REN21 Renewable Energy Policy Network for the 21st Century

RENEWABLES 2013
GLOBAL STATUS REPORT

2013

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FOREWORD

Access to modern energy enables people to live better lives—providing clean heat for cooking, lighting for streets and homes, cooling and refrigeration, water pumping, as well as basic processing and communications. Yet over 1 billion people still lack access to modern energy services.

As a result of the UN Secretary General's Sustainable Energy for All Initiative and the upcoming Decade of Sustainable Energy for All, achieving universal energy access has risen to the top of the international agenda. However, given that the world recently passed 400 parts per million of atmospheric CO_2—potentially enough to trigger a warming of 2 degrees Celsius compared with pre-industrial levels—meeting growing energy needs in a climate-constrained world requires a fundamental shift in how those energy services are delivered. Renewable energy, coupled with energy efficiency measures, is central to achieving this objective.

Renewables already play a major role in the energy mix in many countries around the world. In 2012, prices for renewable energy technologies, primarily wind and solar, continued to fall, making renewables increasingly mainstream and competitive with conventional energy sources. In the absence of a level playing field, however, high penetration of renewables is still dependent on a robust policy environment.

Overall, the rate of policy adoption has slowed relative to the early-to-mid 2000s. Revisions to existing policies have occurred at an increasing rate, and new types of policies have begun to emerge to address changing conditions. Integrated policy approaches that conjoin energy efficiency measures with the implementation of renewable energy technologies, for example, are becoming more common.

Global investment in renewable energy decreased in 2012, but investment expanded significantly in developing countries. Global investment decreased in response to economic and policy-related uncertainties in some traditional markets, as well as to falling technology costs, which had a positive effect on capacity installations. Renewable energy is spreading to new regions and countries and becoming increasingly affordable in developing and developed countries alike.

At the same time, falling prices, combined with declining policy support in established markets, the international financial crisis, and ongoing tensions in international trade, have challenged some renewable energy industries. Subsidies to fossil fuels, which are far higher than those for renewables, remain in place and need to be phased out as quickly as possible. The emergence of shale gas brings a new dynamic to the energy market, and it remains to be seen how it will affect renewable energy deployment globally.

Despite fiscal and policy uncertainties, renewables are bringing modern energy services to millions of people, and increasingly meeting the growing demands for energy in many countries. Widespread deployment of renewable energy technologies is changing the energy-access dynamic in a number of developing countries, and is turning rural villages into thriving centres of commerce. Globally, in just five years, solar PV soared from below 10 GW in 2007 to just over 100 GW in 2012. In the EU, renewables accounted for almost 70% of new electric generating capacity in 2012.

We stand on the cusp of renewables becoming a central part of the world's energy mix. As technical constraints are overcome, most of the alleged limitations to achieving higher shares of renewables are due to a lack of political will to enact the necessary policies and measures. It is time to address this remaining hurdle. The *Renewables 2013 Global Status Report* provides renewable energy proponents and decision makers with information and motivation to tackle the challenges ahead.

On behalf of the REN21 Steering Committee, I would like to thank all those who have contributed to the successful production of the GSR 2013. These include lead author/research director Janet L. Sawin, together with the other section authors; the GSR project managers, Rana Adib and Jonathan Skeen; 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 500 contributors, including authors, researchers, and reviewers, who participated in this year's process and helped make the GSR 2013 a truly international and collaborative effort.

The REN 21 *Renewables 2013 Global Status Report* provides useful insight into the global renewable energy market and policy arena. I trust that it will serve as an inspiration for your work towards a rapid worldwide transition to a renewable energy future.

Arthouros Zervos

Chairman of REN21

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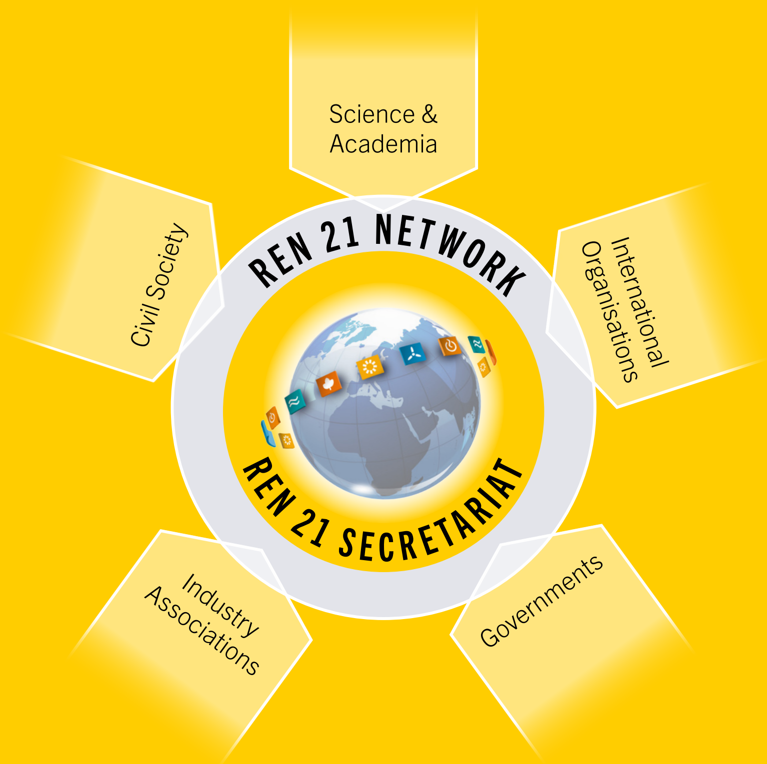
RENEWABLE ENERGY POLICY NETWORK FOR THE 21st CENTURY

REN21 is the global renewable energy policy multi-stakeholder network that connects a wide range of key actors including governments, international organisations, industry associations, science and academia, and civil society, with the aim of facilitating knowledge exchange, policy development, and joint action towards a rapid global transition to renewable energy.

REN21 promotes renewable energy in both industrialised and developing countries that are driven by the need to mitigate climate change while advancing energy security, economic and social development, and poverty alleviation.



www.ren21.net

REN21 Renewable Energy Policy Network for the 21st Century

REN21 FLAGSHIP PRODUCTS AND ACTIVITIES

Renewables Global Status Report

www.ren21.net/gsr

Renewables Interactive Map

www.map.ren21.net

Renewables Global Futures Report

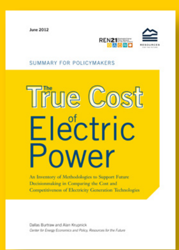
www.ren21.net/gfr

Regional Status Reports

REN21+: REN21's Global Web Platform

www.ren21plus.ren21.net

The True Cost of Electric Power



Facilitation of IRECs

renewables 2004

WIREC 2008

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Global Status Report on Local Renewable Energy Policies

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SUSTAINABLE
ENERGY FOR ALL

The UN Secretary-General's initiative **Sustainable Energy for All** 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. REN21's *Renewables 2013 Global Status Report* includes a section on rural renewable energy, based on input from local experts working around the world. The report highlights how renewables are providing access to energy for millions of people and contributing to a better quality of life through the use of modern cooking, heating/cooling, and electricity technologies.

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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 2013 and is available for download at www.fs-unep-centre.org.


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Source: NASA

EXECUTIVE SUMMARY

Renewable energy markets, industries, and policy frameworks have evolved rapidly in recent years. The *Renewables Global Status 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 500 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 forecasts.[i]

CONTINUED RENEWABLE ENERGY GROWTH

Global demand for renewable energy continued to rise during 2011 and 2012, supplying an estimated 19% of global final energy consumption in 2011 (the latest year for which data are available), with a little less than half from traditional biomass[ii]. Useful heat energy from modern renewable sources accounted for an estimated 4.1% of total final energy use; hydropower made up about 3.7%; and an estimated 1.9% was provided by power from wind, solar, geothermal, and biomass, and by biofuels.

Total renewable power capacity worldwide exceeded 1,470 GW in 2012, up about 8.5% from 2011. Hydropower rose 3% to an estimated 990 GW, while other renewables grew 21.5% to exceed 480 GW. Globally, wind power accounted for about 39% of renewable power capacity added in 2012, followed by hydropower and solar PV, each accounting for approximately 26%.

Renewables made up just over half of total net additions to electric generating capacity from all sources in 2012. By year's end, they comprised more than 26% of global generating capacity and supplied an estimated 21.7% of global electricity, with 16.5% of electricity provided by hydropower. Industrial, commercial, and residential consumers are increasingly becoming producers of renewable power in a growing number of countries.

Demand continued to rise in the heating and cooling sector, which offers an immense, yet mostly untapped, potential for renewable energy deployment. Already, heat from modern biomass, solar, and geothermal sources represents a significant portion of the energy derived from renewables, and the sector is evolving slowly as countries begin to enact support policies. Trends in the sector include the use of larger systems, increasing use of combined heat and power (CHP), the feeding of renewable heat and cooling into district schemes, and the growing use of modern renewable heat for industrial purposes.

After years of rapid growth, biodiesel production continued to expand in 2012 but at a much slower rate; fuel ethanol production peaked in 2010 and has since declined. Small but growing quantities of gaseous biofuels are being used to fuel vehicles, and there are limited but increasing initiatives to link electric transport systems with renewable energy.

Most renewable energy technologies continued to see expansion in manufacturing and global demand during 2012. However, uncertain policy environments and declining policy support affected investment climates in a number of established markets, slowing momentum in Europe, China, and India.

Solar PV and onshore wind power experienced continued price reductions due to economies of scale and technology advances, but also due to a production surplus of modules and turbines. Combined with the international economic crisis and ongoing tensions in international trade, these developments have created new challenges for some renewable industries, and particularly for equipment manufacturers, leading to industry consolidation. However, they also have opened up new opportunities and pushed companies to explore new markets. Renewables are becoming more affordable for a broader range of consumers in developed and developing countries alike.

Renewables are picking up speed across Asia, Latin America, the Middle East, and Africa, with new investment in all technologies. The Middle East and North Africa (MENA) region and South Africa, in particular, witnessed the launch of ambitious new targets in 2012, as well as the emergence of policy frameworks and renewables deployment. Markets, manufacturing, and investment shifted increasingly towards developing countries during 2012.

The top countries for renewable power capacity at year's end were China, the United States, Brazil, Canada, and Germany; the top countries for non-hydro capacity were China, the United States, and Germany, followed by Spain, Italy, and India. By region, the BRICS nations accounted for 36% of total global renewable power capacity and almost 27% of non-hydro renewable capacity. The EU had the most non-hydro capacity at the end of 2012, with approximately 44% of the global total.

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

- In China, wind power generation increased more than generation from coal and passed nuclear power output for the first time.
- In the European Union, renewables accounted for almost 70% of additions to electric capacity in 2012, mostly from solar PV and wind power. In 2011 (the latest year for which data are available), renewables met 20.6% of the region's electricity consumption and 13.4% of gross final energy consumption.
- In Germany, renewables accounted for 22.9% of electricity consumption (up from 20.5% in 2011), 10.4% of national heat use, and 12.6% of total final energy demand.
- The United States added more capacity from wind power than any other technology, and all renewables made up about half of total electric capacity additions during the year.

i REN21's recently published *Global Futures Report* shows the range of credible possibilities for renewable energy futures, based on interviews with over 170 leading experts from around the world and the projections of 50 recently published scenarios. It can be downloaded from www.ren21.net/gfr.

ii Note that there is debate about the sustainability of traditional biomass, and whether it should be considered renewable, or renewable only if it comes from a sustainable source.

SELECTED INDICATORS

		2010	2011	2012
Investment in new renewable capacity (annual)[1]	billion USD	227	279	244
Renewable power capacity (total, not including hydro)	GW	315	395	480
Renewable power capacity (total, including hydro)	GW	1,250	1,355	1,470
Hydropower capacity (total)[2]	GW	935	960	990
Bio-power generation	GWh	313	335	350
Solar PV capacity (total)	GW	40	71	100
Concentrating solar thermal power (total)	GW	1.1	1.6	2.5
Wind power capacity (total)	GW	198	238	283
Solar hot water capacity (total)[3]	GW_{th}	195	223	255
Ethanol production (annual)	billion litres	85.0	84.2	83.1
Biodiesel production (annual)	billion litres	18.5	22.4	22.5
Countries with policy targets	#	109	118	138
States/provinces/countries with feed-in policies	#	88	94	99
States/provinces/countries with RPS/quota policies	#	72	74	76
States/provinces/countries with biofuels mandates[4]	#	71	72	76

[1] Investment data are from Bloomberg New Energy Finance and include all biomass, geothermal, and wind generation projects of more than 1 MW; all hydro projects of between 1 and 50 MW; all solar power projects; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more.

[2] Hydropower data do not include pumped storage capacity. For more information, see Methodological Notes, page 130.

[3] Solar hot water capacity data include glazed water collectors only.

[4] Biofuel policies include policies listed both under the biofuels obligation/mandate column in Table 3 (Renewable Energy Support Policies) and in Reference Table R15 (National and State/Provincial Biofuel Blend Mandates).

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

- Wind and solar power are achieving high levels of penetration in countries like Denmark and Italy, which in 2012 generated 30% of electricity with wind and 5.6% with solar PV, respectively.

As their shares of variable wind and solar power increase, a number of countries (including Denmark, Germany, and Spain) have begun to enact policies and measures to successfully transform their energy systems to accommodate even larger shares.

Impacts of all of these developments on jobs in the renewable energy sector have varied by country and technology, but, globally, the number of people working in renewable industries has continued to rise. An estimated 5.7 million people worldwide work directly or indirectly in the sector.

AN EVOLVING POLICY LANDSCAPE

At least 138 countries had renewable energy targets by the end of 2012. As of early 2013, renewable energy support policies were identified in 127 countries, more than two-thirds of which are developing countries or emerging economies. The rate of adoption of new policies and targets has remained slow relative to the early to mid 2000s. As the sector has matured, revisions to existing policies have become increasingly common.

In response to rapidly changing market conditions for renewable technologies, tight national budgets, and the broader impacts of the global economic crisis, some countries undertook extensive revisions to existing laws, some of which were imposed retroactively. Others increased support for renewables, and several countries around the world adopted ambitious new targets.

Most policies to support renewable energy target the power sector, with feed-in tariffs (FITs) and renewable portfolio standards (RPS) used most frequently. During 2012, FIT policies were enacted in five countries, all in Africa and the Middle East; the majority of FIT-related changes involved reduced support. New RPS policies were enacted in two countries. An increasing number of countries turned to public competitive bidding, or tendering, to deploy renewables.

In the heating and cooling sector, promotion policies and targets continued to be enacted at a slower rate than in the power sector, although their adoption is increasing steadily. As of early 2013, 20 countries had specific renewable heating targets in place, while at least 19 countries and states mandated the use of renewable heat technologies. Renewable heating and cooling are also supported through building codes and other measures.

Biofuel blend mandates were identified at the national level in 27 countries and in 27 states/provinces. Despite increasing pressure in major markets such as Europe and the United States, due to growing debate over the overall sustainability of first generation biofuels, regulatory policies promoting the use of biofuels existed in at least 49 countries as of early 2013.

Thousands of cities and towns around the world have developed their own plans and policies to advance renewable energy, and momentum accelerated in 2012. To achieve ambitious targets, local governments adopted a range of measures, including FITs or technology-specific capacity targets; fiscal incentives to support renewable energy deployment; and new building codes and standards, including solar heat mandates. Others developed renewable district heating and cooling systems; promoted the use of renewably powered electric transport; formed consortia to fund projects; or advanced advocacy and information sharing.

Several cities are working with their national governments to promote renewable energy, while others have begun to organise from the bottom up. In Europe, 1,116 new cities and towns joined the Covenant of Mayors in 2012, committing to a 20% CO_2 reduction target and to plans for climate mitigation, energy efficiency, and renewable energy.

INVESTMENT TRENDS

Global new investment in renewable power and fuels was USD 244 billion in 2012, down 12% from the previous year's record. The total was still the second highest ever and 8% above the 2010 level. If the unreported investments in hydropower projects larger than 50 MW and in solar hot water collectors are included, total new investment in renewable energy exceeded USD 285 billion.

The decline in investment—after several years of growth—resulted from uncertainty about support policies in major developed economies, especially in Europe (down 36%) and the United States (down 35%). Nonetheless, considering only net additions to electric generating capacity (excluding replacement plants) in 2012, global investment in renewable power was ahead of fossil fuels for the third consecutive year.

The year 2012 saw the most dramatic shift yet in the balance of investment activity between developed and developing economies. Outlays in developing countries reached USD 112 billion, representing 46% of the world total; this was up from 34% in 2011, and continued an unbroken eight-year growth trend. By contrast, investment in developed economies fell 29% to USD 132 billion, the lowest level since 2009. The shift was driven by reductions in subsidies for solar and wind project development in Europe and the United States; increased investor interest in emerging markets with rising power demand and attractive renewable energy resources; and falling technology costs of wind and solar PV. Europe and China accounted for 60% of global investment in 2012.

Solar power was the leading sector by far in terms of money committed in 2012, receiving 57% of total new investment in renewable energy (96% of which went to solar PV). Even so, the USD 140.4 billion for solar was down 11% from 2011 levels, due to a slump in financing of CSP projects in Spain and the United States, as well as to sharply lower PV system prices. Solar was followed by wind power (USD 80.3 billion) and hydropower projects larger than 50 MW (estimated at USD 33 billion).

RURAL RENEWABLE ENERGY

The year 2012 brought improved access to modern energy services through the use of renewables. Rural use of renewable electricity has increased with greater affordability, improved knowledge about local renewable resources, and more sophisticated technology applications. Attention to mini-grids has risen in parallel with price reductions in solar, wind, inverter, gasification, and metering technologies.

Technological progress also advanced the use of renewables in the rural heating and cooking sectors. Rural renewable energy markets show significant diversity, with the levels of electrification, access to clean cookstoves, financing models, actors, and support policies varying greatly among countries and regions.

Government-driven electrification and grid extension programmes are still being adopted across the developing world. However, the last two decades have seen increasing private sector involvement in deployment of renewables in remote and rural areas, spurred by new business models and increasing recognition that low-income customers can offer fast-growing markets.

Policies to provide energy access through renewable energy are being integrated increasingly into broader rural development plans. Brazil, China, India, and South Africa are in the lead in the development of large-scale programmes that address the dual challenges of energy access and sustainability. However, for energy access targets to be met, institutional, financial, and legal mechanisms must be created and strengthened to support large-scale renewable energy deployment. The UN General Assembly's 'Energy Access for All' objective of universal access to modern energy by 2030 will require an annual investment of an estimated USD 36-41 billion.

MARKET AND INDUSTRY HIGHLIGHTS AND ONGOING TRENDS

BIOMASS FOR HEAT, POWER, AND TRANSPORT. Use of biomass in the heat, power, and transport sectors increased 2–3% to approximately 55 EJ. Heating accounted for the vast majority of biomass use, including traditional biomass, with modern biomass heat capacity rising about 3 GW_{th} to an estimated 293 GW_{th}. Bio-power capacity was up 12% to nearly 83 GW, with notable increases in some BRICS countries, and about 350 TWh of electricity was generated during the year. Demand for modern biomass is driving increased international trade, particularly for biofuels and wood pellets. Global production and transport of wood pellets exceeded 22 million tonnes, and about 8.2 million tonnes of pellets were traded internationally.

Liquid biofuels provided about 3.4% of global road transport fuels, with small but increasing use by the aviation and marine sectors. Global production of fuel ethanol was down about 1.3% by volume from 2011, to 83.1 billion litres, while biodiesel production increased slightly, reaching 22.5 billion litres. New ethanol and biodiesel production facilities opened, although many ethanol plants operated below capacity.

GEOTHERMAL ENERGY. Geothermal resources provided an estimated 805 PJ (223 TWh) of renewable energy in 2012, delivering two-thirds as direct heat and the remainder as electricity. The use of ground-source heat pumps is growing fast and reached an estimated 50 GW_{th} of capacity in 2012. At least 78 countries tap geothermal resources for direct heat, while two-thirds of global capacity is located in the United States, China, Sweden, Germany, and Japan. Geothermal electric generating capacity grew by an estimated 300 MW during 2012, bringing the global total to 11.7 GW and generating at least 72 TWh.

HYDROPOWER. An estimated 30 GW of new hydropower capacity came on line in 2012, increasing global installed capacity by 3% to an estimated 990 GW.[i] Hydropower generated an estimated 3,700 TWh of electricity during 2012. Once again, China led in terms of capacity additions (15.5 GW), with the bulk of other installations in Turkey, Brazil, Vietnam, and Russia. Joint-venture business models involving local and international partnerships are becoming increasingly prominent as the size of projects and the capacity of hydropower technologies increase.

OCEAN ENERGY. Commercial ocean energy capacity (mostly tidal power facilities) remained at about 527 MW at year's end, with little added in 2012. Small-scale projects were deployed in the United States and Portugal. Governments and regional authorities continued to support ocean energy research and development, while major power corporations increased their presence in the sector, which is seeing measured but steady progress.

SOLAR PV. Total global operating capacity of solar PV reached the 100 GW milestone, led by Europe, with significant additions in Asia late in the year. Driven by falling prices, PV is expanding to new markets, from Africa and the MENA region to Asia to Latin America. Interest in community-owned and self-generation systems continued to grow in 2012, while the number and scale of large PV projects also increased. Cell and module manufacturers struggled as extreme competition and decreases in prices and margins spurred more industry consolidation, and several Chinese, European and U.S. manufacturers went out of business. Thin film's share of global PV production declined further, with production down 15% to 4.1 GW.

CONCENTRATING SOLAR POWER (CSP). Total global CSP capacity increased more than 60% to about 2,550 MW. Most of this capacity was added in Spain, home to more than three-fourths of the world's CSP capacity. No new capacity came on line in the United States, but about 1,300 MW was under construction by year's end. Elsewhere, more than 100 MW of capacity was operating, mostly in North Africa. The industry is expanding into Australia, Chile, China, India, the MENA region, and South Africa. Falling PV and natural gas prices, the global economic downturn, and policy changes in Spain all created uncertainty for CSP manufacturers and developers.

SOLAR THERMAL HEATING AND COOLING. By the end of 2012, global solar thermal capacity reached an estimated 282 GW_{th} for all collector types, with the capacity of glazed water collectors reaching an estimated 255 GW_{th}. China and Europe account for about 90% of the world market (all types) and the vast majority of total capacity. Solar space heating and cooling are gaining ground, as are solar thermal district heating, solar cooling, and process heat systems. The industry continued to face challenges, particularly in Europe, and was marked by acquisitions and mergers among leading players, with rapid consolidation continuing in China. Automation of manufacturing processes increased in 2012, with innovation spanning from adhesives to materials and beyond.

WIND POWER. In another record year for wind power, at least 44 countries added a combined 45 GW of capacity (more than any other renewable technology), increasing the global total by 19% to 283 GW. The United States was the leading market, but China remains the leader for total installed capacity. Wind power is expanding to new markets, aided by falling prices. Almost 1.3 GW of capacity was added offshore (mostly in northern Europe), bringing the total to 5.4 GW in 13 countries. The wind industry has been challenged by downward pressure on prices, combined with increased competition among turbine manufacturers, competition with low-cost gas in some markets, and reductions in policy support driven by economic austerity.

i Hydropower data do not include pure pumped storage capacity except where specifically noted. For more information on data impacts, see Methodological Notes, page 130.

TOP FIVE COUNTRIES

ANNUAL INVESTMENT/ADDITIONS/PRODUCTION IN 2012

	New capacity investment	Hydropower capacity	Solar PV capacity	Wind power capacity	Solar water collector (heating) capacity[1]	Biodiesel production	Ethanol production
1	**China**	**China**	**Germany**	**United States**	**China**	**United States**	**United States**
2	United States	Turkey	Italy	China	Turkey	Argentina	Brazil
3	Germany	Brazil/Vietnam	China	Germany	Germany	Germany/ Brazil	China
4	Japan	Russia	United States	India	India	France	Canada
5	Italy	Canada	Japan	United Kingdom	Brazil	Indonesia	France

TOTAL CAPACITY AS OF END-2012

	Renewable power (incl. hydro)	Renewable power (not incl. hydro)	Renewable power per capita (not incl. hydro)[2]	Bio-power	Geothermal power	Hydropower	Concentrating solar thermal power (CSP)
1	**China**	**China**	**Germany**	**United States**	**United States**	**China**	**Spain**
2	United States	United States	Sweden	Brazil	Philippines	Brazil	United States
3	Brazil	Germany	Spain	China	Indonesia	United States	Algeria
4	Canada	Spain	Italy	Germany	Mexico	Canada	Egypt/Morocco
5	Germany	Italy	Canada	Sweden	Italy	Russia	Australia

	Solar PV	Solar PV per capita	Wind power	Solar water collector (heating)[1]	Solar water collector (heating) per capita[1]	Geothermal heat capacity	Geothermal direct heat use[3]
1	**Germany**	**Germany**	**China**	**China**	**Cyprus**	**United States**	**China**
2	Italy	Italy	United States	Germany	Israel	China	United States
3	United States	Belgium	Germany	Turkey	Austria	Sweden	Sweden
4	China	Czech Republic	Spain	Brazil	Barbados	Germany	Turkey
5	Japan	Greece	India	India	Greece	Japan	Japan/Iceland

1 Solar water collector (heating) rankings are for 2011, and are based on capacity of glazed water collectors only (excluding unglazed systems for swimming pool heating and air collectors). Including all water and air collectors, the 2011 ranking for total capacity is China, United States, Germany, Turkey, and Brazil.

2 Per capita renewable power capacity ranking considers only those countries that place among the top 12 for total renewable power 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 a mix of 2010 data and more recent statistics for some countries.

Note: Most rankings are based on absolute amounts of investment, power generation capacity, or biofuels production; if done on a per capita basis, the rankings would be quite different for many categories (as seen with per capita rankings for renewable power, solar PV, and solar water collector 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 in demand.

01

A concentrating solar thermal power (CSP) plant with a molten salt thermal storage system in the province of Seville, Spain. Installed capacity of many renewable energy technologies is growing rapidly, and renewables have quickly become a vital part of the global energy mix. Falling prices and technology advances are making renewables more affordable for consumers in developed and developing countries alike.

GLOBAL MARKET AND INDUSTRY OVERVIEW

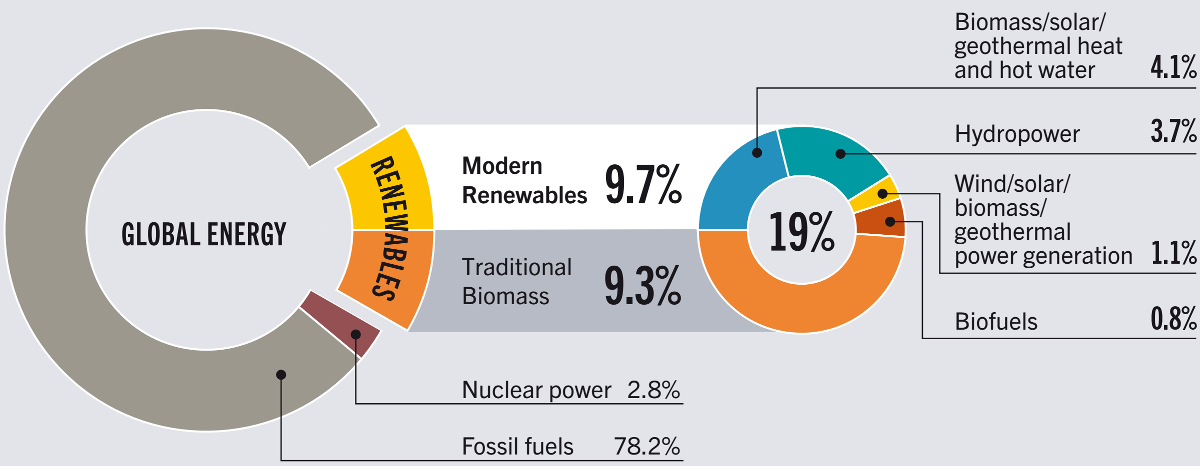
Global demand for renewable energy continued to rise during 2011 and 2012, despite the international economic crisis, ongoing trade disputes, and policy uncertainty and declining support in some key markets. Renewable energy supplied an estimated 19% of global final energy consumption by the end of 2011, the latest year for which data are available.[1i] Of this total, approximately 9.3% came from traditional biomass[ii], which is used primarily for cooking and heating in rural areas of developing countries. Useful heat energy from modern renewable sources accounted for an estimated 4.1% of total final energy use; hydropower made up about 3.7%; and an estimated 1.9% was provided by power from wind, solar, geothermal, and biomass, and by biofuels.[2] (See Figure 1.) Renewables are a vital part of the global energy mix.[3]

Modern renewable energy can substitute for fossil and nuclear fuels in four distinct markets: power generation, heating and cooling, transport fuels, and rural/off-grid energy services. This section provides an overview of recent market and industry developments in the first three sectors, while the Rural Renewable Energy section covers rural/off-grid energy in developing countries. The section that follows provides technology-specific coverage of market and industry developments and trends.

During the five-year period 2008–2012, installed capacity[iii] of many renewable energy technologies grew very rapidly, with the fastest growth in the power sector. Total capacity of solar photovoltaics (PV) grew at rates averaging 60% annually.[4] Concentrating solar thermal power (CSP) capacity increased more than 40% per year on average, growing from a small base, and wind power increased 25% annually over this period.[5] Hydropower and geothermal power are more mature technologies and their growth rates have been more modest, in the range of 3–4% per year.[6] Bio-power is also mature but with steady growth in solid and gaseous biomass capacity, increasing at an average 8% annually.[7] (See Figure 2.)

Demand has also increased rapidly in the heating/cooling sector, particularly for solar thermal systems, geothermal ground-source heat pumps, and some bioenergy fuels and systems. Capacity of glazed solar water heaters has increased by an average exceeding 15% over the past five years, while ground-source heat pumps continue to grow by an average 20% annually, and bio-heat capacity is growing steadily.[8] Wood pellet consumption (for both heat and power) is rising by about 20% per year.[9]

FIGURE 1: ESTIMATED RENEWABLE ENERGY SHARE OF GLOBAL FINAL ENERGY CONSUMPTION, 2011



Source: See Endnote 2 for this section.

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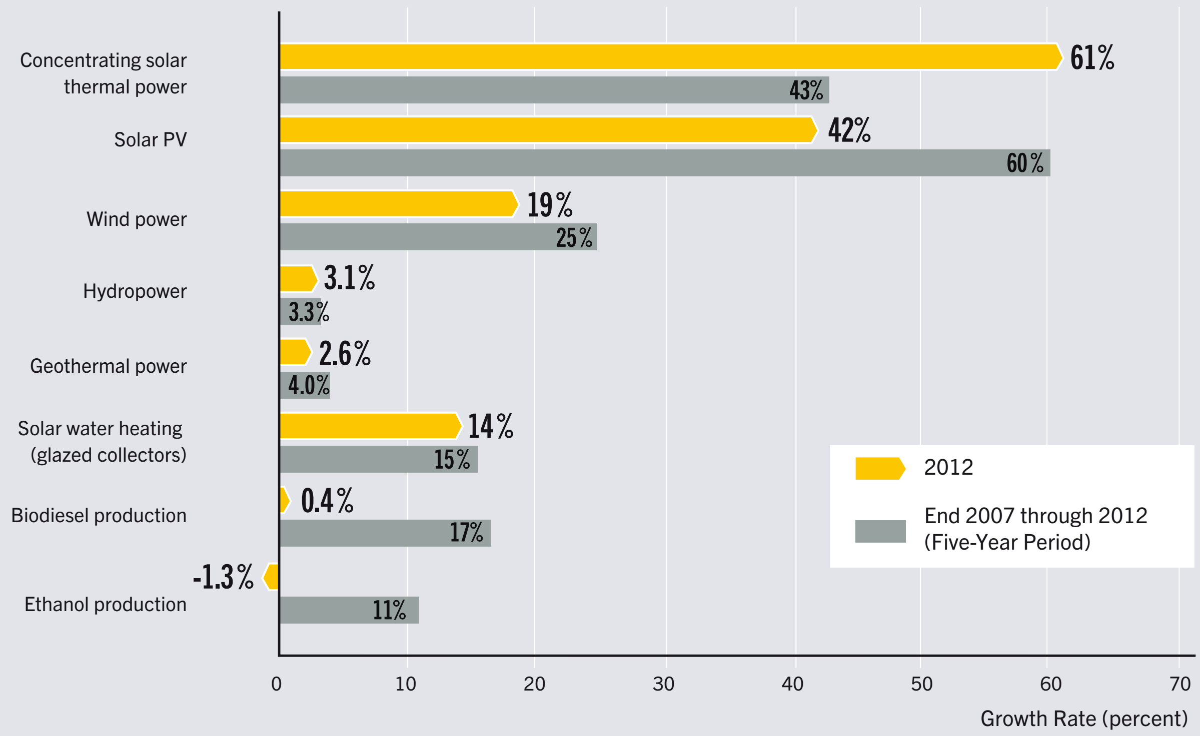
i Endnotes are numbered by section and begin on page 130 (see full version online: www.ren21.net/gsr).

ii Traditional biomass refers to solid biomass that is combusted in inefficient, and usually 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. Traditional biomass currently plays a critical role in meeting rural energy demand in much of the developing world. Modern bioenergy is defined in this report as energy derived efficiently from solid, liquid, and gaseous biomass fuels for modern applications. (See Glossary for definitions of terms used in this report.) There is debate about the sustainability of traditional biomass, and whether it should be considered renewable, or renewable only if it comes from a sustainable source. 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 capacity data. See Methodological Notes, page 130.

FIGURE 2: AVERAGE ANNUAL GROWTH RATES OF RENEWABLE ENERGY CAPACITY AND BIOFUELS PRODUCTION, END 2007-2012



Source: See Endnote 7 for this section.

In the transport sector, the growth of liquid biofuels has been mixed in recent years. The average annual growth rate over the period from the end of 2007 through 2012 was nearly 11% for ethanol and 17% for biodiesel. Although biodiesel production continued to expand in 2012, it was at a much slower rate of growth, whereas ethanol production peaked in 2010 and has since declined.[10]

Most technologies continued to see expansion in both manufacturing and global demand. However, global market growth slowed for most technologies in 2012 relative to the previous few years. Uncertain policy environments and declining policy support—such as policy reversals and retroactive changes—affected investment climates in a number of established markets, and slowed momentum in Europe, China, and India.

Solar PV and onshore wind power experienced continued price reductions in 2012 due to economies of scale and technology advances, but also due to a production surplus of modules and turbines. Combined with the international economic crisis (which has helped drive policy changes) and ongoing tensions in international trade, these developments have created new challenges for some renewable energy industries and, particularly, equipment manufacturers.[11]

In response, industry consolidation continued among players both large and small—most notably in the solar, wind, and biofuel industries—with several high-profile bankruptcies occurring throughout the year.[12] To increase product value and reduce costs, manufacturers vertically integrated their supply chains and diversified products. The move into project development and ownership also continued.

While falling prices have hurt many manufacturers, they have opened up new opportunities. Oversupply and slowing growth in traditional markets have pushed companies to explore new markets. Falling prices and innovations in financing are making renewables more affordable for a broader range of consumers in developed and developing countries alike.[13] Lower prices made 2012 a good year for installers and consumers.

As a result, new markets in Asia, Latin America, the Middle East, and Africa are gaining momentum, with new investment seen in all renewable technologies and end-use sectors.[14] (See Sidebar 2 and Investment Flows section.) Markets, manufacturing, and investment shifted increasingly towards developing countries during 2012.

Renewables are also moving into new applications and industries, including desalination (especially using solar power in arid regions) and the mining industry, whose operations are energy intensive and often in remote locations.[15] Impacts of all of these developments on jobs in the renewable energy sector have varied by country and technology, but, globally, the number of people working in renewable energy industries has continued to rise. (See Sidebar 4 and Table 1, page 57.)

POWER SECTOR

Total renewable power capacity worldwide exceeded 1,470 gigawatts (GW) in 2012, up about 8.5% from 2011. Hydropower[i] rose to an estimated 990 GW, while other renewables grew 21.5% to exceed 480 GW.[16] Globally, wind power accounted for about 39% of renewable power capacity added in 2012, followed by hydropower and solar PV, each accounting for approximately 26%.[17] (See Reference Table R1.) Solar PV capacity reached the 100 GW milestone to pass bio-power and become the third largest renewable technology in terms of capacity (but not generation), after hydro and wind.

Renewables have accounted for an ever-growing share of electric capacity added worldwide each year, and in 2012 they made up just over half of net additions to electric generating capacity.[18] By year's end, renewables comprised more than 26% of total global power generating capacity and supplied an estimated 21.7% of global electricity, with 16.5% of total electricity provided by hydropower.[19] (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 many countries continue to add significant fossil fuel capacity, and much of the renewable capacity being added (wind and solar energy) operates at relatively low capacity factors.

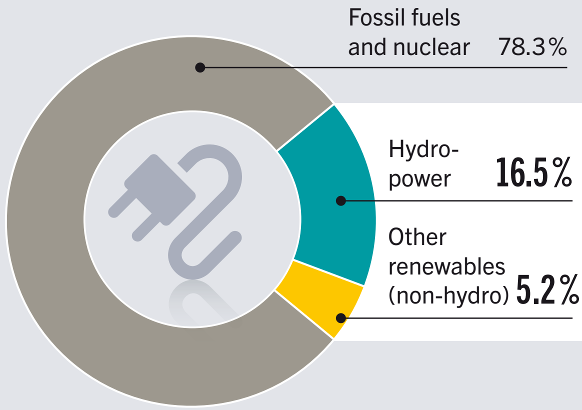
Even so, wind and solar power are achieving high levels of penetration in countries like Denmark and Italy, which generated 30% of electricity with wind and 5.6% with solar PV, respectively, during 2012.[20] In an increasing number of regions—including parts of Australia, Germany, India, and the United States—the electricity generation share from variable resources has reached impressive record peaks, temporarily meeting high shares of power demand, while often driving down spot market prices.[21]

In addition, the levelised costs of generation from onshore wind and solar PV have fallen while average global costs (excluding carbon) from coal and natural gas generation have increased due to higher capital costs.[22] As prices for many renewable energy technologies continue to fall, a growing number of renewables are achieving grid parity in more and more areas around the world.[23]

China, the United States, Brazil, Canada, and Germany remained the top countries for total renewable electric capacity by the end of 2012.[24] The top countries for non-hydro renewable power capacity were China, the United States, and Germany, followed by Spain, Italy, and India.[25] (See Figure 4 and Table R2.) France and Japan tied for a distant seventh, followed closely by the United Kingdom, Brazil, and then Canada and Sweden.[26] Of these 12 countries, the ranking on a per capita basis for non-hydro renewable energy capacity in use puts Germany first, followed by Sweden, Spain, Italy, Canada, the United States, the United Kingdom, France, Japan, China, Brazil, and India.[27ii] (See Top Five Countries Table on page 17 for other rankings.) In total, these 12 countries accounted for almost 84% of global non-hydro renewable capacity, and the top five countries accounted for 64%.[28]

China is home to about one-fifth of the world's renewable power capacity, with an estimated 229 GW of hydropower capacity plus about 90 GW of other renewables (mostly wind) at the end of 2012.[29] Of the 88 GW of electric capacity added in 2012, hydropower accounted for more than 17% and other renewables for about 19%.[30] Renewables met nearly 20% of China's electricity demand in 2012, with hydropower accounting for 17.4%.[31] Relative to 2011, electricity output in 2012 was up 35.5% from wind, and 400% from solar PV, with wind generation increasing more than generation from coal and passing nuclear power output for the first time.[32]

FIGURE 3: ESTIMATED RENEWABLE ENERGY SHARE OF GLOBAL ELECTRICITY PRODUCTION, END-2012



Note: Based on renewable generating capacity in operation at year-end 2012.

Source: See Endnote 19 for this section.

In the United States, renewables accounted for 12.2% of net electricity generation in 2012, and for more than 15% of total capacity at year's end.[33] Hydropower output was down 13.4%, while net generation from other renewables rose from 4.7% in 2011 to 5.4% in 2012.[34] For the first time, wind represented the largest source of electric capacity added, accounting for as much as 45%, and all renewables made up about half of U.S. electric capacity additions during the year.[35]

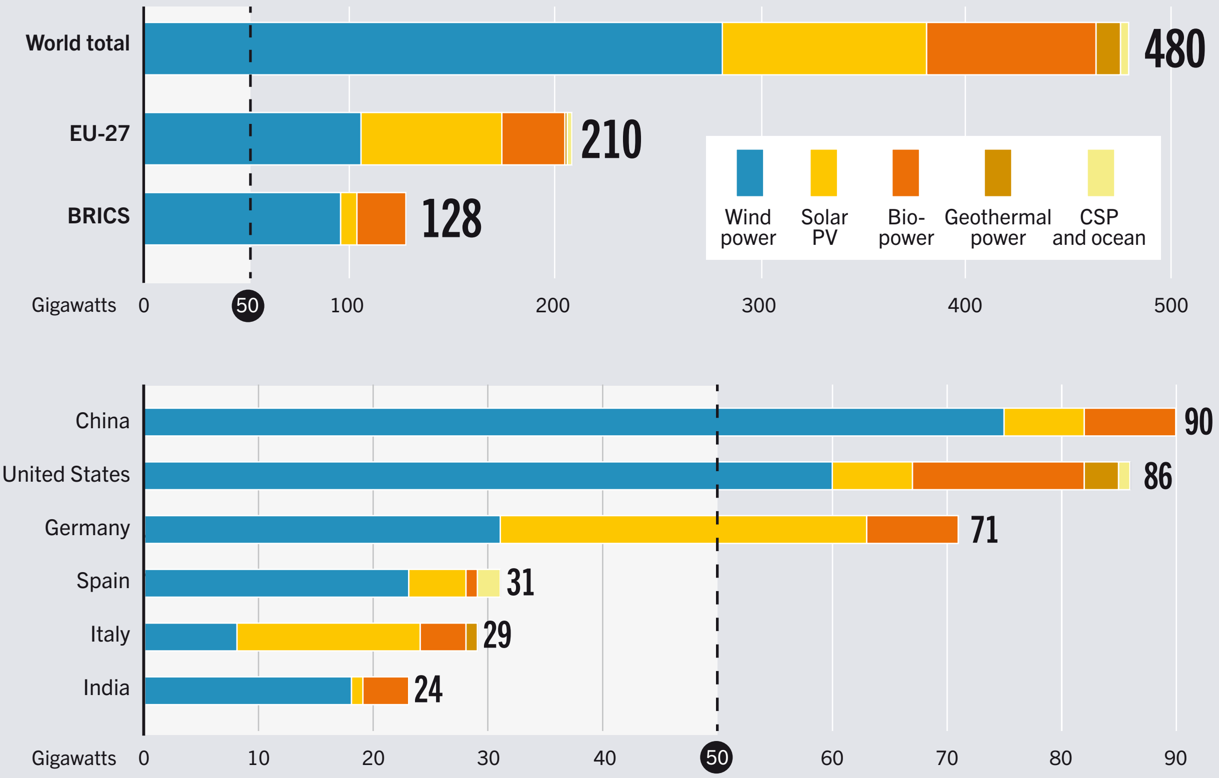
Renewables accounted for 22.9% of Germany's electricity consumption (up from 20.5% in 2011), generating more electricity than the country's nuclear, gas-fired, or hard coal power plants (but not lignite plants).[36] Total renewable electricity generation (136 TWh) was more than 10% above 2011 output, with wind energy representing a 33.8% share, followed by biomass with 30% (more than half from biogas), solar PV 20.6%, and hydropower 15.6%.[37] Renewables met 12.6% of Germany's total final energy needs (up from 12.1% in 2011).[38]

Spain has experienced a slowdown in renewable capacity additions resulting from the economic recession and recent policy changes. (See Policy Landscape section.) However, globally it still ranked fourth for non-hydro renewable power capacity, with an estimated 30.8 GW in operation, plus 17 GW of hydro.[39] Renewable energy provided 32% of Spain's electricity

i Global hydropower data and thus total renewable energy statistics in this report reflect an effort to leave capacity of pure pumped storage out of the totals. For more information, see Methodological Notes, page 130.

ii While there are other countries with high per capita amounts of renewable capacity and high shares of electricity from renewable sources, the GSR focuses here on those with the largest amounts of non-hydro capacity. (See Reference Table R11 for country shares of electricity from renewable sources.)

FIGURE 4: RENEWABLE POWER CAPACITIES* IN WORLD, EU-27, BRICS, AND TOP SIX COUNTRIES, 2012



*not including hydropower

Source: See Endnote 25 for this section.

needs in 2012 (down from 33% in 2011), with wind contributing the largest share, followed by solar power.[40]

Italy remained in fifth place with 29 GW of non-hydro renewables and 18 GW of hydropower by the end of 2012.[41] Renewables met 27% of the country's electricity demand, up from 24% in 2011, with non-hydro renewables accounting for 15%.[42]

About 4.2 GW of renewable power capacity was added in India during 2012, including about 0.7 GW of hydropower and 3.5 GW of other renewables (mostly wind), for a year-end total exceeding 66 GW.[43] Renewables accounted for more than 31% of total installed capacity at year's end, with non-hydro renewables representing over 11% (24 GW).[44]

The BRICS[i] nations accounted for 36% of total global renewable power capacity and almost 27% of non-hydro renewable capacity by the end of 2012. While Russia has a large capacity of hydropower, virtually all of the BRICS' non-hydro capacity is in Brazil, India, and particularly China.[45] South Africa is also starting to gain momentum, with significant wind and CSP capacity under construction by year's end.[46]

While the BRICS countries led for capacity of all renewables, the European Union (EU)[ii] had the most non-hydro capacity at the end of 2012, with approximately 44% of the global total. Renewables accounted for more than half of all electric capacity added in the EU during the 2000–2012 period, and for almost 70% of additions in 2012—mostly from solar PV (37% of all 2012 additions) and wind (26.5%).[47] At year's end, renewables made up more than one-third of the region's total generating capacity, with non-hydro renewables accounting for more than one-fifth.[48] In 2011 (the latest data available), renewables met 20.6% of the region's electricity consumption (up from 20% in 2010) and 13.4% of gross final energy consumption (compared to 12.5% in 2010).[49]

In the EU and elsewhere, an increasing number of households and businesses are making voluntary purchases of renewable energy. Voluntary purchases of heat and transport biofuels are options in some countries, but "green energy" purchasing remains most common for renewable electricity. The largest corporate users are reportedly in Japan, Germany, and Finland.[50]

Germany has become one of the world's green power leaders. Its market grew from 0.8 million residential customers in 2006 to 4.3 million in 2011, or 10% of all private households in the country purchasing 13.1 TWh of renewable electricity; including commercial customers, purchases exceeded 21 TWh.[51] Other major European green power markets include Austria, Belgium (Flanders), Finland, Italy, the Netherlands, Sweden, Switzerland, and the United Kingdom, although the market share in these countries remains below German levels.[52]

In the United States, more than half of electricity customers have the option to purchase green power directly from a retail electricity provider. In 2011, the U.S. green power market grew an estimated 20%, and Green-e Energy, the country's leading

i An association of emerging national economies including Brazil, Russia, India, China, and South Africa.

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

SIDEBAR 1. THE REN21 RENEWABLES GLOBAL FUTURES REPORT

In January 2013, REN21 published a sister report to its annual *Global Status Report*—the REN21 *Renewables Global Futures Report*—that portrays the status of current thinking about the future of renewable energy.

The new report is not one scenario or viewpoint, but a synthesis of the contemporary thinking of many, as compiled from 170 interviews with leading experts from around the world, and from 50 recent energy scenarios published by a range of organisations. This synthesis shows the range of credible possibilities for renewable energy futures based on both scenario projections and expert opinion. The report also features a series of "Great Debates" that frame current development and policy issues and choices on the path to a transformed renewable energy future.

The report shows that much contemporary thinking about the future of renewable energy is rooted in the past. For example, many conservative scenarios show future shares of renewable energy remaining in the 15–20% range globally, about the level today. But such views have become increasingly untenable given the dynamic growth of markets over the past decade and the dramatic technology evolution and cost reductions seen in recent years. Many "moderate" scenarios show long-term shares in the 30–45% range, and this range has become increasingly credible in many countries. Beyond that, many high-renewables projections show long-term shares in the 50–95% range, and such projections are also growing more credible and becoming mainstreamed.

Projections for global renewable energy capacity by 2030 from a variety of scenarios show wind power capacity increasing between 4-fold and 12-fold, solar PV between 7-fold and 25-fold, CSP between 20-fold and 350-fold, bio-power between 3-fold and 5-fold, geothermal between 4-fold and 15-fold, and hydro between 30% and 80% (all based on actual 2011 GW of capacity).

Expert and scenario projections show investments in renewable energy of up to USD 500 billion annually by 2020–25. Finance experts observed that many new sources of finance, from community funds to pension funds, will be needed to support such levels of investment. Finance experts also believed that renewable energy projects are coming to be seen as among the lowest-risk investments, posing "nothing more than standard industrial risk" in the words of one expert, and even lower risk than some fossil fuel-based investments.

The report shows that integration of renewable energy into power grids, buildings, industry, and transport is becoming a pressing and immediate issue. The report outlines a dozen options for balancing high shares of variable renewables on power grids, and dispels the myth that expensive energy storage will be required. It also notes that while some utilities are resisting integration progress, many others are at the forefront, working actively to meet the integration challenge.

Integration into buildings is perhaps the most difficult, given existing building materials and practices, but many cost-effective opportunities exist, and low-energy or zero-energy buildings are important. In transport, integration in the form of advanced biofuels and electric vehicles charged from renewables is key, although still somewhat uncertain, according to many of the experts. These integration opportunities and challenges point to new types of policies needed to support each form of integration, sector by sector, in parallel with the many price- or cost-based policies that have existed historically.

Beyond integration, many experts viewed the long-term future of renewable energy as "transformative" for for energy systems—for example, as electric power becomes much more flexible and multi-level, with variable supply and demand interacting at centralised, distributed, and micro-grid levels; as transport becomes provided by a much wider range of vehicle and fuel types serving more differentiated needs for mobility; and as renewable-energy-integrated building materials and construction practices, coupled with low-energy building designs, become ubiquitous.

Many experts said that the future challenges facing renewables are no longer fundamentally about technology. Nor is economics the bottleneck, as "grid parity" and other measures of competitiveness have arrived, or are soon arriving, for many renewables in numerous locales. Such views suggest that the future of renewable energy is fundamentally a choice, not a foregone conclusion given technology and economic trends.

certifier of voluntary green power, certified 27.8 TWh.[53] By early 2013, the 50 largest purchasers (including municipalities and corporations) in the Environmental Protection Agency's Green Power Partnership were buying more than 17 TWh annually from a variety of renewable sources, with 17 partners covering all of their electricity demand.[54] Green power markets also exist in Australia, Canada, Japan, and South Africa.[55]

More than 50 major international corporations had adopted the *WindMade* label by the end of 2012.[56] The label was launched globally in 2011 to help consumers identify companies and products using wind energy, and plans were announced in 2012 to develop a new label for all renewables.[57] In early 2013, a network of European environmental NGOs introduced "EKOenergy," aiming to provide a green labelling standard for all of Europe.[58]

Major industrial and commercial customers in Europe, India, the United States, and elsewhere continued to install and operate their own renewable power systems, while community-owned and cooperative projects also increased in number during 2012.[59] The year saw expanded installations of small-scale, distributed renewable systems for remote locations as well as grid-connected systems where consumers prefer to generate at least a portion of their electricity on-site. As consumers increasingly become producers of power, particularly in some European countries, some major utilities are losing market share, putting strains on current business models.[60]

SIDEBAR 2. REGIONAL SPOTLIGHT: AFRICA

Having long supported a range of oil and gas industries, Africa is now widely recognised for the potential of its renewable energy resources to provide electricity, heat, and transport fuels. Large areas of Southern and North Africa[i] are now known to have world-class solar resources, and many African countries have among the highest potential for wind and geothermal energy in the developing world. Some estimates suggest that only 7% of the continent's hydropower potential has been realised. Already a heavy user of traditional biomass, much of Africa also is ripe for the adoption of more sustainable bioenergy practices and technologies.

Nonetheless, African renewable energy markets remain the least developed globally. The scale of modern energy use remains fractional relative to total energy demand, and modern renewables (with the exception of large-scale hydro) are typically off-grid and small.

But markets are shifting rapidly. Growing awareness of the potential of African renewables, greater economic resilience, surging growth, and more stable governments are driving the emergence of a diverse portfolio of renewables on a large scale. Many African countries are now shifting their renewable energy focus from small, off-grid systems (a legacy of donor-led rural electrification programmes) to utility-scale systems and infrastructure, as part of a broader vision of sustainable macroeconomic development.

Renewable energy markets have responded strongly, driven by a huge demand for additional generating capacity (expected to average around 7 GW a year for the next decade). North African wind markets continue to lead on the continent, with well over 10 GW targeted by 2020. Significant expansion of geothermal capacity is in various stages of planning and development in the east, led by Kenya, while hydropower capacity at all scales is growing across the continent. In South Africa, 2013 will see construction of the region's first grid-connected wind and solar power projects of 5 MW and larger, after years of planning and regulatory reform.

Renewable heating markets remain small in the global context, but are growing, with sub-Saharan Africa producing more solar heat for domestic water heating per capita than regions such as Asia (excluding China) and the United States and Canada.[ii] And several African countries are actively initiating or expanding local biofuels production, often backed by foreign investment.

Africa remains largely reliant on foreign technologies, but market developments are spurring the growth of local industries. Local manufacturing of "balance of system" components is firmly established in a few more advanced African economies. Promisingly, more complex items such as wind turbines, towers, and blades, as well as solar panels and inverters, are being produced either commercially or as prototypes for future commercial manufacture. Technological innovation is being more strongly promoted in national economic strategies, supported by inter-regional organisations such as the African Technology Policy Studies Network.

Increased adoption of national renewable energy strategies has been a strong catalyst for this nascent upsurge in activity. Around 20 African countries now have formal renewable energy policies in place, representing a significant increase over the past five years, and many of these countries have ambitious renewable energy targets. (See Reference Tables R10–R12.) Intergovernmental organisations or groupings such as EAC, ECOWAS, MENA, and SADC have established regional centres for renewable energy (such as ECREEE in West Africa and RCREEE in North Africa), or developed regional strategies to promote shared visions for cohesive renewable energy development across their member states.[iii]

Keeping pace with surging energy demand will require vast investment in energy infrastructure, equating to more than 6% of the continent's GDP (or roughly USD 41 billion a year) over the coming decade. Foreign direct investment is crucial for closing the investment gap, and China has played a dominant role, funding large hydropower projects in Ethiopia, Nigeria, the Sudan, and Zambia, and geothermal development in Kenya. Chinese firms and investors are also active in wind and solar development across the continent.

While the continent shows unprecedented growth and robustness, most African countries still face urgent, short-term socioeconomic challenges that dominate national budgets and planning strategies. Capital investments in capacity expansion are lagging far behind energy demand, and renewable energy investment in Africa remains low in comparison with other global regions. Negative international perceptions remain. Although foreign companies active in Africa are positive about the continent's prospects as an investment destination, companies with no local presence remain overwhelmingly negative. Potentially harmful impacts of renewable energy growth have also been highlighted, with watchdog organisations citing the danger of land uptake for renewables (particularly biofuels) by governments and foreign investors as a threat to the social and economic prosperity of local communities.

Nonetheless, with economic growth and investments in energy infrastructure at unprecedented levels, Africa is now widely accepted as one of the world's most promising renewable energy markets.

The "Regional Spotlight" sidebar is appearing for the first time in GSR 2013 and will be a regular feature of the report, focusing on developments and trends in a different world region every year.

i REN21 recently published the *MENA Renewables Status Report*, focusing on renewables in the Middle East and North Africa region. The report can be accessed via the REN21 website at www.ren21.net.

ii Based on annual collector yield of glazed (flat plate collectors and evacuated tube collectors) water collectors in operation, in 2010. See Endnote for this sidebar.

iii EAC is the East African Community. ECOWAS is the Economic Community of West African States. MENA is the Middle East and North Africa, which is a geographical grouping of countries and not a formal organisation. SADC is the Southern African Development Community. ECREEE is the ECOWAS Centre for Renewable Energy and Energy Efficiency. RCREEE is the Regional Center for Renewable Energy and Energy Efficiency.

Source: See Endnote 14 for this section.

HEATING AND COOLING SECTOR

Modern biomass, solar thermal, and geothermal energy currently supply hot water and space heating (and some cooling with the use of heat pumps and absorption chillers) for tens of millions of domestic and commercial buildings worldwide. These resources are also used to supply heat for industrial processing and agricultural applications. Passive solar building designs provide a significant amount of heat (and light), and their numbers are on the rise, but due to lack of data they are not included in this report.

Modern biomass accounts for the vast majority of renewable heating worldwide.[61] Europe is the leading region for bio-heat consumption, but demand is rising elsewhere, and biogas is becoming an increasingly important source of cooking fuel in a growing number of developing countries.[62]

Solar collectors are used in more than 56 countries worldwide for water (and increasingly for space) heating in homes, schools, hospitals, hotels, and government and commercial buildings.[63] Their use is extensive in China, where solar water heaters cost less over their lifetimes than do natural gas or electric heaters.[64]

Geothermal energy is used by at least 78 countries for direct heating purposes, including district heat systems, bathing and swimming applications, industrial purposes, agricultural drying, and other uses.[65] Ground-source heat pumps can both heat and cool space and represent the largest and historically fastest-growing segment of geothermal direct use.[66]

Use of 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 better track the share of heat derived from renewable sources and to enact supporting policies. For example, renewables met 10.4% of Germany's heating demand (mostly with biomass) in 2012, and Denmark has banned the use of fossil-fuel fired boilers in new buildings as of 2013.[67] Consumers in some countries—including Denmark, Japan, and the United Kingdom—now can choose "green heat" through voluntary purchasing programmes, although options are relatively limited compared to green power.[68]

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 heat and cooling into district schemes, and the growing use of renewable heat for industrial purposes. In addition, some EU countries are starting to see hybrid systems that link solar thermal and other heat sources, such as biomass. Some are using district heat systems (often based on renewable sources) to balance electricity generation from variable sources, for example by using excess power generation on very windy days to heat water directly or with heat pumps.[69]

TRANSPORT SECTOR

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

Liquid biofuels currently provide over 2.5% of global transport fuels (3.4% of road transport fuels and a very small but growing share of aviation fuels), and account for the largest share of transport fuels derived from renewable energy sources.[70]

Limited but growing quantities of gaseous biofuels (mainly biomethane from purified biogas) are fuelling cars, local trains, buses, and other vehicles in several EU countries (most notably Germany and Sweden) and in some communities in North America and elsewhere.[71] Plans are under way in many countries, including in the Middle East and Asia, to develop facilities for biomethane production and vehicle fuelling.[72]

Electricity is used to power trains, city transit, and a growing number of electric passenger road vehicles and motorised cycles, scooters, and motor bikes. There are limited but increasing initiatives to link electric transport systems with renewable electricity. In early 2013, for example, Deutsche Bahn announced plans for at least 75% of long-distance journeys in Germany to be powered by renewable energy.[73] In some locations, particularly at the local level, electric transport is tied directly to renewable electricity through specific projects and policies. (See Policy Landscape section.)

Fields of corn, a source of fuel ethanol, in the U.S. state of Kansas.

Global production of biofuels dropped slightly in 2012, although some countries increased production, and markets for other renewables continued to expand. It was a difficult year for many manufacturers and some traditional markets, but lower prices made it a good year for installers and consumers.

02 MARKET AND INDUSTRY TRENDS BY TECHNOLOGY

BIOENERGY

The use of biomass to provide modern energy services has continued to increase in the building, industry, and transport end-use sectors in recent years. In addition to being a source of food, fibre, and feed for livestock, as well as feedstock for materials and chemical production, 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).[1]

Biomass used for energy purposes is derived from a number of sources. Residues from forests, wood processing, and food crops dominate. Short-rotation energy crops, grown on agricultural land specifically for energy purposes, currently provide about 3–4% of the total biomass resource consumed annually.[2] The total area of land used for bioenergy crops is difficult to quantify accurately because of large data gaps. Furthermore, some energy crops are grown for competing non-energy uses.[3] For example, ethanol production volumes from sugar cane fluctuate with the sugar commodity market price, and, in the case of palm oil, only around 15% of the total produced is used for biodiesel.[4]

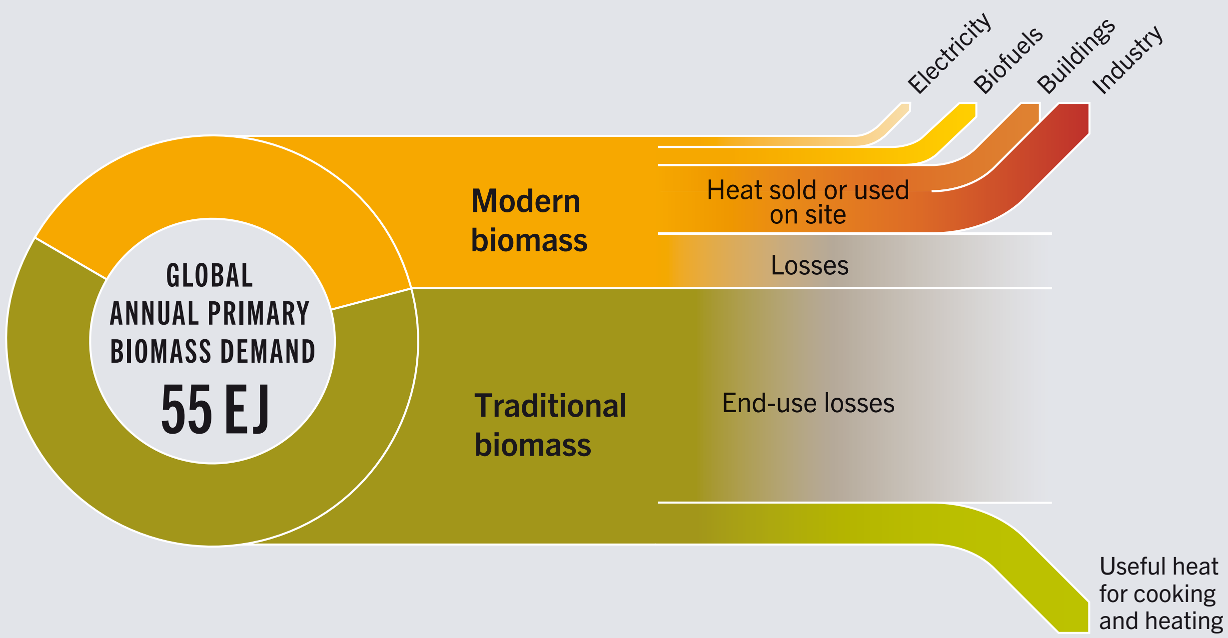
The production of biomass feedstock and its conversion to useful energy have varying environmental and socioeconomic impacts that depend on a number of factors , as with other renewables. The sustainability of biomass production, associated land use change, feedstock competition, trade restrictions, and impacts of biofuels produced from food crops such as corn remain under review and could affect future demand.[5] Ethanol production in the United States, for example, consumes about 10% of annual global corn production, raising concerns about its impact on food supply.[6]

The bioenergy sector is relatively complex because there are many forms of biomass resources; various solid, liquid, and gaseous bioenergy carriers; and numerous routes available for their conversion to useful energy services. Biomass markets often rely on informal structures, which makes it difficult to formally track data and trends. Furthermore, national data collection is often carried out by multiple institutions that are not always well-coordinated, or that report contradictory findings. Consequently, national and global data on biomass use and bioenergy demand are relatively difficult to measure and, as a result, relatively uncertain.

BIOENERGY MARKETS

Total primary energy supplied from biomass increased 2–3% in 2012 to reach approximately 55 EJ.[7] (See Figure 5.) Heating accounted for the vast majority of biomass use (46 EJ), including heat produced from modern biomass and the traditional, inefficient use of animal dung, fuelwood, charcoal, and crop

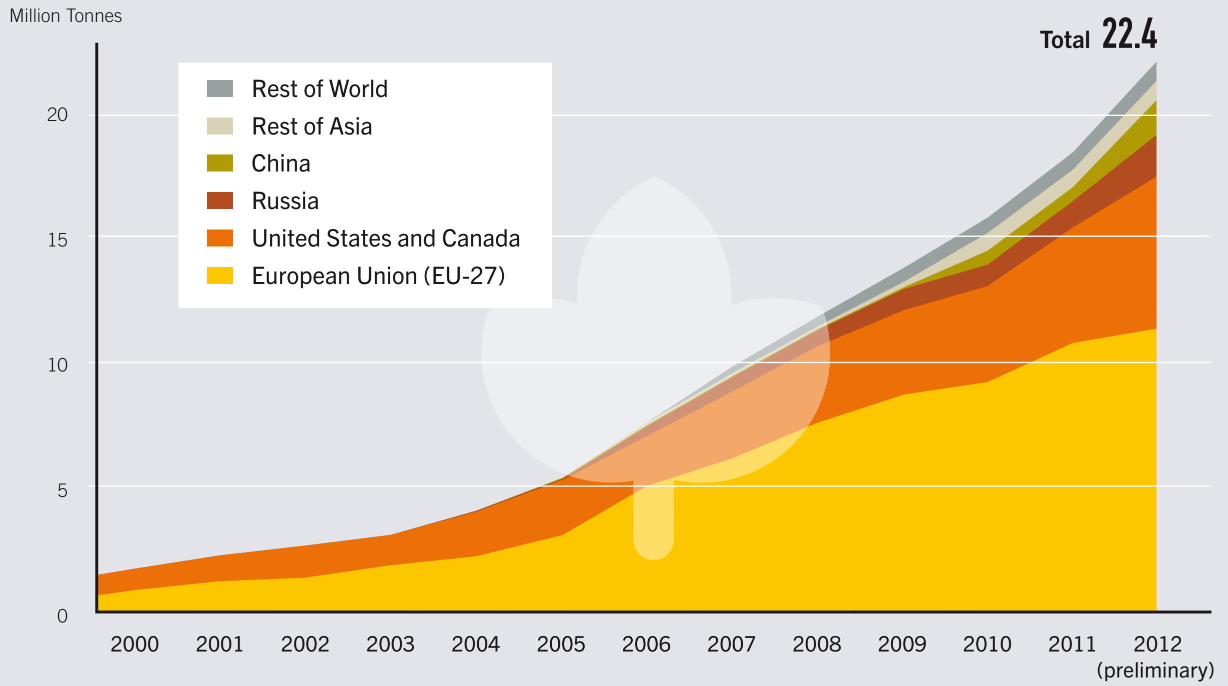
FIGURE 5. BIOMASS TO ENERGY PATHWAYS



Source: See Endnote 7 for this section.

02

FIGURE 6. WOOD PELLET GLOBAL PRODUCTION, BY COUNTRY OR REGION, 2000–2012



Source: See Endnote 16 for this section.

residues for domestic cooking and heating of dwellings and water in developing countries.[8] Biomass of around 4.5 EJ primary energy was consumed for electricity generation, and a similar amount for biofuels.[9]

Traditional biomass heating contributed an estimated 6–7% of total global primary energy demand in 2012.[10] (See Rural Renewable Energy section.) This section focuses on the use of biomass for modern applications, converted into a range of energy carriers (solid, liquid, and gaseous fuels) to efficiently provide useful energy services in the heating, electricity, and transport sectors. In 2012, the total volume of modern biomass consumption contributed an estimated 3–4% of global primary energy, with an energy content of around 18.5 EJ.

Compared with 2011, bio-heat production for the building and industry sectors increased by 1–2%; bio-power (electricity generation), including combined heat and power plant (CHP) production, increased by an estimated 4%; and biofuel production volumes declined by around 1%.[11]

In some regions of the world, available biomass feedstock supplies are insufficient to meet growing demand for bioenergy, whereas other regions can produce supplies in excess.[12] This situation drives international trade in solid and liquid biomass fuels, and has led to the establishment of several biomass exchanges to facilitate both domestic and international trade.[13] Bio-methane, fuelwood, charcoal, briquettes, and agricultural residues are mainly traded locally, whereas wood pellets, wood chips, biodiesel, and ethanol are traded both nationally and internationally.[14] The energy content of traded solid biomass fuels (excluding charcoal) is about twice that of net trade in biofuels.[15]

Smaller, more-compact wood pellets account for only 1–2% of total global solid biomass demand, but they have experienced more rapid growth and account for a large share of solid biomass trade; in 2012, global production and transport (by road, rail, and ship) of pellets exceeded 22 million tonnes.[16] (See Figure 6.) Demand continues to increase due to the pellets' higher energy density and lower moisture content relative to wood chips; ease of handling; convenience of use; suitability for co-firing in coal-fired power plants; and the option of automatic control options in small heat plants.[17] About two-thirds of pellet production is used in small heat plants and one-third in larger power plants.[18]

In 2012, around 8.2 million tonnes of pellets were traded internationally.[19] More than 3.2 million tonnes (40%) of pellets were shipped from North America to Europe, an increase of nearly 50% over 2011.[20] This increased demand was due greatly to rising consumption in the United Kingdom, where large volumes are required to supply the 750 MW Tilbury bio-power station and a 4 GW coal-fired power plant (half of which is being converted to combust 7.5 million tonnes of pellets annually).[21] In anticipation of further pellet demand, the U.K. Port of Tyne, already the largest pellet handler in Europe, is expanding its pellet handling and storage facilities and rail line at a cost of USD 300 million.[22]

Pellet consumption is rising in other regions as well. In South Korea, for example, eight new pellet plants were under construction as of early 2013. There are also plans to import an additional 5 million tonnes of pellets annually by 2020 to achieve the compulsory 2% renewables quota on power generators that was implemented in 2012.[23]

In addition to wood pellets, biodiesel and ethanol are the main fuels traded internationally. Biofuels are used for heating and electricity generation, but primarily as transportation fuels. Two developments in 2012 had a significant impact on liquid biofuels trade: the severe drought in the midwestern United States, which reduced corn yields; and a drop in the sugar commodity price, which resulted in increased ethanol production in Brazil.[24] Consequently, in August 2012, the United States became a net importer of ethanol (mainly from Brazil) for the first time since January 2010.[25]

The leading markets for bioenergy are diverse, and they vary depending on fuel type. Thus far, the pellet market has been limited primarily to Europe (the leading consumer) as well as to North America and Russia.[26] Europe also is the largest market for biogas and biodiesel.[27] The top ethanol-consuming region in 2012 was North America, followed by South America.[28] However, production and consumption of all forms of bio-energy are spreading to new countries, with particularly rapid increases in Asia.

BIO-HEAT (AND COOLING) MARKETS

Combustion of solid, liquid, and gaseous biomass fuels can provide heat over a range of temperatures and at different scales for use by industry, agricultural processes, drying, district heating schemes, water heating, and space heating in individual buildings. In 2012, approximately 3 GW of new modern biomass heating capacity was commissioned, bringing the global total to around 293 GW.[29] Sales of biomass appliances, including domestic wood burners and gasifier stoves (<100 kW), pellet burners (<500 kW), small boilers (<1 MW), and large-scale boilers for industrial and district heating (greater than 1 MW and typically 50 MW and above), continued to grow in 2012 to meet increasing heat demands, although accurate numbers are unavailable.

Europe is the leading consumer of heat generated from biomass, and Sweden, Finland, Austria, Denmark, and Germany are the top five European consumers. Following the mild winter in 2011, when solid biomass demand fell 8% to around 2.9 EJ, Europe's demand rose again in 2012.[30] Sweden's total bioenergy demand increased 10% to around 140 TWh (for heat, power, and CHP), and, by early 2013, biomass met over 70% of total fuel demand for Sweden's district heating plants and fuelled more than 100,000 domestic pellet burners.[31] Germany, using mostly forest residues as fuel, increased its heat plant capacity by 50 MW_{th} to 650 MW_{th}, to produce around 300 GJ of heat and 4.5 TWh of electricity in CHP plants.[32]

Bio-heat demand is increasing steadily elsewhere as well. In Bataan in the Philippines, a new 12 MW_{th} steam boiler was completed to supply local heat demand. Bataan also uses biodiesel, as do many countries in Europe and increasingly the United States, to displace heating oil for some space-heating applications.[33] In addition, some countries use ethanol as a cooking fuel to substitute for traditional solid biomass and charcoal.

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. In developing countries—led by China, India, and Nepal—biogas is combusted directly in small, domestic-scale digesters to provide bio-heat for cooking. (See Rural Renewable Energy section.) China has around 4.3 million domestic-scale biogas plants, and the number of medium- to large-scale (>50 m^3) biogas plants increased from some 10,000 in 2006 to some 80,000 by 2011.[34]

Other developing countries are starting to use biogas for heating purposes. In Rwanda, the 900,000 m^3 total volume of biogas digesters in operation includes units at six prisons (each with about 5,000 residents) that convert human and other wastes to biogas for cooking, displacing 10 tonnes of fuelwood per day.[35]

Cooling systems that use bio-heat to drive the refrigeration cycle (in a fashion similar to solar-assisted absorption chillers) remain in their infancy, and only a few demonstration plants exist.[36]

BIO-POWER MARKETS

By the end of 2012, global bio-power capacity was approaching 83 GW, up 12% over 2011, with notable increases in some of the BRICS countries.[37] Around 350 TWh of electricity was generated worldwide in 2012, a 5% increase over the previous year.[38] Averaging national bio-power generation outputs over the period 2010–12, the United States had a substantial lead, with Germany second, followed closely by Brazil and China, both of which are gaining ground rapidly.[39] (See Figure 7.)

