-turbine technology from U.S.-based Energent Corporation.[40] Another development was the first commercial use of a low temperature bottoming cycle at a flash geothermal plant in Nevada, with the potential to add 10% additional power and improve unit efficiency.[41] Germany-based Siemens entered the geothermal market with its new 60 MW steam turbine.[42]

Several companies now manufacture small-scale geothermal power units that can be built offsite and then integrated into a plant's design for production. A project using this technology came on line this year in Louisiana, this U.S. state's first geothermal project. The method takes brine water that is otherwise discarded as a byproduct of oil and gas development and uses it to produce geothermal power. The Louisiana project is the first commercial use of geothermal at an existing oilfield site, and the technology is potentially applicable at hundreds of existing oilfield wells across the Gulf States, Texas and beyond.[43]

HYDROPOWER

HYDRO MARKETS

An estimated 25 GW of new hydropower capacity came on line in 2011, increasing global installed capacity by nearly 2.7% to an estimated 970 GW.[1i] The top countries for hydro capacity are China, Brazil, the United States, Canada, and Russia, which together account for 51% of total installed capacity.[2] (See Figure 9.) Ranked by generation, the order is the same except that Canada's generation exceeds that in the United States, where hydro resources are more load-following.[3] Globally, hydropower generated an estimated 3,400 TWh of electricity during 2011, including approximately 663 TWh in China, followed by Brazil (450 TWh), Canada (373 TWh), the United States (325 TWh), and Russia (153 TWh).[4]

China continued with significant additions in 2011, installing 12.3 GW of new capacity, followed by Vietnam, Brazil, India, Canada, and Malaysia.[5] (See Figure 10.) China ended the year with 212 GW of total installed hydropower capacity, and with 18.4 GW of pumped storage capacity.[6] The country's 12th Five-Year Plan envisions hydropower capacity reaching 300 GW by 2015, and pumped storage capacity of up to 80 GW.[7]

Vietnam added 1.9 GW in 2011, increasing its total capacity by 35% to 7.4 GW.[8] Most of this increase was attributable to Vietnam's Son La plant, which saw four of six planned 400 MW turbines operating by year's end.[9] Brazil placed nearly 1.6 GW of hydropower into operation in 2011, including 433 MW of reported small-scale (<30 MW) capacity, reaching a total of more than 82.2 GW by year's end; another 20 GW is under construction.[10] India added 1.6 GW to exceed 42 GW total, including 3.3 GW of small-scale capacity (≤25 MW).[11] Canada installed more than 1.3 GW of new hydro capacity, for a total of 76.4 GW.[12] Malaysia added 0.9 GW with the first three of a total of eight 300 MW turbines coming on line at the East-Malaysia Bakun Dam project; this long-delayed project is set to deliver 2.4 GW when fully commissioned.[13]

Other developments of note include Turkey's inauguration of the 320 MW Yedigoze plant and completion of the 120 MW Imboulou plant in the Republic of Congo.[14] September saw full commercial operation of Colombia's 660 MW Porce 3 plant, and Cambodia's 193 MW Kamchay plant—built under concessional contract by Sinohydro of China—went into operation in December.[15]

China's strong presence in the sector extends to projects under the Clean Development Mechanism (CDM), where 61% of hydropower projects in the pipeline were on Chinese soil and only 0.9% were in Africa.[16] Even so, Chinese banks are helping to fill the void in Africa, extending loans for hydropower projects, which are often implemented by Chinese companies.[17]

Some African countries have joined forces to develop projects. In late 2011, Burundi, Rwanda, and Tanzania announced plans to build a 90 MW hydropower plant, with financing expected from the World Bank and the African Development Bank.[18] Uganda and Tanzania agreed to develop the 16 MW Kikagati-Murongo hydropower project along the Kagera River, and 2011 saw completion of a technical feasibility study for the 145 MW Ruzizi III hydroelectric project, a collaboration of Rwanda, Burundi, and the Democratic Republic of the Congo.[19]

A small but promising market for low-capacity (<1 MW) hydropower applications is developing rapidly in a number of countries in Asia, sub-Saharan Africa, and Latin America, aiding in the electrification of rural communities.[20] (See Rural Renewable Energy section.)

Most of the countries that are rapidly expanding their hydro capacity are working to meet an even greater growth in overall energy demand, which stems primarily from rapid industrial expansion and, to a lesser extent, from efforts to expand service to previously underserved populations.

Regions with mature hydropower sectors, such as Europe and North America, are focused more on modernising and refurbishing existing plants, and expansion of pumped storage capability, than the development of new traditional hydropower facilities. RusHydro (Russia), for example, is expecting to replace all obsolete equipment by 2025.[21] In North America, the average age of installed units is well over 40 years.[22] Ontario Power Generation (Canada) is adding 450 MW of new capacity to existing facilities on the Lower Mattagami River without new dam construction.[23] However, new projects are still being constructed in the traditional mature markets, such as Canada's Romaine project, which will add over 1,550 MW of new capacity upon its completion in 2020.[24]

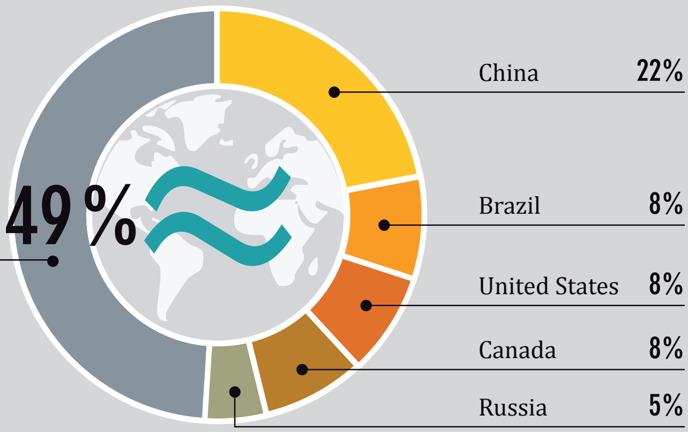
Pumped storage has traditionally been used to capture higher power prices during times of peak demand, and is gaining interest in countries with growing shares of variable renewable resources.[25] (See Sidebar 3, page 44.) Globally, 130–140 GW of pumped storage is in operation, and an estimated 2–3 GW was added during the year.[26] Much of this capacity is in Europe, with 45 GW of pumped storage capacity (170 stations) as of early 2011; an estimated 5.6 GW was installed between 1990 and 2010.[27] Among the projects commissioned in 2011 are the 480 MW capacity addition of Austria's Limberg II.[28] By one estimate, another 60 pumped storage plants (about 27 GW) are expected to be built in Europe by 2020, particularly in Germany, Austria, Switzerland, and Spain.[29] Recent construction activity indicates that significant additions may materialise in the near future.[30]

Japan has significant pumped storage capacity (25.8 GW), which was developed to accommodate baseload

i - Starting with this edition, the GSR makes an effort to separate out pure pumped storage capacity from hydropower data, except where specifically noted. For more information on data impacts, see Note on Accounting and Reporting, page 167.

HYDROPOWER

FIGURE 9. HYDROPOWER TOTAL WORLD CAPACITY, TOP FIVE COUNTRIES, 2011

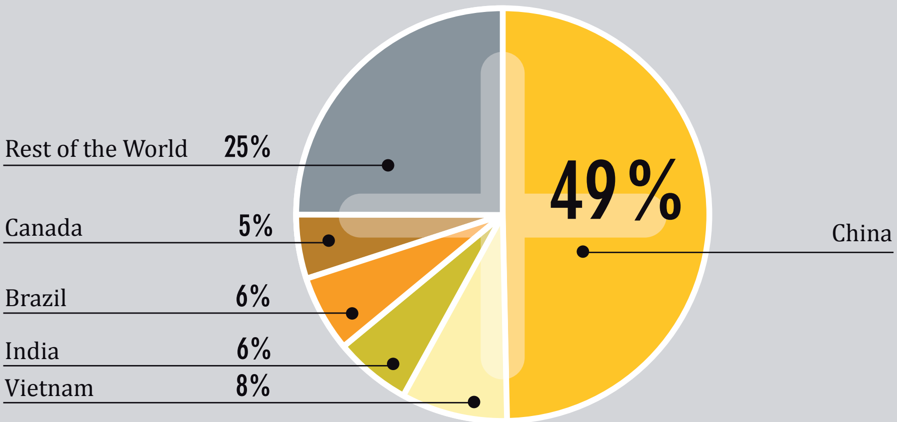


Source: See Endnote 2 for this section.

TOTAL GLOBAL CAPACITY: ~970 GW

TOTAL CAPACITY ADDITIONS: ~25 GW

FIGURE 10. HYDROPOWER ADDED CAPACITY, TOP FIVE COUNTRIES, 2011



Source: See Endnote 5 for this section.

nuclear generation but is now poised to support renewables.[31] In the United States, total installed pumped storage capacity remains around 22 GW.[32] Although there are no projects currently under construction, 2.7 GW are pending licencing and another 34 GW have been issued "preliminary permits" that serve as placeholders in the licencing process.[33]

Elsewhere around the world, development is also picking up pace. South Africa's Ingula pumped storage facility, which will incorporate four 333 MW reversible pump turbines, is scheduled to come on line in 2013–14.[34]

China is said to be accelerating the construction of pumped storage facilities, adjusting the construction goal in its latest five-year plan from 50 GW up to 80 GW.[35]

HYDRO INDUSTRY

While some sort of hydropower is in operation in more than 150 countries, equipment is manufactured in relatively few countries around the world. A few companies have a global manufacturing capability and others a more localised approach, exporting goods; all significant players have branched out from supplying a national market.[36]

SIDEBAR 3. INNOVATING ENERGY SYSTEMS: THE ROLE OF STORAGE

With growing shares of variable renewable electricity in the energy supply mix, the challenges of continually balancing supply with demand are increasing. Storage is one of several strategies for addressing these challenges. Having a broad portfolio of renewable energy sources available, especially across a wide geographic distribution, can reduce the impact of localised changes in wind speeds and cloud cover. Smart-grid technologies and demand-side management services offer the potential to dynamically transfer renewable electricity from times and areas of excess supply to times and areas of peaking demand. Improved short-term weather forecasting can contribute to better demand-and-supply system planning.

Fast-response hydropower, gas turbines, and local bioenergy or geothermal power plants (including combined heat and power designs) are all dispatchable (can be scheduled to generate electricity when required), and thus help system operators to effectively balance demand with supply. Concentrating solar power (CSP) plants are dispatchable when heat is stored for generation at night or during periods of low sunshine. Variable wind, solar, or wave power technologies are deemed to be only partially dispatchable because generation can occur only when the resource is available. (See Sidebar 7 in *GSR 2011*.)

Conventional hydropower has helped to balance demand loads for decades. For example, interconnection between the Norwegian hydropower stations and Danish electricity grids provides system balancing for Denmark's wind turbines while hydropower can be backed down to accommodate extra wind power generation from Denmark.

Conventional hydropower and all fuel-based generation (fossil fuel, nuclear and biomass) can be ramped down to accommodate variable renewables, and energy potential is stored in these fuels and the water held behind dams, but they do not represent pure storage technologies. Energy storage may be defined as any technology that can, on demand, store and release energy generated from any source without backing down energy production from another source.

Energy storage technologies can help to address fluctuations in supply, which can occur over seconds, minutes, hours, days or weeks. They enable electricity (or heat) generated during off-peak times to be retained and then sold to help meet peak demands. Prices are typically higher at peak times, so this has traditionally been a driver for the development of energy storage systems. Increasing shares of variable renewable generation are also driving energy storage development.

The most widely used storage technology today is pumped storage. Pumped storage facilities pump water into elevated reservoirs during periods of excess electricity production or low demand, and release it to generate electricity during periods of high-demand and low variable renewable generation. They account for about 99% of global energy storage capacity; additional facilities are under construction in Europe, the United States, and elsewhere—generally to help integrate rising shares of variable renewables.

Several other energy storage options exist, but they tend to be relatively expensive or not yet fully developed. Battery storage could enable a grid-connected PV system to be dispatched on demand but is more commonly used to ensure supply reliability in a small-scale, off-grid, domestic, renewable electricity system.

Renewable electricity can also be used to produce hydrogen via electrolysis that can be stored for later (re)conversion into electricity or heat via a fuel cell or direct combustion. Although storage technologies are improving and could become competitive in future markets, decentralised and mobile storage systems remain a costly option. Yet, storage is not the only challenge. Grid constraints sometimes pose a more immediate limit on the integration of variable renewable energy than any shortage of storage.

In the medium term, integrating heat and electricity networks with energy storage may lead to greater synergies between electricity, transport, heating, and cooling systems and provide greater flexibility in the application of variable renewable energy sources.

As the shares of variable renewable generation increase, power grids will need to transform from inflexible networks of the past to become smarter and more flexible. The main obstacles to this transition are lack of regulatory clarity and legal frameworks.

Source: See Endnote 25 for this section.

Companies reported increased sales and orders for 2011. For example, Dongfang Electric (China) reported the production of 11 hydro-electric turbine generator sets (2.5 GW) in the first six months of 2011, with a profit margin of over 18%; Voith (Germany) reported that sales were up by 6% and that there was a dramatic increase in forward orders, up 81% over the previous year; other companies—including Andritz (Austria), Alstom (France), IMPSA (Argentina), and Toshiba (Japan)—reported increased sales and/or order backlogs.[37]

With backlogs in the billions of dollars, large manufacturers have been investing in new plants and acquiring smaller firms to keep up with changing technologies. For example, Alstom opened a new equipment factory in India, expanded its turbine factory in Tianjin (China), and agreed with RusHydro on a joint manufacturing facility in Russia.[38] Voith, which spent €82million (USD 106 million) on research and development in 2011, has a new turbine component manufacturing facility in Brazil and a new workshop in Austria, specializing in milled Pelton Runners.[39] Andritz continued to expand its Chengdu (China) facility for large hydropower components, and IMPSA is expected to open a new production facility in Brazil in 2012.[40]

OCEAN ENERGY

OCEAN ENERGY MARKETS

After years that saw development of only small pilot projects, global ocean power capacity almost doubled in 2011. Just over 254 MW of commercial ocean energy capacity was added, bringing total global capacity to 527 MW.[1] The vast majority of this capacity relies on tidal power technologies.

South Korea was responsible for almost all of this new capacity, with the launch of the 254 MW Sihwa Lake tidal power plant in August.[2] This facility is now the world's largest, surpassing the 240 MW Rance tidal power station in France, which has been in operation since 1966. Sihwa Lake is expected to be the first of six tidal power plants along South Korea's west coast, driven by the country's aggressive push for "green growth" and its adoption of a renewable portfolio standard in 2010.[3] Two other projects (totaling 1,840 MW) have been delayed, with the first expecting completion in 2015.[4] While the Sihwa Plant was conceived to be restorative to Sihwa Lake, which had been polluted by sewage, other major projects along the west coast have met significant resistance on grounds of potential ecological disruption.[5]

Another notable project that came on line in 2011, albeit of much smaller scale, was the Mutriku wave energy plant in Spain. This 300 kW facility consists of 16 Wells turbines driven by Voith Hydro Wavegen's oscillating wave columns.[6] It builds on experience with the company's Limpet plant, which has operated in Scotland for over a decade, and is the first commercial implementation of the technology.[7]

Other operating ocean energy projects include a 20 MW tidal plant in Nova Scotia, Canada; a tidal power plant in Zhejiang, China (3.9 MW); and a total of 6.8 MW of tidal current and wave energy projects in the U.K.[8] A number of projects at various scales—small-pilot, and utility—were under development around the world in 2011.

OCEAN ENERGY INDUSTRY

The majority of ocean energy projects continue to be demonstration projects, all poised to be leveraged into full commercial deployment. The U.K. maintains a leadership status in both development and commercialisation of technologies and projects. Scotland, in particular, is credited with supplementing its ample resource base with efficient permitting processes that facilitate deployment of new projects.[9] In September 2011, the Scottish Energy Laboratory (SEL) was launched to strengthen collaboration among all 50 energy research, test, and demonstration facilities, including the European Marine Energy Centre (EMEC) in Orkney, the grid-connected test centre for wave and tidal energy technology.[10] By early 2012, the WATERS fund (launched in 2010) invited project proposals for the second round of funding, attracting overseas companies to test wave and tidal generation technologies in Scottish waters.[11]

Among notable developments in Scotland in 2011, Rolls Royce (U.K.) announced that its subsidiary, Tidal Generation Ltd., had reached the milestone of feeding over 100 MWh into the national grid from its 500 kW tidal turbine at EMEC.[12] EMEC was also the launch site of Atlantis Resources' (U.K.) 1 MW AK1000 tidal turbine.[13] Proposed projects for this turbine include the 400 MW MeyGen project in Pentland Firth, anticipating completion by 2020, and a 50 MW project off the coast of Gujarat, India, with agreement on as much as 250 MW for future development.[14] In late 2011, Hammerfest Strøm (Norway) installed its 1 MW HS1000 tidal turbine at EMEC, expecting it to be fully operational in 2012. Scottish Power Renewables (a subsidiary of Iberdrola, Spain) plans to use this turbine in a 10 MW tidal array in the Sound of Islay, aiming for installation between 2013 and 2015.[15]

Developments with wave energy technologies included deployment of Aquamarine's new Oyster 800 wave energy converter at EMEC, to be followed in 2012 and 2013 by two more devices to form a 2.4 MW array, and Ocean Power Technologies' (OPT, USA) commencement of ocean trials for its 150 kW PB150 PowerBuoy wave energy device.[16] Alstom (France) joined with SSE Renewables (Scotland) to develop the proposed Costa Head Wave Project north of Orkney, aiming for up to 200 MW with the 2.5 MW AWS-III wave energy converter, which is scheduled for full-scale prototype deployment at EMEC in 2014.[17]

Elsewhere in Europe, OpenHydro (Ireland) announced that it was in final stages of preparation for launch in Brittany, France, where it plans to deploy four of its open centre 2 MW tidal turbines in cooperation with the French company EDF. OpenHydro is also working on projects in the U.K.'s Channel Islands and in Nova Scotia.[18]

In the United States, Verdant Power (USA) was issued the nation's first commercial license for tidal power in early 2012. Under the license, Verdant Power continues its Roosevelt Island Tidal Energy (TIDE) project and plans to deploy a 1 MW pilot project (30 turbines) in the East River in New York. The turbines used can pivot on their foundation with changing tides, allowing efficient bidirectional operation.[19] On the U.S. west coast, OPT is in the process of deploying a second PB150 PowerBuoy in preparation for a 50 MW "wave park" near Reedsport, Oregon.[20]

The year saw increased investment by large corporations in existing entities in the ocean power industry. Alstom took a 40% share in the Scottish AWS Ocean Energy Ltd. in 2011.[21] Siemens (Germany) increased its stake in Marine Current Turbines to 45%, and announced in early 2012 that it was planning to complete its acquisition.[22] Having taken an equity share in 2010, ABB (Switzerland) increased its commitment to Aquamarine Power and

its Oyster wave power technology as part of a funding package that is expected to take the company to commercialisation in 2014.[23]

Other companies are investing directly in projects that enable equipment manufacturers to develop and test new generations of their technologies. For example, the utilities E.ON UK and ScottishPower Renewables acquired two P2 Pelamis wave power machines that are located in the EMEC, with an agreement to maximise learning from operating the machines as a wave farm.[24] In early 2012, Vattenfall (Sweden) announced plans to expand on its joint venture with Pelamis Wave Power and to install the latest machine at a test site.[25]

Partnerships offer another approach to gain leverage for execution of new projects. In North America, OPT has partnered with the U.S. Navy, U.S. Department of Energy (DOE), and Lockheed Martin to develop and deploy new technologies.[26] In addition, the U.S. DOE and the U.K. government are partially funding the development of OPT's new 500 kW PB500 PowerBuoy, which OPT plans to use for the proposed 100 MW project at Coos Bay off the coast of Oregon.[27] Atlantis Resources also has joined forces with Lockheed Martin to develop its AK1000 tidal turbine as well as a 400 MW project in Scotland and another in Nova Scotia.[28]

While much of the industry development news is tied to the testing grounds of northern waters, there are signs of advances elsewhere in 2011. Hyundai Heavy Industries (South Korea), a major shipbuilder, completed trials of a 500 kW, bidirectional tidal current power system. Hyundai expects to complete a "megawatt-class" tidal power farm with other Korean companies by 2014.[29] In Russia, generating company RusHydro decided to set up a subsidiary, the Innovative Center of Tidal and Wave Energy, to develop the Severnaya tidal power plant in the Barents Sea. The aim is to establish the feasibility of developing an 8 GW Mezenskaya tidal power plant in the White Sea.[30]

SOLAR PHOTOVOLTAICS (PV)

SOLAR PV MARKETS

The solar photovoltaic (PV) market saw another year of extraordinary growth. Almost 30 GW of new solar PV capacity came into operation worldwide in 2011, increasing the global total by 74% to almost 70 GW.[1] (See Figure 11.) Actual global installations during 2011 were closer to 25 GW because some capacity connected to the grid during the year was installed in 2010.[2i] Much of the new capacity was added in an end-of-year surge, driven by accelerated tariff degressions, imminent policy expirations, and dramatic price reductions. Solar PV capacity in operation at the end of 2011 was about 10 times the global total just five years earlier, and the average annual growth rate exceeded 58% for the period from the end of 2006 through 2011.[3] The thin film market share fell from 16% in 2010 to 15% in 2011.[4]

The number of countries adding more than 1 GW to their grids climbed from three to six, and the distribution of new installations continued to broaden.[5] The top countries for total installed capacity at year-end were Germany, Italy, Japan, and Spain, followed closely by the United States; the top five did not change in 2011, but Italy and Spain traded places.[6] (See Reference Table R5.) The leaders for solar PV per inhabitant were all in Europe: Germany, Italy, the Czech Republic, Belgium, and Spain.[7]

The European Union again dominated the global PV market, thanks to Italy and Germany, which together accounted for 57% of new operating capacity in 2011.[8] The EU installed an estimated 17 GW and connected nearly 22 GW to the grid; this was less PV capacity than was installed during 2011, but far more of it began feeding power into the region's grids.[9] With a total of 51 GW by year-end, the EU accounted for almost three-quarters of the world's total installed solar PV capacity, and had enough solar PV in operation to meet the electricity demand of more than 15 million European households.[10] (See Figure 12.) For the first time ever, solar PV accounted for more additional capacity than any other type of electricity generating technology: PV alone represented almost 47% of all new EU electric capacity that came on line in 2011.[11]

Germany connected its one-millionth PV system to the grid in late 2011, and continued to lead for total installed and operating PV capacity.[12] After a slow start, due in large part to a lower feed-in tariff (FIT) rate and expectations of continuing price reductions, nearly 7.5 GW was newly installed by year's end; almost half of this was added in December, encouraged by mild weather and a rush to receive the existing FIT rate.[13] This brought the total to 24.8 GW, accounting for 3.1% of Germany's electricity generation (up from 1.9% in 2010) and an estimated 8% of peak power demand.[14]

Italy broke new records, bringing 9.3 GW of PV on line and ending the year with nearly 12.8 GW.[15] About 3.7 GW of this total was actually a rush of installations in late 2010; a government decree allowed solar PV projects to benefit from more advantageous FIT rates of 2010.[16] Solar power production during the year was five times the 2010 level, surpassing Italy's wind power output.[17]

Other top markets in Europe included Belgium (nearly 1 GW), the U.K. (0.9 GW), Greece (more than 0.4 GW), Spain (nearly 0.4 GW, dropping from second to fourth place globally), and Slovakia (0.3 GW).[18] The U.K.'s total increased more than 12-fold to 1 GW, driven by a new FIT scheme and two rounds of rate reductions, each of which led to a rush of new connections.[19] France brought on line more than 1.6 GW of PV, most of which was installed in 2010, but little capacity was added in 2011 due to a moratorium on projects greater than 3 kW in size and reduced FIT support.[20] After two years of exceptional growth with almost 2 GW added, the Czech Republic brought only 6 MW on line in 2011, the result of support reductions, a retroactive tax on existing plants, and a moratorium on grid connection.[21]

Beyond Europe, the largest PV markets were China (2.1 GW), the United States (1.9 GW), Japan (1.3 GW), and Australia (0.8 GW).[22] Japan continues to rank third globally for total operating capacity. Through 2010, residential systems represented 95% of Japan's solar PV; the share fell to 80% in 2011 with a rise in industrial and commercial rooftop systems.[23]

In the United States, falling prices combined with state incentives, the extension of one federal incentive, and the imminent expiration of another resulted in a doubling of the market, bringing total operating capacity to nearly 4 GW.[24] California remains the nation's largest market (29% of total), followed by New Jersey (17%) and Arizona (15%).[25] Commercial installations accounted for the largest share (43%) of new capacity, followed by utility-owned installations (41%), which grew 185% relative to 2010, and residential installations (16%).[26]

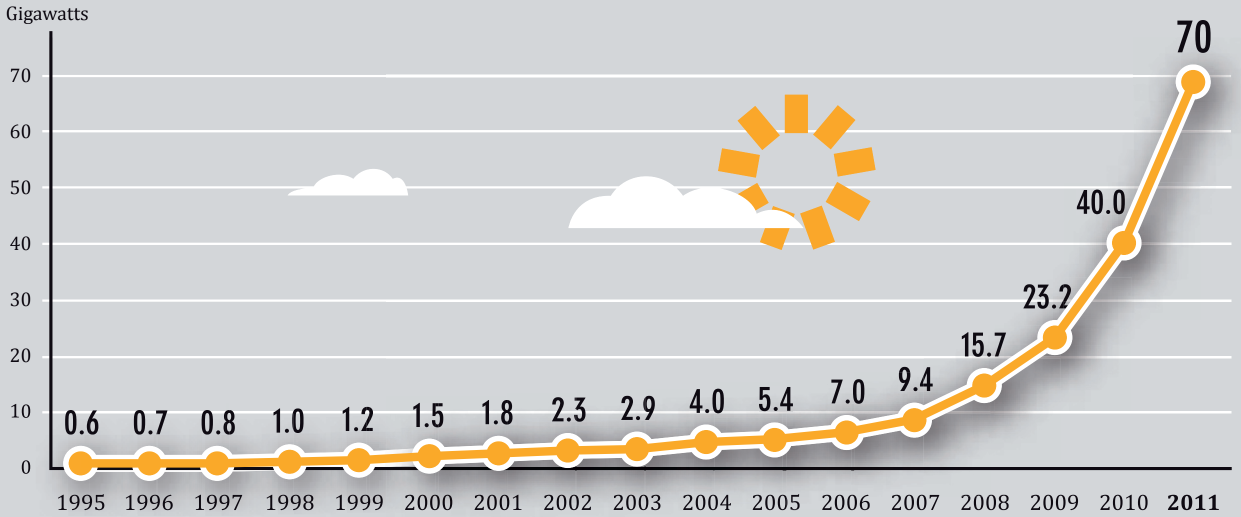
China rose from eighth to sixth as its market nearly quadrupled in 2011, greatly in response to the introduction of a national FIT, bringing total capacity to almost 3.1 GW.[27] China has rapidly emerged as the dominant player in Asia, driving nearly 50% of the region's 2011 demand.[28]

Other countries that saw notable growth include Canada (364 MW) and India (300 MW), both of which more than doubled their total existing capacity.[29] However,

i - Starting with this edition of the Global Status Report, this section focuses primarily on PV capacity that was grid-connected and/or began producing electricity during 2011. See Note on Accounting and Reporting, page 167, for more on installed versus grid-connected capacities.

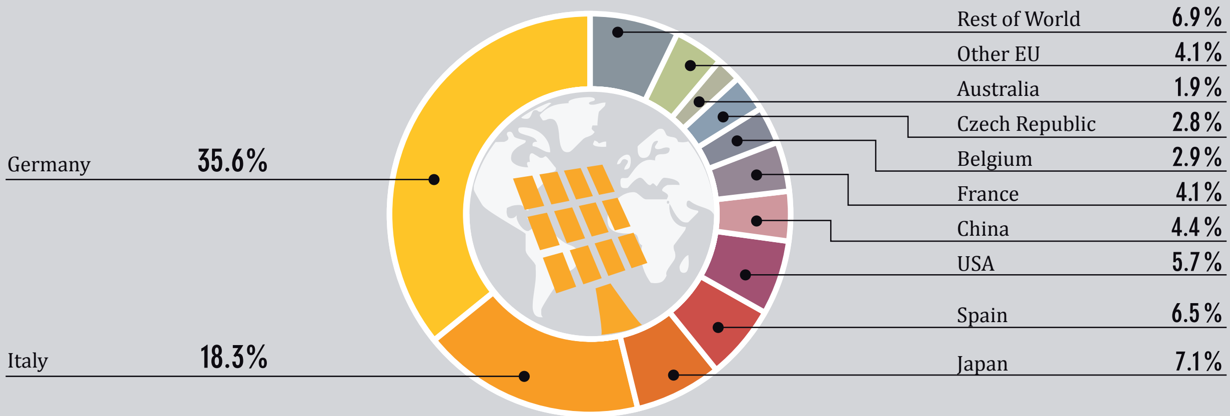
SOLAR PV

FIGURE 11. SOLAR PV TOTAL WORLD CAPACITY, 1995–2011



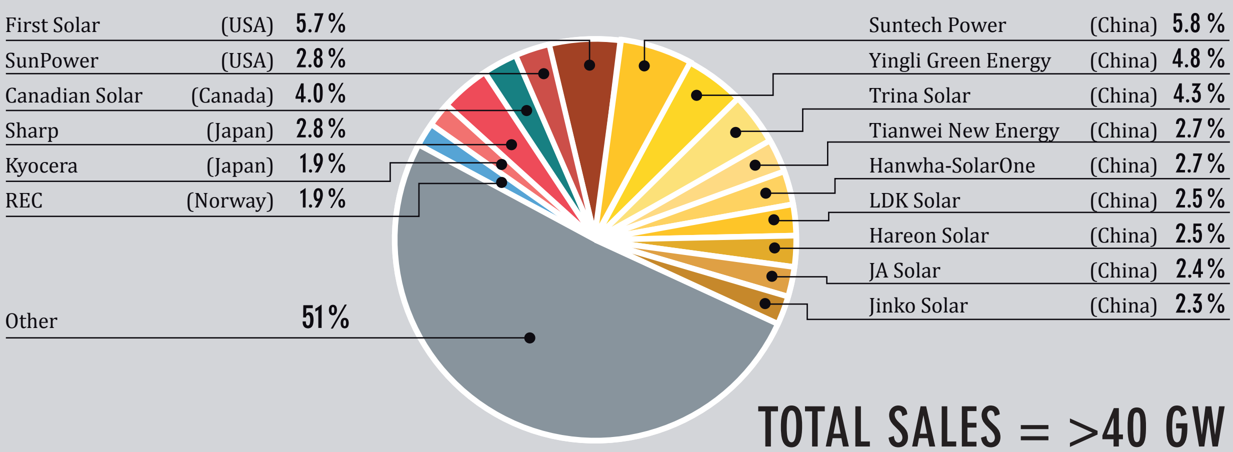
Source: See Endnote 1 for this section.

FIGURE 12. SOLAR PV OPERATING CAPACITY, TOP 10 COUNTRIES, 2011



Source: See Endnote 10 for this section.

FIGURE 13. MARKET SHARES OF TOP 15 SOLAR PV MODULE MANUFACTURERS, 2011



Source: See Endnote 56 for this section.

India came in well below its target due to infrastructure, financing, and weather-related delays.[30]

In India and California, project bids dropped significantly over the year as PV prices fell, with proposed contracts for large projects in California coming in below the projected price of natural gas.[31] In response to lower prices, new markets are emerging worldwide.[32]

The number and scale of solar PV projects continue to rise. By March 2012, at least 12 countries across Europe, North America, and Asia had solar PV plants exceeding 20 MW. Germany led the way with 1.1 GW in very large-scale plants, followed by Spain (480 MW), and the United States (338 MW).[33] Large-scale ground-mounted projects are also driving markets in India, Thailand, and China, including what was reportedly the world's largest (200 MW) in China's Qinghai province.[34] In early 2011, the world's highest grid-connected system, a 10 MW installation in Tibet, went into operation, as did the largest solar PV system in sub-Saharan Africa (0.5 MW), located in Kenya.[35]

Interest in building-integrated PV (BIPV) has also been on the rise. Although the economic downturn has slowed construction, which in turn has dampened BIPV growth, an estimated 1.2 GW was added during 2010, and the global market is experiencing an average annual growth of 56%.[36]

The vast majority of installed PV capacity today is grid-connected, with the off-grid sector accounting for an estimated 2% of global capacity.[37] Yet there is growing interest in off-grid and mostly small-scale systems, particularly in developing countries (see Rural Renewable Energy section). Off-grid systems also represent a significant portion of installed PV capacity in some developed countries, including Australia, Israel, Norway, and Sweden.[38]

The concentrating PV (CPV) market is still tiny compared with non-concentrating PV, but interest in this technology is increasing due in large part to higher levels of efficiency in locations with high insolation and low moisture.[39] Most CPV projects are in the pilot or prototype stage, but the world's first multi-megawatt projects were installed in 2011, and an estimated 33 MW was in operation by early 2012.[40] Spain and the United States (where 10 new projects totaling 12 MW came on line in 2011) have been the largest markets to date, although CPV projects operate in at least 20 other countries, from Australia to Saudi Arabia.[41]

SOLAR PV INDUSTRY

The aggregate size of the global PV industry now exceeds USD 100 billion per year.[42] But while 2011 was a good year for consumers and installers, manufacturers faced stiff competition in a crowded industry. Cell, module, and polysilicon manufacturers struggled to make profits or even survive amidst excess inventory and falling prices, declining government support, slower market growth for much of the year, and significant industry consolidation.[43]

PV module price reductions continued in 2011, due to economies of scale associated with rising production capacities, technological innovations, competition among manufacturers, and a large drop in the price of silicon—and they outpaced cost reductions.[44] By some estimates, module prices fell more than 40% during the year, and the installed costs of roof-mounted systems fell by more than 20%.[45] Thin film prices were also down in 2011. Their price advantage has shrunk, however, due to dramatic price reductions for crystalline modules.[46]

While the market surpassed all previous records, PV-related production ramped up even faster, resulting in a significant oversupply of modules.[47] Approximately 33.1 GW of crystalline silicon cells and 34.8 GW of modules was produced in 2011, up from about 21.2 GW and 20.5 GW, respectively, in 2010.[48] Year-end module production capacity was estimated at 55.7 GW, with effective capacity estimated at 30 GW.[49] Although thin film's share of production continued to fall, from a high of 21% in 2009 to 13% in 2011, actual production increased by an estimated 21% to 4.6 GW.[50] Polysilicon output more than doubled between 2008 and 2010 in response to high global prices, and the PV industry accounted for 81% of 2011 demand.[51]

Over the past decade, leadership in production has shifted from the United States to Japan to Europe and now to Asia.[52] Module[i] manufacturing continued its marked shift, mainly at the expense of European firms, and by 2011, 12 of the top 15 manufacturers were located in Asia (up from 10 in 2010).[53] Firms in mainland China and Taiwan accounted for 61% of global production in 2011 (up from 50% in 2010), while Europe's share dropped to 14% and Japan's share fell to 5%.[54] U.S. wafer and cell production declined, while module production remained flat and the country's share dropped to 4%; about 32% of U.S. production was thin film.[55]

The top 15 solar PV module manufacturers accounted for 49% of the 34.8 GW produced globally.[56] (See Figure 13.) Suntech of China remained in first place, having surpassed U.S.-based First Solar in 2009. First Solar is still the dominant firm for thin film production, but it has suffered from delays in project completion.[57] Yingli Green Energy (China) and Trina Solar (China) retained their spots, but five of the top companies in 2010 (Sanyo, Scott Solar, SolarWorld, Jiawei Solar China, and Renesola) dropped off the list in 2011, Canadian Solar and Sharp (Japan) traded positions, Hanwha-SolarOne (China) fell two places, LDK Solar (China) rose by three, and Kyocera (Japan) and REC (USA) each fell six places.[58] While not represented in the top 15, India is ramping up manufacturing of a range of products and system components to achieve national targets.[59]

As of mid-2011, the global solar value chain included an estimated 250 wafer producers, about as many cell manufacturers, and more than 400 module producers; by year's end, China alone had close to 650 panel manufacturers.[60] However, 2011 and early 2012 were marked by numerous bankruptcies and increased consolidation, with even big players becoming insolvent, shutting down manufacturing facilities, or leaving the industry altogether. Solyndra was one of several U.S. firms that, along with Germany's Q-Cells (once the world's top manufacturer) and many others, declared insolvency or pulled out of the industry in 2011 and early 2012.[61] BP Solar withdrew after 40 years in the solar PV industry, and, in early 2012, First Solar announced its withdrawal from Europe following the reduction of policy support in some key markets.[62]

Among those that remained, several firms, especially in Europe, idled or permanently closed production lines, postponed construction of new facilities, or shifted production to other regions (particularly Asia).[63] Chinese manufacturers have not been immune, and reportedly half of China's PV manufacturing capacity had ceased production by late 2011.[64] At the same time, other players expanded production capacity or announced plans to enter the industry, including General Electric, which plans to build a 400 MW thin film factory in Colorado.[65]

Many solar PV manufacturing firms continued their vertical integration in 2011 by expanding into project development to remain competitive.[66] In Japan, manufacturers have become involved in direct retailing, installation, and after-sale service.[67] In the United States, some solar developers are partnering with real estate developers, and leasing is becoming an increasingly important option.[68]

The failure of U.S.-based Solyndra (a top thin film company in 2010), which received a USD 535 million government loan guarantee before declaring bankruptcy, attracted a high level of scrutiny to U.S. federal funding for renewable energy projects. Solyndra was unable to achieve full-scale operations quickly enough to compete with larger foreign manufacturers; its troubles were furthered by the glut of solar panels and uncertainty over European policies.[69] Troubles at Solyndra and elsewhere were also blamed on Chinese subsidies; in response, several manufacturers filed a trade complaint against China in late 2011.[70] The trade issue has created a rift between U.S. manufacturers struggling to compete with depressed prices and project developers that depend on price reductions to prosper, while affecting procurement patterns and complicating the U.S. supply picture.[71]

Despite the many challenges, innovation continued along the value chain with advances in efficiencies, process improvements, developments of organic materials, plastics, and finance, among others, and cost reductions continued their downwards trajectory, averaging 7–8% annually.[72] Thin film producers continued to improve efficiencies, increase adoption for rooftops and other uses, and reduce costs.[73]

i - Past editions of this report have tracked cell manufacturing in part because data were easier to obtain. Because module data are now accessible and most integrated cell-module manufacturers report their production numbers in modules, the GSR is shifting its focus to modules.

CONCENTRATING SOLAR THERMAL POWER (CSP)

CSP MARKETS

Following the trend of the past few years, the concentrating solar thermal power (CSP) market continued its steady growth in 2011. More than 450 MW of CSP was installed, increasing total global capacity by 35% to nearly 1,760 MW.[1] (See Reference Table R6.) The market was down relative to 2010, but significant capacity was under construction at year's end.[2] Over the five-year period of 2006–2011, total global capacity grew at an average annual rate of almost 37%.[3] (See Figure 14.)

Parabolic trough plants continue to dominate the market, representing about 90% of newly built plants and almost all operating plants, but there is growing investment in other technologies.[4] New central receiver and Fresnel plants have been commissioned and others are under construction, particularly in the United States and Spain.[5]

Most of the world's CSP capacity is in Spain, which led the global market in 2011. In response to an adequate feed-in-tariff (FIT) and legal framework, significant capacity began to come on line in Spain in 2009 and 2010.[6] Almost 420 MW of capacity was added during 2011, and Spain ended the year with nearly 1,150 MW of capacity in operation.[7]

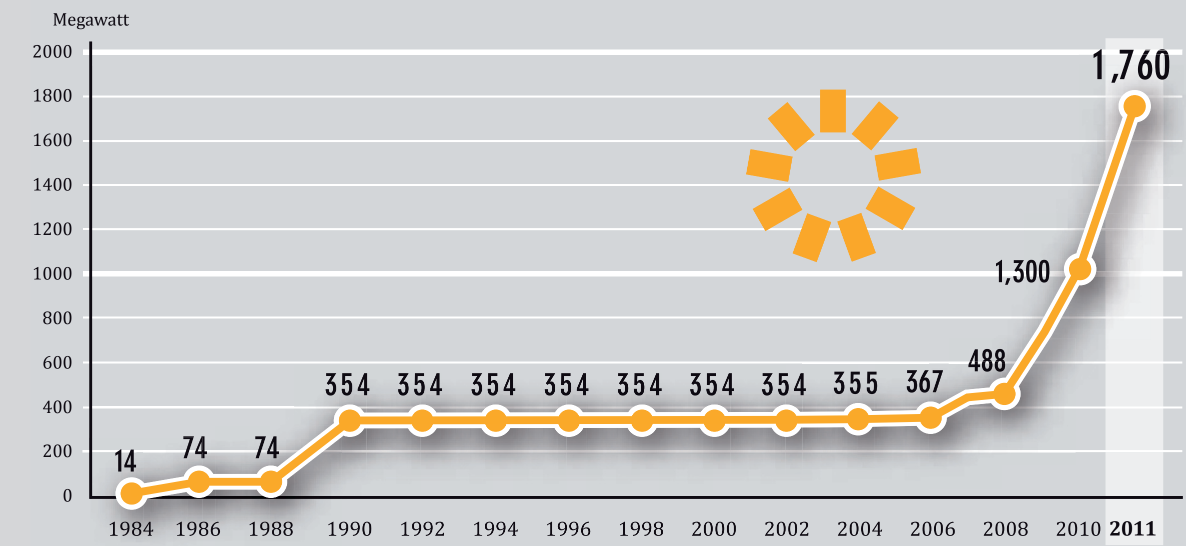
As in the global market, parabolic trough technology dominates the market in Spain. This is due mainly to Royal Decree conditions set up in 2009, which made the development of CSP possible, but also gave a strong position to the technology that was then most mature.[8] And yet, to date Spain has been the only market with utility-scale solar tower powers in operation.[9] The 19.9 MW Gemasolar plant, which started operation in 2011, was the latest of three power towers to come on line; it was also the first CSP plant able to operate for 24 hours under certain conditions, thanks to 15 hours of storage capability.[10] An additional 1.1 GW of CSP capacity was under construction in Spain by year's end, with most of it scheduled to go on line in 2012.[11]

The United States continued as the second largest market in terms of total capacity, ending 2011 with 507 MW in operation.[12] Although no new CSP capacity was completed during the year, more than 1.3 GW was under construction by year's end, all supported by federal loan guarantees, and all expected to begin operation between 2012 and 2014.[13] The estimated capacity of CSP projects with power purchase agreements (PPAs) was revised downwards significantly in 2011, primarily because several projects were signed originally with inexperienced companies at unreasonable profitability ratios. Several planned projects were not developed or were converted to solar PV.[14]

Elsewhere around the world at least 100 MW of capacity was in operation at year's end. Egypt brought 20 MW on line at the end of 2010, as did Morocco (20 MW); they were followed by Algeria (25 MW), Thailand (9.8 MW), and India (2.5 MW), which all launched their first CSP plants in 2011.[15] All facilities in the Middle East and North Africa (MENA) region are integrated solar combined cycle (ISCC) plants—solar fields integrated into large fossil plants.[16] India added the first segment of a solar power tower in Rajasthan that may eventually be a 10 MW plant, due for completion by early 2013.[17] Other countries with CSP capacity that did not add new facilities in 2011 are Italy, Iran, and Australia, where a solar/coal-fired plant generates power and steam.[18]

CSP growth is expected to accelerate internationally, with projects under construction or development in several countries, including Australia (250 MW), China (50 MW), India (470 MW), and Turkey; at least 100 MW of CSP capacity is under construction in the MENA region, with

FIGURE 14. CONCENTRATING SOLAR THERMAL POWER, TOTAL WORLD CAPACITY, 1984–2011



Source: See Endnote 3 for this section.

more in the pipeline.[19] South Africa completed an international tender in 2011 and awarded contracts to build 150 MW of capacity, and the national utility Eskom plans another 100 MW.[20] Several other countries, including Chile, Israel, Italy, Mexico, and Saudi Arabia, have indicated intentions to install CSP plants or have begun work on legislation needed to support CSP development.[21]

An interesting trend is the integration of solar thermal not only in hybrid systems with coal- or gas-fired plants, but also with other renewable energy technologies. For example, a recently completed solar project near Barcelona in Spain includes biomass along with CSP.[22]

While CSP has faced challenges associated with rapidly falling PV prices and the Arab Spring (slowing development in the region), the ability of CSP to provide thermal storage and thus dispatchability, as well as the possibility to easily hybridise with other energy sources, are expected to remain attractive attributes to utilities.[23]

CSP INDUSTRY

Although industry activity continued to focus on Spain and the United States, the industry expanded its attention to Australia, China, India, the MENA region, and South Africa.[24] Sales in 2011 were estimated at USD 545 million, and the installed base of CSP was estimated to be worth USD 9.5 billion by year-end.[25] The Spanish industry continued to lead the world in plant development, design, and operation.[26]

In general, the industry remains vertically integrated, with individual companies involved in many parts of the value chain, from technology R&D to project operation and ownership. Extensive supply chains are emerging in Spain and the United States, with an increasing number of companies involved in the CSP business.[27] Abengoa's (Spain) Solana project, for example, includes 70 companies across 26 U.S. states.[28] There is also a trend towards lasting partnerships between technology developers

SIDEBAR 4. SUSTAINABILITY SPOTLIGHT: WATER IMPACTS OF RENEWABLE ENERGY TECHNOLOGIES

Water and energy are closely linked: water is needed to produce energy, and energy is required to move, treat, and heat water. The global energy sector uses vast amounts of water for fuel production and power generation, accounting for an estimated 8% of all freshwater withdrawals and much higher rates in some countries. For example, energy production accounts for 44% of freshwater withdrawals in the European Union, and the power sector alone represents an estimated 40% of freshwater withdrawals in the United States. In China, the mining, processing, and combustion of coal accounts for 22% of domestic water consumption.

With global energy consumption set to grow considerably in the coming decades, major investments in renewable energy will be needed to meet rising demand while mitigating climate change. Yet renewables, like traditional energy systems, have significant water impacts that must be addressed in the face of growing concerns over water supply and quality. There are already signs that water scarcity may be constraining energy production in many parts of the world. An estimated 2.8 billion people currently live in areas facing physical water scarcity, and this number is expected to increase more than 70%, to 4.8 billion people, by 2050. Meeting the increased water demand from ever-larger populations and expanding economies while also protecting aquatic ecosystems will be a critical global challenge in the coming decades.

The lifecycle water consumption of renewable energy varies widely depending on technology types, manufacturing processes, and operational contexts. In certain cases, the water use of wet-cooled CSP, biomass, and geothermal power plants can be comparable to traditional thermal power, while biofuels processing can be highly water intensive: corn ethanol from irrigated crops requires vastly more water than standard oil refining. The expansion of hydropower production must take into account the potential for significant evaporative water losses from the regional watershed as well as the environmental impacts associated with altering natural water flows and siltation patterns. Water consumption through evaporation from dams cannot necessarily be directly associated with energy production given that dams often serve multiple purposes, including flood control, water storage and recreation, in addition to electricity generation.

Of all the electricity generating technologies, wind and solar PV systems consume the least amount of water per kilowatt-hour produced. Most of the water use is associated with the periodic cleaning of PV panels and wind turbine blades, but this quantity is one to two orders of magnitude less than the amount of water consumed to cool thermoelectric power plants (regardless of fuel type). While water consumption may be a concern in the manufacturing processes for these technologies (PV manufacturing plants can consume over 1,000 m^3 of water per day), these impacts are localised to the region of manufacture.

In addition to water source impacts based on the *quantity* of water used, water *quality* can be adversely affected by certain renewable energy technologies. A study by the U.S. Department of Energy concluded that geothermal waters can contain toxic minerals (e.g., arsenic, cadmium, and mercury, among others) that can seriously degrade and EPC (engineering, procurement, construction) contractors.[29]

Firms have also begun to expand their development efforts to include a variety of technologies in order to increase product value. For example, BrightSource Energy (USA) announced in late 2011 that it would add molten salt storage to three power tower projects in the United States.[30] AREVA (France) is using molten salt storage technologies, and is integrating CSP into existing gas and coal plants to increase their efficiency; and GE unveiled a new ISCC power plant that joins its combined-cycle gas turbines with eSolar's (USA) technology.[31] Start-ups with new technologies are trying to find their place in this very competitive industry.[32]

In addition, the standard size of CSP projects is increasing in some locations. Due to regulatory restrictions, typical plants in Spain have been about 50 MW, but new projects in the United States are tending towards the 150 to 250 MW range. Increasing size helps to reduce costs through economies of scale, but appropriate plant size also depends on technology.[33] Some projects are also integrating cooling solutions that significantly reduce water demand, an advancement that is important in the arid, sunny regions where CSP offers the greatest potential.[34] (See Sidebar 4.)

During 2011, in response to challenges posed by the complicated economic environment, CSP firms found it necessary to strengthen their positions by developing even more competitive technologies and, at the same time, obtaining the financing needed to close their new projects.[35] For example, in Spain, a number of companies established joint ventures, especially with Japanese companies.[36] While some firms used this opportunity to strengthen their market positions, others, like Solar Millennium (Germany) and Stirling Energy Systems (USA), could not deal with liquidity issues and went bankrupt.[37]

water quality if released into surrounding water systems. Similarly, pesticides and fertilizers used to cultivate feedstock crops for the production of bioenergy can cause ground and surface water contamination and environmental damage.

There are several promising technical interventions to ensure the sustainable water use of renewables. The advancement of dry-cooling processes for CSP plants has the potential to reduce associated water usage by up to 90%. The contamination of water systems with geothermal waters can be largely eliminated through proper design and engineering controls. The intelligent reuse of PV manufacturing water streams can lead to significant water savings, while high-efficiency silicon processing methods may reduce cooling requirements and associated water usage. Further, the localised lifecycle characteristic of solar PV components and wind turbines allows for some flexibility to reduce water consumption impacts via the virtual water trade, where these technologies can be exported from water-rich regions of manufacture to water-scarce regions to produce electricity.

Parallel policy interventions will also be crucial. Various international groups and research centres seek to reduce the water impacts of biofuels by identifying opportunities to safely irrigate biofuel crops with wastewater, improving the regulation and enforcement of sustainable groundwater extraction, and promoting the cultivation of cellulosic crops that require little to no irrigation. Water efficiency can also be pursued at the broader national scale: recent government strategy in China, for example, has called for a 30% reduction in water consumption for every U.S. dollar of industrial output.

Just as the water consumption of individual renewable energy technologies is highly variable, so too are the water quality and availability characteristics of different world regions. From a regulatory and policy perspective, efforts will need to be made to match the appropriate technology or bundle technologies to the local water context.

Water is required for all technologies and processes that produce energy. As many nations seek to increase the share of renewables in their national energy portfolios, they will need to evaluate the water impacts of these technology commitments. However, with the appropriate selection and deployment of renewable energy systems, it should be possible to meet the goals of providing clean energy and mitigating greenhouse gas emissions without placing undue burdens on regional water systems.

Source: See Endnote 34 for this section.

SOLAR THERMAL HEATING AND COOLING

SOLAR THERMAL HEATING/COOLING MARKETS

Solar thermal technologies contribute significantly to hot water production in several countries and increasingly also to cooling. In 2010, the world added an estimated 44.3 GW_{th} of solar heat capacity, of which 42.4 GW_{th} were glazed systems and the rest were unglazed systems for swimming pool heating.[1] Glazed water collectors in operation by the end of 2010 provided an estimated 150 TWh (540 PJ) of heat annually.[2]

Market leaders for newly installed capacity (excluding unglazed swimming pool heating) were China, Turkey, Germany, India, and Italy, with Turkey overtaking Germany. China, Turkey, Germany, Japan, and Brazil (overtaking Greece) took the top spots for total installations by the end of 2010.[3] (See Figures 15 and 16 and Reference Table R7.) More than 60% of global unglazed pool heating capacity capacity is in the United States, followed by Australia (17%), and increasingly in other countries, most notably Brazil.[4]

By the end of 2011, total global solar water and heating capacity (glazed) reached an estimated 232 GW_{th}, with net (less retirements) additions of more than 49 GW_{th}.[5] China again led the world for glazed installations, adding a net 18 GW_{th} to end the year with a total capacity of 135.5 GW_{th}—an estimated 58% of capacity in operation worldwide.[6] While solar thermal heating is increasing around the country, its growth in China's urban markets is reported to have been considerable.[7]

The European Union accounted for most of the remaining added capacity, although lower rates of building renovation, due in large part to the economic crisis, have slowed growth in the region.[8] Following a significant drop in 2010, Germany's market remained stable in 2011, with about 0.9 GW_{th} installed for a total of 10.7 GW_{th} of solar heat capacity by year's end.[9] While Germany remains Europe's largest installer, the European market is becoming more diversified.[10] But this trend and the growth in Europe's developing solar heat markets, such as Denmark and Portugal, did not make up for the decrease in the region's larger markets. The Greek market was down slightly in 2011, but fared better than other sectors in the country.[11] In Austria, the market dropped by an estimated 10–20% due to incentive cuts and the new heating oil industry incentive programme.[12]

Turkey's market remains strong, without government incentives and despite an expanding natural gas network, due largely to a high level of public awareness.[13] Turkey added up to 1.3 GW_{th} (1.8 million m^2) of solar thermal capacity during 2011.[14] An estimated 70–80% of hotels in the south have solar thermal systems, as do at least 100 hospitals, and solar thermal is used to heat water for tens of thousands of flats in low-income housing.[15]

In Asia, Japan and India represent the largest markets outside of China, and interest is increasing in South Korea, particularly in the commercial sector.[16] India added about 0.36 GW_{th} (0.52 million m^2) of solar heat capacity in 2011, for an estimated total of 3.5 GW_{th} (5 million m^2), driven by national policies, rising energy prices, and increased public awareness.[17]

The Brazilian market has been expanding rapidly due in part to programmes such as Minha Casa Minha Vida ("My House, My Life"), which mandates solar thermal on low-income housing and accounted for 20% of 2011 sales; the remainder were for household applications (57%) and industry, commerce, and services (23%).[18] Brazil had more than 5 GW_{th} (7.3 million m^2) of solar capacity by year's end, including unglazed.[19] Mexico is also starting to play a role, and there are very small but growing markets in Chile, Uruguay, and Argentina's northern provinces.[20]

The U.S. market (excluding unglazed swimming pool heating) is still relatively small but is gaining ground, with installations increasing 6% in 2010 (the latest data available).[21] The United States dropped from 10th worldwide in 2009 to 12th in 2010 for total installed capacity.[22]

In Africa, several countries added capacity in 2010, including Morocco, Namibia, South Africa, Tunisia, and Zimbabwe.[23] In the Middle East, an estimated 13% of Jordanian households and 72% of Palestinian households rely on solar thermal for water heating.[24]

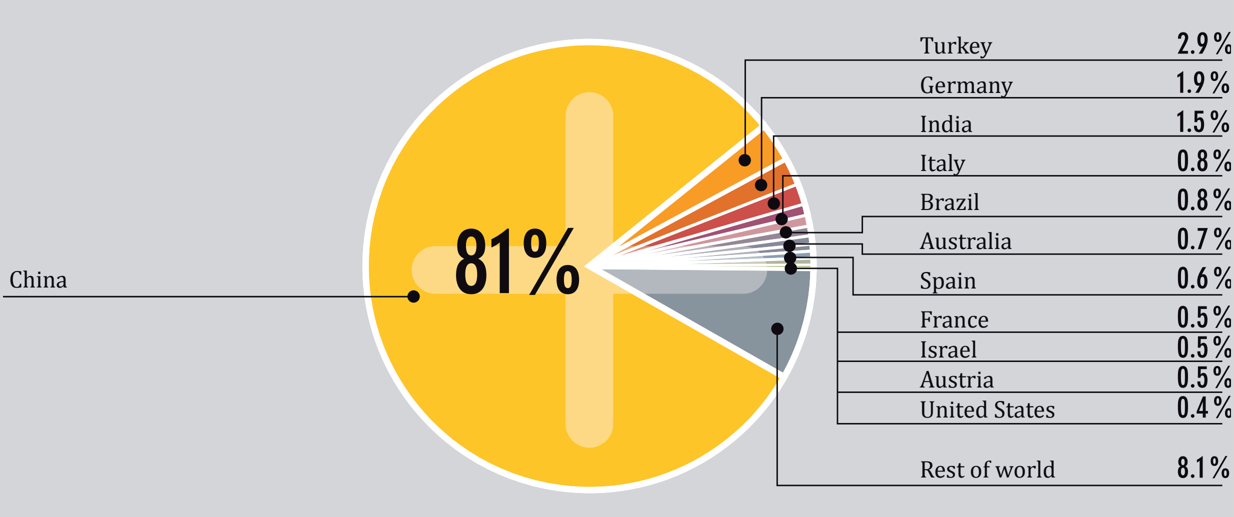
Although it ranked 18th overall, Cyprus remained the world solar heating leader on a per capita basis at the end of 2010, with 575 kilowatts-thermal (kW_{th}) per 1,000 inhabitants, followed by Israel (394 kW_{th})—due at least in part to high subsidies (Cyprus) and mandates (Israel).[25] Austria, which had 337 kW_{th} per 1,000 inhabitants in 2010, remained the leader in continental Europe, followed by Greece (266 kW_{th}) and Germany (112 kW_{th}).[26] China moved up into the top 10 for per capita for the first time in 2010 (88.4 kW_{th}).[27]

Solar space heating and cooling are also gaining ground, and the number of solar cooling installations has increased more than tenfold in the past five years.[28] The most advanced solar thermal markets are in Germany, Spain, and Austria, where advanced applications—such as water and space heating for dwellings of all sizes, hotels, and large-scale plants for district heating, as well as air conditioning and cooling—account for a substantial share of each market.[29] Globally, the market share for systems that provide both water and space heating is about 4% and rising, with installations in established markets in South America (Brazil, Mexico) and Asia (China, India, Japan).[30]

By the end of 2010, Europe had an estimated 149 large-scale (>0.035 MW_{th}) systems, with a combined capacity of 215 MW_{th}; more than 80 solar heating and cooling plants in Europe were larger than 700 kW_{th}.[31] In Denmark and Sweden, solar heat is fed into district networks, and some German providers purchase or offer to "store" their customers' solar heat.[32] Most large solar

SOLAR THERMAL HEATING AND COOLING

FIGURE 15. SOLAR HEATING ADDED CAPACITY, TOP 12 COUNTRIES, 2010



Source: See Endnote 3 for this section.

>200 MILLION HOUSEHOLDS USE SOLAR HOT WATER COLLECTORS

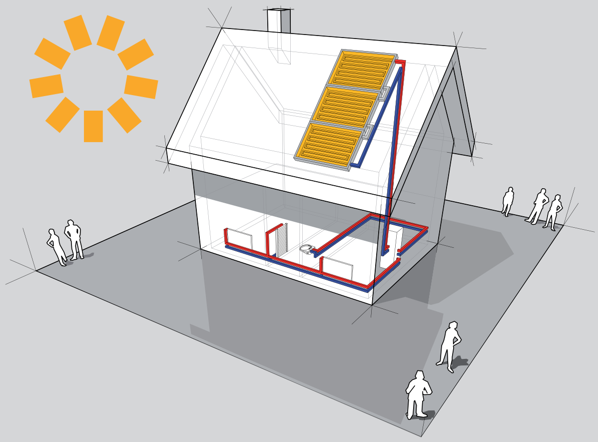
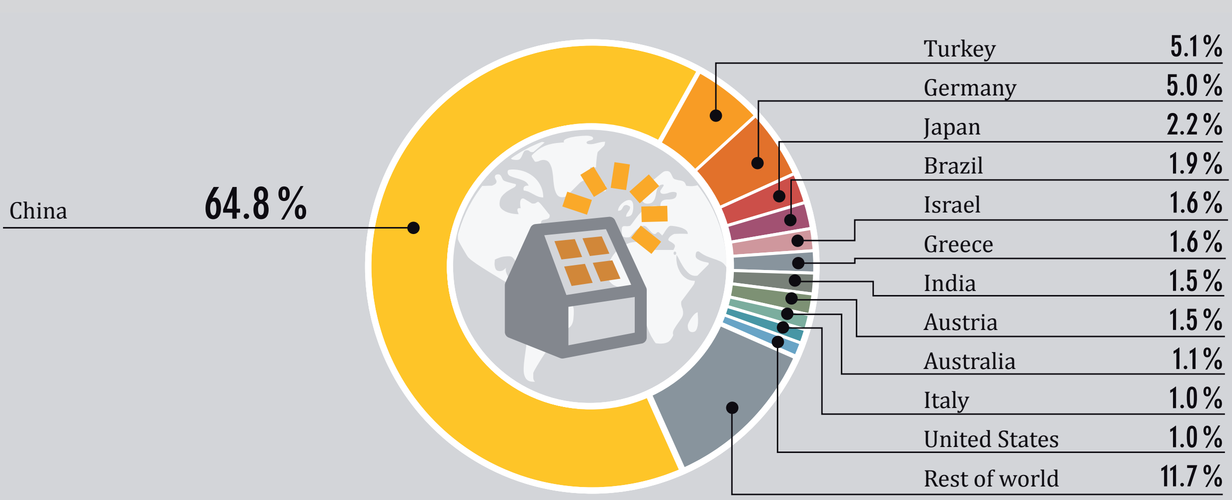


FIGURE 16. SOLAR HEATING TOTAL WORLD CAPACITY, TOP 12 COUNTRIES, 2010



Source: See Endnote 3 for this section.

heating and cooling systems are operating in Europe, but markets are opening up elsewhere.[33]

A new trend is the rise of even larger-scale applications.[34] In 2011, Saudi Arabia installed the world's largest plant, a 25 MW_{th} system in Riyadh, to provide hot water and space heat for 40,000 university students.[35] Australia's largest solar cooling plant was installed in 2011, as was a 1.75 MW_{th} system in Phoenix, Arizona, and what may be the world's largest solar cooling plant (3 MW_{th}) at Singapore's United World College.[36]

Solar heat and steam can be used for various industrial processes as well—for example, in the food, beverage, textile, paper, and pulp industries—although this is the least developed solar thermal technology. Examples include piano maker Steinway & Sons in New York, a concrete plant in Upper Austria, a sheep wool processing facility in Slovenia, and a leather factory in Thailand.[37] In 2011, the largest solar process-heat applications were believed to be operating in China.[38] However, district heating networks, solar air conditioning, and solar process heat for industrial purposes still account for less than 1% of total global installed capacity.[39]

SOLAR THERMAL HEATING/COOLING INDUSTRY

The year 2011 was difficult for parts of the solar thermal industry due to the economic situation in northern Mediterranean countries and the general negative outlook across much of Europe.[40] The industry has been hit hard in some stagnating markets because firms invested in increased production capacity in the boom year of 2008 and the following year, in expectation of continued market growth.[41] In 2011, at least eight companies left the industry or were bought out, including Isofotón of Spain, while nine new companies in eight countries started production.[42]

In contrast to many other renewable energy technologies, the majority of firms in the solar thermal heating (and cooling) segment are not listed companies but large firms from the broader heating and thermal sector or independent actors.[43] They remain highly fragmented, with only one in four companies producing more than 35 MW_{th} (50,000 m^2) per year, and the largest group manufacturing fewer than 7 MW_{th} (10,000 m^2).[44]

China has dominated the global solar heating industry for several years. The largest firms—Linuo New Materials, Sangle, Micoe, Himin, and the Sunrain Group—are starting to integrate vertically to cover all stages of manufacturing.[45] While most Chinese production is installed domestically, export of solar thermal products has increased considerably in recent years.[46] Most export goes to developing countries in Africa and Central and South America, where warmer climates support the use of thermosiphon systems, but Chinese-made systems have also begun to enter the European market.[47]

The largest manufacturers of flat-plate collectors include GreenOneTec (Austria), Bosch Thermotechnik (Germany), Ezinc (Turkey), Soletrol (Brazil), and Viessmann Werke (Germany).[48] German-based companies accounted for almost half of the top 19 flat-plate manufacturers in 2007, but now make up only one-third.[49] An increasing number of companies offer flat-plate and vacuum tube collectors; most are based in China and India and focus on foreign markets.[50]

In Europe, the industry has been marked by acquisitions and mergers among leading players, increased use of systems for water and space heating, and development of new facilities both in and outside of the region to meet rising demand in Brazil, India, Turkey, and elsewhere.[51] The market slowdown in several central and south European countries has forced companies to shut down production capacity and, for the first time, to lay off employees.[52]

Brazil's solar heat sector has grown at an average annual rate of almost 18% over the past five years, but the rate of growth dropped to 6.5% in 2011 in response to policy changes and concerns surrounding the international economic crisis.[53] In 2011, Brazilian production of solar collectors exceeded 0.7 GW_{th} (1.03 million m^2).[54] In 2010, the industry consisted of 200 manufacturers and approximately 1,000 installers.[55] India is also becoming an important player with a growing number of firms; some of the key companies include Tata BP Solar, Emmvee, and Electrotherm.[56]

In South Africa, there has been a dramatic increase in the number of manufacturers over the past five years. The country's oldest manufacturer of solar water heaters, Solardome, closed its Stellenbosch facility in 2011, citing intense competition from lower-priced Chinese products and the domestic regulatory environment.[57]

Price developments differ from country to country.[58] In Austria and Germany for example, European installed system prices have declined little if at all in recent years for detached and semi-detached homeowners (still the dominant market segment), although the collector industry has achieved substantial cost reductions despite a significant rise in copper prices. This is largely because most systems are installed in old buildings and every site is different, making installation relatively costly; suppliers often provide rebates to installers at a percentage of installed costs, and these are rarely passed onto customers.[59] 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.[60]

A number of solar companies have withdrawn from the solar cooling sector, with only a few long-term firms still involved, such as Solarnext (Germany) and S.O.L.I.D. (Austria); however, Steiebel Eltron (Germany) just entered the cooling market, and Hitachi (Japan) established a cooling division in 2011.[61] Small cooling machines (8–30 kW) are produced in sets of only 50–100 annually, so there is great potential for cost cutting; there is less potential for larger devices (>100 kW), which are already produced on a large scale.[62]

WIND POWER

WIND POWER MARKETS

During 2011, an estimated 40 GW of wind power capacity was put into operation, more than any other renewable technology, increasing global wind capacity by 20% to approximately 238 GW.[1] (See Figure 17.) Around 50 countries added capacity during 2011; at least 68 countries have more than 10 MW of reported capacity, with 22 of these passing the 1 GW level; and the top 10 countries account for nearly 87% of total capacity.[2] Over the period from end-2006 to end-2011, annual growth rates of cumulative wind power capacity averaged 26%.[3]

As in 2010, more new turbine capacity was added in developing countries and emerging markets than in OECD countries.[4] The top countries for new installations were China, the United States, India, Germany, and the U.K., followed closely by Canada.[5] The EU represented 23% of the global market and accounted for 41% of total global capacity, down from 51% five years earlier.[6]

China installed about 17.6 GW, accounting for almost 44% of the world market, but additions were down slightly from 2010, making 2011 the first year in which China installed less capacity than it did the year before.[7] (See Figure 18.) The market slowed largely in response to stricter approval procedures for new projects, which were required after a series of major faults at large wind farms.[8] Even so, at year's end China had nearly 62.4 GW of cumulative wind capacity, more than one-quarter of the world's total and more than 24 times China's wind capacity just five years earlier.[9] As in 2010, about 17 GW of this total capacity had not been commercially certified by year-end, although most was in fact already feeding electricity into the grid.[10] In 2011, 13 of China's provinces had more than 1 GW of capacity, with about 28% of total capacity in the Inner Mongolia Autonomous Region, followed by Hebei (11%), Gansu (8.7%), and Liaoning (8.4%) provinces.[11]

The United States added more than 6.8 GW in 2011, enough to power almost 2 million American homes, bringing total wind power capacity to almost 47 GW.[12] The strong market was driven in large part by approaching expiration of key federal incentives.[13] The state of Texas, with nearly 10.4 GW, had more than one-fifth of total U.S. capacity, but in 2011 the leading states for new installations were California (920 MW), Illinois (693 MW), and Iowa (647 MW).[14] Since 2007, wind power has represented 35% of the country's new electric generating capacity, more than twice the share of coal and nuclear power combined.[15]

The European Union added about 9.6 GW in 2011, bringing the region's total to almost 94 GW (equivalent to total global wind capacity in 2007).[16] As in 2010, wind power came in third for new capacity installed (21.4%), behind solar photovoltaics (PV) and natural gas.[17] Yet wind capacity is being installed in an increasing number of countries, and its share of total power capacity in the region has increased from 2.2% in 2000 to 10.5% at the end of 2011.[18] Germany remained the largest market in Europe, adding 2 GW for a total of 29.1 GW, and generating 46.5 TWh of electricity with wind power in 2011.[19]

For the first time, the U.K. ranked second for new installations in Europe, adding 1.3 GW for a total of 6.5 GW by year's end.[20] Spain (just over 1 GW), Italy (almost 1 GW), and France (more than 0.8 GW) were the other leading markets in Europe.[21] Portugal passed Denmark to join the list of the world's top 10 countries for total operating capacity, adding almost 0.4 GW to the grid for a total of 4.1 GW.[22] While markets contracted in some EU countries, others saw significant growth, including Romania (which more than doubled its capacity), Cyprus, and Greece.[23]

India was the third largest market in 2011 for the second year running. India added about 3 GW for a total of approximately 16.1 GW of capacity, maintaining its fifth-place ranking for total installed capacity.[24] Canada had a record year, adding 1.3 GW to bring the national total to almost 5.3 GW.[25]

Elsewhere around the world, the most significant growth was seen in Latin America. Brazil had a strong year, adding more than 0.5 GW for a total of almost 1.5 GW.[26] Wind power attracted significant attention during a series of tenders in Brazil when it became clear that wind power prices had fallen below those for natural gas-fired electricity.[27] Others in the region to add capacity included Argentina, Chile, Honduras, and Mexico.[28] The Dominican Republic and Honduras both installed their first commercial wind capacity in 2011.[29]

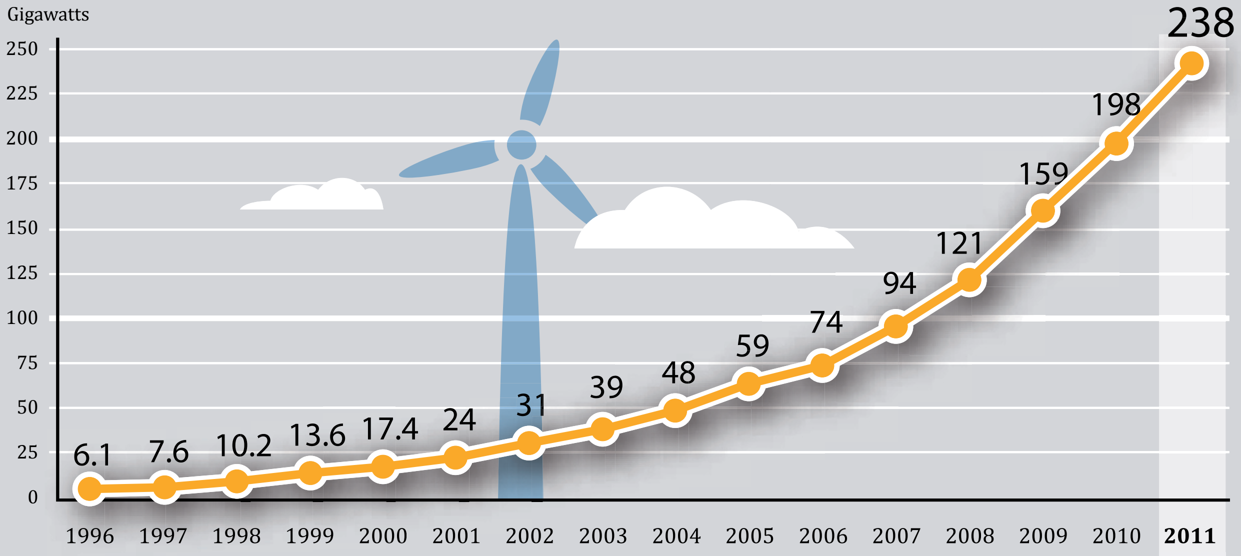
There was little development in Africa and the Middle East, due at least in part to turmoil in the Arab world; Cape Verde accounted for much of the region's new capacity, increasing its total from 2 MW to 27 MW, and Ethiopia joined the list of countries with commercial-scale wind projects.[30] However, the South African market looks set to take off after a successful round of bidding in 2011.[31] Iran, which added 3 MW for a total of 91 MW, remains the only country in the Middle East with large-scale wind projects. Just to the north, Turkey added about 0.5 GW of wind capacity for a year-end total of 1.8 GW.[32]

Although its share of total wind capacity remains small, the offshore wind sector continues to expand, increasing by more than 0.9 GW in 2011 to just under 4.1 GW of capacity operating globally at year-end.[33] This compares to the 1.2 GW added globally in 2010.[34] Most new capacity was added in Europe, with 866 MW installed and grid, connected in 2011, bringing total offshore capacity to 3.8 GW in 10 EU countries.[35] The U.K. accounted for 87% of Europe's offshore additions; the country ended 2011 with a total of nearly 2.1 GW of capacity offshore, followed by Denmark (857 MW) and Germany (200 MW).[36] By year's end, about 5.3 GW of offshore capacity was under construction off of EU coastlines.[37] China finalised two projects with a total just under 100 MW, bringing its offshore capacity to 258 MW.[38]

The trend towards increasing size of individual wind

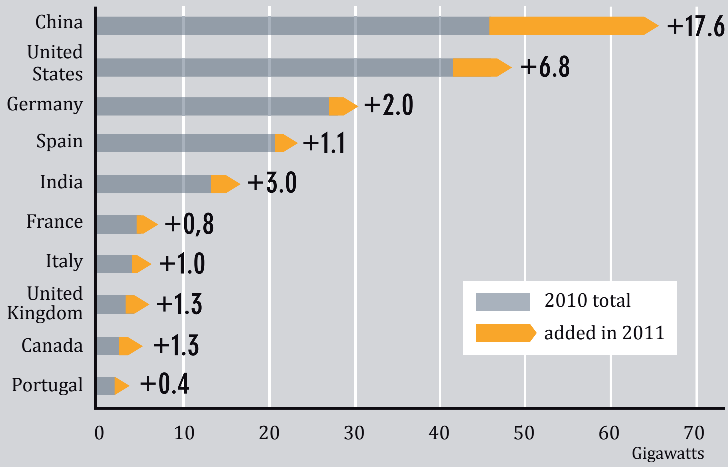
WIND POWER

FIGURE 17. WIND POWER TOTAL WORLD CAPACITY, 1996–2011



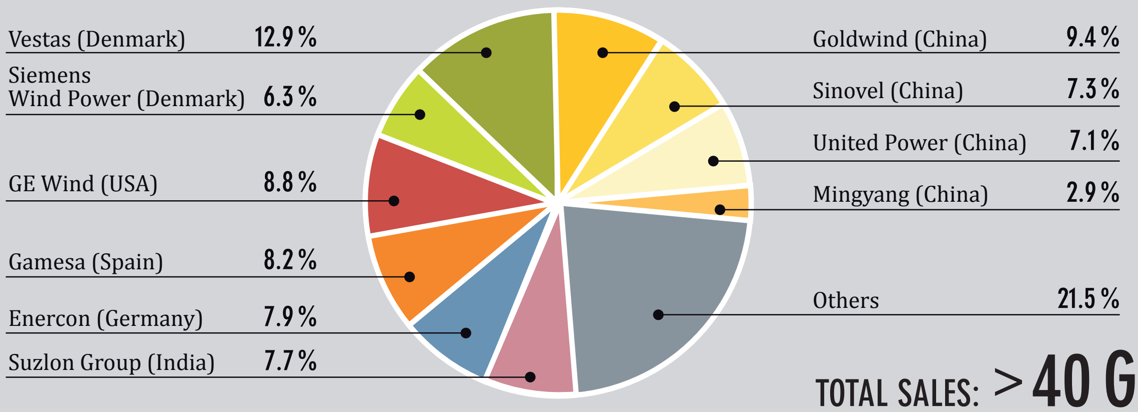
Source: See Endnote 1 for this section.

FIGURE 18. WIND POWER CAPACITY, TOP 10 COUNTRIES, 2011



Source: See Endnote 7 for this section.

FIGURE 19. MARKET SHARES OF TOP 10 WIND TURBINE MANUFACTURERS, 2011



TOTAL SALES: > 40 GW

Source: See Endnote 54 for this section.

projects continued, driven mainly by cost considerations.[39] At the same time, interest in community wind power projects is rising in Australia, Canada, Japan, the United States, Europe, and elsewhere.[40] For example, an estimated 6.7% of U.S. wind capacity is now community owned, up from 5.6% in 2010, and more than 50% of Germany's wind capacity is individually or community owned.[41]

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.[42] Globally, the number of small-scale turbines installed in 2010 exceeded 656,000, up 26% over 2009, and total installed capacity has risen by an average of 35% annually in recent years.[43] China has far more units installed than any other country, while the United States has a slight lead in capacity; the U.K., Germany, Canada, Spain, and Poland are also playing an increasing role in this market.[44] In the United States, however, local permitting and zoning laws, lack of stable state incentives, and falling PV prices pose challenges to the sector.[45]

Total existing wind power capacity by the end of 2011 was enough to meet an estimated 2–3% of global electricity consumption.[46] Existing wind capacity installed in the EU by year-end could meet 6.3% of the region's electricity consumption in a normal wind year.[47] Several countries met higher shares of their electricity demand, including Denmark (nearly 26%), Spain (15.9%), Portugal (15.6%), Ireland (12%), and Germany (7.6%).[48] Four German states met over 46% of their electricity needs with wind in 2011, and the state of South Australia now generates 20% of its electricity with wind power.[49] In the United States, wind power met 2.9% of total electricity demand, and more than 10% of demand in five states, with South Dakota exceeding 22% and Iowa nearing 19% in 2011.[50]

WIND POWER INDUSTRY

As with solar PV, the cost of electricity from wind power has fallen measurably. Wind prices rose between 2005 and 2009 due to rising global demand and the increasing price of steel.[51] However, recent price declines have resulted from over-capacity among manufacturers, increased competition, increasing scale, and greater efficiency, which have combined to drive down turbine costs, increase capacity factors, and reduce operations and maintenance costs.[52] Falling turbine prices can be a challenge for turbine manufacturers, as with PV producers, but they benefit developers by improving the cost-competitiveness of wind power relative to natural gas and coal.[53]

The world's top 10 turbine manufacturers captured nearly 80% of the global market and hailed from Europe (4), China (4), India (1), and the United States (1). Vestas (Denmark) retained its number one ranking, but its share of the global market fell by almost 2%. Goldwind (China) climbed from fourth to second place, replacing Sinovel (China), which fell to seventh. Gamesa (Spain) moved up four ranks, United Power (China) moved up two, and Mingyang (China) joined the top 10 for the first time, while Dongfang (China) dropped off the list.[54] (See Figure 19.)

In China, Goldwind (20.4%) replaced Sinovel (16.4%) as the largest supplier of new turbines. Foreign turbine manufacturers, except for GE, saw smaller market shares in 2011; meanwhile the dominance of China's big players is being challenged by an increasing number of smaller domestic firms.[55]

In the United States, more wind-related manufacturing facilities came on line during 2011 than in any of the past five years.[56] As evidence that community wind power is picking up speed in the United States, Gamesa announced plans to repackage one of its smaller turbines (850 kW) for this market.[57] In Europe, industry activity focused increasingly on project development in Eastern Europe and on offshore technologies, and significant capacity pipelines in Brazil have begun attracting manufacturers and component suppliers to supply regional markets.[58]

The trend towards ever-larger wind turbines has resumed, with the average turbine size delivered to market in 2011 being 1.7 MW; the average size installed offshore was up about 20% over 2010 to 3.6 MW.[59] Preferred turbine sizes were 2.3 MW in the U.K., 2.1 MW in Germany, 2 MW in the United States, 1.5 MW in China, and 1.1 MW in India.[60] Most manufacturers are developing machines in the 4.5–7.5 MW range, with 7.5 MW being the largest size that is commercially available.[61]

In addition to seeing larger turbines, the offshore wind industry is moving into deeper water, farther from shore, and with greater total capacities per project, leading to increased interest in floating platforms.[62] A growing number of manufacturers are producing turbines specifically for offshore use, and there is a trend towards dedicated supply chains for the offshore market.[63] Competition in the sector is driven in part by growing involvement of oil and gas multinationals and large civil engineering firms.[64]

As the number of offshore projects increases, high voltage direct current (HVDC) connections are becoming increasingly important for bringing generated electricity from the turbines to customers.[65]

The small-scale (<100 kW) wind industry also continued its expansion in 2011. By year's end, an estimated 330 manufacturers producing one-piece commercialised systems had been identified in at least 40 countries, and another 300 firms were supplying technology, parts, and consulting and sales services.[66]

i - Small-scale wind systems are generally considered to include turbines that produce enough power for a single home, farm, or small business, and are used for battery charging, irrigation, small commercial, or industrial applications. The World Wind Energy Association and the American Wind Energy Association currently define "small-scale" as less than 100 kW, which is the range also used in the GSR. However, size can vary according to needs and/or laws of a country or state, and there is no globally recognized definition or size limit.

INVESTMENT FLOWS

Global investment in renewable power and fuels increased 17% to a new record of $257 billion in 2011. Solar spectacularly passed wind power, and U.S. investment surged in advance of expiring support policies.

03

Investment in USD billions: China 51, US 48, Germany 31, Italy, 29, India 12.
All country comparison figures exlude hydro power projects larger than 50 MW as well as research and development.

03 INVESTMENT FLOWS

Global new investment in renewable energy increased 17% in 2011, to a new record of USD 257 billion.[i] This was more than six times the figure for 2004, and 94% more than the total in 2007, the last year before the acute phase of the recent global financial crisis.[ii] If the unreported investment in solar hot water collectors of more than (estimated) USD 10 billion is included, total new investment exceeded USD 267 billion.[1] An additional estimated USD 25.5 billion was invested in hydropower projects larger than 50 MW in size.[2]

The increase between 2010 and 2011 was well below the 37% rise between 2009 and 2010, but it took place at a time when the cost of renewable power equipment, particularly solar PV modules and onshore wind turbines, was falling rapidly. (See Market and Industry Trends section.) This meant that the increase in gigawatt capacity in 2011 was significantly greater than the gain in dollar terms. The latest investment increase also took place at a time of uncertainty about economic growth and policy priorities in developed economies.

Two highlights of 2011 were the performance of solar power and developments in the United States. Wind power, the biggest single sector for investment in recent years, was surpassed spectacularly by solar power in 2011. Solar PV attracted nearly twice as much investment as wind. Total investment in solar power jumped 52%, to USD 147 billion. It was helped by booming rooftop PV installations in Germany and Italy, the spread of small-scale PV to other markets from China to the U.K., and a spurt in the financing of large-scale solar thermal electricity generation (CSP) projects in Spain and the United States. By contrast, total investment in wind power slipped 12% to USD 84 billion as a result of lower turbine prices, policy uncertainty in Europe, and a slowdown in China's previously rapid growth in wind installations.

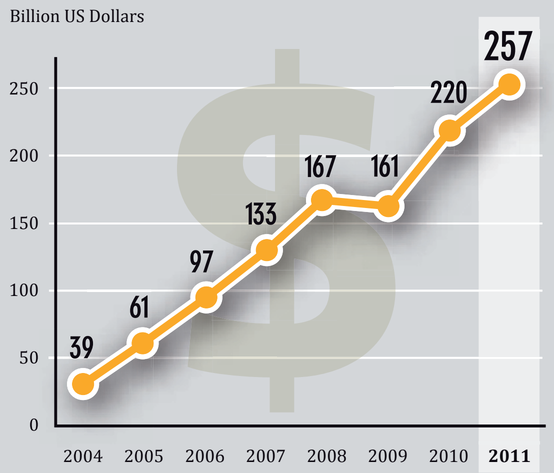
The boom in solar investment in 2011 took place against the backdrop of significant corporate distress in that sector, along with decreasing share prices. The reasons for this apparent inconsistency included the rapidly falling prices of PV modules due to economies of scale in manufacturing, the rise of low-cost Chinese producers, reduced policy support in some countries, and global over-capacity. While the resulting 50% fall in module prices during the year stimulated demand for PV panels, particularly on rooftops, it negatively affected the financial results of many hardware makers. By the end of 2011, PV modules were selling for between USD 1 and 1.20 per watt, which is about 76% below the average price in the summer of 2008.

The second highlight of 2011 was a resurgence—at least temporarily—of U.S. importance in the renewable energy sector. Although still in second place just a hair behind China, the United States performed far better in 2011 relative to the previous year, with a 57% leap to USD 51 billion.[iii] By contrast, investment in China gained only 17%, reaching USD 52 billion, and in Germany it dipped 12% to USD 31 billion (excluding R&D).

The U.S. recovery owed much to the fact that three significant federal incentive programmes for renewable energy expired during 2011 or were heading towards scheduled expiry.[3] Developers rushed to finance projects in time to take advantage of policy measures while they still could.

Figure 20 shows the resilient growth of renewable energy investment between 2004 and 2011, with expansion continuing after the recession of 2008–2009 and the subsequent, disappointing recovery in developed economies.

FIGURE 20. GLOBAL NEW INVESTMENTS IN RENEWABLE ENERGY, 2004–2011



See Footnote ii on this page.

i - This section is derived from United Nations Environment Programme (UNEP)/Frankfurt School/Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2012* (Frankfurt: 2012), the sister publication to the GSR. Figures are based on the output of the Desktop database of BNEF unless otherwise noted. The following renewable energy projects are included: all biomass, geothermal, and wind power projects of more than 1 MW, all hydropower projects between 1 MW and 50 MW, all solar projects, with those less than 1 MW estimated separately and referred to as small-scale projects, or small distributed capacity, all ocean energy projects, and all biofuel projects with a capacity of 1 million litres or more per year. For more detailed information, please refer to the UNEP/Frankfurt School/BNEF *Global Trends* report.

ii - Figures exclude hydropower projects larger than 50 MW. BNEF continuously monitors investment in renewable energy. This is a dynamic process: as the sector's visibility grows, information flow improves. New deals come to light and existing data are refined, meaning that historic figures are constantly updated. For example, specific improvements in the last year have included enhanced coverage of projects in Southeast Asia, better coverage of small hydropower, and the introduction of intensive quality checks for every quarter's data.

iii - If investment in energy-smart technologies such as energy efficiency (see Feature section) and smart grids is also considered, the United States is clearly in the lead.

INVESTMENT BY REGION

Developed economies strengthened their share of investment in renewable power capacity and biofuels production capacity, after developing countries had mounted their strongest challenge yet in 2010. Developed countries made up 65% of this total investment, compared to 35% for developing countries. The top five countries for total investment in 2011 were China, the United States, Germany, Italy, and India.

The strong performance of developed economies was due mainly to the impending expiry of subsidy programmes. The United States was the biggest investor in renewable energy among developed economies, committing USD 51 billion in 2011, with the largest share for asset finance of utility-scale projects. Overall, Europe saw investment of USD 101 billion in renewable energy in 2011, up 10% from 2010.

The developing-country portion of total investment worldwide slipped back after several years of consistent share increases. During 2011, developing economies accounted for USD 89 billion in new investment (up 11% from 2010), compared with USD 168 billion in developed economies (up 21% from 2010). This relative performance marked a shift from 2010, when the developing world increased its total investment in renewable energy by 46% against a 30% rise for richer economies. The three developing economies boasting by far the largest investment in renewable energy in 2011 were China, India, and Brazil: China reached USD 52 billion (up 17%), India USD 12 billion (up 62%), and Brazil USD 7 billion (up 8%).

Although China remained the global leader, its growth in renewable energy investment slowed sharply in 2011. It was India that displayed the fastest expansion in investment of any large renewables market in the world. India's 62% growth rate reflected a sharp rise in the financing of solar projects under the country's National Solar Mission, increases in wind capacity additions, as well as growth in venture capital and private equity investment in renewable energy companies. Brazil saw commitments rise primarily because of wind power rather than ethanol, its dominant renewable energy sector in the first decade of the century.

The renewable energy sector is often seen overwhelmingly as a creature of Europe and the United States, as well as China, India and Brazil. However, some 13% of total investment in 2011 took place outside these economic powerhouses, and this share has been above 10% in each of the last eight years. Total investment in the Americas (excluding the United States and Brazil) was USD 7.1 billion in 2011, while that in the Middle East and Africa was USD 4.9 billion, and in Asia-Oceania (outside China and India) it was USD 19.5 billion. Asia-Oceania was the only region to show growth during 2011, at 5%.

INVESTMENT BY TYPE

Different types of investment displayed very different fortunes during the year. Investment in technology development saw venture capital rising 5% to USD 2.5 billion, but government-funded and corporate research and development both declined. Government R&D slipped 13% to USD 4.6 billion as the effect of "green stimulus" packages faded, and corporate R&D weakened 19% to USD 3.7 billion as companies responded to pressure on their own finances.[4]

Private equity expansion capital investment dropped 15% to USD 2.5 billion. Equity-raising by renewable energy companies on the public markets also dropped in 2011, falling 10% to USD 10.1 billion, as investors shied away from a sector that was suffering heavy declines in share prices.

The two types of new investment that did see significant growth in 2011 were asset finance of utility-scale (1 MW-plus) renewable power plants and biofuel refineries; and small-scale distributed capacity, notably rooftop solar. Asset finance was up 18% to USD 164.4 billion, making up nearly 64% of total new investment in the sector, while small-scale projects saw USD 75.8 billion invested, up 25% from the previous year. Both were record figures. Including large hydro, net investment (which also covers replacement plants) in renewable power capacity was an estimated USD 262.5 billion, some USD 40 billion higher than the same measure for fossil fuels.

Solar water heating continued to be a solid area for activity, particularly in China. There are no reliable figures for the value of investment in solar water heaters worldwide, but it is estimated that at least USD 10–15 billion was spent on new capacity in 2011.

Merger and acquisition activity, which is not counted as new investment, totaled USD 68 billion in 2011, up 5% from the previous year.

INVESTMENT BY TECHNOLOGY

Although 2011 was dominated overall by record highs for solar and a reduction for wind power (in terms of dollar investment, but not gigawatts added), there were intriguing changes among the other technologies.

Biomass[i] power was the third largest sector for total renewable energy investment in 2011, even though its share fell 12% to USD 10.6 billion. Of asset finance in this sector, solid biomass accounted for 71%. Biofuels came fourth in 2011, with a total of USD 6.8 billion, but the sector was down 20% from 2010 levels. (Biofuels ranked second, after wind, in 2006.) Small hydro attracted 59% more capital in 2011, taking investment to USD 5.8 billion. Other sectors showed only modest investment: geothermal was down 5% at USD 2.9 billion, and wave and tidal was down 5% at just USD 246 million. A large (254 MW) tidal barrage project that came on line in South Korea had been financed several years earlier.

i - Includes all waste-to-power technologies, but not waste-to-gas.

Solar was the leading sector to secure venture capital and private equity (VC/PE), with USD 2.4 billion. Biomass and waste-to-power came next, with USD 1 billion of VC/PE money secured, nearly three times the previous figure, and biofuels with USD 804 million secured, up 9%. As a relatively mature technology, wind power has tended to lag behind in terms of VC/PE investment, and in 2011 it came in fourth with just USD 520 million committed, down 66% relative to 2010.