The main types of commercial bio-power systems are medium- to large-scale direct-fired (similar to most coal- and gas-fired power plants), co-fired, gasifiers, and smaller-scale, modular systems. Together, they produce around 1.4% of the world's electricity generation (compared with coal at 41%).[40]

Almost 90% of biopower is generated with solid biomass fuels.[41] Landfill gas, biogas, synthesis gas (also known as syngas), and liquid biofuels are also commonly used for bio-power generation and make up the remaining 10%.

In the United States, 100 bio-power projects (543 MW) came on line in 2012, bringing total capacity to 15 GW—about 18% of the global total.[42] Net bio-power generation increased from 60.5 TWh in 2011 to 65.0 TWh in 2012.[43] To the south, Brazil saw its bio-power capacity increase 8% in 2012 to reach 9.6 GW, and generation rose to around 40 TWh.[44]

In Europe, bio-power capacity increased by almost 2% in 2012 to 31.4 GW, and generated around 136 TWh.[45] Of this total, 35.9 TWh was produced by biogas in CHP plants, and 18.2 TWh was generated with renewable municipal solid waste.[46]

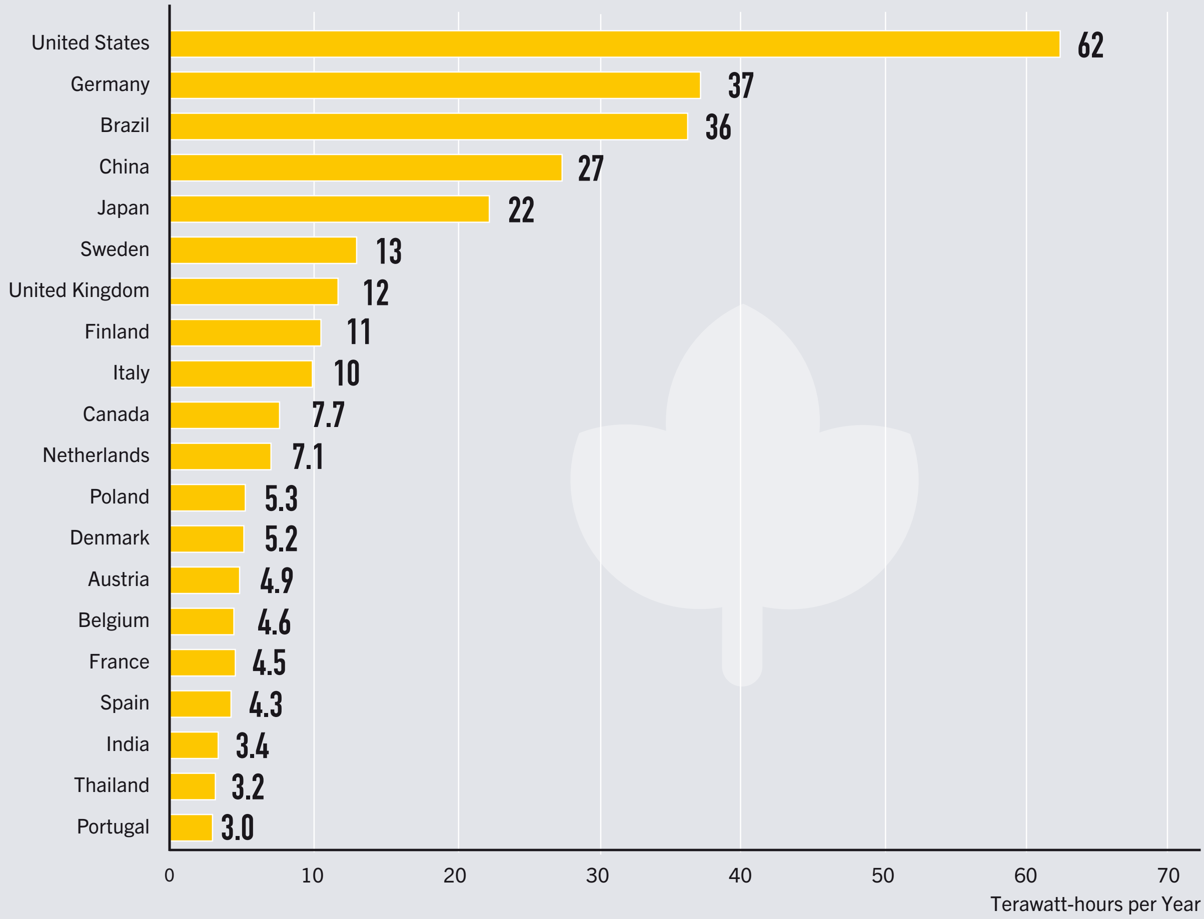
Germany, Europe's leading bio-power producer, increased its generation by 11% to 41 TWh, with half of this coming from biogas plants. Total bio-power capacity rose 0.3 GW (mostly biogas CHP plants) to more than 7.6 GW, although new construction slowed in 2012 relative to previous years.[47] Germany's CHP plants generated 31–36 PJ of heat and 20.5 TWh of electricity in 2012 (up from 17.5 TWh in 2011), amounting to around half of Europe's electricity generated with biogas.[48]

In Asia, China increased its capacity by around 14% to 8 GW by the end of 2012 and saw generation increase 21% to 36 TWh.[49] Japan's capacity remained at 3.3 GW but generation declined 8% to 17.2 TWh.[50] India leads the world in total capacity of small gasifiers for electricity generation, with a capacity exceeding 155 MW. At the end of 2012, India had approximately 1.3 GW of solid biomass and MSW-fired power capacity, as well as more than 2.7 GW of CHP capacity. [51]

Conversion of existing commercial coal- and natural gas-fired power plants continued in order to enable co-firing with solid biomass fuels or biogas/landfill gas. Quantities of biomass used can vary daily in any given plant, making it difficult to obtain

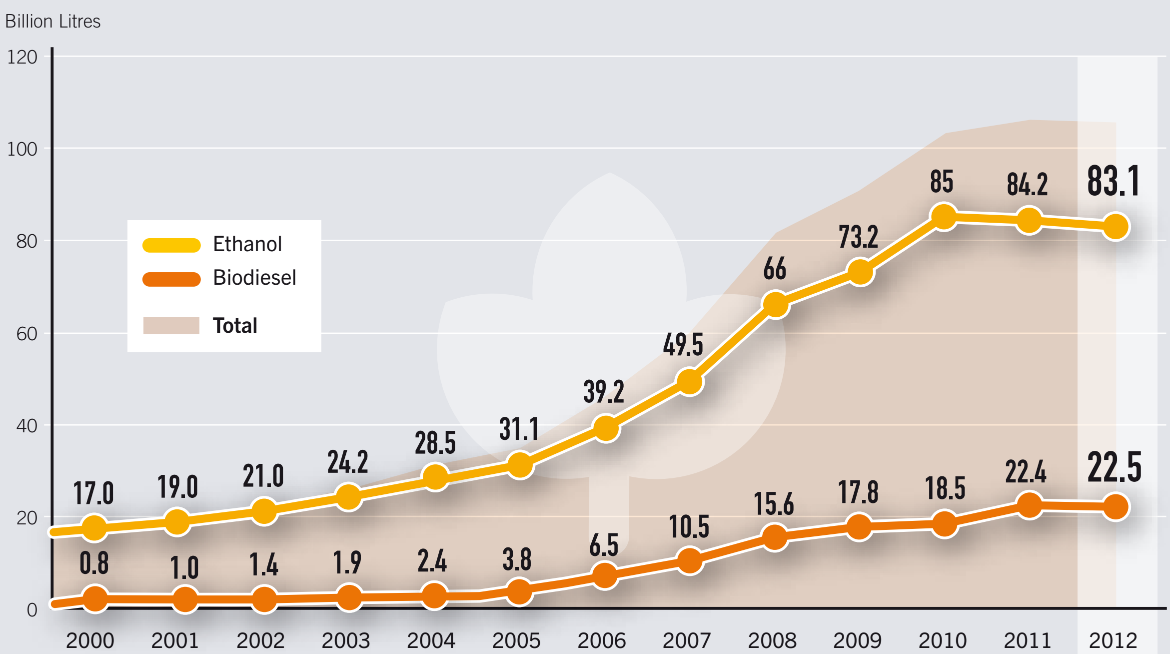
BIOENERGY

FIGURE 7. BIO-POWER GENERATION OF TOP 20 COUNTRIES, ANNUAL AVERAGE 2010–2012



Source: See Endnote 39 for this section.

FIGURE 8. ETHANOL AND BIODIESEL GLOBAL PRODUCTION, 2000–2012



Source: See Endnote 58 for this section.

data. About 230 co-firing plants were operational or planned by year's end, located mainly in northern Europe, the United States, Asia, and Australia.[52]

Most sugarcane-producing countries such as Brazil, generate combined heat and power using bagasse.[53] Grid-connected bagasse CHP plants also exist in Mauritius, Tanzania, Uganda, and Zimbabwe, where a community-scale biogas plant is also being constructed in Harare to convert organic waste to heat and electricity.[54] Several other African countries, including Kenya, plan similar installations.[55]

TRANSPORT BIOFUEL MARKETS

Liquid biofuels continue to make a small but growing contribution to transport fuel demand worldwide, currently providing about 3% of global road transport fuels. They also are seeing small but increasing use in the aviation and marine sectors.[56] Growth in biofuels markets, investment, and new plant construction has slowed in several countries in response to a number of factors: lower margins, spiking of commodity prices, policy uncertainty, increased competition for feedstock, impacts of drought conditions on crop productivity, concerns about competition with food production for land and water resources, and concerns about the sustainability of production more broadly.[57] Even so, biofuel blend mandates continue to drive demand. (See Policy Landscape section).

Global production of fuel ethanol in 2012 was an estimated 83.1 billion litres, down about 1.3% by volume from 2011. This was offset partly by by a small increase in biodiesel production.[58] (See Figure 8.) Outside of the United States, global ethanol production was up by more than 4%, but U.S. ethanol production dropped more than 4% to 50.4 billion litres, due partly to high corn prices resulting from the mid-year drought. By contrast, Brazil's production increased 3% to 21.6 billion litres, although investment in new sugarcane ethanol plants was very low compared with recent years.[59] Overall, the United States accounted for 61% (63% in 2011) of global ethanol production and Brazil for 26% (24% in 2011).[60]

The other leading producers included China, Canada, and France, as in 2011, although at much lower production volumes than the two leaders. Demand continued to rise in Sweden, where around 200,000 flex-fuel vehicles are using high blends (up to E85) of locally produced and imported ethanol.[61]

The average world ethanol price in 2012 was approximately USD 0.85/litre (USD 1.20/litre gasoline equivalent), having increased steadily from around USD 0. 41/litre in 2006; the U.S. domestic price fell from about USD 0.60/litre in 2011 to USD 0.55/litre in 2012, until the mid-year drought pushed it back to 2011 levels.[62] The average world price for biodiesel was around USD 1.55/litre of gasoline equivalent, higher than in the previous five years, when prices ranged between USD 0.90 and USD 1.50 per litre.[63]

Global biodiesel production continued to increase, but at a much slower rate relative to the previous several years, reaching 22.5 billion litres in 2012, compared with 22.4 billion litres in 2011.[64] The United States was again the world's leading producer, followed by Argentina, Germany, Brazil, and France—with German and Brazilian production being approximately equal.[65]

U.S. biodiesel plants produced 3.6 billion litres in 2012, up only slightly over 2011 levels, but approaching the target set by the Environmental Protection Agency (EPA) under the federal Renewable Fuels Standard, or RFS. This standard requires 4.8 billion litres (1.28 billion gallons) of biodiesel to be included in diesel fuel markets in 2013.[66]

Europe accounted for 41% of total global biodiesel production, led by Germany, which produced an estimated 2.7 billion litres in 2012 (down 14% relative to 2011).[67] Production declined 7% across the region and in most European countries—including Spain (-32%), Portugal (-14%), and Italy (-44%)—but it was up in France (18%), Poland (63%), and the United Kingdom (53%).[68]

Brazil's total annual biodiesel production from soybean oil (77–82%), beef tallow (13–17%), and cottonseed oil (2%) remained steady at 2.7 billion litres.[69] Argentina maintained fourth position after the United States, Germany, and Brazil.[70] Elsewhere in Latin America, three jatropha plantations were certified in Mexico by the Roundtable on Sustainable Biofuels, and a small biodiesel plant using jatropha oil was established in Cuba.[71]

China's biofuel production remained unchanged at around 2.1 billion litres of ethanol and 0.2 billion litres of biodiesel.[72] Thailand increased both its ethanol and biodiesel production to a total of 1.6 billion litres, 40% higher than in 2011.[73] India overtook Italy in total biofuel production in 2012, increasing its ethanol production by 25% to 0.5 billion litres.[74]

On a regional basis, North America continued to lead in ethanol production, and Europe in the production of biodiesel. However, production of both ethanol and biodiesel is increasing rapidly in Asia.[75] Biofuels production in Africa is still very limited, but markets are slowly expanding, and ethanol production rose from 270 million litres in 2011 to an estimated 300 million litres in 2012.[76] In Zambia, for example, the 200,000 litres of jatropha biodiesel produced in 2011 was expected to triple in 2012 as more feedstock became available.[77]

In 2012, U.S. production of advanced biofuels from lignocellulosic feedstocks reached 2 million litres; it was anticipated that 36 million litres would be produced in 2013, driven partly by demand from the military.[78] These volumes, however, remain only a small proportion of the original U.S. mandate under the RFS that was subsequently waived.[79] China also made progress on advanced biofuels in 2012, with around 3 million litres of ethanol produced from corn cobs and used in blends with gasoline.[80] Europe has several demonstration plants in operation but each has produced only small volumes to date.[81]

Biomethane (biogas after removal of carbon dioxide and hydrogen sulphide) is now used widely as a vehicle fuel in Europe. During 2012 in Germany, for example, the share of biomethane in natural gas increased from 6% to more than 15%, and the number of fueling stations selling 100% biomethane more than tripled, from 35 to 119.[82] Further, 10% of the natural gas vehicles in Germany used compressed biomethane fuel rather than compressed natural gas methane.[83] In Sweden, 50% of Stockholm city council's car fleet of 800 vehicles ran on biomethane as of October 2012.[84]

BIOENERGY INDUSTRY

The broader bioenergy industry includes: biomass suppliers, processors, and firms that deliver biomass to end-users; manufacturers and distributors of specialist biomass harvesting, handling, and storage equipment; and manufacturers of appliances and hardware components for plants that convert biomass fuels into usable forms and/or energy services. Some parts of the supply chain use technologies that are not exclusive to biomass (such as forage crop and tree harvesters, trucks, and steam boilers).

The bio-refinery industry continues to grow because co-producing a number of products from biomass feedstocks can maximise value and enhance profitability while reducing greenhouse gas emissions. In the United States, there were some 210 ethanol biorefineries operating in 2012 (down four from 2011) that produced co-products including distillers grains for livestock feed, high fructose syrup, citric acid, lactic acid, and lysine.[85]

SOLID BIOMASS INDUSTRY

A large number of companies were actively engaged during 2012 in supplying bioenergy plants that convert biomass to heat and electricity. In Europe, for example, the Finnish company Metso installed several 8 MW_{th} bio-heat plants to replace oil in district heating schemes, and developed a 13.4 MW_{th} heat plant in Värnamo, Sweden.[86] In the United Kingdom, as of early 2013, Etsover Energy was developing three biomass CHP plants totalling 52 MW.[87] And Sweden completed its Pyrogrot demonstration project, which will use 270,000 tonnes of dry forest residues to produce around 160,000 tonnes/year of pyrolysis oil with a total energy content estimated at about 2.59 PJ.[88]

In Japan, JFE Engineering Corporation doubled its orders in 2012 for designing, constructing, and operating bio-power plants using wood, dried sewage sludge, and MSW feedstocks, partly as a result of the new feed-in tariff (FIT) introduced in 2011.[89]

In the United States, Amite BioEnergy (Mississippi) and Morehouse BioEnergy (Louisiana) produced a combined total of 900,000 tonnes/year of pellets using biomass from sustainably managed forests.[90] Southern Company of Texas began commercial operation of its 100 MW Nacogdoches plant, becoming the largest dedicated biomass facility in the United States. Despite having a 20-year contract with Austin Energy, the plant is currently unable to compete with cheaper natural gas-fired power plants, so it is not always operating.[91]

Torrefaction technology is moving from the demonstration phase to commercial scale. In addition to many small batch-scale developers, several large companies—including Andritz (Austria), Thermya/Areva (France), Rotawave (U.K.), SunCoal (Germany), AVA-CO_2 (Switzerland), and New Biomass Energy (USA)—aim to use efficient continuous manufacturing processes. Currently, the industry remains in its infancy and total global production capacity for torrefied biomass is well below 200,000 tonnes/year. This material offers advantages over conventional wood pellets; to advance significantly, however, the poor performance observed in some European power plants will need to be overcome.[92] The International Biomass Torrefaction Council was created in December 2012 to promote the technology.[93]

GASEOUS BIOMASS INDUSTRY

Farm and community-scale biogas plants continue to be manufactured and installed for treating wet waste biomass products, especially in Europe where almost 12,000 plants (mostly CHP) operated in 12 countries in 2011.[94] In addition, 2,250 sewage sludge facilities are operating in Europe; approximately 2% of these plants upgrade the biogas to higher quality biomethane for use as vehicle fuel or for injection into the gas grid.[95] In December 2012, the Port of Amsterdam opened a new vehicle refilling facility where biogas from sewage sludge is upgraded using technology manufactured by BioGast.[96]

Companies in Europe and elsewhere are finding innovative ways to produce energy from their own waste. For example, in 2012 a French multinational retailer announced plans to fuel its trucks with biomethane produced from organic wastes arising from its stores, and a plant in Sweden became one of the world's first to produce liquefied biogas (from local food waste) as an alternative for heavy duty vehicles.[97]

LIQUID BIOFUELS INDUSTRY

The total annual capacity of the approximately 650 ethanol plants operating globally is around 100 billion litres, but many facilities are operating below nameplate capacity and others have closed due to fluctuating demand and concerns about the environmental sustainability of the product. Total U.S. plant capacity remained at around 52 billion litres/year in 2012, despite some temporary closures.[98] Globally, new ethanol plants continued to open, such as the 54 million litre/year Green Future Innovation Inc. plant that began production in the Philippines in January 2013.[99]

The number of operating biodiesel facilities is more difficult to assess as there are many small plants, often using waste cooking oils to produce biodiesel for local or personal vehicle use. As demand for biodiesel continues to increase, new plants are opening around the world. For example, Cargill (USA) commissioned its first biodiesel plant using soybean oil in Brazil, and Lignol Energy (Canada) invested USD 1.2 million to restart a 150 million litre/year biodiesel plant in Darwin, Australia.[100]

In the United States, 80 advanced biofuels companies (30 of which were in California) were producing small volumes in 2012.[101] Several companies claim to be close to commercial production.[102] In December 2012, KiOR (USA) sold about 3,800 litres of bio-oil produced from the pyrolysis of cellulosic feedstocks in its new 500 tonne/day plant in Mississippi.[103]

In Europe, a "Leaders of Sustainable Biofuels" initiative was created to support the commercial development of advanced biofuels.[104] In Australia, two advanced biofuels demonstration plants using ligno-cellulosics and algae were being expanded to near-commercial scale as of early 2013.[105]

On the down side, IOGEN Energy Corporation (Canada), one of the early advanced biofuel companies to use the enzymatic hydrolysis process, and its recent owner Shell Oil, cancelled plans to develop a commercial-scale cellulosic ethanol plant in Manitoba.[106] Advanced biofuel producers in the United States also received a setback in early 2013, when the U.S. Court of Appeals ruled that the EPA must revise its cellulosic ethanol volume projections for 2012; leaving the 2013 standard in doubt. However, the larger category of advanced biofuels was left intact.[107]

The aviation industry has continued to evaluate closely the increasing uptake of advanced biofuels, including those produced from algae. Their interest stems from the current high dependence on petroleum fuels; uncertain long-term supplies; and the lack of other suitable fuel alternatives. Boeing, Airbus, and Embraer were collaborating on biofuel initiatives in 2012, and SkyNRG began buying pre-treated biofuels derived from used cooking oils and further refining them into aviation-grade fuel.[108]

GEOTHERMAL HEAT AND POWER

GEOTHERMAL MARKETS

Geothermal resources provide energy in the form of direct heat and electricity, totalling an estimated 805 PJ (223 TWh) in 2012. Two-thirds of this output was delivered as direct heat, and the remaining one-third was delivered as electricity.

Geothermal direct use continued to increase globally during 2012. Direct use refers to direct thermal extraction for heating and cooling. A sub-category of direct use is the application of ground-source heat pumps (GHP), which use electricity to extract several units of thermal energy from the ground for every unit of electrical energy spent.

Although there are limited data available on recent growth in direct use of geothermal energy, output is known to have grown by an average of 10% annually from 2005 through 2010; much of that growth was attributed to ground-source heat pumps, which experienced an average annual growth of 20%. Assuming that these growth rates have persisted in the last two years, global geothermal heat capacity reached an estimated 66 GW_{th} in 2012, delivering as much as 548 PJ of heat.[1]

GHP represents the largest and historically fastest-growing segment of geothermal direct use. In 2012, it reached an estimated 50 GW_{th} of capacity; this amounts to about three-quarters of estimated total geothermal heat capacity, and more than half of heat output (>300 PJ).[i] Of the remaining direct heat use (nearly half), the largest share goes to bathing and swimming applications, with smaller amounts for heating (primarily district heating), industrial purposes, aquaculture pond heating, agricultural drying, snow melting, and other uses.[2]

At least 78 countries used direct geothermal heating in 2012.[3] The United States, China, Sweden, Germany, and Japan have the largest amounts of geothermal heating capacity, together accounting for about two-thirds of total global capacity.[4] China remains the presumptive leader in direct geothermal energy use (21 TWh in 2010), followed by the United States (18.8 TWh in 2012), Sweden (13.8 TWh in 2010), Turkey (10.2 TWh in 2010), Iceland (7.2 TWh in 2012), and Japan (7.1 TWh in 2010).[5] Iceland, Sweden, Norway, New Zealand, and Denmark lead for average annual geothermal energy use per person.[6] About 90% of Iceland's total heating demand is derived from geothermal resources.[7]

Heat pumps can generate heating or cooling and can be used in conjunction with combined heat and power (CHP) plants.[8] Global installed heat pump capacity doubled between 2005 and 2010, and it appears that this growth has continued in subsequent years.[9] In the EU, GHP capacity rose about 10% between 2010 and 2011, to a total of 14 GW_{th}, led by Sweden (4.3 GW_{th}), Germany (3 GW_{th}), France (1.8 GW_{th}), and Finland (1.4 GW_{th}).[10] Canada had more than 100,000 systems in operation by early 2013, and the United States is adding about 50,000 heat pumps per year.[11] In 2012, Ball State University in Indiana installed the largest U.S. ground-source closed-loop district geothermal system to heat and cool 47 buildings.[12]

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.

Geothermal electricity generation, which occurs through kinetic conversion of high- or medium-temperature steam, is estimated to have reached at least 72 TWh in 2012.[13] Global geothermal electric generating capacity grew by an estimated 300 MW during 2012—with new capacity coming on line in the United States (147 MW), Indonesia (110 MW), Nicaragua (36 MW), and Kenya (7.5 MW)—bringing total global capacity to an estimated 11.7 GW.[14]

The countries with the largest amounts of geothermal electric generating capacity are as follows: the United States (3.4 GW), the Philippines (1.9 GW), Indonesia (1.3 GW), Mexico (1.0 GW), Italy (0.9 GW), New Zealand (0.8 GW), Iceland (0.7 GW), and Japan (0.5 GW).[15]

The United States added 147 MW of geothermal generating capacity in 2012, increasing total capacity by 5% to 3.4 GW. This represents the second highest increase in geothermal power capacity over a calendar year since the 2005 decision to extend the production tax credit (PTC) to cover geothermal projects.[16] Of particular note was the first facility to combine solar PV and geothermal generation at the Stillwater Geothermal Power Plant in Nevada.[17] This hybrid plant was recognised for enhancing thermal efficiency, improving production stability, and reducing investment risk.[18] By early 2013, the United States had 175 geothermal projects in development, representing more than 5.5 GW of potential, of which one-half might come to fruition in the coming decade.[19]

Indonesia has not added much capacity in recent years, but added two 55 MW units at the Ulubelu station in 2012.[20] The country also announced a huge push for a 1,000 MW geothermal energy investment programme with significant international backing.[21] Indonesia initiated plans for a geothermal risk mitigation fund in 2011, which will provide loans to developers in an effort to jumpstart the industry.[22] The country targets 12.6 GW of geothermal capacity by 2025, a significant step up from the current 1.3 GW.[23] Meanwhile, a 165 MW project on Bali was cancelled in the face of sustained local opposition that was based on both environmental and religious concerns.[24]

In late 2012, Nicaragua saw the completion of the second 36 MW phase of the San Jacinto-Tizate project, having completed phase one a year earlier. The 72 MW project is large enough to supply the equivalent of 17% of Nicaragua's electricity needs.[25]

In Kenya, the 2.5 MW Eburru wellhead plant was commissioned in early 2012, and a 5 MW modular wellhead unit came on line at a KenGen facility.[26] Kenya is Africa's largest producer of geothermal power, with total installed capacity of more than 200 MW by year's end.[27] By May 2013, Ormat Technologies announced commercial operation of a new 36 MW unit at the Olkaria III complex.[28] The country is eyeing public-private partnerships to take on the development of an additional 560 MW at Olkaria in 140 MW increments.[29]

Italy's Enel Green Energy started operations in mid-2012 at its refurbished 17 MW Rancia 2 power plant in Tuscany.[30] In addition, construction has commenced on the 40 MW Bagnore 4 power plant, also in Tuscany, at the projected cost of about USD 160 million (EUR 120 million), suggesting almost USD 4 million (EUR 3 million) per MW of capacity.[31]

There is growing interest in Africa beyond Kenya to explore geothermal potential. For example, Rwanda has recently committed funds to commence drilling, starting on a path

to harness some of its estimated 700 MW of geothermal potential.[32] However, the high exploratory costs associated with geothermal power present a significant hurdle for African countries. To address this problem, the World Bank established the Global Geothermal Development Plan to manage the risk of exploratory drilling for developing countries. In collaboration with Iceland, the World Bank also formed a "Geothermal Compact" to support surface-exploration studies and technical assistance for countries in Africa's Rift Valley.[33]

The African Union Commission, the German Ministry for Economic Cooperation and Development (BMZ), and the EU-Africa Infrastructure Trust Fund have established a USD 66 million (EUR 50 million) Geothermal Risk Mitigation Facility for Eastern Africa (Ethiopia, Kenya, Rwanda, Tanzania, and Uganda) to support surface studies and exploration drilling. Eight projects have been short-listed following the first application round in late 2012.[34]

Japan now has over 30 geothermal power projects under development.[35] However, the country has recently seen local opposition to geothermal projects in national parks in Fukushima and Hokkaido, due in part to commercial concerns about impacts on local hot springs.[36] Japan's adoption of feed-in tariffs is expected to provide needed support for geothermal generation.[37]

Aside from the capacity addition in Nicaragua, other news from Latin America includes El Salvador's long-term plans for additional 90 MW of geothermal capacity and Chile's completion of bids for exploration in various areas, with bidding companies committing USD 250 million.[38] Several islands in the Caribbean have plans to begin or increase their use of geothermal power (including Nevis, Dominica, and the U.K. territory of Montserrat), and drilling was set to start in 2013 in Montserrat.[39] Dominica signed a contract in 2012 for expanded drilling in hopes of completing a 10–15 MW plant by 2014.[40]

GEOTHERMAL INDUSTRY

A large number of GHP manufacturers operate in the United States and Europe, with most European companies based in the main markets.[41] In Europe and the United States, there are two distinct classes of companies: general heating companies and electric heating specialists; and manufacturers of heat pump systems.[42]

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 together account for well over 80% of capacity currently in operation around the world.[43] In addition, several companies now manufacture small-scale geothermal power units that can be built offsite and then integrated into a plant's design for production.[44]

Technology continued to advance in the power sector during 2012. In the United States, a government-supported research project made progress on enhanced geothermal systems (EGS) technology, which extracts heat from engineered reservoirs through fluid injection and rock stimulation. The project demonstrated the equivalent of 5 MW of steam at The Geysers in California.[45] In early 2013, AltaRock Energy announced that it had created multiple stimulation zones for a single wellbore at the Newberry EGS demonstration site. The potential benefit is a significant reduction in the cost of production from an EGS field.[46] Finally, in April 2013, Ormat Technologies, the U.S. Department of Energy, and GeothermEx successfully produced an additional 1.7 MW from an existing field in Nevada using EGS technology. This is the first EGS system to be grid connected.[47]

The year 2012 saw another first, with co-production of geothermal power at Nevada's Florida Canyon gold mine.[48] Another U.S. research project showed promise for extracting significant quantities of lithium from geothermal brine; the metal is a critical component in the lithium battery technology that is used extensively in electric vehicles.[49]

In Iceland, Carbon Recycling International started operations at a groundbreaking plant that produces methanol by combining electrolytic hydrogen and carbon dioxide from a geothermal power plant. The product is a fully renewable fuel suitable for blending with gasoline.[50]

Geothermal power projects take 5–7 years to develop from resource discovery to commercial development, and, as with oil and 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.[51] Moreover, no two project sites are the same, and each plant must be designed to project-specific conditions.[52] Nonetheless, once the feasibility of a resource has been established, the probability of project success is better than 80%.[53]

HYDROPOWER

HYDROPOWER MARKETS

An estimated 30 GW of new hydropower capacity came on line in 2012, increasing global installed capacity by about 3% to an estimated 990 GW.[1] [i] The top countries for hydro capacity are China, Brazil, the United States, Canada, and Russia, which together account for 52% of total installed capacity.[2] (See Figure 9.) Ranked by generation, the order is the same except that Canada's generation exceeds that of the United States, where hydropower is more load-following.[3] Globally, hydropower generated an estimated 3,700 TWh of electricity during 2012, including approximately 864 TWh in China, followed by Brazil (441 TWh), Canada (376 TWh), the United States (277 TWh), Russia (155 TWh), Norway (143 TWh), and India (>116 TWh).[4]

China again led the world for new capacity additions, followed by Turkey, Brazil, Vietnam, and Russia.[5] (See Figure 10.) China installed 15.5 GW of new capacity to end the year with almost 229 GW of total installed hydropower capacity, and 20.3 GW of pumped storage capacity.[6] The country's hydropower output was 864 TWh during the year, almost a third more than the 2011 total, due to increased capacity and improved hydrological conditions.[7]

In China, a 812 MW Francis turbine generator, the world's largest unit, was added to the Xianjiaba plant, which will total 6.4 GW when completed.[8] It will be the country's third largest hydropower facility, after the Three Gorges plant (22.5 GW) and the Xiluodu plant (13.9 GW when completed).[9] The Three Gorges achieved full capacity after the last of 32 generators began operation in July, and reached a record output of 98.1 TWh in 2012.[10] In its current five-year plan, China targets 290 GW of installed capacity by 2015, while striving to improve resettlement policies for affected local populations and to strengthen ecological protection.[11] (See Sidebar 3.)

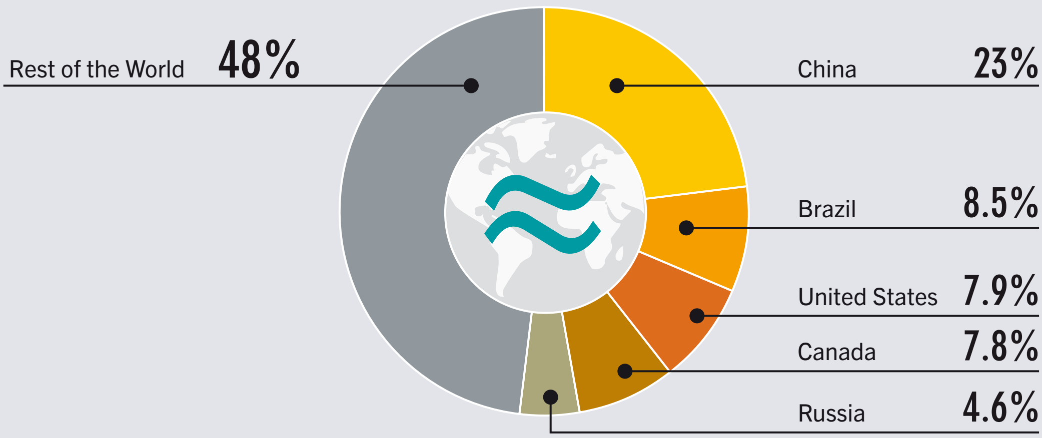
Turkey is increasing its hydropower capacity at a rapid rate to address chronic shortages of electricity and frequent power outages.[12] Approximately 2 GW was added in 2012, to end the year with about 21 GW installed.[13] Construction continued on the 1.2 MW Ilisu Dam on the Tigris River, while scientists prepared for the removal of cultural monuments in areas that will be submerged.[14]

Brazil placed 1.86 GW of hydropower into operation in 2012, including 394 MW of reported small-scale (<30 MW) capacity, for a total of 84 GW by year's end.[15] About 400 MW was added at the Estraito plant and 350 MW at the Maua plant.[16] In addition, nine (of a total 44) 70 MW bulb-type in-stream turbines came on line at the Santo Antonio run-of-river project on the Madeira River in 2012, with two more installed in early 2013. Also well under way on the Madeira River is the 3.75 GW Jirau plant, applying fifty 75 MW bulb turbines.[17] Construction continued on the 11.2 GW Belo Monte project, which is expected to be Brazil's second largest after the 14 GW Itaipu plant.[18] The Itaipu plant set another output record in 2012, matching Three Gorges at more than 98 TWh.[19]

i Hydropower data do not include pure pumped storage capacity except where specifically noted. For more information on data impacts, see Methodological Notes, page 130.

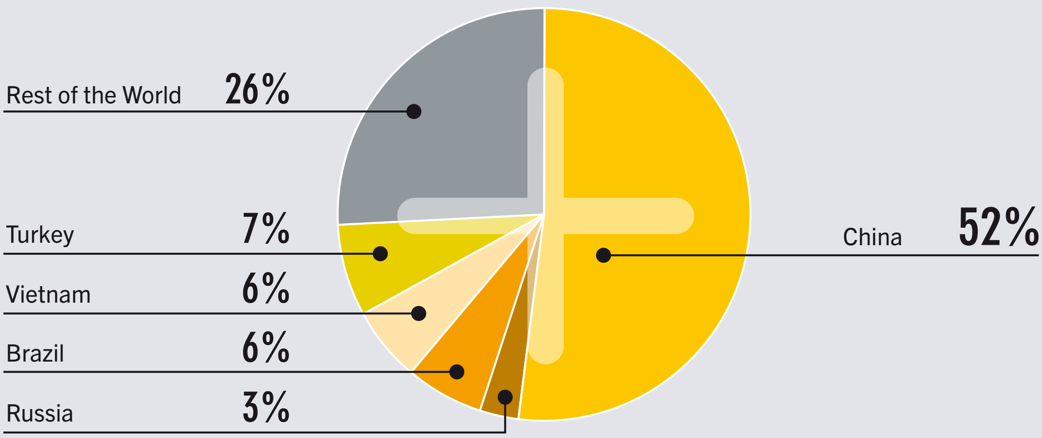
HYDROPOWER

FIGURE 9. HYDROPOWER GLOBAL CAPACITY, SHARES OF TOP FIVE COUNTRIES, 2012



Source: See Endnote 2 for this section.

FIGURE 10. HYDROPOWER GLOBAL NET CAPACITY ADDITIONS, SHARES OF TOP FIVE COUNTRIES, 2012



Source: See Endnote 5 for this section.

Vietnam added at least 1.8 GW of new capacity in 2012 to raise its total capacity to 12.9 GW. A significant portion of this increase was attributable to Vietnam's Son La plant. The final two 400 MW turbines were installed to complete the 2.4 GW project, reportedly the largest hydropower project in Southeast Asia.[20]

In Russia, three 333 MW units at its Boguchanskaya hydropower plant were commissioned in late 2012 and one in early 2013, maintaining the country's total operating capacity at 46 GW.[21] Following a catastrophic accident in 2009, the 6.4 GW Sayano-Shushenskaya plant, the country's largest hydropower facility, is under continuing repairs that will see 10 new turbines installed by 2014.[22] In all, at least 3.4 GW of capacity was installed during 2012, although net capacity additions were lower.[23]

Elsewhere, Mexico brought its 750 MW La Yesca hydropower plant into full operation in late 2012 for a country total of 11.5 GW.[24] The plant is said to have the world's tallest concrete-faced earthfill dam of 220 metres.[25] To the north, Canada commissioned the 200 MW Wuskwatim plant in Manitoba, and Hydro-Québec completed the 768 MW Eastmain 1-A powerhouse, to be followed by the neighbouring 150 MW Sarcelle powerhouse in 2013.[26] India added about 750 MW of hydropower capacity, of which 157 MW was categorised as small-scale (<25 MW), to end the year at about 43 GW.[27]

In Africa, the Grand Renaissance Dam is well under way in Ethiopia, with commissioning of the first phase to start in late 2013. When completed, it is expected to deliver 6,000 MW and to be the largest hydropower facility on the continent.[28] To ensure that Ethiopia's growing hydropower output can be exported to neighbours in the Horn of Africa, several transmission projects have been under way. In 2012, a transmission link was completed between Ethiopia and Sudan, allowing an

SIDEBAR 3. SUSTAINABILITY SPOTLIGHT: HYDROPOWER

Hydropower dates back more than 2,000 years to when the Greeks used water wheels to grind grain. Over the centuries, it has played an important role in providing mechanical energy and, more recently electricity, supporting human and economic development.

Hydropower dams, which provide large-scale water storage, can provide protection from hydrological variability (including floods and droughts) and increase irrigation of agricultural lands, while potentially providing a means of transportation and recreation. Specific applications of hydropower offer significant potential for reducing carbon emissions in the near- and long term. Hydropower is used by electric grid operators to provide baseload power and to balance electricity supply and demand, and it plays an increasingly important role in supporting growing shares of variable renewable resources in power systems. (See Sidebar 3, GSR 2012.)

Notwithstanding these benefits, there is ongoing debate about hydropower's sustainability. The environmental and social impacts of hydro projects include: potential impacts on hydrological regimes, sediment transport, water quality, biological diversity, and land-use change, as well as the resettlement of people and effects on downstream water users, public health, and cultural heritage. The gravity of the particular impacts varies from project to project, as does the scope for their avoidance or mitigation. Also, the opportunity to maximise positive impacts (beyond the renewable electricity generated) varies from site to site.

A number of technological developments offer the potential to improve hydropower's environmental sustainability. These include certain locally effective fish passages; both large and small "fish-friendly" turbine technologies that reduce downstream passage mortality; models for optimising environmental flows; and design changes to minimise or avoid discharges of lubricating oil from turbine equipment (or the use of biodegradable oils). Project planning is beginning to incorporate greater understanding of dynamic climate and environmental impacts, in addition to traditional concerns such as revenue generation and flood control.

Some reservoir management plans incorporate upstream land-use management practices in recognition of associated sedimentation. Other practices include the identification of "no-go" project areas, and the protection of other areas (e.g., through "river offsets") to compensate for project impacts such as biodiversity loss. In Norway, for example, the National Master Plan for hydropower sorts projects into acceptable/not acceptable categories and protects a large number of the nation's rivers. Prioritising existing water storage facilities, or new multipurpose facilities (driven by development, climate change mitigation, and water supply and irrigation concerns) for hydropower capacity expansion can offer a means of reducing associated impacts while broadening related benefits.

With regard to social impacts, model projects have shown increased recognition of the potential risks associated with hydropower and identification of opportunities to avoid them. Although interactions with project-affected communities typically focus on mitigation and compensation, some examples have shown a shift to benefit sharing, with efforts to optimise potential positive impacts through engagement with affected communities and collaborative initiatives to improve local living standards. In instances when a decision is made to move populations, some developers have begun to engage communities in planning for their resettlement. Approximately 10% of the USD 500 million Theun Hinboun Expansion Project in Laos was allocated to address resettlement and social issues after a long participatory process involving a variety of stakeholders, although the overall resulting impact on resettled communities remains a controversial subject.

Since the World Commission on Dams report was released in 2000, both the industry and international agencies have developed a number of standards, principles, and guidelines to optimise sustainability. These include the World Bank Safeguards, Equator Principles, and Hydropower Sustainability Assessment Protocol. The International Finance Corporation (IFC) Performance Standards and Equator Principles require developers to obtain Free, Prior, and Informed Consent (FPIC) for projects that affect indigenous peoples who are closely tied to their lands and natural resources through traditional ownership or customary use. The voluntary Hydropower Sustainability Assessment Protocol aims to guide sustainability in the hydropower sector by measuring a project's performance throughout its life cycle, treating environmental and social issues at parity with other considerations.

Better compliance, further development, and wider adoption of these tools offer the potential to ensure that international practices are applied locally, irrespective of variations in national regulations, while providing common frameworks around which project stakeholders can engage in dialogue about specific projects and their impacts.

The "Sustainability Spotlight" sidebar is a regular feature of the Global Status Report, focusing on sustainability issues regarding a specific renewable energy technology or related issue.

Source: See Endnote 11 for this section.

initial export of 100 MW of hydropower to displace Sudanese thermal generation.[29] In addition, the Ethiopia-Kenya Electricity Highway was approved for construction. The 2,000 MW link is expected to allow Ethiopia to export a portion of its large hydropower resources to the larger supply-constrained East Africa region.[30]

Another region pursuing improved interconnection is Central America. The Central American Electrical Interconnection System, which was nearing completion in early 2013, stretches nearly 1,800 kilometres from Guatemala to Panama. This interconnection is expected to enable the region to harness more of its hydroelectric resources.[31]

Hydropower projects in developing countries have historically benefitted from the Clean Development Mechanism (CDM) but may face challenges due to a significant decline in prices of carbon credits in 2012 and early 2013.[32] Meanwhile, the United Nations moved to set up two regional centres in Africa, one in Togo and another in Uganda, to provide assistance in development of CDM projects.[33] Currently, less than 1% of CDM pipeline projects in the hydropower sector are located in Africa, while the majority is in China.[34]

Pumped storage hydro continues to grow in significance, largely due to its ability to provide ancillary services as shares of variable renewable generation rise. About 3 GW of pumped storage capacity was added in 2012, for a total of 138 GW globally.[35] Europe added 675 MW to push the regional total above 45 GW, and China accounted for just over half of the 2012 addition, bringing 1.5 GW of pumped storage online.[36] China's Fengning station in Hebei Province began construction in 2012; the 3.6 GW project could be the world's largest pumped storage facility when completed.[37]

HYDROPOWER INDUSTRY

The hydropower industry is seeing growing prominence of joint-venture business models in which local and international partnerships share risks and benefits.[38] For example, a public-private partnership brought the 250 MW Bujagali project in Uganda to completion in 2012.[39] The International Finance Corporation (IFC – World Bank Group) joined Korea Western Power Co. to develop at least one project in Laos.[40] In Vietnam, local and international parties, including Samsung of Korea, joined in a contract to build the Trung Son plant for a subsidiary of Electricity of Vietnam.[41]

As the size of large projects increases, manufacturers are developing and testing ever-larger turbine-generator units, including 1,000 MW Francis units produced by Tianjin Alstom (China) and Power Machines (Russia).[42] Having delivered four record 812 MW Francis turbine generators to the Xiangjiaba plant, Alstom also committed to USD 130 million (EUR 100 million) investment in hydropower development needs within China, including the Global Technology Center in Tianjin. The interest of major international hydropower companies staking manufacturing and research ground in China is believed to reflect the significance and stable growth of the country's hydropower development pipeline.[43]

Companies are investing elsewhere as well. In early 2013, Alstom opened the new headquarters of its hydropower technology centre in Grenoble, France, following years of upgrades to the site and the doubling of its hydraulic test laboratory.[44] In Russia, Alstom (France) joined with RusHydro (Russia) to commence construction of a joint hydropower equipment manufacturing plant.[45] After heavy investment in new manufacturing facilities in recent years, Voith Hydro (Germany) increased its emphasis on research and development, particularly for pumped storage technology.[46]

IMPSA of Argentina, which holds a 30% market share in Latin America's hydropower sector, opened a new factory that doubles its production capacity in order to meet the region's sustained demand.[47] In Japan, Toshiba announced the construction of a new thermal, hydro, and renewable power engineering centre in anticipation of growing demand for thermal and hydropower generation equipment in emerging economies.[48]

Manufacturers are also striving to advance pumped storage technology, pursuing requisite flexibility and efficiency through development of variable-speed units and other innovations.[49] Electricité de France plans to upgrade its 485 MW La Cheylas plant to variable speed. The consortium behind the project estimates that European pumped storage facilities could provide another 10 GW of regulation capability if converted to variable-speed operation.[50]

The world's leading hydropower technology and manufacturing companies are Alstom, Andritz (Austria), IMPSA, and Voith, together representing more than 50% of the global market.[51] Other major manufacturers include BHEL (India), Dongfang (China), Harbin (China), Power Machines, and Toshiba.

OCEAN ENERGY

OCEAN ENERGY MARKETS

After the introduction in 2011 of a 254 MW tidal power project in South Korea and a much smaller 300 kW wave energy facility in Spain, little new capacity was added in 2012. Commercial ocean energy capacity remained at about 527 MW by year's end, most of this being tidal power facilities, with additional projects in the pipeline.[1]

In September, the Cobscook Bay Tidal Energy Project off the U.S. coast of Maine began delivering electricity to the grid.[2] The Ocean Renewable Power Company's (USA) TidGen device has a peak output of 180 kW.[3] Across the Atlantic, off the coast of Portugal, AW Energy (Finland) deployed three 100 kW wave energy converters, which they call the WaveRoller. These converters are designed for near-shore applications and sit on the ocean floor at a depth of 8–20 meters.[4]

Other notable ocean energy facilities in operation around the world at the end of 2012 include France's Rance tidal power station (240 MW), which has been in operation since 1966; tidal plants in Nova Scotia, Canada (20 MW) and in Zhejiang, China (3.9 MW); and a collection of tidal current and wave energy projects in the United Kingdom (about 9 MW).[5]

In addition to its Sihwa tidal power plant, which came on line in mid-2011, South Korea has planned to construct several other tidal plants to achieve national green growth targets. As of early 2013, however, the status of these projects is uncertain. The country's 6th Electricity Plan, issued in early 2013, includes the development of the Gangwha (813 MW) and Garorim (520 MW) tidal power plants, but public opposition on ecological grounds may prove to be a hindrance.[6]

In the United States, Ocean Power Technologies (USA) received a license in 2012 for a 1.5 MW wave power station off the coast of Oregon, with deployment of the first 150 kW PowerBuoy (wave energy converter) set for 2013.[7] Having received requisite licenses in 2012, Verdant Power (USA) is now in the build-out phase of its Roosevelt Island Tidal Energy project in New York, which envisions a 1 MW array of up to 30 tidal turbines in the East River.[8]

In the United Kingdom, the Severn River has long been eyed as a potential site for a tidal barrage, but it has faced the dual hurdle of the high economic cost and potential impact on wildlife. The topic resurfaced in 2012 with a new proposal to build a USD 50 billion (GBP 30 billion), 6.5 GW barrage across the 18-kilometre wide Severn estuary south of Cardiff, all with private funds. If constructed, the scheme could deliver 5% of the U.K.'s electricity needs.[9]

The absence of major new commercial project deployments must be considered in the context of this industry still being in relative infancy. There are numerous demonstration projects in the field or soon to be deployed, particularly in the United Kingdom. Ocean energy's slow but steady march towards commercial projects is seen as positive, with particular near-term promise for tidal power technology.[10]

OCEAN ENERGY INDUSTRY

The continental shelf of the United Kingdom is a key testing ground for emerging ocean power technologies. Off the coast of Orkney, the European Marine Energy Center (EMEC) has a number of wave and tidal devices undergoing testing. In 2012, the U.K.'s National Renewable Energy Centre (Narec) opened a rig for testing of tidal devices under simulated conditions, providing valuable information to technology developers.[11]

These facilities, and the ocean energy companies carrying out research and development, receive support from the U.K. government and from regional authorities, including a USD 167 million (GBP 103 million) investment fund launched by the Scottish Government, mainly in support of ocean energy.[12] In Ireland, despite economy-driven funding cuts in recent years, research activities at maritime research facilities are expected to expand in 2013, including work on new grid connection for offshore devices.[13]

The expertise gathered in the fertile waters off Scotland is spawning test facilities elsewhere. EMEC has entered into agreement with counterparts in Taiwan, Japan, China, South Korea, the United States, and Canada to provide technical assistance on ocean power test sites.[14]

Government assistance would not go far without the leverage of funding from private enterprise. As the industry works its way through the long process of developing and testing different technologies to harness wave and tidal power, each entity must secure sustained funding. This generally occurs though partnerships and joint ventures, or through capital injection via acquisition by major corporations.

Major power technology corporations have a growing presence in the ocean energy sector. In 2012, Alstom (France) acquired Tidal Generation Limited (U.K.), a former subsidiary of Rolls Royce specialising in tidal turbine technology. Later in the year, Alstom terminated licencing agreements with Clean Current (Canada), which develops in-stream tidal turbines.[15] In 2011, Alstom had taken a 40% share in the Scottish AWS Ocean Energy Ltd.[16]

Andritz (Austria) increased its stake to a majority share in the Norwegian ocean energy company Hammerfest Strøm AS, now known as Andritz Hydro Hammerfest.[17] Iberdrola (Spain) also holds a share in the company, which has a tidal turbine operating at EMEC in Scotland.[18] Marine Current Turbines (U.K.) is now wholly owned by Siemens (Germany).[19] The company recently celebrated five years of operating its SeaGen turbine, the world's largest grid-connected tidal stream turbine, off the coast of Northern Ireland.[20]

A joint venture between Vattenfall (Sweden) and Pelamis Wave Power (Scotland) to develop a 10 MW wave farm off the west coast of Shetland will be facilitated by an approved 370 MW wind farm on the island, which paves the way for needed interconnection to mainland Scotland.[21] This may indicate a potential synergy between ocean energy and other near-shore renewable energy projects. Vattenfall had noted previously that the project was predicated on such interconnection.[22]

Another joint venture, between Atlantis Resources Corporation (U.K.), investment bank Morgan Stanley, and power generator International Power (U.K.), hopes to start work on the 400 MW Meygen tidal power project in northern Scotland's Pentland Firth in 2013.[23] The project would use Atlantis Resources' AR 1000 1 MW tidal turbine that completed testing at the Narec testing grounds last year, as well as turbines from Andritz Hydro Hammerfest.[24] With USD 5 million in new funding from the Canadian government, Atlantis has joined partners to deploy one of its turbines on Canada's Atlantic coast in the Bay of Fundy, which is famous for having the highest tidal range in the world, at 17 metres.[25]

SOLAR PHOTOVOLTAICS (PV)

SOLAR PV MARKETS

The solar photovoltaic (PV) market saw another strong year, with total global operating capacity reaching the 100 GW milestone in 2012.[1] The market was fairly stable relative to 2011, with slightly less capacity brought on line but likely higher shipment levels, and the more than 29.4 GW added represented nearly one-third of total global capacity in operation at year's end.[2] (See Figure 11 and Table R5.) The thin film market share fell from 15% in 2011 to 13% in 2012.[3]

Eight countries added more than 1 GW of solar PV to their grids in 2012, and the distribution of new installations continued to broaden.[4] The top markets—Germany, Italy, China, the United States, and Japan—were also the leaders for total capacity.[5] By year's end, eight countries in Europe, three in Asia, the United States, and Australia had at least 1 GW of total capacity.[6] The leaders for solar PV per inhabitant were Germany, Italy, Belgium, the Czech Republic, Greece, and Australia.[7]

Europe again dominated the market, adding 16.9 GW and accounting for about 57% of newly installed capacity, to end 2012 with 70 GW in operation.[8] But additions were down from 22 GW and more than 70% of the global market in 2011; the region's first market decline since at least 2000 was due largely to reduced incentives (including FIT payments) and general policy uncertainty, with the most significant drop in Italy.[9] Regardless, for the second year running the EU installed more PV than any other electricity-generating technology: PV represented about 37% of all new capacity in 2012.[10] As its share of generation increases, PV is starting to affect the structure and management of Europe's electricity system, and is increasingly facing barriers that include direct competition with conventional electricity producers and saturation of local grids.[11]

Italy and Germany both ended 2012 with more solar PV than wind capacity in operation, together accounting for almost half of the global total.[12] (See Figure 12.) Germany added a record 7.6 GW, up just slightly over the previous two years, increasing its total to 32.4 GW.[13] Solar PV generated 28 TWh of electricity in Germany during 2012, up 45% over 2011.[14] Italy reached a total capacity of 16.4 GW; however, the 3.6 GW brought on line was far lower than additions in 2011.[15]

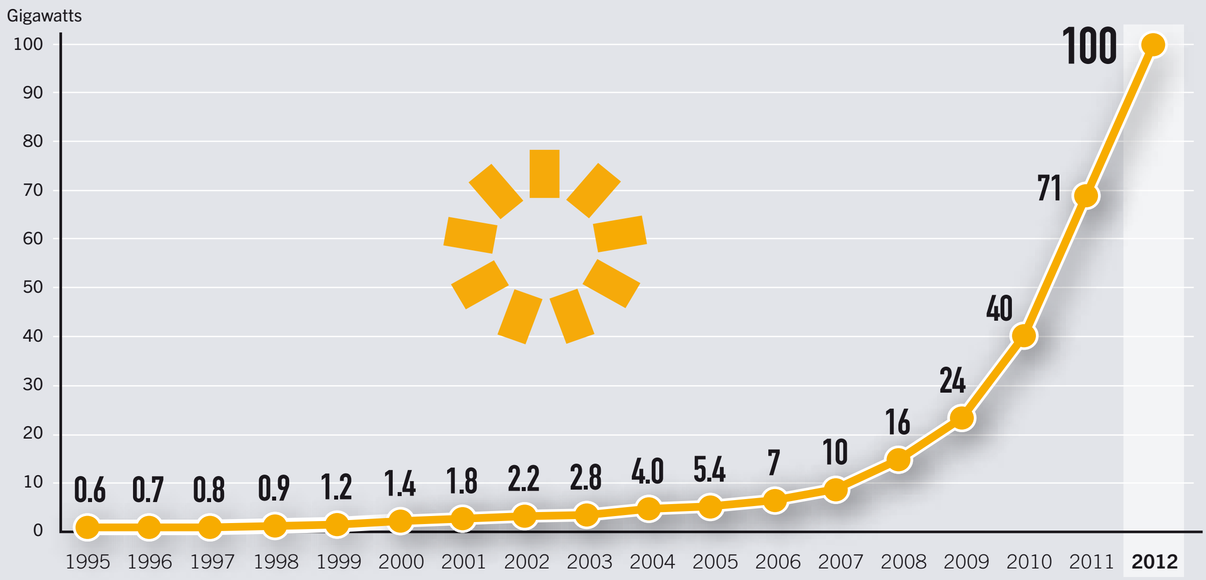
Other top EU markets included France (1.1 GW), the United Kingdom (0.9 GW), Greece (0.9 GW), Bulgaria (0.8 MW), and Belgium (0.6 MW).[16] All saw total operating capacity increase 30% or more, with Bulgaria's capacity rising sixfold, although France's market was down relative to 2011.[17]

Beyond Europe, about 12.5 GW was added worldwide, up from 8 GW in 2011.[18] The largest markets were China (3.5 GW), the United States (3.3 GW), Japan (1.7 GW), Australia (1 GW), and India (almost 1 GW).[19] Asia (7 GW) and North America (3.6 GW) followed Europe for capacity added; by year's end, Asia was rising rapidly and was second only to Europe for total operating capacity.[20]

U.S. capacity was up nearly 85% in 2012 to 7.2 GW.[21] California had a record year (>1 GW added) and was home to 35% of total U.S. capacity.[22] But PV is spreading to more states, driven by falling prices and innovative financing and ownership models such as solar leasing, community solar investments,

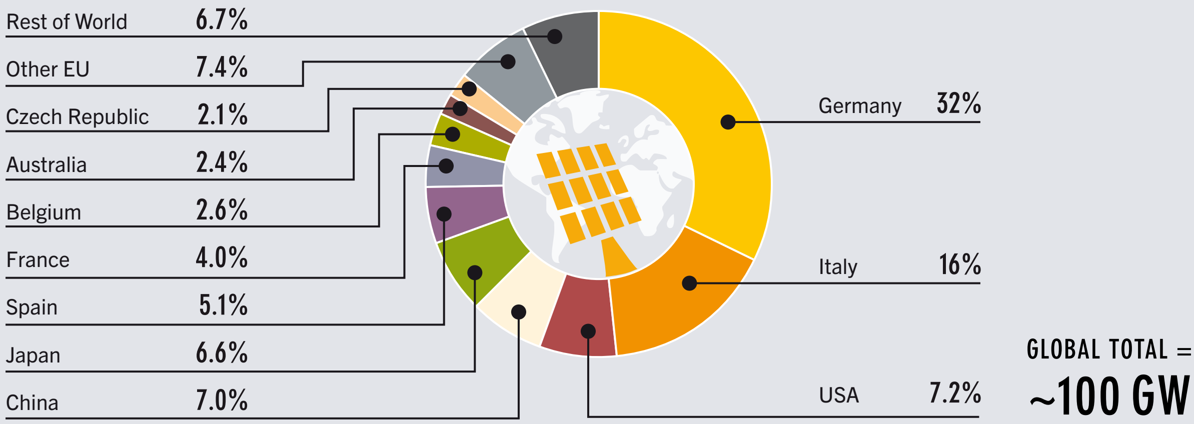
SOLAR PHOTOVOLTAICS (PV)

FIGURE 11. SOLAR PV GLOBAL CAPACITY, 1995-2012



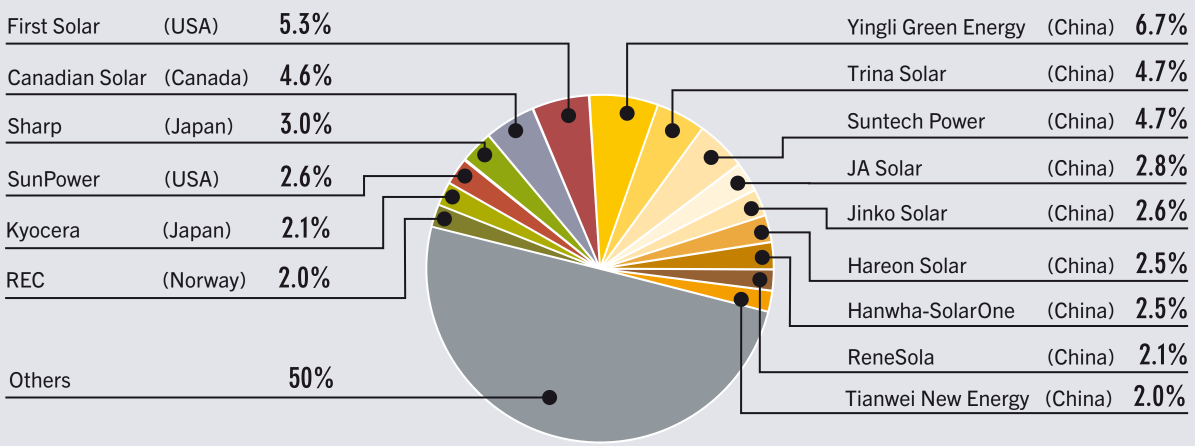
Source: See Endnote 2 for this section.

FIGURE 12. SOLAR PV GLOBAL CAPACITY, SHARES OF TOP 10 COUNTRIES, 2012



Source: See Endnote 12 for this section.

FIGURE 13. MARKET SHARES OF TOP 15 SOLAR PV MODULE MANUFACTURERS, 2012



Based on 35.5 GW produced in 2012.

Source: See Endnote 75 for this section.

and third-party financing.[23] On the negative side, battles are emerging around the future of net metering due to utility concerns about potential stranded costs of existing generating assets.[24] Utility installations represented 54% of additions and accounted for 2.7 GW of U.S. capacity by year's end, with more than 3 GW under construction.[25] Utility procurement is slowing, however, as many utilities approach their Renewable Portfolio Standard (RPS) targets.[26]

China doubled its capacity, ending 2012 with about 7 GW, but below expectations for the year.[27] By the fourth quarter, China accounted for more than a third of global panel shipments, surging past Germany in response to government efforts to cre-

ate a market for the glut of domestic solar panels.[28] The market is dominated by large-scale ground-mounted systems, many of which are in western China, far from load centers.[29] But national policies aim to encourage distributed, building-mounted projects as well.[30]

Total capacity in Japan rose 35% to exceed 6.6 GW, driven by the new feed-in tariff (FIT); by the end of 2012, solar PV accounted for 90% of capacity certified in the FIT system.[31] Japan's rapid demand increase has led to significant investment in PV and a rush into projects that are pushing up land prices.[32]

Australia ended the year with nearly 2.4 GW, up 70% over 2011.[33] By early 2012, an estimated one in five homes in South Australia had rooftop PV.[34] India also saw notable growth, with capacity increasing more than fivefold to 1.2 GW.[35]

Just as some traditional EU markets are starting to slow, falling prices make it easier for PV to compete in new markets across the globe. Namibia and South Africa brought large solar parks on line 2012, and Chinese companies have begun building projects in at least 20 African countries to help spur demand for Chinese exports.[36]

Israel is the only country in the Middle East with a significant market.[37] But in Saudi Arabia and across the Middle East-North Africa (MENA) region, interest in solar power is being driven by rapid increases in energy demand, a desire to free up more crude oil for export, and high insolation rates.[38]

The Southeast Asia region has been dominated by Thailand, but markets are starting to bloom elsewhere.[39] And driven by favourable policies, demand in Latin America is shifting from small off-grid and niche applications to large-scale deployment in the commercial and industrial sectors—especially in Brazil, Chile, and Mexico.[40]

Interest in off-grid systems is growing, particularly in developing countries (see Rural Renewable Energy section).[41] In 2012, one of the world's largest off-grid systems was completed in the South Pacific territory of Tokelau, to provide 100% of electricity needs.[42] Off-grid projects represent a significant portion of installed PV capacity in some developed countries, including Australia, Israel, Norway, Sweden, and the United States.[43] However, the vast majority of PV capacity today is grid-connected, with off-grid accounting for an estimated 1% of the market, down from more than 90% two decades ago.[44]

The market for building-integrated PV (BIPV)—solar panels that double as shingles, walls, or other building materials—represents less than 1% of solar PV capacity being installed worldwide, amounting to an estimated 100 MW added in 2012.[45] The economic downturn has slowed construction, dampening BIPV growth.[46] Europe is the largest market with more than 50 companies active in the sector.[47]

Also on the rise in some countries is interest in community-owned PV. Eight U.S. states have policies to encourage community solar projects; by late 2012, community projects accounted for an estimated 60 MW of U.S. capacity.[48] In Australia, the Melbourne LIVE Community Power Programme enables community members who cannot install their own rooftop systems to invest in the project.[49]

At the same time, the number and scale of large PV projects continues to increase. By early 2013, about 90 plants in operation were larger than 30 MW, and some 400 had at least 10 MW of capacity.[50] The world's 50 biggest plants reached cumulative capacity exceeding 4 GW by the end of 2012, and at least 12 countries across Europe, North America, and Asia had solar PV plants over 30 MW.[i] [51] More than 20 of these facilities came on line in 2012, including the world's two largest: a 250 MW thin-film plant in the U.S. state of Arizona and a 214 MW plant in Gujarat, India.[52] Germany held on to its lead for total capacity of facilities larger than 30 MW, with a cumulative 1.55 GW in operation by year's end, followed by the United States, France, India, Ukraine, China, and Italy.[53] Several projects are planned around the world that range from 50 to 1,000 MW in scale.[54]

The concentrating PV (CPV) market is still comparatively tiny, but interest is increasing due greatly to higher efficiency levels in locations with high insolation and low moisture.[55] The world's first multi-megawatt projects came on line in 2011, and, by mid-2012, more than 100 plants totalling as much as 100 MW were operating in at least 20 countries worldwide.[56] The United States has the largest capacity thanks to a 30 MW Colorado

i It is telling of the rapid changes in PV markets that the 2011 edition of the GSR reported on utility-scale projects of more than 200 kW in size, and the 2012 edition on projects larger than 20 MW.

plant that started operating in 2012, followed by Spain, China and Chinese Taipei/Taiwan, Italy, and Australia.[57] CPV is also spreading to new markets in North Africa, the Middle East, and South America.[58]

Solar PV is starting to play a substantial role in electricity generation in some countries, meeting an estimated 5.6% of national electricity demand in Italy and about 5% in Germany in 2012, with far higher shares in both countries during sunny months.[59] By year's end, PV capacity in the EU was enough to meet an estimated 2.6% of total consumption, and global capacity in operation was enough to produce at least 110 TWh of electricity per year.[60]

SOLAR PV INDUSTRY

As in 2011, 2012 was a good year for solar PV distributors, installers, and consumers, but cell and module manufacturers struggled to survive let alone make a profit. An aggressive capacity build-up in 2010 and 2011, especially in China, resulted in excess production capacity and supply that, alongside extreme competition, drove prices down further in 2012, yielding smaller margins for manufacturers and spurring continued industry consolidation.[61] Low prices also have challenged many thin film companies and the concentrating solar industries, which are struggling to compete.[62]

The average price of crystalline silicon solar modules fell by 30% or more in 2012, while thin film prices dropped about 20%.[63] Installed system costs are also falling, although not as quickly, and they vary greatly across locations. From the second quarter of 2008 to the same period in 2012, German residential system costs fell from USD 7.00/Watt (W) to USD 2.20/W; by contrast, average prices for U.S. residential systems had fallen to USD 5.50/W.[64]

Approximately 31.9 GW of crystalline silicon cells and 35.5 GW of modules were produced in 2012, down slightly from 2011.[65] Despite several plant closures, year-end module production capacity increased in 2012, with estimates ranging from below 60 GW to well over 70 GW.[66] China's production capacity alone exceeded the global market.[67] Thin-film production declined nearly 15% in 2012, to 4.1 GW, and its share of total global PV production continued to fall.[68]

Over the past decade, leadership in module production has shifted from the United States, to Japan, to Europe, to Asia.[69] By 2012, Asia accounted for 86% of global production (up from 82% in 2011), with China producing almost two-thirds of the world total.[70] Europe's share continued to fall, from 14% in 2011 to 11% in 2012, and Japan's share dropped from 6% to 5%.[71] The U.S. share remained at 3%; thin film accounted for 29% of U.S. production, down from 41% in 2011.[72] Europe was still competitive for polysilicon production, however, and the United States was the leading producer.[73]

The top 15 solar PV module manufacturers accounted for half of the 35.5 GW produced globally; 11 of these companies hailed from Asia.[74] Yingli (China) jumped ahead of both Suntech (China) and First Solar (USA) to land in first position. First Solar held its number-two spot, and Suntech fell to fourth after Trina Solar (China). There was also much shifting in the ranks among the other top players.[75] (See Figure 13, and Figure 13 in GSR 2012.)