With regard to investment in renewables via public markets, wind and solar power took first and second place in terms of the value of new equity-raisings, at USD 4.5 and USD 4.2 billion, respectively, down 2% and 23% from their 2010 totals. Biofuels and geothermal obtained USD 654 million and USD 406 million, respectively, up 37% and 360%.

In asset finance of utility-scale projects, wind power retained its lead over solar power, with USD 82.4 billion committed (down 11%), against solar power's USD 62.1 billion (up 147%). The two technologies showed some interesting technological trends, with offshore wind looming large and contributing USD 12.5 billion to the total value of wind assets financed, and CSP accounting for USD 20 billion of the total solar figure—in both cases, the highest on record. These figures are only approximations.

DEVELOPMENT AND NATIONAL BANK FINANCE

Multilateral and national development banks continued to be important to renewable energy asset finance in 2011. Provisional data collected by Bloomberg New Energy Finance from projects in its database suggest that these institutions provided USD 17 billion of finance for renewable energy during the year. This would be the largest commitment yet, beating the previous record of USD 15.2 billion in 2010 and—perhaps most strikingly—amounting to four times the figure reached in 2007.

The two biggest providers of finance among the development banks in 2011 were the European Investment Bank with USD 4.8 billion, and Brazil's BNDES, with USD 4.6 billion. Among the other development banks that are particularly active in the sector are Germany's KfW Bankengruppe, the World Bank's International Finance Corporation, the European Bank for Reconstruction and Development, and the China Development Bank. Several countries, including the U.K. with its Green Investment Bank and Australia with its Clean Energy Finance Corporation, are planning to launch their own national lenders to try to spur on renewable power and energy efficiency deployment.

THREATS TO INVESTMENT

Although the renewable energy sector has continued to grow since 2008, global economic problems have negatively affected the sector, and they remain a threat. In late 2011, the euro-area sovereign debt crisis started to affect the supply of debt for renewable energy projects in Europe, as banks responded to sharp increases in their cost of funding and upgraded their assessments of the risks involved in lending to borrowers in Italy and Spain.

More generally, as consumers find themselves under financial pressure, governments are more reluctant to pass measures that would raise energy prices. In the United States, congressional support for clean energy and carbon pricing has ebbed in the face of low natural gas prices, continuing economic challenges, and new concerns about the cost of renewable energy support, fuelled by the scandal over the bankruptcy of PV technology manufacturer Solyndra, which received USD 538 million of federal loan guarantees.

In Europe, governments struggled to adjust feed-in tariffs, above all to prevent greater-than-intended returns for PV project developers as prices fell. This resulted in installation booms, especially in Italy and Germany. Governments in Europe and elsewhere responded by cutting support sharply. (See Policy Landscape section.)

SIDEBAR 5. INVESTMENT TRENDS IN EARLY 2012

Investment in renewable energy was subdued in the first three months of 2012 in the face of uncertainty over future policy support in both Europe and the United States. Although by May, there were a few signs that governments were trying to clarify specific issues for investors, there was no evidence that investment levels would accelerate over the course of the year.

Figures from the Bloomberg New Energy Finance database of deals and projects show that asset finance of utility-scale renewable energy projects in the first quarter of 2012 was USD 23.3 billion, down 36% from the fourth quarter of 2011 and 14% below the first quarter. In fact, the first quarter of 2012 was the weakest quarter for renewable energy asset finance since the first quarter of 2009, in the depths of the financial crisis.

Venture capital and private equity investment in renewable energy companies was resilient, at USD 1.4 billion worldwide in the first quarter of 2012, up from USD 1.1 billion in the fourth quarter of 2011 and USD 1.2 billion in the first quarter of 2011. Solar and biofuels were the two dominant sectors for VC/PE equity-raisings.

Investment in public markets was just USD 473 million, down 46% from the fourth quarter of 2011 and 87% from the first quarter of 2011. This was not surprising given the poor performance of clean energy shares over the last few quarters. The WilderHill New Energy Global Innovation Index (NEX), which tracks the movements of 97 clean energy shares worldwide, fell 40% in 2011 and inched back just 7% in the first quarter of 2012 as world stock markets rebounded.

POLICY LANDSCAPE

The number of renewable energy policies in place continued to increase in 2011 and early 2012, but at a slower rate of adoption.

04

04 POLICY LANDSCAPE

The number of policies in place to support investments in renewable energy continued to increase in 2011 and early 2012, but at a slower adoption rate relative to previous years.[1] (See Reference Tables R9–R14.) Governments also continued to revise policy design and implementation in response to advances in technologies, decreasing costs and prices, and changing priorities.

Policymakers are increasingly aware of renewable energy's wide range of benefits—including energy security, reduced import dependency, reduction of greenhouse gas (GHG) emissions, prevention of biodiversity loss, improved health, job creation, rural development, and energy access—leading to closer integration in some countries of renewable energy with policies in other economic sectors.[2] Policy development and implementation were stimulated in some countries by the Fukushima nuclear catastrophe in Japan and by the UN Secretary-General's announced goal to double the share of renewables in the energy mix by 2030.[3] Some countries are beginning to tap the synergies between renewable and energy efficiency improvements. (See Special Feature, Section 6.)

At the same time, several countries have undertaken significant policy overhauls that have resulted in reduced support. Some changes have been intended to improve existing instruments and achieve more targeted results as renewable energy technologies mature, but others were introduced as a response to changing national and international economic and fiscal situations.[4] In addition, some policies that provide substantial financing support and/or restrict imports have raised concerns about unfair trade impacts, creating pressure for potential future revisions.

Successful policies depend on predictable, transparent, and stable framework conditions and on appropriate design. Although many policy developments have helped to expand renewable energy markets, encourage investments, and stimulate industry developments, not all policies have been equally effective or efficient at achieving these goals.[5] This report does not evaluate or analyze policies, but it aims to paint a picture of the changing landscape of renewable energy promotion policies and to provide an update of targets, programmes, and policies at local, state/provincial, and national levels.[6]

POLICY TARGETS

Targets for renewable energy now exist in at least 118 countries, more than half of which are developing countries.[7] This is up from the 109 countries reported in 2010. (See Reference Tables R9–R11.) Most countries and states/provinces that have renewable electricity targets in place aim for average annual share increases of 0.2–1.5%. Other targets include renewable energy shares of primary or final energy supply, heat supply, installed electric capacities of specific technologies, and the shares of biofuel blends in road transport fuels. Targets typically apply to a specific future year, although some apply to a range of years.

There were fewer historic targets aimed at the year 2011 than there were for 2010. Of these, Spain landed just short of its target to install just over 22 GW of wind, due at least in part to policy uncertainty.[8] Denmark, Nicaragua, Syria, Thailand, Tunisia, and the United Kingdom had targets in place for 2011.[9] Although supporting data were not available by April 2012, it appears that most targets were close to being met. It is worth noting that 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 required when judging the "success" of meeting a policy target.

New policy targets were introduced in 2011 by nine countries—Algeria, Brazil, India, Israel, Lebanon, Oman, Scotland, South Africa, and Turkey—and the Canadian province of New Brunswick. (See Reference Tables R9–R11.) Examples include: India targeted the addition of 3,400 MW of grid-connected capacity and 130 MW of off-grid capacity during the 2011–12 fiscal year; Lebanon aims for 12% of final energy from renewables by 2020, including installation of an additional 190,000 m^2 of solar thermal collectors on buildings by 2014; Scotland released a roadmap for 2020 with a 100% target for electricity and 30% for total energy supply; and South Africa introduced a new 20-year plan calling for renewables to represent 42% of all new capacity installed up to 2030.[10]

Several countries revised upwards their existing targets. (See Reference Tables R9–R11 in this report and Reference Tables R7–R9 in *GSR 2011*.) China increased targets to be met by end-2015 for grid-connected wind from 90 GW to 100 GW (and to 200 GW by 2020), for hydro from 250 GW to 300 GW, and for solar PV from 9 GW to 10 GW.[11] Denmark aims to increase the share of wind in total generation to 50% by 2020, and for 100% of electricity, heat, and fuels to come from renewables by 2050.[12] Germany increased its minimum renewable share requirements to 35% of electricity by 2020, 50% by 2030, 65% by 2040, and 80% by 2050.[13] Hungary increased its 2020 EU directive target from 13% to 14.65%, and the U.S. state of California set new targets under its existing Renewable Portfolio Standard.[14]

Two countries, both in Europe, reduced targets during 2011. Spain lowered its 2020 target for share of total final energy supply from 22.7% (equivalent to 53.2 GW of installed renewables capacity) to 20.8% (50 GW).[15] The Netherlands also reduced its 2020 target for renewables' share of final energy from 20% to the 14% target mandated under European Directive 2009/28/EC.[16] No new transport fuel targets were introduced, and no new regional targets were adopted in 2011. Only a handful of targets exist at the regional level, including the EU regional and national targets for 2020 (see Figure 21), and the Mediterranean Solar Plan, which aims to add 20 GW of renewable by 2020.[17]

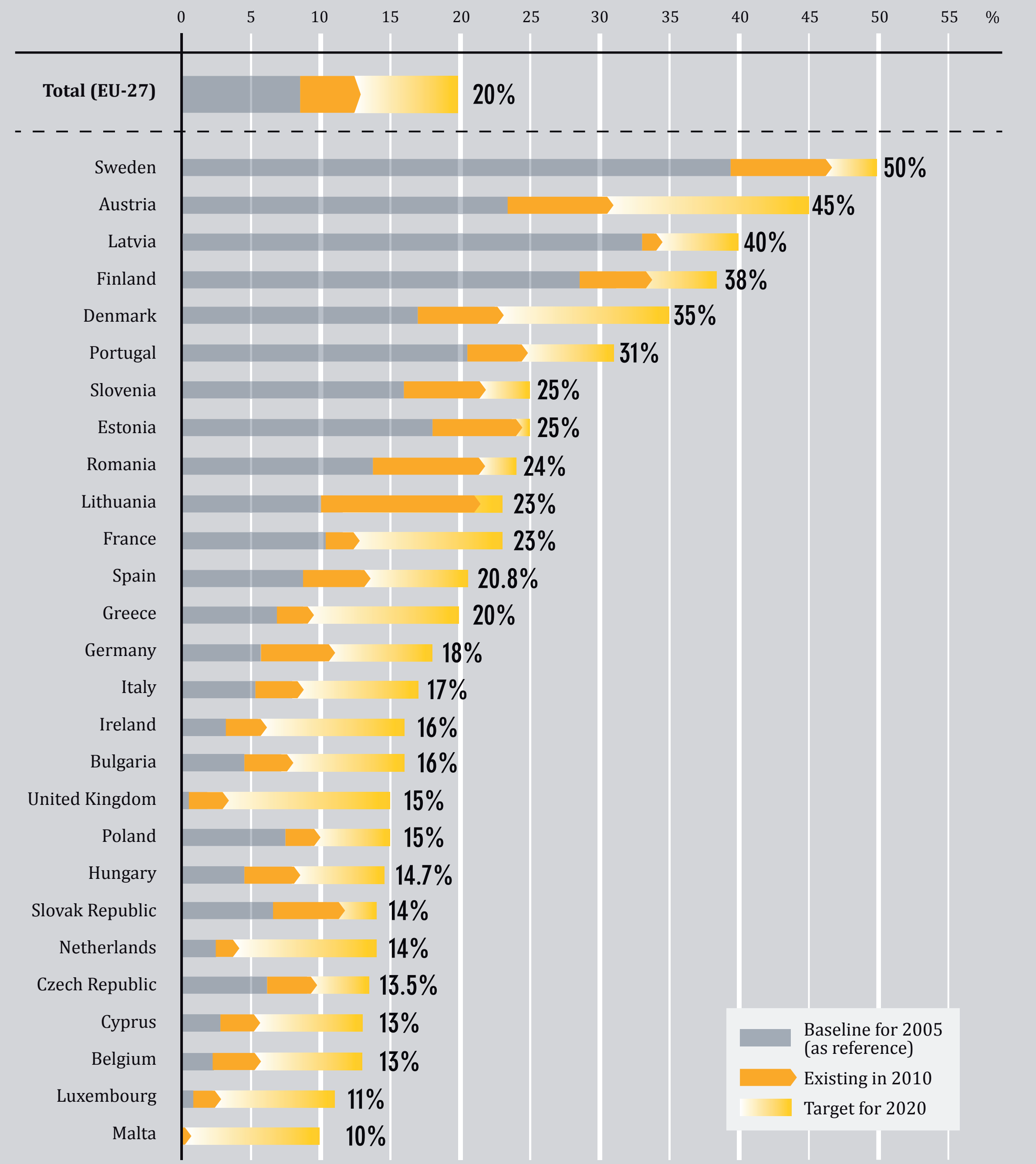
POWER GENERATION POLICIES

At least 109 countries had some type of renewable power policy by early 2012, up from the 96 countries reported in the *GSR 2011*. More than half of these countries are developing countries or emerging economies. Of all the renewable electricity policies employed by national and state/provincial governments, feed-in-tariffs (FIT) and renewable portfolio standards (RPS) are the most common.[18] (See Table 3, pages 70–72.)

Also called premium payments, advanced renewable tariffs, and minimum price standards, the FIT is the most widely used policy type in the electricity sector, having been adopted by at least 65 countries and 27 states/provinces as of early 2012. (See Reference Table R12.)

Four countries and two states/provinces enacted new FITs in 2011 and early 2012. The Netherlands initiated a new feed-in premium system of grant allocations targeting renewable electricity, combined heat and

FIGURE 21. EU RENEWABLE SHARES OF FINAL ENERGY, 2005 AND 2010, WITH TARGETS FOR 2020



Source: See Endnote 17 for this section.

power (CHP), and biogas projects; Syria enacted a new FIT to complement the 2010 renewable energy law; and both the Palestinian Territories and Rwanda adopted FITs in early 2012.[19] At the state/provincial level, Nova Scotia (Canada) introduced a Community Feed-in Tariff (in addition to an existing quota policy) to support small-scale, locally owned renewable energy projects; and the U.S. state of Rhode Island implemented a limited FIT (in addition to a quota policy) to support distributed generation projects.[20]

Other governments were in the process of implementing new FITs or considering their enactment. In early 2011, Uganda implemented a FIT with technology-differentiated tariffs to be applied over a 20-year period but adjusted annually with regard to annual capacity caps increasing out to 2014.[21] Soon after the Fukushima nuclear accident, Japan enacted legislation to instigate a FIT for solar PV and wind, and created a special parliamentary committee to determine how to best achieve implementation in 2012.[22] (See Sidebar 6, page 69.)

Most FIT policy activities in 2011 and early 2012 involved revisions to existing FITs, in response to strong growth and declining costs, among other factors. Countries that extended existing FITs include, in Asia: China doubled its surcharge for solar and other renewables, implemented a FIT for non-tendered solar PV projects, and announced FITs for large solar PV plants; Indonesia required the state-owned utility to purchase geothermal electricity at a fixed price, and increased tariffs for biomass power**;** Malaysia allowed households owning renewable systems under the Small Renewable Energy Programme (SREP) to convert support into a new FIT for solar PV, mini hydro, and biomass and biogas; and Pakistan adopted a novel two-tier system of FITs for wind projects of 5–250 MW whereby domestically owned companies are paid a higher tariff than foreign developers.[23]

In Europe, Italy agreed on a hydro FIT for electricity produced in Serbia and imported; Bulgaria enacted higher tariffs for roof-mounted solar PV and lower ones for ground-mounted; Portugal enacted a new micro-generation law for systems below 20 kW up to an annual cap of 50 MW; and Romania enacted a new FIT for projects smaller than 1 MW.[24] At the state/provincial level, the Australian Capital Territory re-opened the micro-category for solar systems below 30 kW; and the U.S. state of Hawaii approved the third phase of its FIT for small wind and solar power projects.[25]

Other increases in tariff payments in 2011 and early 2012 included: Germany for offshore wind, geothermal, and biomass; the U.K. for micro-power generation; Serbia for all qualifying renewables; and Turkey for wind, hydro, geothermal, solar PV, CSP, and biomass and landfill gas, with bonus payments for local manufacture.[26]

However, some countries and states revised FIT payments (particularly for solar PV) downwards. France reduced FIT support for solar PV through the implementation of a capacity cap, with the largest cuts for systems of more than 100 kW in capacity (now subject to a tendering system).[27] Additional cuts in France saw the existing FIT rate for small-scale solar PV systems lowered, while a moratorium was placed on the approval of new solar PV projects.[28] Germany reduced its solar PV tariffs several times in 2011 and early 2012, and introduced monthly tariff reduction.[29] Italy set capacity caps for new solar PV systems larger than 1 MW, with automatic tariff adjustments based on the rate of installation, effective from 2013.[30] In early 2012, Greece reduced tariffs by 12.5% for systems up to 100 kW and those on non-interconnected islands.[31] The Slovak Republic eliminated financial support for wind and rooftop solar PV projects (<100 kW).[32] Switzerland cut solar PV tariffs and plans further regular cuts.[33] Portugal indefinitely suspended the issuing of new licenses for projects benefiting from its FIT, and Spain halted all new FIT applications in early 2012 as it sought to reform its national energy system.[34] FIT payments vary widely among technologies and countries but are generally trending downwards.[35] (See Sidebar 7, page 74.)

In some European countries, FIT revisions—particularly those introducing retroactive changes—resulted in considerable controversy and sometimes even in legal dispute.[36]

There are many variations in FIT design (see Sidebar 6 in *GSR 2011*); support levels also vary widely. The more mature technologies of wind, geothermal, and hydropower tend to have most of the tariffs concentrated towards the lower end of the range. (See Figure 22, page 74.) Solar PV systems of less than 30 kW in capacity have historically had the highest tariffs due to their relatively higher capital costs, but the gap is narrowing as manufacturing costs and market prices decline.

Outside of Europe, China announced significant reductions in solar FITs with the aim of promoting sustained and steady development of the domestic industry; Israel reduced solar and wind tariffs, although it increased the eligible project size and raised caps on total installations; and Uruguay curtailed its support for biomass power.[37] In North America, Oregon (one of five U.S. states with a FIT) reduced its "solar payment option" tariffs for on-site generation; Nova Scotia (Canada) reduced tariffs for large wind (>50 kW) by about 4%; and in early 2012, Ontario (Canada) reduced significantly its wind and solar PV tariffs.[38] In addition, South Africa replaced its FIT system with a competitive bidding programme.[39]

The Renewable Portfolio Standard (RPS) or "quota"[i] is another common policy existing at the national level in 18 countries and in at least 58 jurisdictions at the state,

i - 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. A penalty may or may not exist for non-compliance. 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.

provincial, or regional level, including in the United States, Canada, and India. (See Reference Table R13.) Only Israel enacted a new quota law in 2011, setting requirements for the addition of 110 MW of on-site generation from decentralised renewable systems, as well as up to 800 MW of centralised wind turbines, 460 MW of large solar systems, and 210 MW of biogas and waste generation plants, all to be grid-connected by 2014.[40] In the United States, 29 states plus the District of Columbia, Puerto Rico, and the Northern Mariana Islands have RPS policies, and eight other states and two U.S. territories have non-binding goals.[41] While no states enacted new RPS laws in 2011, at least three revised existing policies: California changed its "20% by 2010" renewable electricity mandate to 20% by 2013, 25% by 2016, and 33% by 2020; New Jersey lowered the solar carve-out under its existing RPS; and Illinois added a distributed generation requirement.[42] In addition, Indiana established a voluntary RPS for 4% renewable electricity by 2013 and 10% by 2025.[43]

Quota policies are often combined with mandates for utilities to meet their obligations through the trading of certificates. In 2011, India launched a new Renewable Energy Certificate (REC) scheme that is linked to its existing quota policies, and Romania revised the rates for its existing RECs programme.[44]

Across the policy landscape, many other types of policies are being used to promote renewable electricity, including public competitive bidding for fixed quantities of renewable electric capacity. In Latin America, Brazil had a new round of competitive bidding for 20-year contracts for wind and biomass power projects and 30 years for hydroelectric; Peru held auctions for 412 MW of hydro, agricultural residues, wind, and solar power projects in 2010, and for a further 210 MW in 2011; and Uruguay held a successful tender resulting in three wind power projects totalling 192 MW in capacity.[45] In Africa, Egypt moved ahead with a bidding process for the construction of a single wind farm to provide 1,000 MW of new capacity by 2016; and South Africa replaced its REFIT programme with a new procurement programme for independent power producers (IPPs).[46] The 2011 Renewable Energy Bid tender issued by South Africa's Department of Energy was for 3,725 MW of renewable electricity, representing the largest order of renewables in the world.[47] It includes bids for 200 MW of CSP with the aim to reach 1,000 MW installed in the near future.[48]

In Europe, France and Italy modified existing FIT laws to include tenders for large-scale installations.[49] And the Indian state of Gujarat will offer projects on a direct allotment basis with a fixed tariff over 25 years as opposed to the reverse bidding process that has been followed by the states of Rajasthan and Karnataka as well as the National Solar Mission.[50]

Net metering[ii] laws now exist at the national level in at least 14 countries, in eight Canadian provinces, and in 43 U.S. states plus the District of Columbia and Puerto Rico.[51] New net metering policies were enacted during 2011 in the Dominican Republic, Peru, and Spain.[52]

Several other types of government support were enacted or revised during 2011. In North America, for example, the U.S. state of California restored funding to help finance solar installations at local schools and authorised continued collection of funds for the Self-Generation Incentive Program (SGIP) through the end of 2014; Vermont established two funds to support in-state PACE (Property Assessed Clean Energy) programmes; and Ontario (Canada) amended legislation to exempt most renewable energy installations from property tax.[53] Australia announced a fund to support clean energy projects, including renewables, as part of a carbon reduction plan.[54] Ukraine introduced tax exemptions for renewable energy companies, but has also restricted qualification for the green tariff to customers who locally source at least 30% (increasing to 50% in 2014) of materials, works, and services contributing to their renewable energy project.[55] And the Indian state of Rajasthan developed a portfolio of policy measures to expand solar project deployment, including exemption from electricity duty, a levy on electricity sales to support solar parks larger than 1,000 MW and related transmission infrastructure, and guaranteed access to the grid and to sufficient water.[56]

Countries that reduced their fiscal support policies in 2011 and early 2012 included China, which removed subsidies for domestic wind turbine manufacturers now that they can better compete internationally; India, which in April 2012 suspended accelerated depreciation for wind farms, first enacted in 1993/94; and the United States, where federal grants (introduced as part of the financial stimulus package in early 2009) expired in late 2011.[57] The Netherlands' subsidy for co-firing of biomass in coal-fired power plants ended, but it may be replaced by mandatory co-firing legislation.[58] After numerous cuts to tariff payments in 2011, in January 2012, Spain announced a complete moratorium on financial support for all new renewable energy projects.[59]

In addition to promotion policies, governments offered a range of measures to support research, development, and deployment. Programmes announced in 2011 include: Scotland budgeted USD 54 million (GBP 35 million) to support production of full-scale prototypes of next-generation offshore wind turbines; the EU dedicated a specific budget line for wind energy R&D; and the United States pledged grants and loans of at least USD 196 million for solar, offshore wind, and small- to medium-scale hydropower projects.[60]

ii - Net metering, also called "net billing," enables self-generated power used on-site to offset electricity purchases. Any excess power is sold to the grid for a pre-determined price.

SIDEBAR 6. IMPACTS OF FUKUSHIMA

The Fukushima Daiichi nuclear disaster that followed the March 2011 Tōhoku earthquake and tsunami had an enormous impact on almost all aspects of life in Japan, particularly Japanese energy policy and politics. On the morning of 11 March 2011, by strange coincidence, the cabinet agreed to pass the "Feed-in Tariff Law," which suddenly became the most important law under discussion in Parliament. In August 2011, Prime Minister Naoto Kan resigned his position to ensure its enactment.

In response to the accident, almost 80% of the public supported the phase-out of nuclear power by March 2012, and renewable energy is now widely viewed as a critical energy source for the future. While the intensity of public sentiment might change over time, support for renewables is considered irreversible due to increased public awareness about nuclear power and energy in general.

Across Japan, local governments and communities have mobilised to advance renewable energy. Fukushima and Nagano set targets for 100% renewables, while Tokyo and Osaka have become more interested in restructuring their electricity markets. “Community power” is widely supported as important for promoting renewables and advancing change from the bottom up.

Another significant outcome was the launch of the “Japan Renewable Energy Foundation” by Masayoshi Son, the CEO of Softbank, in collaboration with the Institute for Sustainable Energy Policy (ISEP) and other partners. Mr. Son has committed to working for nuclear phase-out and promotion of renewable energy, and his vision of an “Asia Super Grid” to promote regional cooperation for renewable energy deployment has attracted the interest of many politicians, experts, and industries.

Transformation of the energy sector in Japan has begun. Beyond Japan, the Fukushima accident triggered heated debate about the security of nuclear energy and the reorientation of future energy policy in many countries. In May 2011, the Swiss Government decided to phase out nuclear power by 2034. In June 2011, an overwhelming majority (more than 94%) of Italian voters passed a referendum to cancel plans for new nuclear reactors. In Belgium, a decision was made to shut down the three oldest reactors by 2015, and to exit nuclear power completely by 2025 provided that alternative sources can meet energy demands and prevent shortages. In his election campaign, France’s newly elected president François Hollande has called for a reduction in nuclear electricity’s share in the country’s energy mix from 75% currently to 50% by 2025.

In Germany, the incidents in Fukushima led to a more rapid exit from nuclear energy use, now scheduled for 2022. To this end, a decision was taken to completely reform the nation's energy sector through what is referred to as “Energiewende” (Energy Transition), which focuses on energy efficiency and renewable energy sources together with massive energy infrastructure investments. It is Germany’s biggest modernisation and infrastructure project, and will contribute to energy security, jobs, and value creation. Due to Germany’s status as one of the world’s leading economies, the energy transition project has frontrunner character with a global impact.

Nonetheless, several developing economies have stipulated their willingness to continue planned nuclear energy projects, some with delayed schedules. Thailand, for example, postponed its first planned nuclear unit from 2020 to 2030. China’s State Council decided soon after Fukushima to review and adjust its long-term nuclear-power expansion plan with a focus on increased safety.

While it is too early to fully evaluate Fukushima’s impact on global energy policy, the accident represents an inflection point for nuclear power in terms of public acceptance. It has increased the focus on improved governance and safety standards for nuclear energy, with direct economic impacts, and has further highlighted the importance of energy diversification and the move towards sustainable energy. Several investor reports point in this direction, forecasting a short-term boost for natural gas coupled with energy efficiency and renewable energy becoming the preferred investment options in the long term.

Source: See Endnote 22 for this section.

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES

● national-level policy

○ state/provincial 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	●	●	●			●	●				●	
Luxembourg	●						●					
Malta	●		●				●		●			
Netherlands	●			●		●	●	●	●	●	●	
New Zealand							●					
Norway				●		●	●		●		●	
Poland		●		●		●	●		●		●	●
Portugal	●	●	●	●	●		●	●	●		●	●
Singapore			●								●	
Slovakia	●						●		●			
Slovenia	●					●	●	●	●		●	●
South Korea[1]		●	●	●		●	●	●	●		●	
Spain[2]	●			●	●		●	●	●		●	
Sweden		●		●		●	●	●	●		●	
Switzerland	●						●		●			
Trinidad and Tobago							●	●	●			
United Arab Emirates		○			○					○	○	○
United Kingdom	●	●		●	●	●	●		●	●	●	
United States[3]	○	○	○	●	○	○	●	●	●	○	●	○

Source: See Endnote 18 for this section.

Note: Countries are organized according to GNI per capita levels as follows: "high" is USD 12,276 or more, "upper-middle" is USD 3,976 to USD 12,275, "lower-middle" is USD 1,006 to USD 3,975, and "low" is USD 1,005 or less. Per capita income levels and group classifications from World Bank, 2010. Only enacted policies are included in the 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 of technology.

1 The South Korea feed-in tariff that was operational throughout 2011 has been replaced by an RPS policy for 2012.

2 In Spain, the feed-in tariff (FIT) was temporarily suspended in January 2012 by Royal Decree for new renewable energy projects; this does not affect

TABLE 3. 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		●			●		●		●		●	
China	●	●		●	●		●			●	●	●
Colombia				●					●			
Costa Rica	●											
Dominican Republic	●		●		●		●	●	●			●
Ecuador	●								●		●	
Grenada									●			
Iran	●							●		●		
Jamaica				●				●	●			
Jordan			●	●					●		●	●
Kazakhstan	●					●						
Latvia	●			●					●		●	●
Lebanon			●						●			
Lithuania	●										●	
Macedonia	●										●	
Malaysia	●	●		●					●		●	●
Mauritius							●					
Mexico			●		●			●			●	●
Palau		●										
Panama	●		●					●	●	●		●
Peru	●			●					●			●
Romania		●		●		●			●		●	
Russia							●					
Serbia	●						●					
South Africa							●					●
Thailand	●			●					●		●	
Tunisia			●				●		●		●	
Turkey	●						●					
Uruguay	●		●	●	●		●		●		●	●

● national-level policy

○ state/provincial policy

projects that had already secured FIT funding. The Value-Added Tax (VAT) reduction is for the period of 2010–12 as part of a stimulus package.

3 The United States temporarily allowed new facilities that qualified for the federal Production Tax Credit (PTC) to opt instead for an equivalent cash grant. This provision, under the American Recovery and Reinvestment Act of 2009, was available only to systems that began construction prior to 31 December 2011, and is not included here.

4 The area of the Palestinian Territories is included in the World Bank country classification as "West Bank and Gaza." They have been placed in the table using the 2009 "Occupied Palestinian Territory" GNI per capita provided by the United Nations (USD 1,483).

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES (continued)

● national-level policy

○ state/provincial 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
LOWER-MIDDLE INCOME COUNTRIES $$												
Armenia	●											
Cape Verde	●							●	●		●	
Egypt							●		●			●
El Salvador								●	●	●	●	●
Ghana	●				●	●			●			
Guatemala			●	●				●	●			●
Honduras	●							●	●			●
India	●	●		●	○	●	●	●			●	●
Indonesia	●	●		●			●	●	●		●	●
Marshall Islands									●			
Moldova	●								●		●	
Mongolia	●											●
Morocco											●	
Nicaragua	●								●			
Pakistan	●		●				○				●	
Palestinian Territories[4]	●								●			
Paraguay				●					●			
Philippines	●	●	●	●			●	●	●	●	●	●
Senegal	●								●			
Sri Lanka	●	●	●	●			●		●	●	●	
Syria	●		●					●				●
Ukraine	●							●	●			
Vietnam							●	●	●			
Zambia				●			●		●			
LOW INCOME COUNTRIES $												
Bangladesh							●		●		●	
Ethiopia				●					●		●	
Gambia									●			
Haiti											●	
Kenya	●								●			
Kyrgyzstan		●					●		●			
Malawi				●					●			
Mali									●			
Mozambique				●							●	
Nepal							●	●	●		●	●
Rwanda									●		●	
Tanzania	●						●		●			
Uganda	●						●		●		●	

HEATING AND COOLING POLICIES

Policies have emerged in recent years to reflect the significant heat provision potential from modern biomass, direct geothermal, and solar thermal.[61] Heating and cooling using direct renewable energy inputs (excluding traditional biomass and electrical heating) account for more than half of modern non-hydro energy from renewable sources.[62] Despite the significant potential, policies for renewable heating and cooling are not being enacted as systematically as those for renewable electricity and transport fuels.

For most buildings and industries, heat (and cool) is supplied on-site using a wide range of individual combustion appliances and fuels. Therefore, policies to support renewable heating and cooling tend to focus on individual building installations.[63]

Around 19 countries have specific renewable heating/cooling targets in place (including for solar water heating; see Reference Table R11) and at least 17 countries/states have heat obligations/mandates to promote renewable heat (see Table 3), for example through new building code regulations. Numerous local governments also have regulatory policies in place that encourage the deployment of domestic and commercial-scale renewable heat installations. Financial incentives for solar water heating installations are widespread and, together with regulatory policies, have stimulated continued global growth in installations.[64] There is limited national policy support in place for encouraging new district heating and cooling schemes, although these are usually instigated by policies made at the local government level.

Policies to encourage the purchase and installation of renewable heating and cooling have included direct capital grants and tax credits as well as regulatory approaches that mandate energy shares or equipment requirements; in recent years, policies that do not rely on public expenditure, such as mandates and quotas, have been gaining favour.[65] Renewable heat deployment is also being driven by White certificate schemes (as in Italy), CHP regulations, and the increasing number of solar thermal targets in building codes or public procurement programmes.

A number of countries adopted new heat policies during 2011. The United Kingdom implemented the first FIT for heating with its Renewable Heat Incentive (RHI), which covers non-domestic, commercial installations; a FIT for households is now expected in 2013, together with a subsidy for installation costs.[66] The Netherlands enacted and strengthened its Energy Performance Coefficient building code to stimulate the uptake of renewable heating, and plans to commence a renewable heat FIT in 2012.[67] Spain has included a heat FIT in its Renewable Energy Plan 2011–2020.[68] In early 2012, the U.S. state of California doubled its existing rebate for solar water heater installations by low-income utility customers, and increased it by 50% for some consumers displacing natural gas with solar thermal.[69]

New heat mandates were enacted in Greece, which requires that solar provide at least 60% of hot water in all new and retrofitted buildings, and in Italy, where all new and refurbished buildings must meet at least 50% of their hot water and 20% of their space heating demands with renewables or district heating as of 2012.[70] In Poland, a draft bill was introduced for a renewable heat obligation on private and public buildings and to provide a tax deduction for private solar thermal customers.[71]

Beyond Europe, the second phase (2011–14) of Brazil's social housing programme, "My House My Life,'" mandates solar water heaters for the planned construction of 2 million single-family homes for low-wage owners.[72] The 2011 Puerto Rico Building Code mandated the use of solar water heaters for all new one- and two-dwelling units and townhouses, and Uruguay implemented its 2009 Act requiring that large consumers meet more than 50% of their hot water demand with solar.[73] In Asia, South Korea required new, extended, or reconstructed public buildings larger than 3,000 m^2 to generate at least 10% of their total heat demand with ground-source heat pumps, biomass, and/or solar thermal water systems (as well as solar PV); smaller buildings (<1,000 m^2) come under the mandate in 2012.[74] And Rajasthan (India) developed a portfolio of policy measures to expand deployment of solar thermal projects for swimming pools and commercial buildings, and solar steam generation for larger buildings and industry.[75]

Several governments revised or added financial incentives for renewable heat. In Germany, a decline in 2010 installations due to the "stop-go" nature of the market incentive programme led to a decision to increase support for 2011, and Romania re-launched its financial assistance programme "Casa Verde."[76] Canada renewed the ecoENERGY Retrofit for Homes Program, which includes a grant to homeowners installing solar water heaters.[77] In the United States, the state of Virginia enacted a new renewable heat policy, and Maryland added solar water heaters under its electricity RPS; in addition, support for renewable heat now exists in Arizona, Florida, Iowa, New Jersey, New Mexico, New York, North Carolina, Oregon, and South Carolina, whereas Hawaii has a solar heat mandate.[78]

However, there were also instances of reduced support for renewable heat technologies. The Canadian Renewable Heat Program was discontinued.[79] In Europe, Portugal increased the sales tax on solar thermal and other systems from 13% to 23%, which, even by late 2011, had a noticeable impact on demand; and Slovakia ended its domestic solar and biomass heating programme after exceeding the available budget.[80] The U.S. Residential Energy Efficiency Tax Credit, which included biomass burners, expired at the end of 2011.[81] And Australia announced in early 2012 that its rebate scheme for domestic solar water heaters would close at the end of June, although a system for earning renewable energy certificates will continue.[82]

SIDEBAR 7. TARIFFS THAT FIT

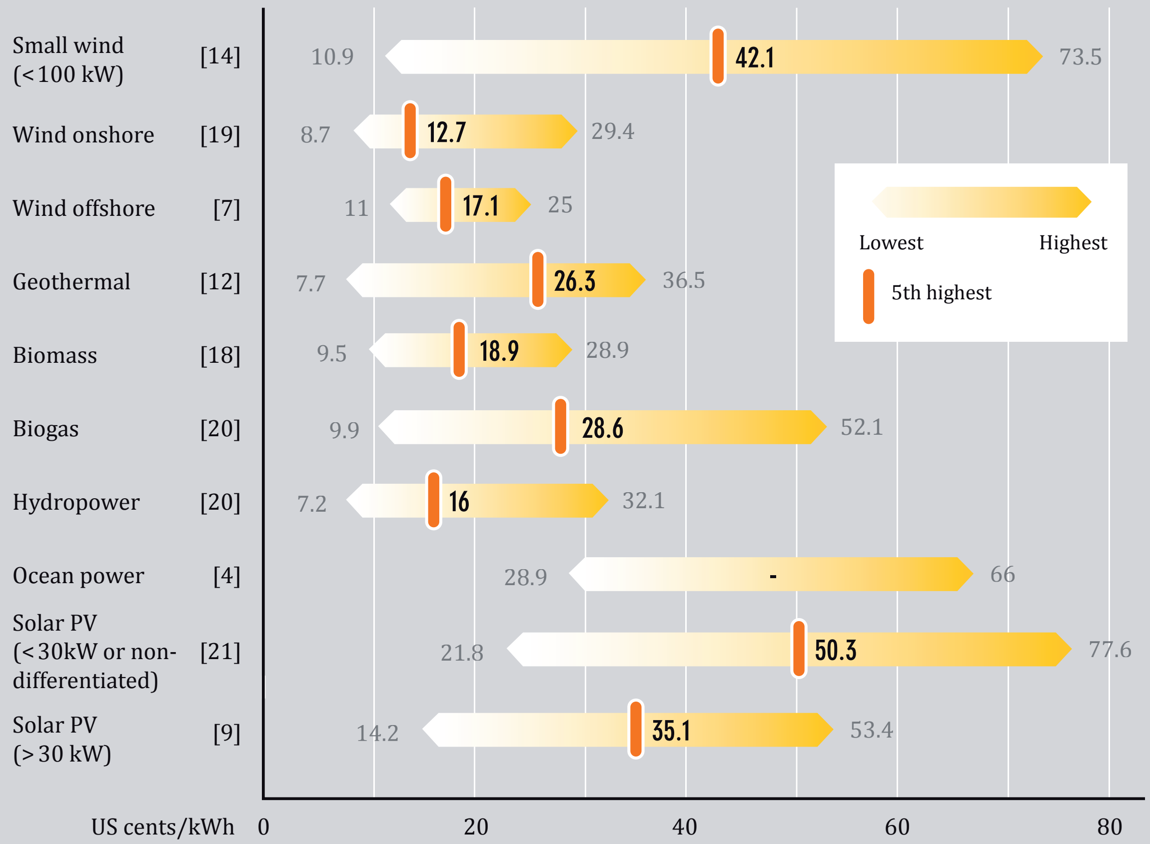
Source: See Endnote 35 for this section.

There are many variations in feed-in tariff (FIT) design. (See Sidebar 6 in GSR 2011.) Levels of support provided under FITs also vary widely and are affected by technology cost, resource availability, and installation size and type (e.g., ground- versus rooftop-mounted solar PV systems).

Tariffs tend to be concentrated towards the lower end of the range for the more mature technologies of wind, geothermal, and hydropower. (See Figure 22.) Historically, the highest tariffs have been set for solar PV systems of less than 30 kW in capacity due to their relatively higher capital costs per kW, but the gap is narrowing as solar PV manufacturing costs and market prices decline. In addition, large-scale renewable power systems typically require lower FIT rates to be cost competitive because they benefit from economies of scale. Some countries have further varied rates within regional boundaries based on local resource potential.

Differentiated payments have been considered necessary for a properly functioning tariff system. Periodic review and re-setting of rates, in line with technology and market developments, are viewed as necessary steps for successful FIT policy implementation over time.

FIGURE 22. FIT PAYMENTS FOR A RANGE OF RENEWABLE ENERGY TECHNOLOGIES, SELECTED COUNTRIES, 2011/2012



Note: Each bar depicts the range of tariffs provided by selected countries with at least 15-year terms. The number of countries analysed by the data source is shown in parentheses; the vertical line depicts the fifth highest tariff provided. Tariff rates for small-scale wind, onshore wind, geothermal, biogas, and small- and large-scale solar PV were updated as of May 2012; offshore wind, biomass, and hydropower rates were updated as of September 2011; ocean energy rates have no given year.

TRANSPORT POLICIES

Policies including biofuel production subsidies, tax exemptions, share in total transport fuel obligations, and blending mandates continue to support liquid biofuels for use in the transport sector. Biofuel obligations and mandates existed in at least 46 countries at the national level and 26 states and provinces by early 2012. (See Table 3 and Selected Indicators.) Blending mandates now exist in at least 23 countries at the national level and in 26 states/provinces.[83] (See Table R14.) And, as of early 2012, fuel-tax exemptions and production subsidies existed in at least 19 countries. (See Table 3 and Reference Table R14.) Governments are also paying increasing attention to biofuel sustainability and environmental standards.

As of mid-2011, mandates in place around the world called for a biofuels market of at least 220 billion litres by 2022, with expected demand to be driven primarily by Brazil, China, the EU, and the United States.[84] The majority of mandates were in EU countries, as part of the 10% target for renewable energy in transport by 2020, with most of the rest in Asia.[85]

New mandates enacted during 2011 include Canada's Renewable Fuel Standard for B2 (2% biodiesel blend) for both transport diesel and heating oil. While Canada's national E5 (5% ethanol blend) mandate remained, four provinces enacted higher individual mandates. In addition, British Columbia increased its biodiesel mandate and Saskatchewan added a new biodiesel mandate.[86] Denmark adopted its first biofuels quota (3.5%) in 2011, and Germany began to roll out an E10 blend.[87]

Several governments revised policies in 2011. Brazil reduced its mandated ethanol blend level from 24% to 18–20%, partly in response to poor sugarcane yields in recent years.[88] The government also announced financing for agribusiness to increase sugarcane yields, as well as loans of USD 2.6 billion to sugar companies to encourage investment in larger ethanol storage facilities to better meet domestic demand during the two months when sugar cane is not harvested. In Europe, Belgium extended its existing B4 and E4 blending mandates, and Spain increased its 2011 biofuels mandate from 5.9% to 6.2% (in terms of energy content), rising to 6.5% for 2012–13; Bulgaria, Finland, Poland, and Italy followed suit.[89] In Australia, New South Wales postponed its biodiesel mandate increase (from B2 to B5) due to a lack of sufficient local supplies to meet the proposed target.[90]

In the United States, the national volumetric ethanol excise tax credit (VEETC), first introduced in the 1980s, expired at year's end; the U.S. import tariff (approximately USD 0.14/litre) was also eliminated at the end of 2011.[91] (See Sidebar 8, page 77.) The U.S. Renewable Fuel Standard, an ethanol blending mandate, remains in place; in addition, a USD 510 million initiative was announced to boost next-generation biofuels, and the Defense Department began investing in biofuels for marine and aviation needs.[92]

Sustainability issues relating to biofuels continue to gain traction, and several government and non-governmental codes of practice have been implemented. For example, the EU has a strong policy in place for imported biofuels, and the U.S. 2011 Renewable Fuels Standard mandates that foreign-grown feedstocks comply with the "renewable biomass" provisions within the law.[93]

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 more than 20 million electric battery vehicles (EVs) operating by 2020, equating to around 2% of light-duty vehicle stocks.[94] During 2011, Uruguay significantly reduced import taxes for all-electric and hybrid light-duty vehicles.[95] Israel is aggressively promoting EVs and aims to become independent of oil by 2020.[96] 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.[97] The governments of Ireland, Portugal, and Denmark are developing similar policies.[98] Most policies linking EVs to the use of renewable electricity have been enacted at the local level. (See sub-section on City and Local Government Policies.)

GREEN ENERGY PURCHASING AND LABELLING

In many countries, consumers have a variety of options for purchasing "green" renewable energy—generally in the form of electricity, although in some countries voluntary purchases of "green" biogas, heat, and transport biofuels are also possible. In addition, governments choose to purchase renewable energy and/or systems directly. The top countries for green power purchasing include Germany, the Netherlands, Switzerland, Australia, the United States, and Japan. Green labelling of energy products, similar to energy efficiency labels for appliances, is also increasing. Few new policy initiatives were established in 2011 to support green purchasing, but sales continued to expand as price premiums for green power over conventional energy continued to decline.

In the United States, regulations in several states require utilities or electricity suppliers to offer green power products; as a result, more than 850 utilities offer green pricing programmes.[99] Governments at the local (see below) and state levels, as well as the federal government, are purchasing significant amounts of green energy and installing renewable energy systems. For example, the U.S. Army had completed 126 renewable energy projects by mid-2011, and an estimated 11.3% of the Defense Department's energy comes from renewable sources.[100] A mandate requires that military bases source one-fourth of their electricity from renewables by 2025.[101] The U.S. Environmental Protection Agency

continues to encourage voluntary corporate green power purchases through its Green Power Partnership.[102]

The European Energy Certificate System (EECS) framework allows for the issue, transfer, and redemption of voluntary RECs and provides "guarantee-of-origin" certificates to confirm the renewable origin of electricity. During 2009, 209 TWh of certificates were issued, more than triple the number in 2006.[103] Certificate markets exist elsewhere as well. Japan, for example, has a green power certificate market and introduced the Green Heat Certificate Programme in 2010 for solar thermal, adding biomass to the programme in 2011.[104]

Green power labels, such as "Grüner Strom" and "ok-power" in Germany and "Naturemade star" in Switzerland, have been introduced in many European countries to strengthen consumer confidence. In many cases, green power labels set minimum standards for the ecological performance of renewable power plants and require suppliers to invest in the expansion of renewable generation beyond what is already stimulated by existing framework conditions.[105]

CITY AND LOCAL GOVERNMENT POLICIES

Thousands of cities and local governments around the world have active policies, plans, or targets for renewable energy and climate mitigation. As in previous years, city and local governments continued to enact and revise policies that integrate renewable energy in electricity generation, builings, heating and cooling, and transport, in 2011. Local governments made increasing use of their authority to regulate; make expenditure and procurement decisions; provide for and ease the financing of renewable energy projects; and influence advocacy and information sharing. (See Reference Table R15.)

Local governments have established significant targets for reducing GHG emissions and advancing renewable energy. By 2011, 62% of the world's largest cities had adopted climate change actions, and 57% had plans for GHG emissions reductions that included the uptake of renewable energy.[106] For example, Cape Town, South Africa, announced plans in 2011 to produce 10% of its energy supply with renewable and clean sources by 2020, and Seoul, South Korea, established a renewable energy supply target of 20% by 2030.[107] By the end of 2011, 759 Sustainable Energy Action Plans were submitted under the EU Covenant of Mayors, all with minimum targets of 20–40% GHG reduction, and several with a 20% renewable energy share in final energy consumption by 2020.[108]

In the United States, Ithaca, New York, switched to renewable electricity in late 2011, with plans to purchase 100% of electricity for all city consumers from renewables starting in 2012.[109] Austin, Texas, met its 2012 target to power municipal facilities with 100% renewables, becoming the largest local U.S. government using 100% green power, and approved one solar and two new wind contracts, enabling the municipal utility to achieve its 30% by 2020 target eight years ahead of schedule.[110]

Cities are also using their procurement power to meet ambitious goals. Palo Alto, California, requested proposals from electric utilities to meet the existing commitment of a 33% renewable share of generation by 2015; San Francisco, California, established a public utility in order to provide the city with 100% renewable electricity by 2020; Boulder, Colorado, aimed to seek ownership of its electric utility; and Cincinnati, Ohio, began working on a power aggregation deal to provide 100% renewable electricity for all city consumers in 2012.[111] Modelled after "Sustainable Energy Utility" initiatives in New York, Vermont, and Delaware, the city of Philadelphia created a sustainable energy authority to invest in renewable energy projects.[112]

In the buildings sector, more and more local authorities target "low" or "zero" -energy or -carbon, often transforming buildings from net consumers to net producers of energy and thereby enhancing local energy security.[i]

i - A carbon-neutral building is defined as a building that uses no fossil fuel, greenhouse gas-emitting energy to operate. A net-zero energy building must produce as much energy on site as it consumes on an annual basis.

Many communities set renewable energy targets for buildings, reformed building codes, and altered permitting and land-use policies to incorporate renewable energy requirements during 2011.[113] Amsterdam, for example, opened new areas for development, with project selection based on energy saving and sustainability criteria, as the city pursued efforts to ensure all new developments will be "energy neutral" from 2015 onwards.[114] Barcelona, Spain, announced plans to install solar PV panels on all public buildings as part of its 2011–2020 Energy Plan.[115] In the United States, Portland, Oregon launched a pilot programme calling for triple (energy, carbon, waste) net-zero buildings to help achieve net-zero GHG emissions in all new buildings by 2030.[116]

As local governments transform their buildings, they also seek to use renewable energy for heating and/or cooling purposes. Strathcona County, in the Canadian province of Alberta, is constructing a biomass district heating system to heat six municipal and three residential buildings.[117] The U.S. city of St. Paul, Minnesota, launched a solar district heating scheme in 2011, providing hot water to 80% of downtown with 144 solar collectors.[118] Danish cities Marstal and Dronninglund added 63 MW_{th} (90,000 m^2) of solar thermal collectors during 2011, bringing Denmark's total installed capacity to 213 MW_{th}.[119] Elsewhere, the Ekurhuleni Municipality in South Africa and Rosario in Argentina launched programmes in 2011 to install solar water heaters in low-cost housing and public buildings, respectively.[120]

Geothermal energy is also being used increasingly for space and water heating. In 2011, Szentlorinc, Hungary, began operating a deep geothermal district heating plant that provides hot water and space heating for some 900 homes, while Xianyang was deemed to become China's "geothermal energy city" after announcing plans to expand capacity for geothermal space heating by more than sixfold to 20 million m^2.[121] In Europe, district heating employing "deep geothermal" installations can be found in The Hague, Paris, and Unterhaching in Germany.[122]

Cities are also implementing and facilitating initiatives in the transport sector. In 2011, Johannesburg, South Africa, introduced 25 ethanol buses into its public transit fleet, while São Paulo in Brazil included in its fleet a total of 60 ethanol buses and 1,200 buses using a B20 blend.[123] Through 2012, São Paulo and Rio de Janeiro are collaborating on a pilot project to fuel city buses with a blend of conventional diesel and biodiesel made from sugar cane. São Paulo has 160 buses running on a 30% biodiesel blend, whereas Rio de Janeiro has 20 buses currently testing a 10% biodiesel blend.[124] The Brazilian city of Curitiba will expand its bus fleet to include 140 buses using B100 in 2012.[125] In India, New Delhi announced a plan to fuel its bus fleet with biogas made from sewage.[126] Elsewhere, the Belgian city of Antwerp

SIDEBAR 8. TRADE BARRIER POLICIES RELATING TO RENEWABLE ENERGY TECHNOLOGIES

In an effort to protect local industries and jobs, some countries have enacted policies that impose trade barriers on imports of renewable energy fuels and technologies, including ethanol, biodiesel, wood pellets, and solar PV modules. High domestic subsidies, regulations, and/or incentives that require or favour local content have been used to secure and maintain domestic benefits, but have also resulted in unfair competitive advantages. Under the rules of the World Trade Organization (WTO), such policies are very complex. Any restriction of international competition as a result of limiting free trade could inhibit the development and deployment of renewable energy globally.

Examples of trade-related developments during 2011 and early 2012 include:

- The EU joined Japan in bringing grievances to the WTO over Ontario's electricity feed-in-tariff (FIT), which requires renewable energy suppliers to meet a minimum local-content level.
- New local-content incentives were enacted. For example, as of January 2011, Turkey pays a premium for solar PV installations if the equipment is locally produced.
- The U.S. government consulted the WTO over Chinese subsidies that apply only to wind power developers using domestically manufactured equipment. China agreed to end such subsidies.
- The U.S. International Trade Commission supported solar PV manufacturers to file a complaint against China for illegally subsidising solar panels and dumping them in the United States. The Department of Commerce took action against Chinese solar imports that received government subsidies of more than USD 30 billion. China responded by launching an investigation into U.S. renewable energy subsidies.
- India agreed to continue importing lower-cost Chinese thin-film solar PV panels as long as they meet local quality standards, but continued an import tax on crystalline panels.
- At the end of 2011, the United States removed long-established ethanol trade barriers when the import tariff expired.

Source: See Endnote 91 for this section

installed 3.3 MW (50,000 m^2) of solar PV panels on top of a high-speed rail tunnel to power the railway infrastructure and trains.[127]

Local governments are increasingly deploying electric vehicles (EVs) and, in some cases, linking them directly to the use of locally generated renewable electricity. Austin, Texas, for example, supplied the city's 50 grid-connected charging stations with green electricity, while Chicago, New York City, and Mexico City built solar-powered charging stations.[128] Mexico City also inaugurated a zero-emissions taxi programme to put 100 EVs on the road by the end of 2012.[129] The utility company in the Australian Capital Territory announced a deal with Better Place to power charging stations in Canberra with wind, hydro, and solar power.[130]

The year 2011 also saw an expansion of the concept of "smart cities," which make extensive use of information and communication technologies (ICT) to enhance energy efficiency, maximise the integration and use of renewable energy in buildings and in the local electricity grid, and ensure the smooth roll-out of EVs.[131] By the end of 2011, there were 102 smart city projects worldwide.[i] Amsterdam continued to be one of the most dynamic projects, with over 500 households testing a domestic energy monitoring system and some 728 households receiving financing from Dutch banks to purchase small wind turbines and solar panels.[132] In China, around 100 new energy technology demonstration cities were under development by the end of 2011, with an emphasis on distributed renewable energy and smart technology applications.[133]

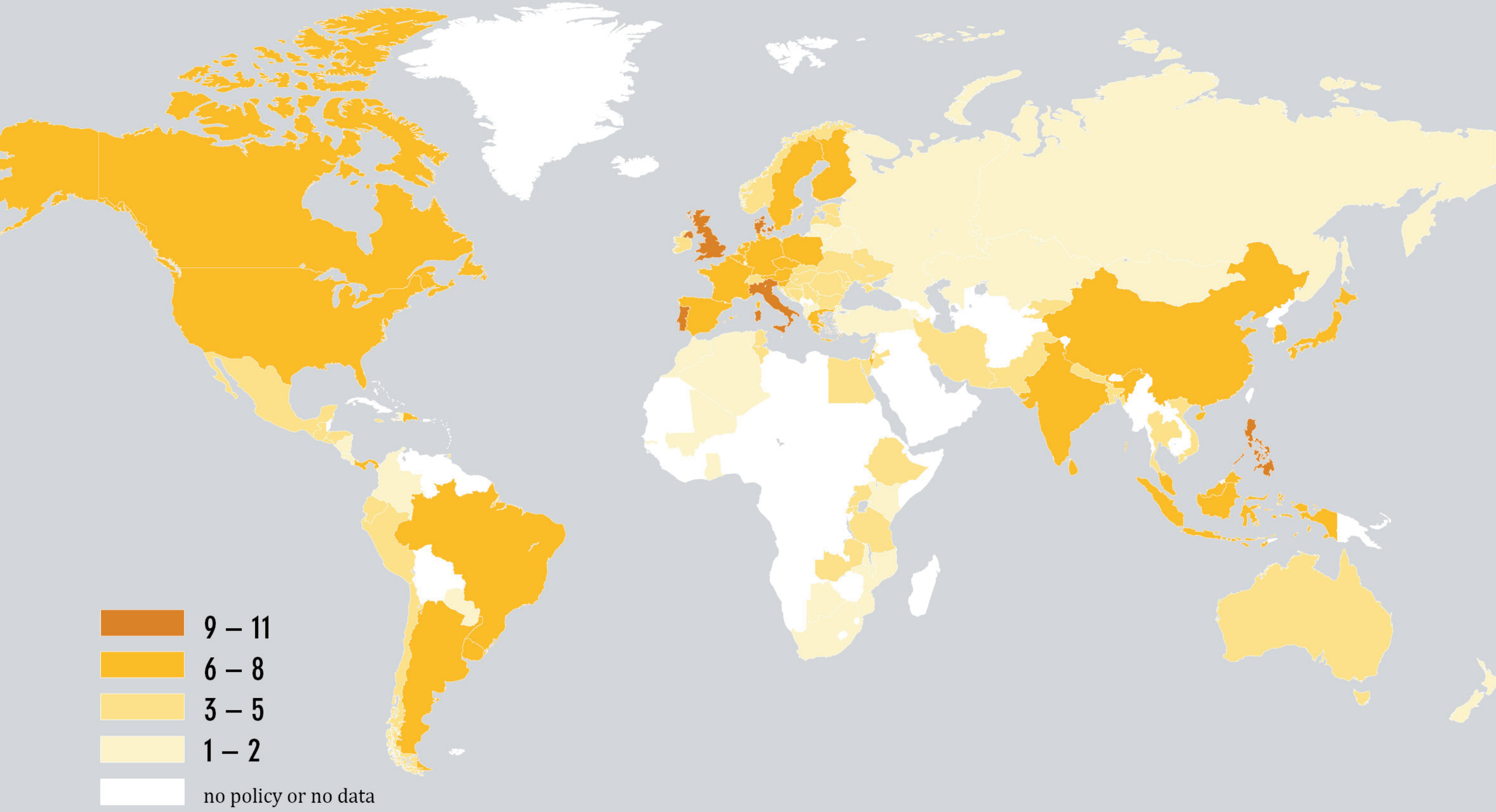
Cities continue to engage collectively in climate mitigation actions by pooling their expertise and knowledge through several networks. In October 2011, the EU Covenant of Mayors welcomed its 3,000th member city.[134] The Mexico Pact, initiated in 2010 under the aegis of the World Mayors Council on Climate Change (WMCCC), was joined by 27 more cities and had 208 signatories at year-end.[135] The *First Mexico Pact Annual Report for 2011*, released at the Durban climate conference in December 2011, reported 297 GHG mitigation actions by member cities.[136]

The *Carbon Cities Climate Registry 2011 Annual Report*, also launched at Durban, showed that 555 climate-friendly actions were under way in 51 cities in 19 countries.[137] There were also 106 registered energy- and climate-related commitments.[138] These networks were increasingly partnering with each other and with other organisations. For example, the C40 formed a partnership with the World Bank to address financial barriers to climate-oriented actions at the city level; ICLEI partnered with the WMCCC on a capacity building programme and with the C40 to review urban GHG emissions standards to boost cities' ability to access funding for climate mitigation actions.[139]

i - According to ABI Research on smart cities, smart city projects are present in 36 cities in Europe, 32 in North America, 21 in Asia Pacific, six in the Middle East, and two in Latin America.

2012 POLICY MAPS

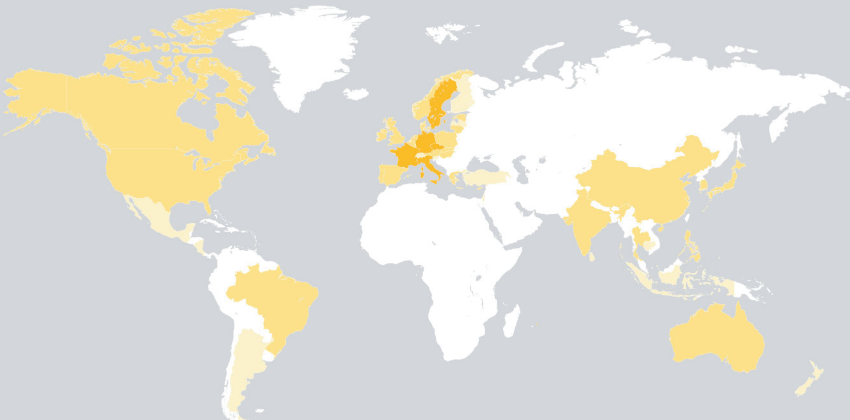
FIGURE 23. COUNTRIES WITH POLICIES, EARLY 2012



+9

NEW COUNTRIES DEFINED RENEWABLE ENERGY TARGETS IN 2011

FIGURE 24. COUNTRIES WITH POLICIES, 2005



THE NUMBER OF COUNTRIES WITH RENEWABLE TARGETS MORE THAN DOUBLED BETWEEN 2005 AND 2012. A LARGE NUMBER OF CITY AND LOCAL GOVERNMENTS ARE ALSO PROMOTING RENEWABLE ENERGY.

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

05 RURAL RENEWABLE ENERGY

Modern renewable energy plays an important role in providing energy services to the billions of people who depend on traditional sources of energy. Traditional biomass—including waste wood, charcoal, and manure —remains the most predominant fuel source in rural areas of developing countries. In addition, people often rely on kerosene lamps or candles for lighting, expensive dry-cell batteries for radio or mobile phone charging, and inefficient, polluting, and costly diesel generators for other purposes.

Access to modern renewable energy not only counters the health and environmental hazards associated with current energy sources, but can also increase the quality and efficiency of providing basic necessities like lighting, communications, heating, and cooling. In addition, modern renewable technologies, such as wind turbines, provide additional services using motor power, such as water pumping, which can improve quality of life and promote economic growth.

Significant technological innovation and cost reductions, along with improved business and financing models, are increasingly creating clean and affordable energy solutions for people and communities in developing countries, providing them with sustainable rural electrification, heating, and cooking solutions.

According to the International Energy Agency, a positive trend has been noted in terms of access to energy in rural areas of the developing world. The IEA reports that approximately 1.3 billion people lacked access to electricity in 2011, a marked improvement over the 1.5 billion people without electricity access in 2010; further, it was estimated that the number of people who cooked their food and warmed themselves using open fires or traditional cookstoves reached 2.6 billion, down from the 3 billion people reported in 2010.[1]

Despite this advancement, the IEA estimates that annual investment in the rural energy sector needs to increase more than fivefold to provide universal access to modern energy by 2030.[2] Achieving this access and expanding the use of renewable energy sources are two of the objectives of the United Nations' Sustainable Energy for All initiative, launched as part of the International Year of Sustainable Energy for All.[3] (See Sidebar 9.)

Rural renewable energy markets in developing countries differ significantly for numerous reasons. Additionally, there exists a large number of active players in this sector –including development banks, international development agencies, private corporations, non-governmental organisations (NGOs), and local governmental bodies –and participants differ from one region to the next. The large diversity of actors and programmes, and the lack of coordination, makes impact assessment and data collection challenging, resulting in the absence of consolidated and credible data. In addition, a large portion of the market for small-scale renewable systems is paid in cash, and such sales are not tracked. 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 programmes and countries.[i]

RURAL RENEWABLE ENERGY TECHNOLOGIES

In the last 10 years, renewable technologies have experienced significant improvements, enabling them to provide competitive and sustainable alternatives to traditional fuels. Most developing countries have a natural advantage because of their abundant renewable resource potential, making the renewable solution to energy problems even more competitive relative to the rising prices of traditional energy sources.

For a majority of very remote and dispersed users, decentralised off-grid electricity is less expensive than extending the existing power grid, due to the high cost of grid extension. At the same time, developing countries have begun deploying more and more grid-connected renewable capacity for urban and other consumers, which is in turn expanding markets and further reducing prices, potentially improving the outlook for rural renewable energy developments.

Off-grid technologies have seen significant advances in recent years:

- Advances in the design, performance, and dissemination of biomass cookstoves have been impressive. Some advanced wood-burning cookstoves emit less particulate matter and carbon monoxide than liquefied petroleum gas does. Thermoelectric generators (TEG) are becoming cost-competitive and allow stoves to generate both heat and electricity, enabling them to operate fans for improved combustion, or to charge mobile phones or provide electricity for other applications.
- Pico PV (or Solar Pico Systems, SPS) has emerged as a new key word in rural electrification. These very small (<10 Wp) systems enable people to access modern energy services in cases where the cost of larger Solar Home Systems (SHS) is not affordable or the energy demand is too low. SPS are "Plug & Play" systems

i - In an effort to cover the existing data gaps and present a holistic view of the existing state of rural energy markets, this section is based on a stakeholder survey, complemented by a literature analysis. It is expected that an improved database of rural energy data and initiatives undertaken to promote the concept of "sustainable energy for all" will help monitor future developments in the field.

SIDEBAR 9. 2012: THE INTERNATIONAL YEAR OF SUSTAINABLE ENERGY FOR ALL

Without access to energy, there can be no development. Yet one in five people on the planet still lacks access to modern energy services. In developed countries, the problem is not one of shortage but of waste, due to inefficient energy use. The key to both challenges is to provide sustainable energy for all—energy that is accessible, affordable, cleaner, and more efficient than current sources.

In December 2010, the United Nations General Assembly declared 2012 as the International Year of Sustainable Energy for All. UN Secretary-General Ban Ki-moon has supported the Year with his new global initiative, Sustainable Energy for All (www.sustainableenergyforall.org), which seeks to mobilise global action on three interlinked objectives to be achieved by 2030: universal access to modern energy services, improved rates of energy efficiency, and expanded use of renewable energy sources.

The Initiative brings all sectors of society to the table, and new and scaled-up commitments will drive action on the ground. Following the Global Launch of the Year at the World Future Energy Summit in Abu Dhabi in January 2012, a series of regional rollout events was held in the lead-up to the UN Conference on Sustainable Development (Rio+20) in June. At Rio+20, the Secretary-General will invite all stakeholders to announce their initial commitments in support of an Action Agenda that generates game-changing momentum for a sustainable energy future.

Action commitments should be transparent and monitored, and can take many forms:

- Governments can develop national energy plans and targets, provide financial support, and remove counter-productive tariffs and subsidies;
- Companies can make their operations and supply chains more energy efficient and form public-private partnerships to expand sustainable energy products and services;
- Investors can provide seed money for clean technologies and invest in both on- and off-grid energy solutions;
- Industry, government, and academia can contribute new research; and
- Civil society groups can train people, conduct advocacy, and encourage transparency.

Source: See Endnote 3 for this section.

that typically have a voltage up to 12 V. Solar lanterns have also seen quality improvements and have been adapted to meet the needs of local communities; they have also become more readily available and affordable.

- While the technological trend in wind energy is moving towards bigger generators, some companies aim to enter the off-grid market with the advent of small and medium-size generators that will make decentralised wind a competitive solution.
- Hybrid systems—consisting of SHS, Pico systems, wind turbines, and hybrid or renewable-powered mini grids—present enormous potential to substitute fossil fuels in existing energy systems, thereby making infrastructure costs decline radically.
- Low-temperature solar thermal has experienced significant growth in developed and developing countries and continues to have a large untapped potential.

Improvement in renewable energy technologies is also visible in other elements such as electronics, batteries, and software (balance of systems, BOS) that make the management and maintenance of all technical solutions more reliable, cheaper, and safer. In addition, water applications using renewable sources have been improved, especially in desalination solutions, maintaining a growing competitiveness in pumping for drinking water and all agriculture uses.

ACTORS IN THE FIELD OF RURAL RENEWABLE ENERGY

While the structure of energy supply in developed countries is complex, the complexity pales in comparison to most developing countries, where circumstances range from countries that have aggressive government "energy access" programmes but face enormous challenges and barriers, to countries with limited government intervention and severe energy poverty. Initiatives in countries that lack government support and funding often end in failure; this is because they are frequently implemented through acts of charity and lack clear conceptualisation, due to insufficient infrastructure and lack of domestic capacity-building potential and expertise.

Because of the diversity of situations as well as the variety of renewable technologies, typologies, and applications, the actors in this field are also very diverse, ranging from small private distributors of solar lanterns, Pico systems, and modern cookstoves, to national governments, international NGOs, and development banks.

The primary actors in the rural renewable energy sector include: end users (private individuals and communities); national, regional, and local governments; utility companies; rural electrification agencies; development banks and multilateral organisations; international and national development agencies; NGOs; private donors; and manufacturing and installation companies. They also include up-and-coming private investment companies, O&M entities, system integrators, national-level importers, regulators, extension agents, local technicians and industries, microenterprises, and micro-finance institutions (MFIs).

INDUSTRY TRENDS AND FINANCIAL MODELS

In recent years, the impressive market growth in renewable energy technologies has spurred a dramatic increase in both the number of manufacturers and the potential to supply renewable energy worldwide, resulting in improved products, better prices, and greater choice. Combined with the overall economic and financial crisis, and changing political frameworks in renewable energy markets in developed countries, this trend has resulted in some important consequences that affect the potential development of rural energy in developing countries.

Although the budgets of international development agencies of some countries have declined, negatively affecting many donor-supported rural energy projects, other trends indicate a positive development in rural renewable energy. Lower prices are making renewable energy technologies more widely affordable, and slower demand in some traditional developed-country markets has led manufacturers and installers to turn their focus to emerging and developing countries. Meanwhile, private investment companies that have profited from and gained experience in the renewable field are looking for new avenues of growth, particularly in developing and emerging economies.

Recent developments also include initiatives that aim to counter challenges arising from the absence in some countries of adequate legal and financial frameworks to facilitate safe investment by private entities. For example, under the Ghana Energy Development & Access Programme GEDAP, the World Bank and Ghana collaborated on the Power Distribution and rural electrification to reform regulations and extend electricity access to rural areas, which led to the introduction of incentives for feeding renewable power into the extended grid (see Table 3). This is the dominant model for rural electrification; nevertheless, there are good examples where rural electrification is implemented by the national electricity company, as in Morocco and Tunisia.

The coordinated efforts between industry, private financing companies, and all other stakeholders will continue to facilitate the momentum required to advance rural energy markets in developing countries. A large number of financial models have been implemented, ranging from the small retail market (such as franchise models) and public and private micro-financing initiatives, up to large national/multistakeholder programmes.

The following sections provide an overview of rural energy developments and trends by region. The Pacific Islands and other smaller regions are not included because of data and space limitations. Africa has by far the lowest rates of access to modern energy services, while Asia presents significant gaps among countries, and the rate of electrification in Latin America is quite high.

AFRICA: REGIONAL STATUS ASSESSMENT

Across Africa, electric utilities have failed to provide adequate service to the majority of the region's population, especially rural communities and the urban poor. Meanwhile, severe drought across the northern sub-Saharan region has reduced generation from existing hydropower capacity, among other impacts. Despite efforts to promote electrification in sub-Saharan Africa, the region has the lowest electrification rate in the world, and more than 650 million people rely on traditional biomass for heating and cooking. (See Reference Tables R16 and R17.)

Solar PV Pico systems (SPS) and solar home systems (SHS) are two of the most popular lighting solutions in Africa. Mini-grids based on PV and hybrid systems (including small hydro and wind) are gaining popularity in villages that are sufficiently dense and well-off, due to their economies of scale and to the demand for electrical services beyond lighting, including communications, space cooling and refrigerators, and motive services (such as water pumping and irrigation). The popularity of advanced cookstoves is also on the rise in many African countries; an increase in numbers can be attributed to a variety of projects in the region.

The 15 ECOWAS countries[i], which plan rural energy advancement programmes through their Centre for Renewable Energy and Energy Efficiency (ECREEE), make up one of the most active regions in Africa in the promotion of renewables and energy efficiency. With support from the Africa-EU Renewable Energy Cooperation Programme (RECP), a flagship programme under the Africa-EU Energy Partnership (AEEP), ECREEE develops regional policy guidelines that are subsequently applied in ECOWAS member states. In addition, ECREEE has several strategic agreements with various international organisations, such as IRENA and UNIDO, to improve rural energy access and energy efficiency. The success of ECREEE is now being studied as a model for other regions in Africa.

ELECTRICITY

Players in Africa developed, implemented, and realised a number of rural energy programmes and targets in 2011 to extend electricity access through renewable energy technologies.

During 2011, Gambia, Ghana, and Nigeria enacted policies to help extend electricity to rural populations. In Gambia, a 10,000 SHS programme, with an estimated budget of nearly USD 7.4 million, was established to provide systems for households, schools, health centres, and ICT centres. Ghana, which has already achieved a 72% electrification rate, enacted a Renewable Energy Law in 2011 and plans to achieve universal energy access by 2020. The law targets the installation of 15,000 solar systems in rural areas by the end of 2013. In Nigeria, the Bank of Industry established an energy loan portfolio to provide power-sector investors with financing at concessionary rates.

In response to these and other policies and programmes, countries saw many significant achievements in 2011, with most in the area of off-grid, stand-alone energy solutions. Botswana's village electrification project, for example, successfully electrified 100 additional villages, for a total of 350 villages.[5] As of late March, the company BPC Lesedi had sold 200 SHS and 280 rechargeable lanterns (as well as 330 efficient cooking stoves) in Botswana.[6] In Ghana, households were supplied with 2,360 SHS and lanterns, for a total of 4,200 solar systems supplied since 2009.[7] In eastern Zambia, 400 solar PV systems had been provided to households under an Energy Service Companies (ESCOs) pilot project.[8]

In Cameroon, off-grid developments during 2011 include the inauguration of the first solar village and solar high school in the Littoral region.[9] And under Malawi's Rural Electrification Programme, three rural villages were electrified with 25 kW centralised solar-wind hybrid systems.[10] In addition, the Local Development Fund constructed 524 houses fitted with solar PV for primary school staff in rural areas, and an NGO-funded micro-hydro plant (75 kW) was completed that is expected to supply electricity to thousands of Malawians in seven rural villages.[11]

South Africa's national electrification programme is under review, with the aim of scaling up delivery. Approximately 5.2 million households in the country were electrified between 1994 and 2010, bringing the electrification rate to 74%, but 3.4 million households still await electrification. Other countries with ongoing national plans include Rwanda, which through its "energy rollout" aims to provide energy access to 350,000 households throughout the country, as well as to 100% of health and administrative centres and more than 500 schools by the end of 2012.[12] In addition, some

i - Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

countries achieved their proposed targets in 2011, such as Tanzania, which increased its rate of rural electrification from 2.5% in 2007 to 14% in 2011.[13]

In northern Africa, Morocco has seen a significant increase in the share of people in rural areas with access to electricity, rising from 20% in 1995 to more than 97% in 2011. In 2010, solar PV represented 2.6% of electrification among households, and 10% for village electrification.[14]

With support from multilateral banks and bilateral aid organisations, countries in Africa and around the world have installed several million small SHS and established market structures for their dissemination. Several countries are piloting innovative business models based on fee for service, pay as you go, or prepaid metering to improve affordability of these systems. The market for solar lanterns has experienced significant momentum: in Africa alone, manufacturers have sold some 502,000 solar lighting applications (all meeting the Lighting Africa quality standards).[15] Lighting Africa is distributing (for USD 30–150) solar lanterns that use light-emitting diodes (LEDs) and offer potential lifetimes of up to five years without battery changes.

Multilateral banks, national development banks, and organisations have spearheaded other efforts as well. Mozambique, for example, has seen significant advances due in large part to funding and other support from the World Bank in partnership with the European Union Energy Facility and the Energy Reform and Access Program, and from the governments of Portugal, Spain, and South Korea. For example, three PV hybrid systems (400–500 kW each) have been installed in 50 villages with funding from South Korea, 50 villages were electrified with funds from Portugal, and 40 villages in four provinces were electrified with funds from Spain; the World Bank-funded programme electrified 150 schools and 150 clinics.

Between 2008 and the end of 2011, off-grid PV capacity in Mozambique increased from 0.3 MW to about 1.1 MW, providing lighting and communication services to over 1.5 million people.[16] In 2011 alone, projects through Fundo de Energia (FUNAE) totaled USD 10 million in various off-grid solar energy projects, including 20 micro-hydro projects in various stages of development and USD 8 million of funds available for further development and implementation, enabling a significant increase in the mini-grid coverage of villages for the coming years.[17]

In Uganda, Germany's KfW Development Bank is supporting an investment programme designed to provide modern energy to 30,000 people, including 30 hospitals and 60 schools, within three years. The remote West Nile region being targeted has a degree of electrification of less than 2%. One of the aims of the programme is to provide energy for improved healthcare services. In total, KfW committed USD 290 million for renewable energy projects in sub-Saharan Africa in 2011.

Throughout Africa, the Dutch-German-Norwegian partnership Energising Development is supporting market development of solar PV systems of various sizes (particularly in Burundi, Ethiopia, Mali, Mozambique, Senegal, and Uganda) and small-scale hydropower plants (in Ethiopia, Mozambique, Rwanda, and Uganda). The partnership is being implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and NL Agency in the form of bilateral government projects.

While most projects in Africa have been for off-grid applications, there are also examples of using renewables to provide grid-connected electrification. Cape Verde inaugurated a wind farm in 2011 with a capacity of 25.5 MW, which provides electricity to four islands of the archipelago; during 2011, the islands generated 7% of their electricity with PV and had peaks of 25% of generation from wind power.[18]

The year 2011 saw some industrial advancement in Africa as well, including the launch of Senegal's first PV module assembly unit (25 MW) in Dakar. Also in 2011, a Kenyan-Dutch joint venture opened the first PV production facility in Naivasha, Kenya, supplying the East African market with PV panels in the range of 30–125 Wp.

HEATING AND COOKING

As of 2010, it was estimated that 65% of Africa's population relied on wood, coal, charcoal, or animal waste for cooking and heating. But there are significant differences from one country to another. For example, more than 93% of Malawi's population (99.5% rural and 85.3% urban) depends on wood biomass for heating and cooking; in contrast, in Rwanda more then 50% of all households owned improved cookstoves in 2008, and the country is well ahead of most of Africa.

Several local, regional, and international policies and initiatives aim to provide an increasing number of households with modern cookstoves as an alternative to polluting and unhealthy traditional appliances.[19] (See Sidebar 10.) To increase the share of its population with access to modern cooking fuels, in 2011 Malawi initiated the Promotion of Alternative Energy Sources Project (PAESP), which aims to substitute wood and charcoal with biomass-waste briquettes and biogas, and introduced a 50% excise tax on wood fuel to discourage its use.[20] Rwanda aims for all households to have improved cookstoves by the end of 2012.[21] In 2011, Botswana developed a rural energy plan that will be in effect until 2016, including biodiesel promotion initiatives related to cooking and heating.

As in the electricity sector, many of the programmes under way are funded and implemented by development banks and other partners. For example, more than 550,000 improved cookstoves have been disseminated in Benin, Burkina Faso, Burundi, Ethiopia, Kenya, Senegal, and Uganda since 2009 with support from Germany's

SIDEBAR 10. STRATEGY FOR UNIVERSAL ADOPTION OF CLEAN COOKSTOVES

Traditional cookstoves and open fires are the primary means of cooking and heating for almost 3 billion people in the developing world. These methods are extremely inefficient, and exposure to their smoke causes 1.5–2 million premature deaths each year, affecting primarily women and children. Foraging for biomass takes time from more productive pursuits, and the unsustainable use of biomass in inefficient stoves increases pressure on local environmental resources. But advances in design, testing, and monitoring, combined with the growth of promising new business models, financing options, and national programmes in some countries, mean that it may now be possible to reach millions of the world's poor with more efficient, cleaner stoves.

The Global Alliance for Clean Cookstoves (GACC), launched in 2010, identifies as one of its primary goals the adoption of clean cookstoves and fuels in 100 million households by 2020. By early 2012, the Alliance had raised USD 30 million and attracted 250 partners, including governments, the private sector, and implementing agencies; the U.S. government has committed USD 50 million. Other programmes include the United Nations' initiative to achieve universal energy access by 2030, and national-level efforts such as the Indian Ministry of New and Renewable Energy's (MNRE) biomass cookstoves pilot initiative for rural community-based applications, launched in 2011.

The GACC pursues a three-pronged strategy focusing on enhancing demand, strengthening supply, and fostering an enabling environment. Efforts are already under way in some countries, including Afghanistan, where 95% of the population relies on traditional cookstoves. The United Nations, GACC, and other partners have teamed up with Afghan villagers to develop clean stoves that will improve indoor air quality, reduce dependence on wood for fuel, and lower associated GHG emissions.

Other international organisations focus on clean cookstoves, including GERES (Group for the Environment, Renewable Energy and Solidarity), which works on cooking and heating projects in Afghanistan, Benin, Cambodia, Mali, Morocco, Tajikistan, and northern India. Germany's GIZ runs several programmes worldwide that focus on decentralised energy-efficient renewable cookstoves. Their aim is to provide modern cooking energy by promoting the sustainable production, marketing, installation, and use of improved cookstoves.

Providing access to cleaner cookstoves is not a new endeavor. SELCO of India, for example, has produced and distributed solar cookstoves for years through programmes run by India's MNRE. But the scale and breadth of efforts now under way are unprecedented. The International Energy Agency's "Energy for All" scenario estimates that about USD 48 billion per year will be needed to achieve universal access to clean cooking energy by 2030.

Source: See Endnote 19 for this section.

GIZ. The ongoing project in Kenya, which is jointly implemented with the Ministries of Energy, Agriculture, and Education, has disseminated approximately 850,000 stoves since it was established in 2005, and provides an example of state-promoted sustainable heating and cooking solutions.

As of 2011, with support from Dutch agency SNV, 8,432 new biogas plants had been installed in nine African countries, and production rates of biogas plants were up 100% compared to 2010. In Rwanda, the National Domestic Biogas Programme (NDBP), with technical and institutional support from the Dutch (SNV) and German (GIZ) development agencies, aims to install at least 15,000 biogas digesters in rural households owning 2–3 cows; a total of 1,846 digesters were installed by the end of 2011.[22]

A joint venture of two private companies aims to replace thousands of charcoal-burning stoves with cleaner ethanol cookers in Mozambique's capital, Maputo. This business, which integrates food, energy, and forest protection, sells clean cookstoves and bottled liquid cooking fuel to low-income households.[23] In Uganda, another joint venture of private companies aims to provide low-income communities with access to energy-efficient household cookstoves; at an estimated cost of USD 20 million, this represents one of the largest carbon-finance commitments made to clean cookstoves in the sector's history.[24]

ASIA:REGIONAL STATUS ASSESSMENT

Although China and India are neighbors and the two largest emerging economies in the world, their energy access situations are strikingly different. With more than 1.3 billion people, China has made extraordinary investments to meet its growing energy needs. The result has been significant increases in access to grid-connected electricity; today, an estimated 5 million Chinese in rural areas lack access to modern energy sources. By contrast, in India almost 290 million people (25% of the population) do not have access to electricity, and 72% of Indians continue to rely on traditional biomass as their primary source of energy.

Both countries have made significant investments in renewable energy capacity, mainly wind and solar. In 2011, the vast majority of China's solar PV installations were grid-connected, but some 20 MW were in off-grid projects and other isolated applications. India installed an estimated 11 MW of off-grid PV in 2011.[25]

Elsewhere in the region, countries have made advances, but countries such as Bangladesh, Afghanistan, Myanmar, and Pakistan continue to experience very low rates of rural electrification and to rely largely on traditional biomass.

ELECTRICITY

During 2011, innovative plans within Asia to advance rural electrification included programmes from Iran in the West to the Philippines in the East. They included government-driven programmes as well as efforts financed by NGOs and development banks.

The Philippines expanded its existing Rural Electrification Programme in 2011 based on experiences gained from previous programmes, with the goal of achieving 90% household electrification by 2017. Nepal implemented its Rural Energy for Rural Livelihood programme in April 2011 to promote rural electrification. In Iran, the Power Ministry, which is responsible for rural electrification, together with the Renewable Energy Organization of Iran (SUNA), has electrified more than 233 households with decentralised PV systems.[26]

The government of China has been proactive in meeting the growing demand for electricity in rural areas. The Renewable Energy Development Program estimates that 400,000 solar home systems were distributed during the period 2006 to 2011.[27] In Bangladesh, the Solar Energy Programme of the national Infrastructure Development Company Limited (IDCOL) has successfully disseminated 1.3 million SHS through 30 partner organisations from the private sector and civil society, with support from the World Bank, the Global Environment Facility (GEF), KfW and GIZ of Germany, the Asian Development Bank, and the Islamic Development Bank.

India's Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) scheme is a major electrification programme mandated by India's national 11th five-year plan (budget allocation of USD 15.5 million (€12 million) per year). Under the RGGVY, the government provides a 90% capital subsidy for participating households, and it has seen the annual rate of rural electrification grow by 18%. As of September 2011, the scheme had electrified 110,000 villages. The RGGVY complements India's remote village electrification programme, and together they have provided approximately USD 16 million for the electrification of 1,483 border villages in northeast India, using solar and hydropower.[28] In addition, the first phase (2009–2013) of India's National Solar Mission promotes off-grid solar systems to provide lighting and basic energy services to people in remote and rural areas, as well as grid-based solar capacity.[29]

While many programmes are focused specifically on solar PV, several initiatives are tapping a variety of renewable energy sources. For example, in Indonesia micro hydropower has been used to provide electricity to 73,000 rural inhabitants, and 800 kW of PV was added during 2011. This is part of a larger programme implemented by the government and the World Bank that provided energy access to 230,000 people in 2011. In Mongolia, between 2007 and 2011, the rural energy access project distributed 41,800 SHS, and installed hundreds of wind turbines and 11 renewable-diesel hybrid systems, and facilitated the rehabilitation of 15 mini-grids.[30]

Distinct from the many government-initiated programmes and targets, a number of initiatives have been developed and implemented entirely by development banks. For example, Germany's KfW financed a programme in Bangladesh that supported about 450,000 SHS. In Nepal, KfW is implementing a programme that aims to install 150,000 SHS.

Nongovernmental actors are also playing a significant role. For example, in India, The Energy and Resources Institute (TERI) launched its "Lighting a Billion Lives (LaBL)" initiative in 2008. This programme is based on enterprise-driven charging of solar lanterns and renting, in a model that aims to benefit the entrepreneurs who manage charging stations, as well as users.[31] (See Sidebar 11.)

It is important to note that there is growing private commercial activity in India, sometimes based in microfinancing schemes, that has enabled the sales of millions of SHS and SPS, as well as stoves and other modern energy systems and appliances.

SIDEBAR 11. RURAL RENEWABLE ENERGY CASE STUDY: LIGHTING A BILLION LIVES

The Energy and Resources Institute (TERI) in India developed the Lighting a Billion Lives (LaBL) initiative in 2008 to facilitate access to clean lighting through solar technologies in rural communities.

OBJECTIVES: To enable rural communities to replace kerosene/paraffin lamps with environmentally friendly solar lanterns and to create incremental livelihood opportunities in rural areas.

TECHNOLOGIES: A typical solar charging station consists of five solar panels with a total capacity of 250 Wp, which can recharge 50 LED lanterns. The charging station acts as a centralised station, and each of the solar panels charges simultaneously 10 solar lanterns connected through a junction box designed appropriately by TERI under the LaBL campaign.

PARTNERS: The initiative has expanded and reaches the most remote corners of India in association with some 80 grassroots partners, referred to as LaBL Partner Organizations. In addition, around 30 Technology Partners are working to promote the collaborative research and development of quality off-grid lighting products together with leading industry partners.

BUDGET: The budget for 2008–11 was INR 90 million (approximately USD 1.7 million), and for 2011–12 is INR 175 million (approximately USD 3.3 million).

FINANCING SCHEME: Funding to cover the initial capital costs comes from multiple sources and community contributions; the operation and maintenance costs are covered by the rental income earned by the entrepreneurs who manage the solar charging stations. The initiative harnesses financial support from the central and state ministries/governments, corporations and individuals, and bilateral and multilateral agencies. Currently, the cost of setting up a charging station is INR 175,000 (USD 3,300), of which INR 40,000 (USD 750) comes as equity from the users/entrepreneurs, and INR 20,000 (USD 370) as a subsidy from the Ministry of New and Renewable Energy under its National Solar Mission. TERI raises the remaining amount from various corporations (as part of their corporate social responsibility) and through fundraising events.

BENEFICIARIES: The total number of beneficiaries, by the end of 2011, was around 74,000 households from 1,486 un-electrified and poorly electrified villages spread across 21 Indian states. Prior to the project, the villagers did not have access to electricity and were completely dependent on kerosene and other inefficient sources to meet their lighting needs.

SOCIAL AND ECONOMIC IMPACTS: So far, the LaBL initiative has improved an estimated 370,400 lives, and has enabled communities to access clean lighting with solar lanterns. Some 1,486 solar energy micro-enterprises have been set up in the form of solar charging stations for recharging and renting of lanterns. The replacement of kerosene lanterns has led to savings of 220,000 litres of kerosene every month.

Source: See Endnote 31 for this section.

HEATING AND COOKING

To address the significant reliance on traditional fuels for cooking in Asia, a number of programmes and projects have aimed to provide access to clean cookstoves and fuels, particularly biogas.

In 2011, India launched a National Cookstove Programme that is expected to avoid 17% of the premature deaths and disabilities, caused by respiratory infections, heart disease and bronchitis, that would otherwise occur by 2020.[32] In Bangladesh, more than 3 million people have received clean cookstoves through a programme implemented by the government and financed by the World Bank and IDC Ltd. In 2011 alone, 13,300 new biogas plants were installed in Bangladesh. Across Asia, approximately 56,740 new biogas plants have been installed as part of various national and international initiatives, all with the support of SNV (Netherlands).[33]

In Nepal, KfW (Germany) and other financing institutions are implementing a programme financing 250,000 biogas plants, benefiting more than 1 million people in rural areas. There are also innovative programmes in place in various regions of India, as well as Cambodia, Sri Lanka, and elsewhere, and a number of Asian countries have joined the Global Alliance for Clean Cookstoves.

The Asian Development Bank (ADB), at the end of 2010, approved support of USD 21 million (funded from the Asian Development Fund) for the Rural Renewable Energy Development Project to help Bhutan expand rural electrification for households, sustain its operations and energy security, and provide a mix of clean energy supply sources, including biogas for cooking.[34]

LATIN AMERICA: REGIONAL STATUS ASSESSMENT

Across Latin America, an estimated 7% of the population (nearly 31 million people) does not have access to electricity, and almost 19% (85 million) depends on traditional biomass for heating and cooking. Lack of access is primarily a rural issue; only about 1% of the urban population lacks electricity, whereas the rural share is 28%. Compared with other developing regions of the world, Latin America is far closer to achieving full energy access, particularly access to electricity.

Due to geographical limitations, the only viable solution for most of the relatively small share of the region's population living in isolated regions is renewable off-grid technology. In the last decade, the Andean region (Colombia, Ecuador, Bolivia, and Peru), as well as some Central American countries, have developed numerous off-grid projects. For example, SHS installations under the main projects include: 60,000 systems (2,600 kW) in Bolivia; 2,200 systems (110 kW) in Ecuador; 6,000 systems (215 kW) in Nicaragua; 5,000 systems (250 kW) in Honduras; 10,000 systems (1,500 kW) in Peru; and 30,000 systems (2,843 kW) in Argentina.

Recent oil price increases have made solar PV more cost competitive, driving the installation of large PV plants to provide electricity to isolated regions that traditionally have been dependent on diesel.

ELECTRICITY

A number of off-grid and mini-grid solutions have been created in countries from Argentina to Mexico.

Specific advancements during 2011 included the installation of 170 electrification systems (of a total of 12,000 planned) in the Argentinian province of Neuquén, as part of the national programme of rural electrification; and the installation of a 1 MW PV plant in Calama in northern Chile.[35] The Calama plant is expected to produce 2.7 GWh of electricity annually, and no subsidies were required for its installation. Both Honduras and Nicaragua have actively promoted SHS and, over the past two years, they have disseminated some 1,600 and 840 systems, respectively, through national programmes.

In Brazil, one of the significant developments during 2011 included 12 mini PV plants with mini networks. This project measures consumption remotely and invoices consumers through a prepayment system that offers a relevant technical-financial solution for remote areas.