Market consolidation continued in 2012. On the project development side, merger and acquisition activity was driven by large companies wanting to buy into project pipelines; among manufacturers, even global companies with solid financing suffered.[76] The string of failures and bankruptcies that began in 2011 continued into 2013, due to overcapacity of module production.[77]

More than 24 U.S. solar manufacturers have left the industry in recent years, and, by one estimate, about 10 European and 50 Chinese manufacturers went out of business during 2012.[78] Even "tier 1" Chinese companies like Yingli and Trina idled plants and struggled to stay afloat.[79] By year's end, China's 10 largest manufacturers had borrowed almost USD 20 billion from state-owned banks, and Suntech Power's main operating subsidiary declared bankruptcy in early 2013.[80] In India, 90% of domestic manufacturing had closed or filed for debt restructuring by early 2013.[81]

Other Asian companies were busy buying up next-generation U.S. solar technology, and Hanwha Group (South Korea) bought the bankrupt Q-Cells (Germany), the top module manufacturer in 2008.[82] First Solar (USA) and Panasonic (Japan) closed production lines and/or suspended plans for new factories; GE (USA) halted construction on its thin-film factory in Colorado and announced plans to return to R&D; Bosch Solar (Germany) announced that it would stop making cells and panels in 2014; and Siemens (Germany) announced its exit from the solar business.[83] Most companies that remained in established markets were investing in improving manufacturing processes, rather than R&D, to reduce their costs.[84]

Even as some manufacturers idled production capacity or closed shop, others opened facilities and aggressively sought new markets—particularly in the developing world.[85] New plants opened around the globe in 2012, from Europe to Turkey, Kazakhstan to Japan, and Malaysia to the United States.[86] Ethiopia's first module-manufacturing facility (20 MW) began operating in early 2013 to supply the domestic market.[87]

Innovation and product differentiation have become increasingly important, and successful manufacturers have diversified both up- and downstream, with many expanding into project development or building strategic partnerships.[88] First Solar moved away from the residential market to focus on development of utility-scale PV plants; First Solar and SunPower (USA) both announced deals that will provide entry into the Chinese market; Trina Solar is becoming a provider of total solar solutions; and Canadian Solar is shifting into project development and ownership.[89]

The year 2012 was also mixed for CPV. Several companies, including Skyline Solar and GreenVolts (both USA), closed their doors, and SolFocus (USA) announced a decision to sell; but those companies that were still operating invested increasing amounts of time and money in building manufacturing facilities in emerging markets.[90] The industry is currently in the commercialisation phase, but several challenges remain, including obtaining financing required to scale up projects, and demonstrating continuous high yield outside the laboratory.[91]

CONCENTRATING SOLAR THERMAL POWER (CSP)

CSP MARKETS

The concentrating solar thermal power (CSP) market continued to advance in 2012, with total global capacity up more than 60% to about 2,550 MW.[1] (See Figure 14 and Table R6.) The market doubled relative to 2011, with Spain accounting for most of the 970 MW brought into operation.[2] From the end of 2007 through 2012, total global capacity grew at an average annual rate approaching 43%.[3]

Parabolic trough is the most mature technology, and it continues to dominate the market, representing about 95% of facilities in operation at the end of 2011, and 75% of plants under construction by mid-2012.[4] Towers/central receivers are becoming more common and accounted for 18% of plants under construction by mid-year, followed by Fresnel (6%) and parabolic dish technologies, which are still under development.[5]

Spain continued to lead the world for both deployment and total capacity of CSP, adding 950 MW to increase operating capacity by 95% to a total of 1,950 MW.[6] As in the global market, parabolic trough technology dominates in Spain, but 2012 saw completion of the world's first commercial Fresnel plant.[7] The world's first hybrid CSP-biomass plant also came on line.[8] However, policy changes in 2012 and early 2013—including a moratorium on new construction, retroactive feed-in tariff (FIT) changes, and a tax on all electricity producers—pose new challenges to Spain's industry.[9]

The United States remained the second largest market in terms of total capacity, ending the year with 507 MW in operation.[10] As in 2011, no new capacity came on line, but just over 1,300 MW was under construction at the close of 2012, all due to begin operation in the next two years.[11] By year's end, the Ivanpah facility under construction in California's Mojave Desert was 75% complete; once on line, this 392 MW power tower plant will be the world's largest CSP facility and is expected to provide enough electricity for 140,000 U.S. homes.[12] The Solana plant (280 MW), which was 80% constructed by year's end, will be the world's biggest parabolic trough plant upon completion.[13]

Elsewhere, more than 100 MW of capacity was operating at year's end, with most of this in North Africa. Some relatively small projects came on line in 2012: Australia added 9 MW to its Liddell Power Station, where solar thermal feeds a coal-fired power plant, and Chile became home to the first CSP plant in South America, a 10 MW facility to provide process heat for a mining company.[14] Other countries with existing CSP that did not add capacity in 2012 include Algeria (25 MW), Egypt (20 MW), and Morocco (20 MW)—all with solar fields included in hybrid solar-gas plants—and Thailand (5 MW).[15] Several additional countries had small pilot plants in operation, including China, France, Germany, India, Israel, Italy, and South Korea.[16] The United Arab Emirates (UAE) joined the list of countries with CSP in March 2013, when Shams 1 (100 MW)—the first full-size pure CSP plant in the Middle East-North Africa (MENA) region—began operation.[17]

Interest in CSP is on the rise, particularly in developing countries, with investment spreading across Africa, the Middle East, Asia, and Latin America. One of the most active markets in 2012 was South Africa, where construction began on a 50 MW solar power tower and a 100 MW trough plant.[18] Namibia announced plans for a CSP plant by 2015.[19] Several development banks committed funds for projects planned in the MENA region, where ambitious targets could result in more than 1 GW of new capacity in North Africa in the next few years for domestic use and export.[20] Saudi Arabia and the UAE plan to install CSP to meet rapidly growing energy demand and reserve more oil for export, and Jordan is evaluating possible projects; in early 2013, Saudi Arabia launched a competitive bidding process that includes significant CSP capacity.[21]

India planned to complete 500 MW by the end of 2013, but only one-third might be ready on time and some projects have been cancelled; phase two of the National Solar Mission has been delayed.[22] In Australia, a 44 MW plant is under construction to feed steam to an existing coal facility.[23] Many other countries, including Argentina, Chile and Mexico in Latin America, several countries in Europe, Israel, and China have projects under construction or have indicated intentions to install CSP plants.[24]

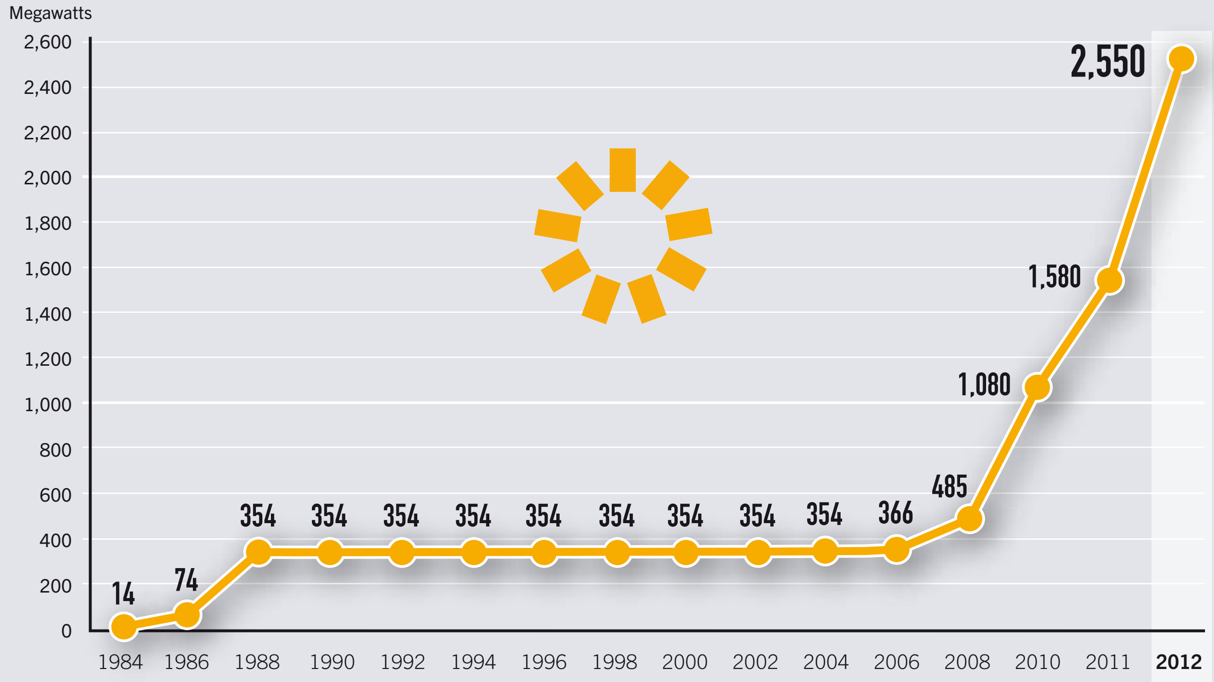
Some experts have expressed concern that the window of opportunity for CSP is closing as solar PV prices continue to fall and utilities become more familiar with PV.[25] However, CSP has a number of attributes that are expected to remain attractive to utilities. These include CSP's ability to provide thermal storage and thus to be dispatchable and to enable an increased share of variable renewables, and its ability to provide low-cost steam for existing power plants (hybridisation).[26] In addition, CSP has the potential to provide heating and cooling for industrial processes and desalination.[27]

CSP INDUSTRY

Although activity continued to focus on Spain and the United States, the industry further expanded its focus in Australia, Chile, China, India, the MENA region, and South Africa.[28] There was a general trend of diversification of employment in Spain, the United States, and beyond, and global manufacturing capacity increased slightly during 2012.[29] Falling PV and natural gas prices, the global economic downturn, and policy changes in Spain all created uncertainty for CSP manufacturers and developers.[30]

The top companies in 2012 included Abengoa (Spain), a manufacturer and developer; manufacturer Schott Solar (Germany); and developers Acconia, ACS Cobra, and Torresol (all Spain),

FIGURE 14. CONCENTRATING SOLAR THERMAL POWER GLOBAL CAPACITY, 1984-2012



Source: See Endnote 1 for this section.

as well as ABB (Switzerland), BrightSource (USA), and ACWA.[31] Saudi-based ACWA emerged as a key player in 2012, with the award of two major projects in alliance with Acciona and TSK (Pakistan), in South Africa and Morocco.[32] Chinese firms have begun to enter the CSP-related component business and are expected to be major suppliers for the foreseeable future.[33]

Spanish companies continued to lead the industry with ownership interest in almost three-fourths of CSP capacity deployed around the world, and more than 60% of capacity under development or construction by early 2013.[34] But Spanish firms were challenged by policy changes at home, and companies based elsewhere were not immune from difficulties. The U.S. subsidiary of Germany's bankrupt Solar Millennium filed for insolvency proceedings, as did SolarHybrid (Germany); BrightSource continued to develop several projects including Ivanpah, but did not go public as planned; and Siemens (Germany) decided to exit the solar business in late 2012, citing intense price pressure in solar markets.[35] Schott Solar produced its one-millionth solar receiver in November, but as of early 2013 was seeking bids for the majority stake in its CSP unit.[36]

Because CSP requires large capital investments, individual companies are 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.[37]

To increase product value or reduce costs, firms also have begun to expand development efforts to include a variety of CSP technologies. German Protarget released a new design for applications in the 1–20 MW range to demonstrate that standardised manufacturing processes and modular construction could result in faster and more cost-effective installations.[38] 3M and Gossamer inaugurated a U.S. demonstration facility with the world's largest aperture parabolic trough; it uses lightweight, highly reflective film rather than glass, with the purpose of significantly reducing installed costs.[39] A few manufacturers have begun to market solar concentrator technologies for industrial heating and cooling, and desalination, including Solar Power Group (Germany), Sopogy (USA), and Abengoa.[40]

Thermal energy storage is becoming an increasingly important feature for new plants as it allows CSP to dispatch electricity to the grid during cloudy periods or at night, provides firm capacity and ancillary services, and reduces integration challenges.[41] Molten salt is the most widely used system for storing thermal energy, but other types—including steam, chemical, thermocline (use of temperature differentials), and concrete—are also in use or being tested and developed.[42]

To reduce costs through economies of scale, the size of CSP projects is increasing. While plants in Spain have been limited to 50 MW because of regulatory restrictions, new projects in the United States and elsewhere are in the 150–500 MW range and even larger. Increasing size helps to reduce costs through economies of scale, but appropriate plant size also depends on technology.[43] Some projects are also integrating dry cooling solutions that significantly reduce water demand, an advancement that is important in the arid, sunny regions where CSP offers the greatest potential.[44]

CSP prices have declined significantly in recent years, for systems with and without thermal storage.[45] (See Characteristics and Costs Table, Table 2, p. 58.) Although subject to changes in commodity prices, the major components of CSP facilities (including aluminum, concrete, glass, and steel) are generally not in tight supply.[46]

SOLAR THERMAL HEATING AND COOLING

SOLAR THERMAL HEATING AND COOLING MARKETS

Solar thermal technologies contribute significantly to hot water production in many countries and increasingly to space heating and cooling as well as industrial processes. In 2011[i], the world added nearly 51 GW_{th} (more than 72 million m^2) of solar heat capacity, for a year-end total of 247 GW_{th}.[1] An estimated 49 GW_{th} (>96%) of the market was glazed water systems and the rest was unglazed water systems for swimming pool heating, as well as unglazed and glazed air collector systems.[2]

The vast majority of solar heat capacity (all types) is in China and Europe, together accounting for more than 90% of the world market and 81% of total capacity in 2011.[3] The top countries for total capacity in operation were China, the United States, Germany, Turkey, and Brazil.[4] China focuses on evacuated tube (glazed) water collectors, whereas most systems in the United States use unglazed water collectors for pool heating. The only other markets of note for unglazed water collectors are Australia and, to a lesser extent, Brazil; other key markets rely primarily on flat plate (glazed) water collector technology.[5]

Counting glazed water systems only[ii], the market grew 15%, and total global capacity in operation by the end of 2011 (223 GW_{th}) provided an estimated 193 TWh (696 PJ) of heat annually.[6] The 2011 market leaders for newly installed glazed water collector capacity were China, Turkey, Germany, India, and Brazil; the same countries led for total capacity, with Brazil ahead of India.[7] (See Figures 15 and 16 and Table R7.)

By the end of 2012, global solar thermal capacity in operation reached an estimated 282 GW_{th}.[8] Global capacity of glazed water collectors reached 255 GW_{th}.[9] (See Figure 17.) China was again the main driver of solar thermal demand, adding 44.7 GW_{th}, a market increase of 11% over 2011. Total capacity rose 18.6% (net 28.3 GW_{th}), to 180.4 GW_{th}—amounting to about two-thirds of global capacity.[10] In China, solar heaters cost far less over their lifetimes than do electric or gas heaters, a major factor driving the market.[11] Even so, deceleration in the building sector and some saturation of rural areas has slowed growth since 2009.[12]

Most demand in China is for residential purposes. A growing share of systems is being installed on large apartment buildings in response to local government mandates.[13] Solar thermal systems incorporated into building walls and balconies also make up a growing portion of China's market; simple rooftop installations account for about 60% of the market and falling.[14]

The European Union accounted for most of the remaining added capacity, although growth continued to be constrained by lower rates of building renovation, due in large part to the economic crisis, and to the reduction of support policies for solar heating.[15] Germany and Austria, the long-term EU leaders for total installations, have both experienced marked declines.[16] Germany remained Europe's largest installer in 2012, adding 805 MW_{th} for a total of 11.4 GW_{th}; but this was down from 889 MW_{th} in 2011, explained partially by a reduction in incentives as of January 2012.[17] The Austrian market shrank 10.3% in 2012, following a 17.8% decline in 2011, due largely to the greater appeal of solar PV for investors.[18] The Greek market has been trending upwards despite economic turmoil, increasing 7.5% in 2011 and 5.7% in 2012, due to rising electricity and heating oil prices.[19] While the European market is becoming more diversified, growth in developing markets, such as Denmark and Poland, did not make up for the decrease in the region's larger markets in 2012.[20]

Turkey had almost 10.2 GW_{th} of glazed water collectors in operation at the end of 2011.[21] Markets remained strong without government incentives and despite an expanding natural gas network due largely to a high level of public awareness about the technology.[22] In addition to hotels and hospitals, the low-income housing sector is an important market in Turkey, and multi-family structures are considered to be the fastest growing market segment.[23]

Japan and India are the largest Asian markets outside of China. India added more than 0.6 GW_{th} during the fiscal year 2011–12 for a total of 4.8 GW_{th} in early 2013.[24] Japan's market experienced limited growth during 2011 and 2012, but is still below 2008 levels, and South Korea has seen installations slow in recent years.[25] But Thailand's market is growing in response to an incentive for new hybrid (solar-waste heat) systems, with the capacity of subsidised systems increasing 13% in 2012.[26]

Brazil added almost 0.6 GW_{th} to end 2012 with about 5.7 GW_{th} (including unglazed water collectors).[27] The Brazilian market has expanded rapidly due in part to programmes such as Minha Casa Minha Vida ("My House, My Life"), which mandates solar thermal on low-income housing.[28] Mexico is also starting to play a role, and there are very small but growing markets in Argentina, Chile, and Uruguay.[29]

To the north, the United States accounted for almost two-thirds of all unglazed water collectors in operation.[30] The U.S. market for glazed water collectors is relatively small, however, and new installations declined in 2011 relative to 2010.[31] At least in California, low natural gas prices and lack of awareness have made it difficult to sell systems in the residential market.[32] As with solar PV, however, third-party ownership represents a growing trend, and some states have set solar thermal carve-outs in their renewable portfolio standards.[33]

Several countries in Africa use solar thermal, including Egypt, Mozambique, Tunisia, Zimbabwe, and South Africa, the most mature market in sub-Saharan Africa.[34] Tunisia's PROSOL programme increased annual installations more than 13-fold over five years, to more than 64 MW_{th}.[35] In the Middle East, Israel leads for capacity installed, followed by Jordan and Lebanon, where penetration is 13% in the residential sector and the market is driven by national subsidies, zero-interest loans, and municipal mandates.[36]

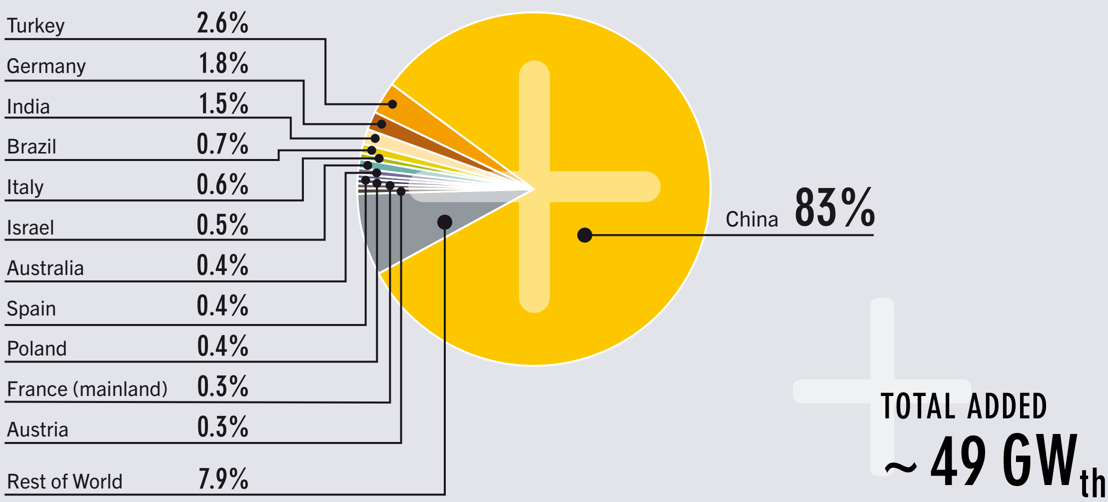
Although it ranked 22nd overall for capacity of glazed water systems at the end of 2011, Cyprus remained the world leader

i The year 2011 is the most recent one for which firm global data and most country statistics are available.

ii Most countries collect data for glazed water collectors only, although the most important markets for unglazed water collectors also track this collector type; air collector capacities are more uncertain, but play a minor role in the market overall. To avoid mixing countries that have detailed data across all collectors with those that do not, the GSR focuses primarily on glazed water collectors.

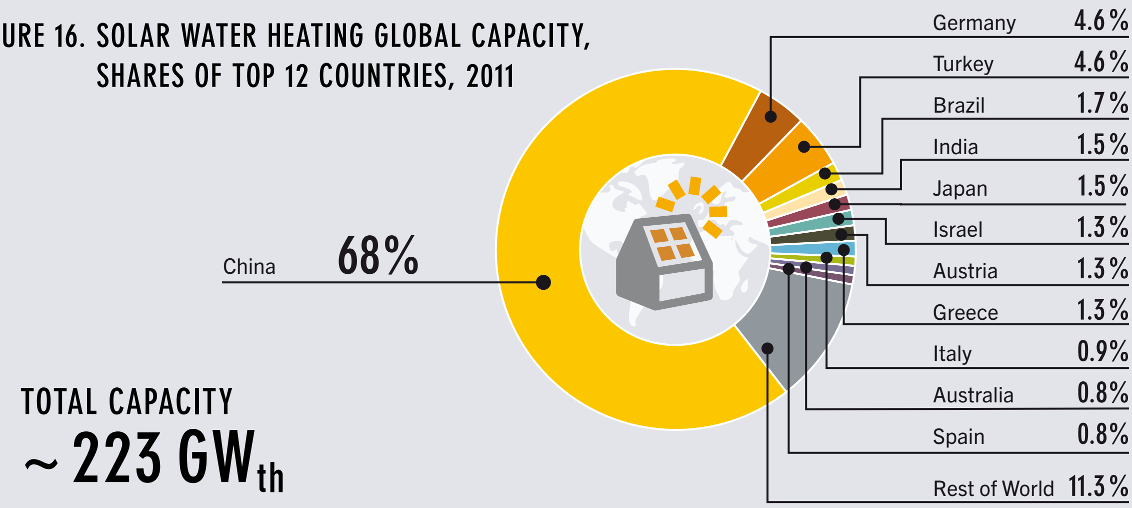
SOLAR THERMAL HEATING

FIGURE 15. SOLAR WATER HEATING GLOBAL CAPACITY ADDITIONS, SHARES OF TOP 12 COUNTRIES, 2011



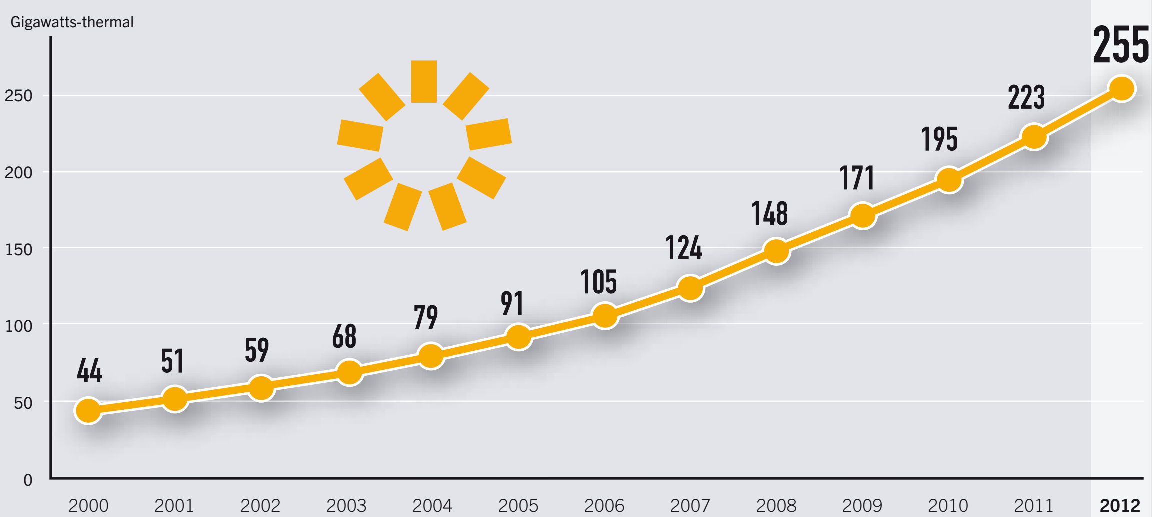
Source: See Endnote 7 for this section.

FIGURE 16. SOLAR WATER HEATING GLOBAL CAPACITY, SHARES OF TOP 12 COUNTRIES, 2011



Source: See Endnote 7 for this section.

FIGURE 17. SOLAR WATER HEATING GLOBAL CAPACITY, 2000-2012



Note: Data are for glazed water collectors only.

Source: See Endnote 9 for this section.

on a per capita basis, with 541.2 kilowatts-thermal (kW_{th}) per 1,000 inhabitants, followed by Israel (396.6 kW_{th}), Austria (355.7 kW_{th}), Barbados (321.5 kW_{th}), and Greece (268.2 kW_{th}).[37] Remarkably, considering newly installed capacity in 2011, China ranked second behind Israel on a per capita basis, followed by Austria, Cyprus, and Turkey.[38]

Solar space heating and cooling are also gaining ground. The most sophisticated markets are in Germany and Austria, where advanced applications—such as water and space heating for buildings of all sizes; large-scale plants for district heating; and air conditioning and cooling—account for a substantial share of each market.[39] Hybrid systems that use solar thermal technology and heat pumps are also gaining popularity in Europe.[40] Globally, the market share of 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).[41]

District heating systems that use solar thermal technology (often linked to other heat sources like biomass) are cost competitive in Austria, Denmark, Germany, and Sweden.[42] During 2012, systems were added, expanded, or planned across Europe; by year's end, the region had 175 large-scale solar thermal systems connected to heating networks, amounting to 319 MW_{th}.[43] Another 200 MW_{th} are planned, with 75% of them in Denmark, home to Europe's 10 largest solar thermal systems.[44] Large heat systems were also installed in South Africa, China, and Canada, where North America's first seasonal storage-solar heating system set a world record for meeting 97% of a community's space heating needs.[45]

The global solar cooling market grew at an average annual rate exceeding 40% between 2004 and 2012, ending the period with about 1,000 solar cooling systems installed, mostly in Europe.[46] Large-scale systems are creating interest due to their more favourable economics, while the availability of small (<20 kW) cooling kits for residential use has increased interest in the residential sector, primarily in Central Europe and sunny dry climates like Australia, Mediterranean islands, and the Middle East.[47] Another driver, particularly in countries with significant cooling needs, is the potential for solar cooling to reduce peak electricity demand.[48]

Solar heat and steam also can provide process heat and cooling for industrial applications. As of 2010, about 200 process heat systems were operating worldwide, totaling about 42 MW_{th}. India was in the lead (with 10%), followed by Brazil (7%) and Israel (6%).[49] New projects in 2012 included a leather tannery in China, and a U.S. turkey processing company, and plans for three Heineken beer producing facilities in Europe.[50] Process heat accounts for the largest share of large-scale solar thermal capacity in Austria and for most of Thailand's commercial solar heat subsidies.[51] However, district heating networks, solar air conditioning, and solar process heat for industrial purposes still account for less than 1% of global solar thermal capacity.[52]

SOLAR THERMAL HEATING/COOLING INDUSTRY

The solar heating/cooling industry continued to face challenges during 2012, particularly in Europe.[53] Large European heating companies have done well, but expansion among solar specialists has been slower.[54] Slow but steady expansion continues in Eastern Europe.[55] However, market deceleration in several central and south European countries has forced companies to increase focus on repairs or replacement of existing systems, and to close production capacity or to develop new production facilities to meet rising demand outside of Europe.[56] The industry also has been marked by acquisitions and mergers among leading players.[57]

Rapid consolidation of the industry continued also in China, where the market share of the top 100 brands has risen from 40% to 70% in recent years, and an estimated 1,000 solar thermal companies have gone out of business since 2010.[58] Attention to quality standards and certification increased during 2012 in response to high failure rates associated with cheap tubes from China.[59]

China maintained its multi-year lead in the global solar heating industry. Its largest companies—Sunrain Group, Linuo Group, Himin Solar, and Sangle Solar—continued to integrate vertically to cover all stages of manufacturing.[60] In May 2012, Sunrain became the first solar water heater company to be listed on the Shanghai Stock Exchange.[61] Although most Chinese water-collector production is vacuum tube systems that are installed domestically, an increasing number of companies offer both flat-plate and vacuum tube collectors, and export of all collectors has increased considerably in recent years.[62]

The largest manufacturers of flat-plate collectors include GreenOneTec (Austria), Bosch Thermotechnik (Germany), Ezinc (Turkey), Soletrol (Brazil), and Viessmann Werke (Germany).[63] German-based companies accounted for almost half of the top 19 flat-plate manufacturers in 2007, but by 2011 they made up only one-third.[64]

Brazil's growing market has attracted interest among large industry players.[65] South Africa has seen a significant increase in the number of installers in recent years, but the number of domestic manufacturers has declined due to rising competition from Chinese imports.[66] Lebanon is also experiencing rapid growth, with the number of registered companies increasing from 25 in 2008 to more than 130 in 2011.[67]

Price developments differ from country to country, with installed system prices depending largely on labor costs and where systems are installed (e.g., new or old buildings).[68] Automation of manufacturing processes continued to increase in 2012, with continuing innovation from adhesives to materials and beyond.[69] Such advances have successfully lowered production costs over the years, but these reductions have been mostly offset by rising materials costs (copper, aluminum alloys).[70]

As the market for solar air collectors expands, the number of manufacturers and products is also increasing.[71] While the largest markets are in Europe and North America, where most suppliers concentrate on air-based systems, manufacturers in China and India are increasingly supplying these as well as water-based systems.[72]

Rising interest in solar cooling is attracting new companies to the solar thermal sector, such as Hitachi and Mitsubishi in Japan.[73] The technology has historically had trouble competing due to its higher investment costs, but costs declined 50% between 2007 and 2012, and the potential remains for further reductions.[74] There are also efforts under way to improve system quality, such as the recent adoption of an Australian standard for solar cooling.[75]

WIND POWER

WIND POWER MARKETS

During 2012, almost 45 GW of wind power capacity began operation, increasing global wind capacity 19% to almost 283 GW.[1] (See Figure 18 and Reference Table R8.) It was another record year for wind power, which again added more capacity than any other renewable technology despite policy uncertainty in key markets.[2] The top 10 countries accounted for more than 85% of year-end global capacity, but the market continued to broaden.[3] Around 44 countries added capacity during 2012, at least 64 had more than 10 MW of reported capacity by year's end, and 24 had more than 1 GW in operation.[4] From the end of 2007 through 2012, annual growth rates of cumulative wind power capacity averaged 25%.[5]

For the first time since 2009, the majority of new capacity was installed in the OECD, due largely to the United States.[6] Developing and emerging economies are moving firmly into the mainstream, however. The United States and China together accounted for nearly 60% of the global market in 2012, followed distantly by Germany, India, and the United Kingdom.[7] Others in the top 10 for capacity added were Italy, Spain, Brazil, Canada and Romania.[8] The EU represented about 27% of the world market and accounted for just over 37% of total global capacity (down from 40% in 2011).[9]

The United States had its strongest year yet and was the world's top market in 2012.[10] (See Figure 19.) U.S. installations nearly doubled relative to 2011, with almost 64% of the 13.1 GW added coming on line in the year's final quarter.[11] The strong market was driven by several factors including increased domestic manufacturing of turbine parts and technology improvements that are increasing efficiency and driving down costs; most important, however, was the expected expiration of the federal Production Tax Credit.[12]

Wind power represented as much as 45% of all new electric generating capacity in the United States, outdoing natural gas for the first time, and the 60 GW operating at year's end was enough to power the equivalent of 15.2 million U.S. homes.[13] The leading states for capacity added were Texas (1.8 GW), with more than 12 GW in operation, California (1.7 GW), and Kansas (1.4 GW), and 15 states had more than 1 GW in operation by year's end.[14]

China installed almost 13 GW, accounting for 27% of the world market, but showed a significant decline in installations and market share relative to 2009–2011.[15] The market slowed largely in response to stricter approval procedures for new projects to address quality, safety, and grid access concerns.[16] Another major constraint has been the high rate of curtailment—averaging 16% in 2011—which results when output temporarily exceeds the capacity of the transmission grid to transfer wind power to demand centres.[17]

Even so, at year's end China had nearly 75.3 GW of wind capacity; as in 2010 and 2011, about 15 GW of this total had not been commercially certified by year-end, although most was feeding electricity into the grid.[18] Wind generated 100.4 billion kWh in 2012, up 37% over 2011 and exceeding nuclear generation for the first time.[19] By year's end, almost 25% of total capacity was in the Inner Mongolia Autonomous Region, followed by Hebei (10.6%), Gansu (8.6%), and Liaoning (8.1%) provinces, but wind is spreading across China—nine provinces had more than 3 GW of capacity each, and 14 had more than 1 GW each.[20]

The European Union passed the 100 GW milestone in 2012, adding a record 11.9 GW of wind capacity for a total exceeding 106 GW.[21] Wind power came in second for electric capacity added (26.5%), behind solar PV (37%) and ahead of natural gas (23%); by year's end, wind accounted for 11.4% of total EU electric capacity.[22] Despite record growth, there is concern that the EU lags on its National Renewable Energy Action Plan (NREAP) targets, and that 2012 additions do not reflect growing economic and policy uncertainty (most capacity was previously permitted and financed).[23] Some emerging markets are poised for significant growth, but grid connectivity and economic issues pose challenges to future development in much of Europe, as do land issues arising from having so much capacity on shore.[24]

Germany remained Europe's largest market, rebounding strongly with its highest installations in a decade (2.4 GW), for a total of 31.3 GW.[25] The United Kingdom ranked second for new installations in Europe for the second year running, adding 1.9 GW (45% offshore) for more than 8.4 GW by year's end; it now ranks third regionally for total capacity, behind Germany and Spain, and sixth globally.[26] Italy (1.3 GW), Spain (1.1 GW), Romania (0.9 GW), and Poland (almost 0.9 GW) were the other leading markets in Europe.[27] Romania and Poland both had record years, with Poland's total capacity up nearly 55% and Romania's almost doubling.[28]

India added about 2.3 GW to maintain its fifth-place ranking with a total of 18.4 GW at year's end.[29] India's most important federal wind power incentives were suspended or reduced in early 2012; despite strong policies in many states, uncertainty at the national level affected investment decisions and slowed markets.[30] Although there was a slowdown in both China and India, Asia remained the largest market for the fourth year in a row, adding a total of 15.5 GW in 2012, compared with North America's 14.1 GW and all of Europe's 12.2 GW.[31]

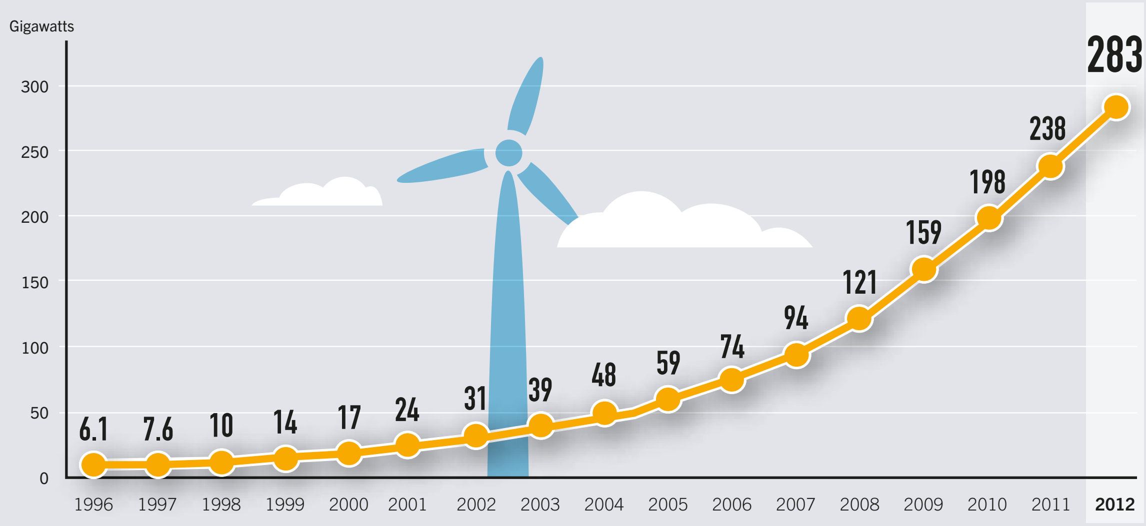
Elsewhere, the most significant growth was seen in Latin America. Brazil added 1.1 GW to rank eighth globally for newly installed capacity, and it ended 2012 with enough capacity (2.5 GW) to meet the electricity needs of 4 million households.[32] Brazil's electric grid is not expanding as rapidly as its wind capacity, however, slowing the ability to get new wind power online.[34] Mexico also had a strong year, adding 0.8 GW to approach 1.4 GW total, and brought the region's largest project (306 MW) on line.[33] Others in the region to add capacity included Argentina, Costa Rica, Nicaragua, Uruguay, and Venezuela, which commissioned its first commercial wind farm (30 MW).[35]

To the north, Canada had its second best year, adding more than 0.9 GW for a total of 6.2 GW. Three provinces reached milestones, with Ontario passing 2 GW total and Alberta and Quebec achieving 1 GW each.[36]

Africa and the Middle East saw little development, but Tunisia almost doubled its capacity, adding 50 MW; Ethiopia joined the list of countries with commercial-scale wind farms, installing 52 MW; and construction began on several South African projects totaling more than 0.5 GW.[37] Elsewhere, Turkey added 0.5 GW for a total of 2.3 GW, and Australia was the only country in the

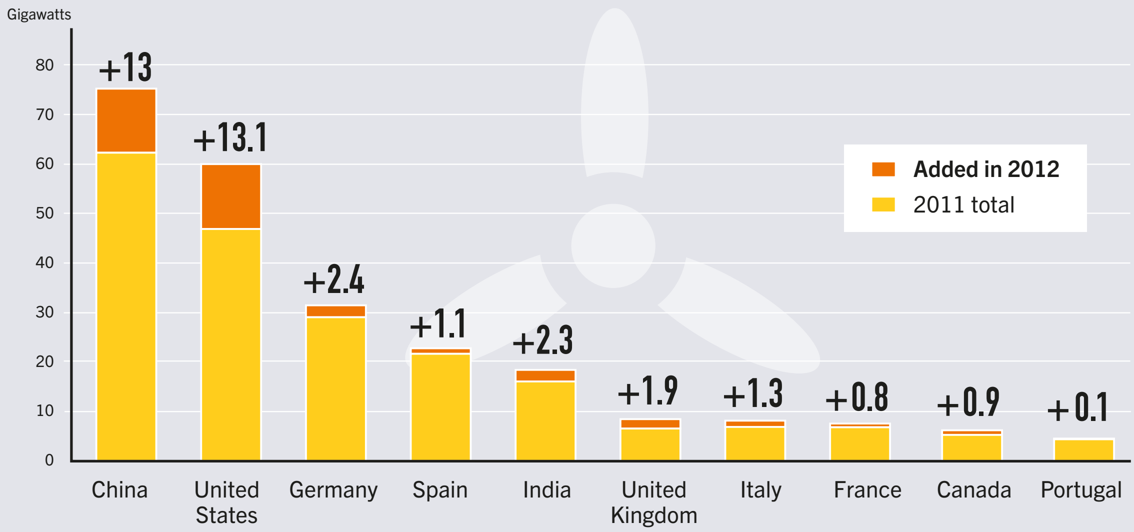
WIND POWER

FIGURE 18. WIND POWER GLOBAL CAPACITY, 1996-2012



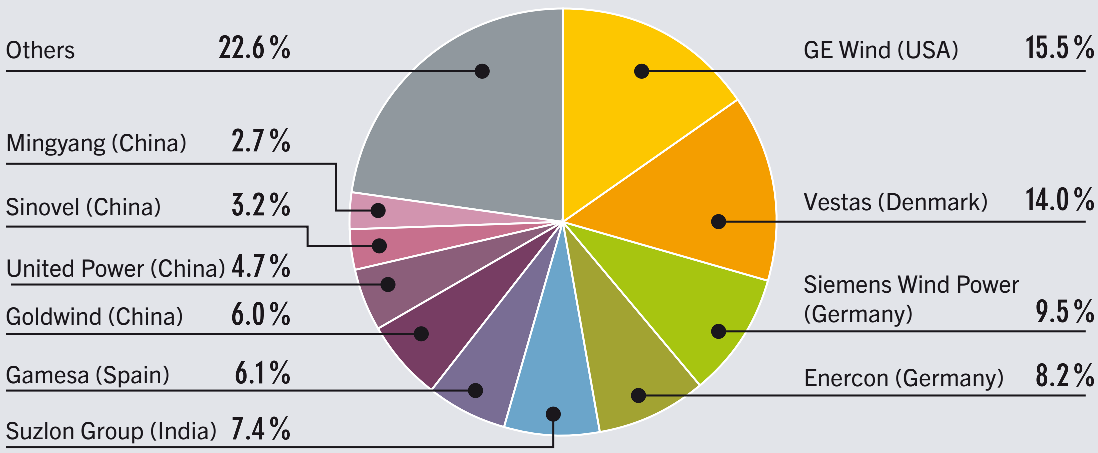
Source: See Endnote 1 for this section.

FIGURE 19. WIND POWER CAPACITY AND ADDITIONS, TOP 10 COUNTRIES, 2012



Source: See Endnote 10 for this section.

FIGURE 20. MARKET SHARES OF TOP 10 WIND TURBINE MANUFACTURERS, 2012



Source: See Endnote 71 for this section.

Pacific to add capacity (0.4 GW), bringing its total to nearly 2.6 GW.[38]

Worldwide, 13 countries had turbines operating offshore by the end of 2012, with 1.3 GW added for a total of 5.4 GW.[39] More than 90% of this capacity was located off northern Europe, which continued to lead in offshore developments, adding a record 1.2 GW (up 35% over 2011) for almost 5 GW total in 10 countries.[40] The United Kingdom accounted for 73% of Europe's additions, due largely to completion of the first phase of the London Array (630 MW), the world's largest offshore wind farm; the U.K. ended 2012 with more than 2.9 GW offshore, followed in Europe by Denmark (0.9 GW), Belgium (0.4 GW), and Germany (0.3 GW).[41] The remaining offshore capacity was in China (0.4 GW), Japan (25.3 MW), and South Korea (5 MW), which added 127 MW, 0.1 MW, and 3 MW, respectively.[42]

The trend towards increasing size of individual projects continued, driven mainly by cost considerations.[43] Europe's largest onshore wind farm (600 MW) was connected to the grid in Romania, and the largest U.S. wind farm (845 MW), which began operating in Oregon, is expected to power 235,000 U.S. homes.[44]

Independent power producers and energy utilities are currently the most important clients in the market in terms of capacity installed, but interest in community-owned wind power projects is rising in Australia, Canada, Japan, the United States, parts of Europe, and elsewhere.[45] In the U.S. state of Iowa alone, at least six community projects came on line in 2012, and several projects were under way in Australia by year's end.[46] In Japan, interest has increased considerably since the Fukushima disaster in March 2011.[47] Community power represents the mainstream ownership model in Denmark and Germany.[48]

The use of small-scale turbines[i] is also increasing to meet energy needs both on- and off-grid and is driven by the development of lower-cost grid-connected inverters; volatile or rising fossil fuel prices; and government incentives.[49] Off-grid and mini-grid uses prevail, particularly in China and other developing countries.[50] Applications are expanding and include rural electrification, water pumping, telecommunications, defence, and other remote uses.[51] There are two distinct markets: models with rated capacity below 10 kW, and those in the 10–500 kW range.[52] In general, the market is evolving towards 50 kW and larger turbines because they are easier to finance.[53]

Worldwide, at least 730,000 small-scale turbines were operating at the end of 2011, totaling 576 MW (up 27% over 2010).[54] China accounts for 40% of global capacity and the United States for 35%, followed by the United Kingdom (11%), Germany (2.6%), Ukraine, Canada, Italy, Poland, and Spain.[55] In 2012, the total capacity of U.S. sales of small-scale turbines was 18.4 MW.[56] With the exception of China, most interest is in North America and Europe, with slow progress in emerging wind markets.[57]

Total wind power capacity by the end of 2012 was enough to meet at least 2.6–3% of global electricity consumption.[58] In the EU, wind capacity operating at year's end was enough to cover 7% of the region's electricity consumption in a normal wind year (up from 6.3% in 2011).[59] Several countries met higher shares of their electricity demand with wind, including Denmark (30% in 2012; up from nearly 26% in 2011), Portugal (20%; up from 18%), Spain (16.3%; up from 15.9%), Ireland (12.7%, up from 12%), and Germany (7.7%; down from 8.1%).[60]

Four German states had enough capacity at year's end to meet over 49% of their electricity needs with wind, and through the month of July the state of South Australia generated 26% of its electricity with wind power.[61] In the United States, wind power represented 3.5% of total electricity generation (up from 2.9% in 2011) and met more than 10% of demand in nine states (five in 2011), with Iowa nearing 25% (up from 19%) and South Dakota at 24% (up from 22%).[62]

WIND POWER INDUSTRY

During 2005–2009, turbine prices increased in response to growing global demand, rising material costs, and other factors; since then, however, growing scale and greater efficiency have combined to improve capacity factors and reduce costs of turbines as well as operations and maintenance.[63] Oversupply in global turbine markets has further reduced prices, benefitting developers by improving the cost-competitiveness of wind power relative to fossil fuels. However, the industry has been challenged by downward pressure on prices, combined with increased competition among turbine manufacturers, competition with low-cost gas in some markets, and reductions in policy support driven by economic austerity.[64]

Relative to their 2008 peak, turbine prices fell by as much as 20–25% in western markets and more than 35% in China before stabilising in 2012.[65] The costs of operating and maintaining wind farms also dropped significantly due to increased competition among contractors and improved turbine performance.[66] As a result, onshore wind-generated power is now cost-competitive with or cheaper than conventional power in some markets on a per kilowatt-hour basis (including some locations in Australia, India, and the United States), although new shale gas in some countries is making it more difficult for wind (and other renewables) to compete with natural gas.[67] Offshore wind remains at least twice as expensive as onshore.[68]

The world's top 10 turbine manufacturers captured 77% of the global market and, as in 2011, they hailed from China (4), Europe (4), India (1), and the United States (1). Vestas (Denmark), the top manufacturer since 2000, surrendered its lead to GE Wind (third in 2011), which blew ahead due mainly to the strong U.S. market.[69] Siemens moved from ninth to third, followed by Enercon (Germany) and Suzlon Group (India), both of which moved up one spot relative to 2011.[70] Other top companies were Gamesa (Spain) and Goldwind, United Power, Sinovel, and Mingyang (all China); both Goldwind and Gamesa dropped out of the top five.[71] (See Figure 20.)

In 2012, more than 550 manufacturing facilities were making wind turbine components in every region of the United States; despite ongoing policy uncertainty, the share of equipment produced domestically increased considerably over the past

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 International Electrotechnical Commission sets a limit at 50 kW, and 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/province, and there is no globally recognised definition or size limit.

decade, reducing transport-related costs and creating jobs.[72] (See Sidebar 4.) In Europe, industry activity focused increasingly on offshore technologies and project development in Eastern Europe and other emerging markets.[73] By late 2012, Brazil was home to 11 manufacturing plants and GE had a facility under construction, and India had 19 manufacturers with a consolidated annual production capacity exceeding 9.5 GW.[74]

In general, however, the turbine manufacturing industry was hit hard by rising costs, reductions in government support, and overcapacity, with several manufacturers delaying or cancelling expansion plans, scaling back operations, reducing their workforce, or filing for bankruptcy [75] In the United States, companies throughout the wind energy supply chain reduced workforces and closed facilities due to policy uncertainty.[76] Vestas (Denmark) chose to restructure, let go of thousands of employees, and end production of its kW size machines.[77] Sinovel (China) put workers on leave, and many suppliers in China in particular have been pushed to the edge of collapse, with overcapacity pushing smaller manufacturers out of the market.[78] Suzlon (India) has lost money for three years running and has struggled with massive debt.[79]

At the same time, expansion and innovation continued in 2012. Local-content requirements (see Policy Landscape section) have not only spawned trade disputes but also led turbine manufacturers to build factories close to growing markets for competitive advantage.[80] Chinese companies are taking package deals (including government-backed loans) to emerging markets and are establishing subsidiaries and partnerships with local companies to deploy their excess capacity.[81] Manufacturers are also assuming more risk to increase their share of the growing market for turbine maintenance, which is expected to provide relatively stable margins.[82]

Turbine designs continue to evolve in order to reduce costs and/or improve performance, with trends towards longer blades, lower wind speeds, and new materials such as concrete for towers and carbon fibre for blades.[83] At least two companies launched turbines for low-wind sites in 2012, and GE started developing blades made of tough, flexible fabric that could reduce blade costs by 25–40%.[84] There is also a shift forwards towards automated manufacturing of blades and a shift back to traditional doubly-fed induction generators and medium-speed hybrid drives.[85]

The trend towards ever-larger turbines continued in 2012, with the average size delivered to market rising to 1.8 MW (from 1.7 GW in 2011).[86] Average turbine sizes were 3.1 MW in Denmark, 2.4 MW in Germany, 1.9 MW in the United States, 1.6 MW in China, and 1.2 MW in India.[87] During 2012, the average size installed offshore in Europe was up 14% over 2011 to 4 MW, and 31 companies announced plans for 38 new offshore turbine models, with three-quarters of these being 5 MW and up.[88] Most manufacturers are developing turbines in the 4.5–7.5 MW range, with 7.5 MW being the largest size that is commercially available, but several companies announced plans in 2012 to develop even larger machines.[89] Turbines are also rising higher and being outfitted with longer blades to capture more energy: REpower erected its tallest turbine to date, with a 143-metre hub height, and Siemens unveiled the "longest blades in the world" at 75 metres.[90]

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.[91] Several countries have pilot programmes for floating turbines, and Japan launched its first (100 kW machine) in 2012, with plans to install a full-scale machine in 2013.[92] In Europe, the average offshore wind farm size increased 36% relative to 2011 (to 271 MW).[93] As offshore projects become larger, there is growing competition for manufacturing capacity and installation resources, creating a trend towards vertical integration and consolidation in the supply chain, including installation vessels, with several project developers securing vessels and some funding new ones.[94]

The small-scale (<100 kW) wind industry also continued to mature in 2012, with hundreds of manufacturers worldwide, expanding dealer networks, and increasing importance of turbine certification.[95] Most manufacturers and service providers are concentrated in China, North America, and Europe.[96]

As an example of efforts to diversify to survive, RRB Energy Ltd. of India is restarting production of a slightly larger-scale 225 kW turbine, discontinued in 2005, with plans to export many of the units to emerging markets in Africa and elsewhere.[97] Gamesa plans to move into development of distributed and community wind projects.[98]

See Table 2 on pages 58–59 for a summary of the main renewable energy technologies and their characteristics and costs.[99]

SIDEBAR 4. JOBS IN RENEWABLE ENERGY

An estimated 5.7 million people worldwide work directly or indirectly[i] in the renewable energy sector, based on a wide range of studies, principally from the period 2009–2012. (See Table 1.) This global figure should not be understood as a direct, year-on-year comparison with the 5 million jobs estimate published in *GSR 2012*, but rather as an ongoing effort to refine the data. Global numbers remain incomplete, methodologies are not harmonised, and the different studies used are of uneven quality. The global renewable energy workforce encompasses a broad variety of jobs and occupations, ranging from low- to very high-skilled.

Although a growing number of countries is investing in renewable energy, the bulk of employment remains concentrated in a relatively small number of countries, including Brazil, China, India, the members of the EU, and the United States. These are the major manufacturers of equipment, producers of bioenergy feedstock, and leading installers of production capacity. Employment is growing in other countries as well, and there are increasing numbers of jobs (technicians and sales staff) in the off-grid sector of the developing world. For example, selling, installing, and maintaining small PV panels in rural Bangladesh provide livelihoods directly for as many as 70,000 people; some 150,000 people are employed directly and indirectly.

By technology, the largest number of jobs, about 1.38 million, is currently in the biofuels value chain—mostly in cultivating and harvesting feedstock, where jobs fluctuate seasonally. Brazil's sugarcane-based ethanol industry is the largest biofuels employer, but increasing mechanisation of feedstock harvesting has reduced the number of direct jobs in sugarcane and ethanol processing to 579,000 in 2011.

With the exception of EU data, the estimates for biomass heat and power are quite soft and dated. Geothermal and hydropower data in Table 1 are based on rough calculations. For solar heating/cooling, there are significant discrepancies among available sources, and estimates range from 375,000 jobs globally to 800,000 for China alone.

Although the growth of jobs in the wind industry has slowed somewhat globally, employment in solar PV has surged in recent years. Yet solar PV is experiencing turbulence, as massive overcapacities and tumbling prices have caused layoffs and bankruptcies on the manufacturing side, while allowing sharp increases in the ranks of installers.

Hit hard by economic crisis and adverse policy changes, Spanish renewable energy employment fell from 133,000 jobs in 2008 to 120,000 in 2011. The CSP industry at first offset a portion of the job loss, but it is in trouble itself now due to policy changes, with employment falling below 18,000 in 2012. In France, 17% of renewable energy jobs were lost between 2010 and 2012, principally in solar PV and geothermal heat pumps. Germany lost 23,000 solar PV jobs in 2012, but added 17,000 wind power jobs.

In the United States, solar employment related to installations is soaring, while the number of wind and biofuels jobs fluctuates in response to policy changes and other factors. For example, U.S. biofuels employment declined from 181,300 to 173,600 in 2012 due to soaring feedstock prices, a drought-induced decline in yield, and lower demand.

Overall, aggregate worldwide renewable energy employment continues to increase in a dynamic—albeit somewhat tumultuous—process that entails both gains and losses in different parts of the world.

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

Technologies	Global	China	EU	Brazil	United States	India	Germany	Spain
	Thousand Jobs							
Biomass[a]	753	266	274		152[f]	58	57	39
Biofuels	1,379	24	109	804[e]	217[g]	35	23	4
Biogas	266	90	71			85	50	1
Geothermal[a]	180		51		35		14	0.3
Hydropower (Small)[b]	109		24		8	12	7	2
Solar PV	1,360	300[d]	312		90	112	88	12
CSP	53		36		17		2	34[j]
Solar Heating/ Cooling	892	800	32		12	41	11	1
Wind Power	753	267	270	29	81	48	118	28
Total[c]	**5,745**	**1,747**	**1,179**	**833**	**611**	**391**	**378[h]**	**120**

a Power and heat applications. b 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. c Derived from the totals of each renewable energy technology. d Estimates run as high as 500,000. e About 365,000 jobs in sugarcane and 213,400 in ethanol processing in 2011; also includes 200,000 indirect jobs in manufacturing the equipment needed to harvest and refine sugar cane into biofuels, and 26,000 jobs in biodiesel. f Bio-power direct jobs run only to 15,500. g Includes 173,600 jobs for ethanol and 42,930 for biodiesel in 2012. h Includes 9,400 jobs in publicly funded R&D and administration; not broken down by technology. j 2011 estimate by the Spanish Renewable Energy Association (APPA); Protermosolar offers a somewhat lower figure for the same year (28,850 jobs) and finds that the number fell to 17,816 in 2012.

i 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.

Notes: Data are principally for 2009–2012, with dates varying by country and technology. Totals may not add up due to rounding.

Source: IRENA, *Renewable Energy and Jobs* (Abu Dhabi: 2013).

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

Technology	Typical Characteristics	Capital Costs (USD/kW)	Typical Energy Costs (LCOE – U.S. cents/kWh)
Power Generation			
Bioenergy combustion: Boiler/steam turbine Co-fire; Organic MSW	Plant size: 25–200 MW Conversion efficiency: 25–35% Capacity factor: 50–90%	800–4,500 Co-fire: 200–800	5.5–20 Co-fire: 4–12
Bioenergy gasification	Plant size: 1–10 MW Conversion efficiency: 30–40% Capacity factor: 40–80%	2,050–5,500	6–24
Bioenergy anaerobic digestion	Plant size: 1–20 MW Conversion efficiency: 25–40% Capacity factor: 50–90%	Biogas: 500–6,500 Landfill gas: 1,900–2,200	Biogas: 6–19 Landfill gas: 4–6.5
Geothermal power	Plant size: 1–100 MW Capacity factor: 60–90%	Condensing flash: 2,100–4,200 Binary: 2,470–6,100	Condensing flash: 6–13 Binary: 7–14
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	2–12
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) Capacity factor: 10–25% (fixed tilt)	2,275 (Germany; average residential) 4,300–5,000 (USA) 3,700–4,300 (Japan) 1,500–2,600 (Industrial)	20–46 (OECD) 28–55 (non-OECD) 16–38 (Europe)
Solar PV: Ground-mounted utility-scale	Peak capacity: 2.5–250 MW Capacity factor: 10–25% (fixed tilt) Conversion efficiency: 10–30% (high end is CPV)	1,300–1,950 (Typical global) Averages: 2,270 (USA); 2,760 (Japan); 2,200 (China); 1,700 (India)	12–38 (OECD) 9–40 (non-OECD) 14–34 (Europe)
Concentrating solar thermal power (CSP)	Types: parabolic trough, Fresnel, tower, dish Plant size: 50–250 MW (trough); 20–250 MW (tower); 10–100 MW (Fresnel) Capacity factor: 20–40% (no storage); 35–75% (with storage)	Trough, no storage: 4,000–7,300 (OECD); 3,100–4,050 (non-OECD) Trough, 6 hours storage: 7,100–9,800 Tower, 6–15 hours storage: 6,300–10,500	Trough and Fresnel: 19–38 (no storage); 17–37 (6 h. storage) Tower: 20–29 (6–7 hours storage); 12–15 (12–15 hours storage)
Wind: Onshore	Turbine size: 1.5–3.5 MW Capacity factor: 25–40%	1,750–1,770 925–1,470 (China and India)	5–16 (OECD) 4–16 (non-OECD)
Wind: Offshore	Turbine size: 1.5–7.5 MW Capacity factor: 35–45%	3,000–4,500	15–23
Wind: Small-scale	Turbine size: up to 100 kW	3,000–6,000 (USA); 1,580 (China)	15–20 (USA)
Hot Water/Heating/Cooling			
Bioenergy heat plant	Plant size: 0.1–15 MW$_{th}$ Capacity factor: ~50–90% Conversion efficiency: 80–90%	400–1,200	4.7–29
Domestic pellet heater	Plant size: 5–100 MW$_{th}$ Capacity factor: 15–30% Conversion efficiency: 80–95%	360–1,400	6.5–36
Bioenergy CHP	Plant size: 0.5–100 kW$_{th}$ Capacity factor: ~60–80% Conversion efficiency: 70–80% for heat and power	600–6,000	4.3–12.6
Geothermal space heating (buildings)	Plant size: 0.1–1 MW$_{th}$ Capacity factor: 25–30%	1,865–4,595	10–27
Geothermal space heating (district)	Plant size: 3.8–35 MW$_{th}$ Capacity factor: 25–30%	665–1,830	5.8–13
Ground-source heat pumps	Plant size: 10–350 kW$_{th}$ Capacity factor: 25–30%	500–4,000	7–23

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

Technology	Typical Characteristics	Capital Costs	Typical Energy Costs
		(USD/kW)	(LCOE – U.S. cents/kWh)
Hot Water/Heating/Cooling (continued)			
Solar thermal: Domestic hot water systems	Collector type: flat-plate, evacuated tube (thermosiphon and pumped systems) Plant size: 2.1–4.2 kWth (single family); 35 kWth (multi-family) Efficiency: 100%	Single-family: 1,100–2,140 (OECD, new build); 1,300–2,200 (OECD, retrofit) 150–635 (China) Multi-family: 950–1,850 (OECD, new build); 1,140–2,050 (OECD, retrofit)	1.5–28 (China)
Solar thermal: Domestic heat and hot water systems (combi)	Collector type: same as water only Plant size: 7–10 kWth (single-family); 70–130 kWth (multi-family); 70–3,500 kWth (district heating); >3,500 kWth (district heat with seasonal storage) Efficiency: 100%	Single-family: same as water only Multi-family: same as water only District heat (Europe): 460–780; with storage: 470–1,060	5–50 (domestic hot water) District heat: 4 and up (Denmark)
Solar thermal: Industrial process heat	Collector type: flat-plate, evacuated tube, parabolic trough, linear Fresnel Plant size: 100 kWth–20 MWth Temperature Range: 50–400° C	470–1,000 (without storage)	4–16
Solar thermal: Cooling	Capacity: 10.5–500 kWth (absorption chillers); 8–370 kWth (adsorption chillers) Efficiency: 50–70%	1,600–5,850	n/a
	Feedstocks	Feedstock characteristics	Production costs (U.S. cents/litre)[i]
Transport Fuels			
Biodiesel	Soy, rapeseed, mustard seed, palm, jatropha, waste vegetable oils, and animal fats	Range of feedstocks with different crop yields per hectare; hence, production costs vary widely among countries. Co-products include high-protein meal.	Soybean oil: 45-90 (Argentina/USA) Palm oil: 30–100 (Indonesia/Malaysia/ Thailand/Peru) Rapeseed oil: 120–140 (EU)
Ethanol	Sugar cane, sugar beets, corn, cassava, sorghum, wheat (and cellulose in the future)	Range of feedstocks with wide yield and cost variations. Co-products include animal feed, heat and power from bagasse residues. Advanced biofuels are not yet fully commercial and have higher costs.	Sugar cane: 45–80 (Brazil) Corn (dry mill): 60–120 (USA)
		Installed costs (USD/kW) or LCOE (U.S. cents/kWh)	
Rural Energy			
Biogas digester	Digester size: 6–8 m^3	n/a	
Biomass gasifier	Size: 20–5,000 kW	LCOE: 8–12	
Solar home system	System size: 20–100 W	LCOE: 40–60	
Household wind turbine	Turbine size: 0.1–3 kW	Capital cost: 10,000/kW (1 kW turbine); 5,000/kW (5 kW); 2,500/kW (250 kW) LCOE: 15–35+	
Village-scale mini-grid	System size: 10–1,000 kW	LCOE: 25–100	

Notes: Costs are indicative economic costs, levelised, and exclusive of subsidies or policy incentives. Several components determine the levelised costs of energy (LCOE), including: resource quality, equipment cost and performance, balance of system/project costs (including labour), operations and maintenance costs, fuel costs (biomass), the cost of capital, and productive lifetime of the project. The costs of renewables are site specific, as many of these components can vary according to location. Costs for solar electricity vary greatly depending on the level of available solar resources. It is important to note that the rapid growth in installed capacity of some renewable technologies and their associated cost reductions mean that data can become outdated quickly; solar PV costs, in particular, are changing rapidly. Costs of off-grid hybrid power systems that employ renewables depend largely on system size, location, and associated items such as diesel backup and battery storage. Data for rural energy are unchanged from GSR 2011, with the exception of wind turbines.

i Litre of diesel or gasoline equivalent

Source: See Endnote 99 in Wind Power section for sources and assumptions.

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Wind turbines on the eastern slopes of the San Gorgonio Pass in California, United States. Global new investment in renewable power and fuels reached USD 244 billion in 2012, down 12% relative to 2011, due to policy uncertainties and falling costs. The balance of investments shifted dramatically, with developing countries accounting for nearly half of the global total.

Source: NASA

03 INVESTMENT FLOWS

Global new investment in renewable power and fuels was USD 244 billion in 2012, down 12% from the previous year's record amount of USD 279 billion.[1 i] (See Sidebar 5, p. 64, and Figure 21.) Despite the setback, the total in 2012 was the second highest ever and 8% above the 2010 level. If the unreported investments in hydropower projects larger than 50 MW and in solar hot water collectors are included, total new investment in renewable energy exceeded USD 285 in 2012.[ii] This is lower than the equivalent estimate for 2011, however.

The decline in investment – after several years of growth – resulted from uncertainty over support policies in Europe and the United States, as well as from actual retroactive reductions in support. On a more positive note, it also resulted from sharp reductions in technology costs.

A major theme of 2012 was a further movement in activity from developed to developing economies, although the former group still accounted for more than half of global investment. In 2007, developed economies invested two-and-a-half times more in renewables (excluding large hydro) than developing countries did; in 2012, the difference was only 15%. China was once again the dominant country for renewable energy investment.

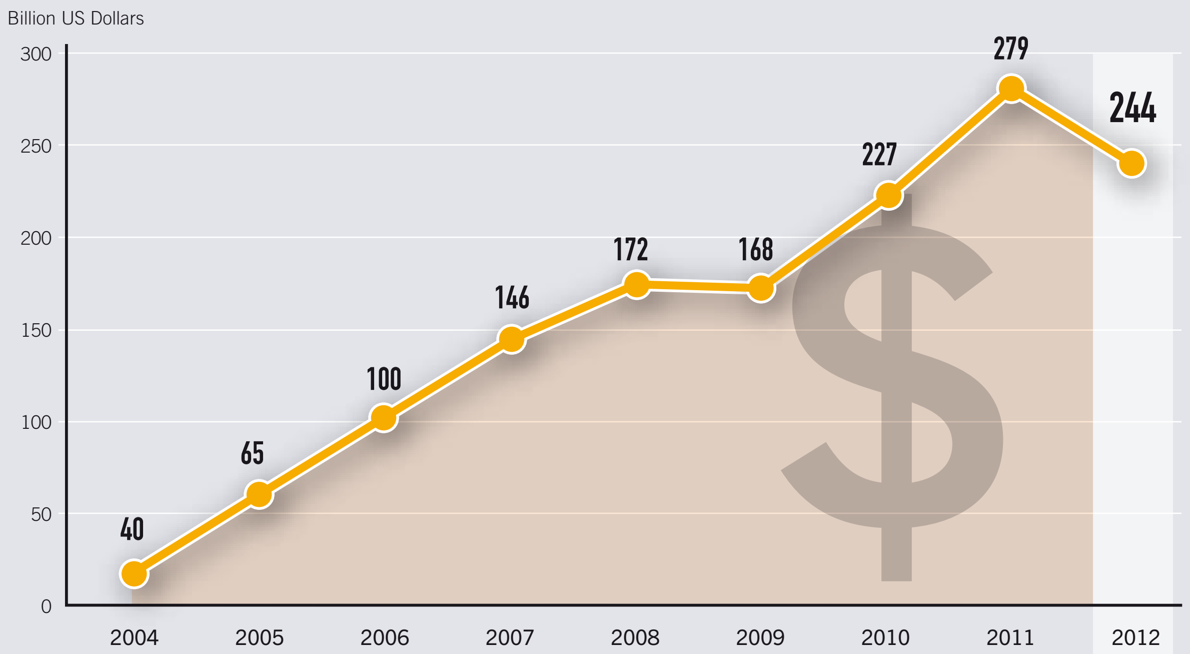
The other major theme of 2012 was a further, significant reduction in the costs of solar PV technology. In fact, the continued improvements in cost-competitiveness for solar and wind power helped to support demand in many markets.

INVESTMENT BY ECONOMY

The year 2012 saw the most dramatic shift yet in the balance of renewable energy investment worldwide, with the dominance of developed countries waning and the importance of developing countries growing. In the developing world, renewable energy outlays reached USD 112 billion, up from USD 94 billion in 2011, and represented some 46% of the world total (up from 34% in 2011 and 37% in 2010). By contrast, outlays by developed economies fell sharply (29%), from USD 186 billion in 2011 to USD 132 billion in 2012, the lowest level since 2009.

This shift reflects three important trends: a reduction in subsidies for wind and solar project development in Europe and the United States; increasing investor interest in emerging markets that offer both rising power demand and attractive

FIGURE 21. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY, 2004–2012



Source: See Endnote 1 for this section.

i This section is derived from Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2013* (Frankfurt: 2013), 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 generation projects of more than 1 MW; all hydro projects of between 1 and 50 MW; all solar power 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 an annual production capacity of 1 million litres or more. For more detailed information, please refer to the FS-UNEP/BNEF *Global Trends* report.

ii Investment in large hydropower (>50 MW) and solar water collectors is not included in the overall total for investment in renewable energy. BNEF tracks only hydropower projects of between 1 MW and 50 MW, and solar water collectors are not included with small-scale projects because they do not generate power.

renewable energy resources; and falling technology costs of wind and solar PV.

Several regions of the world experienced a reduction in investment in 2012 relative to 2011; the exceptions were Asia and the Middle East, the Americas excluding the United States and Brazil, and Africa.[2] (See Figure 22.) Europe and China continued to be the most significant investors; together, they accounted for 60% of the world total in 2012, even though it was Europe's weakest year since 2009.

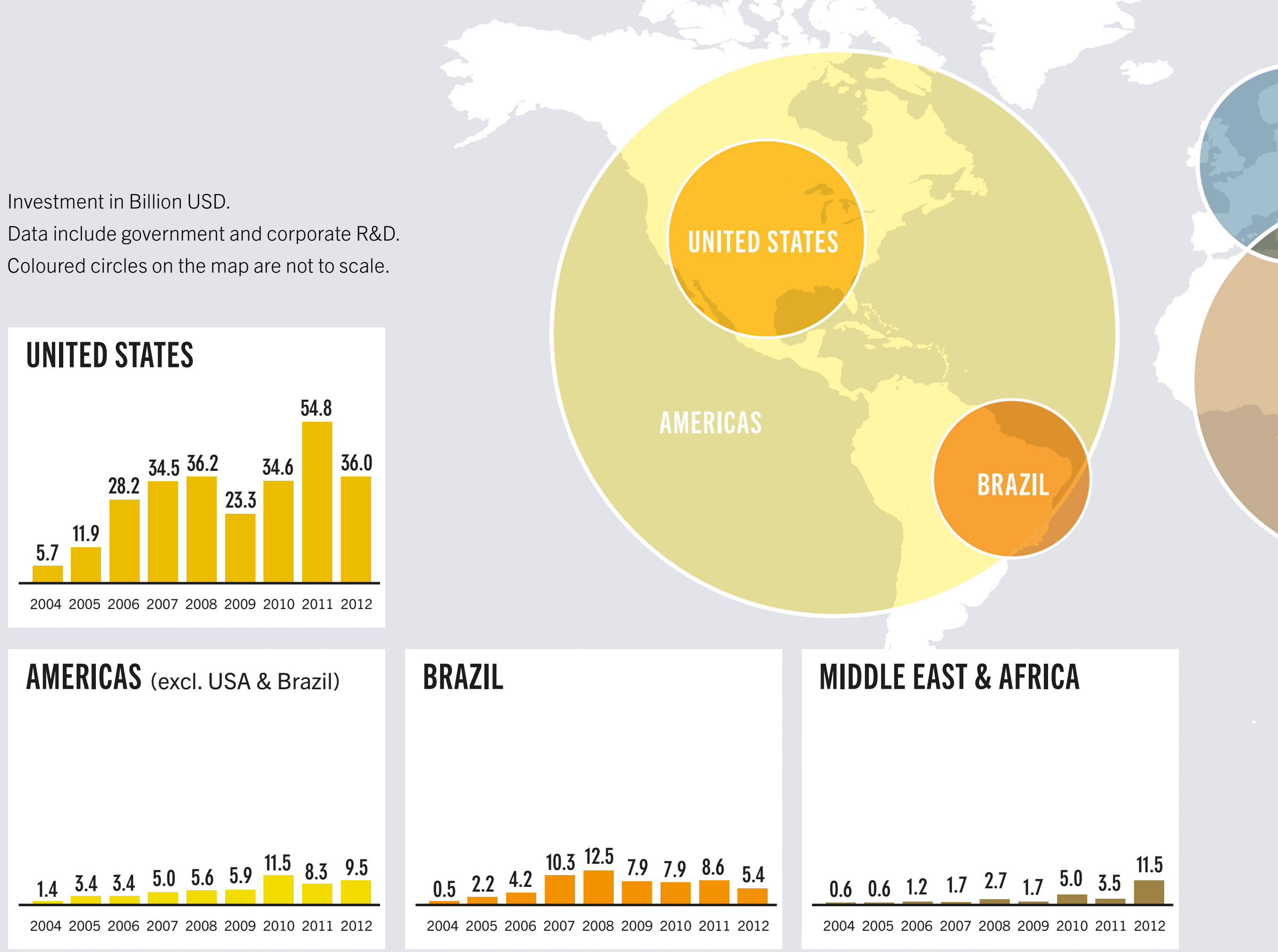
At the national level, the top investors included four developing countries (most of the BRICS countries) and six developed countries. China was in the lead with USD 64.7 billion invested, followed by the United States (USD 34.2 billion), Germany (USD 19.8 billion), Japan (USD 16.0 billion), and Italy (USD 14.1 billion). The next five were the United Kingdom (USD 8.8 billion), India (USD 6.4 billion), South Africa (USD 5.7 billion), Brazil (USD 5.3 billion), and France (USD 4.6 billion).[i]

China accounted for USD 66.6 billion (including R&D) of renewable energy new investment, up 22% from 2011 levels. It was fuelled by strong growth in the solar power sector, including both utility-scale[ii] and small-scale projects (<1 MW).

In the United States, overall asset finance dropped to USD 23.4 billion, which is 49% below the 2011 total. This was due primarily to the decline in large solar project financing, from USD 26.7 billion to USD 6.9 billion, which resulted from the expiration of two renewable energy incentives in late 2011. There was a high level of wind asset finance in 2011, driven by a rush to install projects before expected expiration of the U.S. production tax credit at the end of 2012. Due to the time lag between financing and construction, this translated into record capacity additions in 2012; but the financing of wind rose only 5% in 2012, from USD 14.1 billion in 2011 to USD 14.8 billion.

Although Germany's total investment in renewables slipped 35%, it remained the third largest investor, installing far more solar PV capacity than any other country, most of it small-scale. The value of Germany's investment in small-scale solar PV projects fell by 15% to USD 15 billion, reflecting the sharp reductions in module prices during the year.

FIGURE 22. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY REGION, 2004–2012



i National investment totals do not include government and corporate R&D because such data are not available for all of these countries.

ii Utility-scale refers to wind farms, solar parks, and other renewable power installations of 1 MW or more in size, and biofuel plants of more than 1 million litres' capacity.

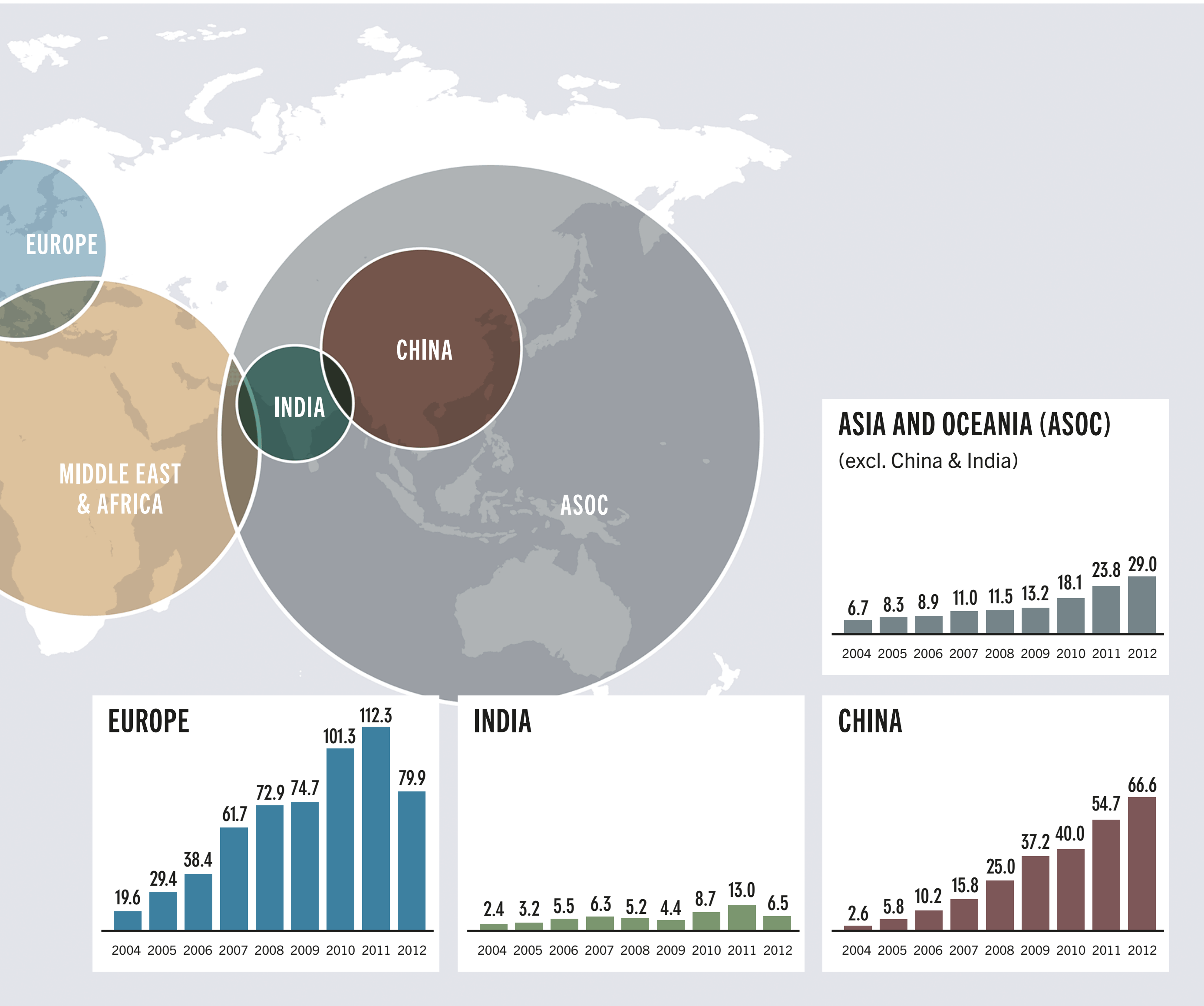
Germany invested more than any other country in small-scale renewables, but there was a fairly narrow gap between Germany's input and investments in Japan and Italy. The United States and China took fourth and fifth places for investment in small-scale capacity.

Japan's utility-scale finance jumped 229% to USD 3 billion, and the country saw spectacular investment in small-scale projects, which grew 56% to USD 13.1 billion. These significant increases in both sectors reflect Japan's decision after the March 2011 Fukushima nuclear disaster to encourage renewable energy deployment more vigorously. Japan's feed-in tariff (FIT) for solar PV installations has been particularly attractive for investors.

In Italy, investment in renewable energy fell 53% in 2012, to USD 14.1 billion. This was due to lower payments under Italy's feed-in tariff (FIT) and to the strict limits put on the amount of new wind and solar power capacity eligible for FIT support. Small-scale investment accounted for most of this total, at USD 13 billion.

While investment was down in most leading developed country markets, it increased substantially in a number of new markets around the world. There is striking momentum in the Middle East and Africa, where annual investment in renewable energy has risen from less than USD 1 billion in the middle of the last decade to USD 11.5 billion in 2012. South Africa experienced a stunning leap in 2012, increasing its investment in renewable energy from a few hundred million dollars to USD 5.7 billion. Elsewhere in Africa, Morocco saw a jump in outlays from USD 297 million to USD 1.8 billion, while Kenya saw commitments rise from almost zero in 2011 to USD 1.1 billion in 2012.

In Latin America, Brazil continued to be the leading investor despite a 38% decline in 2012. But investment in renewable energy is growing rapidly elsewhere. Mexico's investment increased more than fivefold, from USD 352 million in 2011 to USD 2 billion in 2012, and Chile and Peru turned out to be attractive new markets.



Source: See Endnote 2 for this section.

SIDEBAR 5. INVESTMENT TYPES AND TERMINOLOGY

Investments in renewable energy are made by a range of public and private entities and throughout the financing continuum, from the birth of an idea or technology, to the construction of renewable energy plants, to sale of the companies that manufacture renewable energy equipment. Types and levels of investment differ depending on the stage in the process:

1. **Technology Research:** Focused on the development of new knowledge and potential products or ideas. Funding comes from private and (primarily) public R&D funds looking towards a long-term investment horizon with relatively uncertain returns. The share of global new investment in research in renewables technology in 2012 was about 4%.
2. **Technology Development/Commercialisation:** Promising ideas or knowledge that emerge from R&D activities are developed into commercially viable products, processes, or services. Large corporations fund these development activities in-house, whereas smaller entities usually must raise external financing, typically from high-risk investors seeking higher returns such as venture capitalists (VC) and, to a limited extent, private equity investors. The share of global new investment in technology development and commercialisation in 2012 was almost 1%.
3. **Manufacturing:** Commercialised technology is produced at scale through the mobilisation of assets and the establishment of manufacturing facilities. Funding for this stage is derived from private equity expansion capital and from public equity markets (stock markets). The share of global new investment in manufacturing in 2012 was over 2%.
4. **Project (Roll-out):** The most capital-intensive phase, during which technology is installed and commercially operated (requiring expenditure on land, permits, and licenses, as well as engineering, procurement, and construction). Projects are either small-scale distributed capacity (<1 MW) or utility-scale projects. Utility-scale project funding typically comes from corporate finance (e.g., utility balance sheets) or public equity, bonds, and to a limited extent carbon markets. The share of global new investment for utility-scale project finance was 61%, and for small-scale projects it was 33%.)
5. **Mergers and Acquisitions (M&A):** Refinancing and the sale of companies and projects. Merger refers to the joining together of two companies to form a new enterprise; acquisition is the takeover or purchase of one business or company by another.

New investment refers to all money invested in renewable energy projects during stages 1–4 (VC, private equity, public equity markets, debt markets, etc.). Total investment is a larger figure that includes new investment plus M&A activity.

Other Useful Terms:

Asset finance. All money invested in generation projects, whether from internal company balance sheets, from debt finance, or from equity finance.

Investment, net and gross. Net investment is investment in additional capacity installed. Gross investment also includes investment in new capacity that replaces existing capacity.

Private equity (expansion capital). Equity capital that is not publicly traded on a stock exchange or used to advance technology, strengthen the balance sheet, or advance other needs within a corporation. Private equity expansion capital is finance for the growth or expansion of a company to increase production capacity or market or product development, or to provide additional working capital.

Public markets. Markets organised for trading the equity of publicly quoted companies.

Venture capital (VC). Financial capital invested in early-stage, high-potential, and high-risk startup companies in exchange for owning equity in those companies.

Source: See Endnote 1 for this section.

INVESTMENT BY TECHNOLOGY

In 2012, solar power was the leading sector by far in terms of money committed; at USD 140.4 billion, solar accounted for more than 57% of total new investment in renewable energy. Wind power was second with USD 80.3 billion, representing almost 33%. The remaining 10% of total new investment was made up of bio-power and waste-to-energy[i] (USD 8.6 billion), small-scale hydropower (<50 MW) (USD 7.8 billion), biofuels (USD 5 billion), geothermal power (USD 2 billion), and ocean energy (USD 0.3 billion). With the exception of small-scale hydropower and ocean energy, investment in 2012 declined relative to 2011 in all renewable sectors tracked by Bloomberg New Energy Finance (BNEF).[3] (See Figure 23 and Table R9.)

Approximately 96% of investment in the solar sector went to solar PV (USD 135.1), with the remaining share going to concentrating solar thermal power (CSP) (USD 5.3 billion). Solar investment dropped in 2012, due primarily to a slump in financing of CSP projects in Spain and the United States (down USD 14 billion from 2011), as well as to sharply lower PV system prices.

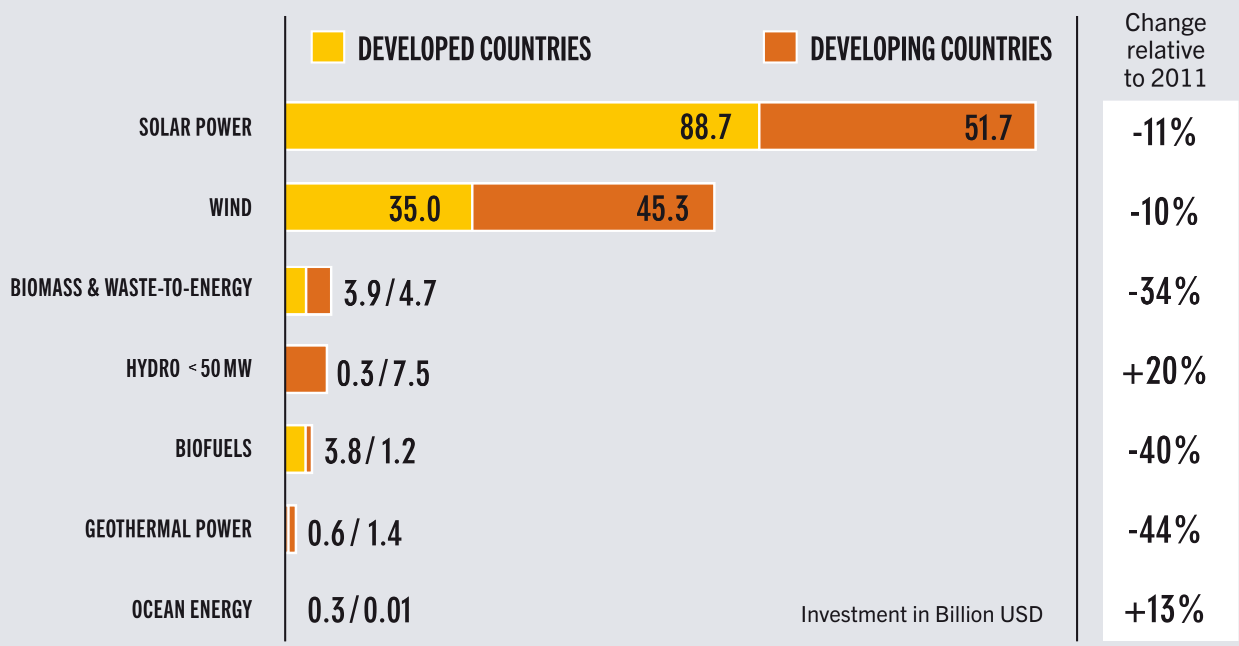
Solar power investment continued to be dominated by developed economies, which together accounted for 63% of the total (down from 80% in 2011).[4] Germany, the United States, Japan, and Italy were four of the five largest investors in solar power capacity in 2012. Even so, China accounted for the largest share, at 22% of global investment. The USD 31.3 billion that China invested in 2012 was up sharply from USD 17.8 billion in 2011. Overall, solar power investment in developing countries rocketed up 72% to USD 51.7 billion, while investment in developed markets fell 31% to USD 88.7 billion.

Aside from solar energy, developed countries maintained a lead only in biofuels and the embryonic sector of ocean energy. In all other technologies—including wind power, small-scale hydro, biomass and waste-to-energy, and geothermal power—developing economies were at the forefront. This represents a dramatic break from previous years; in 2011, developing countries were the major investors only in small-scale hydropower.[5]

Detailed statistics are not available for solar water heating (SWH) technologies or large hydropower projects over 50 MW in size. It is estimated that about 55 GW_{th} of solar collector capacity was added during 2012, with about 80% of this capacity installed in China.[6] The value of this investment is hard to estimate, given the wide range of prices paid for different solar collector technologies, but it is likely to have exceeded USD 10 billion.

Investment in large hydropower projects of more than 50 MW continued to be significant in 2012, exceeding all other renewable energy sectors except wind and solar power. Translating capacity additions into asset finance dollars per year is not straightforward because the average project takes four years to build, but it is estimated that asset financing for large hydro projects commissioned in 2012 totalled at least USD 33 billion—over a fifth of the USD 148.5 billion value of asset finance excluding large hydro.[7]

FIGURE 23. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY TECHNOLOGY, DEVELOPED AND DEVELOPING COUNTRIES, 2012



Source: See Endnote 3 for this section.

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

INVESTMENT BY TYPE

Global research and development (R&D) spending on renewable energy inched 1% higher to USD 9.6 billion in 2012, marking the eighth consecutive year rise. (See Table R9.) Global R&D investment has almost doubled since 2004 in absolute terms (up 93%); however, R&D spending by OECD governments as a proportion of GDP is scarcely a quarter of its level 30 years ago.[8] Europe remained the largest centre for R&D in total, but China moved ahead on government spending. The United States was the only region to show positive, although modest, trends in both corporate and government outlays during 2012.

On the whole, government R&D spending rose 3% to USD 4.8 billion, while corporate R&D fell 1% to just below USD 4.8 billion, making public and private spending broadly equal for

the third year in a row. Solar power continued to dominate at USD 4.9 billion, claiming just over half (51%) of all research dollars spent, despite a 1% fall relative to 2011. It was followed by wind power (up 4% to USD 1.7 billion), and biofuels (up 2% to USD 1.7 billion).

Venture capital and private equity investment (VC/PE) in renewable energy fell by 30% to USD 3.6 billion, the lowest level since 2005, as VC/PE investors faced a bleak economic outlook in Europe, China, and the United States. Other factors driving the decline were overcapacity, plunging product prices, subsidy reductions, and continuing policy uncertainty. Three-quarters of the decline was in private equity expansion capital, and most of the remaining decrease was in early-stage venture capital. By contrast, seed funding, the earliest stage of VC, rose 146% over 2011. While solar remained the largest sector for VC/PE, it suffered the steepest decline, down 40% to USD 1.5 billion, followed by investment in biomass and waste-to-energy, which halved to USD 500 million.

Amid the economic gloom, new *public market investment* (in stock markets) in renewable energy slumped by more than 60% to just over USD 4 billion, scarcely a fifth of the peak level established in 2007. The main reasons for under-performance of renewables shares were distress in the wind and solar supply chains due to overcapacity and unease about policy developments in Europe and the United States. Wind suffered the most, down 72% to USD 1.3 billion. This left solar power as the biggest issuer of new stocks, at USD 2.3 billion, despite the fact that it was down 50% relative to 2011. Biofuels took third place with USD 400 million, but shrank 43%.

Asset finance of utility-scale projects again made up the lion's share (61%) of total new investment in renewable energy, totalling USD 148.5 billion in 2012. This was down 18% from the record USD 180.1 billion in 2011, but ahead of the USD 143.7 billion in 2010. The utility-scale share of all renewable energy investment was down four percentage points from 2011, reflecting the rising share of total investment going to small (<1 MW) residential and commercial solar projects.

Small-scale distributed capacity was the renewable energy stalwart of the year. Investment in small-scale installations rose by 3% to USD 80 billion, compared with the 12% decline in total new investment in renewable energy. This means that projects of less than 1 MW capacity attracted almost a third of the total new investment—up from 28% in 2011 and 27% in 2004. Although the 3% rise was far below the 24% growth seen in 2011, it came despite a further significant drop in solar PV module prices.

Even as global investment in this sector increased, it declined in every European country on the top 10 list for investment in small-scale projects[i], with the exception of Greece, as austerity-hit governments sought to limit pressure on electricity consumers by cutting renewable power subsidies. Greece, which ranked eighth for small-scale investment in 2012, saw a 195% increase, as did China. Investment in small-scale projects also rose in the United States and Japan.

A new mechanism has evolved in recent years to raise capital for projects from a large number of small investors. "Crowd funding," first developed in the United States, is now being applied to renewable energy and spreading through western Europe, and it is particularly well suited to small-scale projects.

Mergers and acquisition (M&A) activity—which is not counted as part of the USD 244 in new investment—fell sharply (29%) in 2012 to USD 52.3 billion, from an all-time high of USD 73.4 billion in 2011. The decline was almost entirely due to a collapse in corporate mergers and acquisitions caused by the general economic slowdown.

i The top 10 countries for small distributed capacity investment are Germany, Japan, Italy, the United States, China, Australia, the United Kingdom, Greece, Belgium, and France.

RENEWABLE ENERGY INVESTMENT IN PERSPECTIVE

Gross investment in renewable electric generating capacity (not including hydro >50 MW) was USD 227 billion in 2012. This compares with gross investment in fossil fuel-based capacity of USD 262 billion. By this measure, the gap between renewables and fossil fuels narrowed in 2012, with investment in renewable power capacity down 10% relative to 2011 and fossil fuel investment down about 13%.

Further, net investment in additional fossil fuels capacity is less than gross investment, which includes spending on replacement plants. By contrast, almost all investment in renewable capacity is net, meaning that it adds to overall generating capacity. Considering only net fossil fuel investment in 2012, renewable power was in the lead for the third consecutive year, with its USD 227 billion taking a wide lead over fossil fuels' estimated USD 147.7. If investment in hydropower projects >50 MW is included, then global investment in renewable power capacity was one-and-a-half to two times the net investment in fossil fuels in 2012.

DEVELOPMENT AND NATIONAL BANK FINANCE

Development banks provided USD 79.1 billion of finance in 2012 to broad clean energy, including hydro and other renewable energy projects, manufacturers, research, energy efficiency, transmissions, and distribution. This was down just over 1% from 2011 levels. Of this amount, USD 50.8 billion of finance went to renewable energy projects, manufacturers, and research efforts, down slightly from the previous year.

The largest player was once again Germany's KfW, which made USD 26 billion (EUR 20 billion) of finance available, down 10% on 2011 levels, followed by China Development Bank with USD 15 billion (up 1%), BNDES of Brazil (USD 11.9 billion), European Investment Bank (USD 6 billion) and World Bank Group (USD 5 billion). Looking at core renewable energy lending, the European investment Bank made some USD 5.6 billion (EUR 4.3 billion) available in 2012.

One key new trend in 2012 was the increasing role of smaller and newer development banks in renewable energy financing. These included the Development Bank of Southern Africa, which approved loan facilities totalling USD 1 billion earmarked for renewable energy projects, and the African Development Bank, which granted Morocco USD 800 million in loans to support renewable energy programmes.

EARLY INVESTMENT TRENDS IN 2013

Global new investment in renewable energy in the first quarter (Q1) of 2013 amounted to USD 40 billion, down 36% relative to the final quarter of 2012, and the lowest level in any quarter since Q1 2009.

Although the first quarter has often been the weakest of the four in recent years, reflecting the fact that subsidies tend to expire at the end of December, the weakness in Q1 2013 was not just seasonal. Asset finance of utility-scale projects, venture capital and private equity investment, and public markets investment together totalled USD 21 billion in the first quarter, down more than a third from the equivalent in the first three months of 2012.

Small-scale project investment was USD 18.5 billion in the first quarter of 2013, down slightly from a USD 20 billion quarterly average in 2012. This reflected the further reduction in PV module costs between Q1 2012 and Q1 2013.

03

04

Strings of solar PV panels, arranged in grids, in the state of Gujarat in western India.

Ambitious new solar power targets were set in the Middle East, North Africa, and Asia, as global PV capacity surpassed the 100 GW milestone. As of early 2013, 127 countries had renewable energy support policies in place, and more than two-thirds of these were developing economies.

04 POLICY LANDSCAPE

The number of policies and targets in place worldwide to support the development and deployment of renewable energy technologies increased yet again in 2012 and early 2013, and the number of countries supporting renewables continued to rise. As of early 2013, renewable energy support policies were identified in 127 countries, an increase of 18 from the 109 countries reported in GSR 2012. More than two-thirds of these countries are developing or emerging economies.[i 1] (See Table 3, p. 80, Figures 25 and 26, and Figure 23 in GSR 2012.)

The pace of adoption of new policies has continued to remain slow relative to the rate at which policies were added in the early-to-mid 2000s. As in recent years, the majority of policy developments continued to focus on changes to existing policies as, in many cases, policymakers felt forced to adapt quickly to rapidly changing market conditions for renewable technologies, primarily solar PV, continuingly tight national budgets, and the broader impacts of the global economic crisis.

Policymakers are increasingly aware of the potential national development impacts of renewable energy. Beyond reducing greenhouse gas emissions from the energy sector, renewables can be an important driver of social, political, and economic growth—providing co-benefits such as expanding energy access; enhancing energy security; promoting improvements in health, education, and gender equality; supporting job creation; and advancing energy security in countries with little or no domestic fossil fuel resources by reducing dependence on expensive fuel imports and fossil fuel subsidies.[2] (See Sidebar 6, p. 71.) Buoyed by these factors and decreasing costs for a number of technologies, renewable energy continued to attract the attention of policymakers in 2012.

This chapter does not aim to assess or analyse the effectiveness of specific policies or policy mechanisms, but rather attempts to give a picture of new policy developments at the national, state/provincial, and local levels around the world.

POLICY TARGETS

Policy targets for the increased deployment of renewable energy technologies have been identified in at least 138 countries as of early 2013, up from the 118 countries reported in GSR 2012, and eight new countries added targets.

Renewable energy targets take many forms, the most common of which is an increase in the renewable share of electricity production. Other targets include renewable shares of primary and final energy, heat supply, and transport fuels, as well as installed and/or operating capacities of specific renewable technologies. Targets most often focus on a specific future year, but some are set for a range of years or with no year reported. (See Reference Tables R10–R12.)

A number of countries had historic targets aimed at the year 2012. Of these, India appears to have met its goal of adding 9,000 MW of new wind capacity between 2007 and 2012, while Tonga delayed its 50% renewable electricity target to 2015.[3] Morocco fell short of its targets of a 10% renewable energy share of final energy consumption (actual share 1.8%), 8% renewable energy share in primary energy consumption (actual share 4%), 20% renewable energy share in electricity consumption (actual share 9.65%), and 0.28 GW_{th} (400,000 m^2) of solar hot water collector area (actual capacity: 0.24 GW_{th}, or 340,000 m^2).[4] Supporting data were not available by early 2013 to assess the remaining targets in India, Kenya, Pakistan, the Palestinian Territories, or Rwanda. As targets are set at varying degrees of strength and ambition, judging the "success" of these and other policy targets must be done with caution.

Two countries with targets expiring in 2012 introduced new future targets. India's 12th Five-Year Plan calls for a doubling of current renewables capacity to a total of 53 GW by 2017.[5] The Palestinian Territories set a new target of a 10% renewable share of electricity generation by 2020, as well as capacity targets for a number of renewable energy technologies.[6]

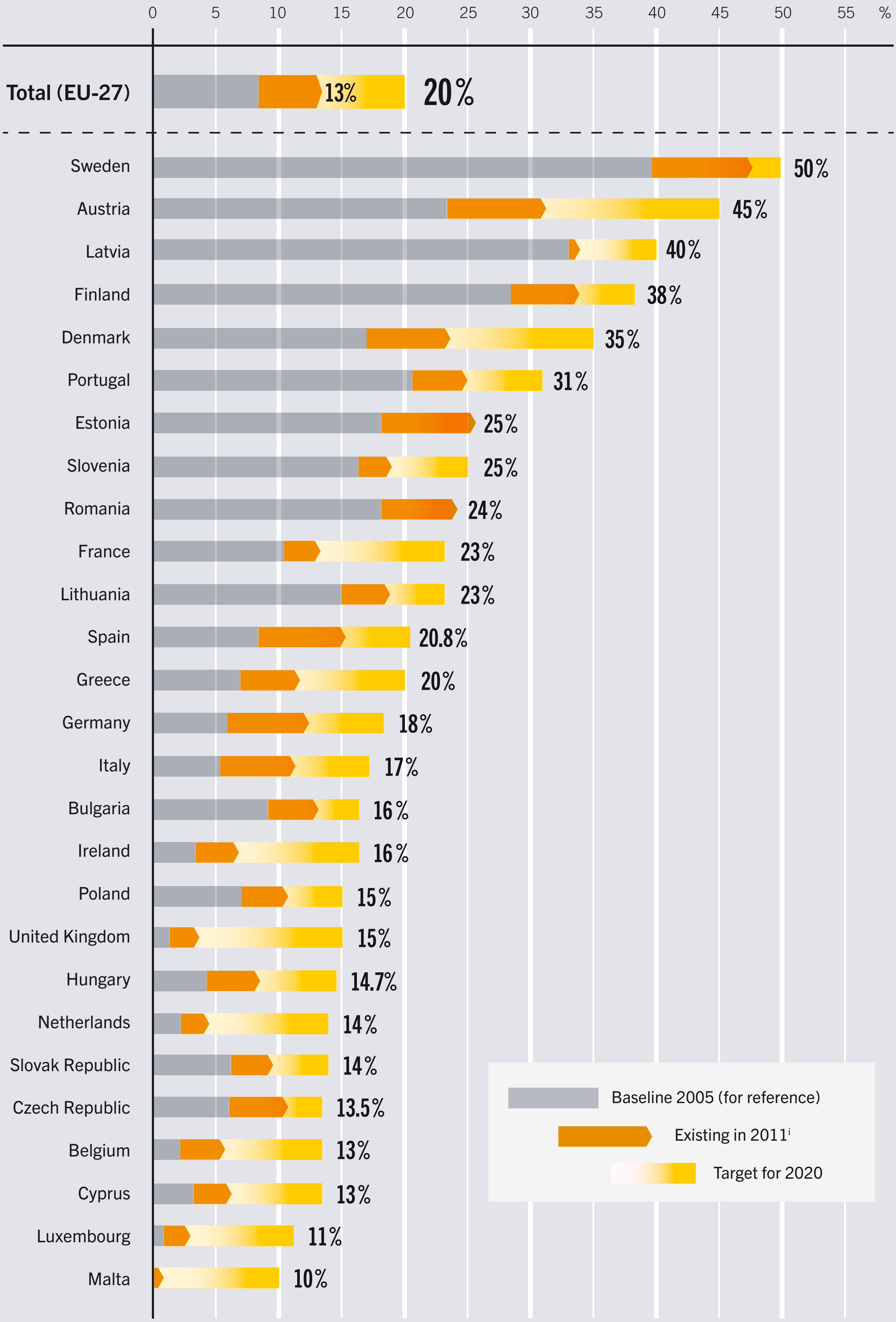
In addition, the Economic Community of West African States (ECOWAS)[ii] and eight new countries introduced policy targets in 2012. The 15 ECOWAS countries adopted a regional renewable energy policy that includes targets of 10% renewable energy penetration in the overall electricity mix by 2020 and 19% by 2030.[7] In the Middle East, Qatar set a target of 2% renewable electricity generation from solar and 640 MW of solar PV capacity by 2020; Iraq announced a target of 400 MW of wind and solar capacity by 2016; and Saudi Arabia set targets of 24 GW renewable power capacity by 2020 and 54.1 GW by 2032.[8] In Eastern Europe, the Energy Community agreed to adopt EU Directive 2009/28/EC (see Figure 24), setting new 2020 renewable energy targets for Bosnia and Herzegovina (40%), Croatia (20%), the former Yugoslav Republic of Macedonia (28%), Montenegro (33%), and Kosovo (25%).[9]

Worldwide, a number of countries with existing targets added new complementary targets in 2012 and early 2013. In Europe, Albania (38%), Moldova (17%), Serbia (27%), and the Ukraine (11%) all set targets for renewable share of final energy.[10] Austria set a target for renewables to meet 85% of electricity consumption by 2020; Denmark established more ambitious goals of a 35% renewable share of final energy by 2020, wind generation to account for 50% of total electricity consumption by 2020, and 100% of all energy demand from renewables by 2050; France doubled its target for solar electric projects in 2013, with a new aim to add 1,000 MW; Germany codified targets for 2030, 2040, and 2050 that had been introduced previously; the Netherlands increased its final energy target to 16% by 2020, 2% higher than that mandated by the EU; Poland

i The increase in policies identified is based on the addition of new policies in 2012 and early 2013 as well as identification of a number of historic policies through further research.

ii The 15 ECOWAS member states are: Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

FIGURE 24. EU RENEWABLE SHARES OF FINAL ENERGY, 2005 AND 2011, WITH TARGETS FOR 2020



i See Table R10 for share percentages existing in 2011

Source: See Endnote 9 for this section.

announced its target to develop 1 GW of offshore wind capacity by 2020; the Russian Federation mandated the release of technology-specific targets to meet its 2020 renewable electricity target of 4.5%; and Scotland raised its near-term renewable electricity target from 31% to 50% by 2015.[11]

In Asia, the Chinese 12th Five-Year Plan for Renewable Energy set 2015 targets for 9.5% of primary energy consumption to come from renewables and for a total of 280 GW_{th} (400 million m^2) of solar heating capacity.[12] Under the Phase II plan for the National Solar Mission, India extended its expiring solar water heating target (4.9 GW_{th}, or 7 million m^2) to 5.6 GW_{th} (8 million m^2) of new capacity to be added between 2012 and 2017; and Japan announced a target to develop 1,500 MW new wave and tidal capacity by 2030.[13] Kazakhstan seeks to develop 1.04 GW of renewable capacity by 2020.[14]

The Middle East and North Africa (MENA) region saw significant new developments in 2012 as the Egyptian Solar Plan, approved in July 2012, set a target for 2,800 MW of concentrating solar thermal power (CSP) and 700 MW of solar PV by 2027; Jordan adopted a target for 1,000 MW of renewable capacity by 2018; and Libya set targets for the share of renewable energy in the national generation mix at 3% by 2015, 7% by 2020, and 10% by 2025.[15] Elsewhere in Africa, Djibouti, which had no renewable power capacity as of 2009, has committed to a goal of 100% renewables by 2020; and the Kingdom of Lesotho set a target of 260 MW of renewable power capacity by 2030.[16]

Several countries and one Canadian province strengthened existing targets in 2012. (See Reference Tables R10–R12 in this report and Reference Tables R9–R11 in GSR 2012.) In addition to setting new targets, China increased existing targets,

SIDEBAR 6. CURRENT STATUS OF GLOBAL ENERGY SUBSIDIES

According to the International Energy Agency (IEA), worldwide subsidies[i] for fossil fuel consumption amounted to an estimated USD 523 billion in 2011, an increase of 27% over 2010—reflecting rising energy prices and increased consumption of subsidised fuels. The International Monetary Fund (IMF) estimates that on a "post-tax basis," which also factors in the negative externalities from energy consumption, total subsidies[ii] for petroleum products, electricity, natural gas, and coal are much higher, at USD 1.9 trillion (2.5% of global GDP or 8% of total government revenues). Dr. Fatih Birol, the chief economist at the IEA, has called fossil fuel subsidies "public enemy number one to sustainable energy development."

Subsidies and financial support for renewable energy (excluding large hydropower) in 2011 totalled USD 88 billion, up 24% over 2010 but still only around one-sixth of fossil fuel subsidies. About 73% went to the electricity sector (mostly to support solar PV), and most of the rest went to biofuels, with very little used to support renewable heating or cooling. The European Union accounted for nearly 57% of these subsidies and the United States for 24%.

Well-designed subsidies for renewable energy can result in long-term economic and environmental benefits, including improved health, employment opportunities, and energy access and security. Conversely, the costs of subsidies directed at fossil fuels generally outweigh the benefits. Fossil fuel subsidies in energy-importing countries usually impose a heavy burden on national budgets, and in fossil fuel-exporting countries they can accelerate the depletion of resources due to wasteful consumption, thereby reducing future export earnings over the long term.

In 2009, leaders of the G20 countries pledged to end fossil fuel subsidies, committing to "rationalize and phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption." They acknowledged that fossil fuel subsidies distort markets, hamper investment in clean energy sources, and undermine efforts to mitigate the climate crisis. This step led to the establishment of a broader international coalition that includes Asia-Pacific Economic Cooperation (APEC) countries as well as many additional countries in which high energy prices have made subsidies financially unsustainable .

At the G20 Finance Ministers Meeting in February 2013, leaders again committed to report on progress to rationalise and phase out fossil fuel subsidies, and to provide targeted support for the poorest people. Very little other international action has followed, with the exception of two reports on the scope of energy subsidies and suggestions for the implementation of their phaseout, published jointly by the IEA, OPEC, OECD, and World Bank. In addition, the IMF published a report in early 2013 urging policymakers to reform subsidies for fossil fuel products, arguing that this could translate into major gains for both economic growth and the environment.

The practical effect on a global basis has been minimal to date due to the lack of a timeline and an organisation to monitor and aid countries wanting to implement their commitments. A small number of countries have taken steps towards energy subsidy reform, and others—including fossil fuel-exporting non-OECD countries like Iran, Indonesia, Nigeria, and the Sudan—have begun to reduce subsidies. Further, since the G20 meeting in 2009, an increasing number of civil society observers has begun to track the issue of fossil fuel subsidies.

At the same time, however, several OECD countries have begun to reduce subsidies for renewable energy sources, due largely to individual domestic political and economic circumstances, lower technology prices, and a lack of long-term policy guidance for renewables.

Source: See Endnote 2 for this section.

i The IEA defines subsidies as government measures that artificially reduce production costs or the price that consumers pay for energy, per IEA, "How Big Are Energy Subsidies and Which Fuels Benefit?" WEO 2011 Factsheet (Paris: 2011).

ii The IMF defines consumer subsidies as the difference between a benchmark price and the price paid by energy consumers (including both households for final consumption and enterprises for intermediate consumption) and producer subsidies as the difference between a benchmark price and prices received by the supplier; the benchmark price for internationally traded energy products is the international price adjusted for distribution and transportation costs. The IMF estimate does not include all producer subsidies due to lack of data.

pledging to install 49 GW of new renewable power capacity in 2013, quadrupling its 2015 solar PV target to 21 GW, and raising its 2020 solar PV target from 20 GW to 50 GW.[17] Indonesia upped its renewable electricity target to 26% by 2025.[18] Building on existing targets for 2020, Japan introduced higher technology capacity targets to continue development up to 2030 for offshore wind (8.03 GW), geothermal (3.88 GW), biomass (6 GW), and tidal (1.5 GW) power; and Thailand increased its target for renewable share in final energy consumption to 25% by 2022.[19]

Elsewhere, Mexico increased its target for renewable electricity to 35% by 2026, and Uruguay increased its 800 MW target for grid-connected wind power to 1 GW by 2015.[20] The Canadian province of Ontario brought forward its target of a total of 10,700 MW of non-hydro renewable capacity from 2018 to 2015.[21]

Two countries reduced targets during 2012: Nigeria lowered its technology-specific targets for wind, solar PV, and small hydro, although it increased targets for biomass; Portugal reduced its 2020 target for installed renewable capacity by 18%, from 19.2 GW to 15.8 GW.[22]

POWER GENERATION POLICIES

Worldwide, a number of policies have been enacted to promote renewable power generation. Developing countries and emerging economies accounted for over two-thirds of all countries with renewable power in place by early 2013. Although several policies were enacted in 2012 and early 2013, the number of new countries adding power generation policies has slowed significantly since 2010; however, existing policies are increasingly being revised and updated.

The feed-in tariff (FIT) remains the most widely adopted renewable power generation policy employed at the national and state/provincial levels. As of early 2013, 71 countries and 28 states/provinces had adopted some form of FIT policy. (See Reference Table 13.) Developing countries now account for the majority of countries with FITs in place, and for the five new FIT policies enacted in 2012.[23] Nigeria, the Palestinian Territories, Rwanda, and Uganda all implemented new FITs in early 2012.[24] Jordan enacted a new FIT in late 2012 to complement the Renewable Energy and Energy Efficiency Law that was passed earlier in the year.[25]

Two countries set initial rates for FIT policies that they enacted in previous years. Following legislation calling for a national FIT in the Renewable Energy Act of 2008, the Philippines set tariffs for the first time in 2012.[26] Under the FIT that was called for in the wake of the 2011 Fukushima nuclear accident, Japan implemented tariffs for solar PV and wind power that were amongst the highest in the world.[27]

As in 2011 and 2010, the majority of activity surrounding FITs in 2012 involved revisions to existing policies. A few countries strengthened specific aspects of their FITs. France increased support to rooftop solar PV systems, raising the FIT rate by 5% and instituting a 10% FIT bonus for systems manufactured in Europe; Indonesia introduced a new FIT for biomass, substantially increased FIT rates for geothermal power, and indicated that tariffs for wind and solar will soon be introduced; and Ireland extended the list of technologies eligible for the new round of FIT support to include onshore wind, small-scale hydro, landfill gas, and biomass technologies.[28]

However, the majority of FIT-related changes maintained the 2011 trend of rate reductions, with several countries lowering payments throughout 2012 and early 2013 in response to shifting economic and market conditions. Austria announced modest reductions to rates on most technologies and the elimination of the FIT for solar PV plants over 500 kW as of 2013; Bulgaria cut rates for wind by 10% and solar PV by 5–39%; Greece announced plans to retroactively cut solar PV FIT rates in early 2013; and Germany reduced support to solar PV by cutting FIT rates, setting a range of desired annual capacity additions, establishing limits on financial support, and allowing producers to switch between the FIT and feed-in premium schemes.[29]

Italy implemented installation caps, reduced FIT rates by 39–43%, and added a number of new requirements; however, it simultaneously extended the contract term for wind projects from 15 to 20 years.[30] Luxembourg significantly lowered FIT rates for solar PV and ended FIT support for solar PV systems over 30 kW.[31] Serbia reduced rates for wind and solar projects but raised rates for small-scale hydropower, which was redefined to include plants up to 30 MW.[32] Spain temporarily suspended its FIT under Royal Decree in early 2012 and, in early 2013, implemented retroactive FIT rate cuts for all PV installations dating back to 2009, and drastically reduced incentives to CSP.[33] Over the course of 2012, the United Kingdom significantly reduced rates for solar PV installations and lowered rates for large-scale wind projects and for small-scale renewables, while the Ukraine lowered rates for solar PV.[34]

Outside of Europe, Mauritius closed its under-50 kW FIT programme to new applications when its expanded cap of 3 MW was reached; and Uganda removed its FIT for solar PV, although it increased FIT rates on hydropower plants between 500 kW and 20 MW in early 2013, less than a year after the policy's implementation.[35]

Although no new state or provincial level FITs were added in North America (a departure from previous years), some revisions were made to existing policies. In the United States, Vermont (one of five U.S. states with a FIT) strengthened incentives under its FIT scheme by raising rates for solar PV and small-scale wind by more than 10% and increasing the programme cap by 10% over the next 10 years.[36] Other state/provincial level FITs were reduced in 2012. In Canada, Ontario's scheduled FIT review resulted in bringing forward the targeted capacity date by three years, to 2015, but also reduced FIT rates for solar (20%) and wind (15%) under FIT 2.0.[37] While still included in the new FIT law, Ontario's domestic-content requirement was struck down by the World Trade Organization in 2012.[38] In India, the state of Gujarat reduced rates for new solar PV projects commissioned after January 2012.[39]

Additional FIT policies under discussion during 2012 included support for solar power in Poland, to be enacted in 2013 or 2014, and a proposed FIT in Saudi Arabia to help meet the country's new targets (see Policy Targets section), which was expected to be confirmed in 2013.[40]

Renewable Portfolio Standards (RPS) or "quotas" are in place in 22 countries at the national level and 54 states/provinces in the United States, Canada, and India. China instituted a 15% renewable quota on utilities in an effort to connect existing capacity to the grid, and Norway enacted a quota policy in early 2012.[41] There were no other quota policies identified that were enacted at the national level in 2012.

In Europe, two existing RPS policies were altered in 2012. Poland increased utility quotas for renewable electricity by 1% per year, and Italy moved to phase out its existing RPS, which will be replaced with its FIT system.[42] In Asia, South Korea implemented the RPS policy that it enacted in 2010, as called for in the initial decree.[43]

No new RPS policies were adopted in the United States, but several existing policies were revised at the state level. Delaware established a solar PV requirement of 3.5% by 2026; Maryland brought the target date for the solar portion of its RPS forward two years to require a 2% solar contribution by 2020; New Hampshire increased the renewable quota to 24.8% by 2025; and New Jersey increased the solar requirement to 4.1% by 2028.[44] There were efforts to reduce or repeal RPS laws in a number of states, although Ohio was the only state to reduce the renewables portion of its mandate, lowering it to 12.5%.[45] In addition, a number of states, such as New Hampshire, revised their eligibility requirements to allow for non-power generation technologies to qualify for the RPS. (See Heating and Cooling Policies section.)

Renewable certificates are often utilised in tandem with RPS and quota systems. In early 2012, a common Norwegian-Swedish green certificate market was established with a target of developing 26.4 TWh of renewable capacity by 2020.[46] At the national level, Australia halved the number of tradable certificates allocated for the installation of small-scale solar PV systems, and Romania adopt a number of new regulations, including limiting new capacity development and the growth of new players, in an effort to make its green certificates scheme more attractive to investors.[47]

At the state and provincial level, certificate-related changes were made in the Indian state of Andhra Pradesh, which enacted a certificate mechanism under its new Solar Power Policy 2012; in the U.S. state of Arizona, which exempted the sale of Renewable Energy Certificates (RECs) from state sales tax; and in the Belgian regions of Brussels, Flanders, and Wallonia, which all decreased incentives under their separate green certificate schemes.[48]

Several countries have turned to public competitive bidding (also tendering or auctions) in recent years, with the number of countries rising from nine in 2009 to 36 by the end of 2011.[49] A total of 43 countries were identified by early 2013, with 30 of these countries classified as upper-middle income or lower.[50] Tendering schemes range from technology-specific to technology-neutral; include varying levels of capacity (some setting volume caps); occasionally set price ceilings; and often include various criteria for project selection so that price is not the only or most important factor.[51]

Throughout 2012 and early 2013, a number of countries held new tenders for the development of wind and solar technologies. Chile placed a call for bids for the construction of a CSP plant.[52] France held its first offshore wind tenders and approved 541 MW of new solar PV and CSP projects through government tenders.[53] Morocco began tenders for 2 GW of wind to be installed by 2020.[54] Saudi Arabia is turning to public tenders to award the first round of utility-scale PV and CSP projects towards its new solar targets.[55] At the state level, India is increasingly turning to tendering to deploy new renewable energy capacity. For example, Tamil Nadu released a tender for 1 GW of solar power in late 2012, and Andhra Pradesh announced plans to allocate 1 GW of new solar PV through a public tender in early 2013.[56]

Net metering polices exist in at least 37 countries—including Canada (in eight provinces) and the United States (in 43 states, Washington, D.C., and four territories). Three new policies were enacted in 2012: Brazil implemented a programme for small-scale power generation of 1 MW or less; Chile approved net billing legislation for renewables up to 100 kW; and Egypt enacted a net metering policy late in the year.[57] In addition, three existing policies were revised in 2012, including in two U.S. states: California nearly doubled the number of systems that qualify for its net metering programme, and Massachusetts doubled the allowance cap for its solar net metering programme, permitting up to 6% of peak demand to qualify.[58] In addition, Denmark reduced support for new solar PV installations through multiple revisions to its net metering programme, including limiting support to 10 years and reducing guaranteed sale prices.[59]

A host of fiscal incentives that are currently used to address the cost and finance barriers that impede the renewable energy sector were added or revised in 2012 and early 2013. In Cameroon, the value-added tax (VAT) was removed on all renewable energy products; India removed import duties on CSP equipment; Ireland extended a mechanism allowing corporations to deduct investments in renewable energy; Libya exempted all renewable energy equipment and components from customs duties; and Madagascar halved import taxes for renewable energy equipment.[60] In the United States, the Production Tax Credit (PTC), a major driver of development for wind power in particular, was extended through 2013.[61] In addition, U.S. PTC eligibility requirements were revised to allow projects to qualify as long as they are under construction (rather than operational) before the end-2013 expiration.[62] Also in the United States, a 50% accelerated depreciation bonus was extended and the 1603 cash grant programme remained in place for existing projects, although new projects no longer qualify.[63]

As with FIT rates, several countries reduced subsidies to renewables during 2012. Belgium removed a tax credit for investments in geothermal, solar thermal, biomass, and biogas power plants.[64] India drastically reduced incentives for wind and solar power in 2012, including suspending the accelerated depreciation tax incentive and discontinuing the generation-based incentive (GBI); however, the GBI was reinstated in early 2013.[65] Also in early 2013, payments to the Indian National Clean Energy Fund, a mechanism designed to support solar deployment under the National Solar Mission, were delayed.[66]

Beyond these reductions, a number of countries began levying taxes on technologies that they subsidised previously. Taxes on renewable energy installations were introduced by three countries in 2012: Bulgaria enacted temporary retroactive taxes on revenue from solar, wind, hydro, and biomass projects; Greece set a tax on consumers of renewable power in 2012, and subsequently raised it in early 2013; and Spain placed a 7% flat tax on all forms of power generation, including renewables.[67] In addition, the U.S. set two rounds of import tariffs on Chinese solar modules and cells as well as tariffs on wind towers imported from China and Vietnam as a result of ongoing trade disputes.[68] (See Sidebar 8, GSR 2012.)

Elsewhere around the world, countries announced new support to renewable energy technologies. Australia pledged over USD 17.7 billion (AUD 17 billion) through the new Australian Renewable Energy Agency and Clean Energy Finance Corporation.[69] Azerbaijan announced plans to invest USD 8.9 billion; Cyprus implemented investment subsidies to support the purchase and installation of new systems; China pledged an additional USD 1.1 billion in subsidies to its solar industry, bringing the year-end subsidy total to about USD 2 billion; Iran made USD 675 million (EUR 500 million) of the National Development Fund available to renewable energy projects; Iraq pledged USD 1.6 billion to meet its 2016 solar and wind targets; Scotland announced a new USD 162 million (GBP 103 million) fund to support renewable energy projects, including wave and tidal power; South Korea pledged USD 9 billion to develop 2.5 GW of offshore wind by 2019; and the United Kingdom pledged USD 4.8 million to be allocated through the U.K. Green Investment Bank.[70 i]

In addition to new pledges, many subsidies to renewable energy were reduced in 2012. China retroactively reduced by 21% solar subsidies that were set earlier in the year under the Golden Sun programme.[71] In Europe, the Czech Republic announced that all renewables subsidies will be abandoned starting in 2014; Estonia reduced subsidies by 15–20%, and it maintained an eligibility cap for wind subsidies that it had previously pledged to remove; Spain removed all financial support for new renewable energy projects in January 2012; and the United Kingdom reduced support for solar PV by 20%, but simultaneously relaxed the existing subsidy cap on bio-power.[72]

Several countries continued to provide financial support to the research and development of new and more-efficient renewable technologies. For example, Australia provided USD 3.4 million (AUD 3.3 million) to support 11 solar PV research projects; Japan provided USD 19 million to establish a programme promoting research and development of geothermal technologies; the Qatar National Research Fund began funding solar initiatives as part of the National Priorities Research Program; the United Kingdom pledged USD 31.5 million (GBP 20 million) to the development of wave energy; and the U.S. Department of Energy's Advanced Research Projects Agency-Energy awarded USD 14 million to eight research projects.[73]

HEATING AND COOLING POLICIES

Countries continued to enact new policies and targets for the promotion of renewable technologies in the heating and cooling sectors during 2012. However, this sector still receives far less attention from policymakers than the renewable power sector does, even though there exists tremendous potential to provide heating (and cooling) with modern biomass, direct geothermal, and solar resources.

Roughly 20 countries have specific renewable heating/cooling targets in place, including those for solar water heating. (See Reference Table R12.) In addition, at least 19 countries/states have heat obligations/mandates to promote the use of renewable heat technologies. (See Table 3.)

Few new obligations were added in 2012. Denmark set new heat regulations that ban the installation of oil and natural gas fired boilers in new buildings as of 2013 and that ban oil boilers in areas with district heating or natural gas availability by 2016, effectively requiring that all heat be derived from renewable sources.[74] Kenya's Energy (Solar Water Heating) Regulations 2012 will require solar water heating to cover 60% of annual demand for buildings that use over 100 litres of hot water per day.[75]

In the United States, a developing trend saw the amendment of multiple state RPS policies to allow renewable heat to qualify towards the quota requirement. New Hampshire was the first state to expand its RPS policy to include mandatory quotas for the share of "useful thermal energy" from renewables; Maryland adopted revisions allowing certain new geothermal heating and cooling installations to qualify for the RPS, as well as thermal energy from biogas systems using animal waste as feedstock; and Ohio revised the list of eligible technologies to include both new and retrofitted CHP and waste-heat recovery systems.[76] Similar changes were under discussion in both Massachusetts and Colorado by the end of 2012.[77] While positive for its promotion, the inclusion of renewable heat in electricity RPS obligations could effectively reduce mandated targets for renewable electricity unless there are overall target increases to make up the difference.

A number of fiscal incentives for renewable heat were adopted or revised in 2012, some in combination with measures to promote building efficiency.[78] (See Sidebar 7.) In Europe, Austria created a USD 135 million (EUR 100 million) fund to support building efficiency improvements that included grants for renewable heating, and the Czech Republic merged support

i All currencies were converted to USD using exchange rates as of 4 February 2013.

SIDEBAR 7. LINKING RENEWABLE ENERGY AND ENERGY EFFICIENCY

Renewable energy deployment and energy efficiency improvements have slowed growth in fossil fuel consumption substantially, and they have the potential to play a crucial role in reducing future global greenhouse gas emissions. Efficiency will be the more important factor in the near term, whereas renewables will become increasingly important over time. The greatest potential could be achieved with the coordination of renewable energy and energy efficiency policies. To date, however, there has been little practical linkage of the two.

Important synergies exist between renewable energy and energy efficiency. As the efficiency of energy use improves, renewable energy can more rapidly become an effective and significant contributor of energy. As the share of energy derived from renewable energy increases, less primary energy will be needed to meet energy demand due to reduced system losses. (See Feature, GSR 2012.)

Over the past few decades, improvements in energy efficiency have reduced global energy intensity (total final energy consumption per unit of GDP) from 0.21 tonnes of oil equivalent (toe)/USD 1,000 in 1970 to 0.13 toe/USD 1,000 in 2010. Over this same period, average energy intensity has declined from 0.16 to 0.08 toe/USD 1,000 in OECD countries and from 0.40 to 0.21 toe/USD 1,000 in non-OECD countries. However, the global rate of decline in energy intensity has slowed considerably (from 1.2% per year on average during 1980-2000 to 0.5% per year on average during 2000-2010) due in part to the ongoing shift of global economic activity towards developing countries.

The potential for further energy efficiency improvements in all countries remains significant. The United Nations Industrial Development Organization (UNIDO) has estimated potential energy savings of 23–26% in the manufacturing sector worldwide: 30–35% in developing countries, and 15–20% in developed countries. Other studies show that in new and existing buildings, global final energy use for heating and cooling could be reduced by some 46% by 2050, compared with 2005 levels, through full use of current best practices and energy efficiency technologies, while also increasing amenities and comfort.

Policies to advance the use of renewable energy and energy efficiency technologies have often been designed independently, implemented by different stakeholders, and overseen by different government agencies. In the past, only sporadic efforts have been made to link the design and implementation of renewable energy policies with energy efficiency policies.

The situation has begun to change, however, particularly at the local level. There is also increasing evidence of improved policy coordination and better communication among policymakers and stakeholders at the national level in some countries. For example, Germany is in the process of transforming its energy sector through the "Energiewende" (Energy Transition) programme, which focuses on significant, long-term investments in energy infrastructure combined with advances in both renewables and energy efficiency in all economic sectors. Italy's new "National Energy Strategy" gives highest priority to the design and implementation of renewable energy and energy efficiency measures, aiming beyond EU 2020 targets, to help spur economic growth. The strategy is expected to drive new investments worth USD 232 million (EUR 180 million) through 2020, while avoiding expenditures on energy imports worth approximately 1% of Italy's 2012 GDP (current values). In the United States, the Environmental Protection Agency is encouraging state, tribal, and local agencies to consider incorporating renewable energy and energy efficiency policies and programmes in their State and Tribal Implementation Plans.

There is also increased awareness of the impact that consumer behaviour has on adoption rates for renewable energy options and energy efficiency products. In recent decades, consumer behaviour strategies were considered to be add-ons to technology-focused programmes. It is now recognised, however, that consumer behaviour strategies are integral to successful policy planning and implementation, and more emphasis is being placed on smarter habits and lifestyles.

Another trend is towards a more strategic and coordinated approach by organisations that are focused on sustainable development linked with renewables and energy efficiency. International organisations are cooperating actively to develop an agenda for a sustainable future in developing countries. For example, in 2011 the World Bank and the Global Environment Facility (GEF) approved "Green Energy Schemes for a Low-Carbon City," a project that integrates energy efficiency and clean energy technologies to reduce greenhouse gas emissions in the Changning District of Shanghai. The Inter-American Development Bank and the Japanese Trust Fund Consultancy are developing a pilot project in Mexico to combine renewable energy (especially solar PV) and energy efficiency for lower-income residences connected to the electric grid. And the UN Food and Agricultural Organization (FAO) has launched a multi-partner programme to increase energy efficiency and renewable energy in the agri-food chain, while improving energy access in rural areas.

Most significant is the UN initiative "Sustainable Energy for All" (SE4ALL), which aims to provide universal access to modern energy services, improved rates of energy efficiency, and expanded use of renewable energy sources across the globe by 2030. As of December 2012, more than 50 governments from Africa, Asia, Latin America, and the Small Island Developing States (SIDS) had joined this initiative and were developing energy plans and programmes, while businesses and investors had committed over USD 50 billion to achieve SE4ALL's objectives.

Source: See Endnote 78 for this section.

for all renewable energy, heat, and power production into one law and instituted a renewable heat bonus of USD 2.60/GJ (EUR 2.00/GJ) for systems that deliver heat to district heating networks or for industry.[79] In Denmark, a number of financial provisions were established to promote renewable heating, including a new fund of USD 7.6 million (DKK 42 million) to facilitate the conversion of oil and gas heat to renewable heat and USD 6.3 million (DKK 35 million) to promote new renewable technologies, including large heat pumps.[80]

Germany increased subsidies for renewable heat projects; Italy approved a grant scheme for renewable heating systems with an eye towards enacting a FIT in the coming years; and Luxembourg strengthened a support mechanism for renewable energy in the building sector, including a USD 2,600 (EUR 2,000) increase in support for geothermal heat pumps, per household.[81] In addition, Portugal enacted a new USD 1.35 million (EUR 1 million) grant scheme to support the installation of solar thermal systems on existing buildings; and the United Kingdom reopened the Renewable Heat Premium Payment grant programme and released proposed rates for the domestic portion of the Renewable Heat Incentive FIT, which was expected to be enacted in summer 2013.[82]

Elsewhere, Uruguay implemented a number of new incentives for solar thermal technologies, including tax exemptions for solar heating equipment; India enacted a new national programme to provide financial support for the development of CSP for heat applications; and the Indian state of Uttarakhand increased existing rebates for solar water heaters.[83]

Not all changes were supportive of renewable heat. The Canadian ecoENERGY Retrofit-Homes programme, which included grants to homeowners installing solar water heaters, was allowed to expire, and the Energy Ministry has suggested removing legislation requiring 2% renewable content in home heating oil.[84] In New Zealand, a grant scheme to support solar water heaters expired in mid-2012.[85]

TRANSPORT POLICIES

Policies supporting the use of renewable fuels in the transport sector have been identified at the national level in 49 countries as of early 2013, up from 46 identified in GSR 2012. Common policies include biofuel production subsidies, biofuel blend mandates, and tax incentives. Blending mandates have been identified in 27 countries at the national level and in 27 states/provinces. (See Table R15.)

New blend mandates were introduced in 2012 by South Africa with an E10 mandate; by Turkey, which implemented an E2 mandate in early 2013; and by Zimbabwe, which approved an E5 mandate.[86] The Canadian province of Saskatchewan enacted a B2 blend mandate to complement its existing E8.5 blend mandate.[87]

During 2012, three countries enacted or revised their existing biofuel blend policies. India began enforcing a national E5 mandate that was initially intended to apply in 2006; Thailand increased its biodiesel blend mandate from B4 to B5; and the U.S. Environmental Protection Agency (EPA) increased the biodiesel volume requirement for 2013 to 4.85 billion litres (1.28 billion gallons), up from 4.16 billion litres (1.1 billion gallons) in 2012.[88]

Biofuel support policies in Europe and the United States continued to come under pressure from groups concerned about the impacts of fuel crops on food production and on land, about biodiversity, and water, as well as net greenhouse gas emissions from biofuels life-cycle processes. As a result, some major markets are facing increasing pressure to move away from supporting both first-generation and advanced feedstock biofuels.

The European Commission proposed setting a 5% cap on the first-generation biofuel share of total transport fuels and eliminating subsidies for food crop-based biofuels production by 2020, while at the same time allowing fourfold counting of the shares of advanced biofuels.[89] Although it is unlikely that these changes will be acted on in 2013, the proposals have had an impact on the sector including in Austria, which temporarily suspended the introduction of E10 pending clarification on EU biofuel regulations.[90] In the United States, the Renewable Fuels Standard remained in place despite significant pressure to waive it in the face of drought conditions.[91] For the second year in a row, however, the cellulosic fuel component of the target was reduced, cut from 1.9 billion litres (500 million gallons) to 39.7 million litres (10.5 million gallons).[92]

Changes in fiscal support for biofuels continued throughout 2012 and early 2013. The U.S. biofuels industry benefited from an extension of the USD 1.01/gallon (USD 0.27/litre) tax credit for cellulosic ethanol production and the reintroduction of the USD 1/gallon (USD 0.26/litre) biodiesel tax credit.[93] Australia pledged USD 15.7 million (AUD 15 million) in grants for the development of advanced biofuels.[94] Brazil doubled an earlier pledge to support the development of new techniques for creating fuel from sugarcane bagasse, committing nearly USD 1 billion (BRL 2 billion) in loans and grants through 2014.[95] However, existing support was allowed to expire in New Zealand, where the biofuels grant scheme ended in June 2012, and in the United Kingdom, where the duty differential on biofuels from used cooking oil closed out in early 2012.[96]

Electric vehicles (EVs) can be an important complement to renewable energy development, as they offer the potential to fuel vehicles with renewable electricity and to serve as a form of electricity storage from renewables. Many countries continued to support the development of markets for EVs and the linkage to renewable energy. This includes countries in the EU, where, since 2009, electricity from renewable energy used in electric vehicles has received preferential standing towards meeting the 10% renewable transport mandate, accounting for 2.5 times

the energy content of the electricity input.[97] As of early 2013, government targets called for an estimated 20 million EVs in operation by 2020, up from the approximately 40,000 in use at the end of 2012; some estimates have anticipated annual sales of 3.8 million EVs by 2020.[98] In 2012, India unveiled targets for 7 million electric and hybrid vehicles by 2020.[99]

GREEN ENERGY PURCHASING AND LABELLING

Labels for "green" energy, similar to those employed for energy efficiency, offer consumers added information when purchasing energy. Green energy labelling provides these consumers the opportunity to purchase "green" electricity as well as "green" biogas, heat, and transport fuels by evaluating the generation source of available energy supply options. Green power labels are employed in a number of countries around the globe, although government adoption remains slow. Among those promoted by NGOs by early 2013 were the Italian "100% Energia Verde"; the trans-European "EKOenergy" label covering 16 countries; the "Green-e Energy" label in the United States; and the "ok-power" label in Germany.[100]

In addition to voluntary green purchasing by individual and business energy consumers, a number of governments require utilities or electricity suppliers to offer green power products. In addition, governments themselves have committed to purchasing green energy to meet their own energy needs. New national-level policies to support green purchasing continue to be slow to develop even as renewable energy is being adopted increasingly worldwide.

CITY AND LOCAL GOVERNMENT POLICIES

Thousands of cities and towns around the world have active plans and policies to advance renewable energy. Despite the slowdown at the national level in 2012, policy momentum continued to accelerate at the local level as city governments took actions to generate employment, plan for rising energy demand, cut carbon emissions, and make cities more liveable. City governments have advanced initiatives and policies that complement and in many cases go beyond national level policies and programmes (see Reference Table R16); in turn, national governments often observe actions on the subnational level as test cases, and, if they prove successful, are more willing to use them as blueprints on the national level.[101]

Several cities are working with their national governments to advance renewable energy. In India, over 50 cities have launched new municipal policies and initiatives in response to the national "solar cities" programme, and, in Japan, 15 cities were moving forward as "model communities" by the end of 2012, propelled by a new federal support programme for renewable energy community projects.[102 i] In Brazil, Indonesia, India, and South Africa, a process was initiated in 2012 to select eight model cities to outline low-emissions development strategies, including the deployment of renewables, using a common methodology developed for local governments.[103]

Elsewhere, particularly in the EU and United States, cities have begun to organise themselves from the bottom up, complementing or moving beyond national and state legislation. In Europe, the Covenant of Mayors has seen a significant increase in signatories, with 1,116 new cities and towns joining in 2012, committing to a 20% CO_2 reduction target and plans for climate mitigation, energy efficiency, and renewable energy.[104] In Germany, cities are evaluating the implications of the "Energiewende" and adapting measures to address the variability of solar and wind power and to shift consumption patterns.[105]

Local governments around the world continued to establish new climate and energy plans in 2012, based on renewable energy and energy efficiency, and to reinforce existing plans. In Denmark, Copenhagen set the goal of becoming the world's first carbon-neutral capital city by 2025, building on its 2009 climate plan, and Frederikshavn, also a long-time frontrunner in renewable energy, announced a new target to become 100% fossil fuel-free by 2030.[106] Helsinki in Finland and the U.S. city of Seattle in Washington State also aim for carbon neutrality, both by 2050.[107] In Japan, the Fukushima Prefecture set a target to become 100% energy self-sufficient using renewable energy by 2040.[108] South Korea's capital Seoul announced a 2020 target to achieve 20% renewable electricity, and China's largest city, Shanghai, published a 12% renewable energy target by 2015 and set technology-specific installations targets, including 150 MW of solar PV.[109]

In order to achieve their ambitious targets, many local governments are moving towards municipal ownership or control of local power distribution and generation infrastructure. Municipally owned or controlled utilities allow for the greater participation of local governments and citizens in the planning and development of renewable energy, enabling local governments to directly advance utility investments, targets, or promotion policies that encourage private investment in renewables.

i The programme aims to help cities build capacity and facilitate local renewable energy projects. This includes helping selected cities with organising local renewable energy councils, appointing local coordinators, making concrete business plans, exploring fundraising options, building social consensus, and starting business projects (within three years).

Several U.S. cities with locally owned utilities adopted feed-in tariffs (FITs) in 2012 to reach existing renewable electricity targets and to complement state-level renewable portfolio standards (RPS). Following on the success of the 2009 solar FIT in Gainesville, Florida, the cities of Los Angeles and Palo Alto in California, as well as Long Island in New York, adopted FITs for solar projects in 2012; the FIT in Marin County, California, was strengthened in 2012 to offer 20-year fixed-price contracts; and Fort Collins in Colorado approved plans to launch FIT programmes effective in 2013.[110]

Local governments can also participate in profit-sharing schemes with local utilities. The Japanese cities of Odawara and Shizuoka established local energy companies through public-private partnerships to advance renewable community power projects in 2012, and the Saudi municipality of Mecca opened a tender for contracts to build and operate a 100 MW renewable energy power plant, which will be transferred to the city once the contracts recoup their investments.[111]

In some cases, city utilities have formed consortia to fund projects jointly. For example, a group of 33 German municipal utilities invested in a 400 MW offshore wind farm in the North Sea that will begin commercial operations in 2013.[112] Local community and cooperative investment models are also increasing in popularity. A citizens' cooperative in Berlin announced its official interest in buying the city's electricity network, under concession to Vattenfall Europe until 2014, joining the other 192 distribution networks in Germany that have remunicipalised since 2007.[113] Iida in Japan announced a municipal regulation in 2012 to facilitate community-based renewable energy project development.[114]

Local governments are also enacting fiscal incentives such as rebates and tax credits to facilitate renewable energy deployment. Valencia in Spain enacted a support programme that subsidises up to 45% of project costs, with additional support for small businesses and individuals.[115] Joining San Francisco, Los Angeles County, and Washington, D.C., 142 U.S. cities signed on to the California Property Assessed Clean Energy "PACE" programme, wherein cities borrow funds from investors and lend these funds to local property owners to finance energy efficiency and renewable energy additions. Owners repay loans through voluntary increases in property taxes, and these loans can be transferred to new owners if properties are sold.[116]

Other cities are leading by example and setting targets to power their municipal operations and/or using city property for renewable energy installations. In 2012, several cities and towns in India—including Rajkot, Jind, and Agratala—installed renewable energy systems for their own use to further their targets to reduce fossil fuel consumption.[117] Seoul announced that it will install solar PV panels on 1,000 schools by 2014, and Dhaka in Bangladesh is deploying solar street lights and traffic lights to enhance public awareness of renewable energy.[118] At least two cities achieved own-use targets in 2012: Calgary in Canada used 100% renewable electricity for its municipal operations, and the U.S. city of Houston, Texas, aimed to purchase 438 GWh, or 35% of the annual electricity consumption of city facilities, from renewables (mostly wind).[119]

In the building sector, local governments are moving away from traditional "percentage savings" goals to "near-zero" or "net-zero" energy-use goals that include on-site renewable energy.[i] To achieve these goals, several cities are advancing new building codes, standards, and demonstration projects. In 2012, Bhopal became home to India's first net-zero building, which produces 100% of its electricity and cooling needs on-site with solar PV that is integrated with energy storage and management systems.[120] Hong Kong unveiled its first net-zero building, designed to run on solar power and biodiesel derived from waste cooking oil.[121] In the United States, Seattle launched a Living Building Pilot programme to encourage the development of 12 "living buildings[ii]" over the next three years and to assess the adoption of the living building standard as the baseline for future city development; and Lancaster, California, mandated the installation of 1–1.5 kW solar systems on new single-family homes built as of 1 January 2014.[122]

In the quest for low-energy buildings, local governments are increasingly mandating solar water heating (SWH)—moving away from heating water with electricity. Spurred on by national targets, several cities in India, and Cape Town and Johannesburg in South Africa, are encouraging the use of SWH. In India in 2012, Surat made SWH mandatory in all buildings, and Chandigarh, Kolkata, Howrah, Durgapur, and Siliguri

i Net-zero buildings produce at least as much energy as they consume, using renewable energy sources. This can include generating energy from renewable energy sources on-site or purchasing electricity generated from renewable energy. Near-zero energy buildings produce/purchase slightly less energy than the energy that they consume.

ii The International Living Building Challenge (ILBC) is a certification scheme that rates buildings, communities, and infrastructures. There are more than 90 Living Building projects in operation or being developed around the world—particularly in Australia, Canada, Ireland, Mexico, and the United States. In order to become certified, "Living Buildings" must meet 100% of their energy demands from on-site renewable energy systems (net-zero-energy), capture and treat the building's own water needs for at least 12 continuous months at full occupancy, and meet standards for sustainable materials and indoor environmental quality. See more details at the International Living Building Institute Web site, http://living-future.org/lbc.

made installation mandatory in all multi-storied commercial establishments, including hospitals and five-star hotels.[123] Johannesburg launched its "Solar Water Heater Programme" with the aim to provide SWH to 110,000 poor and low-income households over the next three years.[124] Cape Town launched two programmes in 2012: one provides free SWH installations for poor households and the other makes SWH available to mid- to high-income households through monthly repayment rates below the cost of electricity saved through the installation.[125] In Asia, Beijing in China now requires new buildings and swimming pools to install SWH, and Kyoto in Japan made the installation of 3 kW solar PV or SWH mandatory in all large buildings.[126]

Other cities are using renewable energy for space and industrial heating and even for cooling. The use of district heating and cooling is becoming a best practice for the integration of renewable energy in cities, particularly in dense areas. Many are advancing local district heating/cooling with renewables in heat-only or combined heat and power (CHP) configurations. New York was the first U.S. city to require the use of "bioheat"—every gallon of oil heat used must be at least 2% biodiesel.[127] Vancouver adopted a "Neighbourhood Energy Strategy" in 2012 that aims to develop, expand, and convert existing steam heat systems to utilise local geothermal, solar, and sewage resources as it works towards its goal to become the World's Greenest City by 2020.[128] Braedstrup in Denmark expanded its solar collector area from 8,000 m² to 18,600 m² (5.6 MW_{th} to 13 MW_{th}) in 2012, to feed heat into its district network; and Dunedin in New Zealand installed a 1,100 kW wood chip boiler to supply seven campus buildings at the University of Otago.[129]

Yet other cities are building on-site CHP plants that use a variety of renewable fuels. For example, in 2012, Aberdeen in Scotland approved plans to build a CHP biomass plant to generate electricity and to provide 90% of the heat required for its paper mill; Aarhus in Denmark approved the construction of a 110 MW straw-fired CHP plant to achieve its objective of becoming carbon-neutral by 2030.[130]

Solar cooling is a new area for cities, with exploration under way mostly in areas with a district heating system and a cool water source close at a hand. In 2012, Singapore became home to the largest solar cooling system in the world, utilising a collector area of 3,900 m² (2.7 MW_{th}).[131]

Cities are also tapping their geothermal potential to advance renewable heating and generate power. Kidapawan in the Philippines approved construction of the city's third geothermal plant in 2012.[132] The U.S. city of Philadelphia, Pennsylvania, deployed the first U.S. commercial-scale geothermal system to heat buildings using domestic waste water.[133] Munich, Germany, in support of its target to have a fully renewable district heating system by 2040, has identified 15 sites where it can exploit geothermal energy, with the first due to come on line in 2013.[134]

In their efforts to green transport systems, several cities—including Bogota in Colombia, Guangzhou in China, and Mexico City—are promoting the use of plug-in hybrid and electric vehicles, while others are increasingly coupling the deployment of these vehicles with renewable energy.[135] The Brazilian city of Curitiba acquired 60 new hybrid electric and biodiesel vehicles for its bus fleet.[136] In the Netherlands, Amsterdam reinstated a USD 13,640 (EUR 10,000) subsidy for new electric taxis and continued to reimburse up to 50% of the additional cost for EV purchases to advance the city's goal of 100% renewable energy-powered electric transport by 2040.[137] Also in 2012, Barcelona in Spain installed the world's first wind-powered EV charging station, and Melbourne in Australia launched its first solar-powered charging station.[138]

"Smart city" initiatives[i] continue to advance as cities around the world transition towards low-carbon and sustainable infrastructure. In 2012, Fujisawa in Japan approved construction of the Fujisawa Sustainable Smart Town project, which will include installation of solar power systems in residential areas and public buildings, and will promote the use of renewably powered electric cars and bikes.[139] In Germany, the city utility in Krefeld implemented smart meters in 200 households to provide real-time energy use data and price fluctuations to consumers via their smart phones (to incentivise customers to shift consumption), and Munich partnered with Siemens to launch a 20 MW virtual power plant that pools and operates small-scale, distributed energy sources as a single installation.[140] Also in 2012, Buzios in Brazil was completed, thereby becoming the first smart city in Latin America; it will soon be followed in 2013 by Chile's demonstration project Smart City Santiago.[141]

An increasing number of cities voluntarily reported on their climate and energy actions in 2012 as they sought to share and scale-up best practices. For example, the carbon*n* Cities Climate Registry (cCCR) reported 561 voluntary climate commitments and 2,092 mitigation and adaptation actions undertaken by 300 cities in over 25 countries, up from 51 cities in 2011.[142] Local governments continued to join forces in 2012, as reflected in increases in the membership of city networks around the world. For example, 77 cities became signatories to the Mexico City Pact in 2012, bringing the total number to 285; the C40 Cities Initiative had 63 affiliated cities as of December 2012; and the EU Covenant of Mayors had almost 5,000 signatories as of early 2013.[143] These platforms, networks, and organisations also continue to partner with each other to advance coordinated action.

i Smart city projects use information and communication technologies (ICT) to develop smart energy systems that enhance energy efficiency, maximise the integration and use of renewable energy in buildings and in the local power grid, and integrate EVs in effective ways.

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES

● indicates national level policy
○ indicates state/ provincial level policy

	REGULATORY POLICIES AND TARGETS							FISCAL INCENTIVES				PUBLIC FINANCING	
	Renewable energy targets	Feed-in tariff/ 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/ tendering
HIGH INCOME COUNTRIES $$$$													
Australia	●	○			○		●	●				●	
Austria	●	●			●		●	●	●			●	
Barbados	●			●								●	
Belgium	●		○	○	●		●		●			●	●
Canada	○	○	○	○	●			●	●	●		●	●
Croatia	●	●						●				●	
Cyprus	●	●			●			●					
Czech Republic	●	●			●		●	●	●	●		●	
Denmark	●	●		●	●		●	●		●		●	●
Estonia	●	●			●						●	●	
Finland	●	●			●		●	●		●	●		
France	●	●			●		●	●	●	●		●	●
Germany	●	●			●	●		●	●	●	●	●	
Greece	●	●			●			●	●	●		●	
Hungary	●	●			●			●		●		●	
Ireland	●	●			●	○	●						●
Israel	●	●	●			●				●		●	●
Italy	●	●	●	●	●	●	●	●	●	●		●	●
Japan	●	●	●	●			●	●	●			●	
Luxembourg	●	●			●			●		●			
Malta	●	●		●				●		●			
Netherlands	●	●		●	●		●	●	●	●	●	●	
New Zealand	●												
Norway	●				●		●	●		●		●	
Oman								●			●	●	●
Poland	●		●		●		●	●		●		●	●
Portugal	●	●	●	●	●	●		●	●	●		●	●
Singapore				●								●	●
Slovakia	●	●						●		●			
Slovenia	●	●						●					●
South Korea	●		●	●	●		●	●	●	●		●	
Spain[1]	●	●		●	●	●		●	●	●		●	
Sweden	●		●		●		●	●	●	●		●	
Switzerland	●	●						●		●			
Trinidad and Tobago	●								●	●			
United Arab Emirates	○		○			○					○	○	○
United Kingdom	●	●	●		●	●	●	●		●	●	●	
United States		○	○	○	●	○	○	●	●	●	●	●	●

1 In Spain, the feed-in tariff (FIT) and net metering programmes have been temporarily suspended by Royal Decree for new renewable energy projects; this does not affect projects that have already secured FIT funding. The Value Added Tax (VAT) reduction is for the period 2010–12 as part of a stimulus package.

Note: Countries are organised according to GNI per capita levels as follows: "high" is USD 12,476 or more, "upper-middle" is USD 4,036 to USD 12,475, "lower-middle" is USD 1,026 to USD 4,035, and "low" is USD 1,025 or less. Per capita income levels and group classifications from World Bank, 2012. 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.

Source: See Endnote 1 for this section.