Brazil established the Luz para Todos ("Light for All") programme in 2003 with the aim of providing universal electricity access by 2014. As of end-2011, 14.5 million people (2.9 million households) had benefited, with almost half of them in the poorest part of Brazil's northeast region.[36] Renewable energy has played a small role in the programme. However, as distances increase between rural villages and load centres, the costs of extending the grid rise as well, and at some point it becomes infeasible to provide electricity via a centralised system. As a result, the role of renewables is rising. Decentralised renewables play more of a role in the current phase, particularly in remote and isolated villages of the Amazon region.

Mexico has created several programmes and projects to advance rural energy access through renewable energy, including several large electrification projects, with the aim of enabling the Federal Electricity Commission (CFE) to provide energy solutions to the 2.5% of Mexicans living in low-income rural communities. The Banderas Blancas ("White Flags") programme plans to electrify more than 700 rural communities (with 100–2,500 inhabitants each) with both conventional methods and distributed solar PV farms (30 kW).

Additionally, a pilot project is being implemented with the Energy Transition Fund (financed by the World Bank) to provide small communities (<100 inhabitants) with individual SHS. It is operated by the local NGO ILUMEXICO, and its goal is to provide 1,050 lighting systems to rural households in two of the poorest states in Mexico. The national Integrated Energy Services Project promotes rural electrification projects, based on renewable energy, in the states of Chiapas, Guerrero, Oaxaca, and Veracruz, with the goal of providing electricity to 50,000 households over the period 2008–12.

Developments in Mexico at the state level include the programme Luz Cerca de Todos ("Light close to All"), implemented by the Querétaro State Government through the Center for Sustainable Development (SEDESU). The SEDESU has implemented mechanisms to finance this programme, which aims to electrify 7,000 households with SHS (85 W) by 2015 to achieve statewide universal energy access.

In Peru, the national electrification strategy is to provide electricity services to 95% of the 500,000 isolated households—using PV systems, wind turbines (4%), and small- and micro-hydro projects (1%)—by the end of 2012. The total capacity to be installed is estimated at 32.2 MW. Peru also has a centralised PV system, in Vilcallamas, which was developed as part of a GEF-financed pilot project, benefiting more than 40 households with the goal of improving productivity of local alpaca fibre processing.[37]

Elsewhere in the region, NGOs and civil society have played a role in increasing access to electricity. For example, the SOLUZ programme in the Dominican Republic, created by the NGO ENERSOL, provides electricity services through a dispersed network of managers. The programme implemented a solar PV leasing scheme that offers unsubsidised electricity service for an installation payment and monthly fee (approximately USD 20 per month for a 50 W system). The first stage of the project focused on providing management experience and was developed through donations; this played a key role in the success of the enterprise, which has led to the installation of more than 3,000 SHS.

Another off-grid project that demonstrates the role of civil society in successful energy initiatives is the FECORSUR project in Argentina. The project is implemented by a group of sheep wool producer's cooperatives (Federación de Cooperativas de la Región Sur) in the southern region of Argentina, with technical support from the National Atomic Energy Commission and Fundación Bariloche, and funding from the Inter-American Development Bank (IDB) through the IDEAS initiative.

HEATING AND COOKING

In contrast with the region's advances in renewable rural electrification, developments in the heating and cooling sector are relatively limited. For example, about one-quarter of Mexico's population still cooks on open fires or with old, inefficient cookstoves, resulting each year in an estimated 18,000 premature deaths, the burning of more than 20 million tons of wood, and significant carbon dioxide emissions.

A number of programmes have been implemented by governments, development banks, and the private sector to address this situation, in Mexico and in other countries in the region. Mexico and Peru have ongoing large-scale programmes to disseminate improved cookstoves, with the aim of reaching 1 million units. A group of Central American countries with common policies[i] has also committed to disseminating 1 million improved cookstoves by 2020. Other countries where improved cookstoves are being promoted include Bolivia and Peru.

EcoZoom completed a pilot programme in Mexico, replacing 10,000 cookstoves across the country with a safer, more efficient version designed specifically for cooking in Latin America. A similar programme is being implemented by the Central American Integration Bank (BCIE), which approved a USD 1 million grant to Honduras to provide 9,575 clean cookstoves to households. A preliminary pilot project was launched in 2011 to demonstrate the potential of larger biomass cookstoves for community-based applications in rural areas. The success of this programme could lead to development of many such programmes in the future.

In the Central American region, dissemination strategies include social marketing, micro-financing, awareness campaigns, and real-time monitoring of stove use. In addition, carbon markets have been used increasingly to finance Central American cookstove projects.

Although most of the focus in the cooking and heating sector is on cookstoves, solar thermal systems also provide an option for water and space heating. In Mexico, the Solar Water Heaters Promotion Program (PROCALSOL), which ends in 2012, aims to promote widespread use of solar thermal energy.

In conclusion, the rural renewable energy market is highly dynamic and constantly evolving; it is also challenged by the lack of structured frameworks and consolidated data sets. Most countries are developing targets for electrification that include renewable off-grid options and/or renewably powered mini grids; there is also some use of grid-connected renewable electricity. In the rural cooking and heating market, advanced cookstoves fueled by renewable sources are gaining impetus as reliable and sustainable alternatives to traditional cookstoves.

Although its use is still minimal in most countries, solar thermal offers enormous potential for heating and cooling as well, including for meeting local industrial needs. In addition to a focus on technologies and systems, most developing countries have started to identify and implement programmes and policies to improve the ongoing operational structures governing rural energy markets. Such developments are increasing the attractiveness of rural energy markets and developing economies for potential investors.

The need for rural energy in developing countries is, above all, related to the need for social and economic development for billions of people around the world. After many years of relatively slow political, technical, financial, industrial, and related developments, the impressive deployment of all renewable energy technologies and the reduction of the cost together point to a brighter future.

i - Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panamá.

FEATURE:

RENEWABLE ENERGY AND ENERGY EFFICIENCY

Improving energy efficiency is valuable irrespective of the primary energy source, but there is a special synergy between energy efficiency and renewable energy sources.

06

FEATURE: RENEWABLE ENERGY AND ENERGY EFFICIENCY: A SYNERGISTIC ALLIANCE

Energy efficiency and renewable energy policies have been defined as the "twin pillars" of a sustainable energy future. The more efficiently energy services are delivered, the faster renewable energy can become an effective and significant contributor of primary energy. And the more energy obtained from renewable sources, the less primary energy required to provide the same energy services.

Energy efficiency and renewables can work together to reduce peak electricity demand on the grid while easing transmission losses and bottlenecks, lowering system-wide environmental and economic costs. Non-fuel renewables even manage to improve system efficiencies on their own, as they remove the losses inherent to the thermal conversion of fossil fuels. A true synergy is obtained when one pillar supports the other, enabling applications that otherwise might not be technically or economically practical; in this instance, the outcome may exceed the sum of the parts.

ENERGY EFFICIENCY AND RENEWABLE ENERGY SYNERGIES

While economies are sometimes measured by the energy that flows through them, more often they are judged by their effectiveness in converting that energy into tangible value. Homes and businesses value energy services—such as lighting, communications, a warm home, cold drinks, etc.—rather than merely units of energy. The total amount of energy required to deliver those services depends on the energy source and on the losses that occur at each step as primary energy is extracted, transformed, transported, and transmitted, including end-use conversion at the point of service. Vast quantities of energy are wasted along the way before actual utility is delivered to people. Worldwide, well over half of the energy consumed does not provide useful services; most of it is lost in the form of waste heat[1]. Each stage, from primary energy extraction through end-use conversion, provides opportunities for improving overall system energy efficiency—or, providing the same services with less energy input.

Improving the efficiency of each step along the way is advantageous irrespective of the primary energy source, but there is a special synergy between energy efficiency and renewable energy sources. This synergy occurs in several ways, both in the technical and policy context. Such synergies include:

- Many renewable energy technologies are well suited for distributed uses, producing useful electricity or heat close to the point of use, reducing transportation and transmission losses. As a result, less primary energy is required to provide the same energy services. By reducing the demand on the electrical transmission and distribution grid, distributed energy improves efficiency and may provide additional cost savings for the total energy system.
- Efficient building design that utilises passive solar heat and light obviates energy conversion technologies while reducing system energy demand.
- Improving end-use efficiency in delivery of energy services reduces primary energy demand for all sources. In addition, lower end-use energy requirements increase the opportunity for renewable energy sources of low energy density, such as solar, or of low energy content, such as low-temperature solar heat, to meet full energy-service needs.
- Improvements in end-use energy efficiency reduce the cost of delivering end-use services by renewable energy. The money saved through efficiency can help finance additional efficiency and deployment of renewable energy technologies.
- Targets for increasing shares of renewable energy, which consist of the provision of energy with renewable sources as a portion of total energy demand, can be achieved through both increasing the amount of renewable energy and/or through reducing total energy consumption (e.g., through improvements in energy efficiency).

Synergies between renewable energy and energy efficiency exist across a number of sectors. Examples include:

ELECTRICAL SERVICES

The more efficient is the pump, refrigerator, computer, lighting, or other appliance, the lower the end-use demand for services, and thus the smaller the size (and the lower the cost) of the renewable energy system required. If electrical storage devices are needed, their scales and costs are reduced as well. When a grid-connected building or factory is powered by distributed energy, such as rooftop solar PV, less electricity needs to be transmitted so transmission and distribution losses are lower, there are no heat-to-electricity conversion losses, and of course there are no carbon dioxide emissions.

With appropriate building design, day lighting can supply a very large portion of lighting services, and the remainder can be provided more efficiently via rapidly evolving lighting technologies. The replacement of traditional incandescent lamps with more-efficient halogen and compact fluorescent lamps (CFLs) has reduced the marginal electricity requirement for lighting services by about 75%, while light-emitting diode (LED) lamps promise even further improvement.

SPACE HEATING AND COOLING

Buildings are not often thought of as renewable energy collectors or appliances, but they can be designed to capture useful renewable energy and to maximise the efficiency of its use. An increasing number of commercial and residential buildings are so tight and well insulated that most heating needs can be met with solar energy, using passive solar design; thermal storage can expand the amount of passively collected heat that can be used. Buildings also can be designed for passive use of cooling with appropriate shading devices and capture of cooling breezes.

In extremely cold or cloudy regions, supplementary energy is needed, but an efficiently designed building can require as little as 10–20% of the energy of a traditional structure, even without passive solar heating.[2] This means that smaller systems can suffice, further reducing the costs of heating with renewable energy technologies such as biomass boilers, or wind or solar PV to power a heat pump. Indeed, if a building is not very tight and well insulated, the size and cost of a solar- or wind-powered heat pump system for heating and cooling might be prohibitive and/or require operation outside optimal parameters, which results in lower system efficiencies. Efficient building shell and efficient heating and cooling technologies are therefore interdependent.

INDUSTRIAL PROCESSES

Industry demands substantial amounts of energy in the forms of electricity, heat, and mechanical services. Hydro resources have powered major industrial development over the past century, while CSP, wind power, and PV are now demonstrating that they also can meet industrial needs. Still, renewables become more effective as industrial processes become less energy-intensive and are modified in ways that reduce the inherent need for fossil fuels. For example, as carbon fibre composites replace energy-intensive steel for auto bodies, it becomes easier to substitute fossil fuels with renewable energy at fabrication plants because both total energy use declines and process-specific demand for natural gas and coal in blast furnace operations is displaced. Harnessing the rich variety of chemical substances and materials from plants will allow industry to take advantage of biochemical conversion methods rather than energy-intensive chemical processes.

TRANSPORT

Renewables offer three potential options for providing mobility—liquid and gaseous biofuels, electricity for battery-powered or hybrid vehicles, and renewably generated hydrogen for fuel cells—and benefit immensely from energy efficiency improvements. As vehicles become more efficient, they require less fuel per kilometer driven, enabling biofuels to make a larger contribution to transportation.

Battery-powered electric vehicles benefit from the greater efficiency of electric motors over internal combustion engines. While internal combustion engines utilise only about 20% of the heat energy in liquid fuels to propel a vehicle and waste the rest as heat, EVs convert 80% of the electrical energy they use into mechanical motion. Because all renewable energy sources can produce electricity, ultimately, all EVs could be powered by renewables. Charging batteries with solar energy during the day, while vehicles are parked, reduces by two-thirds the primary energy relative to thermal power generation; parking lot- or garage-based charging also largely eliminates transmission losses.

Hydrogen-powered fuel cell vehicles are highly efficient (although less so than battery-operated EVs[3]) and, as with battery-electric vehicles, the greater the efficiency of the fuel cell and vehicle, the lower the cost of producing the hydrogen for each kilometer driven. Hydrogen is currently produced from natural gas, but it also can be produced by any renewable electricity source from water, and processes are being developed to produce it through direct use of sunlight.[4]

ENERGY EFFICIENCY POTENTIAL AND CURRENT TRENDS

Between 1990 and 2007, world gross domestic product rose by 156% while primary energy demand increased 39%.[5] Over this period, energy productivity gains—due largely to improvements in energy efficiency—saved the world an estimated 915 EJ of energy, or almost twice the total global primary energy use in 2007.[6] Individual countries have done even more, but still the potential for further improvements is vast; this is particularly true in the developing world, but even the world's most energy efficient economies still have large untapped "resources" of additional potential improvements.

Energy efficiency data and trends can be difficult to measure, and few statistics are currently collected and published on a global level. However, there are some numbers in the lighting, appliance, and building sectors that provide a sense of current trends.

Some of the greatest efficiency gains in end-use energy in recent years have been in supplying lighting. Compact fluorescent lamps (CFLs) have been on the market for over 25 years and provide the same amount of light (measured in lumens) as traditional incandescent bulbs with one-quarter of the electricity. While CFLs remain the most cost-effective lighting, they lack many desirable features of more costly light-emitting diodes (LEDs), which have comparable efficiencies with better colour rendering and longer operating lives.[7] In developing countries, rugged LEDs are being incorporated into portable solar-powered lamps that can include a phone charger and radio.

Appliance standards, which are upgraded periodically, have been in place in both Europe and the United States since the oil shocks of the 1970s. As of 2010, standard U.S. refrigerators used about 75% less energy than those manufactured in the late 1970s.[8] Europe has a system of constant upgrading and abandonment of the least-efficient category, and the region's appliances are among the most efficient in the world.

Vehicle fuel economy has also improved, with the strictest standards and greatest advances in the EU and Japan.[9] In the United States, fuel economy increased by 60% between 1980 and 2006, all factors being equal, but average gas mileage increased by just over 15%. The difference is due to the fact that most of the efficiency gain went to increased vehicle weight and horsepower.[10] Europe experienced a similar trend, with efficiency improvements greatly counterbalanced by increased engine performance and vehicle weight, but this trend reversed starting in 2006, in part because of rising fuel prices.[11]

An estimated 30–40% of total global primary energy use is for buildings.[12] Although they still represent a very small percentage of buildings, the number of "green" and energy efficient buildings is on the rise. Buildings designed to meet the Passivhaus standard are extremely efficient and require little energy for space heating or cooling. As of mid-2010, as many as 25,000 Passivhaus-certified structures—including residential, office, school, and other buildings—existed in Europe.[13]

By November 2011, the U.S. LEED (Leadership in Energy and Environmental Design) certification had been granted to nearly 11,100 projects around the world, accounting for 2 billion square feet (0.19 billion m^2) of floor space; the 1 billion mark was passed during 2010.[14] It was estimated in 2009 that LEED buildings reduce energy use by an average of 33%, and that they had saved a cumulative 400 million vehicle miles (644 million vehicle kilometers) traveled and 0.03 EJ of energy.[15] In addition to Europe and the United States, buildings using these and other certification systems have also been developed in Australia, China, India, Japan, and Taiwan.[16]

POLICIES TO ADVANCE ENERGY EFFICIENCY AND RENEWABLE ENERGY

To date, there has been little systematic linking of energy efficiency and renewable energy in the policy arena. In some cases, efficiency and renewables are even put in competition with one another. For example, building codes in many countries allow the use of renewable heating to compensate for improved insulation, while others allow renewable heating to compensate for efficiency improvements.[17] But there exist an increasing number of policies to advance efficiency of lighting, appliances, buildings, and vehicles.

Advances in lighting technologies have been driven largely by the increasing number of policies around the world to phase out traditional incandescent light bulbs. Cuba exchanged its incandescent bulbs for CFLs in 2005, and Brazil and Venezuela began phasing them out that same year.[18] They were followed by Australia, the EU, and Switzerland a few years later. Other countries with planned phase-outs include Argentina, Canada, Russia (all in 2012), Malaysia (by 2014), and China by 2016.[19] India set a goal in 2009 to replace all of the nation's 400 million bulbs with CFLs by 2012, and Algeria plans to adopt 3.75 million CFLs between 2011 and 2014.[20] While the United States has not banned incandescent bulbs, energy performance standards will apply to all bulbs by 2014, and the U.S. Department of Energy sponsored a competition (with the prize awarded in 2011) to encourage lighting manufacturers to develop high-quality, high-efficiency solid-state lighting products.[21]

Energy efficiency labels and standards for appliances exist in the EU, United States, and many other countries, including China, where minimum energy performance standards were first adopted in 1989. Additional countries including Colombia and South Korea also have strong energy efficient standards, and Thailand has a labelling programme.[22] Realising that about 80% of the environmental impact of a product is determined at its design stage, the EU Ecodesign Directive was enacted to provide a framework for setting compulsory standards for energy-related products. Expected energy savings by 2020, of the first 11 product groups (including lighting, electric motors, TVs, and refrigerators), are the equivalent of 14% of total EU electricity consumption in 2007.[23]

During 2011, Canada strengthened its national building code, requiring a 25% improvement over the 1997 code, and the United States announced USD 40 billion investment in energy upgrades to federal, commercial, and public buildings, which is expected to increase their efficiency by 20% and reduce energy costs by USD 40 billion.[24] The EU Energy Performance of Buildings Directive sets standards for the implementation of energy efficiency measures and the introduction of energy certification schemes.[25] In early 2012, the Indian and Swiss governments signed a Memorandum of Understanding to apply Swiss experience and expertise in India to reduce energy consumption by commercial buildings by 30–40%.[26]

Several countries and regions also have vehicle efficiency standards, including Australia, Canada, China, the EU, India, Japan, South Korea, and the United States[27]; in the EU and U.S. state of California, the focus of standards has shifted towards environmental criteria (GHG emissions). In 2011, the White House reached agreement with U.S. auto manufacturers to increase existing standards 65% by 2025.[28] Several countries also have fiscal incentives and/or traffic control measures that benefit more-efficient vehicles.[29]

A growing number of countries are enacting more broad-reaching mandates and standards. Italy, Portugal, and Poland all enacted energy efficiency-related laws in 2011.[30] China fell short of its 2011 target, but it established new targets for the 12th Five-year Plan, calling for a 16% improvement in national energy intensity by 2015; in early 2012, China increased its target for the industrial sector.[31] Also early in 2012, India announced industrial targets for 2014/15.[32] Several other countries have adopted laws, targets, or programmes, including Australia, Denmark, Mexico, Russia, and Uruguay.[33]

Increasingly, countries and regions are linking efficiency improvements with renewable energy. For decades, Denmark has set mandatory targets and incentives to advance both efficiency and renewables. In early 2012, a new policy package was adopted to achieve the national target of 100% of electricity, heat, and fuels from renewable sources by 2050, including plans for a comprehensive strategy to renovate all of the country's buildings and incentives to shift industry from fossil fuels to efficient use of renewable energy.[34] At the EU level, the triple target of 20% reductions in GHG emissions and in primary energy use, and achieving 20% of EU final energy from renewable resources, is intended to improve energy efficiency and decouple energy demand from economic growth while also increasing the share of energy from renewable sources.[35] A German initiative aims to expand national support activities from 100% renewable municipalities (realising 100% of their energy supply from renewables) to zero-emission regions (combining concrete targets and measures for energy demand and GHG reduction with increasing renewable energy supply), thus leading to a balanced strategic approach implementing both efficiency and renewables.[36]

In early 2012, the U.S. government set a goal to make all new federal buildings Zero Net Energy (ZNE) by 2030, meaning the annual energy needs are met on site by combining energy efficiency and renewables.[37] California aims for 50% of existing buildings and all new commercial buildings in the state to be ZNE by 2030.[38] At least 26 U.S. states now have efficiency targets in place, and most are achieving their goals.[39] Most of these policies apply to electric (and in some states to natural gas) utilities, with some linked directly to renewable energy—either counting renewable capacity as an efficiency gain, or through targets for both.[40] Driven overwhelmingly by state standards, U.S. ratepayer budgets for energy efficiency programmes increased 25% in 2011, to USD 6.8 billion.[41] In addition, the federal government and all U.S. states offer fiscal incentives for efficiency investments.[42]

At the global level, the UN Secretary-General's initiative, Sustainable Energy for All, aims to mobilise global action to achieve, by 2030, universal access to modern energy services, improved rates of energy efficiency, and expanded use of renewable energy sources.

Policies have also begun to address the efficiency of renewable energy systems themselves. For example, Germany provides additional incentives for more-efficient biomass power plants and renewable heating systems in highly efficient buildings, and many financial incentives required minimum efficiency standards of renewable systems.[43]

NEW ENERGY ACCOUNTING WITH EFFICIENCY AND RENEWABLES

Replacing the 500 EJ of current primary energy that is 85% fossil fuels appears to be a daunting task. But the amount of energy needed to deliver the desired energy services is much smaller. Analysts suggest that by 2030, and assuming no improvement in end-use efficiency, an all-renewable energy system would be 30% smaller than one powered by current thermal fuels and technologies—or requiring less energy input than the entire world consumes today.[44] Further efficiency gains would result in even greater reductions in energy input, while still providing desired energy services. According to another study, end-use technologies and practices exist today that require as little as one-fifth of the primary energy utilised in most circumstances today.[45]

This implies that it is not necessary to replace one EJ of primary energy today with one EJ of renewable energy, and that the amount required can be further reduced in the future by improving the efficiency of the multiple energy conversion steps, starting by reducing the energy required to provide energy services. With efficiency and renewable energy, people can receive the same services—or better—with less energy and fewer negative environmental, social, and security consequences.

REFERENCE TABLES

TABLE R1. RENEWABLE ENERGY CAPACITY AND BIOFUEL PRODUCTION, 2011

	Added during 2011		Existing at end of 2011
POWER GENERATION (GW)			
Biomass power	+	5.9	72
Geothermal power	+	0.1	11.2
Hydropower	+	25	970
Ocean power	+	0.3	0.5
Solar PV	+	30	70
Concentrating solar thermal power (CSP)	+	0.5	1.8
Wind power	+	40	238
HOT WATER/HEATING (GW_{th})			
Modern biomass heating	+	10	290
Geothermal heating	+	7	58
Solar collectors for hot water/space heating[1]	+	>49	232
TRANSPORT FUELS (billion litres/year)			
Biodiesel production	+	2.9	21.4
Ethanol production	-	0.4	86.1

Note: Numbers are rounded to nearest GW/GW_{th}/billion litre, except for relatively low numbers and biofuels, which are rounded to nearest decimal point; where totals do not add up, the difference is due to rounding. Rounding is to account for uncertainties and inconsistencies in available data. For more precise data, see Market and Industry Trends by Technology section and related endnotes.

1 Solar collector capacity is for glazed systems only and additions include net annual capacity additions only; it is expected that gross annual additions were higher due to retirements.

Source: See Endnote 1 for this section.

TABLE R2. RENEWABLE ELECTRIC POWER CAPACITY, WORLD AND TOP REGIONS/COUNTRIES, TOTAL YEAR-END 2011

TECHNOLOGY	World Total	EU-27	BRICS	China	United States	Germany	Spain	Italy	India	Japan
	(GW)									
Biomass power	72	26	17.5	4.4	13.7	7.2	0.8	2.1	3.8	3.3
Geothermal power	11.2	0.9	0.1	~ 0	3.1	~ 0	0	0.8	0	0.5
Ocean (tidal) power	0.5	0.2	~ 0	~ 0	~ 0	0	~ 0	0	0	0
Solar PV	70	51	3.7	3.1	4	25	4.5	13	0.5	4.9
Concentrating solar thermal power (CSP)	1.8	1.1	~ 0	0	0.5	0	1.1	~ 0	~ 0	0
Wind power	238	94	80	62	47	29	22	6.7	16	2.5
Total renewable power capacity (not including hydropower)	**390**	**174**	**101**	**70**	**68**	**61**	**28**	**22**	**20**	**11**
Per capita capacity (kW/inhabitant, not including hydropower)	0.06	0.35	0.03	0.05	0.22	0.75	0.60	0.37	0.02	0.09
Hydropower	970	120	383	212	79	4.4	20	18	42	28
Total renewable power capacity (including hydropower)	**1,360**	**294**	**484**	**282**	**147**	**65**	**48**	**40**	**62**	**39**

Note: World total reflects other countries not shown. Countries shown reflect the top seven by total renewable power capacity (not including hydropower); countries and rankings would differ somewhat if hydropower were included. To account for uncertainties and inconsistencies in available data, numbers are rounded to the nearest 1 GW, with the exception of totals below 20 GW, which are rounded to the nearest decimal point, and total renewable power capacities in the world column, which are rounded to the nearest 10 GW. Where totals do not add up, the difference is due to rounding. Small amounts, on the order of a few MW, are designated by "~ 0." For more precise figures, see relevant technology sections in Global Market and Industry Trends by Technology and related endnotes. 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. Hydropower total, and therefore the total world renewable capacity (and totals for some countries), is lower relative to reported data in past editions of the GSR, despite a sizable increase in global capacity during 2011, due to the fact that pure pumped storage capacity is no longer included with the hydropower data. For more information on hydropower and pumped storage, see Note on Accounting and Reporting on page 167.

Source: See Endnote 2 for this section.

TABLE R3. BIOFUEL AND WOOD PELLET TRADE, 2011

FUEL ETHANOL (million litres)

Exporter	→	Importer	Volume
Brazil	→	United States	325
Canada	→	United States	36
El Salvador	→	United States	225
Jamaica	→	United States	109
Trinidad and Tobago	→	United States	46
Brazil	→	EU-27	49
Egypt	→	EU-27	28
Guatemala	→	EU-27	17
Pakistan	→	EU-27	23
Peru	→	EU-27	19
Russia	→	EU-27	12
United States	→	EU-27	18
EU-27	→	EU-27	1,572

BIODIESEL TRADE (million litres)

Exporter	→	Importer	Volume
Argentina	→	EU-27	1,611
Canada	→	United States	103
EU-27	→	EU-27	4,812
EU-27	→	Norway	34
EU-27	→	United States	40
Indonesia	→	EU-27	1,225
Norway	→	EU-27	96
United States	→	EU-27	133
United States	→	Norway	26
United States	→	Canada	10
United States	→	Taiwan	28
United States	→	Israel	10
United States	→	Malaysia	8
United States	→	Australia	6
United States	→	India	50

WOOD PELLETS TRADE (kilotonnes)

Exporter	→	Importer	Volume
Australia	→	EU-27	14
Belarus	→	EU-27	100
Bosnia and Herzegovina	→	EU-27	47
Canada	→	United States	40
Canada	→	Japan	50
Canada	→	South Korea	50
Canada	→	EU-27	1,160
Croatia	→	EU-27	115
Egypt	→	EU-27	10
EU-27	→	Norway	18
EU-27	→	Switzerland	39
EU-27	→	EU-27	4,403
New Zealand	→	EU-27	30
New Zealand	→	Japan	10
New Zealand	→	Australia	30
Norway	→	EU-27	13
Russia	→	EU-27	475
Serbia	→	EU-27	47
South Africa	→	EU-27	43
Southeast Asia	→	Japan	10
Southeast Asia	→	South Korea	10
Ukraine	→	EU-27	149
United States	→	EU-27	1,001

Note: EU-27 to EU-27 denotes trade among countries in the European Union.

Source: See Endnote 3 for this section.

TABLE R4. BIOFUEL PRODUCTION IN TOP 15 COUNTRIES PLUS EU, 2011

	COUNTRY	Fuel Ethanol	Biodiesel	Total
			(billion litres)	
1	United States	54.2	3.2	57.4
2	Brazil	21.0	2.7	23.7
3	Germany	0.8	3.2	3.9
4	Argentina	0.2	2.8	3.0
5	France	1.1	1.6	2.7
6	China	2.1	0.2	2.3
7	Canada	1.8	0.2	2.0
8	Indonesia	0.0	1.4	1.4
9	Spain	0.5	0.7	1.2
10	Thailand	0.5	0.6	1.1
11	Belgium	0.4	0.4	0.8
12	The Netherlands	0.3	0.4	0.7
13	Italy	0.0	0.6	0.6
14	Colombia	0.3	0.3	0.6
15	Austria	0.2	0.4	0.6
	World Total	**86.1**	**21.4**	**107.0**
	EU Total	**4.3**	**9.2**	**13.5**

Note: All figures are rounded to nearest 0.1 billion litres. Ethanol numbers are for fuel ethanol only. Table ranking is by total biofuel production. Data are by volume, not energy content.

Source: See Endnote 4 for this section.

TABLE R5. SOLAR PV ADDITIONS AND TOTAL YEAR-END OPERATING CAPACITY, 2007–2011

COUNTRY	Added					Total				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
	(MW)					(GW)				
Germany	1,270	1,950	3,795	7,405	7,485	4.2	6.1	9.9	17.3	24.8
Italy	60	340	710	2,325	9,280[1]	0.1	0.4	1.1	3.51	12.8
Japan	210	230	480	990	1,295	1.9	2.1	2.6	3.6	4.9
Spain	600	2,790	90	460	385	0.8	3.6	3.7	4.1	4.5
United States	205	340	475	890	1,855	0.8	1.2	1.7	2.5	4.0
China	20	40	160	500	2,140	0.1	0.2	0.3	0.9	3.1
France	15	60	185	820	1,635[2]	0.03	0.08	0.3	1.0	2.8
Belgium	25	80	520	420	975	0.03	0.1	0.6	1.0	2.0
Czech Republic	3	60	400	1,490	6	~ 0	0.06	0.5	2.0	2.0
Australia	6	12	80	390	775	0.05	0.06	0.1	0.5	1.3
Other EU	30	95	135	525	1,850	0.2	0.3	0.4	1	2.8
Other World	120	415	395	815	2,020	1.3	1.7	2.1	2.8	4.9
Total Added	2,530	6,330	7,435	16,815	29,665[3]					
World Total						**9.4**	**15.8**	**23.2**	**40**	**70**

Note: Countries are ordered according to total operating capacity and include the top 10. With a few exceptions for very low totals, added capacities are rounded to nearest 5 MW, and existing capacities are rounded to nearest 0.1 GW (small amounts, on the order of a few MW, are designated by "~ 0"); world totals for 2010-2011 are rounded to nearest 1 GW. This is to reflect uncertainties and inconsistencies in available data (see Market and Industry Trends 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. For more information on Italy and France, and for more specific data points, see relevant endnotes in Solar Photovoltaics section of Market and Industry Trends by Technology.

1 For Italy, about 3.7 GW of 2011 additions noted here was installed in a rush in late 2010, and connected to the grid in 2011. GSE accounts for this as part of 2011 additions.

2 For France, most of this capacity was installed in 2010 but not connected to the grid until 2011, so included with 2011 statistics.

3 For World, note that actual global capacity installations during 2011 were closer to 25 GW because some capacity connected to the grid during the year was installed in 2010; accounting for the additional GW in 2010 would increase the added capacity and total year-end data for 2010. For more information, see Note on Accounting and Reporting on page 167.

Source: See Endnote 5 for this section.

TABLE R6. CONCENTRATING SOLAR THERMAL POWER (CSP) CAPACITY, ADDITIONS AND TOTAL YEAR-END, 2011

COUNTRY	Added 2011	Total End-2011
	(MW)	
Spain	417	1,149
United States	0	507
Algeria	25	25
Egypt	0	20
Morocco	0	20
Iran	0	17
Italy	0	5
Thailand	9.8	9.8
Australia	0	3
India	2.5	2.5
Total	**454**	**1,758**

Note: Table includes all countries with operating commercial CSP capacity at end-2011. (Small amounts of capacity not seen here are likely pilot projects.) Where numbers do not add up to this is due to rounding.

Source: See Endnote 6 for this section.

TABLE R7. SOLAR HOT WATER INSTALLED CAPACITY, TOP 12 COUNTRIES AND WORLD TOTAL, 2010

COUNTRY	Added 2010	Total 2010
	(GW_{th})	
China	34	118
Turkey	1.2	9.3
Germany	0.8	9.2
Japan	0.1	4.0
Brazil	0.3	3.4
Israel	0.2	2.9
Greece	0.1	2.9
India	0.6	2.8
Austria	0.2	2.8
Australia	0.3	2.0
Italy	0.3	1.8
United States	0.2	1.8
Rest of World	~ 4	~ 21
World Total	**42**	**182**

Note: Countries are ordered according to total installed capacity. Data are for water and air collectors, but do not include swimming pool heating (unglazed collectors). World additions are gross capacity added; total numbers include allowances for retirements. Data for China, rest of world, and world total are rounded to nearest 1 GW_{th}; other data are rounded to the nearest 0.1 GW_{th}. By accepted convention, 1 million square metres = 0.7 GW_{th}.

Source: See Endnote 7 for this section.

TABLE R8. WIND POWER CAPACITY IN TOP 10 COUNTRIES, ADDITIONS AND TOTAL YEAR-END, 2011

COUNTRY	Total End-2010	Added 2011	Total End-2011
		(GW)	
China[1]	30/44.7	15/17.6	45/62.4
United States	40.3	6.8	46.9
Germany	27.2	2.0	29.1
Spain	20.6	1.1	21.7
India	13.1	3.0	16.1
France	6.0	0.8	6.8
Italy	5.8	1.0	6.7
United Kingdom	5.2	1.3	6.5
Canada	4.0	1.3	5.3
Portugal	3.7	0.4	4.1
World Total	**198**	**40**	**238**

Note: Countries are ordered according to total installed capacity. 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 or repowering/removal of existing turbines (according to GWEC, project decommissioning totaled approximately 528 MW in 2011). Figures reflect a variety of sources, some of which differ to small degrees, reflecting variations in accounting or methodology. For more detailed information and statistics, see Wind Power section in Market and Industry Trends by Technology section and relevant endnotes.

1 For China, the lower figures are the amounts classified as operational by the end of 2010 and 2011; the higher figures are total installed capacity. The world totals include the higher figures for China. See Wind Power section in Market and Industry Trends by Technology and relevant endnotes in GSR 2011 for further elaboration of these categories.

2 For Germany, 2011 additions are gross; net capacity additions came to 1,885 MW due to repowering.

Source: See Endnote 8 for this section.

TABLE R9. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2009/2010 AND TARGETS

COUNTRY	Primary Energy		Final Energy	
	Share (2009/2010)[1]	Target	Share (2009/2010)[1]	Target
EU-27	**9.0%**		**12.4%**	**→ 20% by 2020**
Albania		→ 18% by 2020		
Algeria				→ 40% by 2030
Austria[2]	27.3%	→ 30.7%		→ 45% by 2020
Belgium	3.9%		5.4%	→ 13% by 2020
Botswana				→ 1% by 2016
Bulgaria	6.2%		12.9%	→ 16% by 2020
Burundi				→ 2.1% by 2020
China				→ 11.4% by 2015 → 15% by 2020
Côte d'Ivoire		→ 3% by 2013 → 5% by 2015		
Cyprus	3.5%		5.5%	→ 13% by 2020
Czech Republic[2]	5.7%		9.7%	→ 13.5% by 2020
Denmark	16.7%		23.0%	→ 35% by 2020 → 100% by 2050
Egypt				→ 20% by 2020
Estonia	13.5%		24.1%	→ 25% by 2020
Fiji				→ 100% by 2013
Finland	23.2%		33.6%	→ 38% by 2020
France	7.5%		12.4%	→ 27% by 2020
Gabon				→ 80% by 2020
Germany[2]	9.7%		11.3%	→ 18% by 2020 → 30% by 2030 → 45% by 2040 → 60% by 2050
Greece[2]	6.1%		9.1%	→ 20% by 2020
Hungary	7.1%		8.5%	→ 13% by 2020
Indonesia		→ 25% by 2025		
Ireland	4.3%		5.9%	→ 16% by 2020
Israel				→ 50% by 2020
Italy	9.5%		10.1%	→ 17% by 2020
Jamaica		→ 15% by 2020 → 20% by 2030		
Japan[3]		→ 10% by 2020		
Jordan	1.9%	→ 7% by 2015 → 10% by 2020		
Latvia	36.2%		34.3%	→ 40% by 2020
Lebanon				→ 12% by 2020
Libya		→ 10% by 2020		
Lithuania	10.5%	→ 20% by 2025	21.1%	→ 23% by 2020

TABLE R9. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2009/2010 AND TARGETS (CONTINUED)

COUNTRY	Primary Energy		Final Energy	
	Share (2009/2010)[1]	Target	Share (2009/2010)[1]	Target
Luxembourg	2.8%	2.6%		→ 11% by 2020
Madagascar				→ 54% by 2020
Malawi		→ 7% by 2020		
Mali		→ 15% by 2020		
Malta			0.3%	→ 10% by 2020
Mauritania		→ 15% by 2015 → 20% by 2020		
Mauritius		→ 35% by 2025		
Moldova		→ 20% by 2020		
Morocco		→ 8% by 2012 → 10–12% by 2020 → 15–20% by 2030		→ 10% by 2012
Netherlands[2]	3.9%		3.8%	→ 14% by 2020
Niger		→ 10% by 2020		
Norway	42.4%			→ 67.5% by 2020
Palau		→ 20% by 2020		
Palestinian Territories	18.0%		18.0%	→ 25% by 2012
Poland	10.8%	→ 12% by 2020	9.9%	→ 15% by 2020
Portugal	19.0%		24.7%	→ 31% by 2020
Romania	14.9%		21.4%	→ 24% by 2020
Samoa		→ 20% by 2030		
Senegal		→ 15% by 2025		
Serbia	13.4%			→ 32.5% (no target date)
Slovakia	7.2%		11.4%	→ 14% by 2020
Slovenia	12.7%		21.7%	→ 25% by 2020
South Korea		→ 4.3% by 2015 → 6.1% by 2020 → 11% by 2030		
Spain[2]	11.3%		13.2%	→ 20.8% by 2020
Sweden[2]	34.4%		46.9%	→ 50% by 2020
Switzerland	16.9%	→ 24% by 2020		
Syria	5.4%	→ 4.3% by 2011	5.2%	
Thailand		→ 20% by 2022		
Tonga				→ 100% by 2013
Turkey		→ 30% by 2023		
Ukraine	1.0%	→ 19% by 2030		
United Kingdom	3.6%		8.1%	→ 15% by 2020
Uruguay	49.3%	→ 100% by 2015		
Vietnam		→ 5% by 2020 → 8% by 2025 → 11% by 2050		

TABLE R9 ANNEX.
PRIMARY ENERGY SHARES OF COUNTRIES WITHOUT PRIMARY OR FINAL ENERGY TARGETS

COUNTRY	Primary Energy Share (2009/2010)[1]
Argentina	9.7%
Barbados	36.1%
Belize	24.8%
Bolivia	12.1%
Bosnia and Herzegovina	19.7%
Brazil	47.5%
Chile	74.9%
Colombia	8.0%
Costa Rica	100%
Croatia	10.9%
Cuba	19.8%
Dominican Republic	100%
Ecuador	5.3%
El Salvador	100%
Grenada	100%
Guatemala	92.1%
Guyana	100%
Haiti	100%
Honduras	100%
Mexico	6.3%
Morocco	2.0%
Nicaragua	100%
Panama	100%
Paraguay	100%
Peru	23.2%
Philippines	38.9%
Suriname	16.3%
Turkey	9.9%
Uganda	92.0%
United States	11.8%
Venezuela	3.1%

1 Primary energy shares figures are given for end-2010, except for the following cases where share figures refer to end-2009: EU-27, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom (shares taken from Eurostat).

2 Final energy targets for all EU-27 countries are set under EU Directive 2009/28/EC. The governments of Austria, Czech Republic, Greece, Hungary, Spain, and Sweden have set additional targets that are shown above EU targets. The German targets for 2030, 2040, and 2050 are also additional targets set by the German government, and are not mandatory. The government of the Netherlands has reduced its more ambitious target to the level set in the EU Directive.

3 The primary energy target for Japan includes large hydropower.

Source: See Endnote 9 for this section.

TABLE R10. EXISTING RENEWABLES SHARE OF ELECTRICITY PRODUCTION

COUNTRY	Electricity Production Share (2010)	Electricity Production Target
Global	**20.0%**[1]	
EU-27	**21.0%**	
Algeria	0.4%	→ 5% by 2017 → 20% by 2030
Australia	8.7%	→ 20% by 2020
Bangladesh		→ 5% by 2015 → 10% by 2020
Belgium	8.0%	→ 20.9% by 2020
Cape Verde		→ 50% by 2020
Chile[2]		→ 8% by 2020 → 10% by 2025
Cook Islands		→ 50% by 2015 → 100% by 2020
Costa Rica		→ 100% by 2021
Czech Republic	8.0%	
Denmark	32.0%	→ 50% by 2020[3] → 100% by 2050
Egypt	10.0%	→ 20% by 2020
Eritrea		→ 50% (no target date)
Estonia	8.0%	→ 18% by 2015
France	15.0%	→ 27% by 2020
Gabon	46.0%	→ 70% by 2020
Greece	16.0%	→ 40% by 2020
Germany	17.1%	→ 35% by 2020 → 50% by 2030 → 65% by 2040 → 80% by 2050
Ghana		→ 10% by 2020
Guatemala	63.0%	→ 70% by 2022
India	9.9%	→ 10% by 2012
Indonesia	13.2%	→ 15% by 2025
Ireland	14.8%	→ 40% by 2020
Israel	0.2%	→ 5% by 2014 → 10% by 2020
Italy	20.1%	→ 26% by 2020
Jamaica	14.0%	→ 15% by 2020
Kiribati		→ 10% (no target date)
Kuwait		→ 5% by 2020
Libya	0%	→ 10% by 2020 → 30% by 2030
Madagascar	57.0%	→ 75% by 2020
Malaysia		→ 10% (no target date)
Mali		→ 25% by 2020
Marshall Islands		→ 20% by 2020
Mauritius		→ 35% by 2025
Mexico	19.0%	→ 35% by 2025
Mongolia		→ 20–25% by 2020
Morocco	18.3%	→ 20% by 2012
New Zealand	73.0%	→ 90% by 2025
Nicaragua	35.0%	→ 38% by 2011
Nigeria[2]		→ 18% by 2025 → 20% by 2030
Niue		→ 100% by 2020
Pakistan[2]		→ 10% by 2012
Palestinian Territories		→ 10% by 2020
Philippines	26.3%	→ 40% by 2020
Portugal	53.0%	→ 55–60% by 2020
Romania	34.0%	→ 43% by 2020
Russia		→ 2.5% by 2015 → 4.5% by 2020
Rwanda		→ 90% by 2012
St. Lucia		→ 5% by 2013 → 15% by 2015 → 30% by 2020
St. Vincent and the Grenadines		→ 30% by 2015 → 60% by 2020
Senegal	10.0%	→ 15% by 2020
Seychelles		→ 5% by 2020 → 15% by 2030

TABLE R10. (CONTINUED)

COUNTRY	Electricity Production Share (2010)	Electricity Production Target
Solomon Islands		→ 50% by 2015
South Africa	1.8%	→ 4% by 2013 → 13% by 2020
Spain	34.0%	→ 38.1% by 2020
Sri Lanka		→ 10% by 2015
Thailand	5.6%	→ 11% by 2011 → 14% by 2022
Tonga		→ 50% by 2012
Tunisia	1.3%	→ 4% by 2011 → 16% by 2016 → 40% by 2030
Turkey	26.0%	→ 30% by 2023
Tuvalu		→ 100% by 2020
Uganda	54.0%	→ 61% by 2017
United Kingdom (Scotland)	7.4%	→ 15% by 2015 → 80% by 2020
Uruguay[2]	10.0%	→ 15% by 2015
Vietnam		→ 5% by 2020

Note: Actual percentages are rounded to the 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 have other types of targets (see Tables R7 and R9). See 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 report contributors. In situations of conflicting shares, figures provided to REN21 by report contributors were given preference. The difference likely stems from calculations using different (and equally valid) methods.

1 Global share is for end-2009.

2 For certain countries, existing shares exclude large hydro, because corresponding targets exclude large hydro.

3 Denmark set a target of 50% electricity consumption supplied by wind power by 2020 in March 2012.

Source: See Endnote 10 for this section.