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES (CONTINUED)

● indicates national level policy
○ indicates state/provincial level policy

	REGULATORY POLICIES AND TARGETS							FISCAL INCENTIVES				PUBLIC FINANCING	
	Renewable energy targets	Feed-in tariff/ 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/ tendering
UPPER-MIDDLE INCOME COUNTRIES $$$													
Algeria	●	●											●
Argentina	●	●			●			●	●	●	●	●	●
Belarus										●			
Bosnia and Herzegovina	●	●						●					●
Botswana	●							●		●			
Brazil	●			●	●	○			●	●		●	●
Bulgaria	●	●			●			●		●		●	
Chile	●		●	●		●		●		●		●	
China	●	●	●		●	●		●		●	●	●	●
Colombia	●				●					●			
Costa Rica	●			○									
Dominican Republic	●	●		●		●		●	●	●			●
Ecuador		●								●		●	
Grenada	●			●						●			
Iran		●							●		●		●
Jamaica	●			●	●				●	●			●
Jordan	●	●		●	●					●		●	●
Kazakhstan		●					●						
Latvia	●	●			●					●		●	●
Lebanon	●			●		●				●		●	
Libya	●									●			
Lithuania	●	●	●		●	●						●	
Macedonia	●	●											
Malaysia	●	●	●		●					●		●	●
Mauritius	●	●											
Mexico	●			●		●			●			●	●
Montenegro	●	●											
Palau	●		●										
Panama		●		●					●	●	●		●
Peru		●			●					●			●
Romania	●		●		●		●			●		●	
Russia	●							●					
Serbia	●	●						●					
South Africa	●							●		●	●	●	●
St. Lucia	●			●									
Thailand	●	●			●					●		●	
Tunisia	●			●				●		●		●	
Turkey	●	●			●			●				●	
Uruguay	●	●		●	●	●		●		●		●	●
LOWER-MIDDLE INCOME COUNTRIES $$													
Armenia		●											
Cameroon										●			
Cape Verde	●			●					●		●		●
Côte d'Ivoire	●									●			
Egypt	●			●				●		●		●	●
El Salvador									●	●	●	●	●

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES (CONTINUED)

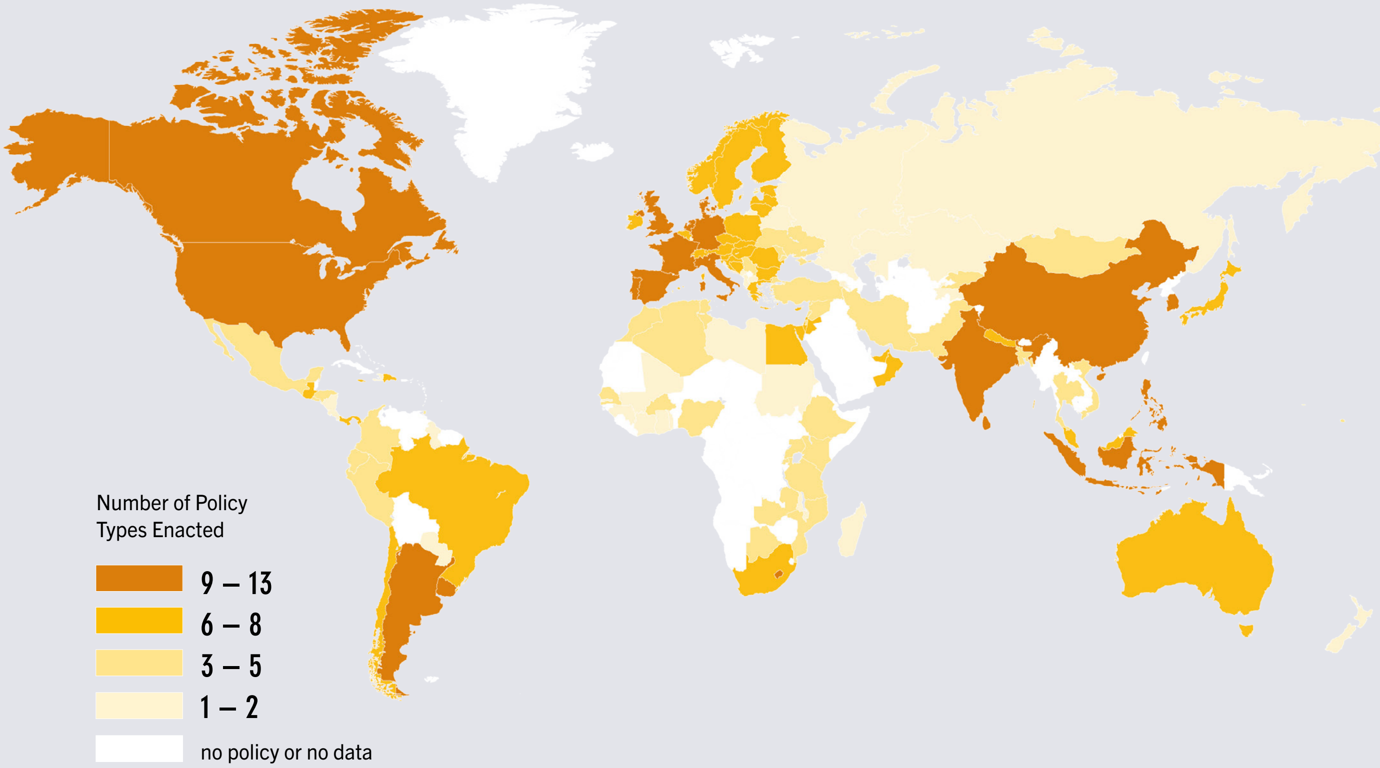
● indicates national level policy
○ indicates state/ provincial level policy

	REGULATORY POLICIES AND TARGETS							FISCAL INCENTIVES				PUBLIC FINANCING	
	Renewable energy targets	Feed-in tariff/ 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/ tendering
Fiji	●								●	●			
Ghana	●	●			●			●				●	
Guatemala	●			●	●				●	●			●
Guyana	●									●			
Honduras		●							●	●			●
India	●	●	●	●	●	○	●	●	●	●	●	●	●
Indonesia	●	●	●		●			●	●	●		●	●
Lesotho	●	●		●				●	●		●	●	●
Marshall Islands	●									●			
Micronesia, The Federated States of	●			○									
Moldova	●	●								●		●	
Mongolia	●	●											●
Morocco	●											●	●
Nicaragua		●								●			
Nigeria	●	●						●				●	
Pakistan	●	●		●				○				●	
Palestinian Territories[2]	●	●			●					●			●
Paraguay					●					●			
Philippines	●	●	●	●	●			●	●	●	●	●	●
Senegal	●	●								●		●	
Sri Lanka	●	●	●	●	●			●		●	●	●	
Sudan	●									●			
Syria	●	●		●					●				●
Ukraine	●	●							●	●			
Vietnam	●						●	●	●				
LOW INCOME COUNTRIES $													
Bangladesh	●							●		●		●	
Burkina Faso									●	●	●		●
Ethiopia	●				●					●		●	
Gambia										●			
Guinea										●			
Haiti												●	
Kenya	●	●				●				●			
Kyrgyzstan			●					●		●			
Madagascar	●									●			
Malawi	●				●					●			
Mali	●									●			
Mozambique	●				●							●	
Nepal	●							●	●	●		●	●
Rwanda	●	●								●		●	
Tajikistan	●	●											
Tanzania		●						●		●			
Togo										●			
Uganda	●	●						●		●		●	
Zambia					●			●		●			

2 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).

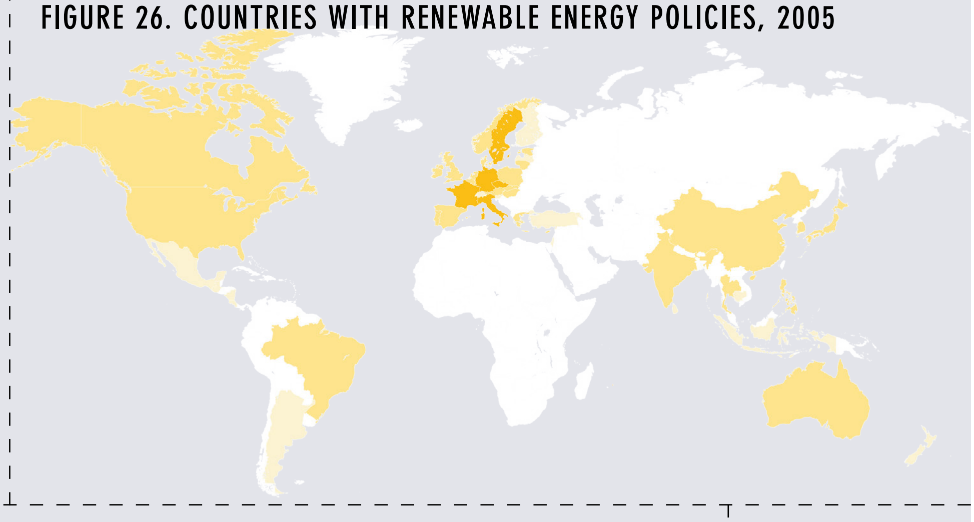
POLICY MAPS

FIGURE 25. COUNTRIES WITH RENEWABLE ENERGY POLICIES, EARLY 2013



138
COUNTRIES
HAVE DEFINED RENEWABLE ENERGY TARGETS

FIGURE 26. COUNTRIES WITH RENEWABLE ENERGY POLICIES, 2005



SUPPORT POLICIES ARE IN PLACE IN
127 COUNTRIES
TWO-THIRDS OF THESE ARE DEVELOPING AND EMERGING ECONOMIES

GSR 2013

04

05

The South Pacific nation of Tokelau, home to around 1,400 people, recently went 100% renewable through a combination of solar PV and biofuel derived from coconuts.

A number of countries are developing large-scale programmes that address the dual challenges of energy access and sustainability through the use of renewable energy.

Source: NASA

05 RURAL RENEWABLE ENERGY

Access to modern energy services is essential for economic growth and is indispensable to sustainable human development. Worldwide, roughly 1.3 billion people continue to lack access to electricity and 2.6 billion rely on traditional biomass stoves and open fires for cooking and heating.[1] More than 99% of people without electricity live in developing regions, and four out of five of them are in rural South Asia and sub-Saharan Africa.[2]

Renewable energy can play an important role in providing modern energy services to the billions of people who depend on traditional sources of energy, often relying on kerosene lamps or candles for lighting, traditional biomass for cooking and heating, and expensive dry-cell batteries to power radios for communications. In many rural areas of developing countries, connections to electric grids are economically prohibitive or may take decades to materialise. Today, there exists a wide array of viable and cost-competitive alternatives to traditional bioenergy and to grid electricity and carbon-based fuels that can provide reliable and sustainable energy services. Renewable energy systems offer an unprecedented opportunity to accelerate the transition to modern energy services in remote and rural areas.

Rural renewable energy markets in developing countries show significant diversity, with the levels of electrification, access to clean cookstoves, financing models, and support policies varying greatly among countries and regions. Due to the diversity of situations as well as to the variety of renewable technologies, typologies, and applications, the actors in this field are very diverse as well, and differ from one region to the next. They range from small private distributors of solar lanterns, pico-hydro systems, and modern cookstoves, to national governments, international nongovernmental organisations (NGOs), and development banks.[3]

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, operations and maintenance (O&M) entities, system integrators, national-level importers, regulators, extension agents, local technicians and industries, microenterprises, and microfinance institutions (MFIs).

The large diversity in the field and lack of coordination make data collection and impact assessment 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, making it difficult to detail the progress of renewable energy in remote and off-grid areas in all countries. Data are available, however, for many individual programmes and countries. This section seeks to update the status of the rural renewable energy markets based on information obtained from a large network of experts.

RENEWABLE TECHNOLOGIES FOR RURAL ENERGY

The year 2012 brought improved access to modern energy services through the use of renewables. Rural use of renewable electricity has increased with greater affordability, improved knowledge about local renewable resources, and more sophisticated technology applications. Attention to mini-grids has risen in parallel with price reductions in wind, solar inverter, gasification, and metering technologies.

Technological progress also advanced the rural heating and cooking sectors, while programmes to educate rural populations about the benefits of clean cooking solutions and other modern energy services solutions continued to gain popularity.[4] In addition, there was a continuation of programmes that focus on local training for repair and maintenance of small renewable energy systems, which is important because service costs in remote areas and islands are often prohibitive.[5]

Solar PV prices continued their downward trajectory, rendering even relatively small installations more affordable. Falling prices, efficient LED lamps, and battery improvements have combined to provide accessible, lightweight, reliable, and long-lived solar lanterns that can meet the basic needs of many people, usually at lower cost than conventional kerosene-based alternatives.[6] Solar pico-PV systems (SPS), which range up to 10 watts and can be easily self-installed and used, are now commonly available in a broad range of capacities. They can be put to a variety of uses, such as powering off-grid medical clinics, as is done in several remote parts of sub-Saharan Africa.[7]

Slightly larger solar home systems (SHS)—solar PV systems generally ranging from 10 to 200 watts—are increasingly being installed in rural areas where small grids are infeasible. In Bangladesh, for example, more than 2.1 million systems had been deployed by March 2013. This development is changing the energy-access dynamic in Bangladesh and turning rural villages into thriving centres of commerce.[8]

Small-scale wind turbines, typically up to 50 kW, have experienced performance improvements due to the advanced wireless technologies and materials that have come into play. Small- and medium-scale wind turbines are becoming increasingly competitive and are easy to integrate into existing grids. In Egypt, Ethiopia, Kenya, Lesotho, Madagascar, and Morocco, plans are under way to add wind to existing mini-grid systems.[9] (See Sidebar 8.) Even in areas with limited infrastructure, medium-scale wind systems in increasing numbers are being transported, installed, and maintained, with generation costs as low as USD 0.10/kWh in 2012.[10]

Micro-hydro power generation schemes as small as 1 kW are used extensively in remote and rural areas. Geothermal

SIDEBAR 8. INNOVATING ENERGY SYSTEMS: MINI-GRID POLICY TOOLKIT

Mini-grids are power solutions for isolated sites, such as islands and towns in remote mountainous or forested areas, where the grid cannot easily reach and where "stand-alone" power systems are not technically or economically viable. They are different from stand-alone solar PV or wind systems because they are larger in capacity (up to 1 MW), serve entire communities through distribution networks (instead of individual sites), and often incorporate a number of technologies (e.g., hybrid generator-wind-PV systems). They are expandable and can be managed by community groups or small businesses. When the national grid does reach an area, they can be connected to it.

There are several types of mini-grids. For example:

- Inverter-connected mini-grids incorporate a variety of technologies (solar PV, wind, diesel, battery banks) and range in size from 2 kW to over 300 kW. This is a rapidly developing field.
- Hydro/pico-hydro mini-grids are mature technologies used by remote missions, tea factories, and small communities.
- Gas-fired generator mini-grids powered by agricultural waste or biogas are maturing technologies, often used commercially by sugar and timber industries.
- Diesel-powered mini-grids were, until recently, the most common option. Cost and environmental concerns, however, have forced project developers to reconsider diesel generation as a "first" solution.

Attention to mini-grids has risen for a variety of reasons. Extending national power grids to remote communities is expensive, and electricity demand in rural areas may prove too low to cover such costs. While petroleum-based generator costs are increasing, mini-grid costs have fallen dramatically with price reductions in solar, wind, inverter, gasification, and metering technologies. Today, "intelligent" community mini-grids can automatically measure power use, bill customers, and provide management data online to system operators. Further, the demand for efficient, low-carbon technologies is at an all-time high, and rural electrification programmes are increasingly demanding green solutions.

For mini-grids to make sense, there usually must be potential for economic activity in the target community or some type of anchor load that can cover investment costs (these include telecom base stations, agricultural processing, and battery charging). There also must be a minimum population density and power demand from consumers; otherwise, stand-alone PV or generator systems tend to be better choices.

Mini-grids have been in use as long as hydro and diesel power generation technologies have been available. Hydro-based community mini-grids are common in Asia; in Africa, they were more widespread before the 1960s, when the focus shifted to large power-grid projects. Diesel mini-grids remain a "first" choice for isolated community electrification all over Africa. Recently, countries like Rwanda and Uganda have adopted strong small-scale hydro programmes. Island or remotely located sugar and lumber plantations often run biomass-waste mini-grid systems for operations and employee housing. Since 2005, use of solar PV/battery and inverter technology in remote communities has increased rapidly: for example, scores of solar mini-grids have been installed in West Africa by rural energy agencies.

Still, important barriers to wider use remain. First, poor understanding of mini-grid technology and a lack of experience with business models often causes decision makers to select more "traditional" solutions rather than "risky" un-proven solutions. Second, both unrealistic grid extension plans and a general unwillingness to invest off-grid stifle more appropriate investments in mini-grids. Third, the large upfront costs associated with mini-grid solutions, combined with business-as-usual support for diesel fuel, reduce investment in new solutions.

The "Mini-Grid Policy Toolkit" project[i] is increasing awareness of the potential offered by mini-grids, resolving common misperceptions, presenting lessons learned, and providing recommendations for senior policymakers and their advisors towards an increased adoption of renewable- and hybrid-based mini-grids into energy planning and policy.

The "Innovating Energy Systems" sidebar is a regular feature of the Global Status Report that focuses on advances in energy systems related to renewable energy integration and system transformation.

i The project is overseen by the Alliance for Rural Electrification (ARE), Energy Initiative Partnership Dialogue Facility (EUEI PDF), and REN21, and is being produced by African Solar Designs and MARGE.

Source: See Endnote 9 for this section.

energy is becoming increasingly popular where resources are available. It is highly competitive for electricity generation in countries with readily accessible high-temperature steam resources; for heat production from low-temperature sources; and for cascading heat[ii] from higher temperature applications.[11] Small-scale electricity installations are not yet competitive, but a few countries, including Ecuador and Kenya, have increased R&D funding in an effort to reduce costs.[12]

Solar thermal technologies are mature, reliable, accessible, and economically competitive, and they offer enormous potential for heating and cooling for residential and commercial needs as well as industrial processes. They are used widely for water heating, particularly in rural and urban China, and they offer significant potential for other developing countries.[13]

ii Cascading heat is a process by which heat surplus from a higher temperature process is used to perform successive tasks requiring lower and lower temperatures.

Solid biomass applications for drying and curing continue to increase in number, as do biogas plants, which are used widely for rural electrification and cooking. Biogas plants are based on simple technology and continue to increase in number where households and commercial farms have access to sufficient animal manure for fuel.[14] High upfront capital costs of larger plants, however, as well as operation and maintenance requirements and the lack of familiarity with biogas systems, have slowed their uptake in poor, rural areas. Even so, approximately 48 million domestic biogas plants have been installed since the end of 2011 for rural electrification, with the vast majority of these in China (42.8 million) and India (4.4 million), and smaller numbers in Cambodia and Myanmar.[15]

Ethanol can also be used as a cooking fuel instead of traditional solid biomass and charcoal. In Mozambique, an ethanol plant with production capacity of almost 2 million litres per year opened in early 2012. The company buys surplus cassava feedstock from about 3,000 local farmers and sells the ethanol fuel and clean cooking stoves at prices that are competitive with the local retail price of charcoal.[16]

POLICIES AND REGULATORY FRAMEWORKS

Policies that promote renewable energy and address barriers to their use have played a critical role in accelerating deployment and attracting investment to this sector, with countries applying a range of formal strategies aimed at promoting renewable solutions to the challenges of energy access.[17] These initiatives are integrated increasingly into broader rural development plans, with a focus on pro-poor policies and frameworks that are broad-based, attract new investment in energy access, and support local participation in developing and managing energy systems.

In many countries, greater political commitment is providing impetus to more integrated policy foundations, driving more decisive action, and opening up substantial public resources in both the medium and long terms. Policymakers are also benefiting from decades of past experience, both good and bad, building programmes that are more sensitive to the social and economic realities of their respective settings. Top-down approaches, such as those adopted by rural electrification agencies in sub-Saharan Africa in the late 1990s, are making way for enabling policy frameworks developed through bottom-up (endogenous) processes.

China, Brazil, India, and South Africa are in the lead, developing large-scale programmes that are making significant inroads into addressing the dual challenges of energy access and sustainability. Progress is also evident in Costa Rica and the Philippines, where rural electrification cooperatives have been adopted to oversee the overall planning and implementation of off-grid electrification programmes. Argentina, Bangladesh, Kenya, Mali, Mexico, and Sri Lanka are encouraging off-grid renewable energy programmes, often with a blend of public and private sector resources, while many countries continue to benefit from international assistance. For example, the EnDev programme (supported by Australia, Germany, the Netherlands, Norway, Switzerland, and the United Kingdom) has provided 9 million people with access to modern energy services in Benin, Bolivia, Burkina Faso, Burundi, Indonesia, Nepal, Nicaragua, and Peru.[18]

Formal targets remain a fundamental building block of these initiatives. Countries with electrification targets include Bangladesh, Botswana, Ethiopia, Malawi, the Marshall Islands, Nepal, Rwanda, South Africa, Tanzania, and Zambia.[19] (See Reference Table R17.) Several countries, including Brazil and China, established new energy-access targets in 2012, with specific resource allocations and monitoring systems being set up to achieve them.

The Economic Community of West African States (ECOWAS) plans to provide electrification to up to 78 million households by 2030, largely through mini-grids.[20] In October 2012, ECOWAS also adopted a regional renewable energy policy that aims to serve 25% of the rural population with decentralised renewable energy systems.[21] These initiatives aim to directly tackle the challenge of energy access in West Africa, where more than 170 million people lack access to electricity.[22]

Many programmes focus on the rollout of specific technologies such as solar home systems. India's Rural Electricity Policy envisions off-grid solutions based on stand-alone systems for villages/habitations where grid connectivity may not be feasible or cost effective, and on the adoption of isolated lighting technologies incorporating solar PV where neither stand-alone systems nor grid connectivity are viable. In Bangladesh, the Rural Electrification and Renewable Energy Development Project is currently installing some 1,000 solar home systems per day. This project is operated by an institutional partnership between the Bangladesh Infrastructure Development Company (IDCOL) and about 40 NGOs.[23]

Significant investment is and will be needed to maintain these and other programmes, and to achieve ambitious electrification

targets. The United Nations General Assembly's "Energy Access for All" objective of universal access to modern energy by 2030 will require an annual investment of an estimated USD 36–41 billion.[24]

The contribution of renewable energy technologies to the development of productive activities can significantly improve financial viability and sustainability of these investments, and large-scale off-grid renewable energy programmes have succeeded in addressing the initial capital costs barrier through a variety of financing instruments.[25] Often, subsidies are applied to incentivise operators to adopt renewable energy technologies while developing electrification schemes in remote communities. This buy-down of initial capital costs has facilitated the pace of deployment of renewable energy systems over the last decade.

Approaches vary by region. In Bangladesh, financing incentives include long-term loans; grants covering up to one-third of the capital costs; low-interest loans; and grace periods of about five years.[26] In the cases of Mali, Senegal, and Uganda, rural electrification funds subsidised up to 80% of the upfront capital costs, allowing energy service companies to engage in rural electrification schemes using renewable energy technologies.[27]

In many areas, the application of locally sourced funding is being used as a tool to achieve greater long-term financial sustainability. Several countries, including Uganda and Malawi, established support policies in 2012 to facilitate the mobilisation of local indigenous funds to contribute to closing the funding gap. These policies aim to allocate funding and resources to create local capacities, and promote energy literacy in order to ensure effective involvement of local people in the energy planning and decision-making processes.

The promotion of local funding is rooted in past programme experiences, where a lack of substantial and inherent local engagement left many programmes detached from the needs and characteristics of targeted communities. This falls against a backdrop of disappointing evidence about the contribution of small-scale, subsidised projects to the growth of energy access.

INDUSTRY TRENDS AND BUSINESS MODELS

The provision of energy services to rural markets has evolved over the last two decades from the centralised, public sector-led approach to a range of different types of public-private partnerships and private ventures in which renewables now play a key role. With the increasing recognition that low-income customers can provide fast-growing markets for goods and services—as in the mobile phone industry—and with the emergence of new models for serving them, rural energy markets are increasingly being recognised as potential business opportunities.[28]

Rural electrification programmes funded exclusively by government and donor resources are still being adopted across the developing world, especially for grid extension in both vertically integrated and liberalised markets. But commercial and quasi-commercial business models are starting to become mainstream options for providing a wider range of energy services to off-grid markets.[29] Promisingly, innovative multi-stakeholder business models are emerging continuously to provide customised and financially sustainable services based on renewable energy across the spectrum of rural energy needs.

Laos, Lesotho, and Nepal are implementing projects under an emerging model dubbed as the pro-poor public-private partnership (5P). The 5P model aims to improve access to energy services for rural populations; enhance the awareness of policymakers; build capacity at the national and local levels to develop policy options for integrating energy and rural development policies; and create an environment conducive to private sector and entrepreneurial investment for value creation that can be sustained and increased in the future.[30]

This variety of business models has been driven by the convergence of several trends. These include increased technology innovation and reduced prices (in both small-scale power generation equipment and devices); rising and more-volatile fossil and cooking fuel prices; growing awareness of the energy access challenge; and donor preference for cleaner, modern technologies.[31] At the same time, the rise of social entrepreneurship and "impact investment" is helping to shape the structure of innovative ventures in rural markets by integrating lessons from past experiences, including the importance of after-sale activities, availability of micro financing, and the creation of an enabling business environment.[32]

Over the past two decades, the so-called dealer and fee-for-service models have been the primary means for commercial dissemination of solar PV to serve household and small business electricity needs. Both models rely on concessions or exclusivity rights to serve a specific area or territory, and they often rely on targeted subsidies (e.g., full or partial capital cost subsidies). Over time, these schemes have evolved to include different types of public-private partnerships that have developed to meet the requirements of specific business environments. For example, Bolivia's programme is based on medium-term service contracts with output-based aid[i], and combines the dealer model with the traditional energy supply company concession scheme. It has an exclusivity term of only 2–5 years and offers a broad menu of ownership options.[33]

Other models include leasing arrangements. Soluz is providing SHS services via direct lease or lease-to-own arrangements in Honduras and the Dominican Republic.[34] The most notable public-private partnership projects—for the volume of SHSs and solar kits delivered—are active in Argentina, Bangladesh, China, India, Indonesia, Mongolia, and Vietnam.[35] They are carried out jointly by national governments in partnership with major donor bodies like the World Bank, and focus on replacing lanterns and diesel generators with portable, sustainable, and affordable alternatives.[36]

In general, mini-utility[ii] business models require complex planning and management skills and are strongly dependent on load volume, availability of a reliable low-cost primary energy source, customer affordability, and robust regulatory frameworks. Notwithstanding, there are many examples of private firms running successful and innovative mini-utilities with renewable energy.[37]

The following sections provide an overview of rural energy developments and trends by region, updated from the GSR 2012. Africa, particularly sub-Saharan Africa, has by far the lowest rates of access to modern energy services, while Asia presents significant gaps among countries, and the rate of

i Output-based aid refers to performance-based subsidies to support the delivery of basic energy services; payment of public funds is tied to the actual delivery of these services.

ii A mini-utility operates as an electricity company, but on a smaller scale, running mini-grid systems that can stand alone to serve a small community, and that may or may not be connected to the national grid. Mini-utilities are a common business model for rural electrification in many developing countries. They are either lighting-focused or provide total electrification, and they rely on a range of technologies, including diesel generators or hydropower as well as biomass, solar PV, and other renewables. Mini-utilities generally handle the full value chain from fuel sourcing to development and maintenance of distribution infrastructure, to billing and revenue collection; they are often regulated, much like their larger counterparts.

energy access in Latin America is comparatively high. (See Reference Table R17.)

A growing number of developing countries are transitioning to clean and sustainable cooking technologies and fuels, and away from the traditional practice of cooking over smoky open fires, driven by considerable health and climate co-benefits of using clean cookstoves and fuels. Yet in sub-Saharan Africa, more than 650 million people—about 76% of the region's inhabitants—rely on traditional biomass for heating and cooking.[38] The shares of population relying on traditional biomass for heating and cooking in Asia and Latin America are significantly lower by comparison. (See Reference Table R18.)

AFRICA: REGIONAL STATUS

Despite efforts to promote electrification in sub-Saharan Africa, the region has the lowest electrification rate in the world. An estimated 70% of the region's population does not have access to electricity.[39]

The ECOWAS member countries[i] plan rural energy advancement programmes collaboratively through their Centre for Renewable Energy and Energy Efficiency (ECREEE). This is one of the most active regions in Africa for the promotion of renewable energy and energy efficiency. ECREEE develops regional policy guidelines that are subsequently applied in ECOWAS member states, and has several strategic agreements with various international organisations (e.g., IRENA, UNIDO, FAO) to improve rural energy access and energy efficiency. In October 2012, ECOWAS countries adopted a target for renewables to make up 10% of the region's electricity mix by 2020 and 19% by 2030. As part of this target, the region aims to serve 25% of the rural population with off-grid electricity systems by 2020.[40]

Across the ECOWAS region, renewable energy micro-grids, which are smaller than mini-grids in scale but able to service multiple homes or a small business enterprise, are increasingly viewed as options for providing electricity to people in isolated areas. During 2012, several regional and international organisations—including ECREEE, Lighting Africa, and IRENA—worked to promote micro-grid projects through dissemination workshops.[41]

Encouraged by developments in the ECOWAS region, countries and regions elsewhere on the continent plan to emulate its programmes. In 2012, the energy ministers of the Southern African Development Community (SADC) and the East African Community (EAC) formally agreed to establish similar regional renewable energy and energy efficiency promotion programmes.[42]

Rural electrification rates in North Africa remain the highest on the continent. With the exception of Sudan, all countries in the Maghreb region are implementing "last mile" electrification programmes.[43] With support from the Regional Center for Renewable Energy and Energy Efficiency (RCREEE), Sudan announced a national energy efficiency action plan in 2012 that includes building seven large-scale wind, solar, and bio-power plants. In consultation with stakeholders, Sudan is currently designing and implementing an integrated renewable energy programme to advance domestic renewable energy deployment and is establishing the necessary regulatory and administrative frameworks to encourage public and private investment.[44]

Under the framework of its "Global Rural Electrification Program," Morocco electrified 3,663 villages (51,559 households) with off-grid systems and mini-grids. Renewable energy, particularly solar PV, played a significant role in increasing energy access for households in very remote areas.[45]

Also in 2012, Ghana announced a pilot programme to replace kerosene lanterns with solar lanterns in remote off-grid communities in order to reduce the national kerosene subsidy. The annual budget for the kerosene subsidy was equivalent to the cost of providing over 400,000 solar lanterns to poor rural households; the subsidy has now been partially scaled back. Studies to electrify island and rural communities in the Greater Accra, Volta, and Brong Ahafo regions were completed in 2012, and a mini-grid electrification programme was initiated.[46]

Mali's rural electrification programme has brought electricity to 740,000 people in the last six years, primarily (98%) with off-grid systems, thereby increasing the share of people with electricity access in rural areas from 1% to nearly 17%. While currently only 3% of the electricity is derived from renewables, the share of renewables in the mix is set to rise to 10% by 2015.[47]

Mozambique also has increased access through off-grid solar PV; the 0.5 MW of capacity added between 2010 and the end of 2012 brought the national total to 1.3 MW. An estimated USD 13 million was invested in solar power by the energy fund FUNAE in 2012 alone, contributing significantly to the increase in capacity. FUNAE planned to implement eight micro-hydro projects in 2013, and has earmarked USD 8 million to promote the development of renewable energy mini-grids.[48]

The programme "Increase Rural Energy Access in Rwanda through Public-Private Partnerships," co-financed by the

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

Rwandan national government and the European Union, involves electrifying rural areas primarily through hydro- and geothermal power.[49] The aim is to increase the share of Rwandans with electricity access from 6% in 2009 to 50% by 2017.[50] Under this programme, Spanish-based Isofoton made the winning bid in 2010 for a project to supply, install, and maintain solar PV systems at 300 schools across the country.[51]

Tanzania saw construction of several grid-connected small-scale renewable power plants during 2012, as a consequence of the newly established Small Power Producer (SPP) Framework; at year's end, the country had a pipeline of 60 projects totaling more than 130 MW, enough to bring power to more than 12 villages.[52] Also in 2012, Zimbabwe earmarked USD 1.5 million for solar lanterns to be distributed in rural schools across the country, while the country's Rural Electrification Authority (REA) worked with local industries to develop solar lamps and create solar power jobs.[53]

In Uganda, the World Bank concluded the Uganda Accelerated Rural Electrification Plan (UAREP) and was awaiting government approval at year's end. By the end of 2012, the government along with donor bodies had installed several mini-grids and thousands of isolated systems, including systems powered by hydropower, biomass, geothermal, solar, and wind. In addition, a collective fund that combines different types of financing was created in 2012 to accelerate grid extension in Uganda.[54]

ASIA: REGIONAL STATUS

Both China and India have made major national investments in renewable energy in recent years, and they have seen significant progress in extending energy access through decentralised solutions.[55] Elsewhere in the region, progress has been mixed. While several other countries—including Mongolia, Nepal, and Vietnam—have made measurable progress, Afghanistan, Bangladesh, Myanmar, and Pakistan continue to experience very low rates of rural electrification and still rely largely on traditional biomass for cooking and heating.[56]

Although China and India are neighbours and are 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, although an estimated 4 million Chinese in rural areas still lack access to modern energy sources.[57] India, in contrast, has a long way to go: more than 290 million people (25% of the population) lack access to electricity, and 66% of Indians continue to rely on traditional biomass as their primary source of energy despite the progress made in recent years.[58]

India announced in mid-2012 a goal to achieve universal access to electricity by 2017. Under the "Remote Village Electrification Programme," renewable energy systems were provided to 905 villages/hamlets over the 10 months leading to February 2012, far more than the targeted 500 villages/hamlets.[59] At the state level, Chhattisgarh initiated two schemes to replace the use of kerosene lamps with solar PV systems.[60]

In October 2012, China's State Council officially released its second energy policy-related white paper since 1991, which reflected the increased importance of renewable energy in the context of rural development. China is investing in technical upgrades of the existing grid infrastructure in rural areas to achieve 100% access to electricity by 2015. To address energy supply shortfalls in rural areas and to advance the phaseout of burning traditional wood fuels, old hydropower stations are being refurbished and deployment of small-scale hydropower and solar water heaters is being promoted.[61]

Sri Lanka announced in 2012 that it had achieved its target of providing electricity for all people in the Eastern Province after the commissioning of six off-grid and nine grid-extension projects in Kantale, Padhaviya-Sripura, and Seruwila. The aim is to bring reliable electricity services to un-electrified or under-electrified remote areas of the country that are covered by the National Power Corporation's (Napocor) Small Power Utilities Group.[62]

Although the focus in Asia is primarily on increasing access to electricity, there are a number of programmes and projects to address the heavy reliance on traditional biomass for cooking throughout the region, by providing access to clean cookstoves and alternative fuels, particularly biogas. In 2012, India launched its "National Cookstove Programme," which aims to avoid 17% of the premature deaths and disabilities associated with traditional biomass emissions that would otherwise occur by 2020.[63] In Bangladesh, a World Bank-financed programme will support NGO efforts to provide rural households with clean cooking solutions through the dissemination of 1 million cookstoves and 20,000 biogas units.[64]

LATIN AMERICA: REGIONAL STATUS

Compared with other developing regions of the world, Latin America is far closer to achieving full energy access, particularly to electricity. Across Latin America, an estimated 6% of the population (29 million people) remains without access to electricity, and about 14% (65 million people) depends on traditional biomass for heating and cooking.[65] Lack of access is primarily a rural issue, with 28% of the rural population lacking electricity, whereas in urban areas the share is about 1%.[66]

Due to geographical limitations, the only viable solution for most of the region's population living in isolated areas is the installation of off-grid renewable technologies. Because systems are generally installed by companies not based in these isolated areas, education and training programmes have been essential for developing local expertise and for training technicians to operate and maintain these systems. L'Institut Technique de la Côte-Sud (ITCS) in southern Haiti is one example of such a programme.[67]

Mexico has created several programmes to advance rural energy access through renewable energy and has made significant progress, achieving an overall electrification rate of nearly 98%. Even so, some 130,000 small communities remained without access to electricity by the end of 2012.[68] In the rural areas of southern Mexico, some 3.5 million people still lack access because they are very far from the grid, communities are very small, and economic resources are limited.[69]

To help advance energy access, the Mexican State Power Company started operating its first off-grid solar PV plant in 2012—the 65.5 kWp plant in the Sonoran town of Guaycora—which is the first of its kind in the country and is expected to provide electricity for more than 50 homes.[70] In addition, the Mexico Renewable Energy for Agriculture Project, financed by the World Bank and the Global Environment Facility, focuses on the deployment of renewable technologies for agricultural productive purposes. As of 2012, the project supported about 600 undertakings.[71]

Electricity coverage in Peru's rural areas increased from 30% in 2007 to 55% by late 2010. In early 2012, the government further extended the grid to reach a total of 92,000 households, with greater inclusion of renewable technologies to provide electricity to micro and small rural enterprises.[72] In Nicaragua, between 2007 and 2011, five new mini hydro plants and 20 micro turbines were added to provide more than 57,000 households with electricity services, and more than 6,900 individual household solar panels were installed in isolated areas.[73]

While the region has made important advances in renewable rural electrification, developments in the heating and cooking sector are relatively limited. In Mexico, for example, about one-quarter of the total population still cooks on open fires or with old, inefficient cookstoves.[74] To address this situation in Mexico and other countries in the region, a number of programmes have been implemented at both the national and regional levels.

Mexico and Peru have ongoing large-scale programmes to disseminate improved cookstoves, with the aim of reaching 1 million units each, and Bolivia also is promoting their use.[75] A group of Central American countries[i] with common policies has also committed to disseminating 1 million improved cookstoves in each country by 2020; strategies include social marketing, micro-financing, awareness-raising campaigns, and real-time monitoring of stove use.[76] Central American and Caribbean countries—including Guatemala, Honduras, and Nicaragua—are also relying increasingly on carbon markets to finance cookstove projects.[77]

THE PATH FORWARD

The need for rural energy in developing countries is, above all, a social and economic development matter for billions of people around the world. Renewable energy technologies, combined with business models adapted to specific countries or regions, have proven to be both reliable and affordable means for achieving access to modern energy services. And they are only growing more so as technological advances and rapidly falling prices (particularly for solar PV and wind power) enable renewables to spread to new markets.[78]

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 that govern rural energy markets. Such developments are increasing the attractiveness of rural energy markets for potential investors and leading to poverty alleviation and economic development.

Renewable energy has the potential to play a crucial role in achieving the target of energy access for all by 2030, while also creating millions of local jobs.[79] These targets can be achieved if institutional, financial, legal, and regulatory mechanisms are established and strengthened to support renewable energy deployment, improve access to financing, develop the necessary infrastructure, build awareness about renewable energy technologies and their potential, and train workers.[80]

i These countries include Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama.

06

A reservoir serving a hydropower facility near the town of Mingachevir in northwestern Azerbaijan.
Flexible plants such as hydro and bio-power facilities can respond rapidly to system fluctuations, supporting increasingly higher shares of variable solar and wind power.

06 FEATURE: SYSTEM TRANSFORMATION

By Rainer Hinrichs-Rahlwes (German Renewable Energies Federation – BEE; European Renewable Energy Council – EREC)

Renewable energy is growing rapidly and is likely to become the backbone of a secure and sustainable energy supply in an increasing number of developed and developing countries. Variable renewables such as wind and solar are growing particularly quickly in the electricity sector. Hydropower, geothermal, and bioenergy are being integrated into existing energy systems and markets in a growing number of countries, as fossil fuel and nuclear capacity is replaced with renewable-based technologies, and as supply chains are adapted. By contrast, integrating large shares of variable wind and solar requires that the energy mix and infrastructure become increasingly flexible and, where feasible, interconnected.[1] A number of countries are aiming beyond mere integration of renewable energy by enacting policies and measures to transform their energy systems to accommodate rising shares of variable renewables.

For countries and regions planning to achieve very high shares[i] of wind and solar energy, system transformation is the most efficient and least costly way to do so. "System transformation" is defined as the process of adapting the energy system by replacing traditional baseload power from coal-fired and nuclear power plants with a flexibility-driven system that enables significant increases in shares of variable renewables. It entails shifting from a system that is relatively rigid and centralised to one that is more nimble and decentralised. Producers, consumers, grid operators, and other actors will play greater roles in optimising supply and demand, in part through the use of information technologies (sometimes called "smart grids"), and also through increased interconnection of all energy sectors—power, heating and cooling, and transport.

The earliest and biggest challenges have to be met within the electricity sector, where relatively inflexible, conventional power plants and grid systems must, over time, be integrated with intelligent, flexibility-driven systems to support rising shares of a mix of variable and dispatchable renewable energy. Excess electricity can be used increasingly for transportation, heating, and cooling. Therefore, although transformation will require a change in the energy system as a whole, transformation of the electricity system is both feasible and most urgent.

SHIFTING PARADIGMS: FROM INTEGRATING RENEWABLES TO SYSTEM TRANSFORMATION

For many years, it was believed that renewable energy technologies (other than large hydro) could only supplement the established electricity system and that there was an inherent limit on the share of variable renewable sources that it could accommodate.[ii] Experience in Denmark, Germany, Spain, and elsewhere, however, has demonstrated that the implementation of suitable policies can enable the successful integration of higher shares of variable renewables than was thought possible only a few years ago, while also providing unforeseen benefits.[2] Most of the alleged constraints to achieving higher shares of renewables either have resulted from a lack of political will to enact the required enabling legislation and actions, or they have been disproven as technical solutions to overcome the various challenges have emerged. Hence, variable renewables are becoming a major part (meaning around 15–20% or more) of the electricity supply in an increasing number of countries.[3]

It is now evident that a mix of variable and dispatchable renewables can provide a stable and reliable electricity supply.[4] As installed capacities of renewables increase, a portfolio of different renewable technologies can often cover the major part of the power demand and, where inter-connected to other grids, can provide a surplus to export. They can provide electricity around the clock and throughout the year at reasonable costs, if the grid system and the regulatory framework are flexible and operated smartly. Further, it has been shown that renewables can reduce electricity prices considerably and thus alleviate energy costs for consumers.[5][iii]

Rising shares of variable renewable energy sources have triggered discussions about potential risks for system stability, the need for back-up capacities, and limitations of existing market designs that may no longer be able to provide adequate signals for needed future investment in power plants and infrastructure.[6] These discussions began in countries and regions where wind power shares of the total electricity mix exceeded 15% (e.g., Denmark, northern Germany, northern Spain, South Australia). The debate is expanding to other regions and technologies with, for example, high shares of solar PV emerging in Spain, Italy, and increasingly throughout Germany. Although the present debate focuses on these OECD countries, it will soon become relevant for other countries (including major emerging economies) as their shares of wind and solar

i - There is no specific percentage that applies. In a very inflexible system, the need for transformation may start at a level of 10%, whereas in other, more flexible, systems—including those with high existing shares of large hydropower—it may start well beyond 20 or 30%.

ii - This apprehension and doubt was less evident and less widely accepted in countries with high shares of hydropower, a resource that is quickly dispatchable and can serve as balancing power.

iii - This is a consequence of the merit order effect. Due to very low marginal costs of wind and solar power generation, all other power plants are pushed out of the merit order so that their full-load hours and resulting capacity factor decrease constantly. In addition, prices per kWh tend to be very low in times of high wind and solar yields.

electricity generation increase.

More interaction among the sectors could help improve overall system efficiency, could increase system stability and security of supply, and would be more cost effective. Thus, it could conceivably facilitate the transition towards an energy supply based on very high shares of renewable energy. In conventional energy systems, the interaction among the electricity, heating, cooling, and transport sectors is minimal, although in many markets electricity demand is closely linked to heating and cooling demand for buildings. Liquid and solid fuels and electricity are sourced, traded, and used through different channels. Infrastructure and markets are technically different, and are operated and maintained by different actors and under different technical and economic regulations. To address this situation, some countries have begun to integrate sectors using a variety of strategies discussed below.

Some industrialised countries (for example, Denmark and Germany) have decided to base their electricity supply and/or final energy supply predominantly on variable renewables.[7] They are moving their electricity supply away from systems based on traditional (relatively inflexible) base load that is complemented by marginal cost-driven balancing power to more flexible systems that are driven by and designed for variable renewables.

THE TECHNOLOGY CHALLENGE

Electricity generation must closely balance demand at all times. Most of the electricity in conventional power systems is produced by baseload power plants, which are available 24 hours a day, all year round. Additional generation above base load, anticipated to meet increased demand as the daily profile changes, is sourced from dispatchable intermediate cycling plants (those between peaking and baseload plants). Peak load is met by flexible plants that can vary their output within minutes or even seconds, such as gas turbines running on natural gas or biogas and hydropower, particularly dammed or pumped storage hydro systems. As the share of variable renewables increases in the resource mix, a system will need more plants that are optimised for providing rapid responses to system fluctuations.

For reasons of grid stability, particularly for frequency control, only limited variations in electricity supply (not following demand) can be tolerated. Excess power production must be limited by reducing electricity generation, disconnecting capacity from the grid, or shifting demand loads.

Most existing grids were designed, built, and equipped to deliver power from large-scale conventional baseload power plants using intermediate cycling plants and additional peak-power plants when needed. High-voltage transmission lines, combined with lower-voltage distribution networks, deliver electricity from large centralised power plants to dispersed consumers. The power grid in its present form was not designed to take power fed in from numerous decentralised generators of varying sizes and grid levels. Thus, as more distributed generation comes in from small-scale renewable energy systems, existing grids often need to be upgraded to accommodate the shift in transmission loads and to help guarantee stable and reliable power flow wherever and whenever needed.

A variety of solutions are already in use or are being evaluated, particularly in Europe, for facilitating significant increases in shares of renewable energy (particularly variable) while reducing shares of traditional baseload power. These solutions include:

- Using a diverse portfolio of both variable and dispatchable renewable power plants (e.g., pumped storage hydro, biogas) that are geographically dispersed. Many individual renewable power plants can be combined into a virtual power plant that consists of various distributed generation facilities of different sizes and using different sources, and that are operated collectively by a central control entity and thus provide power to meet continually changing demand;
- Ramping down flexible plants in periods of excess generation;
- Increasing interconnection capacity at all voltage levels across regions and between countries. Grid systems are becoming interconnected, often across borders, and balancing areas are being extended;
- Advancing the quality of forecasting of solar and wind resources to improve accuracy of resource predictability;
- Shifting demand through demand-side management (DSM);
- Shifting demand by directing excess electricity generation to other sectors—such as charging electric vehicles, heating water, or producing hydrogen;
- Using price signals to shift demand to times when high wind and solar availability occurs;
- Locating distributed electricity generation closer to the point of consumption, thereby reducing transmission losses and the need for transmission capacity;
- Using intelligent grids and smart software that can improve grid security by improving real-time information flow between the system operator and power plants that are technically equipped to deliver flexible system services;
- Using electric vehicles as decentralised flexible storage systems with remote charging and discharging capability;
- Integrating storage capacity into the system or with specific plants—for example, molten salt thermal storage with CSP plants. Storage technologies, from batteries to pumped hydro, are advancing and offer the capacity to store energy for periods of a few minutes to several months. This can meet a range of needs, from short-term use in electric vehicles to seasonal use for balancing weeks of low wind or no sun. (See Sidebar 3, GSR 2012.)

All of these technologies exist, but refinement and deployment need to be facilitated through clear political decisions and the development of enabling frameworks. Several countries have begun to implement these options—including Denmark, Germany, Spain, and Japan—using smart energy systems and increasing the flexibility of demand and supply by developing smart grid systems and adequate centralised and decentralised storage solutions.

THE ECONOMIC CHALLENGE

Conventional electricity markets are driven mainly by generation costs per unit of energy. Levelised costs of energy and the resulting merit order are the main elements of price building on the different market levels (futures, day ahead, intra-day, etc.). For thermal power plants, capital costs make up a relatively small share of generation costs, whereas (and to a lesser extent also for nuclear plants) fuel costs are a major portion of the total. Therefore, volatile fuel prices have an important impact on the economic viability of a power plant. In contrast, with the exception of bio-power plants, renewable power has zero fuel costs and the major share of the cost is capital invested up front for the technology, project construction, and grid connection.

Consequently, a fundamental difference between most renewable energy generation and fossil and nuclear power is the cost ratio between capital and operating costs. The marginal costs of most renewables (including hydro, geothermal, solar, and wind power) are low and often prevail over conventional power generation on spot markets, thereby reducing the economic viability of marginal cost based generation.

The result is ambiguous. Where high capacities of wind and solar are installed, they can significantly reduce electricity prices, with resulting benefits for residential and industrial consumers; on the other hand, this effect makes it increasingly difficult to recover costs and thus achieve a reasonable (if any) return on investment.[9] In combination with priority or guaranteed grid access for renewable energy, existing conventional power plants (in particular those providing peaking power) are more often pushed out of the merit order and thus operated with decreasing capacity factors and, therefore, reduced profitability.[10]

As with technology-related challenges, solutions are being developed to create sufficient signals for investment in grids and in strategic capacity reserves as well as in new and flexible power plants. Capacity markets[i], which offer remuneration for available capacity instead of for the electricity generated, as well as other flexibility mechanisms, are tools to secure (new) capacity to meet demand at any time. However, such payments risk locking-in conventional thermal capacity, which may be needed for only a few years until the transition towards renewables is further advanced. Mechanisms that are not well designed could result in subsidising environmentally harmful power plants that might otherwise be taken off line as stranded assets.

Discussion is ongoing regarding how to best design flexibility-driven capacity mechanisms—including, but not limited to, capacity markets. Several other options to advance and enable system transformation are evolving, however. These include the following:

- All technical and economic aspects of the energy system must be developed around the need to support variable renewables;[11]
- Incentives and regulations must support the development and deployment of improved flexibility options (e.g., grid infrastructure, storage capacity, DSM, and highly flexible power plants), rather than supporting capacity alone;[12]
- Regulatory frameworks need to enable the participation of both dispatchable and variable renewables in balancing markets in order to further reduce system costs;
- Reduction in gate closure times[ii] (including in intra-day trading) can facilitate the inclusion of variable renewables in balancing markets. Grid systems that are "smart" and diverse, and that cover large balancing areas, can be used in combination with properly functioning balancing markets.

SYSTEM TRANSFORMATION HAS BEGUN

In developing economies, where power systems are growing rapidly and still taking shape, systems can be designed to be highly flexible in order to accommodate variable renewables. In most OECD countries, however, the optimal way to achieve a system based on a high penetration of variable renewables is to transform the existing system towards one that is highly flexible.

Various elements of transformation are already in place in existing supply systems and energy mixes. Some of these elements are mature solutions that help with integration and, on a larger scale, can be elements of transformation as well; others are being introduced as new options. For example:

- Solar hot water systems with and without electricity back-up are combined with conventional decentralised and district heating systems;
- Bio-methane/biogas is injected into natural gas grids, where it is used for electricity, heating and cooling, and for fuelling vehicles;
- Abundant electricity from renewable sources is used for heating and for producing hydrogen, or for other applications that enable energy to be stored for later use;
- Natural gas and biogas and solid biomass are interacting in combined heat and power (CHP) systems;
- Electricity used in public vehicle fleets and private cars with the batteries serving as storage and balance for the electricity system is another option that is being explored.

Denmark, which pioneered the use of wind power and CHP biomass, achieved a renewable share that exceeded 24% of total final energy use in 2012.[13] In 2011, more than 40% of Denmark's electricity came from renewables; by the end of 2012, wind alone contributed more than 30% of the country's electricity consumption.[14] Biomass-CHP is a key domestic element of balancing power and system stability, while variability is balanced further by interconnecting the Danish grid with grids of other Scandinavian countries that source electricity either mainly from hydropower (Norway) or from hydropower and biomass CHP (Sweden).

Energienet.dk (ENDK), the state-owned grid operator for the gas grid and the electricity system, is working towards targets of 50% wind power by 2020 and a fully renewables-based energy system by 2050.[15] ENDK is developing and implementing new market regulations, including demand-side incentives, to cope

i - Capacity markets have been used without reference to renewables deployment for a long time in the United States and elsewhere around the world.

ii - Gate closure time describes how long in advance of actual delivery of energy the bids have to be placed. The shorter these times and the closer to real time, the easier it is for variable renewables—particularly in larger balancing areas—to participate in these markets, since weather forecasts are more accurate.

with increasing shares of wind power and the resulting cost effects. It is enhancing and enforcing the power (and gas) grids, setting up new transmission lines (some of which are being installed underground, particularly at lower voltage levels) to connect different parts of Denmark, connecting new offshore wind farms, and enhancing connections with neighbouring countries including Germany, the Netherlands, and particularly Norway and its hydropower resources.[16]

The Iberian Peninsula lacks sufficient interconnection capacity to the north (i.e., France) for the grids of European neighbours to help balance variable renewable energy. Only recently has an agreement been reached to double the interconnection capacity between Spain and France. Despite this shortcoming, **Spain**[i] and **Portugal**[ii] are among the countries with the highest wind power shares in Europe.[17] Both countries are dealing successfully with the resulting challenges. In Portugal, hydropower, and some bio-power (as well as some waste-to-energy plants) provide the major share of the country's flexible capacity. In Spain, the main tool for dealing successfully with high shares of wind and solar power is a special control centre (CECRE), established in 2006. CECRE's sole purpose is to monitor and safely integrate the highest possible amount of electricity from renewables.[18]

Germany is in the process of "Energiewende" (energy transition or turnaround), a transformation that started long before the 2011 decision to phase out nuclear power by 2022. The first feed-in law was enacted in 1991, and the uptake of renewable energy was significantly accelerated when the Renewable Energy Sources Act (EEG) entered into force in 2000. By granting priority grid access and priority dispatch to renewable energy, the EEG facilitated a process of transforming the power grid to accommodate increasing shares of renewable energy. The obligation for wind turbines (and recently also for solar PV) to provide system services (e.g., remote control by the grid operator and scalable output) was enacted and implemented in the 2004 and 2009 amendments to the law.[19] Renewables' share of total consumption in the power sector increased from 6.8% in 2000 to 22.9% in 2012, with wind and solar contributing more than half of this share.[20]

For 2020, Germany's targets are to meet at least 35% of national electricity demand (80% by 2050) with renewables, to provide more than 18% of the overall total final energy (more than 60% in 2050) with renewables, and to reduce greenhouse gas emissions by 40% by 2020 (80–95% by 2050). The process is labelled and planned as system transformation, to be implemented in a cost-efficient way while maintaining a high level of supply security.[21] Smart grids, grid extension, demand response, strategic reserves, and/or capacity mechanisms for balancing power are being discussed. An ordinance that entered into force at the end of 2012 obliges operators of strategically important power plants to keep them available as reserve capacities for the power system. Discussion about incentives for flexible capacities and/or capacity payments is also ongoing.[22]

China and India have the highest installed capacities of variable renewables of any developing countries and have both adopted ambitious targets to further increase the capacity and related shares of renewable energy consumption. (See Policy Landscape section.) China, India, and other countries with rapidly increasing capacities and resulting shares of variable renewables already face the challenge of integrating them into existing energy systems, which are often weak and inflexible. However, they have the opportunity to design infrastructure and markets alongside their developing wind and solar capacity; to integrate the power grid with dispatchable energy sources and CHP; and to integrate electricity with other sectors such as solar heating, electric vehicles, and other innovative products.

OUTLOOK

The process of developing, enacting, and implementing electricity systems with very high shares of renewables, particularly variable renewables, is ongoing. Several scenarios underline the possibility and viability of having an energysupply based predominantly on renewable energy.[23] They have been developed by high-level institutions, such as the IEA and the European Commission, and they frequently inform policy decisions. In December 2011, the European Commission published an "Energy Roadmap 2050" showing that all "decarbonisation scenarios" (those in compliance with the European Union's greenhouse gas reduction targets of minus 80–95% below 1990 levels by 2050) will be based on very high shares of renewables—i.e., as much as 54–75% of final energy consumption, and 59–83% of electricity supply, with variable renewables playing a major role.

Of the 164 scenarios examined by the Intergovernmental Panel on Climate Change in the *Special Report on Renewable Energy Sources and Climate Change Mitigation*, the most ambitious scenario with regard to the growth of renewable energy, improvements in energy efficiency, and the resulting greenhouse gas mitigation emphasised that implementation must be based on clear and unambiguous policy decisions, including the removal of fossil fuel and nuclear power subsidies (in all sectors, including electricity, heating and cooling, and transport fuels), in order to create a level playing field for renewable energy and to avoid further costly lock-in of fossil- and nuclear-based energy production.[24]

System transformation will be the most efficient and least costly means for achieving high renewable electricity shares with variable resources. The technologies needed to achieve transformation of the electricity system, from one based on thermal baseload plants fired with fossil fuels to one with high shares of variable renewables, are well understood. The requirements for designing and operating a supply system to accommodate high shares of variable renewables are also better understood, and the potential economic costs and benefits have been demonstrated. What is needed now is the political will to implement them.

i - In Spain, 32% of electricity was derived from renewables in 2012 (down from 33% in 2011), with 57% of that from wind, 13% from solar, and the rest from dispatchable renewable sources including hydro and bio-power, per Red Eléctrica Corporación, *Corporate Responsibility Report 2012* (Madrid: 2013), p. 60.

ii - In Portugal, 42.7% of electricity was derived from renewables in 2012, with about half (50.5%) from wind, 1.8% from solar, and the rest mainly from hydropower and biomass, per Direcção Geral de Energia e Geologia (DGEG), *Renováveis, Estatísticas Rápidas 2012* (Lisbon: January 2013).

REFERENCE TABLES

TABLE R1. GLOBAL RENEWABLE ENERGY CAPACITY AND BIOFUEL PRODUCTION, 2012

	Added During 2012	Existing at End-2012
Power Generation	(GW)	
Bio-power	+ 9	83
Geothermal power	+ 0.3	11.7
Hydropower	+ 30	990
Ocean power	~ 0	0.5
Solar PV	+ 29	100
Concentrating solar thermal power (CSP)	+ 1	2.5
Wind power	+ 45	283
Hot Water/Heating	(GW_{th})	
Modern bio-heat	+ 3	293
Geothermal heating	+ 8	66
Solar collectors for water heating[1]	+ 32	255
Transport Fuels	(billion litres/year)	
Biodiesel production	+ 0.1	22.5
Ethanol production	– 1.1	83.1

1 Solar collector capacity is for glazed water systems only. Additions are net; gross additions were estimated at 53 GW_{th}.

Note: Numbers are rounded to nearest GW/GW_{th}, 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 Tables R4–R8, Market and Industry Trends by Technology section and related endnotes.

Source: See Endnote 1 for this section.

TABLE R2. RENEWABLE ELECTRIC POWER GLOBAL CAPACITY, TOP REGIONS AND COUNTRIES, 2012

Technology	World Total	EU-27	BRICS	China	United States	Germany	Spain	Italy	India
	(GW)								
Bio-power	83	31	24	8	15	7.6	1	3.8	4
Geothermal power	11.7	0.9	0.1	~0	3.4	~0	0	0.9	0
Ocean (tidal) power	0.5	0.2	~0	~0	~0	0	~0	0	0
Solar PV	100	69	8.2	7.0	7.2	32	5.1	16.4	1.2
Concentrating solar thermal power (CSP)	2.5	2	~0	~0	0.5	~0	2	~0	~0
Wind power	283	106	96	75	60	31	23	8.1	18.4
Total renewable power capacity (not including hydropower)	**480**	**210**	**128**	**90**	**86**	**71**	**31**	**29**	**24**
Per capita capacity (W/inhabitant, not including hydropower)	70	420	40	70	280	870	670	480	20
Hydropower	990	119	402	229	78	4.4	17	18	43
Total renewable power capacity (including hydropower)	**1,470**	**330**	**530**	**319**	**164**	**76**	**48**	**47**	**67**

Note: Global total reflects additional countries not shown. Table shows the top six countries by total renewable power capacity not including hydropower; if hydro were included, countries and rankings would differ somewhat. To account for uncertainties and inconsistencies in available data, numbers are rounded to the nearest 1 GW, with the exception of the following: totals below 20 GW are rounded to the nearest decimal point; and per capita numbers are rounded to the nearest 10 W. Where totals do not add up, the difference is due to rounding. Small amounts, on the order of a few MW (including pilot projects), are designated by "~0." For more precise figures, see Global Market and Industry Overview and relevant 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 totals, and therefore the total world renewable capacity (and totals for some countries), do not include pure pumped storage capacity. For more information on hydropower and pumped storage, see Methodological Notes on page 130.

Source: See Endnote 2 for this section.

TABLE R3. WOOD PELLET GLOBAL TRADE, 2012

Exporter		Importer	Volume
			(kilotonnes)
United States	→	EU-27	1,956
Canada	→	EU-27	1,221
Russia	→	EU-27	676
Ukraine	→	EU-27	227
Croatia	→	EU-27	132
Belarus	→	EU-27	111
Bosnia and Herzegovina	→	EU-27	61
South Africa	→	EU-27	88
Serbia	→	EU-27	22
Australia	→	EU-27	19
Norway	→	EU-27	45
New Zealand	→	EU-27	14
Other	→	EU-27	49
Canada	→	Japan	50
Canada	→	South Korea	50
Canada	→	United States	30

Note: Trade data used in this analysis are complex and are not always standardised among countries.
Source: See Endnote 3 for this section.

TABLE R4. BIOFUELS GLOBAL PRODUCTION, TOP 15 COUNTRIES PLUS EU-27, 2012

Country	Fuel Ethanol	Biodiesel	Total	Comparison with Volumes Produced in 2011
	(billion litres)			
United States	50.4	3.6	54.0	– 2.4
Brazil	21.6	2.7	24.3	+ 0.6
Germany	0.8	2.7	3.5	– 0.5
Argentina	0.2	2.8	3.0	+ 0.1
France	1.0	1.9	2.9	+ 0.2
China	2.1	0.2	2.3	No change
Canada	1.8	0.1	1.9	+ 0.2
Thailand	0.7	0.9	1.6	+ 0.5
Indonesia	0.1	1.5	1.6	+ 0.2
Spain	0.4	0.5	0.9	– 0.3
Belgium	0.4	0.4	0.8	No change
The Netherlands	0.2	0.5	0.7	– 0.1
Colombia	0.4	0.3	0.7	No change
Austria	0.2	0.4	0.6	No change
India	0.5	>0.0	0.5	+ 0.1
World Total	**83.1**	**22.5**	**105.6**	**– 1.0**
EU-27	**4.2**	**9.1**	**13.3**	**– 0.7**

Note: All figures are rounded to nearest 0.1 billion litres; comparison column notes "no change" if difference is less than 0.05 billion litres. Ethanol numbers are for fuel ethanol only. Table ranking is by total volumes of biofuel produced in 2012 (from preliminary data), and not by energy content. Where totals do not add up, the difference is due to rounding.

Source: See Endnote 4 for this section.

TABLE R5. SOLAR PV GLOBAL CAPACITY AND ADDITIONS, TOP 10 COUNTRIES, 2012

Country	Total End-2011	Added 2012	Total End-2012
	(GW)		
Germany	24.8	7.6	32.4
Italy	12.8	3.6	16.4
United States	3.9	3.3	7.2
China	3.5	3.5	7.0
Japan	4.9	1.7	6.6
Spain	4.9	0.2	5.1
France[1]	2.9	1.1	4.0
Belgium	2.1	0.6	2.7
Australia	1.4	1.0	2.4
Czech Republic	2.0	0.1	2.1
Other Europe	3.3	4.1	7.4
Other World	4.1	2.6	6.7
World Total	**71**	**29**	**100**

1 For France, previously installed projects were connected to the grid in 2012, along with a limited contribution from new installations, per European Photovoltaics Industry Association, *Market Report 2012* (Brussels: February 2013).

Note: Countries are ordered according to total operating capacity. Capacities are rounded to the nearest 0.1 GW; world totals are rounded to nearest 1 GW. Rounding is to account for uncertainties and inconsistencies in available data; where totals do not add up, the difference is due to rounding. Data reflect a variety of sources, some of which differ quite significantly, reflecting variations in accounting or methodology. For more detailed information and statistics, see Solar Photovoltaics section in Market and Industry Trends by Technology and related endnotes.

Source: See Endnote 5 for this section.

TABLE R6. CONCENTRATING SOLAR THERMAL POWER (CSP) GLOBAL CAPACITY AND ADDITIONS, 2012

Country	Total End-2011	Added 2012	Total End-2012
	(MW)		
Spain	999	951	1,950
United States	507	0	507
Algeria	25	0	25
Egypt	20	0	20
Morocco	20	0	20
Australia	3	9	12
Chile	0	10	10
Thailand	5	0	5
World Total	**1,580**	**970**	**2,550**

Note: Table includes countries with operating commercial CSP capacity at end-2012. Several additional countries had small pilot plants in operation by year's end, including China (about 2.5 MW), France (at least 0.75 MW), Germany (1.5 MW), India (as much as 5.5 MW), Israel (6 MW), Italy (5 MW), South Korea (0.2 MW), and Thailand (5 MW). GSR 2012 also included 17 MW in Iran; this was removed because capacity is reportedly not in operation. Data are rounded to nearest MW. Rounding is to account for uncertainties and inconsistencies in available data; where totals do not add up, the difference is due to rounding.

Source: See Endnote 6 for this section.

TABLE R7. SOLAR WATER HEATING GLOBAL CAPACITY AND ADDITIONS, TOP 12 COUNTRIES, 2011

Country	Added 2011	Total End-2011
	(GW_{th})	
China	40	152
Germany	0.9	10.3
Turkey	1.3	10.2
Brazil	0.4	3.7
India	0.7	3.3
Japan	0.1	3.3
Israel	0.3	3.0
Austria	0.2	2.9
Greece	0.2	2.9
Italy	0.3	2.1
Australia	0.3	1.9
Spain	0.2	1.8
Rest of World	4	25
World Total	**49**	**223**

Note: Countries are ordered according to total installed capacity. Data are for glazed water collectors only (excluding unglazed collectors for swimming pool heating). 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}. Rounding is to account for uncertainties and inconsistencies in available data; where totals do not add up, the difference is due to rounding. By accepted convention, 1 million square metres = 0.7 GW_{th}. The year 2011 is the most recent one for which firm global data and most country statistics are available. It is estimated, however, that there were 282 GW_{th} of solar thermal capacity of all types in operation by the end of 2012, and 255 GW_{th} of glazed water collectors in operation worldwide. For details and source information, see Solar Heating and Cooling section of Market and Industry Trends by Technology.

Source: See Endnote 7 for this section.

TABLE R8. WIND POWER GLOBAL CAPACITY AND ADDITIONS, TOP 10 COUNTRIES, 2012

Country	Total End-2011	Added 2012	Total End-2012
		(GW)	
China[1]	45.1/62.4	15.8/13	60.8/75.3
United States	46.9	13.1	60.0
Germany	29.1	2.4	31.3
Spain	21.7	1.1	22.8
India	16.1	2.3	18.4
United Kingdom	6.6	1.9	8.4
Italy	6.9	1.3	8.1
France	6.8	0.8	7.6
Canada	5.3	0.9	6.2
Portugal	4.4	0.1	4.5
World Total	**238**	**45**	**283**

1 For China, left-hand data are the amounts classified as official additions to the grid or operational by year's end; right-hand data 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 for further elaboration of these categories.

Note: Countries are ordered according to total installed capacity; order of top 10 for 2012 additions is United States, China, Germany, India, United Kingdom, Italy, Spain, Brazil, Canada, and Romania. 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 data. Figures reflect a variety of sources, some of which differ to small degrees, reflecting variations in accounting or methodology. For more information and statistics, see Wind Power text in Market and Industry Trends by Technology section and relevant endnotes.

Source: See Endnote 8 for this section.

TABLE R9. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT, 2004–2012

Category	2004	2005	2006	2007	2008	2009	2010	2011	2012
	USD Billion								
New Investment by Stage									
1 Technology Research									
Government R&D	2.0	2.1	2.3	2.7	2.8	5.2	4.7	4.7	4.8
Corporate RD&D	3.0	2.9	3.3	3.6	4.0	4.0	4.6	4.8	4.8
2 Development/Commercialisation									
Venture Capital	0.4	0.6	1.2	2.2	3.2	1.6	2.5	2.6	2.3
3 Manufacturing									
Private Equity Expansion Capital	0.3	1.0	3.0	3.7	6.8	2.9	3.1	2.6	1.4
Public Markets	0.3	3.8	9.1	22.2	11.6	12.5	11.8	10.6	4.1
4 Projects									
Asset Finance	24.8	44.0	72.1	100.6	124.2	110.3	143.7	180.1	148.5
(re-invested equity)	(0.0)	(0.1)	(0.7)	(3.1)	(3.4)	(1.8)	(5.5)	(3.7)	(1.5)
Small distributed capacity	8.9	10.5	9.8	14.3	22.5	33.5	62.4	77.4	80.0
Total New Investment	**39.6**	**64.7**	**100.0**	**146.2**	**171.7**	**168.2**	**227.2**	**279.0**	**244.4**
5 M&A Transactions	8.6	25.9	35.6	58.6	59.4	64.3	57.8	73.5	52.2
Total Investment	**48.4**	**90.7**	**135.6**	**204.7**	**231.0**	**232.5**	**285.8**	**352.5**	**296.7**
New Investment by Technology									
Solar power	12.3	16.4	22.1	39.1	59.3	62.3	99.9	158.1	140.4
Wind power	14.4	25.5	32.4	57.4	69.9	73.7	96.2	89.3	80.3
Biomass and waste-to-energy	6.3	8.3	11.8	13.1	14.1	13.2	13.7	12.9	8.6
Hydro <50 MW	1.5	4.6	5.4	5.9	7.1	5.3	4.5	6.5	7.8
Biofuels	3.7	8.9	26.1	28.2	19.3	10.6	9.2	8.3	5.0
Geothermal power	1.4	0.9	1.4	1.8	1.8	2.7	3.5	3.7	2.1
Ocean energy	0.0	0.1	0.9	0.7	0.2	0,3	0.2	0.3	0.3
Total New Investment	**39.6**	**64.7**	**100.0**	**146.2**	**171.7**	**168.2**	**227.2**	**279.0**	**244.4**

Note: Where totals do not add up, this is due to rounding. For more information about the categories in this table, please see Investment Flows section and Sidebar 5.

Source: See Endnote 9 for this section.

TABLE R10. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2010/2011 AND TARGETS

Country	Primary Energy		Final Energy	
	Share (2010/2011)[1]	Target	Share (2011)	Target
EU-27			**13%**	**→ 20% by 2020**
Albania		→ 18% by 2020		→ 38% by 2020
Algeria				→ 40% by 2030
Argentina	9.8%			
Australia	3.7%			
Austria[2]	27%		31%	→ 45% by 2020
Barbados		→ 10% by 2012 → 20% by 2016		
Belarus	6.5%			
Belgium			5.5%	→ 13% by 2020
Bosnia and Herzegovina	7.7%			→ 40% by 2020
Botswana				→ 1% by 2016
Brazil	46%			
Bulgaria	7.0%		13%	→ 16% by 2020
Burundi				→ 2.1% by 2020
Cameroon	69% (2009)			
Canada	17%			
Chile	27%			
China	8%			→ 9.5% by 2015
Colombia	32%			
Costa Rica	83%			
Côte d'Ivoire		→ 3% by 2013 → 5% by 2015		
Croatia	12%			→ 20% by 2020
Cyprus			6%	→ 13% by 2020
Czech Republic[2]	8%		10%	→ 13.5% by 2020
Democratic Republic of the Congo	97%			
Denmark	19%		26%	→ 35% by 2020 → 100% by 2050
Djibouti				→ 100% by 2020
Dominican Republic				→ 25% by 2025
Ecuador	17%			
Egypt	4.1%			
El Salvador	76%			

TABLE R10. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2010/2011 AND TARGETS (CONTINUED)

Country	Primary Energy		Final Energy	
	Share (2010/2011)[1]	Target	Share (2011)	Target
Eritrea	65%			
Estonia	18%		26%	→ 25% by 2020
Fiji				→ 100% by 2013
Finland	20%		33%	→ 25% by 2015 → 28% by 2020 → 40% by 2025
France	6%		13%	→ 23% by 2020
Gabon				→ 80% by 2020
Germany[2]	9%		12%	→ 18% by 2020 → 30% by 2030 → 45% by 2040 → 60% by 2050
Greece[2]	6.1%		11%	→ 20% by 2020
Grenada		→ 20% by 2020		
Guatemala	94%			→ 80% by 2026
Honduras	97%			
Hungary[2]	8.3%		8.2%	→ 14.65% by 2020
India	7%		4.9%	
Indonesia	3.8%	→ 25% by 2025		
Iran	1.2%			
Ireland	9.1%		6.2%	→ 16% by 2020
Israel				→ 50% by 2020
Italy	11%		12%	→ 17% by 2020
Jamaica		→ 15% by 2020 → 20% by 2030		
Japan	6.9%	→ 10% by 2020		
Jordan		→ 7% by 2015 → 10% by 2020		
Kenya	69%			
Kosovo				→ 25% by 2020
Laos				→ 30% by 2025
Latvia	50%		33%	→ 40% by 2020
Lebanon				→ 12% by 2020
Libya		→ 10% by 2020		
Lithuania	14%	→ 20% by 2025	18%	→ 23% by 2020
Luxembourg			2.8%	→ 11% by 2020
Macedonia	10%			→ 28% by 2020
Madagascar				→ 54% by 2020

TABLE R10. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2010/2011 AND TARGETS (CONTINUED)

Country	Primary Energy		Final Energy	
	Share (2010/2011)[1]	Target	Share (2011)	Target
Malawi	88% (2012)	→ 7% by 2020		
Mali		→ 15% by 2020		
Malta			0.4%	→ 10% by 2020
Mauritania		→ 15% by 2015 → 20% by 2020		
Mauritius		→ 35% by 2025		
Mexico	6.9%			
Moldova		→ 20% by 2020		→ 17% by 2020
Mongolia		→ 20–25% by 2020		
Montenegro				→ 33% by 2020
Morocco		→ 8% by 2012		→ 10% by 2012
Mozambique	97% (2009)			
Netherlands[2]			4.4%	→ 16% by 2020
New Zealand	39%			
Nicaragua	65%			
Niger		→ 10% by 2020		
Norway	65%			→ 67.5% by 2020
Peru	24%			
Palau		→ 20% by 2020		
Palestinian Territories				→ 25% by 2020
Philippines	41%			
Poland	8.9%	→ 12% by 2020	11%	→ 15% by 2020
Portugal	23%		25%	→ 31% by 2020
Romania	16%		24%	→ 24% by 2020
Russia	5.6%			
Rwanda	87%			
Samoa		→ 20% by 2030		
Serbia	12%			→ 27% by 2020
Slovakia	7.5%		9.5%	→ 14% by 2020
Slovenia	14%		19%	→ 25% by 2020
Somalia	96% (2008)			
South Korea	2.75%	→ 4.3% by 2015 → 6.1% by 2020 → 11% by 2030		
South Sudan	66%			

TABLE R10. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2010/2011 AND TARGETS (CONTINUED)

Country	Primary Energy		Final Energy	
	Share (2010/2011)[1]	Target	Share (2011)	Target
Spain[2]	13%		15%	→ 20.8% by 2020
St. Lucia		→ 20% by 2020		
Sudan	70 (2009)			
Sweden[2]	38%		48%	→ 50% by 2020 → 49% by 2020
Switzerland	14%	→ 24% by 2020		
Syria		→ 4.3% by 2011		
Tanzania	>90%			
Thailand	21%	→ 25% by 2022		
Tonga				→ 100% by 2013
Turkey	11%	→ 30% by 2023		
Uganda	90%			
Ukraine	1.8%	→ 19% by 2030		→ 11% by 2020
United Kingdom	4%		3.8%	→ 15% by 2020
Uruguay	44%	→ 50% by 2015		
Vietnam	3.2%	→ 5% by 2020 → 8% by 2025 → 11% by 2050		

1 National share is for 2010/2011 unless otherwise noted.

2 Final energy targets for all EU-27 countries are set under EU Directive 2009/28/EC. The governments of Austria, the Czech Republic, Germany, Greece, Hungary, Spain, and Sweden have set additional targets that are shown above EU targets. The government of the Netherlands has reduced its more ambitious target to the level set in the EU Directive. Some countries shown have other types of targets (see Tables R11 and R12).

Source: See Endnote 10 for this section.

TABLE R11. SHARE OF ELECTRICITY PRODUCTION FROM RENEWABLES, EXISTING IN 2011 AND TARGETS

Country	Share (2011)[1]	Target
EU-27	**20.6%**	
Algeria	2.2% (2012)	→ 5% by 2017 → 40% by 2030
Antigua and Barbuda		→ 5% by 2015 → 10% by 2020 → 15% by 2030
Argentina	31%	→ 8% by 2016
Australia	11%	→ 20% by 2020
Bahamas, The		→ 15% by 2020 → 30% by 2030
Bangladesh	4.6%	→ 5% by 2015 → 10% by 2020
Barbados		→ 29% by 2029
Belgium	10.8%	→ 20.9% by 2020
Cape Verde	7.5%	→ 50% by 2020
Chile[2]	5.9%	→ 5% by 2014 → 10% by 2024
Cook Islands		→ 50% by 2015 → 100% by 2020
Costa Rica		→ 100% by 2021
Croatia	46%	→ 35% by 2020
Denmark[3]	40%	→ 50% by 2020 → 100% by 2050
Dominica		→ 100% (no date)
East Timor		→ 50% by 2020
Egypt	11% (2012)	→ 20% by 2020
Eritrea		→ 50% (no date)
Estonia	9.1%	→ 18% by 2015
Fiji		→ 90% by 2015
France	12%	→ 27% by 2020
Gabon	42%	→ 70% by 2020
Germany	21%	→ 35% by 2020 → 50% by 2030 → 65% by 2040 → 80% by 2050
Ghana		→ 10% by 2020
Greece	15%	→ 40% by 2020
Guatemala	64%	→ 60% by 2022
Guyana		→ 90% (no date)
India	11%	→ 10% by 2012
Indonesia	16%	→ 26% by 2025
Iraq	11%	→ 2% by 2030
Ireland	20%	→ 40% by 2020
Israel	0.5%	→ 5% by 2014 → 10% by 2020
Italy[2]	14% non-hydro	→ 26% by 2020
Jamaica		→ 15% by 2020
Kiribati		→ 10% (no date)
Kuwait		→ 15% by 2030
Latvia	51%	→ 60% by 2020
Lebanon		→ 12% by 2020
Libya	0% (2012)	→ 7% by 2020 → 10% by 2025
Lithuania	8.4%	→ 20% by 2020
Luxembourg[2]	11.6%	→ 11.8% by 2020
Madagascar	52%	→ 75% by 2020
Malaysia		→ 5% by 2015 → 9% by 2020 → 11% by 2030 → 15% by 2050
Mali	58%	→ 25% by 2020
Marshall Islands		→ 20% by 2020
Mauritius		→ 35% by 2025
Mexico	16%	→ 35% by 2026
Mongolia		→ 20-25% by 2020
Morocco	33% (2012)	→ 42% by 2020
New Zealand	76%	→ 90% by 2025
Nigeria	20.1%	→ 5% by 2015 → 10% by 2025
Niue		→ 100% by 2020
Pakistan[2]	~0%	→ 10% by 2012
Palestinian Territories	0.72% (2012)	→ 10% by 2020
Philippines	2%	→ 40% by 2020
Portugal	47%	→ 59% by 2020
Qatar		→ 20% by 2030
Romania	28.1%	→ 43% by 2020
Russia[2]	0.3%	→ 2.5% by 2015 → 4.5% by 2020
Rwanda	55%	→ 90% by 2012
Senegal		→ 15% by 2020
Seychelles		→ 5% by 2020 → 15% by 2030
Solomon Islands		→ 50% by 2015
South Africa	2.2%	→ 9% by 2030
Spain	30.5%	→ 38.1% by 2020
Sri Lanka[2]	0.1%	→ 10% by 2016 → 20% by 2020
St. Kitts and Nevis		→ 20% by 2015
St. Lucia		→ 5% by 2013 → 15% by 2015 → 30% by 2020
St. Vincent and the Grenadines		→ 30% by 2015 → 60% by 2020
Sudan		→ 10% by 2016
Thailand		→ 11% by 2011 → 14% by 2022
Tonga		→ 50% by 2015
Tunisia	5.5% (2012)	→ 4% by 2011 → 16% by 2016 → 40% by 2030
Turkey	25.3%	→ 30% by 2023
Tuvalu		→ 100% by 2020
Uganda	54%	→ 61% by 2017
United Kingdom Scotland	10.3%	→ 50% by 2015 → 100% by 2020
Uruguay	74.6%	
Vanuatu		→ 23% by 2014
Vietnam		→ 5% by 2020
Yemen		→ 15% by 2025

TABLE R11 ANNEX. SHARE OF ELECTRICITY PRODUCTION FROM RENEWABLES, EXISTING IN 2011, COUNTRIES WITHOUT TARGETS

Country	Share (2011)[1]
Austria	69%
Bahrain	0.006% (2012)
Belarus	0.8%
Bosnia and Herzegovina	29%
Brazil	89%
Bulgaria	8.4%
Canada	63%
Cameroon	88%
China	18%
Colombia	80%
Costa Rica	91%
Côte d'Ivoire	30%
Cuba	3.2% (2010)
Cyprus	4.7%
Czech Republic	9.2%
Democratic Republic of the Congo	99.6% (2009)
El Salvador	63%
Ethiopia	84%
Finland	32%
Honduras	65% (2010)
Hungary	7.6%
Iceland	100%
Iran	5.1%
Japan	10.5%; 3.8% not including hydro >10 MW
Jordan	0.5%
Kazakhstan	14%
Kenya	67.5%; 17.6% not including hydro
Lebanon	12% (2012)
Macedonia	21%

Country	Share (2011)[1]
Malawi	96.8%; 2.8% not including hydro
Malta	0.8%
Moldova	2.1%
Montenegro	43%
Mozambique	99.9%
Netherlands	10.9%
Nicaragua	32.7%
Norway	96.6%
Papua New Guinea	35.5%
Peru	56.9%
Poland	11.9%
Senegal	10.3%
Serbia	23.9%
Slovakia	17.2%
Slovenia	25.1%
Somalia	69% (2012)
South Korea	3%
Sudan	63%
Sweden	55%
Switzerland	57%
Tanzania	46%
Thailand	7%
Togo	0.6%
Tunisia	5.5% (2012)
Ukraine	5.8%
United States	13%
Uzbekistan	18%
Venezuela	73%
Zambia	99.6% (2010)

1 National share is for 2011 unless otherwise noted.

2 For certain countries, existing shares exclude large-scale hydro, because corresponding targets exclude large-scale hydro. These include: Chile, Italy, Luxembourg, Pakistan, Russia, and Sri Lanka.

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

Notes: Actual percentages are rounded to the nearest whole decimal for figures over 10% except where associated targets are expressed differently. A number of state/provincial and local jurisdictions have additional targets not listed here. The United States and Canada have de-facto state or provincial-level targets through existing RPS policies), but no national targets (see Tables R12-R16). Some countries shown have other types of targets (see Tables R10 and R12). See text of Policy Landscape section for more information about sub-national targets. Existing shares are indicative and are not intended to be a fully reliable reference. Share of electricity can be calculated using different methods. Reported figures often do not specify which method is used to calculate them, so the figures in this table for share of electricity are likely a mixture of the different methods and thus not directly comparable or consistent across countries. In particular, certain shares sourced from Observ'ER are different from those provided to REN21 by report contributors. In situations of conflicting shares, figures provided to REN21 by report contributors were given preference.

Source: See Endnote 11 for this section.

TABLE R12. OTHER RENEWABLE ENERGY TARGETS

Country	Sector/Technology	Target
EU-27	Transport	All EU-27 countries are required to meet 10% of final energy consumption in the transport sector with renewables by 2020
Algeria	Wind	10 MW by 2013; 50 MW by 2015; 270 MW by 2020; 2,000 MW by 2030
	Solar PV	25 MW by 2013; 241 MW by 2015; 946 MW by 2020; 2,800 MW by 2030
	CSP	25 MW by 2013; 325 MW by 2015; 1,500 MW by 2020; 7,200 MW by 2030
Argentina	Renewable electricity	3 GW by 2016
	Geothermal	30 MW electricity generation by 2016
Australia (South Australia)	Renewable electricity	33% of electricity generation by 2020
Austria	Wind	2,000 MW addition by 2020
	Solar PV	1,200 MW addition by 2020
	Hydro	1,000 MW addition by 2020
	Bioenergy and biogas	200 MW addition by 2020
Bangladesh	Solar	500 MW by 2015
	Rural off-grid solar	2.5 million units by 2015
	Bioenergy	2 MW electricity plant by 2014
	Biogas	150,000 plants by 2016; 4 MW electricity plant by 2014
Belgium	Heating and cooling	11.9% share of renewables in gross final consumption in heating and cooling by 2020
	Transport	10.14% share of renewables in gross final consumption in transport by 2020
(Walloonia)	Final energy	20% share of renewables by 2020
(Walloonia)	Renewable electricity	8 TWh/year of renewable power by 2020
Benin	Rural energy	50% of rural electricity from renewables by 2025
Brazil	Wind	15.6 GW by 2021
	Small-scale hydro	7.8 GW by 2021
	Bioenergy	19.3 GW by 2021
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		
(New Brunswick)	Renewable electricity	40% renewable power by 2020; increase renewable share 10% by 2016
(Nova Scotia)	Renewable electricity	20% by 2012; 25% by 2015
(Saskatchewan)	Renewables in general	33.3% by 2030
(Prince Edward Island)	Wind	30 MW increase by 2030 relative to 2011
(Ontario)	Renewable electricity	10,700 MW by 2022
(Ontario)	Wind	5,000 MW by 2025
(Ontario)	Solar PV	40 MW by 2025
(Ontario)	Hydro	1,500 MW by 2025
China	Renewable electricity	49 GW of new renewable capacity in 2013
	Wind	100 GW on-grid by 2015; 200 GW by 2020
	Solar PV	10 GW in 2013; 20 GW by 2015
	CSP	1 GW by 2015
	Hydro	290 GW by 2015
	Bioenergy	13 GW by 2015
	Solar thermal	280 GW_{th} (400 million m^2) by 2015

TABLE R12. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

Country	Sector/Technology	Target
Colombia	Grid-connected renewables	3.5% by 2015; 6.5% by 2020
	Off-grid renewables	20% of off-grid generation by 2015; 30% by 2020
Czech Republic	Transport	10.8% share of renewables in gross final consumption in transport by 2020
Denmark	Wind	50% share in electricity consumption by 2020
	Heating and cooling	39.8% by 2020
	Transport	10% by 2020
Djibouti	Solar PV	30% of rural electrification by 2017
Egypt	Non-hydro renewables	14% of electricity by 2020
	Wind	12% of electricity and 7,200 MW by 2020
	Solar PV	220 MW by 2020; 700 MW by 2027
	CSP	1,100 MW by 2020; 2,800 MW by 2027
Eritrea	Wind	50% of electricity generation (no date)
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 for bioenergy	103.5 MW (no date)
Finland	Wind	884 MW by 2020
	Hydro	14,598 MW by 2020
	Bioenergy	13,152 MW by 2020
France	Solar PV and CSP	Install 1 GW new capacity in 2013
	Wind	25 GW by 2020
	Offshore wind and ocean	6 GW by 2020
	Heating and cooling	33% by 2020
	Transport	10.5% by 2020
Germany	Heat	14% renewables in total heat supply by 2020
Greece	Solar PV	2,200 MW by 2030
	Heating and cooling	20% renewables in heating and cooling by 2020
Guinea-Bissau	Solar PV	2% of primary energy by 2015
India	Renewable electricity	53 GW capacity by 2017
	Wind	5 GW by 2017
	Solar	10 GW by 2017; 20 GW grid-connected by 2022; 2,000 MW off-grid by 2020; 20 million solar lighting systems by 2022
	Small-scale hydro	2.1 GW by 2017
	Bioenergy	2.7 GW by 2017
	Solar water heating	5.6 GW_{th} (8 million m^2) of new capacity to be added between 2012 and 2017
Indonesia	Wind, solar, hydro	1.4% share in primary energy (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
	Pumped storage[1]	3 GW by 2025
	Geothermal	6.3% share in primary energy and 12.6 GW electricity by 2025
	Biofuels	10.2% share in primary energy by 2025
Iraq	Wind	80 MW by 2016
	Solar PV	240 MW by 2016
	CSP	80 MW by 2016

TABLE R12. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

Country	Sector/Technology	Target
Ireland	Heating	15% renewables share 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 capacity 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; 300 ktoe in heating and cooling by 2020
	Bioenergy	19,780 GWh generation and 3,820 MW capacity by 2020; 5,670 ktoe in heating and cooling by 2020
	Heating and cooling	17.1% by 2020
	Solar water and space heating	1,586 ktoe by 2020
	Transport	17.4% by 2020
	Biofuels	2,899 ktoe in transport by 2020
Japan	Wind	5 GW by 2020; 8.03 GW offshore by 2030
	Solar PV	8 GW by 2020
	Hydro	49 GW by 2020
	Geothermal	0.53 GW by 2020; 3.88 GW by 2030
	Bioenergy	3.3 GW by 2020; 6 GW by 2030
	Wave and tidal	1,500 MW new capacity by 2030
Jordan	Renewable electricity	1,000 MW by 2018
	Wind	1,200 MW by 2020
	Solar PV	300 MW by 2020
	CSP	300 MW by 2020
	Solar water heating	30% of households by 2020 (from 13% in 2010)
Kazakhstan	Renewable electricity	1.04 GW by 2020
Kenya	Renewable electricity	Double installed capacity by 2012
	Geothermal	5,000 MW by 2030
	Solar water heating	Cover 60% of annual demand for buildings using over 100 litres of hot water per day
Kuwait	Wind	3.1 GW and 7.5 TWh by 2030
	Solar PV	3.5 GW and 4.2 TWh by 2030
	CSP	1.1 GW and 3.2 TWh by 2030
Lebanon	Wind	60–100 MW by 2015
	Hydro	40 MW by 2015
	Biogas	15–25 MW by 2015
	Solar water heating	133 MW_{th} (190,000 m^2) newly installed capacity during 2009–2014
Lesotho	Renewable electricity	260 MW by 2030
	Rural energy	35% of rural electrification from renewables by 2020
Libya	Wind	260 MW by 2015; 600 MW by 2020; 1,000 MW by 2025
	Solar PV	129 MW by 2015
	CSP	125 MW by 2020; 375 MW by 2025
	Solar water heating	80 MW_{th} by 2015; 250 MW_{th} by 2020

TABLE R12. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

Country	Sector/Technology	Target
Luxembourg	Heating and cooling	8.5% renewables in gross final consumption in heating and cooling in 2020
Malawi	Hydro	346.5 MW installed capacity by 2014
Malaysia	Renewable electricity	2,065 MW (excluding large-scale hydro), 11.2 TWh, or 10% of national supply; 6% capacity by 2015; 11% capacity by 2020; 14% capacity by 2030; 36% capacity by 2050
Micronesia	Renewable electricity	10% renewable power in urban centers and 50% in rural areas by 2020
Morocco	Wind	2,000 MW by 2020
	Solar	2,000 MW by 2020
	Hydro	2,000 MW by 2020
	Solar water heating	280 MW_{th} (400,000 m^2) by 2012; 1.2 GW_{th} (1.7 million m^2) by 2020
Mozambique	Wind, solar, hydro	2,000 MW each (no date)
	Solar PV	82,000 systems installed (no date)
	Solar water and space heating	100,000 systems installed in rural areas (no date)
	Wind for water pumping	3,000 stations installed (no date)
	Biodigesters for biogas	1,000 systems installed (no date)
	Renewable-energy based productive systems	5,000 installed (no date)
Nepal	Wind	1 MW by 2013
	Solar	3 MW by 2013
	Micro hydro	15 MW by 2013
Netherlands	Biofuels	5% in transport fuel mix by 2013; 10% by 2020
Nigeria	Wind	1 MW by 2015; 20 MW by 2025; 40 MW by 2035
	Solar PV utility-scale (>1 MW)	1 MW by 2015; 50 MW by 2025
	Small-scale hydro	100 MW by 2015; 734 MW by 2025; 19,000 MW by 2035
	Bioenergy	100 MW 2025; 800 MW by 2035
Norway	Renewable electricity	30 TWh electricity production 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
	Bioenergy	21 MW by 2020
Philippines	Renewable electricity	Triple 2010 renewable power capacity by 2030
	Wind	1,975 MW added by 2030
	Solar	284 MW added by 2030
	Hydro	5,394.1 MW added by 2030
	Geothermal	1,165 MW added by 2030
	Bioenergy	81 MW added by 2030
	Ocean	71 MW by 2030
Poland	Wind (offshore)	1 GW by 2020

TABLE R12. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

Country	Sector/Technology	Target
Portugal	Renewable electricity	15.8 GW by 2020
Qatar	Solar PV	1.8 GW by 2014
Romania	Heating and cooling	22% by 2020
	Transport	10% by 2020
Rwanda	Hydro	340 MW by 2017
	Small-scale hydro	42 MW by 2015
	Geothermal	310 MW by 2017
	Biogas	300 MW by 2017
	Off-grid renewables	5 MW by 2017
Samoa	Renewable electricity	Increase contribution of renewables for energy services and supply 20% by 2030
Saudi Arabia	Renewable electricity	24 GW by 2020; 54 GW by 2032
	Solar	41 GW by 2032 (25 GW CSP and 16 GW PV)
	Wind, geothermal, and waste-to-energy[2]	Combined 13 GW by 2032
Serbia	Wind	1,390 MW (no date)
	Solar	150 MW by 2017
South Africa	Renewable electricity	17.8 GW by 2030
South Korea	**Capacity**	
	Wind	4.155 million toe by 2020
	Solar PV	1.364 million toe by 2030
	Solar thermal	1.882 million toe by 2030
	Hydro	1.477 million toe by 2030
	Geothermal	1.261 million toe by 2030
	Bioenergy	10.357 million toe by 2030
	Organic MSW[2]	11.021 million toe by 2030
	Ocean	1.540 million toe by 2030
	Electricity Generation	
	Renewable electricity	13,016 GWh (2.9%) by 2015; 21,977 GWh (4.7%) by 2020; 39,517 GWh (7.7%) by 2030
	Wind	100 MW by 2013; 900 MW by 2016; 1.5 GW by 2019; 16,619 GWh by 2030
	Solar PV	2,046 GWh by 2030
	Solar thermal	1,971 GWh by 2030
	Large-scale hydro	3,860 GWh by 2030
	Small-scale hydro	1,926 GWh by 2030
	Geothermal	2,803 GWh by 2030
	Forest bioenergy	2,628 GWh by 2030
	Biogas	161 GWh by 2030
	Landfill gas	1,340 GWh by 2030
	Ocean	6,159 GWh by 2030

TABLE R12. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

Country	Sector/Technology	Target
Spain	**Electricity**	
	Onshore wind	35,000 MW by 2020
	Offshore wind	750 MW by 2020
	Solar PV	7,250 MW by 2020
	CSP	4,800 MW by 2020
	Hydro	13,861 MW by 2020
	Pumped storage[1]	8,811 MW by 2020
	Geothermal	50 MW by 2020
	Bioenergy (from solids)	1,350 MW by 2020
	Organic MSW[2]	200 MW by 2020
	Biogas	400 MW by 2020
	Ocean energy	100 MW by 2020
	Heating and Cooling	
	Renewables in general	18.9% by 2020
	Solar water and space heating	644 ktoe by 2020
	Geothermal	9.5 ktoe by 2020
	Bio-heat	4,653 ktoe by 2020
	Heat pumps	50.8 ktoe by 2020
	Transport	
	Renewables in general	11.3% renewables in final consumption of energy in transport by 2020
	Biodiesel	7% of total energy in transport fuel use by 2012 and 2013; 2,313 ktoe by 2020
	Ethanol/bio-ETBE	400 ktoe by 2020
	Electricity for transport	501 ktoe from renewable sources by 2020
	Final Energy	
	Wind	6.3% by 2020
	Solar	3% by 2020
	Hydro	2.9% by 2020
	Geothermal, ocean energy, and heat pumps	5.8% by 2020
	Bioenergy, biogas, and organic MSW[2]	0.1% by 2020
	Biofuels	2.7% by 2020
Sri Lanka	Wind, small-scale hydro, and bio-power	10% of electricity generation by 2015
	Biofuels	20% supply of all liquid fuels by 2020
Sudan	Wind	320 MW by 2031
	Solar PV	350 MW by 2031
	CSP	50 MW by 2031
	Hydro	54 MW by 2031
	Bioenergy (from solids)	80 MW by 2031
	Biogas	150 MW by 2031

TABLE R12. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

Country	Sector/Technology	Target
Swaziland	Solar water heating	Installed in 20% of all public buildings by 2014
Sweden	Renewable electricity	25 TWh more renewable electricity than in 2002 by 2020
	Common electricity certificate market with Norway	26.4 TWh by 2020
	Transport	Vehicle fleet that is independent from fossil fuels by 2030
Switzerland	Renewable electricity	11.94 TWh by 2035; 24.22 TWh by 2050
	Hydro	43 TWh by 2035
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
	Bioenergy	140 MW by 2020; 260 MW by 2025; 400 MW by 2030
Tajikistan	Small-scale hydro	100 MW by 2020
Thailand	**Electricity**	
	Wind	1,200 MW by 2022
	Solar	2,000 MW by 2022
	Hydro	1,608 MW by 2022
	Geothermal	1 MW
	Bioenergy	3,630 MW by 2022
	Biogas	600 MW by 2022
	Organic MSW[2]	160 MW by 2022
	Wave and tidal	2 MW by 2022
	Heating	
	Solar	100 ktoe by 2022
	Solid biomass	8,200 ktoe by 2022
	Biogas	1,000 ktoe by 2022
	Organic MSW[2]	35 ktoe by 2022
	Transport	
	Ethanol	9 million litres/day by 2022
	Biodiesel	5.97 million litres/day by 2022
	Advanced biofuels	25 million litres/day by 2022
Trinidad and Tobago	Renewable electricity	5% of peak demand (or 60 MW) by 2020
Tunisia	Renewable electricity	1,000 MW (16%) by 2016; 4,600 MW (40%) by 2030
	Wind	1,500 MW by 2030
	Solar PV	1,900 MW by 2030
	CSP	300 MW by 2030
	Bioenergy (from solids)	300 MW by 2030

TABLE R12. OTHER RENEWABLE ENERGY TARGETS (CONTINUED)

Country	Sector/Technology	Target
Uganda	Solar home systems (PV)	400 kWp by 2012; 700 kWp by 2017
	Large-scale hydro	830 MW by 2012; 1,200 MW by 2017
	Mini and micro hydro	50 MW by 2012; 85 MW by 2017
	Geothermal	25 MW by 2012; 45 MW by 2017
	Organic MSW[2]	15 MW by 2012; 30 MW by 2017
	Solar water heating	4.2 MW_{th} (6,000 m^2) by 2012; 21 MW_{th} (30,000 m^2) by 2017
	Biofuels	720,000 m^3/year produced by 2012; 2.16 million m^3/year produced by 2017
Ukraine	Solar	10% of energy balance by 2030; 90% annual increase to 2015
United Arab Emirates		
(Abu Dhabi)	Renewable Electricity	7% renewables in generation capacity by 2020
(Dubai)	Renewable Electricity	5% of generating capacity and 1 GW by 2030
United Kingdom	Heat	12% by 2020
	Biofuels	5% by 2014
Uruguay	Wind	1 GW by 2015
	Bioenergy	200 MW by 2015
Vietnam	Biofuels	Equivalent to 1% of domestic petroleum demand by 2015; 5% of demand by 2025
Yemen	Wind	400 MW by 2025
	Solar PV	4 MW by 2025
	CSP	100 MW by 2025
	Geothermal	200 MW by 2025
	Bioenergy	6 MW by 2025
Zimbabwe	Biofuels	10% share in liquid fuels by 2015

1 Pure pumped storage plants are not energy sources but instead means for energy storage; as such, pumped storage involves conversion losses. Further, pumped storage plants can be fed by renewable and non-renewable energy sources. Pumped storage is included here because it can play an important role as balancing power, in particular for balancing variable renewable resources.

2 It is not always possible to determine whether municipal solid waste (MSW) is total (including plastics) or only the organic share. Thailand is confirmed all-organic and Uganda is predominantly organic.

Note: Some countries shown have other types of targets (see Tables R10 and R11).

Source: See Endnote 12 for this section.

TABLE R13. 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
2008	70	Queensland (Australia); California (USA); Chhattisgarh, Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu, and West Bengal (India); Iran; Kenya; Philippines; Tanzania; Ukraine
2009	81	Australian Capital Territory, New South Wales, and Victoria (Australia); Hawaii, Oregon, and Vermont (USA); Japan; Kazakhstan; Serbia; South Africa; Taiwan
2010	86	Bosnia and Herzegovina; Malaysia; Mauritius; Malta; United Kingdom
2011	92	Rhode Island (USA); Nova Scotia (Canada); Ghana; Montenegro; Netherlands; Syria
2012	97	Jordan; Nigeria; Palestinian Territories; Rwanda; Uganda
2013 (early)	97	
	99	**Total Existing**

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

Source: See Endnote 13 for this section.

TABLE R14. 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	44	Illinois, New Hampshire, North Carolina, and Oregon (USA); Northern Mariana Islands (USA)
2008	51	Michigan, Missouri, and Ohio (USA); Chile; India; Philippines; Romania
2009	52	Kansas (USA)
2010	55	British Columbia (Canada); South Korea; Puerto Rico (USA)
2011	56	Israel
2012	58	China; Norway
2013 (early)	58	
	76	**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 18 jurisdictions believed to have RPS/Quota policies but whose year of enactment is not known (Indonesia, Kyrgyzstan, Lithuania, Malaysia, Palau, Portugal, Romania, Sri Lanka, United Arab Emirates, and the Indian states of 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). The Italian RPS is being phased out according to new directives from the government but it was still in place as of early 2013.

Source: See Endnote 14 for this section.

TABLE R15. NATIONAL AND STATE/PROVINCIAL BIOFUEL BLEND MANDATES

Country	Mandate
Angola	E10
Argentina	E5 and B7
Australia	**Provincial:** E4 and B2 in New South Wales; E5 in Queensland
Belgium	E4 and B4
Brazil	E18–25 and B5
Canada	**National:** E5 and B2. **Provincial:** E5 and B4 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
Colombia	E8
Costa Rica	E7 and B20
Ethiopia	E5
Guatemala	E5
India	E5
Indonesia	B2.5 and E3
Jamaica	E10
Malawi	E10
Malaysia	B5
Mozambique	E10 in 2012–2015; E15 in 2016–2020; E20 from 2021
Paraguay	E24 and B1
Peru	B2 and E7.8
Philippines	E10 and B2
South Africa	E10
South Korea	B2.5
Sudan	E5
Thailand	E5 and B5
Turkey	E2
United States	**National:** The Renewable Fuels Standard 2 (RFS2) requires 136 billion litres (36 billion gallons) of renewable fuel to be blended annually with transport fuel by 2022. **State:** E10 in Missouri and Montana; E9–10 in Florida; E10 in Hawaii; E2 and B2 in Louisiana; B4 by 2012, and B5 by 2013 (all by July 1 of the given year) in Massachusetts; E10 and B5, B10 by 2013, and E20 by 2015 in Minnesota; B5 after 1 July 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 and B2, increasing to B5 180 days after in-state feedstock and oil-seed crushing capacity can meet 3% requirement in Washington.
Uruguay	B5; E5 by 2015
Vietnam	E5
Zambia	E10 and B5
Zimbabwe	E5, to be raised to E10 and E15

Note: Mexico has a pilot E2 mandate in the city of Guadalajara. 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 with a mandate expected. 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 programme in several provinces. Table R15 lists only biofuel blend mandates, additional transportation and biofuel targets can be found in Table R12.

Source: See Endnote 15 for this section.

TABLE R16. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES

Targets for Renewable Share of Energy, 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
Fukushima Prefecture, Japan	100% of total energy by 2040
Hamburg, Germany	20% of total energy by 2020; 100% by 2050
London, U.K.	25% of total energy by 2030
Nagano Prefecture, Japan	70% of total energy by 2050
Paris, France	25% of total energy by 2020
Skellefteå, Sweden	Net exporter of biomass, hydro, or wind energy by 2020
Targets for Renewable Share of Electricity, All Consumers	
Adelaide, Australia	15% by 2014
Amsterdam, Netherlands	25% by 2025; 50% by 2040
Austin, TX, USA	35% by 2020
Cape Town, South Africa	15% by 2020
Munich, Germany	100% by 2025
Nagano Prefecture, Japan	30% by 2050; 20% by 2030; 10% by 2020
San Francisco, CA, USA	100% by 2020
Skellefteå, Sweden	100% by 2020
Taipei City, Taiwan	12% by 2020
Ulm, Germany	100% by 2025
Wellington, New Zealand	78–90% by 2020
Targets for Renewable Electric Capacity	
Adelaide, Australia	2 MW of solar PV on residential and commercial buildings by 2020
Los Angeles, CA, USA	1.3 GW of solar PV by 2020
San Diego, CA, USA	50 MW renewable energy goal by 2013
San Francisco, CA, USA	100% of peak demand (950 MW) by 2020
Targets for Government Own-Use Purchases of Renewable Energy	
Bhubaneswar, India	Reduce conventional energy use 15% by 2012 through the use of renewables and energy efficiency
Hepburn Shire, Australia	100% of own-use energy in public buildings; 8% of electricity for public lighting
Malmö, Sweden	100% of own-use energy by 2030
Portland, OR, USA	100% of own-use electricity by 2030
Surat, India	82% of own use electricity from non-conventional sources by 2014
Sydney, Australia	100% of own-use electricity in buildings; 20% for street lamps
Washington, DC, USA	100% of its own-use electricity in 2012

TABLE R16. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES (CONTINUED)

Heat-Related Mandates	
Amsterdam, Netherlands	District heating for at least 200,000 houses by 2040 (using biogas, biomass, and waste heat)
Chandigarh, India	Mandatory use of solar water heating in industries, hotels, hospitals, jails, canteens, housing complexes, and government and residential buildings as of 2013
Los Angeles, CA, USA	Solar-ready roofs and electric vehicle-ready components required for all new buildings (as of 2010)
Loures, Portugal	Solar thermal systems mandated in all sports facilities and schools that have good sun exposure as of 2013
Munich, Germany	Reduce heat demand 80% by 2058 (base 2009) through passive solar design (space, process and water heating)
Nantes, France	Extend district heating system to source heat from biomass boilers for half of city inhabitants by 2017
Fossil Fuel Reduction Targets, All Consumers	
Göteborg, Sweden	100% of total energy fossil fuel-free by 2050
Madrid, Spain	20% reduction in fossil fuel use by 2020
Rajkot, India	10% reduction in fossil fuel use by 2013
Seoul, South Korea	30% reduction in fossil fuel and nuclear energy use by 2030
Växjö, Sweden	100% of total energy fossil fuel-free by 2030
Vijayawada, India	10% reduction in fossil fuel use by 2018
CO_2 Emissions Reductions Targets, All Consumers	
Aarhus, Denmark	Carbon-neutral by 2030
Bottrop, Germany	Reduce 50% by 2020 (base 2010)
Chicago, IL, USA	Reduce 80% by 2050 (base 1990)
Copenhagen, Denmark	Reduce 20% by 2015; carbon-neutral by 2025
Dallas, TX, USA	Carbon-neutral by 2030
Göttingen, Germany	Reduce 50% by 2020; 100% by 2050
Hamburg, Germany	Reduce 40% by 2020; 80% by 2050 (base 1990)
Malmö, Sweden	Zero net emissions by 2020
Oslo, Norway	Reduce 50% by 2030 (base 1991); carbon-neutral by 2050
Seoul, South Korea	Reduce 30% by 2020 (base 1990)
Stockholm, Sweden	Reduce emissions to 3 tons per capita by 2015 (base 5.5 tons per capita in 1990)
Tokyo, Japan	Reduce 25% by 2020 (base 2000)
Toronto, ON, Canada	Reduce 80% by 2050; 30% by 2020 (base 1990)

TABLE R16. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES (CONTINUED)

Urban Planning	
Glasgow, Scotland, U.K.	"Sustainable Glasgow" aims for a 30% reduction in CO_2 by 2020 (base 2006) and breaks down emission reduction targets as follows: combined heat and power/district heating: 9%; biomass: 2%; biogas and waste: 6%; other renewable energy: 3%; transport: 3%; fuel switching: 3%; and energy management systems: 6%. The plan includes: all new buildings must access their heating from the district heating system or propose a lower carbon alternative; 76 GWh of annual wind generation; and fiscal incentives for low-carbon transport (biogas/EVs).
Hong Kong, China	Target to become China's "greenest region." Strategy includes: limit the contribution of coal to less than 10% of the electricity generation mix by 2020, and phase out existing coal plants by 2020–2030; invest in construction/operation of district cooling infrastructure to use seawater; meet power demand of 100,000 households with biogas (from landfill and waste water) by 2020; install SWH on all government buildings and swimming pools; install wind turbines to meet 1–2% of total electricity demand by 2020; and achieve E10 and B10 by 2020. Also, raise awareness through: PV arrays on government buildings; website to provide information on renewable energy technology suitable for use in Hong Kong; and news/events, educational resources, and information on suppliers of renewable energy equipment in Hong Kong.
Malmö, Sweden	"Climate Neutral by 2020" outlines a plan to transform the energy mix to mainly solar, wind, hydro, and biogas. The city also targets a decrease in per capita energy consumption of 20% by 2020 (baseline: average annual use during the period of 2001 to 2005). Key strategies include: expansion of district heating and cooling; development of 100% renewable energy districts; replacement of older vehicles with 100% "green fleet"; and deployment of EV infrastructure.
Seoul, South Korea	By 2030, Seoul targets: 20% total energy from renewables; 20% reduction in energy consumption; 40% reduction in greenhouse gas emissions (base 1990); 1 million new green jobs by promoting 10 green technologies, including solar cells, waste recovery, and green buildings. To foster a domestic market, Seoul is providing, among other things: seed funding; capital loans; trust guarantees to small-to medium-sized businesses; USD 100 million investment (USD 20,000 per technology/year) in R&D by 2030; and support for overseas marketing.
Sydney, Australia	"Sustainable Sydney 2030" outlines how the city can significantly reduce greenhouse gas emissions and take a holistic approach to planning. It targets a 70% reduction in emissions from 2006 levels by 2030 and a 25% renewable share of electricity by 2020. The city's master plan will identify 15 "low-carbon zones" to be powered by biogas trigeneration plants; the development of a decentralised generation, transmission, and distribution network (infrastructure) to deliver power/heat/cooling with (bio) gas; a target for 360 MW of electric capacity from trigeneration using biogas by 2030; and 11 "energy-plus" buildings in Central Park.
Vancouver, BC, Canada	"Greenest City 2020" is an action plan to achieve goals of zero carbon, zero waste, and healthy ecosystems by 2020. It consists of 10 smaller plans, each with a long-term goal and 2020 targets including: a carbon-neutral target for all buildings constructed from 2020 onward; financial incentives for the installation of SWH; EV charging stations in buildings; and a target to double the number of green jobs by 2020 (over 2010 levels).
Yokohama, Japan	"Yokohama Energy Vision" targets buildings, EVs, solar PV, wind, biomass, biogas, and SWH to reduce greenhouse gas emissions more than 30% per person by 2020, and more than 80% by 2050 (base 1990). Includes mid-term targets: 1,300 EVs, 4,000 smart meters, and 4,400 solar power systems deployed by 2013; subsidies for SWH installations and EV purchases; low-interest loans for renewables and energy efficiency; and a pilot, Yokohama Smart City Project.

Source: See Endnote 16 for this section.

TABLE R17. ELECTRICITY ACCESS BY REGION AND COUNTRY

Region/Country	Electrification Rate	People Without Access to Electricity	Target
	Share (%) of population with access	Million	Share (%)
All Developing Countries	**76.0%**	**1,265**	
Africa	43.0%	590	
North Africa	99.0%	1	
Sub-Saharan Africa	30.0%	585	
ECOWAS[1]	27.2%	173	→ 100% by 2030
Developing Asia[2]	82.0%	628	
China and East Asia	91.0%	182	
South Asia	68.0%	493	
Latin America	94.0%	29	
Middle East	91.0%	18	
Afghanistan	16.0%	23.8	
Algeria	99.3%	0.2	
Angola	26.2%	13.7	
Argentina	95.0%	1.1	
Bahrain	99.4%	0.0	
Bangladesh[3]	46.0%	88.0	→ 100% by 2021
Barbados	98.0%	0.005	
Belize	96.2%	0.01	
Benin	24.8%	6.7	
Bolivia	71.2%	2.2	
Botswana	55.0%	1.1	→ 80% by 2016
Brazil	99.7%	3.3	
Brunei	99.7 %	0.0	
Burkina Faso	14.6%	12.6	
Cambodia	24.0%	11.3	
Cameroon	48.7%	10.0	
Cape Verde	87.0%	64.0	
Chile	99.5%	0.0	
China[4]	~100%	4.0	→ 100% by 2015
Colombia	94.9 %	2.9	
Costa Rica	99.2%	0.0	
Côte d'Ivoire	47.3%	10	
Cuba	97.0%	0.3	
Democratic People's Republic of Korea	26.0%		
Democratic Republic of the Congo	15.0%	58	
Dominican Republic	96.2%	0.4	
Ecuador	93.4%	1.1	
East Timor	22.0%	0.9	
Egypt	> 99.0 %	0.3	
El Salvador	96.8%	0.8	
Eritrea	32.0%	3.4	
Ethiopia	23.0%	65	→ 75% by 2015
Federated States of Micronesia[5]	4.0% (rural)		
Gabon	36.7%	0.9	

TABLE R17. ELECTRICITY ACCESS BY REGION AND COUNTRY (CONTINUED)

Region/Country	Electrification Rate	People Without Access to Electricity	Target
	Share (%) of population with access	Million	Share (%)
Ghana	70.0%	9.4	
Grenada	82.0%		
Guatemala	84.4%	2.7	
Guinea	15.0%	8	
Guinea-Bissau	15.0%	1	
Guyana	82.0%		
Haiti	34.0%	6.2	
Honduras	79.3%	2.2	
India	75.0%	293	→ 100% by 2017
Indonesia[6]	73.0%	63	
Iran	98.4%	1.2	
Iraq	86.0 %	4.1	
Israel	99.7 %	0.0	
Jamaica	96.8%	0.2	
Jordan	99.0%	0.0	
Kenya	18.0%	33	
Kuwait	100%	0.0	
Laos	55.0%		
Lebanon	100%	0.0	
Lesotho	16.0%	1.7	
Liberia	15.0%	3	
Libya	99.0%	0.0	
Madagascar	19.0%	15.9	
Malawi	1% (rural) < 9% (national)	12.7	→ 30% by 2020
Malaysia	99.4%	0.2	
Mali	18.0%	13	
Marshall Islands	100% (urban)		→ 95% (rural) by 2015
Mauritius	99.4%	0.0	
Mexico	97.6%		
Mongolia	67.0%	0.9	
Morocco	97.0%	1.0	
Mozambique	12.0%	20.2	
Myanmar	13.0%	43.5	
Namibia	34.0%	1.4	
Nepal	10.0%	16.5	→ 30% by 2030
Nicaragua	64.8%	1.6	
Niger	8.0%	14	
Nigeria	50.0%	79	
Oman	98%	0.1	
Pakistan	67.0%	56	
Palestinian Territories[7]	99.4%		
Panama	83.3%	0.4	

TABLE R17. ELECTRICITY ACCESS BY REGION AND COUNTRY (CONTINUED)

Region/Country	Electrification Rate	People Without Access to Electricity	Target
	Share (%) of population with access	Million	Share (%)
Paraguay	98.4%	0.2	
Peru	78.6%	4.2	
Philippines[6]	83.0%	16.0	
Qatar	98.7%	0.0	
Rwanda			→ 16% by 2012
Saudi Arabia	99.0%	0.3	
Senegal	42.0%	7.3	
Sierra Leone	15.0%	5	
Singapore	100%	0.0	
South Africa	75.0%	12.3	→ 100% by 2014
South Sudan	1.0%		
Sri Lanka	76.6%	4.8	
Sudan	36.0%	27.1	
Suriname	90.0%		
Syria	99.8% (rural)	1.5	
Tanzania	2% (rural) 15.0% (national)	38.0	→ 30% (rural) by 2015
Thailand	> 99%	0.5	
Togo	22.0%	5.3	
Trinidad and Tobago	92.0%	0.0	
Tunisia	99.5%	0.1	
Uganda	8.0%	29.0	
United Arab Emirates	100%	0.0	
Uruguay	99.8%	0.1	
Venezuela	97.3%	0.3	
Vietnam	98.0%	2.0	
Yemen[6]	42.0%	14.2	
Zambia	3.1% (rural) 47.6% (urban) 20.3% (national)	10.5	→ 51% (rural) → 90% (urban) → 66% (national) by 2030
Zimbabwe	41.5%	7.3	

1 ECOWAS is the Economic Community of West African States, comprising the 15 West African countries of Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

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

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

4 China data calculated using 2011 official report of 4 million people with no access to electricity and total population of 1.3 billion.

5 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).

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

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

Note: Rates and targets are national unless otherwise specified.

Source: See Endnote 17 for this section.

TABLE R18. POPULATION RELYING ON TRADITIONAL BIOMASS FOR COOKING

Regions and Selected Countries	Population	
	Percent	Millions
Africa	68%	698
Nigeria	74%	117
Ethiopia	96%	82
Democratic Republic of the Congo	93%	63
Tanzania	94%	42
Kenya	80%	33
Other Sub-Saharan Africa	75%	328
North Africa	1%	2
Developing Asia[1]	51%	1,814
India	66%	772
Bangladesh	91%	149
Indonesia	55%	128
Pakistan	64%	111
Philippines	50%	47
Vietnam	56%	49
Rest of Developing Asia	54%	171
Latin America	14%	65
Middle East	5%	10
All Developing Countries	**49%**	**2,558**
World[2]	**38%**	**2,588**

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 and regions excluding South Asia; South Asia includes Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka.

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

Source: See Endnote 18 for this section.

METHODOLOGICAL NOTES

This 2013 report edition follows seven previous editions of the *Renewables Global Status Report* (produced since 2005, with the exception of 2008). 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 2012 data for national and global capacity, growth, and investment portrayed in this report are preliminary and are rounded as appropriate. Where necessary, information and data that are conflicting, partial, or older are reconciled by using reasoned judgment and historical growth trends. Endnotes provide additional details, including references, supporting information, and assumptions where relevant.

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 renewable energy statistics. Some global aggregates must be built from the bottom up, adding or aggregating individual country information. Relatively little material exists that covers developing countries as a group, for example. The latest data available for developing countries are often some years older than data for developed countries, and thus extrapolations to the focus year have to be made from older data, based on assumed and historical growth rates. More precise annual increments are generally available only for wind, solar PV, and solar water collector capacity, as well as biofuels production.

The GSR endeavours to accurately cover all renewable energy sources on a global level and to provide the best data available. Data should not be compared with prior versions of this report to obtain year-by-year increases as some adjustments are due to improved or adjusted statistics rather than to actual capacity changes.

NOTE ON ACCOUNTING AND REPORTING

A number of issues arise when accounting for and reporting renewable energy capacities and output. 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

This report aims to give accurate estimates of capacity additions and totals, as well as energy generation. Both are subject to uncertainty, with the level of uncertainty differing from technology to technology. The section on Global Markets and Industry by Technology includes estimates for energy produced where possible but focuses mainly on electric power or thermal capacity data. This is because capacity data can be estimated with a greater degree of certainty. Actual heat and electricity generation figures are usually available only 12 months or more after the fact, and sometimes not at all. (For a better sense of average energy production from a specific technology or source, see capacity factors in Table 2.)

2. CONSTRUCTED CAPACITY VERSUS CONNECTED CAPACITY AND OPERATIONAL CAPACITY

Over the past few years, the solar PV and wind power 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 2012 for wind power installations in China. This has increasingly also been the case with solar PV, notably in Belgium, France, Germany, and Italy in recent years. Various sources use different timelines 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 for 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* focused primarily on constructed capacity because it best correlates with flows of capital investments during the year. Starting with the 2012 edition, and particularly for the solar PV and wind power sections, the focus began shifting to capacity that has become operational—defined as 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 are becoming increasingly difficult to obtain. Some renewable industry groups, including the European Photovoltaic Industry Association and the Global Wind Energy

Council[i], have shifted to tracking and reporting on operational/grid-connected rather than installed capacities.

As a result, some solar PV capacity that was installed in 2011 is counted as newly connected capacity in 2012; and some capacity installed during 2012 that was not operational/grid-connected by year-end will not be counted until 2013. This can have an impact on reported annual global growth rates, as well as on national data from year to year. The situation with wind power in China has been somewhat different from solar PV in that, even though a significant amount of new capacity was not yet commercially certified by year-end, most installed capacity was connected and feeding power into the grid. The situation in China is not likely to persist due to recent changes in permitting regulations.

3. BIO-POWER CAPACITY

This report strives to provide the best and latest available data regarding bioenergy developments given existing complexities and constraints (see Sidebar 2 in GSR 2012). The reporting of biomass-fuelled combined heat and power (CHP) systems varies among countries, which adds to the challenges experienced when assessing total heat and electricity capacities and bioenergy outputs. Wherever possible, the total bio-power data presented include capacity and generation from both electricity-only and CHP systems using solid biomass, landfill gas, biogas, and liquid biofuels as well as the portion of electricity generated from biomass fuels when co-fired with coal or natural gas.

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 the 2012 edition of the GSR, capacity and output are included in the main text as well as in the global bio-power data presented in Reference Tables R1 and R2. This change was due to the fact that international databases (e.g., from the IEA, U.S. EIA, and EU) now track and report the biogenic portion of MSW separately from other MSW. 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 the 2012 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, pumped storage can play an important role as balancing power, in particular when a large share of variable renewable resources appears in the generation mix.)

This method of accounting is accepted practice by the industry. 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; and the International Hydropower Association is working to track and report the numbers separately as well.

In this and the 2012 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 and the 2012 report should not be compared with prior data for total hydropower and total generating capacity. (Note, however, that the capacity number for 2010 in the Selected Indicators Table on page 14 of this report accounts 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.

i For example, see European Photovoltaic Industry Association, *Global Market Outlook for Photovoltaics 2013-2017* (Brussels: May 2013). Also, the Global Wind Energy Council (GWEC) reported 569 MW of 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).

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 www.eia.gov/totalenergy/data/monthly/pdf/historical/msw.pdf). A report from the IEA Bioenergy Task 36 defines biogenic waste as "food and garden waste, wood, paper and to a certain extent, also textiles and diapers" (see www.ieabioenergytask36.org/Publications/2007-2009/Introduction_Final.pdf).

GLOSSARY

ABSORPTION CHILLERS. Chillers that use heat energy from any source (solar, biomass, waste heat, etc.) to drive air-conditioning or refrigeration systems. The heat source replaces the electric power consumption of a mechanical compressor. Absorption chillers differ from conventional (vapor compression) cooling systems in two ways: the absorption process is thermo-chemical in nature rather than mechanical; and water is circulated as a refrigerant, rather than chlorofluorocarbons (CFCs) or hydro chlorofluorocarbons (HCFCs), also called Freon. The chillers are generally supplied with district heat, waste heat, or heat from cogeneration, and they can operate with heat from geothermal, solar, or biomass resources.

BIODIESEL. A fuel 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. Biodiesel is used in diesel engines installed in cars, trucks, buses, and other vehicles, as well as in stationary heat and power applications.

BIOENERGY. Energy derived from any form of biomass, including bio-heat, bio-power, and biofuel. Bio-heat arises from the combustion of solid biomass (such as dry fuelwood) or other liquid or gaseous energy carriers. The heat can be used directly or used to produce bio-power by creating steam to drive engines or turbines that drive electricity generators. Alternatively, gaseous energy carriers such as biomethane, landfill gas, or synthesis gas (produced from the thermal gasification of biomass) can be used to fuel a gas engine. Biofuels for transport are sometimes also included under the term bioenergy (*see* Biofuels).

BIOFUELS. 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 also can 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 produced commercially in several plants.

BIOGAS/BIOMETHANE. Biogas is a gaseous mixture consisting mainly of methane and carbon dioxide produced by the anaerobic digestion of organic matter (broken down by microorganisms in the absence of oxygen). Organic material and/or waste is converted into biogas in a digester. Suitable feedstocks include agricultural residues, animal wastes, food industry wastes, sewage sludge, purpose-grown green crops, and the organic components of municipal solid wastes. Raw biogas can be combusted to produce heat and/or power; it can also be transformed into biomethane through a simple process known as scrubbing that removes impurities including carbon dioxide, siloxanes, and hydrogen sulphides. Biomethane can be injected directly into natural gas networks and used as a substitute for natural gas in internal combustion engines without fear of corrosion.

BIOMASS. Any material of biological origin, excluding fossil fuels or peat, that contains a chemical store of energy (originally received from the sun) and available for conversion to a wide range of convenient energy carriers. These can take many forms, including liquid biofuels, biogas, biomethane, pyrolysis oil, or solid biomass pellets.

BIOMASS PELLETS. Solid biomass fuel produced by compressing pulverised dry biomass, such as waste wood and agricultural residues. Torrefied pellets produced by heating the biomass pellets have higher energy content per kilogram, as well as better grindability, water resistance, and storability. Pellets are typically cylindrical in shape with a diameter of around 10 millimetres and a length of 30–50 millimetres. 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.

BRIQUETTES. Blocks of flammable matter made from solid biomass fuels, including cereal straw, that are compressed in a process similar to the production of wood pellets. They are physically much larger than pellets, with a diameter of 50–100 millimetres and a length of 60–150 millimetres. They are less easy to handle automatically but can be used as a substitute for fuelwood logs.

CAPACITY. The rated capacity of a heat or power generating plant refers to the potential instantaneous heat or electricity output, or the aggregate potential output of a collection of such units (such as a wind farm or set of solar panels). Installed capacity describes equipment that has been constructed, although it may or may not be operational (e.g., delivering electricity to the grid, providing useful heat, or producing biofuels).

CAPACITY FACTOR. The ratio of the actual output of a unit of electricity or heat generation over a period of time (typically one year) to the theoretical output that would be produced if the unit were operating without interruption at its rated capacity during the same period of time.

CAPITAL SUBSIDY. A subsidy that covers a share of the upfront capital cost of an asset (such as a solar water heater). These include, for example, consumer grants, rebates, or one-time payments by a utility, government agency, or government-owned bank.

COMBINED HEAT AND POWER (CHP) (also called cogeneration). CHP facilities produce both heat and power from the combustion of fossil and/or biomass fuels, as well as from geothermal and solar thermal resources. The term is also applied to plants that recover "waste heat" from thermal power-generation processes.

CONCENTRATING PHOTOVOLTAICS (CPV). Technology that uses mirrors or lenses to focus and concentrate sunlight onto a relatively small area of photovoltaic cells that generate electricity (*see* Solar photovoltaics). Low-, medium-, and high-concentration CPV systems (depending on the design of reflectors or lenses used) operate most efficiently in concentrated, direct sunlight.

CONCENTRATING SOLAR THERMAL POWER (CSP) (also called concentrating solar power or solar thermal electricity, STE). Technology that uses mirrors to focus sunlight into an intense solar beam that heats a working fluid in a solar receiver, which then drives a turbine or heat engine/generator to produce electricity. The mirrors can be arranged in a variety of ways, but they all deliver the solar beam to the receiver. There are four types of commercial CSP systems: parabolic troughs, linear Fresnel, power towers, and dish/engines. The first two technologies are line-focus systems, capable of concentrating the sun's energy to produce temperatures of 400°C, while the latter two are point-focus systems that can produce temperatures of 800°C or higher. These high temperatures make thermal energy storage simple, efficient, and inexpensive. The addition of storage—using a fluid (most commonly molten salt) to store heat—usually gives CSP power plants the flexibility needed for reliable integration into a power grid.

CONVERSION EFFICIENCY. The ratio between the useful energy output from an energy conversion device and the energy input into it. For example, the conversion efficiency of a PV module is the ratio between the electricity generated and the total solar energy received by the PV module. If 100 kWh of solar radiation is received and 10 kWh electricity is generated, the conversion efficiency is 10%.

DISTRIBUTED GENERATION. Generation of electricity from dispersed, generally small-scale systems that are close to the point of consumption.

ENERGY. The ability to do work, which comes in a number of forms including thermal, radiant, kinetic, chemical, potential, 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. When primary energy is converted into useful energy there are always losses involved.

ENERGY SERVICE COMPANY (ESCO). A company that provides a range of energy solutions including selling the energy services from a renewable energy system on a long-term basis while retaining ownership of the system, collecting regular payments from customers, and providing necessary maintenance service. An ESCO can be an electric utility, cooperative, NGO, or private company, and typically installs energy systems on or near customer sites. An ESCO can also advise on improving the energy efficiency of systems (such as a building or an industry) as well as methods for energy conservation and energy management.

ENERGIEWENDE. German term that means "transformation of the energy system." It refers to the move away from nuclear and fossil fuels towards a sustainable economy by means of energy efficiency improvements and renewable energy.

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." Note that some ethanol production is used for industrial, chemical, and beverage applications rather than for fuel.

FEE-FOR-SERVICE MODEL. An arrangement to provide consumers with an electricity service, in which a private company retains ownership of the equipment and is responsible for maintenance and for providing replacement parts over the life of the service contract. A fee-for-service model can be a leasing or ESCO model.

FEED-IN TARIFF (also called feed-in policy, or FIT). 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.

GENERATION. The process of converting energy into electricity and/or useful heat from a primary energy source such as wind energy, solar energy, natural gas, biomass, etc.

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 in a thermal power plant or to provide heat directly at various temperatures for buildings, industry, and agriculture.

GREEN ENERGY PURCHASING. Voluntary purchase of renewable energy—usually electricity, but also heat and transport fuels—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, also called green tags or guarantees of origin). It can create additional demand for renewable capacity and/or generation, often going beyond that resulting from government support policies or obligations.

GRID PARITY. Occurs when the levelised cost of energy (LCOE) of an electricity source (e.g., solar PV) becomes equal to or less than the retail price of electricity from the grid.

HEAT PUMP. A device that transfers heat from a heat source to a heat sink using electricity to drive the transfer, using a refrigeration cycle. It can use the ground, a body of water, or the surrounding air as a heat source in heating mode, and as a heat sink in cooling mode. A heat pump can extract energy in several multiples of the electrical energy input, depending on its inherent efficiency and operating conditions.

HYDROPOWER. Electricity derived from the potential energy of water captured when 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). 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. Purchase of an item of value with an expectation of favourable future returns. In this report, new investment in renewable energy refers to investment in: technology research and development, commercialisation, construction of manufacturing facilities, and project development (including construction of wind farms, purchase and installation of solar PV systems). Total investment refers to new investment plus merger and acquisition (M&A) activity (the refinancing and sale of companies and 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 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 by 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; and so on. The potential chemical energy stored in one barrel of oil and released when combusted is approximately 6 GJ; a tonne of dry wood contains around 20 GJ of energy.

LEASING OR LEASE-TO-OWN. A fee-for-service arrangement in which a leasing company (generally an intermediary company, cooperative, or NGO) buys stand-alone renewable energy systems and installs them at customer sites, retaining ownership until the customer has made all payments over the lease period. Because the leasing periods are longer than most consumer finance terms, the monthly fees can be lower and the systems affordable for a larger segment of the population.

LEVELISED COST OF ENERGY (LCOE). The unique cost price of energy outputs (e.g., USD/kWh or USD/GJ) of a project that makes the present value of the revenues equal to the present value of the costs over the lifetime of the project.

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. Mandates can include renewable portfolio standards (RPS); 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 transport fuel.

MARKET CONCESSION MODEL. A model in which a private company or NGO is selected through a competitive process and given the exclusive obligation to provide energy services to customers in its service territory, upon customer request. The concession approach allows concessionaires to select the most appropriate and cost-effective technology for a given situation.

MODERN BIOENERGY. Energy derived efficiently from solid, liquid, and gaseous biomass fuels for modern applications, such as space heating, electricity generation, combined heat and power, and transport (as opposed to traditional bioenergy).

NET METERING. A regulated arrangement in which utility customers who have installed their own generating systems pay only for the net electricity delivered from the utility (total consumption minus on-site self-generation). A variation that employs two meters with differing tariffs for purchasing electricity and exporting excess electricity off-site is called "net billing."

OCEAN ENERGY. Energy captured from ocean waves (generated by wind passing over the surface), tides, salinity gradients, and ocean temperature differences. Wave energy converters capture the energy of surface waves to generate electricity; tidal stream generators use kinetic energy of moving water to power turbines; and tidal barrages are essentially dams that cross tidal estuaries and capture energy as tides flow in and out.

POWER. The rate at which energy is converted per unit of time, expressed in Watts (Joules/second).

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 (also called auction or tender). A procurement mechanism by which public authorities solicit bids for a given amount of renewable energy supply or capacity, generally based on price. Sellers offer the lowest price they would be willing to accept, but typically at prices above standard market levels.

PUMPED STORAGE HYDROPOWER. Plants that 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 and can have overall system efficiencies of around 80–90%.

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 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.

RENEWABLE ENERGY TARGET. An official commitment, plan, or goal set by a government (at the 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.

SMART ENERGY SYSTEM. A smart energy system aims to optimise the overall efficiency and balance of a range of interconnected energy technologies and processes, both electrical and non-electrical (including heat, gas, and fuels). This is achieved through dynamic demand- and supply-side management; enhanced monitoring of electrical, thermal, and fuel-based system assets; control and optimisation of consumer equipment, appliances, and services; better integration of distributed energy (on both the macro and micro scales); as well as cost minimisation for both suppliers and consumers.

SMART GRID. Electrical grid that uses information and communications technology to co-ordinate the needs and capabilities of the generators, grid operators, end users, and electricity market stakeholders in a system, with the aim of operating all parts as efficiently as possible, minimising costs and environmental impacts, and maximising system reliability, resilience, and stability.

SOLAR COLLECTOR. A device used for converting solar energy to thermal energy (heat), typically used for domestic water heating but also used for space heating, industrial process heat, or to drive thermal cooling machines. Evacuated tube and flat-plate collectors that operate with water or a water/glycol mixture as the heat-transfer medium are the most common solar thermal collectors used worldwide. These are referred to as glazed water collectors because irradiation from the sun first hits a glazing (for thermal insulation) before the energy is converted to heat and transported away by the heat transfer medium. Unglazed water collectors, often referred to as swimming pool absorbers, are simple collectors made of plastics and used for lower temperature applications. Unglazed and glazed air collectors use air rather than water as the heat-transfer medium to heat indoor spaces, or to pre-heat drying air or combustion air for agriculture and industry purposes.

SOLAR HOME SYSTEM (SHS). A stand-alone system composed of a relatively small photovoltaic (PV) module, battery, and sometimes a charge controller, that can power small electric devices and provide modest amounts of electricity to homes for lighting and radios, usually in rural or remote regions that are not connected to the electricity grid.

SOLAR PHOTOVOLTAICS (PV). A technology used for converting solar radiation (light) into electricity. PV cells are constructed from semi-conducting materials that use sunlight to separate electrons from atoms to create an electric current. Modules are formed by interconnecting individual solar PV cells. Monocrystalline modules are more efficient but relatively more expensive than polycrystalline silicon modules.. Thin-film solar PV materials can be applied as flexible films laid over existing surfaces or integrated with building components such as roof tiles. Building-integrated PV (BIPV) replaces conventional materials in parts of a building envelop, such as the roof or façade.

SOLAR PICO SYSTEM (SPS). A very small solar PV 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 WATER HEATER (SWH). An entire system—consisting of a solar collector, storage tank, water pipes, and other components—that converts the sun's energy into "useful" thermal (heat) energy for domestic water heating, space heating, process heat, etc. Depending on the characteristics of the "useful" energy demand (potable water, heating water, drying air, etc.) and the desired temperature level, a solar water heater is equipped with the appropriate solar collector. There are two types of solar water heaters: pumped solar water heaters use mechanical pumps to circulate a heat transfer fluid through the collector loop (active systems), whereas thermosiphon solar water heaters make use of buoyancy forces caused by natural convection (passive systems).

SUBSIDIES. Government measures that artificially reduce the price that consumers pay for energy or reduce production costs.

TRADITIONAL BIOMASS. Solid biomass—including agricultural residues, animal dung, forest products, and gathered fuelwood—that is often used unsustainably and combusted in inefficient and usually 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 bioenergy).

TORREFIED WOOD. Solid fuel, often in the form of pellets, produced by heating wood to 200–300°C in restricted air conditions. 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; and so on. A megawatt electrical (MW) 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 (100 W) that is on for one hour consumes 100 Watt-hours (100 Wh) of energy, which equals 0.1 kilowatt-hour (kWh), or 360 kilojoules (kJ). This same amount of energy would light a 100 W light bulb for one hour or 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.

ENERGY UNITS AND CONVERSION FACTORS

METRIC PREFIXES

kilo (k) = 10^3

mega (M) = 10^6

giga (G) = 10^9

tera (T) = 10^{12}

peta (P) = 10^{15}

exa (E) = 10^{18}

VOLUME

1 m^3 = 1,000 litres (l)

1 U.S. gallon = 3.78 l

1 Imperial gallon = 4.55 l

Example: 1 TJ = 1,000 GJ = 1,000,000 MJ = 1,000,000,000 kJ = 1,000,000,000,000 J = 1012 J

1 J = 0.001 MJ = 0.000001 GJ = 0.000000001 TJ

ENERGY UNIT CONVERSION

multiply by:	GJ	Toe	MBtu	MWh
GJ	1	0.024	0.948	0.278
Toe	41.868	1	39.683	11.630
MBtu	1.055	0.025	1	0.293
MWh	3.600	0.086	3.412	1

Toe = tonnes oil equivalent

1 Mtoe = 41.9 PJ

Example: 1 MWh x 3.600 = 3.6 GJ

HEAT OF COMBUSTION (HIGH HEAT VALUES)

1 l gasoline = 47.0 MJ/kg = 35.2 MJ/l (density 0.75 kg/l)

1 l ethanol = 29.7 MJ/kg = 23.4 MJ/l (density 0.79 kg/l)

1 l diesel = 45.0 MJ/kg = 37.3 MJ/l (density 0.83 kg/l)

1 l biodiesel = 40.0 MJ/kg = 35.2 MJ/l (density 0.88 kg/l)

Note: 1) These values can vary with fuel and temperature.
2) Around 1.5 litres of ethanol is required to equate to 1 litre of gasoline.

SOLAR THERMAL HEAT SYSTEMS

1 million m^2 = 0.7 GW_{th}

Used where solar thermal heat data have been converted from square metres (m^2) into gigawatts thermal (GW_{th}), by accepted convention.

LIST OF ABBREVIATIONS

BIPV	Building-integrated solar photovoltaics
BNEF	Bloomberg New Energy Finance
BOS	Balance of system
BRICS	Brazil, Russia, India, China, and South Africa
CDM	Clean Development Mechanism
CHP	Combined heat and power
CO_2	Carbon dioxide
CPV	Concentrating solar photovoltaic
CSP	Concentrating solar (thermal) power
DSM	Demand-side management
ECOWAS	Economic Community of West African States
ECREEE	Centre for Renewable Energy and Energy Efficiency
EEG	German Renewable Energy Sources Act – "Erneuerbare-Energien-Gesetz"
EMEC	European Marine Energy Centre
EPA	U.S. Environmental Protection Agency
ESCO	Energy service company
EU	European Union (specifically the EU-27)
EV	Electric vehicle
FIT	Feed-in tariff
FUNAE	Mozambican Energy Fund – "Fundo de Energia"
GACC	Global Alliance for Clean Cookstoves
GEF	Global Environment Facility
GFR	Global Futures Report
GHG	Greenhouse gas
GHP	Ground-source heat pump
GSR	Renewables Global Status Report
GW/GWh	Gigawatt/gigawatt-hour
GW_{th}	Gigawatt-thermal
IEA	International Energy Agency
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
kW/kWh	Kilowatt/kilowatt-hour
LED	Light-emitting diode
LCOE	Levelised Cost of Energy
m^2	Square metre
MENA	Middle East and North Africa
MFI	Microfinance institution
MSW	Municipal solid waste
mtoe	Million tonnes of oil equivalent
MW/MWh	Megawatt/megawatt-hour
MW_{th}	Megawatt-thermal
NGO	Non-governmental organisation
NREAP	National Renewable Energy Action Plan
OECD	Organisation for Economic Co-operation and Development
PPP	Public-private partnership
PTC	Production Tax Credit
PV	Photovoltaics
RPS	Renewable portfolio standard
SHS	Solar home system (PV)
SPS	Solar pico system (PV)
SWH	Solar water heater/heating
TW/TWh	Terawatt/terawatt-hour
UNIDO	United Nations Industrial Development Organization
Wp	Watt-peak (nominal power)
WTO	World Trade Organization

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GLOBAL MARKET AND INDUSTRY OVERVIEW

1 Estimated shares based on the following sources: total 2010 final energy demand (estimated at 8,076 Mtoe) is based on 7,881 Mtoe for 2010 from International Energy Agency (IEA), *World Energy Statistics 2012* (Paris: OECD/IEA, 2012) and escalated by the 2.48% increase in global primary energy demand from 2010 to 2011, derived from BP, *Statistical Review of World Energy 2012* (London: 2012). The figure differs conceptually from estimates in previous editions of the GSR in that total final consumption now excludes non-energy use of fossil fuels. The total final energy demand is about 9.2% smaller than total final consumption, thus making the share of renewables (and nuclear power) proportionately larger. Traditional biomass use in 2010 was estimated at 751 Mtoe (31.4 EJ), and this value was used for 2011 as well, from IEA, *World Energy Outlook 2012* (Paris: 2012), p. 216. In 2011, the Intergovernmental Panel on Climate Change (IPCC) indicated a higher range for traditional biomass of 37–43 EJ, and a proportionately lower figure for modern biomass use, per IPCC, *Special Report on Renewable Energy Resources and Climate Change Mitigation*, prepared by Working Group III of the IPCC (Cambridge, U.K. and New York: Cambridge University Press, 2011), Table 2.1. Bio-heat energy values for 2011 (industrial, residential, commercial, and other uses, including heat from heat plants) was estimated at 305 Mtoe (12.7 EJ), based on preliminary estimates from IEA, *Medium-Term Renewable Energy Market Report 2013* (Paris: OECD/IEA, forthcoming 2013). Bio-power generation was estimated at 28 Mtoe (324 TWh), based on 74 GW of capacity in 2011 (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 U.S. Energy Information Administration (EIA), *Electric Power Annual 2010* (Washington, DC: 2011), Table 1.2, (Existing Capacity by Energy Source, 2010)) 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* (Petten, The Netherlands: 28 November 2011)). Applying a five-year growth rate to the 2010 value found in IEA, *World Energy Statistics 2012*, op. cit. this note, would yield a lower estimate of 293 TWh. Other renewable electricity generation estimates include: wind power was 45 Mtoe (522 TWh), based on global capacity of 238.5 GW using a CF of 25%; solar PV was estimated at 6.7 Mtoe (78 TWh), based on 70.8 GW capacity and average CF of 12.5%; concentrated solar thermal power (CSP) was 0.3 Mtoe (4 TWh), based on 1.6 GW capacity and CF of 25%; and ocean power was 0.1 Mtoe (1.2 TWh), based on 527 MW 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 6.0 Mtoe (70 TWh), based on estimated capacity of 11.35 GW from global inventory of geothermal power plants by Geothermal Energy Association (GEA) (unpublished database), per Benjamin Matek, GEA, personal communication with REN21, May 2013. Generation based on the global average capacity factor for geothermal generating capacity in 2010 (70.44%), derived from 2010 global capacity (10,898 MW) and 2010 global generation (67,246 GWh), see Ruggero Bertani, "Geothermal Power Generation in the World, 2005–2010 Update Report," *Geothermics*, vol. 41 (2012), pp. 1–29; hydropower was assumed to contribute 301 Mtoe (3,498 TWh), per BP, op. cit. this note. Solar thermal hot water/ heat output in 2011 was estimated at 17.8 Mtoe (0.74 EJ), based on Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2011, Edition 2013* (Gleisdorf: Austria: IEA Solar Heating and Cooling Programme, May 2013). Adjusted upwards by REN21 to account for 100% of the world market, as the Weiss and Mauthner report covers an estimated 95%. Geothermal heat was estimated at 11.7 Mtoe (0.49 EJ), assuming 57.8 GW_{th} of capacity yielding 489 PJ of heat, based on estimated growth rates and 2010 capacity and output figures 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 44.6 Mtoe (1.87 EJ) and biodiesel use at 18.5 Mtoe (0.77 EJ), based on 84.2 billion litres and 22.4 billion litres, respectively, from F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," 2013, and from F.O. Licht, "Biodiesel: World Production, by Country (1000 T)," 2013; 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 228 Mtoe (2,649 TWh) of final energy, from BP, op. cit. this note.

2 Ibid. Figure 1 based on sources in Endnote 1.

3 Based on data found in REN21, *Renewables Global Status Report* (Paris: various years), and in IEA, *World Energy Outlook 2012*, op. cit. note 1.

4 Based on 9,443 MW in operation at the end of 2007, from European Photovoltaic Industry Association (EPIA), *Market Report 2012* (Brussels: February 2013), and on 100 GW at the end of 2012. See relevant section and endnotes for more details regarding 2012 data and sources.

5 CSP based on 430 MW in operation at the end of 2007, from Fred Morse, Abengoa Solar, personal communication with REN21, 4 May 2012, and from Red Eléctrica de España (REE), "Potencia Instalada Peninsular (MW)," https://www.ree.es/ingles/sistema_electrico/series_estadisticas.asp, updated 29 April 2013, and on about 2,550 MW at the end of 2012. Wind power based on 24.9% from Navigant's BTM Consult, *International Wind Energy Development: World Market Update 2012* (Copenhagen: March 2013), and data for 2007 and 2012 from Global Wind Energy Council (GWEC), *Global Wind Report – Annual Market Update 2012* (Brussels: April 2013). See relevant section and endnotes in Market and Industry Trends by Technology for more details regarding 2012 data and sources.

6 Hydropower based on an estimated 840–870 MW in operation at the end of 2007 from REN21, *Renewables Global Status Report 2009 Update* (Paris: 2009), and on 990 GW at the end of 2012. The GSR 2009 puts total hydropower capacity in 2008 at 945 GW, with 31–38 GW added during 2008, meaning an estimated 914–907 GW at the end of 2007; however, this includes pumped storage capacity, for which an adjustment has been made. Hydropower 3% average annual growth also from Observ'ER, "Electricity Production in the World: General Forecasts," Chapter 1 in *Worldwide Electricity Production from Renewable Energy Sources: Stats and Figures Series, 2012 edition* (Paris: 2012). Geothermal based on 9.6 GW in operation at the end of 2007, from REN21, op. cit. this note, and 11.65 GW at the end of 2012 based on global inventory of geothermal power plants compiled by GEA, op. cit. note 1. See relevant sections and endnotes in Market and Industry Trends by Technology for more details regarding 2012 data and sources.

7 Figure of 7.8% average annual growth is based on global bio-power capacity for the period end-2005 through 2010, the latest data available from U.S. EIA, "International Energy Statistics," www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm, viewed 23 May 2013. Figure 2 based on data and sources provided in Endnotes 4-6 and 8 in this section, and from F.O. Licht, op. cit. note 1, both references.

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16 See Table R1 and related endnote for details and references.

17 Based on total additions of 115 GW, with about 45 GW from wind, 30 GW from hydropower, and more than 29.4 GW from solar PV. For details and references see Reference Table R1 and related endnote.

18 Growing share based on data from REN21, *Renewables Global Status Report*, previous editions, and from U.S. EIA, IEA, and BNEF, provided in FS–UNEP and BNEF, 2013, op. cit. note 14. Estimate for net additions and renewable share based on a total of 115 GW of renewable capacity added, as noted in this report; on 3.7 GW of net nuclear power capacity added, from International Atomic Energy Agency, cited in "Nuclear Power Capacity Grew Again in 2012: IAEA," *Agence France Presse*, 5 March 2013; on 152 GW coal-fired capacity installed and just over half was additional, and 72 GW natural gas-fired capacity installed and a little more than one-third was additional, for a total of 109 GW of net capacity additions from fossil fuels, from FS–UNEP and BNEF, 2013, op. cit. note 14. Based on these data, total global net capacity additions in 2012 were estimated to be about 228 GW, putting the renewable share at just over 50%.