TABLE R10 ANNEX.
EXISTING RENEWABLES SHARE OF ELECTRICITY PRODUCTION IN COUNTRIES WITHOUT TARGETS

COUNTRY	Electricity Production Share (2010)
Argentina	31.0%
Austria	68.0%
Belarus	0.3%
Bolivia	26%
Bosnia and Herzegovina	47.0%
Brazil	85.0%
Bulgaria	13.0%
Cameroon	88.0%
Canada	60.0%
Columbia	70.0%
Costa Rica	94.0%
Côte d'Ivoire	30.0%
Croatia	61.0%
Cuba	7.0%
Cyprus	0.9%
Dominican Republic	9.0%
Ecuador	45.0%
El Salvador	65.0%
Eritrea	1.0%
Ethiopia	88.9%
Finland	30.0%
Guyana	6.0%
Haiti	35.0%
Honduras	65.0%
Hungary	7.3%
Iceland	100%
Iran	4.0%
Iraq	1.1%
Japan[2]	3.5%
Jordan	0.2%
Kazakhstan	11.0%
Kenya	66.0%
Latvia	55.0%
Lebanon	12.0%
Lithuania	28.0%
Luxembourg	35.0%
Malawi	2.8%
Malta	0.1%
Moldova	2.0%
The Netherlands	9.7%

COUNTRY	Electricity Production Share (2010)
Norway	96.0%
Panama	59%
Papua New Guinea	36.0%
Paraguay	100%
Peru	55.0%
Poland	6.4%
Saudi Arabia	0%
Serbia	33.0%
Slovakia	23.0%
Slovenia	30.0%
South Korea	1.9%
Sudan	81.0%
Suriname	73.0%
Sweden	55.0%
Switzerland	58.0%
Syria	6.0%
Taiwan	4.3%
Tanzania	46.0%
Uganda	54.0%
Ukraine	7.0%
United States	11.0%
Uzbekistan	22.0%
Venezuela	66.0%

TABLE R11. OTHER RENEWABLE ENERGY TARGETS

COUNTRY	Target	Description
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	Renewables in general	Install an additional 22,000 MW of renewable power generating capacity between 2011 and 2030; 110 MW by 2013; 650 MW by 2015; 2,600 MW by 2020; 12,000 MW for domestic use and 10,000 MW for export by 2030
	Large-scale renewables	41,000 GWh/year by 2020
	Wind	50 MW wind farm development from 2011–2015; 3% of final energy by 2030; 1,700 MW installed from 2016–2030; 3% of final energy by 2030
	Solar PV	800 MW by 2020; 200 MW/yr every year from 2021–2030; 2,800 MW by 2030
	Solar (PV and CSP)	37% of final energy by 2030
	CSP	300 MW 2012–2013; 1,200 MW 2016–2020; 500 MW/yr every year from 2021–2023; 600 MW/yr every year from 2024–2030
Argentina	Wind	1.2 GW by 2016
	Solar	3.3 GW by 2020
	Geothermal	30 MW electric capacity by 2012
Austria	Wind	2,000 MW addition by 2020
	Solar PV	1,200 MW addition by 2020
	Hydro	1,000 MW addition by 2020
	Biomass, biogas	200 MW addition by 2020
Bangladesh	Solar	500 MW by 2015
	Rural off-grid solar	2.5 million units by 2015
	Biomass	2 MW biomass electricity plant by 2014
	Biogas	4 MW biogas electricity plant by 2014
	Biodigesters	150,000 installed by 2016
Belgium	Electricity	8 TWh/year by 2020 (Wallonia)
	Heating and cooling	11.9% share of renewable energy in gross final consumption in heating and cooling by 2020
	Transport	10.15% share of renewable energy in gross final consumption in transport by 2020
Benin	Rural energy	50% of rural electricity from renewables by 2025
Brazil	Wind	11.5 GW by 2020
	Small hydro	6.4 GW by 2020
	Biomass	9.1 GW by 2020
Bulgaria	Solar PV:	80 MW PV park operational by 2014
	Hydro:	80 MW hydroelectric plant commissioned by 2011; three 174 MW hydropower plants by 2017–18
Canada	Wind	10 GW by 2015

TABLE R11. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

COUNTRY	Target	Description
China	Wind	100 GW on-grid by 2015; 5 GW offshore by 2015 and 30 GW offshore by 2020
	Solar	15 GW by 2015 (1 GW CSP)
	Hydro	284 GW by 2015
	Biofuels	5 million tonnes of ethanol fuel used between 2011 and 2015
Colombia	Renewables in general	5% of total energy mix by 2015 (excluding large hydro) New renewables to reach 6.5% of interconnected electricity system by 2020
	Rural off-grid	Renewables installed capacity share of 20% by 2015 and 30% by 2030 (currently 8%)
Czech Republic	Transport	10.8% share of renewable energy in gross final consumption in transport by 2020
Denmark	Wind	50% share in electricity consumption by 2020
	Heating and cooling	39.8% by 2020; 100% by 2050
	Transport	10% by 2020; 100% by 2050
	Industry	100% renewables by 2050
Djibouti	Rural energy	30% of rural electrification to come for solar PV by 2017
Egypt	Wind	12% of electricity and 7,200 MW by 2020
	Hydro, solar, and other renewables	8% of electricity by 2020
Eritrea	Wind	50% of electricity generation
Ethiopia	Wind	770 MW by 2014
	Hydro	10,641.6 MW (>90% large-scale) by 2015; 22,000 MW by 2030
	Geothermal	75 MW by 2015; 450 MW by 2018; 1,000 MW by 2030
	Bagasse	103.5 MW
Finland	Renewables in general	Increase use of renewables by at least 25% by 2015 and 40% by 2025
	Wind	884 MW by 2020
	Hydro	14,598 MW by 2020
	Biomass	13,152 MW by 2020
France	Wind	25 GW, including 6 GW offshore, by 2020
	Heating and cooling	33% by 2020
	Transport	10.5% by 2020
Germany	Heating and cooling	14% renewable energy in total heat supply by 2020
Ghana	Renewables in general	10% by 2020
Greece	Solar PV	2,200 MW by 2030
	Heating and cooling	20% renewable energy in heating and cooling by 2020
Guinea-Bissau	Solar PV	2% of primary energy by 2015

TABLE R11. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

COUNTRY	Target	Description
India	Renewables in general	3.5 GW new renewables 2011–12
	Wind	9,000 MW by 2012
	Solar	20 GW grid-connected solar by 2022; 2,000 MW off-grid by 2020; 20 million solar lighting systems by 2022; 14 GW_{th} (20 million m^2) solar thermal collector area by 2022
Indonesia	Wind, solar, hydro	1.4% share (combined) by 2025
	Wind	0.1 GW by 2025
	Solar PV	156.76 MW by 2025
	Hydro	2 GW, including 0.43 GW micro-hydro, by 2025
	Geothermal	6.3% share in primary energy and 12.6 GW electricity by 2025
	Biofuel	10.2% share in primary energy by 2025
Ireland	Heating	15% by 2020
Italy	Wind (onshore)	18,000 GWh generation and 12,000 MW capacity by 2020
	Wind (offshore)	2,000 GWh generation and 680 MW by 2020
	Solar PV	23,000 MW by 2017
	Hydro	42,000 GWh generation and 17,800 MW capacity by 2020
	Geothermal	6,750 GWh generation and 920 MW capacity by 2020; 12,560 TJ in heating and cooling by 2020
	Solar thermal	66,403 TJ (1,586 ktoe) by 2020
	Biofuels	121,375 TJ (2,899 ktoe) in transport by 2020
	Biomass	19,780 GWh generation and 3,820 MW capacity by 2020; 237,391 TJ in heating and cooling by 2020
	Heating and cooling	17.1% by 2020
	Transport	17.4% by 2020
Japan	Wind	5 GW by 2020
	Solar PV	28 GW by 2020
	Hydro	49 GW by 2020
	Geothermal	0.53 GW by 2020
	Biomass	3.3 GW by 2020
Jordan	Wind	1,000 MW by 2020
	Solar thermal	300–600 MW by 2020
	Solar water heaters	30% of households by 2020 (from 13% in 2010)
Kenya	Renewables in general	Double installed capacity by 2012
	Geothermal	5,000 MW by 2030
Lebanon	Solar water heaters	0.13 GWth (190,000 m^2) new solar water installed during 2009–2014
Lesotho	Rural energy	35% of rural electrification from renewables by 2020
Libya	Wind	500 MW by 2015; 1,000 MW by 2020
	Solar PV	100 MW by 2015; 500 MW by 2020
	CSP	200 MW by 2015; 750 MW by 2020
	Solar water heaters	80 MW by 2015; 250 MW by 2020

TABLE R11. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

COUNTRY	Target	Description
Malawi	Hydro	346.5 installed capacity by 2014
Malaysia	Electricity	2,065 MW (excluding large hydro), 11.2 TWh, or 10% of national supply; 6% capacity and 5% generation by 2015; 11% capacity and 9% generation by 2020; 14% capacity and 11% generation by 2030; 36% capacity and 15% generation by 2050
Micronesia	Electricity	10% renewable energy in electricity generation in urban centers and 50% in rural areas by 2020
Morocco	Wind	1,440 MW by 2015; 2,000 MW by 2020
	Solar	2,000 MW by 2020
	Small hydro	400 MW by 2015
	Solar hot water	0.28 GW_{th} (400,000 m^2) by 2012, 1.19 GW_{th} (1.7 million m^2) by 2020
Mozambique	Wind, solar, and hydro	2,000 MW each
	Solar PV	Installation of 82,000 systems
	Biodigesters	1,000 systems installed
	Wind pumping stations	3,000 installed
	Solar heaters	100,000 installed in rural areas
	Renewable energy-based productive systems	5,000 installed
Namibia	Renewables in general	40 MW renewable capacity (excluding hydro) by 2011
Nauru	Renewables in general	50% of energy demand from alternative energy sources by 2015
Nepal	Wind	1 MW by 2013
	Solar	3 MW by 2013
	Micro-hydro	15 MW by 2013
Netherlands	Biofuels	5% biofuels in transport fuel mix by 2013; 10% by 2020
Nigeria	Wind	40 MW by 2025
	Solar PV	300 MW by 2015; 4,000 MW by 2025
	Small hydro	100 MW by 2015; 760 MW by 2025
	Biomass	5 MW biomass-fired capacity by 2015; 30 MW by 2025
Norway	Renewables in general	30 TWh by 2016
	Common electricity certificate market with Sweden	26.4 TWh by 2020
Palestinian Territories	Wind	44 MW by 2020
	Solar PV	45 MW by 2020
	CSP	20 MW by 2020
	Biomass power	21 MW by 2020

TABLE R11. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

COUNTRY		Target	Description
Philippines		Renewables in general	Triple 2010 renewable power capacity by 2030
		Wind	2,378 MW by 2030
		Solar	285 MW by 2030
		Hydro	8,724.1 MW by 2030
		Geothermal	3,461 MW by 2030
		Biomass	315.7 MW by 2030
		Ocean	70.5 MW by 2030
Romania		Renewables in general	8.3% by 2011
		Heating and cooling	22% by 2020
		Transport	10% by 2020
Rwanda		Small hydro	42 MW by 2015
Serbia		Wind	1,390 MW
		Solar	10–150 MW by 2017
South Africa		Renewables in general	3,100 MW capacity (including 500 MW wind and 50 MW CSP), and 10,000 GWh produced by 2013
South Korea		Renewables in general	13,016 GWh (2.9%) by 2015; 21,977 GWh (4.7%) by 2020; 39,517 GWh (7.7%) by 2030
		Solar thermal	2,046 GWh by 2030
		Solar PV	1,971 GWh by 2030
		Wind	16,619 GWh by 2030
		Small hydro	1,926 GWh by 2030
		Forest biomass	2,628 GWh by 2030
		Biogas	161 GWh by 2030
		Geothermal	2,803 GWh by 2030
		Ocean	6,159 GWh by 2030
		Large hydro	3,860 GWh by 2030
Spain	Capacity	Hydro	13,861 MW by 2020
	Capacity	Pumping	8,811 MW by 2020
	Capacity	Geothermal	50 MW by 2020
	Capacity	Solar PV	7,250 MW by 2020
	Capacity	Solar thermoelectric	4,800 MW by 2020
	Capacity	Ocean energy	100 MW by 2020
	Capacity	Onshore wind	35,000 MW by 2020
	Capacity	Offshore wind	750 MW by 2020
	Capacity	Solid biomass	1,350 MW by 2020
	Capacity	Waste	200 MW by 2020
	Capacity	Biogas	400 MW by 2020

TABLE R11. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

COUNTRY		Target	Description
Spain	Final Energy:	Hydro	2.9% by 2020
		Wind	6.3% by 2020
		Biomass, biogas, and waste	5.8% by 2020
		Solar	3% by 2020
		Biofuels	2.7% by 2020
		Geothermal, ocean energies, and heat pump	0.1% by 2020
		Transport	11.3% renewable energy share in final consumption of energy in transport by 2020
		Bioethanol/bio-ETBE	400 ktoe by 2020
		Biodiesel	2,313 ktoe by 2020
		Electricity for transport	20,976 TJ (501 ktoe) from renewable energy sources by 2020
		Heating and cooling	18.9% by 2020
		Geothermal	9.5 ktoe by 2020
		Solar thermal	644 ktoe by 2020
		Biomass	4,653 ktoe by 2020
		Heat pump	212.7 TJ (50.8 ktoe) by 2020
Sri Lanka		Biofuels	20% supply by 2020
		Non-traditional renewables	10% of power generation by 2015
Swaziland		Solar hot water	Installed in 20% of all public buildings by 2014
Sweden		Electricity	25 TWh more renewable electricity than in 2002 by 2020
		Transport	Vehicle fleet that is independent from fossil fuels by 2030
		Common electricity certificate market with Norway	26.4 TWh by 2020
Syria		Wind	150 MW by 2015; 1,000 MW by 2020; 1,500 MW by 2025; 2,000 MW by 2030
		Solar PV	45 MW by 2015; 380 MW by 2020; 1,100 MW by 2025; 1,750 MW by 2030
		CSP	50 MW by 2025
		Biomass power	140 MW by 2020; 260 MW by 2025; 400 MW by 2030

Note: Indonesia has a target of 3 GW pumped storage by 2025; South Korea has a target of 1,340 GWh from landfill gas by 2030; additional targets exist at the state/provincial level in a number of countries. For more detailed information, see the REN21 Renewables Interactive Map.

Source: See Endnote 11 for this section.

TABLE R11. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

COUNTRY		Target	Description
Thailand	Electricity:	Wind	1,200 MW by 2022
		Solar	2,000 MW by 2022
		Hydro	1,608 MW by 2022
		Biomass	3,630 MW by 2022
		Biogas	600 MW by 2022
		MSW	160 MW by 2022
		New energy	3 MW by 2022
	Heating:	Solar	100 ktoe by 2022
		Biomass	8,200 ktoe by 2022
		Biogas	1,000 ktoe by 2022
		Waste	1,465 TJ (35 ktoe) by 2022
	Transport:	Ethanol	9 million litres/day by 2022
		Biodiesel	5.97 million litres/day by 2022
		New fuel	25 million litres/day by 2022
Tunisia		Wind	330 MW by 2011
		Solar PV	15 MW by 2011
		Solar hot water	0.525 GW_{th} (750,000 m^2) by 2011
		Renewable capacity	1,000 MW (16%) by 2016; 4,600 MW (40%) by 2030
Uganda		Capacity	188 MW from small hydro, biomass, and geothermal by 2017
		Solar water heaters	30,000 m^2 installed by 2017
		Biogas digesters	100,000 by 2017
Ukraine		Solar	10% of energy balance by 2030; 90% annual increase until 2015
United Kingdom		Heat	12% by 2020
		Transport	5% biofuels in transport by 2014
Uruguay		Wind	1,000 MW by 2015
		Biomass power	200 MW by 2015
		Non-traditional renewables	25% of generation by 2015
Yemen		Wind	400 MW by 2025
		Solar PV	8.25 MW by 2025
		CSP	100 MW by 2025
		Geothermal	160 MW by 2025
		Biomass	6 MW by 2025
Zimbabwe		Biofuels	10% share of biofuels in liquid fuels by 2015

TABLE R12. CUMULATIVE NUMBER OF COUNTRIES/STATES/PROVINCES ENACTING FEED-IN POLICIES

Year	Cumulative #	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); Chhattisgarh, 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	88	Rhode Island (USA); Nova Scotia (Canada); Netherlands; Syria
2012 (early)	90	Palestinian Territories; Rwanda
	92	**Total Existing**

Note: "Cumulative" number refers to number of jurisdictions that had enacted feed-in policies as of the given year. "Total existing" discounts four countries that are known to have subsequently discontinued policies (Brazil, South Africa, South Korea, and the United States) and adds six countries that are believed to have feed-in tariffs but with an unknown year of enactment (Costa Rica, Honduras, Mauritius, Peru, Panama, and Uruguay). The U.S. PURPA policy (1978) is an early version of the feed-in tariff, which has since evolved.

Source: See Endnote 12 for this section.

TABLE R13. CUMULATIVE NUMBER OF COUNTRIES/STATES/PROVINCES ENACTING RPS/QUOTA POLICIES

Year	Cumulative #	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	21	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	45	Illinois, New Hampshire, North Carolina, Northern Mariana Islands and Oregon (USA); China
2008	52	Michigan, Missouri, and Ohio (USA); Chile; India; Philippines; Romania
2009	53	Kansas (USA)
2010	56	British Columbia (Canada); South Korea; Puerto Rico (USA)
2011	57	Israel
2012 (early)	58	Norway
	71	**Total Existing**

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 13 jurisdictions believed to have RPS/Quota policies but whose year of enactment in not known (Kyrgyzstan, Portugal, United Arab Emirates, Uruguay, and the Indian states Chhattisgarh, Haryana, Kerala, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal). In the United States, there are 10 additional states/territories with policy goals that are not legally binding RPS policies (Guam, Indiana, North Dakota, Oklahoma, South Dakota, U.S. Virgin Islands, Utah, Vermont, Virginia, and West Virginia). Three additional Canadian provinces also have non-binding policy goals (Alberta, Manitoba, and Quebec). Two additional RPS policies (Northern Mariana Islands (2007), and Puerto Rico (2010) that have previously not been included have been added to past years.

Source: See Endnote 13 for this section.

TABLE R14. NATIONAL AND STATE/PROVINCIAL BIOFUEL BLEND MANDATES

COUNTRY	**Mandate**
Argentina	E5 and B7
Australia	New South Wales: E6 and B2; Queensland: E5
Belgium	E4 and B4
Brazil	E18–25 and B5
Canada	National: E5 and B2. Provincial: E5 and B3–5 in British Columbia; E5 and B2 in Alberta; E7.5 and B2 in Saskatchewan; E8.5 and B2 in Manitoba; E5 in Ontario
China	E10 in nine provinces
Columbia	E8 and B7; B20 by 2012
Ethiopia	E10
Germany	E10
Guatemala	E5
India	E10
Indonesia	B2.5 and E3
Jamaica	E10 and B5
Malawi	E20
Malaysia	B5
Paraguay	E24 and B5
Peru	B5 and E7.8
Philippines	E10 and B2
South Korea	B2.5
Spain	Mandate for biofuel blend: 6.2% currently, 6.5% for 2012 and 2013; B6 currently and B7 for 2012
Thailand	E5 and B5
United Kingdom	B4
United States	*National:* The Renewable Fuels Standard 2 (RFS2) requires 36 billion gallons of renewable fuel to be blended annually with transport fuel by 2022. State-level: E10 in Missouri and Montana; E9–10 in Florida; E2 and B2 in Louisiana; B2 by 2010, B3 by 2011, B4 by 2012, B5 by 2013 (all by July 1 of the given year) in Massachusetts; E10 and B5, B10 by 2012, B20 by 2015 in Minnesota; B5 after July 1, 2012 in New Mexico; E10 and B5 in Oregon; B2 one year after in-state production of biodiesel reaches 40 million gallons, B5 one year after 100 million gallons, B10 one year after 200 million gallons, and B20 one year after 400 million gallons in Pennsylvania; E2, B2, increasing to B5 180 days after in-state feedstock and oil-seed crushing capacity can meet 3% requirement in Washington State.
Uruguay	B2; B5 by 2012; E5 by 2012
Zambia	E10 and B5

Note: South Africa's biofuel policy issued in 2007 includes mandates for E5 and B2 blending that are yet to be implemented. Mexico has an E2 mandate in Guadalajara. Costa Rica has a pilot programme in place to assess the possibility of blending up to E7 and B2 in Barranca. The Dominican Republic has a target of B2 and E15 for 2015 but has no current blending mandate. Chile has a target of E5 and B5 but has no current blending mandate. Panama is planning the introduction of an ethanol mandate in 2013 at E4 in 2014, E7 in 2015, and E10 in 2016. Fiji approved voluntary B5 and E10 blending in 2011. The Kenyan city of Kisumu has an E10 mandate. Nigeria has a target of E10 but has no current blending mandate. Ecuador has set targets of B2 by 2014 and B17 by 2024; it also has an E5 pilot program in several provinces.

Source: See Endnote 14 for this section.

TABLE R15. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES

CO_2 EMISSIONS REDUCTIONS TARGETS, ALL CONSUMERS

Bottrop, Ruhr Area, Germany	Reduce 50% by 2020 (base 2010)
Chicago IL, USA	Reduce 80% by 2050 (base 1990)
Copenhagen, Denmark	Reduce 20% by 2015; zero net emissions by 2025
Dallas TX, USA	Carbon neutral by 2030
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 30% by 2020 (base 1990)
Stockholm, Sweden	Reduce per capita emissions to 3 tonnes CO_2 by 2015 (base 5.5 tonnes 1990)
Sydney, Australia	Reduce 70% by 2030 (base 2006)
Tokyo, Japan	Reduce 25% by 2020 (base 2000)

CO_2 EMISSIONS REDUCTIONS TARGETS, ALL CONSUMERS

Boulder CO, USA	30% of total energy by 2020
Calgary AB, Canada	30% of total energy by 2036
Cape Town, South Africa	10% of total energy by 2020
Madrid, Spain	20% reduction in fossil fuel use by 2020
Rajkot, India	10% reduction in conventional energy by 2013
San Francisco CA, USA	100% of total energy by 2020
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) by 2030)

TARGETS FOR SHARE OF RENEWABLE ELECTRICITY, ALL CONSUMERS

Adelaide, Australia	15% by 2014
Austin TX, USA	35% by 2020
Cape Town, South Africa	15% by 2020
Freiburg, Germany	10% by 2010
Sydney, Australia	25% by 2020
Taipei City, Taiwan	12% by 2020

TABLE R15. 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 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 in 2011
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 by 2012 (currently35%)
Portland OR, USA	100% of own-use electricity (currently 12%)
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, U. K.	10% of homes with solar hot water and/or solar PV by 2010

TABLE R15. 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 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

SUBSIDIES, GRANTS, AND LOANS

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

TABLE R15. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES (CONTINUED)

TRANSPORT INFRASTRUCTURE AND FUELS MANDATES, OPERATION, INVESTMENT, AND SUBSIDIES

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

ELECTRIC UTILITY POLICIES

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

GOVERNMENT FUNDS AND INVESTMENTS

Beijing, China	RMB13 billion ($2 billion) investment fund to achieve 4% energy target
Edinburgh, Scotland, U.K.	Climate Change Fund totaling £18.8 million
Kunming, China	Fund for solar PV industry development and solar PV projects
Montreal QC, Canada	CAD24 million energy fund over 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

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

Source: See Endnote 15 for this section.

TABLE R16. ELECTRICITY ACCESS BY REGION AND COUNTRY

COUNTRY	Electrification Rate (rural, urban and/or national)	Target
All Developing Countries	75.0%	
Africa	42.0%	
North Africa	99.0%	
Sub-Saharan Africa	30.0%	
Developing Asia[1]	81.0%	
China and East Asia	91.0%	
South Asia	68.0%	
Latin America	93.0%	
Middle East	90.0%	
Afghanistan	16.0%	
Algeria	99.3%	
Angola	26.2%	
Argentina	95.0%	
Bahrain	99.4%	
Bangladesh[2]	63.4% (rural)	100% by 2021
Barbados	98.0%	
Belize	96.2%	
Benin	24.8%	
Bolivia	71.2%	
Botswana	55.0%	80% by 2016
Brazil	99.7%	
Brunei	99.7 %	
Burkina Faso	14.6%	
Cambodia	24.0%	
Cameroon	48.7%	
Chile	99.5%	
China[3]	>99.5%	
Colombia	94.9 %	
Costa Rica	99.2%	
Côte d'Ivoire	47.3%	
Cuba	97.0%	
Democratic Republic of the Congo	11.0%	
Dominican Republic	96.2%	
Ecuador	93.4%	
East Timor	22.0%	
Egypt	>99.0 %	
El Salvador	96.8%	
Eritrea	32.0%	

COUNTRY	Electrification Rate (rural, urban and/or national)	Target
Ethiopia	45.0%	75% by 2015
Federated States of Micronesia[4]	4.0% (rural)	
Gabon	36.7%	
Ghana	70.0%	
Grenada	82.0%	
Guatemala	84.4%	
Guyana	82.0%	
Haiti	34.0%	
Honduras	79.3%	
India	75.0%	
Indonesia[5]	65.1%	
Iran	98.4%	
Iraq	86.0 %	
Israel	99.7 %	
Jamaica	96.8%	
Jordan	99.0%	
Kenya	4.0% (rural) 51.0% (urban)	
Korea	26.0%	
Kuwait	100%	
Laos	55.0%	
Lebanon	100%	
Lesotho	16.0%	
Libya	99.0%	
Madagascar	19.0%	
Malawi	1% (rural) <9% (national)	30% by 2020
Malaysia	99.4%	
Marshall Islands	100% (urban)	95% rural by 2015
Mauritius	99.4%	
Mexico	97.6%	
Mongolia	67.0%	
Morocco	97.0%	
Mozambique	12.0%	
Myanmar	13.0%	
Namibia	34.0%	
Nepal	10.0%	30% by 2030
Nicaragua	64.8%	
Nigeria	51.0%	

TABLE R16. ELECTRICITY ACCESS BY REGION AND COUNTRY (CONTINUED)

COUNTRY	Electrification Rate (rural, urban and/or national)	Target
Oman	98.0%	
Pakistan	62.0%	
Palestinian Territories[6]	99.4%	
Panama	83.3%	
Paraguay	98.4%	
Peru	78.6%	
Philippines[5]	84.0%	
Qatar	98.7%	
Rwanda		16% (national) by 2012
Saudi Arabia	99.0%	
Senegal	42.0%	
Singapore	100%	
South Africa	75.0%	100% (nat.) by 2014
South Sudan	1.0%	
Sri Lanka	76.6%	
Sudan	36.0%	
Suriname	90.0%	
Syria	99.8% (rural)	
Tanzania	2% (rural) 13.9% (national)	30% (rural) by 2015
Thailand	>99%	
Togo	20.0%	
Trinidad and Tobago	92.0%	
Tunisia	99.5%	
Uganda	5.0%	
United Arab Emirates	100%	
Uruguay	99.8%	
Venezuela	97.3%	
Vietnam	97.6%	
Yemen[5]	42.0%	
Zambia	3.1% (rural) 47.6% (urban) 20.3% (national)	51% (rural) 90% (urban) 66% (nat.) by 2030
Zimbabwe	41.5%	

Note: Rates and targets are national unless otherwise specified.

1 Developing Asia is divided as follows: China and East Asia includes Brunei, Cambodia, China, East Timor, Indonesia, Laos, Malaysia, Mongolia, Myanmar, the Philippines, Singapore, South Korea, Taiwan, Thailand, Vietnam, and other Asian countries; South Asia includes Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka.

2 Bangladesh electrification rate is defined by the government as the number of villages electrified: 50,000 villages out of a total 78,896.

3 China data calculated using 2011 official report of 5 million people with no access to electricity and total population of 1.3 billion.

4 For the Federated States of Micronesia, rural electrification rate is defined by electrification of all islands outside of the four that host the state capital (which is considered urban).

5 For Indonesia, the Philippines, and Yemen, the rate is defined by the number of households with electricity connection.

6 Palestinian Territories rate is defined by number of villages connected to the national electricity grid.

Source: See Endnote 16 for this section.

TABLE R17. POPULATION RELYING ON TRADITIONAL BIOMASS FOR COOKING

REGIONS AND SELECTED COUNTRIES	Population	
	Millions	Percent
Africa	657	65%
Nigeria	104	67%
Ethiopia	77	93%
Democratic Republic of the Congo	62	94%
Tanzania	41	94%
Kenya	33	83%
Other Sub-Saharan Africa	335	74%
North Africa	4	3%
Developing Asia[1]	1,921	54%
India	836	72%
Bangladesh	143	88%
Indonesia	124	54%
Pakistan	122	72%
Myanmar	48	95%
Rest of Developing Asia	648	36%
Latin America	85	19%
Middle East	n.a.	n.a.
All Developing Countries	2,662	51%
World[2]	**2,662**	**39%**

1 Developing Asia is divided as follows: China and East Asia includes Brunei, Cambodia, China, East Timor, Indonesia, Laos, Malaysia, Mongolia, Myanmar, the Philippines, Singapore, South Korea, Taiwan, Thailand, Vietnam, and other Asian countries; South Asia includes Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka.

2 Includes countries in the OECD and Eastern Europe/Eurasia.

Source: See Endnote 17 for this section.

GLOBAL MARKET AND INDUSTRY OVERVIEW

1 Estimated shares and Figure 1 based on the following sources: Total 2010 final energy demand (estimated at 8,823 Mtoe) is based on 8,353 Mtoe for 2009 from International Energy Agency (IEA), World Energy Statistics 2011 (Paris: 2011) and escalated by the 5.62% increase in global primary energy demand from 2009 to 2010, derived from BP Statistical Review of World Energy 2011 (London: 2011). Traditional biomass use in 2008 was estimated at 746 Mtoe (31.2 EJ) and reflects consumption of the residential sector in developing countries, from IEA, World Energy Outlook 2010 (Paris: 2010), p. 342. This value was held constant because 1) the exact value for 2008 is uncertain as is the aggregate change since then, and, 2) there is reason to believe that use of traditional biomass may have stabilised or declined as the number of people using traditional biomass for cooking and heating has declined over this period (as per IEA World Energy Outlook, see Rural Renewable Energy Section).

Three biomass heat energy values for 2010 were derived from values for 2009 from IEA, World Energy Statistics 2011, op. cit. this note. Residential and commercial use of non-CHP modern biomass heat (including solid biofuels, biogenic municipal waste, and biogases) was estimated at 74 Mtoe (3.1 EJ). This value was derived by subtracting the 746 Mtoe of traditional biomass use (see above) from the total 2010 combined residential and commercial use of biomass for heat, estimated at 820 Mtoe (34.3 EJ) in 2010. The 820 Mtoe was derived by applying a five-year average growth rate to the 2009 values, based on historical data from IEA, World Energy Statistics 2011, op. cit. this note. Industrial use of biomass heat was estimated at 178 Mtoe (7.5 EJ), based on five-year average growth rates as above. (Note that previous editions of the GSR have not reported this value in total modern biomass use for heat). Biomass heat from combined heat and power (CHP) was estimated at 11.5 Mtoe (0.48 EJ), based on five-year growth rates as above.

Biomass electricity was estimated at 25 Mtoe (289 TWh), based on 66 GW of capacity in 2010 (see Reference Table R1) and a capacity factor of 50%, which was based on the average capacity factors (CF) of biomass generating plants in the United States (49.3% CF based on data from "Table 1.2: Existing Capacity by Energy Source, 2010," in U.S. Energy Information Administration (EIA), Electric Power Annual 2010 (Washington, DC: 2011)), and in the European Union (52% CF based on data in Energy Research Centre of the Netherlands/ European Environment Agency, Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States, 28 November 2011, at http://www.ecn.nl/docs/library/report/2010/e10069.pdf). Applying a five-year growth rate to the 2009 value found in IEA, World Energy Statistics 2011, op. cit. this note, would yield a lower estimate of 260 TWh.

Other renewable electricity generation estimates: Wind power was 45 Mtoe (520 TWh), based on global capacity of 198 GW using a CF of 30%, which is in the middle of the range documented in this report; solar PV was estimated at 5.4 Mtoe (63 TWh), based on 40 GW capacity and average CF of 18%; concentrated solar thermal power (CSP) was 0.2 Mtoe (2.5 TWh), based on 1.3 GW capacity and CF of 25%; ocean power was 0.1 Mtoe (0.6 TWh), based on 273 GW capacity and CF of 25%. (For 2011 year-end operating capacities for wind, solar PV, CSP, and ocean power, see Reference Table R1; for capacity factors see Table 2 on Status of Renewable Energy Technologies: Characteristics and Costs.) Geothermal was 5.8 Mtoe (67 TWh), based on Ruggero Bertani, "Geothermal Power Generation in the World, 2005–2010 Update Report," Geothermics, vol. 41 (2012), pp. 1–29; hydropower was assumed to contribute 295 Mtoe (3,428 TWh), from BP, op. cit. this note.

Solar thermal hot water/heat output in 2010 was estimated at 14.6 Mtoe (0.6 EJ), based on Werner Weiss and Franz Mauthner, Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2010, Edition 2012 (Gleisdorf: Austria: IEA Solar Heating and Cooling Programme, May 2012). A conservative 5% was added to the estimates to account for the estimated 10% of the market not included in the Weiss and Mauthner survey.

Geothermal heat was estimated at 10.5 Mtoe (0.4 EJ), based on 50.8 GWth of capacity yielding 438 PJ of heat, from John W. Lund, Derek H. Freeston, and Tonya L. Boyd, "Direct Utilization of Geothermal Energy: 2010 Worldwide Review," in Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, 25–29 April 2010; updates from John Lund, Geo-Heat Center, Oregon Institute of Technology, personal communication with REN21, March, April, and June 2011.

For liquid biofuels, ethanol use was estimated at 44 Mtoe (1.8 EJ) and biodiesel use at 15 Mtoe (0.64 EJ), based on 86.5 billion litres and 18.5 billion litres, respectively, from F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," 2012, and from F.O. Licht, "Biodiesel: World Production, by Country (1000 T)," 2012; and conversion factors from Oak Ridge National Laboratory, found at https://bioenergy.ornl.gov/papers/misc/energy_conv.html.

Nuclear power generation was assumed to contribute 238 Mtoe (2,767 TWh) of final energy, from BP, op. cit. this note.

2 Figure 2 based on the following sources: solar PV from European Photovoltaic Industry Association (EPIA), Global Market Outlook for Photovoltaics until 2016 (Brussels: May 2012); wind power data from Global Wind Energy Council (GWEC), Global Wind Report: Annual Market Update 2011 (Brussels: March 2012), from World Wind Energy Association (WWEA), World Wind Energy Report 2011 (Bonn: 2012), and from Navigant's BTM Consult ApS, World Market Update 2011 (Copenhagen: 2012), Executive Summary; CSP from several sources, particularly Comisión Nacional de Energía of Spain (CNE), Madrid, April 2012, provided by Instituto para la Diversificación y Ahorro de la Energía (IDAE), Ministerio de Industria, Energía Y Turismo, personal communications with REN21, 17 and 18 May 2012, from Morse Associates, Inc., personal communication with REN21, March, April, and May 2012, and from U.S. National Renewable Energy Laboratory (NREL), "Concentrating Solar Power Projects," Solar Paces, http://www.nrel.gov/csp/solarpaces/ (see endnote for Reference Table R1 for additional sources for 2011 data); geothermal from Mannvit, "90 MW Addition to Iceland's Hellisheidi Geothermal Power Plant," press release (Reykjavik: 11 October 2011), at www.mannvit.com/AboutUs/News/Readarticle/90mwadditiontoicelandshellisheidigeothermalpowerplant, from Ram Power, "San Jacinto Tizate I & II – Nicaragua," http://ram-power.com/current-projects/san-jacinto-tizate-i-ii-nicaragua, from Terra-Gen Power, LLC, "Terra-Gen Power and TAS Celebrate Innovative Binary Geothermal Technology," press release (Beowawe, Nevada: 20 April 2011), at http://www.terra-genpower.com/News/TERRA-GEN-POWER-AND-TAS-CELEBRATE-INNOVATIVE-BINAR.aspx, from Geothermal Energy Association (GEA), Annual US Geothermal Power Production and Development Report (Washington, DC: April 2012), and from Bertani, op. cit. note 1; hydropower from International Hydropower Association (IHA), London, personal communication with REN21, April 2012 and in past years for previous editions of this report, and from International Journal on Hydropower & Dams (IJHD), Hydropower & Dams World Atlas 2011 (Wallington, Surrey, U.K.: 2011); solar thermal from Weiss and Mauthner, op. cit. note 1 and from previous editions of this annual report; ethanol and biodiesel from F.O. Licht, op. cit. note 1, both references. Ethanol data were converted from cubic metres to litres using 1,000 litres/cubic metre. Biodiesel data were reported in 1,000 tons and converted using a density value for biodiesel (0.88 kg/litre) based on "Bioenergy in Germany: Facts and Figures," January 2012, at http://www.biodeutschland.org/tl_files/content/dokumente/biothek/Bioenergy_in-Germany_2012_fnr.pdf, viewed 30 April 2012, and on NREL, Biodiesel Handling and Use Guide, Fourth Edition (Golden, CO: January 2009), at http://www.nrel.gov/vehiclesandfuels/pdfs/43672.pdf.

3 European Wind Energy Association (EWEA), "Wind in Power: 2011 European Statistics" (Brussels: February 2012); EPIA, personal communication with REN21, 3 April 2012.

4 Solar thermal from Weiss and Mauthner, op. cit. note 1; heat pumps from Lund, Freeston, and Boyd, op. cit. note 1; updates from Lund, op. cit. note 1; wood pellets, for example, from IEA, Bioenergy Annual Report 2011 (Paris: 2011). Pellet production rose from 9 million tonnes in 2008 to 12 million tonnes in 2009, and 16 million tonnes in 2010; it could rise to 20 million tonnes in 2011, per United Nations Economic Commission for Europe (UNECE), "Forest product markets across the UNECE region rebound in 2010 after two years of falling production and consumption," press release (Geneva: 3 August 2011), at http://www.unece.org/press/pr2011/11tim_p05e.html.
5 F.O. Licht, op. cit. note 1, both references.
6 Hydropower from IHA, op. cit. note 2 and from IJHD, op. cit. note 2, and see also various sources noted in Hydropower section; geothermal based on data from GEA, op. cit. note 2 and from Bertani, op. cit. note 1. Fossil fuels grew at an average annual rate of 1–4% between 2006 and 2010, but growth rates dropped off early in this period and accelerated toward the end of it (no data available for 2011 as of publication), based on data from BP, op. cit. note 1.
7 Bloomberg New Energy Finance (BNEF) Energy: Week in Review, 15–21 November 2011.
8 Slowdown from EIC Monitor, EIC Monthly News, March 2012, at http://issuu.com/publishingevents/docs/eicmarchnews2012/1#download%20quarterly%20report .
9 Sidebar 1 is based on the following sources: Most global numbers are aggregates of individual countries and regions shown in Table 1; however, the global biofuels figure (as well as data for U.S. hydropower and Brazil wind) are taken from REN21, Renewables 2011 Global Status Report (Paris: 2011) and global wind power is from WWEA, World Wind Energy Report 2010 (Bonn: April 2011). CSP estimate, as well as wind and solar overcapacities, based on BNEF, "Solar and Wind Sectors on Course to Employ 2m People Worldwide by 2020," Wind, Solar Research Note, 5 March 2012. Spanish job loss from Spanish Renewable Energy Association, Study of the Macroeconomic Impact of Renewable Energies in Spain. Year 2010 (Madrid: November 2011). China statistics from the following: biomass power from Li Junfeng, Deputy Director General of the Energy Research Institute of the National Development and Reform Commission in Beijing, and General Secretary of the Chinese Renewable Energy Industries Association (CREIA), personal communication with Yingling Liu, Worldwatch Institute, 12 November 2007; biogas from Institute for Urban and Environmental Studies and Chinese Academy of Social Sciences, Study on Low Carbon Development and Green Employment in China (Beijing: International Labour Organization (ILO) Office for China and Mongolia, April 2010); solar PV from Greenpeace, China Wind Power Outlook 2011 (Beijing: 2011); solar heating/cooling from Institute for Labor Studies and Chinese Ministry of Human Resources and Social Security, Study on Green Employment in China (Beijing: ILO Office for China and Mongolia, March 2010); wind from Li Junfeng, Shi Pengfei, and Gao Hu, 2010 China Wind Power Outlook (Beijing and Brussels: CREIA, GWEC, and Greenpeace, October 2010). India figures from Ministry of New and Renewable Energy (MNRE) and Confederation of Indian Industry, Human Resource Development Strategies for Indian Renewable Energy Sector. Final Report (New Delhi: October 2010). Brazil biofuels from General Secretariat of the Presidency of the Republic, The National Commitment to Improve Labor Conditions in the Sugarcane Activity (Brasilia: undated), and from Edmar Fagundes de Almeida, Jose Vitor Bomtempo, and Carla Maria de Souza e Silva, The Performance of Brazilian Biofuels: An Economic, Environmental and Social Analysis. Joint Transport Research Centre Discussion Paper No. 2007-5 (Paris: OECD, International Transport Forum, December 2007). U.S. statistics from the following: biomass and high-end biofuels from Roger Bezdek, Renewable Energy and Energy Efficiency: Economic Drivers for the 21st Century (Boulder, CO: American Solar Energy Society, 2007); low-end biofuels (as well as APEC biofuels) from Asia-Pacific Economic Cooperation, A Study of Employment Opportunities from Biofuel Production in APEC Economies (Singapore: 2010); geothermal (which includes geothermal power only, excluding heat) from Dan Jennejohn, Green Jobs Through Geothermal Energy (Washington, DC: GEA, October 2010); solar from The Solar Foundation, National Solar Jobs Census 2011 (Washington, DC: October 2011), and from U.S. Solar Energy Trade Assessment 2011, study prepared for Solar Energy Industries Association, August 2011; wind power from American Wind Energy Association (AWEA), "Annual report: Wind power bringing innovation, manufacturing back to American industry," press release (Washington, DC: 12 April 2012). EU figures derived from EurObserv'ER, État des Énergies Renouvelables en Europe. Édition 2011 (Brussels: 2011), except for the German and Spanish figures (which diverge from the Eurobserv'ER data in some cases). German data from Marlene O'Sullivan et al., Bruttobeschäftigung durch Erneuerbare Energien in Deutschland im Jahr 2011 (Berlin: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, 14 March 2012); Spanish data from Instituto para la Diversificación y Ahorro de la Energía, Observatorio Energías Renovables (Madrid: November 2011), and from Spanish Association of Solar Thermal Industry (Protermosolar), Macroeconomic Impact of the Solar Thermal Electricity Industry in Spain (Seville: October 2011). U.S. wind job loss from AWEA, "New study: Wind energy success story at risk with 54,000 American jobs in the balance," press release (Washington, DC: 12 December 2011), at http://awea.org/newsroom/pressreleases/Navigant_study.cfm. Bangladesh solar PV from Dipal Barua, Clean Energy Imperative: Improving Energy Access or Promoting Energy Poverty. Panel discussion at The Tufts Energy Conference, Medford, MA, 16 April 2011; Nepal biogas from United Nations Conference on Trade and Development (UNCTAD), Renewable Energy Technologies for Rural Development (New York and Geneva: 2010); wind, various countries, from GWEC, Global Wind Report 2010 (Brussels: April 2011); Australia biomass, hydro, and solar heating/cooling from Clean Energy Australia, "Renewable Energy Jobs," http://cleanenergyaustraliareport.com.au/money-talk/renewable-energy-jobs/, viewed 10 March 2012 . See also IRENA, Renewable Energy Jobs and Access, at http://www.irena.org/DocumentDownloads/Publica-tions/Renewable_Energy_Jobs_and_Access.pdf, and IRENA, Renewable Energy Jobs: Status, Prospects and Policies, at http://www.irena.org/DocumentDownloads/Publications/RenewableEnergyJobs.pdf.
10 See, for example, Nina Chestney, "Renewable energy deals hit record high in 2011-PwC," Reuters, 30 January 2012, at http://af.reuters.com/article/commoditiesNews/idAFL5E8CR1Z620120130?sp=true; also see technology sections in this report.
11 See, for example, "Will Italy's FiTs Survive the Fall of Berlusconi?" RenewableEnergyWorld.com, 23 February 2012, at http://www.renewableenergyworld.com/rea/news/article/2012/02/will-italys-fits-survive-the-change-in-government?cmpid=SolarNL-Thursday-February23-2012; also see technology sections in this report.
12 About 208 GW added in 2011, based on 106 GW of conventional thermal capacity from U.N. Environment Programme (UNEP)/Frankfurt School/BNEF, Global Trends in Renewable Energy Investment (Paris: 2012), and about 102 GW of renewable capacity based on data noted in this report. See Reference Table R1 and related references.
13 Share for 2004 from UNEP/Frankfurt School/BNEF, op. cit. note 12; share for 2011 based on 208 GW total capacity added and approximately 77 GW of non-hydro capacity added based on data throughout this report and sources listed in note 1 of this section. See also Reference Table R1. BNEF estimates that the share of non-hydro renewables has risen from 4.3% to more than 9% during this period.
14 Year-end capacity for 2011 and increase in capacity during 2011 based on data throughout this report: 5.9 GW biomass power added for total of 71.9 GW; more than 0.1 GW geothermal capacity added for 11.2 GW; and estimated 25 GW hydropower added for an estimated 970 GW; 0.3 GW ocean power added for 0.5 GW; almost 30 GW solar PV added for almost 70 GW; more than 0.5 GW CSP added for about 1.8 GW, and about 40 GW wind power added for nearly 238 GW. See Reference Table R1 and related references.

15 Ibid.

16 Based on data throughout this report; see Endnote 1 for this section, Reference Table R1, and related references for details.

17 Global capacity in 2011 based on 4,961 GW in 2009 from IEA, World Energy Outlook 2011, Annex A (Paris: 2011); plus 2010 capacity additions based on 92 GW fossil and 5 GW nuclear capacity from UNEP/Frankfurt School/BNEF, op. cit. note 12, plus 2011 conventional thermal capacity additions from idem, plus renewable capacity additions (about 92 GW in 2010 and 102 GW in 2011) from various sources provided in Endnote 1 of this section. (Also see Reference Table R1 and related references.) Share of generation and Figure 3 based on the following: Total global electricity generation in 2011 is estimated at 22,273 TWh, based on 21,325 TWh in 2010 from BP, op. cit. note 1, and an estimated 4.45% growth rate in global electricity generation for 2011. The growth rate is based on the total change in generation for the following countries (which account for more than 60% of 2010 generation): United States (-0.47% change in annual generation), EU-27 (+0.96%), Russia (+1.64%), India (+9.03%), and China (+11.68%). Sources for 2010 and 2011 electricity generation are: "Table 7.2a, Electricity Net Generation," in U.S. EIA, Monthly Energy Review, April 2012, at http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf; European Commission, Eurostat database, http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database; Ministry of Energy of the Russian Federation, http://minenergo.gov.ru/activity/statistic/ [in Russian]; Government of India, Ministry of Power, Central Electricity Authority, http://www.cea.nic.in/monthly_gen.html; China Electricity Council, "Statistics Newsletter of Electricity Industry in China 2011," 1 January 2012, at http://tj.cec.org.cn/tongji/niandushuju/2012-01-13/78769.html [in Chinese].