19 Renewable share of total global electric generating capacity is based on renewable total of 1,470 GW and on total global electric capacity in the range of 5,640 GW. Estimated total world capacity for end-2012 is based on 2010 total of 5,183 GW, from IEA, *World Energy Outlook 2012*, op. cit. note 1, p. 554; on about 105 GW of renewables added in 2011, from REN21, op. cit. note 14, and adjusted data for 2011; on 132 GW net additions of fossil fuel-fired capacity in 2011, from Angus McCrone, BNEF, personal communication with REN21, 28 May 2013; on a net reduction in nuclear power capacity of 7 GW in 2011, from "Nuclear Power Capacity Grew...," op. cit. note 18; and on a net total of 228 GW added from all sources in 2012. Share of generation based on the following: Total global electricity generation in 2012 is estimated at 22,389 TWh, based on 22,018 TWh in 2011 from BP, op. cit. note 1, and an estimated 1.68% growth in global electricity generation for 2012. The growth rate is based on the total change in generation for the following countries (which account for more than 60% of 2011 generation): United States (-1.13% change in annual generation), EU-27 (-2.41% for January through September only), Russia (+1.30%), India (+4.65%), China (+5.50%), and Brazil (+4.06%). Sources for 2010 and 2011 electricity generation are: U.S. EIA, *Monthly Energy Review*, April 2013, Table 7.2a (Electricity Net Generation); European Commission, Eurostat database, http://epp.eurostat.ec.europa.eu; System Operator of the Unified Power System of Russia, at www.so-ups.ru; Government of India, Ministry of Power, Central Electricity Authority, "Monthly Generation Report," www.cea.nic.in/monthly_gen.html; China Electricity Council (CEC), "CEC Released the Country's Electricity Industry in 2012 to Run Profiles," 18 January 2013, at http://tj.cec.org.cn/fenxiyuce/yunxingfenxi/yuedufenxi/2013-01-18/96374.html; National Operator of the Electrical System of Brazil (ONS), "Geração de Energia," at www.ons.org.br/historico/geracao_energia.aspx. Hydropower generation in 2012 is estimated at 3,700 TWh, based on reported 2011 global generation and estimation that output increased by over 6% in 2012. The increase in generation over 2011 is based on reported changes in countries that together accounted for over 70% of global hydropower generation in 2011: United States (-14.9% in annual output), Canada (+1.0%), EU-27 (+5.4% for January through September), Norway (+17.1%), Brazil (-2.0%), Russia (+1.1%), India (-12.1% for facilities larger than 25 MW), and China (+30.4%). The combined hydropower output of these countries was up by about 6.8% relative to 2011. Total 2011 hydro generation was 3,498 TWh per BP, op. cit. note 1, and 3,467 TWh per International Journal on Hydropower & Dams (IJHD), *Hydropower & Dams World Atlas 2012* (Wallington, Surrey, U.K.: 2012); 2011 and 2012 generation by country: United States from U.S. EIA, op. cit. this note; Canada from Statistics Canada, http://www5.statcan.gc.ca; EU-27 from European Commission, op. cit. this note; Norway from Statistics Norway, www.ssb.no; Brazil from ONS, op. cit. this note; Ministry of Energy of the Russian Federation, http://minenergo.gov.ru; Government of India, op. cit. this note; CEC, op. cit. this note. Non-hydro renewable generation of 1,159 TWh was based on 2012 year-end generating capacities shown in Reference Table R1 and representative capacity factors in note 1, or other specific estimates as detailed by technology in Section 2. Figure 3 based on sources in this endnote.

20 Figure of 30% from wind in Denmark based on preliminary 2012 data from Danish Energy Agency (Energi Styrelsen), "Elforsyning," (Electricity supply), Månedsstatistik (Monthly Statistics), January

2013, at www.ens.dk; solar PV met an estimated 5.6% of national demand in Italy from Terna, "Early Data on 2012 Electricity Demand: 325.3 Billion kWh The Demand, -2.8% Compared to 2011," press release (Rome: 9 January 2013).

21 Prices are being driven down via the merit order effect and, in some cases, this is increasing financial pressure on some conventional generators, per "Energy Firm RWE Gives Up on Renewables Target," ENDSEurope.com, 5 March 2013; Rachel Morison and Julia Mengewein, "Wind Blows German Power Swings to Five-Year High," RenewableEnergyWorld.com, 22 February 2013; wind energy undercutting power prices already driven down by lows in natural gas, and below zero in several U.S. states, from Julie Johnsson and Naureen S. Malik, "Nuclear Industry Withers in U.S. as Wind Pummels Prices," Bloomberg.com, 11 March 2013; Giles Parkinson, "Wind, Solar Force Energy Price Cuts in South Australia," 3 October 2012, at http://reneweconomy.com.au.

22 FS–UNEP/BNEF, 2013, op. cit. note 14. According to BNEF, the average cost per MWh of new gas- and coal-fired capacity increased by some 40% worldwide between the second quarter of 2009 and the first quarter of 2013, reflecting higher bills for capital equipment.

23 For example, a Citi Research report found that solar is cheaper than domestic electricity tariffs in many parts of the world, that wind is competitive with lower wholesale prices in a growing number of regions, and that renewables can compete against combined-cycle gas turbines in regions with higher-priced gas, per Jason Channell, Timothy Lam, and Shahriar Pourreza, *Shale & Renewables: A Symbiotic Relationship* (London: Citi Research, a division of Citigroup Global Markets Inc., September 2012); a BNEF study found that the levelised cost of electricity from best-in-class wind sites is lower than that from the cheapest natural gas-fired plants and cheaper than the lowest cost new fossil fuel plants in Australia, per BNEF, "Australia LCOE update: Wind Cheaper than Coal and Gas," *Asia & Oceania Clean Energy Research Note*, 31 January 2013; electricity from wind can be supplied below the cost of coal-fired generation in parts of India according to Greenko Group Plc., cited in Natalie Obiko Pearson, "In Parts of India, Wind Energy Proving Cheaper Than Coal," RenewableEnergyWorld.com, 18 July 2012; in India, peak demand prices on the spot market have reached Rs. 12/kWh; by comparison, the LCOE of most solar plants under construction as of early 2013 was an estimated Rs. 8–9/kWh, per Sourabh Sen, "Assessing Risk and Cost in India: Solar's Trajectory Compared to Coal," RenewableEnergyWorld.com, 17 April 2013; solar PV is cost-competitive in remote rural and island communities that depend on diesel-fired generation, and has achieved grid parity in some locations earlier than expected, per Sarasin, op. cit. note 12, p. 9; solar PV is cheaper than grid power for commercial consumers in Maharashtra, Delhi, and Kerala in India, even without a subsidy, per Bridge to India, *India Solar Compass*, April 2013, p. 26; analysis from the International Renewable Energy Agency (IRENA) suggests that, in most OECD countries with good wind resources, the most competitive onshore wind projects are now cost-competitive with fossil fuels and that price reductions mean this is increasingly true, per IRENA, *Renewable Power Generation Costs in 2012: An Overview* (Abu Dhabi: January 2013); and according to the IEA, in some countries with good wind resources, including Brazil and Turkey, wind power projects are successfully competing without subsidies against fossil fuel-based power projects in wholesale electricity markets, from IEA, *Tracking Clean Energy Progress 2013* (Paris: OECD/IEA, 2013). Note that offshore wind levelised costs increased between the second quarter of 2009 and the first quarter of 2013, as project developers moved further from shore and into deeper waters, and some CSP and geothermal power technologies also saw cost increases during this period, from FS–UNEP and BNEF, 2013, op. cit. note 14.

24 Rankings were determined by gathering data for the world's top countries for hydropower, wind, solar, biomass, and geothermal power capacity. **China** based on 228.6 GW hydropower (not including pure pumped storage capacity) from CEC, op. cit. note 19, and from China National Renewable Energy Center (CNREC), "China Renewables Utilization Data 2012," March 2013, at www.cnrec.org.cn/english/publication/2013-03-02-371.html; 75,324 MW wind from Chinese Wind Energy Association (CWEA), with data provided by Shi Pengfei, personal communication with REN21, 14 March 2013, and from GWEC, op. cit. note 5; 7,000 MW of solar PV from IEA Photovoltaic Power Systems Programme (IEA-PVPS), *PVPS Report, A Snapshot of Global PV 1992–2012* (Paris: 2013); 8,000 MW of bio-power from CNREC, op. cit. this note; 26.6 MW geothermal from GEA, op. cit. note 1; and small amounts of CSP (pilot projects) and ocean energy capacity. **United States** based on 78.3 GW hydropower from EIA, *Electric Power Annual 2010*, op. cit. note 1, Table 4.3 (Existing Capacity by Energy Source); projected net additions in 2012 of 99 MW from idem, Table 4.5 (Planned Generating Capacity Changes by Energy Source, 2012–2016); 60,007 MW of wind from American Wind Energy Association (AWEA), *AWEA U.S. Wind Industry Annual Market Report, Year Ending 2012* (Washington, DC: April 2013), Executive Summary; 7,219 MW of solar PV from GTM Research and U.S. Solar Energy Industries Association (SEIA), *U.S. Solar Market Insight Report, 2012 Year in Review* (Washington, DC: 2013), p. 21; 15 GW bio-power from Federal Energy Regulatory Commission (FERC), Office of Energy Projects, *Energy Infrastructure Update for December 2012* (Washington, DC: 2012); 3,386 MW of geothermal power from GEA, op. cit. note 1; 507 MW of CSP from SEIA, "Utility-scale Solar Projects in the United States Operating, Under Construction, or Under Development," www.seia.org/sites/default/files/resources/Major%20Solar%20Projects%20List%202.11.13.pdf, updated 11 February 2013, and from Fred Morse, Abengoa Solar, personal communication with REN21, 13 March 2013. **Brazil** based on 84,000 MW of hydropower, 7.6 MW of solar PV, and 9.66 GW of bio-power from ANEEL – National Electric Energy Agency, "Generation Data Bank," February 2013, at www.aneel.gov.br/aplicacoes/capacidadebrasil/capacidadebrasil.cfm (in Portuguese); and 2,508 MW of wind from GWEC, op. cit. note 5. **Canada** based on 77.1 GW of hydropower from the following: existing capacity of 75.08 GW at the end of 2010 from Statistics Canada, Table 127-0009, "Installed generating capacity, by class of electricity producer," at http://www5.statcan.gc.ca; plus capacity additions in 2011 of 1.34 GW from Marie-Anne Sauvé, Hydro Québec, and Domenic Marinelli, Manitoba Hydro, personal communications via International Hydropower Association (IHA), April 2012; plus capacity additions in 2012 of 0.68 GW from IHA, personal communication with REN21, March 2013; also on 6,200 MW wind from GWEC, op. cit. note 5; 765 MW solar PV from IEA-PVPS, op. cit. this note; 1,821 MW bio-power from preliminary estimates from IEA, *Medium-Term...,* op. cit. note 1; and 20 MW of ocean from IEA Implementing Agreement on Ocean Energy Systems (IEA-OES), "Ocean Energy in the World," www.ocean-energy-systems.org/ocean_energy_in_the_world/, and from IEA-OES, *Annual Report 2012* (Lisbon: 2012), Table 6.1. **Germany** based on 4.4 GW of hydropower, 31,315 MW of wind, and 7,647 MW of bio-power from German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources 2012," data from Working Group on Renewable Energy-Statistics (AGEE-Stat), provisional data (Berlin: 28 February 2013), p. 18; 32,411 MW of solar PV from EPIA, *Global Market Outlook for Photovoltaics 2013–2017* (Brussels: May 2013) and from IEA-PVPS, op. cit. this note; and 12.75 MW geothermal power from GEA, op. cit. note 1.

25 China, United States, and Germany from ibid, all references. **Spain** based on 17,057 MW of hydropower from REE, op. cit. note 5; 22,796 MW of wind from GWEC, op. cit. note 5; 5,100 MW solar PV from IEA-PVPS, op. cit. note 24; 952 MW bio-power from REE, *Boletin Mensual*, No. 72, December 2012; and 1,950 MW CSP from Comisión Nacional de Energía (CNE), provided by Eduardo Garcia Iglesias, Protermosolar, Madrid, personal communication with REN21, 16 May 2013, and from REE, *Boletín Mensual*, op. cit. this note. **Italy** based on 18.2 GW hydropower and 3,800 MW of bio-power from Gestore Servizi Energetici (GSE), "Impianti a fonti rinnovaili in Italia: Prima stima 2012," 28 February 2013; 8,144 MW of wind from GWEC, op. cit. note 5; 16,420 MW of solar PV from GSE, "Rapporto Statistico 2012, Solare Fotovoltaico," 8 May 2013, p. 8, at www.gse.it; 880 MW of geothermal power from GEA, op. cit. note 1; and 5 MW (demonstration) of CSP from EurObserv'ER, *The State of Renewable Energies in Europe*, 12th EurObserv'ER Report (Paris: 2012), p. 88. **India** based on 42.8 GW of hydropower from Indian Ministry of New and Renewable Energy (MNRE), "Achievements," www.mnre.gov.in/mission-and-vision-2/achievements/, 28 February 2013, from MNRE, *Annual Report 2012–2013* (Delhi: 2013), and from Government of India, Ministry of Power, Central Electricity Authority, "Installed Capacity (in MW) of Power Utilities in the States/UTS Located in Northern Region Including Allocated Shares in Joint & Central Sector Utilities," www.cea.nic.in/reports/monthly/inst_capacity/jan13.pdf, viewed 11 April 2013; 18,421 MW of wind from GWEC, op. cit. note 5; 1,205 MW of solar PV from EPIA, op. cit. note 24, and from IEA-PVPS, op. cit. note 24; about 4 GW of bio-power from MNRE, "Achievements," op. cit. this note. **Figure 4** based on sources in this note and on the following sources for EU-27 and

BRICS: **EU-27** based on 120.5 GW hydropower in 2011 (although this includes some mixed pumped storage plants for Austria and Spain), from IJHD, op. cit. note 19, and adjusted to 119 GW to account for 1.5 GW of pure pumped storage capacity in Spain; 106,041 MW of wind from European Wind Energy Association (EWEA), *Wind in Power: 2012 European Statistics* (Brussels: February 2013); 61.9 GW of solar PV from Gaetan Masson, EPIA and IEA-PVPS, personal communication with REN21, April 2013; 31.4 GW of bio-power, from REN21, op. cit. note 14; from BMU, op. cit. note 24; from GSE, "Impianti a fonti rinnovabili in Italia...," op. cit. this note; from U.K. Government, Department of Energy and Climate Change (DECC), "Energy trends section 6: renewables," and "Renewable electricity capacity and generation (ET6.1)," 9 May 2013, at https://www.gov.uk/government/publications/renewables-section-6-energy-trends; Électricité Réseau Distribution France (ERDF), "Installations de production raccordées au réseau géré par ERDF à fin décembre 2012," www.erdfdistribution.fr/medias/Donnees_prod/parc_prod_decembre_2012.pdf; from REE, *The Spanish Electricity System: Preliminary Report 2012* (Madrid: 2012); from Directorate General for Energy and Geology (DGEG), Portugal, 2013, www.precoscombustiveis.dgeg.pt. (Note that IEA Energy Statistics online data services, 2013, were used to check against OECD country data from other references used for bio-power capacity, and 2011 capacity data for Austria, Belgium, Canada, Denmark, the Netherlands, and Sweden were assumed to have increased by 2%); 934 MW of geothermal from GEA, op. cit. note 1; 1,950 MW of CSP from Spain's CNE, op. cit. this note, and from REE, *Boletín Mensual*, op. cit. this note; and 241 MW of ocean energy from IEA-OES, *Annual Report 2011* (Lisbon: OES Secretary, 2011), Table 6.1, p. 122. In addition to references for Brazil, China, and India, BRICS from the following: **Russia** based on 46 GW of hydropower from System Operator of the Unified Energy System of Russia, "Operational Data for December 2012," www.so-ups.ru/fileadmin/files/company/reports/ups-review/2013/ups_review_jan13.pdf; 15 MW wind from EWEA, op. cit. this note; 1.5 GW bio-power from preliminary estimates from IEA, *Medium-Term*..., op. cit. note 1; 147 MW geothermal power from GEA, op. cit. note 1; and a small amount of ocean energy capacity. **South Africa** based on 670 MW of hydropower (not including pumped storage), from Hydro4Africa, "African Hydropower Database—South Africa," http://hydro4africa.net/HP_database/country.php?country=South%20Africa, viewed 21 May 2013; 10 MW of wind from GWEC, op. cit. note 5, p. 54; 30 MW solar PV from EScience Associates, Urban-Econ Development Economists, and Chris Ahlfeldt, *The Localisation Potential of Photovoltaics (PV) and a Strategy to Support Large Scale Roll-Out in South Africa*, Integrated Report, Draft Final v1.2, prepared for the South African Department of Trade and Industry, March 2013, p. x, at www.sapvia.co.za; 25 MW bio-power based on IEA, *Medium-Term*..., op. cit. note 1.

26 See previous endnotes for Brazil and Canada details and sources. **France** based on 7,564 MW of wind from GWEC, op. cit. note 5; 4,003 MW solar PV from Commissariat Général au Développement Durable, Ministère de l'Écologie, du Développement durable et de l'Énergie, "Chiffres et statistiques," No. 396, February 2013, at www.statistiques.developpement-durable.gouv.fr; 1,305 MW bio-power based on REN21, op. cit. note 14, on IEA Energy Statistics online data services, 2013, on EurObserv'ER, op. cit. note 25, and on additions of 0.3 GW in 2012 from ERDF, op. cit. note 25, and 1.574 GW from preliminary estimates from IEA, *Medium-Term*..., op. cit. note 1; 240 MW of ocean energy from IEA-OES, op. cit. note 25, Table 6.1, p. 122. **Japan** based on 2,614 MW of wind from GWEC, op. cit. note 5; 6,632 MW of solar PV from IEA-PVPS, provided by Gaetan Masson, EPIA and IEA-PVPS, personal communication with REN21, 15 May 2013; 3.3 GW of bio-power from Institute for Sustainable Energy Policies (ISEP), *Renewables 2013 Japan Status Report* (Tokyo: 2013); 535 MW of geothermal from GEA, op. cit. note 1. **United Kingdom** based on 8,445 MW wind from GWEC, op. cit. note 5; 1,830 MW from IEA-PVPS, op. cit. note 24; and from EPIA, op. cit. note 24; 2,651 MW bio-power from DECC, op. cit. note 25; 9 MW ocean from renewableUK, "Wave & Tidal Energy," at www.renewableuk.com/en/renewable-energy/wave-and-tidal/index.cfm. **Sweden** from 3,745 MW wind from GWEC, op. cit. note 5; 24 MW solar PV from IEA-PVPS, op. cit. note 24; 3,992 MW bio-power from preliminary estimates from IEA, *Medium-Term*..., op. cit. note 1.

27 Based on data and sources in previous endnotes in this section and population data for 2011 from World Bank, "Population, Total," http://data.worldbank.org/indicator/SP.POP.TOTL. For details, see Table R2.

28 Figure of 84% is based on total capacity among the top 12 countries of 401 GW, and 64% is based on total capacity among the top five of 308 GW. Data derived from previous endnotes in this section.

29 Hydropower capacity was 228.6 GW (not including 20.3 GW of pure pumped storage), from CEC, op. cit. note 19; 75.3 GW of wind power capacity from GWEC, op. cit. note 5, and from CWEA, op. cit. note 24; 7 GW of solar PV from Gaetan Masson, EPIA, personal communication with REN21, 12 February and 21 March 2013; 7 GW also from IEA-PVPS, op. cit. note 24; 8 GW bio-power capacity and small amounts of geothermal and ocean energy capacity from Wang Wei, CNREC, "China renewables and non-fossil energy utilization," www.cnrec.org/cn/english/publication/2013-03-02-371.html, viewed April 2013; and small amounts of geothermal and ocean energy capacity from CNREC, "China Renewables Utilization Data 2012," op. cit. note 24; China also has small amounts of CSP capacity in pilot projects (see CSP section).

30 China added 88.2 GW from Wang, "China renewables...," op. cit. note 29. Total additions and renewable energy shares were adjusted by REN21 for different levels of wind and solar PV capacity used in this report. Wind additions were an estimated 14.6 GW per Wang, idem, compared with 12.96 GW added from CWEA, op. cit. note 24, and GWEC, op. cit. note 5; and solar PV additions were an estimated 1.06 GW (on-grid only) per Wang, "China renewables...," op. cit. note 29, compared with 3.51 GW added from IEA-PVPS, op. cit. note 24. The CWEA/GWEC and IEA-PVPS numbers were used because these reports were released at a later date and, presumably, based on more final data. The result is 88.6 GW of capacity added in 2012, which was used for calculating shares from hydropower and other renewables, based on wind capacity additions of 12.96 GW per GWEC, solar PV additions of 3.51 GW per IEA-PVPS, hydro additions of 15.51 GW per CEC, North China Electricity Regulatory Bureau, "China's Electric Power Industry in 2012," 22 February 2013, www.cec.org.cn/yaowenkuaidi/2013-02-22/97555.html (using Google Translate), and bio-power capacity additions of 1 GW from Wang, op. cit. this note. China added 80.2 GW (including 12.85 GW of wind and 1.19 GW solar PV), for a national total of 1,145 GW of electric capacity in operation CEC, op. cit. this note. To be conservative, the GSR used the higher CNREC number for added capacity, from Wang, "China renewables...," op. cit. note 29.

31 Share comes to 19.52% based on output from hydro (864 TWh), wind (3.5 TWh) and solar (3.5 TWh), from State Electricity Regulatory Commission, cited in "China's Power Generating Capacity from Renewable Energy in 2012 up 30.3 Percent YoY," ChinaScope Financial, 6 February 2013, at www.chinascopefinancial.com; and total electricity consumption of 4.9591 trillion kWh, from CEC, op. cit. note 19; and 20% "generation ratio of renewables" from Wang, "China renewables...," op. cit. note 29.

32 Increase in wind and solar PV output from CEC, op. cit. note 19. Note that hydropower output was up 29% in 2012 relative to 2011, but this was due more to hydrological variability than increased capacity; more than coal and passing nuclear from idem.

33 Figure of 12.2% of generation from U.S. EIA, *Monthly Energy Review March 2013* (Washington, DC: March 2013), Table 7.2a (Electricity Net Generation: Total (All Sectors)), p. 95; share of capacity (15.4%) from Federal Energy Regulatory Commission (FERC), Office of Energy Projects, "Energy Infrastructure Update for December 2012" (Washington, DC: 2013). All renewables accounted for 12.5% of net generation in 2011.

34 In 2012, hydropower accounted for 6.8% of total electricity generation and other renewables for 5.4%. All data derived from U.S. EIA, op. cit. note 33, p. 95. Hydro generation declined in 2012 relative to 2011 because the water supply in the Pacific Northwest fell from unusually high levels in 2011, from U.S. EIA, op. cit. note 33.

35 Wind accounted for more than 45% of U.S. electric capacity additions in 2012 (based on 12,799 MW of wind capacity added) from U.S. EIA, "Wind Industry Brings Almost 5,400 MW of Capacity Online in December 2012," viewed 25 April 2013, at www.eia.gov/electricity/monthly/update/?scr=email; wind accounted for nearly 41%, natural gas for 33%, coal for 17.1%, and solar power for 5.6% of U.S. electric capacity additions in 2012, based on data from FERC, op. cit. note 33. Wind accounted for 42% (based on 13,124 MW added) according to AWEA, "4Q report: Wind energy top source for new generation in 2012; American wind power installed new record of 13,124 MW," *Wind Energy Weekly*, 1 February 2013. About half from FERC, op. cit. note 33.

36 Share of consumption from BMU, op. cit. note 24; power generation from lignite still exceeds that from renewable sources, all from "Bruttostromerzeugung in Deutschland von 1990 bis 2012 nach Energieträgern," 14 February 2013, at www.unendlich-viel-energie.de/uploads/media/AEE_Strommix_Deutschland_2012_mrz13.jpg.

37 BMU, op. cit. note 24.

38 Ibid.

39 Spain based on data and sources in Endnote 25 in this section. Note that REE put the total at 29.6 GW (22,362 MW of wind; 4,410 MW of PV; 1,878 MW of CSP; 943 MW of bio-power), per REE, *The Spanish Electricity System...*," op. cit. note 25.

40 Wind accounted for more than 18% of total demand and solar for more than 4%, from Red Eléctrica Corporación, *Corporate Responsibility Report 2012* (Madrid: 2013), p. 60.

41 Italy based on data and sources in Endnote 25 in this section.

42 GSE, "Impianti a fonti rinnovabili in Italia...," op. cit. note 25.

43 Additions of small-scale hydropower and bio-power from MNRE, "Achievements," op. cit. note 25, and from MNRE, *Annual Report 2012–2013*, op. cit. note 25; large-scale hydropower from Government of India, Ministry of Power, Central Electricity Authority, http://www.cea.nic.in/reports/monthly/inst_capacity/jan13.pdf, viewed 11 April 2013; wind power from GWEC, op. cit. note 5; solar PV from EPIA, op. cit. note 24, and from IEA-PVPS, op. cit. note 24.

44 Based on 213 GW of total installed capacity from Sourabh Sen, "Assessing Risk and Cost in India: Solar's Trajectory Compared to Coal," RenewableEnergyWorld.com, 17 April 2013, and 211 GW of total capacity as of 31 December 2012 (but with MNRE data as of 31 October 2013) from Indian Ministry of Power, Central Electricity Authority, "Highlights of Power Sector," www.cea.nic.in/reports/monthly/executive_rep/dec12/1-2.pdf; and on all renewables total of about 66.4 GW and non-hydro renewables total of almost 24 GW from sources in endnote earlier in this section.

45 See Endnotes 24 and 25 in this section for data and sources for Brazil, China, India, Russia, and South Africa.

46 Based on 636 MW of wind capacity under construction from GWEC, op. cit. note 5, p. 54, and 150 MW of CSP capacity under construction from "Abengoa Kicks Off South Africa's First CSP Plants Construction," CSP-World.com, 6 November 2012.

47 EWEA, op. cit. note 25, pp. 6–7. In 2012, 44,601 MW of electric capacity was added; of this total, 30,968 MW was renewable. Natural gas accounted for 23% of added capacity, coal for 7%, CSP for 2%, hydro 1%, and other technologies smaller shares, from ibid.

48 All renewables represented 33.9% (up from 22.5% in 2000) and non-hydro renewables 20.3% of the EU's total installed electric capacity, from EWEA, op. cit. note 25.

49 Shares of electricity and final energy from EurObserv'ER, op. cit. note 25, pp. 102–03.

50 A study commissioned by Vestas on the largest users of renewable power found that Japan's OJI Paper is the largest corporate user, followed by German building materials company Sto and the Finnish pulp and paper company UPM-Kymmene. Of the 389 companies in the index, 36 sourced 100% of their power from renewables, including Adobe Systems, Kohl's, and Whole Foods Market. In the Carbon Renewable Energy Index, prepared by BNEF, from BNEF, "Japan to Disengage from Nuclear to Embrace Renewable Energy," *Energy: Week in Review*, vol. VI, iss. 151, 11–17 September 2012.

51 Joß Florian Bracker, Öko-Institut, Freiburg, personal communication with REN21, 3 May 2013.

52 Ibid.

53 The EPA's Green Power Partnership, which works with more than 1,400 U.S. organisations to facilitate green power purchasing, saw sales grow 22%, from Jenny Heeter, Philip Armstrong, and Lori Bird, *Market Brief: Status of the Voluntary Renewable Energy Certificate Market* (2011 Data) (Golden, CO: NREL, September 2012); the Center for Resource Solutions' Green-e Energy certification programme, the leading certifier of green power, saw sales increase 21%, from Center for Resource Solutions, *2011 Green-e Verification Report* (San Francisco, CA: January 2013).

54 U.S. Environmental Protection Agency (EPA), Green Power Partnership, "National Top 50 Partner List," as of 9 January 2013, at www.epa.gov; 17 partners from EPA, "National Top 50," www.epa.gov/greenpower/toplists/top50.htm, 9 January 2013.

55 REN21, op. cit. note 14; Australia from "GreenPower," viewed 1 May 2013, at www.greenpower.gov.au; South Africa from "How to Buy Green Electricity Certificate (GECs)," www.capetown.gov.za/en/electricity/GreenElectricity/Pages/Howtopurchasegreenelectricitycertificates.aspx, viewed 15 February 2013; Japan from United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Low Carbon Green Growth Roadmap for Asia and the Pacific. Case Study: Stimulating Consumer Interest in Businesses that Go Green—Japan's Green Power Certificate Scheme," 2012, at www.unescap.org.

56 Vince Font, "WindMade Label to Expand to Other Renewables," RenewableEnergyWorld.com, 4 December 2012.

57 WindMade, "Consumer Demand for Climate Solutions Leads to Expansion of WindMade Label," press release (Doha, Qatar: 4 December 2012).

58 EKOenergy Web site, www.ekoenergy.org.

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6 World corn production in 2012 was around 830 million tonnes, per Oklahoma State University, Department of Plant and Soil Sciences, Nitrogen Use Efficiency Web, "World Wheat, Corn & Rice," http://nue.okstate.edu/Crop_Information/World_Wheat_Production.htm; Laborde, op. cit. note 5. The U.S. Department of Agriculture's monthly supply and demand estimates for agricultural commodities, released in mid-December 2012, put consumption of corn for ethanol production at 27% of U.S. maize crop production in 2010/11, although about one-third of the processed corn ends up as an animal feed co-product, per Pangea, *Who's Fooling Whom? The Real Drivers Behind the 2010/2011 Food Crisis in Sub-Saharan Africa* (Brussels: October 2012). The amounts of distillers dried grains with solubles (DDGS) produced are provided in U.S. Grains Council, *A Guide to Distiller's Dried Grains with Solubles* (DDGS) (Washington, DC: October 2012).

7 Figure 5 based on bioenergy data for 2010 from IEA, op. cit. note 1. Based on 1,277 Mtoe (53.7 EJ) in 2010 and considering a growth rate of 1.4% per year. CHP with biomass is included under both electricity and heat. Available datasets used to compile each component of Figure 5 have uncertainties in the region of +10% or more. The losses shown occur during the process when converting from the various "primary" biomass feedstocks to obtain useful heat, electricity, or liquid and gaseous biofuels. Traditional biomass is converted inefficiently into useful heat for direct use, whereas modern biomass is converted into a range of energy carriers (solid, liquid, and gaseous fuels as well as electricity and heat) which are then consumed by end-users to provide useful energy services in the three sectors.

8 Traditional biomass (see Glossary for definitions of traditional and modern biomass used in this report) is fuelwood, charcoal, animal dung, and agricultural residues combusted in simple appliances (such as cooking stoves) with very low efficiencies (typically around 10–15%) to produce heat used mainly for cooking and the heating of dwellings in non-OECD countries. This definition is debatable, because stoves with relatively energy-efficient designs are becoming more widely used and, in addition, some older designs of large-scale biomass conversion technologies with relatively low efficiencies are included under "modern biomass." Heat data are very uncertain, but the GSR 2012 reported that total heat generated from biomass was around 45.5 PJ in 2011, which rose to about 46 PJ in 2012. This was based on global demand for biomass of 1,230 Mtoe (51.5 EJ) in 2009 and considering a growth rate of 1.4% per year, from IEA, *World Energy Outlook 2011* (Paris: 2011), and on the breakdown of bioenergy use for traditional and modern applications based on Chum et al., op cit. note 1.

9 IEA, op. cit. note 1.

10 IEA op. cit. note 1. Also see Endnote 1 for assumptions about total primary energy consumption and the share from biomass.

11 There are three major sources of biofuel production and consumption data: F.O. Licht, IEA *Medium Oil Market Reports*, and the FAO Agricultural Outlook (see OECD, "Agricultural Outlook," http://stats.oecd.org/viewhtml.aspx?QueryId=36348&vh=0000&vf=0&l&il=&lang=en). The quoted data for 2012 are preliminary and vary considerably between them, so throughout this section, to assess the trends and biofuel production in 2012 compared with 2011, F.O. Licht data were mainly used. The 1% drop in total biofuel volume produced in 2012 (from 106.5 billion litres in 2011 to 105.5 billion litres) was offset partly by an increase in the total energy content because ethanol (~23 MJ/l) declined but biodiesel (~40MJ/l) increased. By way of comparison on a volume basis, the IEA *Medium Term Oil Market Report 2013* (Paris: 2013) showed a 7% reduction of total biofuel production from 106.5 billion litres in 2011 to 101.1 billion litres in 2012.

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13 Biomass exchanges include the North American (nabiomass-exchange.com/), Minneapolis (www.mbioex.com), Minnesota (mnbiomassexchange.org), and Biomass Commodity Exchange (www.biomasscommodityexchange.com). Rotterdam also has an exchange for pellets, see "World's First Biomass Commodity Exchange," Rotterdam Port Information Yearbook, 52nd Edition, at www.rotterdamportinfo.com.

14 Details of pellet trading routes in REN21, *Renewables 2012 Global Status Report* (Paris: 2012), Figure 6, p. 34. Note that these were preliminary data and that volumes of flows change from year to year. For wood chip trade, see P. Lamers et al., *Global Wood Chip Trade for Energy* (IEA Bioenergy, Task 40, 2012).

15 Based on 300 PJ of solid biomass fuels (excluding charcoal) traded in 2010, from P. Lamers et al., "Developments in international solid biofuel trade – an analysis of volumes, policies, and market factors," *Renewable and Sustainable Energy Reviews*, vol. 16, no. 5 (2012), pp. 3176–99, and on 120–130 PJ of net trade in fuel ethanol and biodiesel in 2009, from P. Lamers et al., "International bioenergy trade – a review of past developments in the liquid biofuels market," *Renewable and Sustainable Energy Reviews*, vol. 15, no. 6 (2011), pp. 2655–76.

16 Data for 2012 are preliminary. Figure 6 from the following sources: "World Pellets Map," *Bioenergy International Magazine* (Stockholm: 2013); Maurizio Cocchi et al., *Global Wood Pellet Industry Market and Trade Study* (IEA Bioenergy, Task 40, Sustainable Bioenergy Trade, December 2011); Eurostat, "Data explorer - EU27 trade since 1995 by CN8," 2013, at http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database; C.S. Goh et al., "Wood pellet market and trade: a global perspective," *Biofuels, Bioproducts and Biorefining*, vol. 7 (2013), pp. 24–42; Lamers et al., op. cit. note 15.

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18 IEA, *Bioenergy Annual Report 2011* (Paris: 2011).

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26 Cocchi et al., op. cit. note 16.

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28 F.O. Licht, op. cit. note 24, both sources.

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38 See Figure 7, footnotes, and Endnote 37 for assessment methods and references used. Percentage growth of electricity in 2012 was lower than percentage growth of capacity over the same period due to annual variations in the merit orders and amount dispatched, as shown by specific national capacity factors.

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61 Bayar, op. cit. note 31.

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91 Bioenergy Insight, "Renewable energy facility celebrates year in production," 1 March 2013, at www.bioenergy-news.com; T. Probert, "Biomass industry 2012 review – a mixed bag," RenewableEnergyWorld.com, 24 December 2012.

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contain eight times the energy content of the same volume of green wood chips so logistics costs can be reduced, even by 30% lower than other densified products such as wood pellets. Torrefaction of biomass has been presented as a game-changer for coal substitution, but even though major advances have been made, this has not yet become evident. Michael Deutmeyer et al., *Possible Effects of Torrefaction on Biomass Trade* (IEA Bioenergy, Task 40, Sustainable Bioenergy Trade, 2012).

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GEOTHERMAL HEAT AND POWER

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2 Lund, Freeston, and Boyd, op. cit. note 1; updates from Lund, op. cit. note 1.

3 Ibid.

4 Two-thirds based on 64% from Lund, Freeston, and Boyd, op. cit. note 1; updates from Lund, op. cit. note 1.

5 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, *Monthly Energy Review* (Washington, DC: March 2013), 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). Based on total geothermal energy consumption of 227 trillion Btu less 163 trillion Btu for electricity generation, yielding 64 trillion Btu for direct use, or 18,757 GWh. Iceland from Orkustofnun, *Energy Statistics in Iceland 2012* (Reykjavik: 2013). Based on 42.2 PJ total geothermal energy use, of which 61%, or 7,156 GWh, is direct use.

6 Lund, Freeston, and Boyd, op. cit. note 1.

7 Orkustofnun, op. cit. note 5.

8 Electricity generated by CHP unit drives the electric heat pump, allowing for heating and cooling of space and high levels of efficiency, per Chris Webb, "Developers Warm to Small-Scale Geothermal," RenewableEnergyWorld.com, 11 September 2011. Note that some regard the net thermal contribution of heat pumps as an efficiency improvement in the heating and cooling use of electricity rather than a portion of the thermal energy balance. This appears to be the convention in Sweden; see Energimyndigheten (Swedish Energy Agency), *Energiläget 2011* (Stockholm: November 2011), p. 67. But the cooling load is not always "considered as geothermal" because heat is discharged into the ground or groundwater (see, for example, Lund, Freeston, and Boyd, op. cit. note 1). Nonetheless, the net thermal contribution made possible by the use of heat pumps is equally valid whether the desired service is cooling or heating, so the distinction is unnecessary for the purpose of quantifying the contribution of GHPs.

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11 "Small-scale Renewables: Big Problem, Small Solution," in *REW Guide to North American Renewable Energy Companies 2013, supplement to Renewable Energy World Magazine*, March-April 2013, pp. 18–24.

12 As of late 2012, the system provided cooling for 47 buildings and heat for 22, per ibid., pp. 18–24.

13 Total global installed capacity in 2012 of 11.65 GW based on global inventory of geothermal power plants by Geothermal Energy Association (GEA) (unpublished), per Benjamin Matek, GEA, personal communication with REN21, May 2013. Estimate for geothermal electricity generation of 72 TWh based on the global average capacity factor for geothermal generating capacity in 2010 (70.44%), derived from 2010 global capacity (10,898 MW) and 2010 global generation (67,246 GWh), see Ruggero Bertani, "Geothermal Power Generation in the World, 2005–2010 Update Report," *Geothermics*, vol. 41 (2012), pp. 1–29. Calculation is based on estimated 2012 year-end capacity.

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HYDROPOWER

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this section; leaders for total capacity from Masson, op. cit. note 1, and from IEA-PVPS, op. cit. note 1. Note that China ranks third, ahead of the United States, per EPIA, op. cit. note 1, p. 13. Spain fell from fourth to sixth according to all sources in this note.

6 This was up from eight in 2011; European countries were Germany, Italy, Spain, France, Belgium, the Czech Republic, the U.K., and Greece; Asian countries were China, India, and Japan, from EPIA, op. cit. note 1, and from IEA-PVPS, op. cit. note 1.

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13 Based on the following: Germany added 7,604 MW for 32,411 MW at year's end, from EPIA, op. cit. note 1, p. 20, and from IEA-PVPS, op. cit. note 1; Germany added 7,604 MW for a total of 32,643 MW from BMU, op. cit. note 12; and year-end 2012 capacity of PV systems installed under the EEG was 32,388.6 MW (based on end-March data and monthly installations in 2013), per German Federal Network Agency (Bundesnetzagentur), "Monatliche Veröffentlichung der PV-Meldezahlen," at "Photovoltaikanlagen: Datenmeldungen sowie EEG-Vergütungssätze," at www.bundesnetzagentur.de, viewed 18 May 2013.

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22 California from GTM Research and SEIA, op. cit. note 19, p. 21.

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24 Diane Cardwell, "Solar Panel Payments Set Off a Fairness Debate," *New York Times*, 4 June 2012; Felicity Carus, "Net Energy Metering Battle Fires Up Solar Industry," PV-tech.com, 5 February 2013; Travis Bradford, Prometheus Institute, New York, personal communication with REN21, 27 March 2013.

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26 GTM Research and SEIA, op. cit. note 19, p. 19.

27 Figure of 7 GW and below expectations from Masson, op. cit. note

1; 7 GW also from IEA-PVPS, op. cit. note 1; 8,300 MW from EPIA, op. cit. note 1, p. 13. Below expectations also from Peng, op. cit. note 19. Note that China added 1.06 GW of on-grid PV capacity in 2012 for a total of 3.28 GW, per Wang Wei, China National Renewable Energy Center (CNREC), "China renewables and non-fossil energy utilization," www.cnrec.org/cn/english/publication/2013-03-02-371.html, viewed April 2013.

28 One-third of panel shipments from Michael Barker, "China Consumes 33% of Global Photovoltaic Panel Shipments in Q4'12, According to NPD Solarbuzz," RenewableEnergyWorld.com, 22 January 2013; exceeded Germany from "Solarbuzz: PV demand reaches 29 GW in 2012," op. cit. note 2; government efforts from Ucilia Wang, "First Solar, SunPower Ink Major Deals in China," Forbes, 3 December 2012.

29 About 25% of capacity in operation by mid-2012 was considered distributed, according to the State Grid Corporation, cited in Frank Haugwitz, "January 2013-Briefing Paper-China Solar Development," Asia Europe Clean Energy (Solar) Advisory Co., Ltd, contribution to REN21, 21 February 2013.

30 To help achieve China's Energy Policy 2012, the National Energy Administration issued the "12th Five-Year Plan for Solar Power Development," which includes a focus on the construction of distributed solar systems linked to buildings or facilities in eastern and central China, per Gary Wigmore, James Murray, and Shepard Liu, "China Policy: Strategic Developments in Solar and Wind Power Policies," in U.S.-China Market Review..., op. cit. note 19, p. 15. At year's end, a pipeline of projects under the Golden Sun and Solar Rooftop programmes was expected to bring more than 2.5 GW of capacity into operation during 2013, per Steven Han, "Distributed PV Power Generation to Accelerate China Market Growth," NPD SolarBuzz, 6 December 2012, at www.renewableenergyworld.com.

31 An estimated 1,718 MW was added for a total of 6,632 MW, per IEA-PVPS, provided by Masson, op. cit. note 1. This number was used as it was the latest data available. Note that estimates for Japan were wide ranging, including 2,000 MW added for a total of 7,000 MW at the end of 2012, per IEA-PVPS, op. cit. note 1; 6,914 MW per EPIA, op. cit. note 1, p. 32; and as high as 7.3 GW, per Japan Photovoltaic Energy Association (JPEA), provided by Matsubara Hironao, Institute for Sustainable Energy Policies (ISEP), Tokyo, personal communication with REN21, 21 April 2013; 90% in the FIT system (with 40% for projects >1 MW) from www.enecho.meti.go.jp/saiene/kaitori/index.html (in Japanese), provided by Hironao, op. cit. this note.

32 Yuriy Humber and Tsuyoshi Inajima, "Japan's Aggressive FIT Already Unlocking Gigawatts of Wind and Solar Power," Bloomberg, 1 October 2012, at www.renewableenergyworld.com.

33 Australia added an estimated 1,000 MW for a total of 2,400 MW, per IEA-PVPS, op. cit. note 1; and added 1,000 MW for a total of 2,412 MW, per EPIA, op. cit. note 1, p. 32. Note, however, that final numbers could come in lower, per Masson, op. cit. note 1.

34 "Rooftop PV in South Australia Lowers Energy Demand," PV News, September 2012, p. 8. Grid electricity demand fell about 5% in 2011–12, due greatly to these systems, according to South Australian Electricity Report, August 2012, cited in idem.

35 India's capacity increased from 225 MW at year-end 2011 to 1,205 MW at year-end 2012, from PVPS, op. cit. note 1, and from EPIA, op. cit. note 1, p. 32.

36 Namibia (237 kW; largest in country, on roof of supermarket), South Africa 630 kW (largest roof-installed solar PV system in Africa); also, in Botswana (1 MW partially installed by early 2013, from "SolarWorld Expands its International Business," SonnenSeite.com, 8 February 2013. Also, there are two larger PV installations in South Africa (1 MW Dilokong Chrome and 850 kW Cape Town Solar), per PLATTS UDI World Electric Power Plants Database, provided by Caspar Priesemann, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, personal communication with REN21, 19 April 2013. Note that South Africa has approved solar PV projects under the Renewable Energy IPP Programme (REIPPP), has signed agreements with "window 1" bidders, and is about to reach project closure under "window 2"; none of the plants have been commissioned as yet, per W. Jonker Klunne, Council for Scientific and Industrial Research, Pretoria, personal communication with REN21, 21 April 2013. Chinese companies from Bloomberg New Energy Finance (BNEF), "Germany and US Report Strong Growth in Solar Installations," *Energy: Week in Review*, 12–18 June 2012. Most projects are for powering street lamps, from idem.

37 EPIA, op. cit. note 1, p. 31.

38 Scott Burger, "Turkey Solar Market Outlook, 2013-2017," *PV News*, February 2013, p. 1; Matt Carr, "Photovoltaic Opportunities in Saudi Arabia Growing," RenewableEnergyWorld.com, 5 February 2013; Wael Mahdi, "Saudi Arabia Plans $109 Billion Boost for Solar Power," Bloomberg.com, 22 November 2012; "Saudi Arabia's Largest PV System Installed," *PV News*, March 2013, p. 13; Isofoton signed a joint venture agreement for 300 MW in August, per "Isofoton to Develop PV Plants in MENA, India with INDSYS," *PV News*, November 2012, p. 12.

39 IMS Research, "Thailand and Indonesia to Drive South East Asia PV Market," press release (Shanghai: 1 November 2012); Malaysia had an estimated 22 GW by the end of 2012, per EPIA, op. cit. note 1, p. 31. Thailand ranks fifth in the Asia-Pacific region, after China, Japan, India, and Australia, from idem.

40 Masson, op. cit. note 1; NPD Solarbuzz, *Emerging PV Markets Report: Latin America & Caribbean*, cited in Chris Sunsong, "Latin America and Caribbean PV Demand Growing 45% Annually Out to 2017," NPD Solarbuzz, 2 January 2013, at www.renewableenergyworld.com; commercial (e.g., IKEA) and industrial (e.g., Grupo Mesa) sectors from Bea Gonzalez, "Off-grid CPV in Latin America," 13 February 2013, at http://news.pv-insider.com; and "Solar in Latin America & The Caribbean 2013: Markets, Outlook and Competitive Positioning," *PV News*, February 2013, p. 13. Chile went from zero grid-connected capacity in early 2012 to 3.6 MW in operation in January 2013, with 1.3 MW under construction, per Rodrigo Escobar Moragas, Pontificia Universidad Católica de Chile, personal communication with REN21, 18 April 2013.

41 See, for example, International Renewable Energy Agency (IRENA), *International Off-grid Renewable Energy Conference: Key Findings and Recommendations* (Abu Dhabi: forthcoming 2013).

42 Becky Beetz, "Tokelau Officially Becomes World's First 100% PV Powered Territory," *PV Magazine*, 15 November 2012, at www.pv-magazine.com.

43 Australia, Israel, Norway, and Sweden from Solar Server, "Electricity for the rest of the world – opportunities in off-grid solar power," www.solarserver.com/solar-magazine/solar-report/solar-report/electricity-for-the-rest-of-the-world-opportunities-in-off-grid-solar-power.html. Australia had an estimated 16.1 MW of rural off-grid capacity by the end of 2012, up from 13.7 MW at the end of 2011, per Green Energy Markets, "Small-Scale technology certificates data modeling for 2013 to 2015," February 2013. Off-grid systems accounted for 10% of the U.S. market in 2009 but have declined since then; Australia and South Korea also installs dozens of MW of off-grid capacity each year, per EPIA, op. cit. note 1, p. 10.

44 Paula Mints, "12 Solar Power Myths and the Saving Grace of a Worthwhile Cause," RenewableEnergyWorld.com, 10 December 2012.

45 Figures of 1% and 100 MW from Masson, op. cit. note 1. The market is about 1% from GTM Research, cited in Dave Levitan, "Will Solar Windows Transform Buildings to Energy Producers?" *Yale Environment 360*, 3 May 2012, at http://e360.yale.edu. The market was an estimated 400 MW at a value of just over USD 600 million from Pike Research, cited in "BIPV, BAPV Markets to Grow Five-Fold by 2017," *PV Intelligence Brief*, 20 December 2012–8 January 2013, at http://news.pv-insider.com.

46 BCC Research, "Building-integrated Photovoltaics (BIPV): Technologies and global markets," cited in "BIPV technology and markets: Explosive growth now predicted for BIPV players," *Renewable Energy World*, November-December 2011, p. 10.

47 Robin Whitlock, "Report: BIPV to Be One of the Fastest Growing PV Segments," RenewableEnergyFocus.com, 21 August 2012.

48 Elisa Wood, "Gardens that Grow Gigawatts: Community Solar Poised to Hit Big Time," Large Scale Solar Supplement, *Renewable Energy World*, September–October 2012, pp. 18–20. Most projects are in the 1 MW range, from idem.

49 By the end of 2012 or early 2013, the first phase (37 kW) of the project had been installed, per "Australian Community Solar Project Begins Operation," *PV News*, January 2013, p. 11.

50 Figure of 30 MW and up from Denis Lenardic, pvresources.com, personal communication with REN21, 31 March 2013; 10 MW and up from Philip Wolfe, "The Rise and Rise of Utility-scale Solar," Large Scale Solar Supplement, *Renewable Energy World*, March–April 2013, pp. 4–6.

51 More than 4 GW and at least 12 from Denis Lenardic, pvresources.com, personal communications with REN21, 24 February and 31 March 2013, and from "Large-scale Photovoltaic Power Plants

Ranking 1-50," www.pvresources.com/PVPowerPlants/Top50.aspx, updated 21 January 2013. The countries are Canada, China, the Czech Republic, France, Germany, India, Italy, Portugal, Spain, Thailand, Ukraine, and the United States, per Lenardic, op. cit. note 50.

52 Considering extensions of existing PV power projects as well as single stages completed in 2012, at least 24 plants of more than 30 MW were connected to the grid in 2012, per Lenardic, op. cit. note 50; rankings from "Large-scale Photovoltaic Power Plants Ranking 1-50," op. cit. note 51. The plant in Arizona (Agua Caliente), which uses First Solar panels, is expected to be completed in 2014 when it reaches a total of 290 MW capacity, per First Solar, "Agua Caliente Solar Project," www.firstsolar.com/en/Projects/Agua-Caliente-Solar-Project, viewed 14 March 2013; the first 250 MW came on line in 2012, per GTM Research and SEIA, op. cit. note 19, p. 18.

53 Germany and other leaders from "Large-scale Photovoltaic Power Plants Ranking 1-50," op. cit. note 51, and from Lenardic, op. cit. note 50. Considering plants larger than 10 MW, China led for new installations during the 12-month period up to March 2013. China was followed by the United States, Germany, India, and France, from Wiki-Solar, cited in "5.75 GW of Large Solar PV Plants Added Globally in the Last 12 Months," SolarServer.com, 25 February 2013.

54 For example: in Ghana, the 155 MW Nzema solar project is expected to be online by late 2015, per Daniel Cusick, "Ghana Will Build Africa's Largest Solar Array," *E&E*, 4 December 2012; Adam Vaughan, "Africa's Largest Solar Power Plant to Be Built in Ghana," *The Guardian* (U.K.), 4 December 2012; South Africa plans two 75 MW projects, per Vince Font, "Financial Green Lights Signal Upswing in Global Solar PV Development," RenewableEnergyWorld.com, 16 November 2012; in Serbia, a definitive agreement was signed with the government in October for the OneGiga project, per Misha Savic, "Securum, Serbia Sign Agreement to Build 1,000-MW Solar Park," Bloomberg, 31 October 2012, at www.renewableenergyworld.com; plans were announced in 2012 for a 200 MW plant in Java, Indonesia, per Bryony Abbott, "Southeast Asia's Solar Market Continues to Attract International and Regional Interest," RenewableEnergyWorld.com, 5 October 2012; in the United States, an 800 MW solar farm is planned for California (Mt. Signal Farm), per Font, op. cit. this note; in Mexico, a letter of intent was signed with the Comision Federal de Electricidad with SunEdison for a 50 MW PV plant, per Charles W. Thurston, "Mexico's Sunny Sonora State Fosters Solar PV Growth," RenewableEnergyWorld.com, 6 November 2012; a 250 MW plant was approved for construction in the southern Japanese city of Setouchi, per Yuriy Humber and Tsuyoshi Inajima, "Japan's Aggressive FIT Already Unlocking Gigawatts of Wind and Solar Power," Bloomberg, 1 October 2012, at www.renewableenergyworld.com; China plans a 310 MW project for Shanxi province, per Tim Culpan, "GCL-Poly Planning Massive Solar Power Installations in China," Bloomberg, 3 October 2012, at www.renewableenergyworld.com; in January 2012, Oman announced plans for a 400 MW solar PV plant, per Ian Stokes, "Full Version: Renewable Energy Project Monitor," RenewableEnergyFocus.com, 30 April 2012.

55 Alasdair Cameron, "Tracking the Market: focus on the concentrating photovoltaic sector," *Renewable Energy World*, July–August 2011, pp. 71–75; locations from Travis Bradford, Prometheus Institute, Chicago, personal communication with REN21, 21 March 2012.

56 MW projects from Debra Vogler, "CPV ramps to utility status in 2011," *Renewable Energy World*, 18 October 2011, at www.electroiq.com; 116 plants were identified with a combined capacity just over 100 MW, per *PV Insider*, "CPV World Map 2012," June update, prepared for CPV USA 2012, 4th Concentrated Photovoltaic Summit USA 2012, www.pv-insider.com/cpv12; global capacity totaled 88 MW, per Steve Leone, "Amonix Closes 150-MW Las Vegas HCPV Plant," RenewableEnergyWorld.com, 19 July 2012.

57 United States (50 MW) including Colorado plant, Spain (26 MW), China (6 MW) and Chinese Taipei/Taiwan (5 MW), Italy (3.2 MW), Australia (3.1 MW); all estimates derived from *PV Insider*, "CPV World Map 2012," op. cit. note 56. Other countries with CPV capacity include: Denmark, France, Greece, Malta, and Portugal in Europe; Egypt, Morocco, and South Africa in Africa; Israel, Saudi Arabia, and the United Arab Emirates in the Middle East; Australia; Japan, Korea, and Malaysia in Asia; and Chile and Mexico in Latin America. The United States had 37 MW in operation at the end of 2012, with 7 MW of this installed in 2011 and 30 MW in 2012, and another 4 MW came on line in New Mexico in January 2013 (data include only "utility-scale" projects), per SEIA, "Utility-Scale Solar Projects in the United States Operating, Under Construction, or Under Development," updated 11 February 2013. Australia has a 500 kW test plant at Bridgewater that began operation in March 2012, per Silex Systems, "Solar Systems' Bridgewater Test Facility Commences Operation," press release (Lucas Heights, NSW: 21 March 2012; and a plant at Mildura, with the first 1.5–2 MW of a planned (up to) 150 MW coming on line in April 2013, per Giles Parkinson, "Solar Systems Begins Operation at Mildura Power Plant," REneweconomy.com, 15 April 2013, at http://reneweconomy.com.au.

58 Jason Deign, "What Lies in Store for CPV in 2013?" *PV Insider*, 23 January 2013, at http://news.pv-insider.com. Note that a 50 MW project, the world's largest to date, was under construction in China's Qinghai Province in early 2013, per Frank Haugwitz, consultant, personal communication with REN21, April 2013.

59 Italy based on preliminary data from Terna, "Early Data on 2012 Electricity Demand: 325.3 Billion kWh The Demand, -2.8% Compared to 2011," press release (Rome: 9 January 2013); in Germany, solar PV generated 28 billion kWh in 2012, corresponding to 4.7% of total gross electricity consumption, per BMU, op. cit. note 12; about 5% in Germany from BSW (Federal Solar Industry Association), "Rekordjahr 2012: Deutschland erzeugt Solarstrom für 8 Millionen Haushalte," at www.solarwirtschaft.de (using Google Translate); and 5.6% of annual demand from IEA-PVPS, op. cit. note 1; in May 2012, distributed solar PV systems in Germany produced 10% of the country's total electricity consumption, up 40% over May of 2011, per Stephen Lacey, "Solar Provides 10 Percent of Germany's Electricity in May," Climate Progress, 12 June 2012, at www.renewableenergyworld.com; in August, PV met 8.4% of Italy's electricity demand, according to grid operator Terna SpA, cited in "PV Provides 8.4% of Italian Electricity in August," *PV News*, October 2012, p. 6.

60 EPIA, op. cit. note 1, pp. 13, 44.

61 Build-up especially in China from Bowden, op. cit. note 23, p. 7; impacts from Sarasin, "Working Towards a Cleaner and Smarter Power Supply" (Basel, Switzerland: December 2012).

62 "Strong Year for Solar PV as Support Subsidies Slashed," *Renewable Energy Focus*, July/August 2012; Doug Young, "Solar Bits: LDK Woes, Hanwha Loan," RenewableEnergyWorld.com, 31 December 2012; excluding cadmium telluride (CdTe) thin films, per Masson, op. cit. note 1.

63 Estimates of 30% and 20% from Izumi Kaizuka, RTS Corporation and IEA-PVPS, personal communication with REN21, 15 April 2013; module prices declined 28% and thin-film prices 19% from "Hanergy Sees Thin-Film Solar Gaining Market Share," Bloomberg, 8 March 2013, at www.renewableenergyworld.com; reduction of 38.1% in 2012 after a drop of 44.1% in 2011, from GTM Research Competitive Intelligence Tracker, April 2013; average global module prices fell by 42%, from USD 1.37/Wp in 2011 to USD 0.79/Wp in 2012, per Paula Mints, "Solar PV Profit's Last Stand," RenewableEnergyWorld.com, 22 March 2013. Note that between 2005 and late 2012, solar module prices declined more than 70%, per Chris Cather, "Are Solar Developer Fees Declining?" RenewableEnergyWorld.com, 19 November 2012.

64 Costs are in 2011 USD, and U.S. system costs ranged from USD 4–8/W, all from IRENA, *Renewable Power Generation Costs in 2012: An Overview* (Abu Dhabi: January 2013), p. 54. Note that installed costs were as low as USD 2/Watt in Germany and higher in the United States, where balance-of-system costs have not fallen as quickly, per Pernick, Wilder and Winnie, op. cit. note 2; costs in Germany were as low as 1 EUR/W in the utility-scale segment and easily below 1.6 EUR/W in the residential segment, per Masson, op. cit. note 1. Further, installed costs of residential systems in Germany are significantly lower than those in the United States due greatly to lower "soft costs" (permitting fees, installation, balance of systems), per Joachim Seel, Galen Barbose, and Ryan Wiser, "Why Are Residential PV Prices in Germany So Much Lower Than in the United States? A Scoping Analysis" (Berkeley, CA: Lawrence Berkeley National Laboratory, February 2013). See Table 2 for year-end data.

65 Production in 2012, down from 32.9 MW of cells and 36.1 MW of modules in 2011, from GTM Research Competitive Intelligence Tracker, April 2013. Note that production capacity was roughly 36 GW, a slight increase from about 35 GW in 2011, while actual production was almost 29 GW and shipments increased about 10% to 26 GW, per Paula Mints, SPV Market Research, cited in James Montgomery, "Solar PV Module Rankings in 2012, and

What Comes Next," RenewableEnergyWorld.com, 3 May 2013.

66 Based on production capacity of 56.5 GW from IHS Solar, per EPIA, op. cit. note 1, p. 54; 75.8 GW of modules and 61.2 GW of cells in 2012, up from 65.9 GW of modules and 56.2 GW of cells in 2011, from GTM Research Competitive Intelligence Tracker, April 2013; 70 GW of modules according to SEIA and GTM Research, op. cit. note 23. The wide range of numbers reflects the difficulty of counting production capacities when the industry is in overcapacity, per Masson, op. cit. note 1. Production capacities often refer to announced capacities, which are generally higher than actual, and contract manufacturing increases risk of double counting, per EPIA, op. cit. note 1, p. 52.

67 Based on China representing 64% of global production in 2012, per GTM Research Competitive Intelligence Tracker, April 2013; and on estimate that mainland China alone has capacity for more than 59 GW of annual production, and Taiwan has about 8 GW, per Tim Ferry, "Capacity Control: How Will China and Taiwan Solar Manufacturers Survive Post-Tariffs?" RenewableEnergyWorld.com, 13 November 2012; China's production capacity was equal to the global market from Labwu ZengXian, "Domestic Demand Can Save Chinese PV," RenewableEnergyWorld.com, 12 December 2012.

68 Thin-film's share of total production in 2012 was 11%, per GTM Research Competitive Intelligence Tracker, April 2013. Its share fell from a high of 21% in 2009, and 13% in 2011, per GTM Research, *PV News*, May 2012.

69 Paula Mints, "Reality Check: The Changing World of PV Manufacturing," RenewableEnergyWorld.com, 5 October 2011.

70 China's share was 64% (up from 59% in 2011), per GTM Research Competitive Intelligence Tracker, April 2013. Firms in mainland China and Taiwan alone accounted for 70% of global cell production in 2012, per Ferry, op. cit. note 67.

71 GTM Research Competitive Intelligence Tracker, April 2013.

72 Ibid.

73 EPIA, op. cit. note 1, p. 50.

74 GTM Research Competitive Intelligence Tracker, April 2013. Ten of the top 15 manufacturers were in Asia in 2010, per Greentech Media, *PV News*, April 2011.

75 Based on data from GTM Research Competitive Intelligence Tracker, April 2013. Note that Suntech was in fifth place behind Canadian Solar, followed by Sharp, Jinko Solar, Sunpower, REC Group, and Hanwha SolarOne, to round out the top 10, and Solar Frontier and Kyocera (both Japan) were in the 11th and 12th spots (up from 14 and 17, respectively), per IHS, cited in Jonathan Cassell, "China's Yingli Tops PV Module Supplier Rankings in 2012; Suntech Slips to Fifth," Solarplaza.com, 11 April 2013. Yingli and First Solar were in the top two spots, followed by Suntech and Canadian Solar; Sharp is ranked sixth, followed by Jinko Solar, JA Solar, SunPower, and with Hanwha SolarOne in 10th position, per SolarBuzz, cited in Zachary Shahan, "Graph of the Day: World's Top Ten Solar PV Suppliers," solar360.com, 15 April 2013.

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77 Shyam Mehta, "Global PV Module Manufacturers 2013: Competitive Positioning, Consolidation and the China Factor," GTM Research, 2013. Companies filing for insolvency included: Solon SE, Solar Millennium AG, and Solarhybrid in Germany, per Stefan Nicola, "China Price War Draining Jobs in Germany's Solar Valley," Bloomberg, 7 September 2012, at www.renewableenergyworld.com; Sovello and Solecture in Germany from Ucilia Wang, "Solar Woes Continue with Sovello's Bankruptcy Filing," RenewableEnergyWorld.com, 14 May 2012; CIGs thin-film manufacturer Centrotherm in Germany from Ucilia Wang, "No End In Sight? The Struggle of Solar Equipment Makers," RenewableEnergyWorld.com, 30 November 2012, and from BNEF, "Star Shines Bright for China as Europe's Subsidies Fade," *Energy: Week in Review*, 9–16 July 2012; Renewable Energy Corp. (REC) Wafer Norway AS from Stephen Treloar, "REC ASA to File for Insolvency of Norway Solar Wafer Unit," Bloomberg, 14 August 2012, at www.renewableenergyworld.com; REC shut down all manufacturing in Europe by April 2012, per Kari Williamson, "REC Closes Remaining Norwegian Solar Production," RenewableEnergyFocus.com, 27 April 2012; Siliken (Spain) from Mercom Capital Group, "Siliken Files for Insolvency," *Market Intelligence Report – Solar*, 4 February 2013; Alicante (IATSO, Spain) from Mercom Capital Group, "Spanish Module Producer Iatso Files for Insolvency," *Market Intelligence Report – Solar*, 25 February 2013; U.S. thin-film manufacturer Konarka Technologies from Jennifer Runyon, "Thin Film Organic Solar PV Maker Konarka Technologies Files for Chapter 7," RenewableEnergyWorld.com, 4 June 2012; Abound Solar (USA) from GTM Research, cited in Ucilia Wang, "Q2 Report Shows US Solar Market Booming, Utility-Scale Projects Leading," RenewableEnergyWorld.com, 10 September 2012; amorphous silicon thin-film startup Signet Solar (USA) from Ucilia Wang, "No End In Sight? The Struggle of Solar Equipment Makers," RenewableEnergyWorld.com, 30 November 2012, and from BNEF, op. cit. this note; a-Si manufacturing pioneer UniSolar (USA) from Paula Mints, "PV Still Facing a Bumpy Ride: Working in a Low-incentive World," Navigant Consulting, 10 September 2012, at www.renewableenergyworld.com. In addition, Schüco International KG (Germany) reported plans to stop production and R&D of thin-film products, per "Schüco shuts doors on thin film," *PV Intelligence Brief*, 1–14 August 2012, at http://news.pv-insider.com; Schott Solar (Germany) withdrew from crystalline silicon sector but remained in thin film, BIPV, and CSP market, per Sile McMahon, "Solar shakeout: Schott Solar announces surprise exit from c-Si manufacturing," PV-tech.org, 29 June 2012.

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81 Centre for Science and Environment, *Fortnightly News Bulletin*, 17 January 2013, at www.downtoearth.org.in.

82 China's Hanergy Holding Group bought U.S. CIGs maker Miasole; SK Group (South Korea) bought HelioVolt; Chinese-Singaporean joint venture TFG Radiant Group's interest in Colorado's Ascent Solar Technologies Inc., and Taiwan Semiconductor Manufacturing Co. Ltd.'s stake in San Jose, California-based Stion, which also received a strategic investment from Korean solar equipment maker Avaco, per "Solar Wind Blows Up a Flurry of Deals," *Sunday Morning Herald* (Australia), 18 October 2012; Q-Cells filed for insolvency in early 2012, per "Strong Year for Solar PV as Support Subsidies Slashed," *Renewable Energy Focus*, July/August 2012; Q-Cells purchase from Vince Font, "Newly Launched Hanwha Q.CELLS Becomes World's Third Largest Solar Manufacturer," RenewableEnergyWorld.com, 25 October 2012; top in 2008 from Paula Mints, "The Often Unprofitable, Always Challenging Road to Success of the Photovoltaic Industry," RenewableEnergyWorld.com, 6 February 2013.

83 Wang, op. cit. note 28; Chisaki Watanabe, "Panasonic Starts Malaysia Solar-Panel Plant to Meet Japan Demand," Bloomberg.com, 13 December 2012; GE in response to the rapid decline in wholesale prices for solar panels, from GTM Research, cited in Ucilia Wang, "Q2 Report Shows US Solar Market Booming, Utility-Scale Projects Leading," RenewableEnergyWorld.com, 10 September 2012; GE return to R&D from Paula Mints, "Marketing Optimism versus Healthy Optimism," Navigant Consulting, 9 July 2012, at www.renewableenergyworld.com; GTM Research and SEIA, op. cit. note 19, p. 73; Bosch will try to sell solar ingot, wafer, cell, and panel production assets, but will keep developing solar thin-film technology for the time being, per Stefan Nicola and Christoph Rauwald, "Bosch Quits $2.6 Billion Solar Foray in Week of Suntech Failure," Bloomberg.com, 22 March 2013; Julia Chan, "Siemens Plans Solar Business Exit," PV-tech.org, 22 October 2012.

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85 Font, op. cit. note 54; Jennifer Runyon, "Staying Alive: Could Thin-Film Manufacturers Come Out Ahead in the PV Wars," *Renewable Energy World*, May-June 2012, pp. 79–83.

86 For example, Total and subsidiary SunPower commissioned new 44 MW module manufacturing and assembly plant in Porcelette,

France, per "Total and SunPower Commission Manufacturing Facility in France," *PV News*, July 2012, p. 8; China Sunergy opened a new manufacturing facility in Istanbul, Turkey, from "China Sunergy Begins Manufacturing in Turkey," *PV News*, February 2013, p. 4, and from Anna Watson, "Turkish Solar PV Market Set to Sizzle," RenewableEnergyWorld.com, 1 October 2012; Astana Solar opened a new wafer and module manufacturing plant in Kazakhstan, per "Kazakhstan PV Manufacturing Industry Poised for Growth," *PV News*, February 2013, p. 5; companies like Sharp and Kyocera are gearing up to meet rising demand in Japan, per Chisaki Watanabe, "Solar Boom Heads to Japan Creating $9.6 Billion Market," Bloomberg, 18 June 2012, at www.renewableenergyworld.com; other international companies are aiming to enter Japan's market, planning new facilities, setting up Japanese subsidiaries, per Ucilia Wang, "Japan: A Beacon for Weary Solar Makers," 5 December 2012, at http://gigaom.com/cleantech/japan-a-beacon-for-weary-solar-makers/; Panasonic Corporation started production at a new 300 MW facility in Malaysia in December, per "Panasonic Begins Manufacturing in Malaysia," *PV News*, January 2013, p. 8; Isofoton (Spain) facility in Ohio (50 MW initial capacity with plans to expand up to 300 MW), per "Isofoton Opens Facility in Ohio," *PV News*, October 2012, p. 5; "Wafer Factory Opens in Massachusetts," *PV News*, March 2013, p. 10.

87 "First PV Module Factory Opens in Ethiopia," *PV News*, March 2013, p. 10.

88 Bowden, op. cit. note 23, p. 7.

89 First Solar and SunPower from Wang, op. cit. note 28; Trina Solar from Joyce Laird, "Survival Strategies," *Renewable Energy Focus*, July/August 2012. For example, SunPower agreed to form a joint venture with Tianjin Zhonghuan Semiconductor, Inner Mongolia Power Group, and Hohhot Jinqiao City Development Company to produce and install its panels in China. "Canadian Solar Shifts Focus Downstream," and "Q1 2012 PV Manufacturer Earnings Update," both in *PV News*, June 2012, pp. 5, 9.

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91 "Consolidation: A Step to Commercial CPV," *PV Insider*, 2 January 2013, at www.renewableenergyworld.com.

CSP

1 Total capacity was an estimated 2,549 MW, based on 1,950 MW in Spain, per Comisión Nacional de Energía (CNE), provided by Eduardo Garcia Iglesias, Protermosolar, Madrid, personal communication with REN21, 16 May 2013, and Red Eléctrica de España (REE), *Boletín Mensual*, No. 72, December 2012; 507 MW in the United States from U.S. Solar Energy Industries Association (SEIA), "Utility-scale Solar Projects in the United States Operating, Under Construction, or Under Development," www.seia.org/sites/default/files/resources/Major%20Solar%20Projects%20List%202.11.13.pdf, updated 11 February 2013, and from Fred Morse, Abengoa Solar, personal communication with REN21, 13 March 2013; 25 MW in Algeria from Abengoa Solar, "Integrated solar combined-cycle (ISCC) plant in Algeria," www.abengoasolar.com/corp/web/en/nuestras_plantas/plantas_en_operacion/argelia/, viewed 27 March 2012, and from New Energy Algeria, "Portefeuille des projets," www.neal-dz.net/index.php?option=com_content&view=article&id=147&Itemid=135&lang=fr, viewed 6 May 2012; 20 MW in Egypt 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, and from "A newly commissioned Egyptian power plant weds new technology with old," RenewablesInternational.net, 29 December 2010; 20 MW in Morocco from World Bank, "Nurturing low carbon economy in Morocco," November 2010, at http://go.worldbank.org/KIN4DEUC70, and from Moroccan Office Nationale de l'Électricité Web site, www.one.org.ma, viewed 7 March 2012; 10 MW in Chile from Abengoa Solar, "Minera El Tesoro Brings South America's First Solar Thermal Plant, Designed and Built by Abengoa, Online," press release (Seville: 2 January 2013), and from Chilean Ministry of Energy, "En pleno desierto de Atacama Ministro de Energía inaugural innovadora planta solar," 29 November 2012, at www.minenergia.cl (using Google translate); 12 MW in Australia from the following sources: CSP World, "Liddell Solar Thermal Station," www.csp-world.com/cspworldmap/liddell-solar-thermal-station; Elena Dufour, European Solar Thermal Electricity Association (ESTELA), personal communication with REN21, 3 April 2013; U.S. National Renewable Energy Laboratory (NREL), "Lake Cargelligo," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=261, updated 5 February 2013; NREL, "Liddell Power Station," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=269, updated 5 February 2013; and Novatec Solar, "Novatec Solar's Australian Fuel-Saver Commences Operation," press release (Karlsruhe: 24 October 2012). 5 MW in Thailand from "Thailand's First Concentrating Solar Power Plant," Thailand-Construction.com, 27 January 2012; from "CSP in Thailand," RenewablesInternational.net, 6 February 2012; and from NREL, "Thai Solar Energy 1," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=207, updated 5 September 2012. Note that year-end global capacity was 2,580 MW, per "Protermosolar: CSP Spanish Companies involved in 64% of the Solar Thermal Power Projects in the World," HelioCSP.com, 7 March 2013. Figure 14 compiled from various sources in this note and from REN21, *Renewables 2012 Global Status Report* (Paris: June 2012), pp. 51–52.