Hydropower generation in 2011 is estimated at 3,400 TWh, based on reported 2010 global generation and assumption that output remained fairly stable in 2011. Unchanged global 2011 output is based on reported changes in countries that together accounted for over 75% of global hydropower generation in 2010: United States (+24.9% in annual output), Canada (+7.3%), EU-27 plus Norway (-25.9%), Brazil (+11.1%), Russia (-5.4%), India (+18.9% for facilities larger than 25 MW), and China (-3.52%). The combined hydropower output of these countries was virtually unchanged on average or down slightly, resulted in an estimated 1.4% reduction in output. Total 2010 hydro generation was 3,428 TWh per BP, op. cit. note 1, and 3,410 TWh per IJHD, op. cit. note 2; 2010 and 2010 generation by country from "Table 7.2a, Electricity Net Generation," in U.S. EIA, op. cit. this note; Statistics Canada, http://www5.statcan.gc.ca; EU-27 and Norway from European Commission, op. cit. this note; Brazil 2010 generation from IJHD, op. cit. this note, and 2011 generation from Mauricio Tolmasquim, EPE Brazil, personal communication with IHA on behalf of REN21, 4 April 2012; Ministry of Energy of the Russian Federation, http://minenergo.gov.ru/activity/powerindustry/powersector/structure/manufacture_principal_views/ [in Russian]; Government of India, op. cit. this note; China Electricity Council, op. cit. this note.

Non-hydro renewable generation of 1,125 TWh was based on 2011 generating capacities shown in Reference Table R1 and representative capacity factors in Endnote 1.

18 UNEP/Frankfurt School/BNEF, op. cit. note 12.

19 Kilian Reiche, iiDevelopment GmbH, personal communication with REN21, April 2012.

20 Based on data noted in this report. See Reference Table R2 and related references.

21 From ibid. and population data from U.S. Central Intelligence Agency (CIA), World Factbook, July 2012 estimate, at https://www.cia.gov/library/publications/the-world-factbook/index.html, viewed 22 May 2012.

22 Based on 90.41 GW total added capacity for a total electric capacity of 1,050 GW from the following: China Electricity Council, op. cit. note 17; 12.25 GW new hydropower capacity and 2.14 GW solar PV from idem; 17.6 GW wind power capacity from Shi Pengfei, Chinese Wind Energy Association (CWEA), personal communication with REN21, 1 April 2012; 0.4 GW biomass power capacity from "China's first biomass-fired power plant goes into operation," Xinhua, 2 December 2006, at http://english.peopledaily.com.cn/200612/02/eng20061202_327476.html; Bernhard Raninger, GIZ Project Optimization of Biomass Use, personal communication with REN 21, April 2012. Another document shows electric capacity increasing 90 GW from 966 GW to 1,055 GW, from Liu Zhan, China Power Investment Corporation, "Clean coal power generation in China," Speech at 2012 APEC Clean Fossil Energy Technology and Policy Seminar, Australia, February 2012.

23 China Electricity Council, op. cit. note 17; "Use of Fossil Fuels to Decline," China Daily, 10 February 2012, at http://www.china.org.cn/business/2012-02/10/content_24601666.htm.

24 Based on data for 2009–2011 from "Table 7.2a Electricity Net Generation," in U.S. EIA, op. cit. note 17.

25 Estimate of 39% and most from wind (31% of the total), from AWEA, "U.S. Wind Industry Annual Market Report, Year Ending 2011," a Product of AWEA Data Services, p. 5; 11.6% from U.S. EIA, Monthly Energy Review, January 2012, at http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf.

26 Estimate of 11.8% of total primary energy production in 2011, up from 10.9% in 2010, and nuclear share of 10.6% in 2011 all based on data from "Table 1.2 Primary Energy Production by Source," in U.S. EIA, op. cit. note 25, p. 5, at http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_5.pdf.

27 Stephen Lacey, "Wind power helps drive strong increase in US renewable electricity generation," RenewableEnergyWorld.com, 17 April 2012.

28 German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Renewable Energy Sources 2011, based on information supplied by the Working Group on Renewable Energy - Statistics (AGEE-Stat), 8 March 2012, at http://www.erneuerbare-energien.de/english/renewable_energy/data_service/renewable_energy_in_figures/doc/48506.php; data for past years from BMU, Renewable Energy Sources 2011, based on information supplied by the Working Group on Renewable Energy – Statistics (AGEE-Stat), 20 February 2012; Stefan Nicola, "Germany's Renewable Output Beats Nuclear, Hard Coal in Power Mix," Bloomberg.com, 16 December 2011, at http://www.businessweek.com/news/2011-12-16/germany-s-renewable-output-beats-nuclear-hard-coal-in-power-mix.html.

29 BMU, "Development of renewable energy sources in Germany 2011, Graphics and tables," based on statistical data from the Working Group on Renewable Energy – Statistics (AGEE-Stat), version March 2012.

30 GWEC, op. cit. note 2, p. 57. See also Reference Table R2 and related endnotes.

31 Gestore Servizi Energetici (GSE), "Impianti a fonti rinnovabili in Italia: Prima stima 2011," 6 March 2012, at http://www.gse.it/it/Dati%20e%20Bilanci/Osservatorio%20statistico/Pages/default.aspx; other data and sources can be found throughout this report; see particularly Reference Table R2 and related endnotes.

32 Additions based on 3 GW wind from GWEC, op. cit. note 2, p. 44; 0.6 GW biomass power from MNRE, "Achievements," http://www.mnre.gov.in/mission-and-vision-2/achievements/, updated 31 January 2012; about 0.5 GW solar PV from EPIA, op. cit. note 2. In addition, India added about 210 MW of small-scale hydropower installations (≤25 MW) during 2011, tracked by MNRE, op. cit. this note, as well as 1.4 GW of large-scale (defined as >25 GW), from Government of India, Ministry of Power, Central Electricity Authority, Monthly Review of Power Sector Reports (Executive Summary), at http://www.cea.nic.in/executive_summary.html, and from Bridge to India, New Delhi, personal communications with REN21, April-May 2012. In addition, an estimated 91 MW equivalent of off grid capacity was added during 2011 for a cumulative total of 660 MW, from MNRE, op. cit. this note.

33 Based on 2.5 GW wind from GWEC, op. cit. note 2; 4.9 GW solar PV from Japan Photovoltaic Energy Association, http://www.jpea.gr.jp/04doc01.html; 3.3 GW biomass from Hironao Matsubara, Institute for Sustainable Energy Policies, Japan, personal communication with REN21, March 2012; 535 MW geothermal capacity from Bertani, op. cit. note 1; National

Institute of Advanced Industrial Science and Technology, Japan, "Geothermal Power Plants in Japan," as of April 1998, at http://www.aist.go.jp/GSJ/dGT/hatsuden.html. Japan also has an estimated 27.6 GW of hydropower capacity. For more information and sources see Reference Table R2 and related sources.

34 Based on data provided throughout this report. See Reference Table R2 and relevant notes for sources.

35 Fourth year in a row from GWEC, op. cit. note 2; record share and solar PV from EWEA, op. cit. note 3. More renewable power capacity was added in Europe than ever before (32 GW), with total installations up almost 38% over the previous year. The EU installed a total of 45 GW new electric capacity in 2011. Note that the region has an estimated 120 GW of hydropower capacity, per IJHD, op. cit. note 2, and that new hydropower capacity (606 MW) represented about 1% of total additions during 2011, from EWEA, op. cit. note 3.

36 EWEA, op. cit. note 3.

37 EurObserv'ER, The State of Renewable Energies in Europe (Paris: December 2011), pp. 101 and 105.

38 Ali Adil, ICLEI South Asia- Local Governments for Sustainability, personal communication with REN21, April 2012.

39 Veit Bürger, Oeko-Institut e.V., Freiburg, personal communication with REN21, 23 February 2012; 2006 data from Bundesnetzagenture für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, Monitoringbericht 2010 (Berlin: 20 November 2010). More than 3% of the country's total net electricity demand is covered by the voluntary green power market, per Bürger, op. cit. this note.

40 Rainer Hinrichs-Rahlwes, German Renewable Energies Federation/European Renewable Energy Federation, personal communication with REN21, March 2012.

41 REN21, op. cit. note 9, p. 57.

42 Jenny Heeter and Lori Bird, Status and Trends in U.S. Compliance and Voluntary Renewable Energy Certificate Markets (2010 Data) (Golden, CO: NREL, October 2011), at http://apps3.eere.energy.gov/greenpower/pdfs/52925.pdf; 18 TWh of "green" renewable power was purchased in 2007.

43 Kari Williamson, "US companies commit to '5 Year Renewable Energy Pledge'," RenewableEnergyFocus.com, 19 December 2011, at http://www.renewableenergyfocus.com/view/22769/us-companies-commit-to-5-year-renewable-energy-pledge/; Windmade Web site, http://www.windmade.org/about.aspx.

44 Bürger, op. cit. note 39; REN21, op. cit. note 9, pp. 57–58.

45 For example, see Victoria Kenrick, "Executive decision: renewables procurement, investment and trading," Renewable Energy World, November–December 2011, pp. 47–50.

46 Werner Weiss and Franz Mauthner, Solar Heat Worldwide (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme: 2011), at http://www.iea-shc.org/publications/downloads/Solar_Heat_Worldwide-2011.pdf; more than 100 large-scale thermal systems for process heat have been installed, from D. Arvizu et al., "Direct Solar Energy," in Intergovernmental Panel on Climate Change, IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (Cambridge, U.K.: Cambridge University Press, 2011).

47 BMU, 20 February 2012, op. cit. note 28.

48 IEA, Technology Roadmaps, Biofuels for Transport (Paris: 2011), at http://www.iea.org/publications/free_new_Desc.asp?PUBS_ID=2389.

49 Ethanol and biodiesel production from F.O. Licht, op. cit. note 1; for more details and information about advanced fuels for aviation and other uses, see Bioenergy section.

50 See, for example, Nicolaj Stenkjaer, "Biogas for Transport," Nordic Folkecenter for Renewable Energy, November 2008, at www.folkecenter.net/gb/rd/transport/biogas_for_transport; Switzerland from Dunja Hoffmann, Deutsce Gesellschaft für Internationale Zusammenarbeit (GIZ), personal communication with REN21, 29 April 2011.

51 Natural and Bio Gas Vehicle Association (NVGA Europe) Web site, www.ngvaeurope.eu, viewed March 2011. Sweden also from Stenkjaer op. cit. note 50; Switzerland also from Hoffmann, op. cit. note 50. See also Stephan Kabasci, "Boosting Biogas with Heat Bonus: How Combined Heat and Power Optimizes Biogas Utilization," Renewable Energy World, September/October 2009.

52 Swedish Energy Agency, Transportsektorns energianvändning 2010, (Energy Use in the Transport Sector 2010) (Eskilstuna, Sweden: 2011).

53 Erik Kirschbaum, "Analysis: German Rail to Run on Sun, Wind to Keep Clients Happy," Reuters, 23 August 2011, at http://planetark.org/wen/63027.

54 The primary source for this table is Intergovernmental Panel on Climate Change (IPCC), Special Report on Renewable Energy Sources and Climate Change Mitigation (Cambridge, U.K.: Cambridge University Press, 2011). Note that monetary data from the IPCC are converted from USD 2005 to USD 2012 using U.S. Bureau of Labor Statistics, Consumer Price Index Inflation Calculator, http://stats.bls.gov/data/inflation_calculator.htm, viewed 12 April 2012. LCOE/LCOH data from IPCC assume a discount rate of 7% except as noted.

POWER SECTOR

Biomass power: IPCC, op. cit. this note. LCOE low-end is based on feedstock costs of USD 1.47/GJ and low-end capital costs; high-end figure is based on feedstock cost of (2005) USD 5.87/GJ and high-end capital costs. **Geothermal power:** Capacity factor and per kWh costs from IPCC, op. cit. this note, pp. 425–26, 1,004–06. Cost ranges are for greenfield projects, at a capacity factor of 74.5%, a 27.5-year economic design lifetime, and a discount rate of 7% and using the lowest and highest investment cost, respectively; capital cost range was derived from IPCC (condensing flash: USD 2,110–4,230; binary: USD 2,470–6,100) and from worldwide ranges (condensing flash USD 2,075–4,150; and binary USD 2,480–6,060) for 2009 from C.J. Bromley, et al., "Contribution of geothermal energy to climate change mitigation: The IPCC renewable energy report," in: Proceedings World Geothermal Congress 2010, Bali, Indonesia, 25–30 April 2010, at www.geothermal-energy.org/pdf/IGAstandard/WGC/2010/0225.pdf. (All monetary units converted from USD 2005 to current dollars.) **Hydropower:** Characteristics based on IPCC, op. cit. this note, and on Arun Kumar, Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, personal communication with REN21, March 2012. For grid-based projects, capital cost ranges and LCOE for new plants of any size provided in table are from International Energy Agency (IEA), Deploying Renewables: Best and Future Policy Practice (Paris: 2011). Note that IPCC, op. cit. this note, estimates capital costs in the range of USD 1,175–3,500, and LCOE in the range 2.1–12.9 U.S. cents/kWh assuming a 7% discount rate. Investment costs for hydropower projects can be as low as USD 400–500 per kW but most realistic projects today are in the range of USD 1,000–3,000 per kW, per IPCC, p. 1,006. Off-grid capital costs and LCOE from REN21, Renewables 2011 Global Status Report (Paris: 2011). Note that the cost for hydropower plants is site-specific and may have large variations. Small capacity plants in some areas even may exceed these limits. The cost is dependent on several factors especially plant load factor, discount rate, and life of the projects. Normally small-scale hydro projects last 20–50 years compared to large-scale hydro, which may last 30–80 years. However, the generation cost of a reservoir-based project may be also high as it serves in many instances as peak power. **Ocean Energy:** All data are from IPCC, op. cit. this note. Note that this is based on a very small number of installations to date; LCOE range assumes a 7% discount rate. **Solar PV:** All cost data are based on Europe, as are characteristics, and drawn from European Photovoltaic Industry Association (EPIA), Market Report 2011 (Brussels: January 2012), at http://www.epia.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/EPIA_docs/publications/epia/EPIA-market-report-2011.pdf&t=1331313369&hash=cbfab7920963574a77a42182a06e071b, and from EPIA, personal communication with REN21, 3 April 2012. Conversion efficiency is from IPCC, op. cit. this note, p. 1,004; note that utility-scale ground-mounted data are based on one-axis tilt.

Other cost estimates are as follows: capital costs for rooftop of USD 3,300–5,800 and for ground-mounted utility-scale of USD 2,700–4,100, and LCOE for rooftop of 13.8–68.8 U.S. cents/kWh and for utility-scale of 11.3–48.6 U.S. cents/kWh are all as of June 2011, from IEA, op. cit. this note; rooftop LCOE of 14–23 U.S. cents/kWh (with no specifications for scale, global average costs assuming 6% discount rate, 16–26% capacity factor; O&M costs of USD 6–26/kW) from Ron Pernick, Clint Wilder, and Trevor Winnie, Clean Energy Trends 2012, March 2012; utility-scale capital cost averaging USD 2,600 (€2 million per MW) for 2011 from Denis Lenardic, PVresources, personal communication with REN21, March, 2012. Note that while PV module prices are global, balance of system costs are much more local. Also, note that prices have been changing rapidly. **CSP:** Characteristics include tower plant sizes and storage ranges from European Solar Thermal Electricity Association (ESTELA), personal communication with REN21, 22 March 2012; Fred Morse, Abengoa Solar, personal communication with REN21, 26 March 2012; storage ranges and capacity factors also from Claudia do Valle, Renewable Energy Analyst, IITC, "Power Sector Costing Study – Concentrated Solar Power," presentation to the 3rd Thermal Electricity Industry Forum, Cologne, Germany, 30 January 2012, at http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/events/3RD_STEI_FORUM/Presentations/1.3_Claudia_Do_Valle_ESTELA_3rd_STEI_Forum_15Feb2012.pdf; the capacity factor of parabolic trough plants with six hours of storage, in conditions typical of the U.S. Southwest, was estimated to be 35–42%, per IPCC, op. cit. this note, pp. 1,004, 1,006. Note that the Gemasolar plant, which began operation in Spain in 2011, has storage for up to 15 hours, per Torresol Energy, "Gemasol," http://www.torresolenergy.com/TORRESOL/gemasolar-plant/en. Parabolic trough plants are typically in the range of 50–200 MW; tower 20–70 MW; and Linear Fresnel in the range of 1–50 MW, per Bank Sarasin, Solar Industry: Survival of the Fittest in the Fiercely Competitive Marketplace (Basel: Switzerland, November 2011), and Protermosolar, the Spanish Solar Thermal Electricity Industry Association, April 2012. Note that multiple systems can be combined for higher capacity plants. Capital costs for parabolic trough plants without storage and solar tower plants with 6–18 hours storage are based on do Valle, op. cit. this note; parabolic trough plants with six hours storage based on ranges of USD 7,100–9,800 from do Valle, op. cit. this note, and USD 7,070–8,600 from IPCC, op. cit. this note, pp. 1,004–1,006. LCOE range from IPCC, op. cit. this note, p. 1,004, assuming 7% discount rate; other LCOE estimates include 26 U.S. cents/kWh based on 2010 data (estimated from chart) from Luis Crespo, ESTELA, "Solar Thermal Electricity: The Real Uptake," presentation to the 3rd Thermal Electricity Industry Forum, Cologne, Germany, 15 February 2012, at http://www.estelasolar.eu/fileadmin/ESTELAdocs/documents/events/3RD_STEI_FORUM/Presentations/1.2_Luis_Crespo_CSP_in_Europe_ESTELA_3rd_STEI_Forum_15Feb2012.pdf (assumptions include 250 MW, Europe-based (i.e., Spain), eight hours storage); about 18 U.S. cents/kWh for trough also from Frank Wilkins, CSP Team Lead, Solar Energy Technologies Program, U. S. Department of Energy, "New at DOE: SunShot initiative," presented at CSPToday USA Conference, 29–30 June 2011. **Wind power:** Characteristics based on turbine size from JRC Scientific and Technical Reports, op. cit. this note; on- and offshore capacity factor from IPCC, op. cit. this note, p. 1,005. Installed capital costs and LCOE for on- and offshore from IPCC, op. cit. this note, p. 1,005; assumes 7% discount rate. Range of 4–16 U.S. cents/kWh from IEA, op. cit. this note. For U.S. costs and trends, see also Mark Bolinger and Ryan Wiser, Understanding Trends in Wind Turbine Prices Over the Past Decade (Berkeley, CA: Lawrence Berkeley National Laboratory, October 2011), at http://eetd.lbl.gov/ea/ems/reports/lbnl-5119e.pdf. Note that the lowest-cost onshore wind projects have been installed in China; higher costs have been experienced in Europe and the United States. All small-scale data from World Wind Energy Association, 2012 Small Wind World Report (Bonn: March 2012).

HEAT SECTOR

Biomass heat: IPCC, op. cit. this note, Annex III and Helena Chum, National Renewable Energy Laboratory (NREL), personal communications with REN21, 31 March 2012. Assumes feedstock cost of 4.4–7.3 USD/GJ for CHP plants, and 11.8–23.5 USD/GJ for pellet heating; 7% discount rate for CHP and 10% discount rate for domestic pellet heating. **Geothermal heat:** IPCC, op. cit. this note, pp. 427, 1,010–11 (converted from USD 2005), assuming 7% discount rate. Also, for building heating, assumptions included a load factor of 25–30%, and a lifetime of 20 years, and for district heating, the same load factor and a lifetime of 25 years. For heat pumps, assumed 25–30% as the load factor and 20 years as the operational lifetime; it is worth taking into account that actual LCOH are influenced by electricity market prices. Drilling costs are included for commercial and institutional installations, but not for residential installations. **Solar thermal:** Solar heating plant sizes and capital costs for Europe from Werner Weiss, personal communication with REN21, April 2012. Global and China capital costs and LCOE from IPCC, op. cit. this note, p. 1,010. IPCC LCOE assume 7% discount rate. Domestic hot water (China) and domestic hot water, thermosiphon, combi-systems (elsewhere) from IPCC, op. cit. this note, Annex A3, p. 1,010, assuming 7% discount rate. (European data were converted from Euro/m^2. For domestic hot water systems, original data were: Small-scale: 900–930 Euro/m^2; Large-scale: 550–570 Euro/m^2; for domestic heating hot water systems, original data were: Small-scale: 750–800 Euro/m^2; Medium-scale: 470–550 Euro/m^2; District heat: 250–420 Euro/m^2; with storage: 570 Euro/m^2.)

TRANSPORT SECTOR

For biodiesel, feedstock cost represents 10-15% of total production cost for waste oils, and 80-90% for vegetable oils; for ethanol, feedstock cost represents 50–80% of total production cost. Note that for many years the cost of ethanol produced from Brazilian sugar cane was lower than that of corn ethanol in the United States. Weather impacts in Brazil and other sugar-producing countries over several years reduced global sugar production and stocks. At the same time, consumption increased in a number of developing countries, particularly China, leading to record-high market prices for sugar, and increasing competition between sugar and ethanol production. Historical cost data (cents per kilowatt-hour) for Brazilian sugarcane include: 20 (2004/5); 35 (2006/7); and for U.S. corn ethanol (dry mill) they include: 33 (2004/5); 47 (2006/7). Biofuels based on estimated production costs with lifetime of 20 years for plants varying in size from 5–250 million litres/year of fuel using a 10% discount rate. Data compiled from H. Chum et al., "Bioenergy," Chapter 2 in IPCC, op. cit. this note, pp. 244–45; A. Milbrandt and R.P. Overend, Future of Liquid Biofuels for APEC Economies, report prepared for Asia-Pacific Economic Cooperation (Golden, CO: NREL, 2008), at www.biofuels.apec.org/pdfs/ewg_2008_liquid_biofuels.pdf; 2011 sugarcane ethanol production costs from U.S. Department of Agriculture, Global Agriculture Information Network, Biofuels Annual (Brazil) (Washington, DC: 2012); selected examples from T. Bruckner et al., "Annex III: Cost Table," in IPCC, op. cit. this note, pp. 1,014–17; early ethanol data from L. Tao and A. Aden, "The economics of current and future biofuels," In Vitro Cellular & Developmental Biology - Plant, vol. 45, no. 3 (2009), pp. 199–217.

BIOMASS ENERGY

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GEOTHERMAL POWER AND HEAT

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3 Ibid, both sources.

4 Ibid, both sources.

5 Two-thirds based on 64% from Lund, Freeston, and Boyd, op. cit. note 1; updates from Lund, op. cit. note 1.

6 Data for China, Sweden, Turkey, and Japan are for 2010, from Lund, Freeston, and Boyd, op. cit. note 1; updates from Lund, op. cit. note 1; United States from U.S. Energy Information Administration, Table 10.1 (Production and Consumption by Source), Table 10.2c (Consumption: Electric Power Sector), and Table A6 (Approximate Heat Rates for Electricity and Heat Content of Electricity), in Monthly Energy Review (Washington, DC: April 2012). Based on total geothermal energy consumption of 226 trillion Btu less 163 trillion Btu for electricity generation, yielding 63 trillion Btu for direct use, or 18,465 GWh; Iceland from Orkustofnun, Energy Statistics in Iceland 2011, at http://www.os.is/gogn/os-onnur-rit/orkutolur_2011-enska.pdf. Based on 41.4 PJ total geothermal energy use, of which 61%, or 7,016 GWh, is direct use.

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8 Orkustofnun, op. cit. note 6.

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HYDROPOWER

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OCEAN ENERGY

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SOLAR PV

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15 Estimates of 9.3 GW and 12.75 GW from GSE, op. cit. note 10; 9,284 MW from EPIA, op. cit. note 1. Note that year-end total for installed capacity does not include hundreds of megawatts that were listed in the allocation register during 2011 and expected to come on line during 2012, per EurObserv'ER, op. cit. note 4, p. 115.

16 Estimate of 3.7 GW from GSE, op. cit. note 10. Italy officially connected 9,280 MW to the grid in 2011, ending the year with a total of 12,763.5 MW. Note that 3,740 MW that was installed in 2010 is included in official statistics for 2011. Government decree from EPIA, op. cit. note 1. EPIA also notes that significant capacity installed during 2010 was connected to the grid in 2011 due to Italy's "Salva Alcoa," legislation, per EPIA, op. cit. note 1.

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19 U.K. capacity increased from 77 MW at the end of 2010 to an estimated 1,014 MW at the end of 2011, from DECC, op. cit. note 18, p. 50. The U.K. added 784 MW for a total of 875 MW, per EPIA, op. cit. note 1.

20 FIT reductions and a connection process that takes up to 18 months explain the relatively low installation levels in 2011, per EPIA, op. cit. note 3. France connected 1,634 MW to the grid in 2011, for a total of 2,831 MW, per the French Observation and Statistics Office (SOeS), cited in EurObserv'ER, op. cit. note 4, p. 119. Less than 10% of capacity that was connected in 2011 was installed during the year, per EPIA, op. cit. note 1, p. 27. In December 2010, France announced a moratorium on approval of systems larger than 3 kW, followed in February 2011 by an annual capacity cap of 500 MW and in March by reductions in funding for solar PV, per "French reduce solar PV funding," RenewableEnergyFocus.com, 11 March 2011, at http://www.renewableenergyfocus.com/view/16563/french-reduce-solar-pv-funding/.

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22 China added 2,140 MW from China Electricity Council, and 3 GW from National Bureau of Statistics of China, both cited in EurObserv'ER, op. cit. note 4, p. 111; United States (1,855 MW added for total of 3,954 MW) from SEIA and GTM Research, op. cit. note 6; Japan (1,296 MW added for a total of 4,914) from Japan Photovoltaic Energy Association, op. cit. note 10; Australia (774 MW added for total of 1,298 MW) from EPIA, op. cit. note 1. Note that China added 2,200 MW for a total of 3,093 MW, from EPIA, op. cit. note 1. Australia's new installations declined over the year as incentive schemes were removed, per Mark Osborne, "China leads solar PV demand in Asia Pacific region with 2.9GW installed in 2011," PV-tech.org, 25 January 2012, at http://www.pv-tech.org/news/npd_solarbuzz_china_leads_solar_pv_demand_in_asia_pacific_region_with_2.9gw.

23 EPIA, op. cit. note 1, p. 52.

24 Extension of investment tax credit and expiration at year-end of a federal grant programme from SEIA and GTM Research, op. cit. note 6; 3,954 MW at end of 2011 from SEIA, op. cit. note 10.

25 Larry Sherwood, Interstate Renewable Energy Council, "U.S. Solar Market Trends 2010," June 2011; SEIA and GTM Research, op. cit. note 6.

26 "The U.S. Solar Market Q4 & 2011 Review: State Markets to Watch," PV News, March 2012. Utility involvement has increased dramatically since the federal government started allowing utilities to benefit from a 30% tax credit, and as states liberalise rules prohibiting utilities from building and owning generating plants. Elisa Wood, "A Study in extremes: From mammoth to miniscule," Renewable Energy World, November-December 2011, pp. 53–58.

27 Quadrupled based on 550 MW added in 2010, from Ma Lingjuan, CREIA, communication with REN21, May 2011, and from EPIA, op. cit. note 1; total capacity of 3,040 MW based on 2,140 MW added in 2011, from China Electricity Council (additions for 2011) cited in EurObserv'ER, op. cit. note 4, p. 111, to the 0.9 GW existing at the end of 2010, from CREIA, op. cit. this note; drivers also from EurObserv'ER, op. cit. note 4, p. 111. Quadrupled based on 2,140 MW added in 2011, from China Electricity Council (additions for 2011) cited in EurObserv'ER, op. cit. note 4, p. 111, and 550 MW added in 2010, from Ma, op. cit. this note, and from EPIA, op. cit. note 1; total capacity of 3,093 MW from EPIA, op. cit. note 1; drivers also from EurObserv'ER, op. cit. note 4, p. 111. Note that China's National Bureau of Statistics estimates that 3 GW was installed in 2011, meaning that almost 29% of that capacity was awaiting grid connection by year-end, from EurObserv'ER, op. cit. note 4, p. 111.

28 Osborne, op. cit. note 22.

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CONCENTRATING SOLAR THERMAL POWER (CSP)

1 Based on estimates of 454 MW added in 2011 for a total of 1,758 MW in operation. Estimates based on total installations worldwide gathered from the following: Comisión Nacional de Energía of Spain (CNE), Madrid, April 2012, provided by Instituto para la Diversificación y Ahorro de la Energía (IDAE), Ministerio de Industria, Energía y Turismo, personal communications with REN21, 17 and 18 May 2012. Note that these are near-final data and subject to final revisions. Note also that another source shows a lower year-end total for Spain (949 MW rather than 1,148.6 MW) in 2011, from Red Eléctrica de Espagña (REE), El Sistema Eléctrico Espagña – Avance del informe 2011 (Madrid: January 2012), and from Protermosolar, the Spanish Solar Thermal Electricity Industry Association, April 2012; United States from Morse Associates, Inc., personal communication with REN21, March, April, and May 2012, and from U.S. National Renewable Energy Laboratory (NREL), "Concentrating Solar Power Projects," Solar Paces, http://www.nrel.gov/csp/solarpaces/; Algeria from NREL, "ISCC Argelia," http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=44, viewed 7 March 2012, from Abengoa Solar, "Integrated solar combined-cycle (ISCC) plant in Algeria," http://www.abengoasolar.com/corp/web/en/nuestras_plantas/plantas_en_operacion/argelia/, viewed 27 March 2012, and from New Energy Algeria, "Portefeuille des projets," http://www.neal-dz.net/index.php?option=com_content&view=article&id=147&Itemid=135&lang=fr, viewed 6 May 2012; Egypt's 20 MW CSP El Kuraymat hybrid plant began operating in December 2010, from Holger Fuchs, Solar Millennium AG, "CSP – Empowering Saudi Arabia with Solar Energy," presentation at Third Saudi Solar Energy Forum, Riyadh, 3 April 2011, at http://ssef3.apricum-group.com/wp-content/uploads/2011/02/2-Solar-Millennium-Fuchs-2011-04-04.pdf, and from "A newly commissioned Egyptian power plant weds new technology with old," Renewables International, 29 December 2010, at http://www.renewablesinternational.net/a-newly-commissioned-egyptian-power-plant-weds-new-technology-with-old/150/510/29807/; Ain Beni Mathar began generating electricity for the Moroccan grid in late 2010, from World Bank, "Nurturing low carbon economy in Morocco," November 2010, at http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/MENAEXT/0,,contentMDK:22750446~menuPK:324177~pagePK:2865106~piPK:2865128~theSitePK:256299,00.html, and from Moroccan Office Nationale de l'Électricité Web site, http://www.one.org.ma, viewed 7 March 2012; Iran from Gavin Hudson, "First Solar Energy Plant Completed in Iran," 2 January 2009, at http://ecolocalizer.com/2009/01/02/first-solar-energy-plant-completed-in-iran/, and from "The second unit of gas turbine of Yazd solar- thermal combined cycle power plant has been synchronized with the National Grid," 4 November 2009, at http://news.tavanir.org.ir/press/press_detail.php?id=14714; Italy from Archimedes Solar Energy Web site, http://www.archimedesolarenergy.it, viewed 6 March 2012; Thailand from Energy Policy and Planning Office, "Thailand's VSPP Status," 2011, at http://www.eppo.go.th/power/data/STATUS_VSPP_Dec%20 2011.xls; Australia's Liddell CSP/coal plant from AREVA Solar, "Liddell Solar Thermal Station," http://www.areva.com/mediatheque/liblocal/docs/pdf/activites/energ-renouvelables/Areva_Liddell_flyer_HR.pdf; India from ACME, "ACME's first 2.5 MW solar thermal power plant has been commissioned which will be scaled up to 10MW at Bikaner, Rajasthan," http://acme.in/solar/thermal.html, viewed 28 March 2012, and from "Views of Manoj Upadhyay," Renewable Watch, August 2011, pp. 32–33, at

http://www.acme.in/pdf/mano-kumar-upadhyay-interview.pdf.

2 Based on 570.6 MW added in 2010 from the following sources: 76 MW added during 2010 in the United States from Morse Associates, Inc., Washington, DC, personal communication with REN21, 4 May 2012; 450 MW added in Spain from CNE, op. cit. note 1; 5 MW added in Italy from Archimedes Solar Energy Web site, op. cit. note 1; 20 MW in Egypt from Fuchs, op. cit. note 1, and from "A newly commissioned Egyptian power plant…," op. cit. note 1; 20 MW in Morocco from World Bank, op. cit. note 1, and from Moroccan Office Nationale de l'Électricité, op. cit. note 1.

3 Estimate of 37% based on global capacity of 367 MW in 2006 (sum of all LUZ plants in United States (354 MW) installed during 1985–1991, plus 11 MW in Spain, from REE and CNE, cited in Ministerio de Industria, Turismo y Comercio, La Energia en España 2008 (Madrid: 2009), pp. 198, 200; 1 MW plant installed in Arizona during 2006 from Morse Associates, Inc., Washington, D.C., personal communication with REN21, May 2012; Australia's Liddell plant (1 MW installed in 2004) from AREVA Solar, op. cit. note 1. Figure 14 compiled from various sources in Endnote 1.

4 Fred Morse and Florian Klein, Abengoa Solar, Washington, DC and Madrid, personal communication with REN21, March 2012.

5 Protermosolar, the Spanish Solar Thermal Electricity Industry Association, April 2012, http://www.protermosolar.com/boletines/23/Mapa.pdf. Examples include BrightSource Energy's Ivanpah 329 MW project under construction in the United States, and Abengoa's 50 MW power tower under financing in South Africa. Elisa Prieto and Florian Klein, Abengoa Solar, Madrid, personal communication with REN21, March 2012.

6 CNE, op. cit. note 1; Protermosolar, op. cit. note 5; REE, La Energia en España, various years; REE, "El sistema eléctrico Español. Avance del informe 2011" (Madrid: January 2012).

7 Estimate of 416.7 MW added for a total of 1,148.6 MW at year-end from CNE, op. cit. note 1. Earlier preliminary estimates included 949 MW operating at the end of 2011 from REE, "El sistema eléctrico Español…," op. cit. note 6.

8 Protermosolar, op. cit. note 5; Morse and Klein, op. cit. note 4.

9 Note that the first towers in the United States were under construction at time of publication. Florian Klein, Abengoa Solar, personal communication with REN21, March 2012; ESTELA, The European Solar Thermal Electricity Association, Brussels, personal communication with REN21, 3 May 2012.

10 Figures of 19.9 MW capacity, 24 hours, and 15 hours storage from Torresol Energy, "Gemasol," http://www.torresolenergy.com/TORRESOL/gemasolar-plant/en; latest of three from Klein, op. cit. note 9. The world's first commercial solar tower was commissioned in Spain in 2007.

11 Protermosolar, op. cit. note 5; Klein, op. cit. note 9.

12 Morse Associates, Inc., op. cit. note 3.

13 Rikki Stancich, "SEIA: US solar capacity to crank up in 2012," in CSP Today, Weekly Intelligence Brief: March 12 –19, at http://social.csptoday.com/markets/weekly-intelligence-brief-march-12-19?utm_source=http%3a%2f%2fuk.csptoday.com%2ffc_csp_pvlz%2f&utm_medium=email&utm_campaign=CSP+eBrief+19+Mar+12+EN&utm_term=CSP+for+enhanced+oil+recovery%3a+Fuel+efficient+solution&utm_content=125566; Morse Associates, Inc., Washington, DC, personal communication with REN21, March and April 2012.

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15 Egypt's 20 MW CSP El Kuraymat hybrid plant began operating in December 2010, from Fuchs, op. cit. note 1, and from "A newly commissioned Egyptian power plant…," op. cit. note 1; Ain Beni Mathar began generating electricity for the Moroccan grid in late 2010, from World Bank, op. cit. note 1; Algeria from NREL, op. cit. note 1, from Abengoa Solar, op. cit. note 1, and from New Energy Algeria, op. cit. note 1; Thailand from Energy Policy and Planning Office, op. cit. note 1; India from ACME, op. cit. note 1, and from "Views of Manoj Upadhyay," op. cit. note 1.

16 ESTELA, personal communication with REN21, April 2012.

17 "Views of Manoj Upadhyay," op. cit. note 1.

18 Italy (5 MW) from Archimedes Solar Energy Web site, op. cit. note 1; Iran (17 MW) from Hudson, op. cit. note 1, and from "The second unit of gas turbine…," op. cit. note 1; Australia (3 MW electric and 9 MW thermal) from AREVA Solar, op. cit. note 1.

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22 "Solar thermal markets: solar thermal power facing headwinds?" op. cit. note 19, pp. 14, 16.

23 "Concentrating solar power," op. cit. note 18; Morse and Klein, op. cit. note 4.

24 ESTELA, Report on The First 5 Years of ESTELA (Brussels: February 2012); Morse and Klein, op. cit. note 4.

25 "Concentrating solar power," op. cit. note 19.

26 Morse and Klein, op. cit. note 4.

27 Ibid.

28 This plant, a 280 MW facility under construction in Arizona, is expected to be the world's largest when commissioned. Morse and Klein, op. cit. note 4.

29 Ibid.

30 Stephen Lacey, "Value of CSP Increases Substantially at High Solar Penetration," RenewableEnergyWorld.com, 20 December 2011, at http://www.renewableenergyworld.com/rea/news/article/2011/12/

value-of-csp-increases-substantially-at-high-solar-penetration?cmpid=WNL-Wednesday-December21-2011.

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34 "Abengoa awarded two CSP projects by Africa's Department of Energy," press release (Seville: 7 December 2011), at http://www.abengoasolar.com/corp/web/en/acerca_de_nosotros/sala_de_prensa/noticias/2011/solar_20111207.html; Andrew Eilbert, "The Trade-off Between Water and Energy: CSP Cooling Systems Dry Out in California," ReVolt (Worldwatch Institute blog), 31 December 2010, at http://blogs.worldwatch.org/revolt/the-trade-off-between-water-and-energy-csp-cooling-systems-dry-out-in-california/; Jordan Macknick, Robin Newmark, and Craig Turchi, U.S. National Renewable Energy Laboratory, "Water Consumption Impacts of Renewable Technologies: The Case of CSP," presentation at AWRA 2011 Spring Specialty Conference, Baltimore, MD, 18–20 April 2011, and Strategic Energy Technologies Information System (SETIS), "Concentrated Solar Power Generation," http://setis.ec.europa.eu/newsroom-items-folder/concentrated-solar-power-generation, viewed 24 May 2012. Sidebar 4 is based on the following sources: 8% of withdrawals from N. Brune, "Presentation from the 2011 World Water Week in Stockholm: Water-Energy Security Nexus" (Albuquerque, NM: Sandia National Laboratories, 2011); 44% in the EU from J. Granit and A. Lindström, "Constraints and opportunities in meeting the increasing use of water for energy production," in Proceedings of the ESF Strategic Workshop on Accounting for Water Scarcity and Pollution in the Rules of International Trade, Amsterdam, 25–26 November 2010; 40% in the U.S. from C. Clark et al., Water Use in the Development and Operation of Geothermal Power Plants (Chicago: Argonne National Laboratory, Environmental Science Division, 2011) at http://www1.eere.energy.gov/geothermal/pdfs/geothermal_water_use.pdf; 22% in China from R. Cho, How China is Dealing With Its Water Crisis, State of the Planet blog, 2011, at http://blogs.ei.columbia.edu/2011/05/05/how-china-is-dealing-with-its-water-crisis/; 2.8 billion from Brune, op. cit. this note; 4.8 billion from Veolia and IFPRI, Finding the Blue Path for a Sustainable Economy: A White Paper by Veolia Water (Chicago, IL: Veolia Water North America, 2010), at http://www.veoliawaterna.com/north-america-water/ressources/documents/1/19979,IFPRI-White-Paper.pdf; comparable to traditional thermal power from European Photovoltaic Industry Association, EPIA Factsheet: Sustainability of Photovoltaic Systems: The Water Footprint (Brussels: 2012); corn ethanol and China hydropower from Brune, op. cit. this note; solar PV and wind uses of water from V. Fthenakis and H.C. Kim, "Life-cycle Uses of Water in U.S. Electricity Generation," Renewable and Sustainable Energy Reviews, September 2010, pp. 2039–48.; PV manufacturing plants from R. Williams, "Solar Cell Makers, Consider Another (Potentially) Renewable Resource: Water," RenewableEnergyWorld.com, 17 June 2011, at http://www.renewableenergyworld.com/rea/news/article/2011/06/solar-cell-makers-consider-another-potentially-renewable-resource-water; geothermal from Clark, op. cit. this note; pesticides and fertilizers for bioenergy crops from Cornell Cooperative Extension, Impacts of Pesticides and Fertilizers on Water Quality, at http://www.glc.org/basin/pubs/projects/ny_RipErCon_pub4.pdf; CSP potential reductions from JRC European Commission, 2011 Technology Map of the European Strategic Energy Technology Plan (SET-Plan) Technology Descriptions. EUR 24979 EN – 2011, 2011; geothermal from Clark, op. cit. this note; China strategy to reduce consumption from Cho, op. cit. this note. Additional references used include: Morgan Bazilian et al., "Considering the energy, water and food nexus: Towards an integrated modelling approach," Energy Policy, December 2011; Nina Chestney, "Scarce Resources To Slow Low-Carbon Growth: Study," Reuters, 28 March 2012, at http://planetark.org/wen/65038; Ryan C. Christiansen, "Irrigation Mitigation," Ethanol Producer Magazine, 3 January 2009 at http://www.ethanolproducer.com/articles/5155/irrigation-mitigation; Dolf Gielen, "Renewables Technology, Energy Access and the Nexus," presentation in Bonn, Germany, 17 November 2011, at http://www.water-energy-food.org/documents/hottopicsessions/ht03/nexus_ht3_gielen.pdf; Jakob Granit, "Water and energy nexus: Will growth in energy demand compete for scarce water resources?" Stockholm Water Front, December 2011, pp. 6–7; A.Y. Hoekstra, M.M. Aldaya, and B. Avril, Value of Water Research Report Series No. 54 (Delft: UNESCO – IHE Institute for Water Education, October 2011).

35 Morse and Klein, op. cit. note 4.

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SOLAR THERMAL HEATING AND COOLING

1 Data adjusted upwards by 5% to account for those countries not included, from Werner Weiss and Franz Mauthner, Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2010, edition 2012 (Gleisdorf, Austria: International Energy Agency Solar Heating & Cooling Programme, April 2012), p. 15.
2 Ibid., p. 22.
3 Figures 15 and 16 from ibid.
4 Based on data for 2010, from ibid. In Brazil, the market for unglazed collectors has risen faster than that for glazed systems and surpassed the glazed market in 2010. Data from DASOL/ABRAVA cited in Bärbel Epp, "Intersolar speakers present latest figures of key solar thermal markets," SolarThermalWorld.org, 17 June 2011, at http://www.solarthermalworld.org/node/2932.
5 Solar collector capacity of 232 GWth for 2011 is estimated from Weiss and Mauthner, op. cit. note 1, which provides an estimated 2011 year-end total of more than 245 GWth for all collectors. Total is adjusted upwards by 5% to 257.25 GWth to account for those countries not included in the Weiss and Mauthner survey. Subtracting an estimated 10% market share for unglazed collectors brings the total to 231.5 GWth. The net added capacity during 2011 of more than 49 GWth is estimated based on the difference between 2010 (182.2 GWth) and 2011 unglazed capacity totals in the Weiss and Mauthner survey. Note that Weiss and Mauthner include 55 countries representing 4.2 billion people, or about 61% of world's population. Installed capacity represents more than 90% of installed solar thermal capacity worldwide; the GSR estimates an additional 5% to make up for this unrepresented share. In past years, the GSR has estimated gross additions based on retirements, with the assumption that systems outside of China have a 25-year system life, and assuming a 10-year system lifetime (according to China Renewable Energy Industries Association, CREIA). However, there is considerable uncertainty regarding statistics in China, which makes reliable estimates for 2011 difficult. Hopefully this issue will be resolved within the next year or two. Also, note that the share of unglazed water collectors is declining over time; they accounted for just over 4% of additions in 2010, per Weiss and Mauthner, op. cit. note 1, p. 32.
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11 Bärbel Epp, "Greece: How will the Solar Thermal Industry survive the Financial Crisis?" SolarThermalWorld.org, 7 October 2011, at http://www.solarthermalworld.org/node/3075.
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35 Largest plant from ibid.; size and location from Bärbel Epp, “Saudi Arabia: Largest Solar Thermal Plant in the World with 36,305 m2,” SolarThermalWorld.org, 2 July 2010.

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37 Steinway (installed in 2009), from James Barron, “Coming Soon at Steinway, Solar Power,” City Room blog (New York Times), 26 December 2008, at http://cityroom.blogs.nytimes.com/2008/12/26/steinway-by-barron-for-sat/, and from Roger Clark, “Steinway’s Astoria Piano Factory Ready To Go Green,” NY1, 9 March 2009, at http://www.ny1.com/content/top_stories/95197/steinway-s-astoria-piano-factory-ready-to-go-green; Asamer plant in Upper Austria and Slovenia from Christiane Egger and Christine □hlinger, “Solar process heat for Europe: developing the market,” Renewable Energy World, January–February 2011, pp. 44–47; Thailand from Bärbel Epp, “Thailand: Solar Process Heat in Leather Factory Awarded,” 28 July 2011, at http://www.solarthermalworld.org/node/2989.

38 Weiss and Mauthner, op. cit. note 1.

39 Ibid.

40 Bärbel Epp, “New ISOL Navigator Study Compares Solar Thermal System Prices and Market Attributes,” SolarThermalWorld.org, 10 January 2012, at http://www.solarthermalworld.org/node/3243; http://www.solrico.com/en/navigator.html; Solrico, “ISOL Navigator December 2011: Analyses of Global And National Market Development,” http://www.solrico.com/en/navigator.html.

41 Bärbel Epp, “Solar Navigating: trends in solar heating and cooling,” Renewable Energy World, September-October 2011.

42 Bärbel Epp, “India and China are setting the pace,” Sun & Wind Energy, December 2011, pp. 48–64.

43 Bank Sarasin, op. cit. note 8.

44 Data as of 2009, from Epp, op. cit. note 41.

45 Based on 2010 surface area production levels, from Epp, op. cit. note 42, and from Bank Sarasin, op. cit. note 8.

46 China’s export business increased 12-fold between 2005 and 2011, per CSTIF/CREIA cited in Epp, op. cit. note 7.

47 Matthias Fawer and Magyar Balzas, Solar Industry: The first green shoots of recovery (Basel, Switzerland: Bank Sarasin, November 2009). A thermo-siphon hot water circulating system relies on the principle that hot water rises, and does not require a pump. In such a system, the water heater must be below system fixtures in order to work.

48 Based on 2010 surface area production levels, from Epp, op. cit. note 42. Viessmann Werke produces both flat-plate and vacuum tube collectors.

49 Epp, op. cit. note 42.

50 Ibid.

51 Outside Europe from Bärbel Epp, “ISH 2011: Solar Trends in the Heating Industry,” SolarThermalWorld.org, 31 March 2011, at http://www.solarthermalworld.org/node/2857; Joachim Berner, “Spanish Collector Manufacturers Expand Exports or Abandon Production,” SolarThermalWorld.org, 5 July 2011, at http://www.solarthermalworld.org/node/2956; Eva Augsten, “Spain: Export Helps Solar Thermal Industry Survive,” SolarThermalWorld.org, 12 January 2012, at http://www.solarthermalworld.org/node/3246; Eurobserv’ER, op. cit. note 33.

52 Bank Sarasin, op. cit. note 8.

53 DASOL, op. cit. note 18.

54 Data include both glazed and unglazed collectors, from ibid.

55 Renata Grisoli, CENBIO, Brazil, personal communication with REN21, April 2011; Departamento Nacional de Aquecimento Solar da ABRAVA, www.dasolabrava.org.br/quem-somos/.

56 Tobias Engelmeier, Bridge to India, Delhi, personal communication with REN21, winter 2012.

57 Melanie Gosling, “Sun Sets on Solar Heating Factory,” Independent Online Media, 11 November 2011, at http://www.iol.co.za/capetimes/sun-sets-on-solar-heating-factory-1.1176303.

58 Bärbel Epp, Solrico, personal communication with REN21, 3 April 2012.

59 Bärbel Epp, Solrico, “Cost reduction – an important objective,” in Bank Sarasin, op. cit. note 8.

60 Bärbel Epp, “Can Europe compete in the global solar thermal market?” RenewableEnergyWorld.com, 21 March 2011.

61 Interview with Uli Jakob, Vice President, Green Chiller-Association for Sorption Cooling, from “Solar cooking market to experience big changes,” July 2011, http://www.solarthermalworld.org/node/2968.

62 Ibid.

WIND POWER

1 Estimates include: 40,564 MW added for a total of 237,669 MW, per Global Wind Energy Council (GWEC), Global Wind Report: Annual Market Update 2011 (Brussels: March 2012); 39,483 MW added for total of 237,017.5 MW, per World Wind Energy Association (WWEA), World Wind Energy Report 2011 (Bonn: 2012); and 41,712 MW added for total of 241,029 MW, per Navigant's BTM Consult ApS, World Market Update 2011 (Copenhagen: 2012), Executive Summary. Note that approximately 528 MW of capacity was decommissioned worldwide, per GWEC, op. cit. this note. Figure 17 based on sources in this note.

2 "Around 50" based on estimate of 50 countries from WWEA, op. cit. note 1, and 49 countries from Steve Sawyer, Secretary General, GWEC, personal communication with REN21, April 2012; 68 countries from WWEA, op. cit. note 1; 62 countries from Steve Sawyer, Secretary General, GWEC, personal communication with REN21, May 2012; 22 countries from idem and from GWEC, op. cit. note 1; top 10 from GWEC, op. cit. note 1. GWEC estimates that 71 countries had commercial wind power installations by year-end, per Sawyer, op. cit. this note, April 2012.

3 Based on 2011 data and 2006 year-end capacity of 74,052 MW, per GWEC, op. cit. note 1.

4 GWEC, "Wind energy powers ahead despite economic turmoil: 21% increase in global installed capacity," press release (Brussels: 7 February 2012).

5 Rankings from GWEC, op. cit. note 1, and from European Wind Energy Association (EWEA), Wind Directions, April 2012. Note that GWEC and EWEA estimate that the U.K. added 1,293 MW during 2011, putting it ahead of Canada (with 1,267 MW added, per GWEC), whereas WWEA estimates that 730 MW was added for a total of 6,018 MW, putting the U.K. well behind Canada (which GWEC and WWEA both agree installed 1,267 MW in 2011 for a total of 5,265 MW at year-end). An estimated 1,092 MW was added in the U.K, per U.K. Department of Energy and Climate Change (DECC), Energy Trends (London: March 2012), at http://www.decc.gov.uk/assets/decc/11/stats/publications/energy-trends/4779-energy-trends-mar12.pdf.

6 Share for 2011 based on EWEA, "Wind in Power: 2011 European Statistics" (Brussels: February 2012), and on GWEC, op. cit. note 1; 51% from Navigant's BTM Consult ApS, op. cit. note 1.

7 Estimate of 17,631 MW added and reductions relative to 2010 from Shi Pengfei, Chinese Wind Energy Association (CWEA), personal communication with REN21, 1 April 2012. Figure 18 based on various sources throughout this section.

8 Stricter approval procedures from "Goldwind led China turbine installations in 2011 with 3.6 GW," World Wind Energy, 26 March 2012, at http://en.86wind.com/?p=2615. The Chinese market is likely to maintain a similar installation level, at least for the next two years, with a new focus on improving quality and addressing some serious grid issues, per Steve Sawyer, GWEC, personal communication with REN21, April 2012. Furthermore, in recent years, local grid infrastructure has failed to keep up with new installations, and grid companies have been unable to manage the transmission system effectively, requiring increasing curtailment of wind production at peak periods, per GWEC, op. cit. note 1.

9 Total of 62,364 MW from Shi, op. cit. note 7; five years earlier based on year-end 2006 capacity of 2,600 MW, from GWEC, 2007, cited in REN21, Renewables 2007 Global Status Report (Paris: REN21 Secretariat and Washington, DC: Worldwatch Institute, 2008), p. 37.

10 At the end of 2011, 45 GW was reported in commercial operation, with 15 GW added during the year; the cumulative by the end of 2010 was 30 GW (down from 31 GW reported in early 2011), per China Electricity Council, provided to REN21 by Shi, op. cit. note 7. Note that the process of finalizing the test phase and getting a commercial contract with the system operator takes time, accounting for the delays in reporting. 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).

11 Figure of 13 provinces from GWEC, op. cit. note 1; provincial shares from Shi, op. cit. note 7.

12 Data for 2011 are 6,816 MW added for total of 46,916 MW, per American Wind Energy Association (AWEA), "Annual industry report preview: supply chain, penetration grow," Wind Energy Weekly, 30 March 2012; 2 million homes from Denise Bode, AWEA, cited in GWEC, op. cit. note 4. This compared with 5 GW added in 2010 and more than 10 GW in 2009, per 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).

13 Gloria Gonzalez, "US Wind Industry Set to Slump, PTC or No PTC," Environmental Finance, 28 March 2012, available at http://www.croh.info/index.php?option=com_content&view=article&id=2130:gloria-gonzalez-environmental-finance-wwwenvironmental-financecom&catid=10:news.

14 AWEA, "U.S. Wind Industry Fourth Quarter 2011 Market Report" (Washington, DC: January 2012).

15 AWEA, "Wind rebounds in 2Q, but continued growth depends on consistent tax policy, Iowa hits 20 percent wind power," press release (Washington, DC: 4 August 2011), at http://www.awea.org/newsroom/pressreleases/2q-2011-release.cfm.

16 Based on 9,616 MW installed in EU-27 for total of 93,957 MW, per EWEA, op. cit. note 5; 2007 based on 93,820 MW from GWEC, op. cit. note 1.

17 EWEA, op. cit. note 6.

18 Ibid.

19 An estimated 2,007 MW was added, with net capacity additions slightly lower (1,885 MW) due to repowering, for a total of 29,075 MW at year-end. Capacity and generation from German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Renewable Energy Sources 2011, based on information supplied by the Working Group on Renewable Energy – Statistics (AGEE-Stat), 8 March 2012.

20 The U.K. added 1,293 MW according to EWEA, op. cit. note 5, GWEC, op. cit. note 1, and Navigant's BTM Consult ApS, op. cit. note 1; total installed capacity of 6,540 MW from EWEA, op. cit. note 5, and from GWEC, op. cit. note 1. Note that the country added 1,092 MW for a total of 6,470 MW (preliminary data), per DECC, op. cit. note 5, and WWEA puts U.K. additions at 730 MW for a total of 6,018 MW, per WWEA, op. cit. note 1.

21 Spain added 1,050 MW for a total of 21,674 MW, Italy added 950 MW for a total of 6,747 MW (provisional), and France added 830 MW for a total of 6,800 MW (provisional), per EWEA, op. cit. note 5. Note that France added 980 MW for a total of 6,640 MW, per WWEA, op. cit. note 1.

22 Based on 4,083 MW in Denmark by year-end, from GWEC, op. cit. note 1, WWEA, op. cit. note 1, and EWEA, op. cit. note 5. Note that Portugal installed 377 MW for a total of 4,083 MW from GWEC, op. cit. note 1, and EWEA, op. cit. note 5; it added 375 MW for a total of 4,083 MW per WWEA, op. cit. note 1; and added 434 MW for a total of 4,346 MW, per Portuguese Directorate General for Energy and Geology (DGEG), Lisbon, Portugal, country report for REN21, February 2012; the DGEG data were preliminary data and more recent statistics were chosen for this report, particularly as there was agreement across other sources.

23 Contraction from EWEA, op. cit. note 6; Romania's capacity was up by 520 MW to 982 MW, Cyprus was up 63% by 52 MW to 134 MW, Greece was up 24% by 311 MW to 1,629 MW, per EWEA, op. cit. note 5; Romania installed 235 MW for a total of 826 MW, and Greece ended the year with a total of 1,626.5 MW, according to WWEA, op. cit. note 1.

24 Estimates include: 3,019 MW added for total of 16,084 MW, per GWEC, op. cit. note 1; 2,827 MW added for total of 15,880 MW, per WWEA, op. cit. note 1; 3,300 MW added from Navigant's BTM Consult ApS, op. cit. note 1; and 1,922 MW added during 2011 from Indian Ministry of New and Renewable Energy (MNRE), "Achievements," http://www.mnre.gov.in/mission-and-vision-2/achievements/, viewed 30 April 2012. MNRE shows 16,179 MW of capacity by the end of January 2012, and 101 MW added during January, for a 2011 total of 16,078 MW at year-end.

25 Figures for Canada of 1,267 MW added and 5,265 MW total from WWEA, op. cit. note 1, and from GWEC, op. cit. note 1.

26 Brazil added 544 MW for a total of 1,471 MW, per Brazilian National Electric Energy Agency (ANEEL), Generation Data Bank, updated 23 February 2012, at www.aneel.gov.br/aplicacoes/

capacidadebrasil/capacidadebrasil.asp [In Portuguese]; additions were 583 MW for a total of 1,509 MW, per GWEC, op. cit. note 1; and 498 MW was added for total of 1,429 MW, per WWEA, op. cit. note 1.

27 Luiz Claudio S. Campo and Lucio Teixiera, "Renewable Energy Recap: Brazil," RenewableEnergyWorld.com, 2 January 2012, at http://www.renewableenergyworld.com/rea/news/article/2012/01/renewable-energy-recap-brazil. By April 2012, Brazil had 1,507 MW under construction and an additional 5,643 MW was authorised for construction, per ANEEL, op. cit. note 26.

28 Additions were 79 MW, 33 MW, 102 MW, and 50 MW, respectively, per GWEC, op. cit. note 1. Note that Mexico added more than 350 MW during the year but, according to GWEC, most of this capacity was not grid connected until early 2012. Additions were slightly different according to WWEA, which estimated 75.2 MW, 20 MW, 70 MW, and 408 MW, respectively, per WWEA, op. cit. note 1.

29 GWEC, op. cit. note 1.

30 Little development from GWEC, op. cit. note 1. Note that GWEC puts total additions in the region at 31 MW. Cape Verde 2 MW from GWEC, op. cit. note 1; 25.5 MW added from ECOWAS Regional Centre for Renewable Energy and Energy Efficiency, "Cape Verde pertains 25% renewable energy penetration," ECREEE Newsletter, vol. 4 (2012), at http://ecreee.vs120081.hl-users.com/website/download.php?f=6cba8eb3868884845c6c47e0533f22bb; Ethiopia from "Wind energy markets: Gathering new momentum," Renewable Energy World, November-December 2011, p. 7; Ethiopia added 30 MW, per WWEA, op. cit. note 1.

31 GWEC, op. cit. note 1.

32 Ibid. Note that Iran did not add capacity during 2011 and ended the year with 100 MW, per WWEA, op. cit. note 1. Turkey added 525 MW for a total of 1,799 MW from WWEA, op. cit. note 1, and it added 470 MW for a total of 1,799 MW from GWEC, op. cit. note 1.

33 Estimate of more than 0.9 GW capacity added and 4.1 GW operating globally from GWEC, op. cit. note 1. Note that 330 MW was added during 2011 for a total capacity of 2,105 MW offshore, according to Navigant's BTM Consult ApS, op. cit. note 1; 397 MW was added for a total of 3,522.4 MW offshore globally at year-end according to WWEA, op. cit. note 1. There remains disagreement among sources regarding the amount of capacity installed offshore; the U.K. accounts for most of the differences among these figures.

34 Data for 2010 from WWEA, World Wind Energy Report 2010 (Bonn: April 2010).

35 EWEA, op. cit. note 6.

36 Based on U.K. additions of 752.45 MW from EWEA, op. cit. note 6; Denmark from GWEC, op. cit. note 1, and from EWEA, op. cit. note 6; Germany added 108.3 MW for a total of 200.3 MW, per J.P. Molly, "Status der Windenergienutzung in Deutschland - Stand 31.12.2011," http://www.dewi.de/dewi/fileadmin/pdf/publications/Statistics%20Pressemitteilungen/Statistik_2011_Folien.pdf. Note that the U.K. added 497 MW offshore for a total of 1,838 MW (preliminary estimates) per DECC, op. cit. note 5; it added 183.6 MW offshore for a total of 1,524.6 MW offshore per WWEA, op. cit. note 1; and it added 330 MW for a total of 2,105 MW per Navigant's BTM Consult ApS, op. cit. note 1. The large difference in U.K. estimates appears to stem from accounting practices. For example, EWEA tracks projects by wind turbine, counting capacity as machines are installed, connected, and start feeding electricity into the grid, whereas others (such as RenewableUK) count capacity only once the entire project is fully completed with all turbines connected, per Steve Sawyer, Secretary General, GWEC, personal communication with REN21, 18 May 2012. For example, the 183.6 MW of additions counted by WWEA were for the Walney 1 project, the only one that was fully completed during 2011. Elsewhere in Europe, Denmark had a total of 857.6 MW at year-end and Germany had 215.3 MW per WWEA, op. cit. note 1; Denmark's total was 832.9 MW and Germany's was 198 MW per Navigant's BTM Consult ApS, op. cit. note 1.

37 EWEA, op. cit. note 6. Only four EU coastal states (Bulgaria, Lithuania, Romania, and Slovenia) did not have identified pipelines for offshore wind by mid-2011, per EWEA, "Wind in our sails: The coming of Europe's Offshore Wind Energy Industry" (Brussels: 2011), Executive Summary.

38 China added 99.3 MW offshore, from GWEC, op. cit. note 1; 108 MW added according to Navigant's BTM Consult ApS, op. cit. note 1; 258 MW from Steve Sawyer, GWEC, personal communication with REN21, March 2012, and from GWEC, op. cit. note 1. In addition, Japan has nearly 25 MW of wind capacity offshore and South Korea has 5 MW; neither country brought new capacity on line in 2011.

39 Cost considerations include cost of infrastructure such as sub-stations or grid connection points as well as licencing and permitting costs. Note, however, that there are indications that medium-sized projects are most cost-efficient. See, for example, John Farrell, "Wind Farm Size Hitting a Sweet Spot?" RenewableEnergyWorld.com, 14 April 2011, at http://www.renewableenergyworld.com/rea/blog/post/2011/04/wind-farm-size-hitting-a-sweet-spot.

40 Stefan Gsänger, WWEA, Bonn, personal communication with REN21, 29 February 2012.

41 U.S. share in 2010 and 2011 from AWEA, "U.S. Wind Industry Annual Market Report, Year Ending 2011," a Product of AWEA Data Services, p. 12. The share is estimated to be 5% if municipal and publicly owned utilities are included, per Lisa Daniels, Windustry, cited in WWEA, "Community power update North America," Quarterly Bulletin, March 2012. Excluding any utilities, the total is estimated at 2% of the 40 GW in operation at the end of 2010, per Mark Bolanger, U. S. Lawrence Berkeley National Laboratory, cited in WWEA, op. cit. this note. In addition, several thousand megawatts are under contract in Ontario, Canada, per WWEA, op. cit. this note. Germany as of 2010 from Paul Gipe, "'Citizen Power' Conference to Be Held in Historic Chamber Where World's First Feed-in Law Was Enacted; 51% of German Renewables Now Owned by Its Own Citizens," 5 January 2012, at http://www.wind-works.org/coopwind/CitizenPowerConferencetobeheldinHistoricChamber.html.

42 Small-scale turbines from Andrew Kruse, Southwest Windpower Inc., personal communication with REN21, 21 May 2011.

43 WWEA, 2012 Small Wind World Report (Bonn: March 2012), Summary.

44 U.S. capacity in 2011 was an estimated 198 MW, per AWEA, "2011 U.S. Small wind turbine market report," (Washington, DC: 2011), at http://www.irecusa.org/wp-content/uploads/2011_GMR_SmallWind_1pager_revised-041012.pdf; the others are from WWEA, op. cit. note 43; in 2010, China had 166 MW, the U.K. 43 MW, and Germany, Canada, Spain, and Poland were all in the 7–15 MW range, per WWEA, op. cit. note 43.

45 AWEA, op. cit. note 44.

46 Share of 2.3% from Navigant's BTM Consult ApS, op. cit. note 1; 3% from WWEA, "World market for wind turbines recovers and sets a new record: 42 GW of new capacity in 2012, worldwide total capacity at 239 GW," press release (Bonn: 7 February 2012).

47 Based on 204 TWh generation and shares from EWEA, op. cit. note 6. This is up from 4.8% in 2009, per EWEA, "Offshore and Eastern Europe New Growth Drivers for Wind Power in Europe," www.ewea.org; and from 5.3% in 2010, per EWEA, op. cit. note 6.

48 Denmark, Spain, Portugal, and Ireland from EWEA, op. cit. note 6; Germany's share of total gross national consumption, up from 6.2% in 2010, from BMU, op. cit. note 19. All saw increased shares in 2011, relative to 2010, except Portugal.

49 German states included Sachsen–Anhalt (48.1%), Brandenburg (47.7%), Schleswig-Holstein (46.5%), and Mecklenburg-Vorpommern (46.1%); in addition, Niedersachsen met 25%, per J.P. Molly, "Status der Windenergienutzung in Deutschland - Stand 31.12.2011," http://www.dewi.de/dewi/fileadmin/pdf/publications/Statistics%20Pressemitteilungen/Statistik_2011_Folien.pdf; South Australia from GWEC, op. cit. note 1.

50 U.S. share was up from 1.8% in 2009 and 2.3% in 2010. Based on 120 TWh generated. Generation, 2.9% in 2011, and five states from AWEA, "Annual industry report preview…," op. cit. note 12; 1.8% in 2009 from Debra Preikis-Jones, AWEA, Washington, DC, personal communication with REN21, 8 June 2011; 119.7 TWh and 2.3% in 2010 from AWEA, op. cit. note 41, p. 6; South Dakota and Iowa from AWEA, "Annual report: Wind power bringing innovation, manufacturing back to American industry," press release (New York: 12 April 2012).

51 Bloomberg New Energy Finance (BNEF), "Wind turbines prices fall to their lowest in recent years," press release (London and New York: 7 February 2011).

52 BNEF, "Onshore wind energy to reach parity with fossil-fuel electricity by 2016," press release (London and New York: 10 November 2011); JRC Scientific and Technical Reports, 2011 Technology Map of the European Strategic Energy Technology Plan, Institute for Energy and Transport, JRC, European Union (Petten, The Netherlands: 2011); Ryan Wiser et al., "Recent developments in the levelized cost of energy from U. S. wind power projects" (Golden, CO: National Renewable Energy Laboratory, February 2012).

53 BNEF, op. cit. note 51.

54 Navigant's BTM Consult ApS, op. cit. note 1. Other manufacturers retained their 2010 rankings. Figure 19 based on idem.

55 "China world's wind power leader: new figures," China Daily, 23 March 2012, at http://www.chinadaily.com.cn/china/2012-03/23/content_14899003.htm. The industry had a challenging year due to slower project construction and a number of accidents.

56 AWEA, "Annual industry report preview...," op. cit. note 12. More than 470 manufacturing facilities produced components for the wind industry in 44 states. Note that another AWEA document reports 42 states, per AWEA, op. cit. note 41, p. 14.

57 AWEA, "With distribution deal, Gamesa eyes distributed, community wind space," Wind Energy Weekly, 23 March 2012.

58 GWEC, op. cit. note 1.

59 Navigant's BTM Consult ApS, op. cit. note 1; offshore Europe based on EWEA, op. cit. note 35; Navigant's BTM Consult ApS puts average at 3.7 MW.

60 U.K., China, and India from Navigant's BTM Consult ApS, op. cit. note 1; Germany and United States from GWEC, op. cit. note 1. The average rated capacity of new turbines in China was 1.5 MW, up 5.4% compared to 2010, per WWEA, "2011 China wind power development status," Quarterly Bulletin, March 2012.

61 JRC Scientific and Technical Reports, op. cit. note 52; Sawyer, op. cit. note 8. Siemens introduced a 6 MW direct-drive machine for the offshore market in 2011, and Vestas and Mitsubishi announced production of 7 MW machines, while Enercon is offering a 7.5 MW machine exclusively for on-shore use. Vestas has a multi-stage gear drive, and Mitsubishi a hydraulic drive, per Steve Sawyer, Secretary General, GWEC, technology contribution to REN21, March 2012; Enercon from "E-126 / 7.5 MW," http://www.enercon.de/en-en/66.htm; Stefan Gsänger, Secretary General, WWEA, personal communication with REN21, May 2012.

62 EWEA, op. cit. note 37; EWEA, op. cit. note 35. Interest in floating platforms particularly in deep waters off of Japan, Norway, and Portugal.

63 EWEA, op. cit. note 37. Despite the growing number of manufacturers, Siemens supplied an estimated 80% of offshore turbine capacity installed during 2011, SSE and RWE Innogy were the most active developers, and DONG Energy was the most active equity player. "European offshore wind sector holds steady," Renewable Energy World, January-February 2012, p. 10.

64 EWEA, op. cit. note 37.

65 David Appleyard, "HVDC stealing a march," Renewable Energy World, September-October 2011, pp. 10–12. ABB has emerged as a major player in this area in Europe, as has Siemens, which is stepping up its role in China.

66 WWEA, op. cit. note 43.

INVESTMENT FLOWS

1 Note that the scale of investment in solar heat systems worldwide is difficult to estimate because the price of devices varies widely from one country or region to the next. In addition, the Bloomberg New Energy Finance (BNEF) estimate includes only the actual devices or panels; it is not installed costs. The estimate is also based on newly installed global capacity for the year 2010; this Renewables Global Status Report estimates that the market for solar thermal heat systems increased by at least 20% in 2011, per 2011 estimates in Werner Weiss and Franz Mauthner, Solar Heat Worldwide: Markets and Contributions to Energy Supply 2010 (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme, 2012).

2 The BNEF estimate for investment in large hydropower (>50 MW) is based on 15 GW of capacity commissioned during 2011 and a capital cost per megawatt of USD 1.7 million, bringing the total investment in large hydropower to USD 25.5 billion. Estimates are approximate only, due greatly to the fact that timing of the investment decision on a project may be about four years on average away from the moment of commissioning. As a result, a large share of the investment total for the projects that were commissioned in 2011 was actually invested in prior years; in addition, there was investment during 2011 for projects that are currently under construction and are not included in the BNEF estimates. Note also that this Renewables Global Status Report estimates that closer to 25 GW of hydropower capacity was commissioned worldwide during 2011, and a significant portion of this was projects larger than 50 MW; further, since the vast majority of this capacity came online in developing countries (with more than 12 GW in China alone), the BNEF assumed capital cost per megawatt may be on the high side.

3 The U.S. federal loan guarantee programme, which ceased at the end of September 2011, covered USD 16.1 billion of debt for projects. The U.S. Treasury grant programme came to an end on 31 December; the programme was introduced in 2009 to provide an alternative to the tax-equity market, which was hard hit by the financial crisis. The Production Tax Credit, the main support scheme for U.S. wind power, is due to expire at the end of 2012, and few investors are confident that Congress will agree to extend the legislation into 2013 and beyond.

4 Figures were aggregated by BNEF. For corporate R&D, data are from BNEF database and the Bloomberg Terminal; for government R&D, data are from BNEF database and the International Energy Agency database.

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) and International Renewable Energy Agency (IRENA) Global Renewable Energy Policies and Measures Database, the U.S. Database of State Incentives for Renewables & Efficiency (DSIRE), 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.

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7 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, this can be exacerbated by the varying interpretations used when presenting information in the databases and literature upon which this section is based.

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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 oil sources such as waste cooking oil and animal fats.

BIOFUEL A wide range of liquid and gaseous fuels derived from biomass. Biofuels—including liquid fuel ethanol and biodiesel, as well as biogas—can be combusted in vehicle engines as transport fuels and in stationary engines for heat and electricity generation. They can also be used for domestic heating and cooking (for example, as ethanol gels). Advanced biofuels are made from sustainably produced non-food biomass sources using technologies that are still in the pilot, demonstration, or early commercial stages. One exception is hydro-treated vegetable oil (HVO, where hydrogen is used to remove oxygen from the oils to produce a hydrocarbon fuel more similar to diesel), which is now commercially produced in several plants.

BIOGAS/BIOMETHANE Biogas is a gaseous mixture of methane and carbon dioxide produced by the anaerobic digestion (or breakdown by microorganisms in the absence of oxygen) of organic matter, such as agricultural and food industry wastes, sewage sludge, and organic components of municipal solid wastes. It is combusted to produce heat and/or power. A biogas digester is the unit in which organic material and/or waste is converted into biogas. Biogas can be transformed into biomethane (similar to natural gas and derived by removing impurities—including carbon dioxide, siloxanes, and hydrogen sulphides—from biogas), which can be injected into natural gas networks and used as a substitute for natural gas.

BIOMASS ENERGY/BIOENERGY The term biomass energy/bioenergy refers to energy derived from biomass. Biomass is any material of biological origin, excluding fossil fuels or peat. Biomass can take many forms, including liquid biofuels, biogas, biomethane, solid biomass derived from dedicated energy plantations, wastes and residues from industrial processes (e.g., agriculture and forestry), and wet as well as solid municipal waste.

BIOMASS PELLETS A solid biomass fuel produced by compressing pulverized dry biomass, such as waste wood and agricultural residues. Pellets are typically cylindrical in shape with a diameter of around 1 centimetre and a length of 3–5 centimetres. Wood pellets are easy to handle, store, and transport and are used as fuel for heating and cooking applications, as well as for electricity generation and combined heat and power.

BRIQUETTING The process of producing briquettes, which are similar to wood pellets but physically much larger with a diameter of 5–10 centimetres and a length of 6–15 centimetres and less easy to handle automatically. They can be used as a substitute for fuelwood logs.

CAPITAL SUBSIDY, CONSUMER GRANT, REBATE One-time payments by a utility, government agency, or government-owned bank to cover a share of the capital cost of an investment in a renewable energy asset such as a solar water heater or a solar PV system.

COMBINED HEAT AND POWER (CHP)/COGENERATION PLANTS Facilities that produce both heat and power from fossil fuel combustion, and also from biomass fuel combustion and geothermal and solar thermal resources. The term is also used to refer to plants that recover "waste heat" that otherwise would be discarded from thermal power generation processes.

CONCENTRATING SOLAR POWER (CSP) Systems that use mirrors or lenses to concentrate solar thermal energy (radiation) into a smaller area, thereby converting the sun's incoming light energy to heat to drive a heat engine—usually a steam turbine or Stirling engine—in order to generate electricity. The majority of capacity in operation is based on the parabolic trough design, which uses a parabolic sun-tracking reflector to concentrate light on a receiver tube filled with fluid that is heated to temperatures generally between 150 and 350°C. Solar power towers use thousands of mirrors to track, capture, and focus the sun's thermal energy on a central tower, heating molten salt, which is pumped to a steam generator to drive a standard turbine. Dish systems focus sunlight into a central receiver in a large, reflective, parabolic dish; the receiver captures the heat and transforms it into useful energy using a Stirling engine. Linear Fresnel systems use flat mirror strips to concentrate sunlight onto a fixed absorber and into thermal fluid that goes through a heat exchanger to power a steam generator.

CONCENTRATING PHOTOVOLTAICS (CPV) Technology that uses mirrors or lenses to focus sunlight onto a small area of photovoltaic cells to generate electricity (see Photovoltaics). Low, medium, and high concentration CPV systems (depending on the design of reflectors or lenses used) operate most efficiently in concentrated, direct sunlight.

ENERGY The ability to do work, which comes in a number of forms including thermal, radiant, kinetic and electrical. Primary energy is the energy embodied in (energy potential of) natural resources, such as coal, natural gas, and renewable sources. Final energy is the energy delivered to end-use facilities (such as electricity to an electrical outlet), where it becomes usable energy and can provide services such as lighting, refrigeration, etc.w.

ETHANOL (FUEL) A liquid fuel made from biomass (typically corn, sugar cane, or small cereals/grains) that can replace 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 POLICY A policy that (a) sets a fixed, guaranteed price over a stated fixed-term period when renewable power can be sold and fed 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 ENERGY Heat energy emitted from within the Earth's crust, usually in the form of hot water or steam. It can be used to generate electricity or provide direct heat for buildings, industry, and agriculture. In addition, ground-source heat pumps use shallow geothermal heat (up to around 20 metre depth, also deemed to be stored solar heat) to heat and cool water and space. Technically similar to a refrigerator, a ground-source heat pump transfers heat from a colder to a hotter place, and vice versa. It uses the earth as a heat source in winter or heat sink in the summer. Enhanced geothermal systems (EGS) use water- or CO_2-based hydraulic stimulation in hot, non-permeable rock to enable closed-loop heat extraction where lack of water and permeability preclude cost-effective conventional geothermal projects.

GREEN ENERGY PURCHASE Voluntary purchase of renewable energy, usually electricity, by residential, commercial, government, or industrial consumers, either directly from an energy trader or utility company, from a third-party renewable energy generator, or indirectly via 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, reservoir-based capacity, and low-head in-stream technology (the least developed). Run-of-river hydro is a regular baseload supply, with some flexibility of operation for daily fluctuations in demand through water flow that is regulated by that facility. 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 new investment in renewable energy includes venture capital and private equity, equity raised through public markets, corporate and government research and development spending, and asset financing (all money invested in renewable energy generation projects).

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.

JOULE/KILOJOULE/MEGAJOULE/GIGAJOULE/TERAJOULE/PETAJOULE/EXAJOULE A joule (J) is a unit of work or energy and is equal to the energy expended to produce one watt of power for one second. (For example, one joule is equal to the energy required to lift an apple straight up one metre; the energy released as heat by a person at rest is about 60 J per second.) A kilojoule (KJ) is a unit of energy equal to one thousand (10^3) joules; a megajoule (MJ) is one million (10^6) joules; a gigajoule (GJ) is one billion (10^9) joules; and so on. Approximately 6 GJ represent the amount of potential chemical energy stored in one barrel of oil, and released when combusted.

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 renewable electricity 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 requirements; and requirements for blending biofuels into transportation fuel.

MODERN BIOMASS ENERGY Energy derived from solid, liquid, and gaseous biomass fuels for modern applications, such as space heating, electricity generation, combined heat and power, and transportation (as opposed to traditional biomass energy). Modern bioenergy involves direct combustion of biomass or conversion of biomass into more convenient fuels—for example, pyrolysis and gasification of solid biomass to produce liquid and gaseous fuels; anaerobic digestion of suitable biomass materials to produce biogas; transesterification of vegetable oils to produce biodiesel; and fermentation of sugar to ethanol.

NET METERING A power supply arrangement that allows a two-way flow of electricity between the electricity distribution grid and customers who have installed 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."

OCEAN ENERGY Energy that can be captured from ocean waves (generated by wind passing over the surface), tides, salinity gradients, and ocean temperature differences. The technologies covered in this report tap the energy potential of waves and tides. Wave energy converters capture the energy of ocean surface waves to generate electricity. Tidal stream generators use the kinetic energy of moving water to power turbines, similarly to wind turbines capturing wind to generate electricity. Tidal barrages are essentially dams that cross tidal estuaries and make use of potential energy in the height differences between high tides (when sea level rises and the basin behind the dam fills) and low tides (when water is released through turbines to create electrical power as it recedes).

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 energy supply 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 set 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 PICO SYSTEM (SPS) A very 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 that typically has a voltage up to 12 volt.

SOLAR PHOTOVOLTAICS (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.

SOLAR WATER HEATERS 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.

RENEWABLE ENERGY CERTIFICATE (REC) A certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat). In systems based on RECs, 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.

THERMOSIPHON SOLAR WATER HEATER A thermosiphon solar water heater relies on the physical principle that hot water rises so does not require a pump. In such a system, the solar collector must be located below the hot water storage tank in order to work.

TRADITIONAL BIOMASS ENERGY Solid biomass, including agricultural residues, animal dung, forest products, and gathered fuel wood, that is combusted in inefficient, and normally polluting open fires, stoves, or furnaces to provide heat energy for cooking, comfort, and small-scale agricultural and industrial processing, typically in rural areas of developing countries (as opposed to modern biomass energy).

TORREFIED WOOD Solid fuel, often in the form of pellets, produced by heating wood to 200–300 ^{o}C in restricted air. It has useful characteristics for a solid fuel including relatively high energy density, good grindability into pulverised fuel, and water repellency.

WATT/KILOWATT/MEGAWATT/GIGAWATT/TERAWATT-HOUR A watt is a unit of power that measures the rate of energy conversion or transfer. A kilowatt is equal to one thousand (10^3) watts; a megawatt to one million (10^6) watts; a gigawatt is 10^9 watts; and a terawatt is 10^{12} watts. A megawatt electrical (MW_e) is used to refer to electric power, whereas a megawatt thermal (MW_{th}) refers to thermal/heat energy produced. Power is the rate at which energy is consumed or generated. For example, a lightbulb with a power rating of 100 watts (W) that is on for one hour consumes 100 Watt-hours (Wh) of energy, 0.1 kilowatt-hour (kWh), or 360 kilojoules (kJ). This same amount of energy would light a 25 W bulb for four hours. A kilowatt-hour is the amount of energy equivalent to steady power of 1 kW operating for one hour.

NOTE ON ACCOUNTING AND REPORTING

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

1. CAPACITY VERSUS ENERGY DATA

The section on Global Markets and Industry by Technology includes energy produced and/or consumed (i.e., kWh, MWh, GWh, TWh) data where possible but focuses mainly on capacity (i.e., kW; MW, GW) data. This is because capacity data is the only thing that can be measured with any degree of certainty. Actual generation figures may only be available 12 months or more after the fact, and sometimes not at all. For countries or technologies where updated annual data are not available, it is easier to extrapolate the expansion of capacity from year to year than the production of renewable energy. In addition, capacity data better mimic investment trends over time. (For a better sense of average energy production from a specific technology or source in a given environment, see capacity factors in Table 2.) For heating, output is provided in joules where production data are available; otherwise, capacity data are given in Watts-thermal (W_{th}). Biofuel data are provided as annual volumes (billion litres/year) produced.

2. CONSTRUCTED CAPACITY VERSUS CONNECTED CAPACITY AND OPERATIONAL CAPACITY

Over the past few years, the solar PV and wind markets have seen increasing amounts of capacity that was connected but not yet deemed officially operational, or constructed capacity that was not connected to the grid by year-end (and, in turn, capacity that was installed in one year and connected to the grid during the next). This phenomenon has been particularly evident from 2009 to 2011 for wind power installations in China (especially as it was the market leader) and increasingly also with solar PV, notably in France and Italy. Various sources use different time lines and methodologies for counting. Further, differences in figures for constructed, connected, and operational capacities are temporal and are also due to the rapid pace of deployment. In some cases, installations have kept well ahead of the ability, willingness and/or legal obligation of grid connection, and/or have overshot official capacity limits. This situation will likely continue to make detailed annual statistics collection problematic in the fastest growing markets, and as long as frequent changes to support frameworks and/or technical and legal frameworks for grid connection remain under discussion.

In past editions, the *Renewables Global Status Report* has focused primarily on constructed capacity because it best correlates with flows of capital investments during the year. Starting with this edition, and particularly for the solar PV section, the focus is shifting to capacity that has become operational—connected and feeding electricity into the grid (or generating electricity, if off-grid installations)—during the calendar year (January to December), even if some of this capacity was installed during the previous year. The reason for this is the sources that the GSR draws from often have varying methodologies for counting installations, and most official bodies report grid connection statistics, at least with regard to solar PV. As a result, in many countries the data for actual installations is becoming increasingly difficult to obtain. Some renewable industry groups, including the European Photovoltaic Industry Association and the Global Wind Energy Council[i], are shifting toward tracking and reporting on operational/grid-connected rather than installed capacities.

As a result, some capacity that was installed in 2010 is counted as newly connected capacity in 2011; and some capacity installed during 2011 that was not operational/grid-connected by year-end will be counted for 2012. This has an impact on reported growth rates. For solar PV, considering installed capacity rather than operational capacity would result in a lower relative growth rate for 2011 than that presented in this report, and a higher growth rate for 2010; however, the five-year growth rate remains unchanged. The situation with wind power in China has been somewhat different because, reportedly, most installed capacity was connected and feeding power into the grid at the end of the calendar year in 2010 and 2011, even though a significant amount of new capacity had not yet been commercially certified by year-end. The situation in China is not likely to persist due to recent changes in permitting regulations.

i For example, see European Photovoltaic Industry Association, Global Market Outlook for Photovoltaics Until 2016 (Brussels: May 2012), at http://files.epia.org/files/Global-Market-Outlook-2016.pdf. Also, the Global Wind Energy Council (GWEC) reported 569 MW cumulative installed capacity in Mexico at the end of 2011, with an annual market of only 50 MW, even though an additional 304 MW were completed by year-end, because this capacity was not fully grid-connected until early 2012, see GWEC, Global Wind Report, Annual Market Update 2011 (Brussels: 2012).

NOTE ON ACCOUNTING AND REPORTING (CONTINUED)

3. BIOMASS POWER CAPACITY

This report strives to provide the best available data regarding biomass energy developments given existing complexities and constraints (see Sidebar 2). In past editions of this report, the energy derived from incineration of the "biogenic"[ii] or "organic" share of municipal solid waste (MSW) was not included in the main text and tables (although where official data were specified, they were included in relevant Endnotes). Starting with this edition of the GSR, capacity and output are included in the main text as well as the global biomass power data in Reference Tables R1 and R2. This change is due to the fact that international databases (e.g., IEA, U.S. EIA, EU) now track and report the biogenic portion of MSW separately from other MSW. The GSR comes as close as possible to covering this source on a global level; as a result, the global biomass power statistics differ from past statistics and thus should not be compared directly to those in previous editions of this report. Note that definitions vary slightly from one source to another, and it is not possible to ensure that all reported biogenic/organic MSW falls under the same definition.

4. HYDROPOWER DATA AND TREATMENT OF PUMPED STORAGE

Starting with this edition, the GSR attempts to report hydropower generating capacity without including pure pumped storage capacity (the capacity used solely for shifting water between reservoirs for storage purposes). The distinction is made because pumped storage is not an energy source but rather a means of energy storage; as such, it involves conversion losses and is potentially fed by all forms of energy, renewable and non-renewable. (As noted in Sidebar 3, however, pumped storage can play an important role as balancing power, in particular for balancing variable renewable resources.)

This method of accounting is accepted practice, according to industry insiders. Reportedly, the *International Journal of Hydropower and Dams* does not include pumped storage in its capacity data; the German Environment Ministry (BMU) does not report pumped storage capacity with its hydropower and other renewable power capacities; the International Hydropower Association is working to track and report the numbers separately as well.

In this 2011 edition, the removal of pumped storage capacity data from hydropower statistics has a substantial impact on reported global hydropower capacity, and therefore also on total global renewable electric generating capacity, relative to past editions of the GSR. As a result, the global statistics in this report should not be compared with prior data for total hydropower and total generating capacity. (Note, however, that the capacity data for 2009 and 2010 in the Selected Indicators Table on page 19 account for this change in methodology.) Data for non-hydro renewable capacity remain unaffected by this change. For future editions of the GSR, ongoing efforts are being made to further improve data.

ii The U.S. Energy Information Administration (EIA) defines biogenic waste as "paper and paper board, wood, food, leather, textiles and yard trimmings" (see http://205.254.135.7/cneaf/solar.renewables/page/mswaste/msw.html) and reports that it "will now include MSW in renewable energy only to the extent that the energy content of the MSW source stream is biogenic" (see http://www.eia.gov/cneaf/solar.renewables/page/mswaste/msw_report.html). A report from the IEA Bioenergy Task 36 defines it biogenic waste as "food and garden waste, wood, paper and to a certain extent, also textiles and diapers" (see http://www.ieabioenergytask36.org/Publications/2007-2009/Full_report_Final_hres.pdf).

NOTE ON FURTHER INFORMATION AND SOURCES OF DATA

This 2012 report edition follows six previous editions of the *Renewables Global Status Report* (produced in 2005, 2006, 2007, 2009, 2010, and 2011). While the knowledge base of information used to produce these reports continues to expand with each passing year, along with the renewables industries and markets themselves, readers are directed to the previous report editions for historical details and elaborations that have formed the foundation for the present report.

Most data for national and global capacity, growth, and investment portrayed in this report are estimates and are rounded as appropriate. Endnotes provide additional details. Where necessary, information and data that are conflicting, partial, or older are reconciled by using reasoned judgment and historical growth trends.

Each edition draws from hundreds of published references, a variety of electronic newsletters, numerous unpublished submissions from report contributors from around the world, personal communications with experts, and websites.

Generally, there is no single exhaustive source of information for global statistics. 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, for example. Data for developing countries are 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.

ENERGY CONVERSION FACTORS

multiply by:	TJ	GJ	Gcal	Mtoe	MBtu	GWh	MWh
TJ	1	10^{-3}	238.8	2.388×10^{-5}	947.8	0.2778	277.8
GJ	10^{3}	1	238.8×10^{-3}	2.388×10^{-8}	947.8×10^{-3}	0.2778×10^{-3}	277.8×10^{-3}
Gcal	4.1868×10^{-3}	4.1868	1	10-7	3.968	1.163×10^{-3}	1.163
Mtoe	4.1868×10^{4}	4.1868×10^{7}	107	1	3.968 x 107	1.163×10^{4}	1.163×10^{7}
MBtu	1.0551×10^{-3}	1.0551	0.252	2.52×10^{-8}	1	2.931×10^{-4}	0.2931
GWh	3.600	3.600×10^{3}	859.8	859.8×10^{-7}	3.412×10^{3}	1	103
MWh	3.600×10^{-3}	3.600	0.8598	0.8598×10^{-7}	3.412	10^{-3}	1

POWER CONVERSION FACTORS (ELECTRICAL AND THERMAL)

multiply by:	kW	MW	GW
kW	1	10^{-3}	10^{-6}
MW	10^{3}	1	10^{-3}
GW	10^{6}	10^{3}	1

OTHER CONVERSION FACTORS

- **ETHANOL VOLUME:** Ethanol data have been converted from cubic metres (m3) into litres (L) using a conversion ratio of 1,000 L per m^3.
- **BIODIESEL MASS:** Biodiesel data have been converted from litres (L) into kilograms (kg) using a density of 0.88 kg/L.
- **SOLAR THERMAL HEAT SYSTEMS:** Solar thermal heat data have been converted by accepted convention, 1 million m^2 = 0.7 GW_{th}.

LIST OF ABBREVIATIONS

BNEF	Bloomberg New Energy Finance
CHP	combined heat and power
CO_2	carbon dioxide
CPV	concentrating solar photovoltaics
CSP	concentrating solar (thermal) power
EJ	exajoule
EU	European Union (specifically the EU-27)
EV	electric vehicle
FIT	feed-in tariff
GACC	Global Alliance for Clean Cookstoves
GHG	greenhouse gas
GJ	gigajoule
GSR	Renewables Global Status Report
GW/GWh	gigawatt/gigawatt-hour
kW/kWh	kilowatt / kilowatt-hour
m^2	square metre
mtoe	million tonnes of oil equivalent
MW/MWh	megawatt/megawatt-hour
MSW	municipal solid waste
NGO	non-governmental organisation
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
SPS	solar pico system
TJ	terajoule
TW/TWh	terawatt/terawatt-hour

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