2 Figure of 970 MW added based on 951 MW added in Spain, from CNE, op. cit. note 2; from REE, op. cit. note 1; and from REE, *Boletín Mensual*, No. 60, December 2011; 10 MW in Chile, from Abengoa Solar, op. cit. note 1, and from Chilean Ministry of Energy, op. cit. note 1; 9 MW in Australia from "Liddell Solar Thermal Station," op. cit. note 1, and from Dufour, op. cit. note 1. In addition, at least 1 MW appears to have come on line in China, but it is likely a pilot plant and is unconfirmed, so it is not included in the total.

3 Estimate of 42.8% based on 430 MW in operation at the end of 2007, including 419 MW in the United States and the remainder in Spain, from the following sources: Fred Morse, Abengoa Solar, personal communication with REN21, various dates during 2010–12; NREL, "Concentrating Solar Power Projects," SolarPaces, www.nrel.gov/csp/solarpaces/by_country.cfm; 2012 year-end capacity from sources provided in note 1.

4 "Cost Drivers Fuel Technology Switch for Concentrated Solar," *Renewable Energy Focus*, July/August 2012, p. 42.

5 "Ibid., p. 42; under development from Elena Dufour, ESTELA, personal communication with REN21, 24 January 2013.

6 Year-end total for 2012 from REE, op. cit. note 1; additions (951 MW) derived from idem, and from CNE, op. cit. note 1, and from REE, op. cit. note 2.

7 Technology dominates from Protermosolar (the Spanish Solar Thermal Electricity Industry Association), "Localización de centrales solares termoeléctricas en España," April 2012, at www.protermosolar.com/boletines/23/Mapa.pdf; the Puerto Errado II (30 MW) Linear Fresnel Plant came into operation in late 2012, per Beatriz Gonzalez, "Makkah Announces $640m Solar Energy Project," in CSP Today, *Weekly Intelligence Brief*, 1–8 October 2012; world's first from "TÜV Rheinland examines Puerto Errado 2 plant," in CSP Today, *Weekly Intelligence Brief*, 19–26 November.

8 A 22.5 MW parabolic trough capacity combined with biomass boilers, per "World's first hybrid CSP-Biomass plant comes on-line," CSP-World.com, 13 December 2012. In addition, a commercial-scale pilot hybrid solar power tower-natural gas plant began operating in 2012, per "SOLUGAS, a new hybrid solar-gas demonstration facility comes on-line," CSP-World.com, 27 June 2012.

9 Protermosolar estimates that policy changes will reduce expected revenues by 33%, per "International Investment Funds to Take Spain to International Courts," CSP-World.com, 18 February 2013.

10 SEIA, op. cit. note 1; Morse, op. cit. note 1.

11 No new capacity added and more than 1,300 MW (1,317 MW) from SEIA, op. cit. note 1; all due on line from Morse, op. cit. note 1, and from SEIA and GTM Research, *Solar Market Insight Report Q3* (Washington, DC: 2012). Plants with about 1,200 MW of capacity were under construction at the end of 2012, per CSP World, "CSP 2012, A Review," January 2013, at www.csp-world.com.

12 Estimate of 75% complete from Ivanpah Solar, "Ivanpah Team Installs 100,000th Heliostat," 28 December 2012, at http://ivanpahsolar.com; 140,000 homes from BrightSource Energy, "Ivanpah Project Overview," www.brightsourceenergy.com/ivanpah-solar-project, viewed 7 March 2013.

13 SEIA and GTM Research, op. cit. note 11; "Abengoa's 280 MW Solana Project 80% Complete," in CSP Today, *Weekly Intelligence Brief*, 26 November–2 December 2012. This plant will have six hours of molten salt thermal energy storage, per Abengoa Solar, "Solana, The Largest Solar Power Plant in the World," www.abengoasolar.com/web/en/nuestras_plantas/plantas_en_construccion/estados_unidos#seccion_1, viewed 13 March 2013.

14 The Liddell plant, in New South Wales, first became operational in 2004 with 1 MW electric capacity and was expanded to 9 MW_{th} by 2008 by Areva Solar; Novatec Solar expanded the plant with another 9.3 MW_{th}, which was completed in 2012, from "Liddell Solar Thermal Station," op. cit. note 1, and from Novatec Solar, op. cit. note 1. There is conflicting information about how much of this capacity is electric versus thermal, with one source saying that there are 6 MW of power capacity and 18 MWth, per Keith Lovegrove et al., "Realising the Potential of Concentrating Solar Power in Australia – Summary for Stakeholders," prepared by IT Power (Australia) PTY LTD for the Australian Solar Institute, May 2012. It is expected that the Chilean plant will substitute more than 55% of the diesel fuel that was previously used for the copper electro-extraction process at the mine, per Abengoa Solar, op. cit. note 1. The plant was inaugurated in November 2012, per Chilean Ministry of Energy, op. cit. note 1.

15 Abengoa Solar, op. cit. note 1; New Energy Algeria, op. cit. note 1; 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...," op. cit. note 1; Ain Beni Mathar began generating electricity for the Moroccan grid in late 2010, from World Bank, op. cit. note 1, and from Moroccan Office Nationale de l'Électricité, op. cit. note 1; TSE 1 began operation in Thailand in late 2011, per "Concentrating Solar Power: Thai Solar Energy Completes Nation's First CSP Plant," SolarServer.com, 7 December 2011.

16 Plants include China (about 2.5 MW), France (at least 0.75 MW), Germany (1.5 MW), India (as much as 5.5 MW), Israel (6 MW), Italy (5 MW), and South Korea (0.2 MW). China's Beijing Badaling Solar Tower plant, with 1–1.5 MW capacity (depending on the source), began operating in 2012, per "China's first megawatt-size power tower is complete and operational," CSP-World.com, 30 August 2012; China information also from the following sources: CSP World, "Yanqing Solar Thermal Power (Dahan Tower Plant)," www.csp-world.com/cspworldmap/yanqing-solar-thermal-power-dahan-tower-plant; "Hainan, China builds second concentrating solar project," GreenProspectsAsia.com, 2 November 2012 (has 1.5 MW); NREL, "Beijing Badaling Solar Tower," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=253, updated 12 February 2013; Dong Chunlei, "Mirror: By Sunlight Producing Green Electricity," Xinmin Evening News, 29 July 2010, at www.e-cubetech.com/News_show.asp?Sortid=30&ID=204 (using Google Translate); France's capacity includes two small Fresnel pilot plants (totaling <1 MW), from EurObserv'ER, *The State of Renewable Energies in Europe*, 12th EurObserv'ER Report (Paris: 2012), p. 88, and from "Fresnel Pilot Plant Commissioned at CEA Cadarache, France," CSP-World.com, 30 October 2012; Germany from NREL, "Jülich Solar Tower," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=246, updated 12 February 2013, and from Deutschen Zentrum für Luft- und Raumfahrt (DLR), Institute für Solarforschung, "Solarthermisches Versuchskraftwerk Jülich," www.dlr.de/sf/desktopdefault.aspx/tabid-7160/11955_read-33199, viewed 5 May 2013; India from Bridge to India, *India Solar Compass*, October 2012 Edition, p. 3; a 2.5 MW power tower became operational in April 2011, per NREL, "ACME Solar Tower," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=262, updated 12 February 2013; Israel from CSP World, "BrightSource SECD," www.csp-world.com/cspworldmap/brightsource-sedc, viewed 5 May 2013; Italy has a 5 MW prototype, from Archimedes Solar Energy Web site, at www.archimedesolarenergy.it, viewed 6 March 2012, and from EurObserv'ER, op. cit. this note, p. 88; South Korea from CSP World, "Daegu Solar Power Tower," www.csp-world.com/cspworldmap/daegu-solar-power-tower, viewed 5 May 2013.

17 Daniel Fineren, "UAE Opens First Big Solar Energy Plant," *Reuters*, 18 March 2013; first full-size pure CSP from "Concentrating Solar Power: Masdar to Inaugurate Shams 1 Plant on March 17th, 2013," HeliosCSP.com, 7 March 2013.

18 Most active from Herman K. Trabish, "CSP 2012: Concentrated Solar Power Review," Greentechmedia.com, 13 December 2012; 50 MW solar power tower plant (Khi Solar One) and 100 MW parabolic trough plant (KaXu Solar One), per "Abengoa Kicks Off South Africa's First CSP Plants Construction," CSP-World.com, 6 November 2012. ACWA will build another 50 MW plant, per CSP World, op. cit. note 11.

19 Funding will come from various sources including the Development Bank of Southern Africa, the Clinton Climate Initiative, and Namibian institutions, per "Namibia's First CSP Plant Gets Closer," CSP-World.com, 20 February 2013.

20 World Bank and Asian Development Bank (ADB) funded projects are planned to be built in Algeria, Egypt, Jordan, Morocco, and Tunisia, per "Developing countries embrace CSP technology," in CSP Today, *Weekly Intelligence Brief*, 3–10 December 2012. The MENA CSP Scale-Up Initiative among Algeria, Egypt, Jordan, Morocco, and Tunisia aims for 1 GW of capacity, per Allison Ebbage, "CSP in MENA: Challenges and Opportunities," CSP Today, December 2012, at http://social.csptoday.com; The Mediterranean Solar Plan has been announced in most northern African countries, calling for 100s to 2,000 MW of capacity per country, per Dufour**,** op. cit. note 5. In addition, financing contracts for a 160 MW CSP plant in Morocco were signed in late 2012. KfW (on behalf of the German Government), the European Commission, the European Investment Bank (EIB), Agence Française de Developpement (AfD), the World Bank, and the African Development Bank will provide financing for the USD 990 million (EUR 750 million) cost for the parabolic trough plant in Quarzazate. This project is the first phase, with an even larger second phase to follow, per Jens Drillisch, KfW, personal communication with REN21, April 2013.

21 Reserve oil from Ebbage, op. cit. note 20. It is expected that about 900 MW will be allocated in Saudi Arabia for the first round (to be announced during 2013) and 1,200 MW for the second round; all must provide at least four hours of storage, per CSP Today, "Saudi Arabia Solar Programs Gives Massive Boost to Concentrated Solar Power Industry," 25 February 2013, at http://social.csptoday.com. Jordan from Eduardo Garcia Iglesias, Protermosolar, personal communication with REN21, 3 April 2013.

22 Complete 500 MW from "Developing countries embrace CSP technology," op. cit. note 20. See also NREL, "Concentrating Solar Power Projects in India," SolarPaces, www.nrel.gov/csp/solarpaces/by_country_detail.cfm/country=IN. Some projects have been delayed and some cancelled because developers have been unable to obtain heat-transfer fluid from U.S. suppliers due to a backlog of orders, and because it has been determined that high dust levels in areas where some plants were to be built diffuse the necessary solar radiation, per Natalie Obiko Pearson, "Completion of Concentrating Solar Power Plants in India Delayed," RenewableEnergyWorld.com, 16 November 2012; see also Natalie Obiko Pearson, "India May Defer Penalties on $1 Billion of Solar Thermal Plants, RenewableEnergyWorld.com, 8 May 2013.

23 Information on 44 MW plant from Piers Evans, "Strong on Solar:

Australia Eyes CSP Leadership," RenewableEnergyWorld.com, 29 August 2012, and from "Kogan Creek Solar Boost Project – Case Study," CleanEnergyActionProject.com, viewed 26 April 2013.

24 Argentina plans for a 20 MW trough plant, but no target date has been set and financing is a challenge, from Jason Deign, "Argentina moves into CSP with 20MW plant," CSP Today, November 2012, at http://social.csptoday.com, and from Jason Deign, "Argentina Salta Plant Developer Responds," CSP Today, 15 February 2013, at http://social.csptoday.com; Chile launched a tender in February 2013 for the country's first CSP plant for electricity generation, per "Chile Launches Tender for CSP Plant," CSP-World.com, 28 February 2013; 12 MW (net) Agua Prieta II parabolic trough under construction in Mexico is due for completion in 2013, per NREL, "Agua Prieta II," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=135, updated 24 January 2013; four projects have been selected for funding under the EU Emissions Trading System framework—in Cyprus, Greece, and Spain—that total just over 225 MW (two large-scale dish Stirling power plants and two large central receivers), per European Commission, "Questions and Answers on the Outcome of the First Call for Proposals Under the NER300 Programme," press release (Brussels: 18 December 2012); France's 12 MW Alba Nova 1 linear Fresnel demonstration plant is under construction with completion scheduled for 2014, per NREL, "Alba Nova 1," SolarPaces, www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=221, updated 12 February 2013; there is also a 9 MW plant in the pipeline in France, per Dufour, op. cit. note 5; Israel from CSP World, op. cit. note 11; China plans to begin construction on 250 MW of plants with more than 4,000 MW in the pipeline awaiting clearly defined policies, per Dufour, op. cit. note 5.

25 Joyce Laird, "Is CSP Still on Track," RenewableEnergyFocus.com, 26 June 2012.

26 Fred Morse and Florian Klein, Abengoa Solar, Washington, DC and Madrid, personal communications with REN21, March 2012; Laird, op. cit. note 25.

27 See, for example, "First harvest of CSP-grown cucumbers in Qatar served to COP18 attendees," CSP-World.com, 11 December 2012.

28 ESTELA, *Report on The First 5 Years of ESTELA* (Brussels: February 2012); Morse and Klein, op. cit. note 26; Dufour, op. cit. note 1.

29 Dufour, op. cit. note 5.

30 Laura Hernandez, "CSP's Growth Directly Connected to the Industry's Diversification," RenewableEnergyWorld.com, 24 September 2012.

31 Dufour, op. cit. note 5

32 CSP World, op. cit. note 11; alliance from Dufour, op. cit. note 1.

33 China is expanding its manufacturing capacity, per Dufour, op. cit. note 5. Development in China has been relatively slow due to challenges such as vast distances between solar resources and demand centers, lack of necessary transmission infrastructure, and the government's focus on solar PV and wind power, per Paul French, "China to Remain the Dominant Component Supplier to CSP 'Indefinitely' Says Analyst," CSP Today, September 2012, at http://social.csptoday.com.

34 "Protermosolar: CSP Spanish Companies involved in 64% of the Solar Thermal Power Projects in the World," HelioCSP.com, 7 March 2013. By the end of 2012, Abengoa alone had more than 740 MW in operation and 910 MW under construction, per "Extremadura Solar Complex inaugurated," in CSP Today, *Weekly Intelligence Brief*, 3–10 December 2012.

35 Solar Millennium and SolarHybrid from Rikki Stancich, "Solar Trust of America Files for Bankruptcy," in CSP Today, *Weekly Intelligence Brief*, 2–9 April 2012; Steve Leone, "Developer of 1,000-MW Blythe Solar Project Files for Chapter 11," RenewableEnergyWorld.com, 2 April 2012; BrightSource from CSP World, op. cit. note 11; Siemens from Bank Sarasin, "Working Towards a Cleaner and Smarter Power Supply – Prospects for Renewables in the Energy Revolution" (Basel, Switzerland: December 2012), p. 11. Siemens entered in 2009 by acquiring Archimede Solar Energy and Solel Solar Systems, per Bloomberg New Energy Finance, "China Redirects State Support to Solar Power Developers," in *Energy: Week in Review*, 23–29 October 2012.

36 One millionth from "Schott Solar Achieves a Milestone," in CSP Today, *Weekly Intelligence Brief*, 19–26 November 2012; seeking bids from "Update 1 – Schott Expects Bids for Solar Ops in February – Source," *Reuters*, 8 February 2013.

37 Morse and Klein, op. cit. note 26.

38 "German Company Unveils Its New Plant Type," in CSP Today, *Weekly Intelligence Brief*, 26 November–2 December 2012.

39 "3M and Gossamer inaugurate the world's largest aperture parabolic trough demonstration facility," CSP-World.com, 3 May 2012.

40 Solar Power Group and Sopogy from Kris De Decker, "The bright future of solar thermal powered factories," *LowTech Magazine*, 26 July 2011, at www.lowtechmagazine.com. See also Solar Power Group Web site, www.solar-power-group.de, and Sopogy Web site, http://sopogy.com; Abengoa from Abengoa Solar, "Minera El Tesoro..." op. cit. note 1.

41 Paul Denholm and Mark Mehos, *Enabling Greater Penetration of Solar Power via the Use of CSP with Thermal Energy Storage* (Golden, CO: NREL, November 2011); Dufour, op. cit. note 5.

42 Jorge Alcauza, "To store or not to store, that is NOT the question (anymore)," CSP-World.com, 1 February 2013. Note that steam storage has been operating for years in some plants, per Elisa Prieto Casaña, Abengoa Solar, personal communication with REN21, April 2013.

43 Bank Sarasin, *Solar Industry: Survival of the Fittest in the Fiercely Competitive Marketplace* (Basel, Switzerland: November 2011); Protermosolar, op. cit. note 7.

44 Abengoa Energy, "Abengoa Awarded Two CSP Projects by Africa's Department of Energy," press release (Seville: 7 December 2011); Andrew Eilbert, "The Trade-off Between Water and Energy: CSP Cooling Systems Dry Out in California," ReVolt (Worldwatch Institute blog), 31 December 2010; Jordan Macknick, Robin Newmark, and Craig Turchi, NREL, "Water Consumption Impacts of Renewable Technologies: The Case of CSP," presentation at AWRA 2011 Spring Specialty Conference, Baltimore, MD, 18–20 April 2011; 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.

45 Fred Morse, Abengoa Solar, Washington, DC, personal communication with REN21, March 2013.

46 Heba Hashem, "Grid Parity Solar: CSP Gains on PV," CSP Today, 25 May 2012, at http://social.csptoday.com.

SOLAR THERMAL HEATING AND COOLING

1 Total additions and capacity based on Franz Mauthner, AEE – Institute for Sustainable Technologies (AEE-INTEC), Gleisdorf, Austria, personal communication with REN21, 14 May 2013, and on Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2011*, edition 2013 (Gleisdorf, Austria: International Energy Agency (IEA) Solar Heating and Cooling Programme, May 2013). The Weiss and Mauthner report covers 56 countries and is assumed to represent 95% of the global market. Data provided were 48.1 GW_{th} added (68.6 million m^2) for a total of 234.6 GW_{th}, which were adjusted upwards by REN21 to 100% for the GSR to reach 50.6 GW_{th} added (72.2 million m^2) and 246.9 GW_{th} total. Note that collector area (and respective capacity) in operation were estimated by Weiss and Mauthner based on official country reports regarding the lifetime basis used; where such reports were not available, a 25-year lifetime was assumed except in the case of China, where the Chinese Solar Thermal Industry Federation (CSTIF) considers lifetime to be below 10 years. Also, note that in 2004 the represented associations from Austria, Canada, Germany, the Netherlands, Sweden, and the United States, as well as the European Solar Thermal Industry Federation (ESTIF) and the IEA Solar Heating and Cooling Programme agreed to use a factor of 0.7 kW_{th}/m^2 to derive the nominal capacity from the area of installed collectors; this conversion rate is also used in the GSR.

2 Glazed water collectors accounted for a 96.4% share of the global market in 2011 (unglazed water systems accounted for about 3.2% of the global market in 2011, and glazed and unglazed air systems for 0.2%), and global capacity added in 2011 was 46.4 GW_{th}, per Mauthner, op. cit. note 1, and Weiss and Mauthner, op. cit. note 1. The 46.4 GW_{th} was adjusted upwards by REN21 from an estimated 95% of the global market to 100%, to reach 48.9 GW_{th}.

3 Weiss and Mauthner, op. cit. note 1, p. 2.

4 Ibid., p. 2.

5 Franz Mauthner, AEE-INTEC, Gleisdorf, Austria, personal

communication with REN21, 4 April 2013.

6 Based on an estimated global capacity of 211.5 GW_{th} glazed water collectors at the end of 2011, producing an estimated 183,545 MWh (660,761 TJ), from Weiss and Mauthner, op. cit. note 1, p. 23, and adjusted from an estimated 95% of the global market up to 100% to reach 222.6 GW_{th} and output of 193.2 GWh (695.5 PJ).

7 Weiss and Mauthner, op. cit. note 1, pp. 9, 17. Figures 15 and 16 based on data from idem. Global numbers are adjusted upwards by REN21 from an estimated 95% of the global market to 100%.

8 Total solar thermal capacity in operation and gross additions based on preliminary estimate of 268.1 GW_{th} of total global capacity at the end of 2012, and gross capacity additions of 52.6 GW_{th}, from Mauthner, op. cit. note 1, and Weiss and Mauthner, op. cit. note 1. Estimates for 2012 are based on available market data from Austria, Brazil, China, Germany, and India; data for the remaining countries were estimated by Weiss and Mauthner according to their trends for the previous two years. Data were adjusted upwards by REN21 from an estimated 95% of the global market to 100% (i.e., 268.1 GW_{th}/0.95 = 282.2 GW_{th}) to reach 282 GW_{th} of total solar thermal capacity in operation and 55.4 GW_{th} of gross additions.

9 Glazed water collector capacity is based on the above estimate of 282.2 GW_{th} for all types of collectors in operation worldwide at the end of 2012, and the assumption that glazed collectors accounted for 90.2% of total global collector capacity in 2012, as they did in 2011, per Mauthner, op. cit. note 1, and Weiss and Mauthner, op. cit. note 1. (In other words, estimated 2012 glazed water collector capacity = 282.2 GW_{th} * 0.902 = 254.5 GW_{th}.) Net additions totaled about 32 GW_{th}, derived by subtracting the estimated 2011 total (223 GW_{th}) from the estimated 2012 total. Gross added capacity of glazed water collectors in 2012 is based on 55.4 GW_{th} gross additions of all collectors and assumption that glazed water collectors represented 96.4% of the global market in 2012, as they did in 2011, per Mauthner, op. cit. note 1. This brings gross additions of glazed water collectors to an estimated 53.4 GW_{th} for 2012. Figure 17 based on data from Weiss and Mauthner, op. cit. note 1, and from IEA, *SHC Solar Heat Worldwide Reports* (Gleisdorf, Austria: 2005–2013 editions), revised figures based on long-term recordings from AEE-INTEC, supplied by Franz Mauthner, 18 April 2013; and from Mauthner, op. cit. note 1. Global data adjusted upwards from 95% to 100% per Franz Mauthner, AEE-INTEC, Gleisdorf, Austria, personal communications with REN21, 18 April and 14 May 2013.

10 China's installations and total capacity from Zhentao Luo, CSTIF, presentation (in Chinese) for Annual CSTIF meeting, Beijing, 16 December 2012; two-thirds based on 67% share from Franz Mauthner, AEE - Institute for Sustainable Technologies, personal communication with REN21, 4 April 2013, and on China's share of the estimated 282.2 GW_{th} in operation at the end of 2012. China added 44.73 GW_{th} in 2012, and total capacity increased by 28.3 GW_{th} (from 152.1 GWth to 180.4 GW_{th}), implying that 16.43 GW_{th} were taken out of service during the year, based on data from CSTIF, op. cit. this note.

11 Solar heaters cost an estimated 3.5 times less than electric water heaters and 2.6 less than gas heaters over the system lifetime, per CSTIF, cited in Bärbel Epp, "Solar Thermal Competition Heats Up in China," RenewableEnergyWorld.com, 10 September 2012; and Bärbel Epp, "Solar Thermal Shake-Out: Competition Heats Up in the Chinese Market," *Renewable Energy World*, July–August 2012, pp. 47–49. Annual market growth has increased fairly steadily year-by-year, up from 4,480 MW_{th} in 2000, per Weiss and Mauthner, op. cit. note 1.

12 Slowdown and since 2009 from Luo, op. cit. note 10; causes from Bärbel Epp, "China: Trends in the Largest Solar Thermal Market Worldwide," presentation for Intersolar Europe 2012, Munich, June 2012.

13 Most demand is residential (85% of market in 2011) from Jiuwei Wang, Deputy General Manager, Himin, cited in Bärbel Epp, "Solar Thermal Scales New Heights in China," RenewableEnergyWorld.com, 27 June 2012; growing share from idem.

14 Walls and balconies from Epp, op. cit. note 13; 60% and falling per Yunbin Le, Deputy General Manager, Linuo Paradigma, cited in idem.

15 EurObserv'ER, *Solar Thermal and Concentrated Solar Power Barometer* (Paris: May 2012), p. 55; Pedro Dias, Deputy Secretary General, European Solar Thermal Industry Association (ESTIF), Brussels, personal communication with REN21, 4 May 2013. In 2011, Europe added 3.92 GW_{th}; China and Europe together accounted for 92.2% of the global market, per Weiss and Mauthner, op. cit. note 1; in 2012, Europe added an estimated 2.2 MW_{th} (based on preliminary statistics covering 93% of the market), per Dias, op. cit. this note.

16 EurObserv'ER, op. cit. note 15, p. 65.

17 Additions in 2011 of 889 MW_{th} (1.27 million m²) and in 2012 of 805 MW_{th}, (1.15 million m²) and total capacity of 11.41 GW_{th} (16.3 million m²) from German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources 2012," with data from Working Group on Renewable Energy-Statistics (AGEE-Stat), provisional data, 28 February 2013, at www.erneuerbare-energien.de. Total capacity in 2012 was 12,350 MW_{th} per ESTIF, provided by Dias, op. cit. note 15. Additions and year-end total in 2012 were 805 MW_{th} and 11.5 GW_{th}, respectively, from Bundesverband Solarwirtschaft e.V. (BSW-Solar), "Statistische Zahlen der deutschen Solarwärmebranche (Solarthermie)," February 2013, at www.solarwirtschaft.de. The German market peaked towards the end of 2011 in anticipation of lower incentive rates starting in 2012, per ESTIF, *Solar Thermal Markets in Europe, Trends and Market Statistics 2011* (Brussels: June 2012).

18 Dias, op. cit. note 15. Austria's market shrank 11% in 2012 following a 17% decline in 2011, from Mauthner, op. cit. note 10. However, Austria achieved the milestone of 5 million square metres installed in September, from Solid, "5 Million Square Meters of Solar Thermal Collectors in Austria Installed," SDH Solar District Heating/ Intelligent Energy Europe, Newsletter October 2012 (25 October 2012), at www.solar-district-heating.eu.

19 Data for 2011 from ESTIF, op. cit. note 17, p. 7; 2012 and despite economic turmoil from Dias, op. cit. note 15; rising electricity and heating oil prices per Greek Solar Industry Association (EBHE), cited in Yorgos Karahalis, "Solar Water Heating Exports Proves a Success for Recession-Mired Greece," *Reuters*, 29 April 2013.

20 More diversified from Bank Sarasin, *Solar Industry: Survival of the Fittest in a Fiercely Competitive Marketplace* (Basel, Switzerland: November 2011); growth in developing markets from Mauthner, op. cit. note 10, and from Dias, op. cit. note 15. Note that the market for small-scale applications in Denmark has been declining, and growth has been led by solar district heating plants, which account for the vast majority of the Danish market, from Dias, op. cit. note 15.

21 Weiss and Mauthner, op. cit. note 1.

22 Raquel Costa, "Turkey: Kutay Ülke Speaks About Ezinç and the Turkish Market during ESTEC 2011," SolarThermalWorld.org, 26 January 2012.

23 Eva Augsten, "Turkey: High-quality Solar Hot Water Systems Across Earthquake Area," SolarThermalWorld.org, 26 November 2012.

24 Based on 0.91 million m² added for total of 6.92 million m² in operation at the end of February, from Government of India Ministry of New and Renewable Energy (MNRE), "Achievements—Cumulative deployment of various renewable energy systems/ devices in the country as on 28/02/2013," http://mnre.gov.in/mission-and-vision-2/achievements/, viewed 24 March 2013.

25 Japanese Solar System Development Association, cited in Bärbel Epp, "Japan: Stagnating Market Despite Renewables' Image Boost," SolarThermalWorld.org, 30 October 2012. Note that Japan added about 0.12 GW_{th} in fiscal year 2011 for a cumulative total of about 3.7 GW_{th} at the end of the fiscal year, from Matsubara Hironao, Institute for Sustainable Energy Policy, personal communication with REN21, April 2013; South Korea's installations peaked in 2009 and have slowed since; 54,732 m² were added in 2011 for a total of 1,649,322 m² at year's end, from KEMCO (Korea Energy Management Corporation), *New & Renewable Energy Statistics 2011* (2012 Edition).

26 Thailand subsidised 11,155 m² in 2012, up from 9,879 m² in 2011, from Thailand Department of Alternative Energy Development and Efficiency, cited in Stephanie Banse, "Thailand: Government Continues Subsidy Programme in 2013," SolarThermalWorld.org, 15 February 2013.

27 Based on 0.8 million m² added and 8.11 million m² cumulative at year's end, from DASOL (National Solar Heating Department), ABRAVA (Brazilian Association for HVAC&R), "Sector's Data," 2013.

28 DASOL, ABRAVA, "Sector's Data 2011," 2012, at www.dasolabrava.org.br.

29 Argentina from Eva Augsten, "Argentina: Solar Water Heaters for Rural Schools," SolarThermalWorld.org, 29 October 2011,

and from Eva Augsten, "Argentina: ASADES' Network for Solar Energy," SolarThermalWorld.org, 6 April 2012; Mexico, Chile, and Uruguay from DENA (German Energy Agency), cited in "Overview of Solar Power and Heat Markets," RenewablesInternational.net, 1 October 2013. In Chile, more than 10,000 m^2 installed were within two years, more than doubling cumulative capacity, in response to tax rebates, from Asociacion Chilena de Energia Solar (ACESOL), Christian Antunovic, "Columna de Presidente de ACESOL Publicada en le Tercera," 10 January 2012, at www.acesol.cl/noticias/columna-de-presidente-de-acesol-publicada-en-la-tercera (using Google Translate). Chile added about 11 MW_{th} (15,869 m^2) in 2012, for a total of 17.3 MW_{th} (24,685 m^2) installed during 2010–12, from Ministry of Energy of Chile, Estudio de Mercado de la Industria Solar Térmica en Chile y Propuesta Metodológica para su Actualización Permanente (Santiago: September 2012), p. 10.

30 The United States had 13,987 MW_{th} of unglazed water collectors in operation in 2011, from Weiss and Mauthner, op. cit. note 1.

31 The United States added 138.1 MW_{th} of glazed water collectors in 2011 compared with 157.8 MW_{th} in 2010. Data for 2011 from Weiss and Mauthner, op. cit. note 1; data for 2010 from 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, 2012). The United States ranked 10th worldwide in 2009 for total capacity of glazed water collectors, 12th in 2010, and 13th in 2011, from Weiss and Mauthner, op. cit. note 1 and past editions of the same report.

32 "California Solar Statistics" (www.californiasolarstatistics.ca.gov), cited in Bärbel Epp, "USA: More Incentives and Marketing in California," SolarThermalWorld.org, 21 August 2012.

33 "Small-scale Renewables: Big Problem, Small Solution," in REW Guide to North American Renewable Energy Companies 2013, special supplement in *Renewable Energy World*, March–April 2013, pp. 18–24.

34 Weiss and Mauthner, op. cit. note 1. Egypt has a small market, with most systems installed on new buildings of the upper-middle class and hotels near the Red Sea, and the latest data show Egypt adding about 8,000 m^2/year, from Ahmed El Sherif, Egyptian Solar Energy Development Association (SEDA), cited in Eva Augsten, "Egypt: Solar Water Heaters to Help Cut Down Energy Subsidies," SolarThermalWorld.org, 11 October 2012; and 42,046 high-pressure SWH systems were installed in South Africa from June 2008 to 29 November 2012, with 13,548 systems installed in the first 11 months of 2012; South Africa also had about 200,000–300,000 low-pressure SWHs, based on number of claims processed by Deliotte for Eskom, provided by Mike Mulcahy, Green Cape, South Africa, personal communication with REN21, 27 March 2013.

35 Based on increase from 7,000 m^2 to 92,000 m^2, from Eva Augsten, "Egypt: Solar Water Heaters to Help Cut Down Energy Subsidies," SolarThermalWorld.org, 11 October 2012.

36 Israel, Jordan, and Lebanon rankings from Weiss and Mauthner, op. cit. note 1; 13% penetration and market drivers from Lebanese Center for Energy Conservation, Central Bank of Lebanon, and Ministry of Energy and Water, cited in Pierre El Khoury, "Solar Water Heaters in Lebanon: An Emerging $100 Million Market," RenewableEnergyWorld.com, 11 January 2013; Lebanese Republic, Ministry of Energy and Water, United Nations Development Programme, and Global Environment Facility, "The Residential Solar Water Heaters Market in Lebanon in 2011" (Beirut: September 2012).

37 Weiss and Mauthner, op. cit. note 1. Also among the top 10 were Turkey, Germany, Australia, China, and Jordan. Rankings were slightly different considering capacity for glazed and unglazed capacity combined: Cyprus remained in first place, followed by Austria, Israel, Barbados, and Greece. For unglazed systems, Australia ranked first for per capita capacity in 2011, followed by Austria, the United States, the Czech Republic, and Switzerland.

38 Ibid. Considering newly installed capacity for all water collectors (glazed and unglazed), Israel ranked first, followed by Australia, China, Austria, and Cyprus.

39 Ibid.; Uli Jakob, Solem Consulting/ Green Chiller, personal communication with REN21, April 2013. For example, combi-systems, which provide both domestic hot water and space heating, accounted for more than 40% of the market in Germany and Austria as of 2011, per Weiss and Mauthner, op. cit. note 1.

40 This is particularly true in Austria, Germany, and Switzerland, where policies and high electricity prices create favourable conditions, per "Solar + Heat Pump Systems," *Solar Update* (IEA Solar Heating and Cooling Programme), January 2013.

41 Market share from Weiss and Mauthner, op. cit. note 1, p. 3; established markets from Weiss and Mauthner, op. cit. note 31.

42 Other heat sources from Jan-Olof Dalenbäck and Sven Werner, CIT Energy Management AB, *Market for Solar District Heating*, supported by Intelligent Energy Europe (Gothenburg, Sweden: September 2011, revised July 2012); cost-competitive from Rachana Raizada, "Renewables and District Heating: Eastern Europe Keeps It Warm," RenewableEnergyWorld.com, 13 September 2013. In Denmark, solar district heat systems cost about USD 0.05/kWh (EUR 0.04/kWh) without subsidies as of 2010, and not much more in Austria, from Jan-Olof Dalenbäck, CIT Energy Management AB, *Success Factors in Solar District Heating*, prepared for Intelligent Energy Europe (Gothenburg, Sweden: December 2010); and started at USD 0.04/kWh (EUR 0.03/kWh) in Denmark in early 2013, from Andreas Häberle, PSE AG, Freiburg, personal communication with REN21, 25 April 2013.

43 Systems across Europe from Solar District Heating, *SDHtake-off—Solar District Heating in Europe, Global Dissemination Report*, edited by Solites, Steinbeis Research Institute for Solar and Sustainable Thermal Energy Systems, supported by Intelligent Energy Europe (Stuttgart, Germany: 2012), p. 2; France from Eva Augsten, "France: Solar District Heating with Energy Costs Around 0.06 EUR/kWh," SolarThermalWorld.org, 4 December 2012; Austrian Climate and Energy Fund, cited in Bärbel Epp, "Austria: More and Less Successful Subsidy Schemes," SolarThermalWorld.org, 18 January 2013; "Eibiswald District Heating Doubles its Roof-top Solar Thermal Plant to 2,450 m2," SDH Solar District Heating/Intelligent Energy Europe, Newsletter February 2013 (6 February 2013), at www.solar-district-heating.eu; Solid, "5 Million Square Meters of Solar Thermal Collectors in Austria Installed," SDH Solar District Heating/ Intelligent Energy Europe, Newsletter October 2012 (25 October 2012), at www.solar-district-heating.eu; Braedstrup Fjernvarme, "Braedstrup Solar Park in Denmark is Now a Reality," SDH Solar District Heating/ Intelligent Energy Europe, Newsletter October 2012 (25 October 2012), at www.solar-district-heating.eu; Eva Augsten, "Norway: Solar Collectors Support District Heating," SolarThermalWorld.org, 11 February 2013; Rachana Raizada, "Renewables and District Heating: Eastern Europe Keeps It Warm," RenewableEnergyWorld.com, 13 September 2013; 175 systems and 319 MW_{th} from Weiss and Mauthner, op. cit. note 1.

44 Planned and Denmark 75% from Solar District Heating, *SDHtake-off...*," op. cit. note 42, p. 2; Europe's 10 largest from Weiss and Mauthner, op. cit. note 1.

45 The University of Pretoria's 672 m^2 solar thermal system provides warm water for apartments for 550 students, from Stephanie Banse, "South Africa: University of Pretoria's 672 m^2 Solar Thermal System," SolarThermalWorld.com, 12 April 2012; China's "Utopia Garden" project in Dezhou covers 10 blocks of apartment buildings with 5.025 m^2 combined with seasonal storage beneath the complex, per Bärbel Epp, "China: Utopia Garden Sets New Standard for Architectural Integration," SolarThermalWorld.org, 10 April 2012; 97% of community's needs was over a one-year period, per Natural Resources Canada, "Canadian Solar Community Sets New World Record for Energy Efficiency and Innovation," press release (Okotoks, Alberta: 5 October 2012); first large seasonal storage from "Solar Community Tops World Record," in *Solar Update* (IEA Solar Heating and Cooling Programme), January 2013, p. 16; Government of Canada, "Drake Landing Solar Community," brochure, www.dlsc.ca/DLSC_Brochure_e.pdf, viewed 23 March 2013.

46 Europe accounted for about 80% of installed systems worldwide as of 2012. All based on data from Jakob, op. cit. note 39, and from Uli Jakob, "Status and Perspective of Solar Cooling Outside Australia," in Proceedings of the Australian Solar Cooling 2013 Conference, Sydney, 12 April 2013. Note that roughly 600 solar cooling systems were installed worldwide in 2010, per H.M. Henning, "Solar Air-conditioning and Refrigeration—Achievements and Challenges," Conference Proceedings of International Conference on Solar Heating, Cooling and Buildings—EuroSun 2010, Graz, Austria, 2010.

47 IEA, *Technology Roadmap, Solar Heating and Cooling* (Paris: OECD/IEA, 2012), p. 11. Several hundred small cooling kits were sold in these countries in 2011.

48 Daniel Rowe, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, personal communication with REN21, 29 April 2013.

49 Data from IEA, Solar Heating and Cooling Programme, cited in Stephanie Banse, "Solar Process Heat: Higher Yield than in Domestic Applications," SolarThermalWorld.org, 17 August 2012.

50 Tannery Heshan Bestway Leather, a German joint venture, uses solar thermal technology to produce heat for industrial processes and hot water for worker dormitories, per Jiuwei Wang, Deputy General Manager, Himin, cited in Epp, op. cit. note 13; Bärbel Epp, "USA: Contractor Runs 7,804 m² Collector System at Prestage Foods Factory," SolarThermalWorld.org, 19 April 2012; as of early 2012, Heineken planned to installed systems in Austria, Spain, and Portugal to provide heat at two breweries and a malting plant, expected to cover 18–24% of process heat demand, from Eva Augsten, "Europe: Heineken Brewery to Install Three Big Solar Plants," SolarThermalWorld.org, 18 April 2012.

51 An estimated 11,316 m² of large-scale projects were approved in Austria during 2012, with process heat representing the largest share of capacity (40%), followed by district heating (33%), and heating of commercial buildings (19%); also four solar cooling projects totaling 863 m², from Austrian Climate and Energy Fund, cited in Bärbel Epp, "Austria: More and Less Successful Subsidy Schemes," SolarThermalWorld.org, 18 January 2013; most Thai government commercial solar thermal subsidies are going to process heat applications in the industrial sector, followed by hotels, farms, and hospitals. The subsidy covers commercial solar thermal installations that are combined with waste heat from air conditioners or boilers, per Thailand Department of Alternative Energy Development and Efficiency, cited in Stephanie Banse, "Thailand: Government Continues Subsidy Programme in 2013," SolarThermalWorld.org, 15 February 2013.

52 Weiss and Mauthner, op. cit. note 1, p 3.

53 Stephanie Banse and Joachim Berner, "Lowering Costs, Maintaining Efficiency," *Sun & Wind Energy*, December 2012, pp. 62–65; Chris Laughton, "Great Britain: Insolvency of Collector Manufacturer After the PV Crash," SolarThermalWorld.org, 21 June 2012.

54 Bärbel Epp, "Solar Industry in Upheaval," *Sun & Wind Energy*, December 2012, pp. 28–39.

55 Ibid.

56 In Cyprus, for example, greatly in response to the decline in the new home market, the industry is shifting from a focus on systems for new construction to replacement of older systems, per Bärbel Epp, "Cyprus: System Replacements Increase Efficiency," SolarThermalWorld.org, 5 December 2012; in the U.K., companies are turning to repairs of existing systems, per Chris Laughton, "Great Britain: Insolvency of Collector Manufacturer after the PV Crash," SolarThermalWorld.org, 21 June 2012; close production capacity from Epp, op. cit. note 54, pp. 28–39, and from Bank Sarasin, op. cit. note 20; Bärbel Epp, "Germany: Schüco Closes Bielefeld Collector Factory," SolarThermalWorld.org, 17 December 2012; meet demand outside of Europe from Epp, op. cit. note 54; Joachim Berner, "Spanish Collector Manufacturers Expand Exports or Abandon Production," SolarThermalWorld.org, 5 July 2011; Eva Augsten, "Spain: Export Helps Solar Thermal Industry Survive," SolarThermalWorld.org, 12 January 2012; Bärbel Epp, "ISH 2011: Solar Trends in the Heating Industry," SolarThermalWorld.org, 31 March 2011. Production by many EU manufacturers declined in 2011 relative to 2010; for example, GreenOneTec production fell from 800,000 m² to 700,000 m², and Ritter Solar fell from 136,000 m² to 100,000 m², per EurObserv'ER, *Solar Thermal and Concentrated Solar Power Barometer* (Paris: May 2012), p. 66.

57 Epp, op. cit. note 54; Berner, op. cit. note 56; Augsten, op. cit. note 56; Schüco International KG (Germany) made the decision to close its Bielefeld factory in December 2013, with plans to shut it down at the end of March, per Bärbel Epp, "Germany: Schüco Closes Bielefeld Collector Factory," SolarThermalWorld.org, 17 December 2012.

58 Rapid consolidation from Bärbel Epp, "Solar Thermal Competition Heats Up in China," RenewableEnergyWorld.com, 10 September 2012; top 100 from Epp, "Solar Thermal Shake-Out...," op. cit. note 11, pp. 47–49; 1,000 companies from Yunbin Li, Linuo Paradigma, cited in Epp, "Solar Thermal Competition...," op. cit. this note.

59 Stephanie Banse and Joachim Berner, "Lowering Costs, Maintaining Efficiency," *Sun & Wind Energy*, December 2012, pp. 62–65.

60 Largest companies from Epp, "Solar Thermal Competition…," op. cit. note 58; vertical integration from Bärbel Epp, "China: Trends in the Largest Solar Thermal Market Worldwide," presentation for Intersolar Europe 2012, Munich, June 2012.

61 Epp, "Solar Thermal Shake-Out…," op. cit. note 11, pp. 47–49; Bärbel Epp, "China: Sunrain Group Goes Public," SolarThermalWorld.org, 29 May 2012.

62 Installed domestically and China's export business increased 12-fold between 2005 and 2011, per CSTIF/Chinese Renewable Energy Industries Association, cited in Bärbel Epp, "China: Industry Increased Export Business 12-fold," SolarThermalWorld.org, 2 February 2012; an increasing number of companies manufacturing both (with most of these companies in China and India), from Bärbel Epp, "India and China Are Setting the Pace," *Sun & Wind Energy*, December 2011, pp. 48–64.

63 Based on 2010 surface area production levels, from Epp, "India and China...," op. cit. note 62, pp. 48–64.

64 Ibid., pp. 48-64.

65 Epp, op. cit. note 54, pp. 28-39.

66 Michael Mulcahy, Green Cape, personal communication with REN21, April 2013.

67 Lebanese Center for Energy Conservation, Central Bank of Lebanon, and Ministry of Energy and Water, cited in Pierre El Khoury, "Solar Water Heaters in Lebanon: An Emerging $100 Million Market," RenewableEnergyWorld.com, 11 January 2013.

68 Bärbel Epp, Solrico, personal communication with REN21, 3 April 2012; Bärbel Epp, Solrico, "Cost Reduction – an Important Objective," in Bank Sarasin, op. cit. note 20; Bärbel Epp, "Can Europe Compete in the Global Solar Thermal Market?" RenewableEnergyWorld.com, 21 March 2011.

69 EurObserv'ER, op. cit. note 20, p. 67, 69.

70 Banse and Berner, op. cit. note 59, pp. 62–65.

71 Stephanie Banse, "Poised for Growth," *Sun & Wind Energy*, December 2012, pp. 30–35.

72 Stephanie Banse, "Hard-earned Upward Trend," *Sun & Wind Energy*, December 2012, pp. 40–41.

73 Rising interest from Eva Augsten, "Europe/Asia: Solar Cooling Gains Traction," SolarThermalWorld.org, 3 September 2012; new to sector from Uli Jakob, "Overview Market Development and Potential for Solar Cooling with Focus on the Mediterranean Area," in Proceedings of Fifth European Solar Energy Conference, Marseille, November 2011; Hitachi began offering solar cooling kits in 2011 and Mitsubishi sells new compact adsorption chillers, per Eva Augsten, "Europe/Asia: Solar Cooling Gains Traction," SolarThermalWorld.org, 3 September 2012. Sorption chillers above 35 kW capacity are manufactured primarily in Asia; new small and medium-scale systems were developed only within the past decade, and standardised solar cooling kits are produced by several companies in Europe as well as Asia. These include EAW (Germany), Climatewell (Sweden), AGP, Pink (Austria), Tranter Solarice (Germany), Yazaki (Japan), Thermax (India), and Jiansu Huineng (China), from Jakob, op. cit. this note.

74 Trouble competing and costs declined from Jakob, op. cit. note 46; potential for further cost reductions from Daniel Mugnier, TECSOL, "Quality assurance & support measures for solar cooling with IEA SHC task 48: overview and first results," in Proceedings of the Australian Solar Cooling Conference 2013, North Ryde, Sydney, Australia, 11–12 April 2013.

75 Mugnier, op. cit. note 74; standard in Australia from M. Goldsworthy, CSIRO, "AS5389 Solar Air-conditioning Australian Standard – Overview of development," in Proceedings of the Australian Solar Cooling Conference 2013, North Ryde, Sydney, Australia, 11–12 April 2013.

WIND POWER

1 A total of 44,799 MW was added in 2012, bringing the year-end total to 282,587 MW, according to Global Wind Energy Council (GWEC), *Global Wind Report – Annual Market Update 2012* (Brussels: April 2013); 44,951 MW added for total of 285,761 MW from Navigant's BTM Consult, *International Wind Energy Development: World Market Update 2012* (Copenhagen: March 2013); 44,712 MW added from C. Ender, "Wind Energy Use in Germany – Status 31.12.2012," *DEWI Magazine* (German Wind Energy Institute), February 2013, p. 31. Up 19% (18.7%) based on data for 2011 and 2012 from GWEC, op. cit. this note, and from Navigant's BTM Consult, op. cit. this note. Figure 18 based on GWEC, op. cit. this note, and on Navigant's BTM Consult, op. cit. this note.

2 Key markets with policy uncertainty included the United States, Europe (Spain, Italy, France, Portugal, the U.K.), Asia (India, Japan), and Australia.

3 Estimate of 86% based on GWEC, op. cit. note 1, and on Navigant's BTM Consult, op. cit. note 1.

4 Figures of 44, 64, and 24 countries from GWEC, op. cit. note 1; 24 also from Navigant's BTM Consult, op. cit. note 1. The 24 countries include 15 in Europe, four in the Americas, three in Asia, plus Australia and Turkey. Note that GWEC has 79 countries in its database, per GWEC, personal communication with REN21, April 2013, and that there are 100 countries or regions with wind power capacity, per World Wind Energy Association (WWEA), *World Wind Energy Report 2012* (Brussels: May 2013).

5 Estimate of 24.9% from Navigant's BTM Consult, op. cit. note 1; 24.7% from GWEC, op. cit. note 1.

6 GWEC, op. cit. note 1.

7 The United States added 13,131 MW, per American Wind Energy Association (AWEA), "AWEA U.S. Wind Industry Annual Market Report, Year Ending 2012" (Washington, DC: April 2013), Executive Summary. It was followed by China (12,960 MW), Germany (2,415 MW), India (2,336 MW), and the United Kingdom (1,897 MW), per GWEC, op. cit. note 1, and Navigant's BTM Consult, op. cit. note 1. Note that data from both sources agree for all countries except the U.K., which added 1,958 MW according to Navigant's BTM Consult.

8 Additions were Italy (1,273 MW), Spain (1,122 MW), Brazil (1,077 MW), Canada (935 MW), and Romania (923 MW), per GWEC, op. cit. note 1. Rankings are the same with only slight differences in added capacity, per Navigant's BTM Consult, op. cit. note 1. Mexico was in the top 10 according to WWEA, op. cit. note 4.

9 Share of the global market was 26.6% and share of total global capacity was 37.5%, based on data from GWEC, op. cit. note 1; share of global market was 28.5% and share of the global total was 38.5%, based on data from Navigant's BTM Consult, op. cit. note 1.

10 AWEA, op. cit. note 7. Figure 19 based on various sources throughout this section.

11 The United States added 13,131 MW in 2012, according to AWEA, op. cit. note 7; 6.8 MW were added in 2011, per AWEA, "Annual industry report preview: supply chain, penetration grow," *Wind Energy Weekly,* 30 March 2012.

12 Vince Font, "AWEA Reports 2012 the Strongest Year on Record for U.S. Wind Energy, Continues Success Uncertainty," RenewableEnergyWorld.com, 23 October 2012.

13 Wind accounted for more than 45% of U.S. electric capacity additions in 2012 (based on 12,799 MW of wind capacity added), per U.S. Energy Information Administration (EIA), "Wind Industry Brings Almost 5,400 MW of Capacity Online in December 2012," www.eia.gov/electricity/monthly/update/?scr=email, viewed 25 April 2013. Wind was nearly 41% and natural gas accounted for 33% of U.S. capacity additions in 2012, based on data from U.S. Federal Energy Regulatory Commission, Office of Energy Projects, "*Energy Infrastructure Update for December 2012*" (Washington, DC: 2013). Wind accounted for 42% (based on preliminary 13,124 MW added), according to AWEA, "4Q report: Wind energy top source for new generation in 2012; American wind power installed new record of 13,124 MW," *Wind Energy Weekly,* 1 February 2013. The United States ended 2012 with 60,007 MW, per AWEA, op. cit. note 7.

14 Texas added 1,826 MW, followed by California (1,656 MW), Kansas (1,440 MW), Oklahoma (1,127 MW), and Illinois (823 MW), per AWEA, "4Q report..," op. cit. note 13; more than 12 GW in Texas and 15 states from AWEA, op. cit. note 7.

15 China added an estimated 12,960 MW of capacity in 2012, from Chinese Wind Energy Association (CWEA), with data provided by Shi Pengfei, personal communication with REN21, 14 March 2013; from GWEC, op. cit. note 1; and from Navigant's BTM Consult, op. cit. note 1. Note that 15,780 MW of capacity was brought into operation (including capacity previously installed), per China Electricity Council, with data provided by Pengfei, op. cit this note. Share of world market was about 27% in 2012, down from 43% in 2011 and 49.5% in 2010, per GWEC, op. cit. note 1. Decline relative to 2009–2011 based on data from GWEC, op. cit. note 1.

16 Shruti Shukla, GWEC, personal communication with REN21, 13 February 2013; Zoë Casey, "The Wind Energy Dragon Gathers Speed," *Wind Directions*, June 2012, pp. 32, 34.

17 CWEA, op. cit. note 15.

18 Figure of 75,324 MW installed by year-end from GWEC, op. cit. note 1, and from CWEA, op. cit. note 15. About 14.5 GW of installed capacity was not yet officially operating at year's end, based on data from CWEA and from China Electricity Council, provided by Pengfei, op. cit. note 15; most of the capacity added in 2012 was feeding the grid, per Steve Sawyer, GWEC, personal communication with REN21, 2 April 2013. Note that the process of finalising the test phase and getting a commercial contract with the system operator takes time, accounting for delays in reporting. The difference is explained by the fact 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). Liming Qiao, GWEC, personal communication with REN21, 26 April 2013.

19 Figures of 100.4% and 37%, and exceeding nuclear from China Electricity Council, provided by Pengfei, op. cit. note 15.

20 CWEA, op. cit. note 15; 14 with more than 1 GW from GWEC, op. cit. note 1.

21 The EU added 11,895 MW for a total of 106,041 MW, from European Wind Energy Association (EWEA), *Wind in Power: 2012 European Statistics* (Brussels: February 2013); new record from GWEC, "Release of Global Wind Statistics: China, US vie for market leader position at just over 13 GW of new capacity each" (Brussels: 11 February 2013). All of Europe added 12,744 MW for a total of 109,581 MW, from EWEA, op. cit. this note. Accounting for closings and repowering, the EU's net capacity increase was lower, per idem.

22 EWEA, op. cit. note 21. Wind's share of capacity added was up from 21.4% in 2011, and its share of total electric generating capacity in 2012 was up from 2.2% in 2000 and 10.4% in 2011.

23 NREAP targets for end-2012 totaled 107.6 GW, from EWEA, op. cit. note 21, and from Shruti Shukla, GWEC, personal communication with REN21, 13 February 2013. Market in 2012 does not reflect growing uncertainty because most capacity was previously permitted and financed, per EWEA, op. cit. note 21.

24 Some emerging markets are spurred by rapid increases in electricity demand, a desire for independence from Russian gas, good wind resources, and new support policies, from Tildy Bayar, "Can Emerging Wind Markets Compensate for Stagnating European Growth?" RenewableEnergyWorld.com, 25 January 2013, and from EWEA, "Eastern Winds: Emerging European Wind Power Markets" (Brussels: February 2013); challenges from Steve Sawyer, GWEC, personal communication with REN21, 4 September 2012.

25 Germany installed 2,415 MW in 2012, EWEA, op. cit. note 21; year-end total of 31,315 MW (31,035 MW onshore plus 280 MW offshore) and highest additions since 2002 or 2003 based on data from German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources 2012," data from Working Group on Renewable Energy-Statistics (AGEE-Stat), provisional data (Berlin: 28 February 2013), p. 18. Much of the capacity added was for repowering: 1,433 MW of new turbines replaced 626 MW of old ones, per "German wind sector strong again in 2012," RenewablesInternational.net, 1 February 2012.

26 The United Kingdom added 1,897 MW (854 MW offshore) for a total of 8,445 MW, from EWEA, op. cit. note 21, and from GWEC, op. cit. note 1. It added 1,958 MW for a total of 9,113 MW, according to Navigant's BTM Consult, op. cit. note 1.

27 Italy added 1,273 MW for a total of 8,144 MW; Spain added 1,122 MW for a total of 22,796 MW; Romania added 923 MW for a total

of 1,905 MW; and Poland added 880 MW for a total of 2,497 MW, all from EWEA, op. cit. note 21. Italy added 1,272 MW for a total of 7,998 MW, and Spain added 1,112 MW for a total of 22,462 MW, from Navigant's BTM Consult, op. cit. note 1.

28 EWEA, op. cit. note 21.

29 India added an estimated 2,336 MW in 2012 for a year-end total of 18,421 MW, from GWEC, op. cit. note 1. This compares with about 3 GW installed during 2011, from GWEC, *Global Wind Report: Annual Market Update 2011* (Brussels: March 2012).

30 Steve Sawyer, GWEC, personal communication with REN21, 5 December 2012; Natalie Obiko Pearson, "India Wind Investment May Stall on Tax-Break cut, Industry Says," Bloomberg News, 2 April 2012, at www.businessweek.com.

31 Asia (almost entirely China and India) added 15,510 MW in 2012, and North America (not including Mexico) added 14,059 MW, per GWEC, op. cit. note 1. Europe (not including Russia or Turkey) added 12,238 MW (EU-27 added 11,895 MW), per EWEA, op. cit. note 21. Note that Europe lost its position as top regional installer in 2012, per Navigant's BTM Consult, op. cit. note 1.

32 Brazil added an estimated 1,077 MW in 2012 for a total of 2,508 MW and 4 million, from GWEC, op. cit. note 1, and from Associacão Brasileira de Energia Eólica, Boletim Mensal de Dados do Setor Eólico – Publico," January 2013, p. 2, at www.abeeolica.org.br. The strong market in Brazil has attracted European developers as subsidies decline at home, per Vittorio Perona, Grup BTG Pactual SA, cited in Stephan Nielsen, "Cheapest wind energy spurring renewables deals in Brazil," RenewableEnergyWorld.com, 29 January 2013.

33 Wind increasing faster than grid from Steve Sawyer, GWEC, personal communication with REN21, 4 September 2012.

34 Mexico added 801 MW for a total of 1,370 MW, from GWEC, op. cit. note 1; largest project from Lindsay Morris and Jennifer Runyon, "Wind in 2012: booming in North America; tops 100 GW in Europe," RenewableEnergyWorld.com, 21 December 2012. Mexico added 0.4 GW for a total of 1.5 GW, per Navigant's BTM Consult, op. cit. note 1. The difference between GWEC and Navigant data is probably a matter of accounting (in which year capacity is counted).

35 GWEC, op. cit. note 1, p. 15.

36 Canada added 935 MW for total of 6,200 MW, from GWEC, op. cit. note 1; provinces from Richard Baillie, "Is it crunch time for Canada's wind sector?" RenewableEnergyWorld.com, 27 December 2012. Canada added more capacity during 2011 than 2012, per GWEC, op. cit. note 1.

37 Tunisia (added 50 MW for a total of 104 MW) and Ethiopia from GWEC, op. cit. note 1; South Africa from GWEC, "Release of Global Wind Statistics: China, US vie for market leader position at just over 13 GW of new capacity each" (Brussels: 11 February 2013).

38 Turkey added 506 MW for a total of 2,312 MW, per EWEA, op. cit. note 21; Australia added 358 MW for a total of 2,584 MW, per GWEC, op. cit. note 1.

39 The 13 countries include 10 in Europe plus China, Japan, and South Korea, with 1,296 MW added worldwide for a total 5,415 MW in operation at the end of 2012, per GWEC, op. cit. note 1, p. 40. Ten countries had offshore capacity with a total of 5.1 GW, per Navigant's BTM Consult, op. cit. note 1.

40 Europe added 1,166 MW of offshore capacity for a year-end total of 4,995 MW; 10 countries include Belgium with a total of 379.5 MW, Denmark (921 MW); Finland (26.3 MW), Germany (280.3 MW), Ireland (25.2 MW), the Netherlands (246.8 MW), Norway (2.3 MW), Portugal (2 MW), Sweden (163.7 MW), the United Kingdom (2,947.9 MW), and a European total (4,995 MW), per GWEC, op. cit. note 1, p. 40. The global offshore market added 1,131 MW in 2012, with 66% of this in the U.K., according to Navigant's BTM Consult, op. cit. note 1.

41 The United Kingdom's share of additions based on 854 MW added in the U.K. and a total of 1,166 MW added in Europe, followed by Belgium (185 MW added), Germany (80 MW), and Denmark (46.8 MW), all from GWEC, op. cit. note 1, p. 40; "London Array: All the Latest News and Developments," January 2013, at www.londonarray.com/wp-content/uploads/LONDON-ARRAY-NEWS-JAN-2013-Email-version.pdf; Sally Bakewell, "Largest Offshore Wind Farm Generates First Power in U.K.," Bloomberg, 29 October 2012, at www.renewableenergyworld.com.

42 All from GWEC, op. cit. note 1, p. 40; China also from CWEA, with data provided by Liming Qiao, GWEC, personal communication with REN21, 26 April 2013. Note that China added 127 MW (7 projects) of intertidal and near-short capacity in 2012, per CWEA. China added three projects with a combined total of 110 MW, per Navigant's BTM Consult, op. cit. note 1. Note that offshore capacity was added in the United Kingdom (756 MW), Belgium (184.5 MW), China (110 MW), and Germany (80 MW) only, per Navigant's BTM Consult, , op. cit. note 1. Totals differ between GWEC and Navigant for China, for which Navigant has 329 MW total in operation, Denmark (833 MW), the U.K. (2,861 MW), and includes the Republic of Ireland (25 MW).

43 Cost considerations include cost of infrastructure such as sub-stations or grid connection points as well as licencing and permitting costs.

44 Fantanele-Cogealac wind farm in Romania, per Morris and Runyon, op. cit. note 34; "Caithness Shepherds Flat Commences Official Operations; Becomes One of the World's Largest Wind Farms," PRNewswire.com, 22 September 2012.

45 Clients from Sarasin, "Working Towards a Cleaner and Smarter Power Supply: Prospects for Renewables in the Energy Revolution" (Basel, Switzerland: December 2012); Australia et al. from Stefan Gsänger, WWEA, Bonn, personal communication with REN21, 29 February 2012; Europe also from Richard Cowell, "Community Wind in Europe – Strength in Diversity?" *WWEA Quarterly Bulletin*, December 2012, pp. 10–15, and from Tildy Bayar, "Community Wind Arrives Stateside," RenewableEnergyWorld.com, 5 July 2012.

46 Iowa projects (1.6–3.2 MW in size) from AWEA, "American wind power reaches 50-gigawatt milestone: 2012 sets red-hot pace, but layoffs hit supply chain amid policy uncertainty for 2013," *Wind Energy Weekly,* 10 August 2012; Australia from Taryn Lane (Hepburn Wind & Embark), "Community Wind: The Australian Context," *WWEA Quarterly Bulletin*, September 2012, pp. 22–25.

47 Shota Furuya, Institute for Sustainable Energy Policies, "Energy Policy Reform and Community Power in Japan," *WWEA Quarterly Bulletin*, September 2012, pp. 26–29.

48 Stefan Gsänger, WWEA, Bonn, personal communication with REN21, 1 April 2013.

49 Drivers from Andrew Kruse, Southwest Windpower Inc., personal communication with REN21, 21 May 2011; from Andrew Kruse, Endurance Wind Power Inc., Surrey, Canada, personal communication with REN21, 21 April 2013; and from WWEA, *Small World Wind Power Report 2013* (Bonn: March 2013), Summary. Feed-in tariffs in the United Kingdom, Italy, Canada, and the United States are driving the distributed-scale market. The most common is the 50 kW class, which is often used by rural farmers to both offset energy production and for investing, per Kruse, Endurance Wind Power Inc., op. cit this note.

50 Off-grid and mini-grid from WWEA, op. cit. note 49, and from Simon Rolland, "Campaigning for Small Wind—Facilitating Off-Grid Uptake," *Renewable Energy World*, March-April 2013, pp. 47–49.

51 Pike Research, "Small Wind Power," www.pikeresearch.com/research/small-wind-power, viewed March 2013; WWEA, op. cit. note 49.

52 Kruse, Endurance Wind Power Inc., op. cit. note 49.

53 Ibid.

54 Note that the total excludes data for Italy and India, both of which are important markets, per WWEA, op. cit. note 49.

55 WWEA, op. cit. note 49; WWEA, "WWEA Releases the 2013 Small Wind World Report Update," press release (Husum/Bonn: 21 March 2013).

56 AWEA, op. cit. note 7.

57 WWEA, op. cit. note 49.

58 More than 2.6% is a 2013 forecast based on 2012 installed capacity, per Navigant's BTM Consult, op. cit. note 1; more than 3% from Gsänger, op. cit. note 48.

59 EWEA, op. cit. note 21.

60 Unless otherwise noted, 2012 data from EWEA, op. cit. note 21; Denmark 2012 data from GWEC, op. cit. note 1, p. 34; Portugal 2012 and 2011 data from APREN - Portuguese Renewable Energy Association and from Redes Energéticas Nacionais (REN), "Dados Técnicos Electricidade 2012," at www.centrodeinformacao.ren.pt/PT/InformacaoTecnica/Paginas/DadosTecnicos.aspx; Germany from BMU, op. cit. note 25; 2011 data for Denmark, Spain, and Ireland from EWEA, op. cit. note 21. Spain covered an average of 17.2% of its production with wind, and Denmark covered 29.5%, per MERCOM, Market Intelligence Report, "Wind Energy," 5

February 2013. The output in Spain over a 100-day period from November to early February averaged 26% of total electricity, enough to cover all households in Spain, per Spanish Wind Energy Association, cited in National Public Radio, Morning Edition, "Spain's Wind Farms Break Energy Record," 8 February 2013, at www.npr.org.

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63 Bloomberg New Energy Finance (BNEF), "Wind turbines prices fall to their lowest in recent years," press release (London and New York: 7 February 2011); materials included steel and cement, per IRENA, *Renewable Power Generation Costs in 2012: An Overview* (Abu Dhabi: January 2013), p. 31; 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* (Petten, The Netherlands: Institute for Energy and Transport, JRC, European Union, 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 (NREL), February 2012).

64 David Appleyard," Supply Chain Quality Play – Industry Switches to Oversupply," *Renewable Energy World*, Wind Technology Supplement, March-April 2012, pp. 5–7; "Vestas Sells Factory to Titan Wind Energy," *Reuters*, 13 June 2012; GWEC, op. cit. note 1.

65 Estimate of 20–25% in western markets and more than 35% in China (compared with 2008 peak prices) from BTM Consult—A Part of Navigant, "Preliminary Data Indicates Change in Global Wind Turbine OEM Market Leader," press release (Chicago, IL: 11 February 2013); average global decline of 25% from Eduardo Tabbush, BNEF, cited in Stephan Nielsen, "Uruguay Boosts Wind-power Estimate to 1,000 Megawatts by 2015," Bloomberg, 21 June 2012, at www.renewableenergyworld.com. Preliminary data suggest that quotes in the United States fell about 25% relative to peak prices, per IRENA, op. cit. note 63, p. 31. Over the two years leading up to late 2012, the price of onshore wind turbines fell by 10–15%, per Sarasin, op. cit. note 45. Data from CWEA suggest that turbine prices in China stabilised in 2011, per Michael Taylor, IRENA, personal communication with REN21, April 2013, with reference to IRENA, op. cit. note 63, p. 31.

66 Data analyzed by BNEF and from a survey of 38 developers and service providers in more than 24 markets showed that operations and maintenance contracts for onshore wind farms fell from EUR 30,900/MW in 2008 to EUR 19,200/MW in 2012, per Louise Downing, "Wind Farm Operating Costs Fall 38% in Four Years, BNEF Says," Bloomberg, 1 November 2012, at www.renewableenergyworld.com.

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71 Navigant's BTM Consult, op. cit. note 1. Make Consulting's ranking of the final four (all Chinese) in the same, per Morales, op. cit. note 69. Figure 20 based on Navigant's BTM Consult, op. cit. note 1.

72 Figure of 550 from AWEA, op. cit. note 7; the share was up from 35% in 2005–2006, and from 60% in 2010 to 67% in 2011, per Ryan Wiser et al., *2011 Wind Technologies Market Report*, prepared for NREL (Golden, CO: August 2012), p. v. According to data from the U.S. International Trade Commission and analysis from the U.S. Department of Energy, the domestic content of wind turbines was less than 25% prior to 2005 and approximately 67% at the end of 2011, cited in AWEA, op. cit. note 7; transport costs from AWEA, cited in "U.S. Wind Manufacturing," *Renewable Energy World*, November-December 2012, p. 61.

73 GWEC, op. cit. note 29. The United Kingdom, for example, added significant manufacturing capacity for on- and offshore wind in 2012, per GWEC, op. cit. note 1, p. 64.

74 Brazil from Morris and Runyon, op. cit. note 34; India from GWEC, op. cit. note 1, p. 44. Another source puts India's total at 24, nearly double the number in 2010, from Indian Wind Turbine Manufacturers Association (IWTMA) data, cited in Natalie Obiko Pearson, "GE Wind Indian Wind Share as Suzlon, Vestas Suffer Market Shift," Bloomberg, 12 November 2012, at www.renewableenergyworld.com.

75 Rising costs, overcapacity, and reduced support from "Vestas Sells Factory to Titan Wind energy," op. cit. note 64. For example, Siemens delayed a turbine factory in Hull, U.K., and eliminated a number of jobs, from Ben Warren and Klair White, Ernst and Young, "Renewable Energy Review: United Kingdom," RenewableEnergyWorld.com, 1 January 2013, and from Richard Weiss, "Siemens to Cut 615 US Wind Energy Jobs as New Orders Dry Up," Bloomberg, 19 September 2012, at www.renewableenergyworld.com; turbine maker Fuhrländer filed for bankruptcy, per BNEF, "Europe Skirmishes With America on Airline Emissions, and With China on Solar," *Energy: Week in Review*, 18–24 September 2012.

76 Carl Levesque, "U.S. wind energy layoffs continue in Colorado, Iowa as federal policy uncertainty continues" in AWEA, *Wind Energy Weekly,* August 24, 2012; also, BP announced in early 2013 its intention to exit the U.S. wind industry, following its exit from solar a year earlier, per James Montgomery, "BP Selling US Wind Unit, Pares Renewable Energy Interests to Fuels," RenewableEnergyWorld.com, 3 April 2013.

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78 "Sinovel to Put 351 Workers on Leave Amid Slump in Turbine Sales," Bloomberg.com, 15 November 2012; edge of collapse from Appleyard, op. cit. note 64, pp. 5–7; overcapacity and smaller manufacturers from GWEC, op. cit. note 1.

79 BNEF, op. cit. note 75; Natalie Obiko Pearson and Anurag Joshi, "Wind Turbine Manufacturer Suzlon to Default on Bond Debt," Bloomberg, 11 October 2012, at www.renewableenergyworld.com.

80 Navigant's BTM Consult, "Preliminary Data Indicates Change in

Global Wind Turbine OEM Market Leader," press release (Chicago, IL: 11 February 2013). For example, Suzlon (India) plans to build in Brazil and South Africa, per BNEF, "Star shines bright for China as Europe's subsidies fade," *Energy: Week in Review*, 9–16 July 2012.

81 Package deals from Stephan Nielsen, "China Grabs Share in Latin America Wind with Cheap Loans," Bloomberg.com, 20 November 2012; subsidiaries and partnerships from Elisa Wood, "China Focuses on Overseas Wind Partnerships," RenewableEnergyWorld.com, 2 October 2012.

82 Navigant's BTM Consult, op. cit. note 80.

83 Longer blades and lower wind speeds from David Appleyard, "Turbine Tech Turn Up: Machines for an Evolving Market," RenewableEnergyWorld.com, 19 June 2012. Concrete is cheaper than steel and can be manufactured locally; Enercon has manufactured its own concrete rings for several years, and JUWI and Acconia Windpower are starting to opt for concrete, using it in Spain, Latin America, and United States. Concrete has the potential to reduce tower costs by 30–40%, from Crispin Aubrey, "Towers: Concrete Challenges Steel," *Wind Directions*, September 2012, pp. 48–50, and from AWEA, op. cit. note 13; carbon fibre for blades from David Appleyard and Dan Shreve, "Wind Turbine Blades," *Renewable Energy World*, March-April 2012, p. 8.

84 Gamesa, "Gamesa launches a new turbine, the G114-2.0 MW: maximum returns for low-wind sites," press release (Vizcaya, Spain: 12 April 2012); Suzlon 2.1 MW S111 low-wind turbine from David Appleyard, "New Turbine Technology: Key Players On- and Offshore," RenewableEnergyWorld.com, 11 April 2013; GE, "GE Developing Wind Blades That Could Be the "Fabric" of Our Clean Energy Future," press release (Niskayuna, NY: 28 November 2012). Turbines for low-wind sites have enabled capacity factors to be maintained, or even raised, even as less-ideal wind resource sites are developed.

85 Automated from James Lawson, "Blade Materials," *Renewable Energy World*, Wind Technology Supplement, May-June 2012, pp. 5–6; shift back from Navigant's BTM Consult, op. cit. note 80.

86 Average size delivered to market (based on measured rated capacity) was 1,847 kW in 2012, up an average 170 kW over 2011, from Navigant's BTM Consult, op. cit. note 1.

87 Germany from MERCOM, op. cit. note 60; Denmark (3,080 kW), United States (1,930 kW), China (1,646 kW), and India (1,229 kW) from Navigant's BTM Consult, op. cit. note 1.

88 Offshore Europe's increase based on 3.5 MW average size turbine connected to the grid during 2011 from EWEA, *The European Offshore Wind Industry: Key 2011 Trends and Statistics* (Brussels: January 2012), p. 15; and on 4 MW average in 2012 from EWEA, *The European Offshore Wind Industry – Key Trends and Statistics 2012* (Brussels: January 2013), p. 3; 31 countries from EWEA, idem, p. 4.

89 Most manufacturers and 7.5 GW from JRC Scientific and Technical Reports, op. cit. note 63. Note that 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, GWEC, technology contribution to REN21, March 2012; Enercon from "E-126 / 7.5 MW," www.enercon.de/en-en/66.htm; Stefan Gsänger, WWEA, personal communication with REN21, May 2012. Even larger turbines based on Siemens testing a 6 MW machine and considering developing a 10 MW turbine, from Stefan Nicola and Gelu Sulugiuc, "Vestas and Mitsubishi Planning to Build Biggest Offshore Wind Turbine," Bloomberg, 27 November 2012, at www.renewableenergyworld.com; Vestas announced plans to develop an 8 MW machine with Mitsubishi Heavy Industries and DONG Energy for offshore use, from idem, and from Vestas, "DONG Energy advances its involvement in Vestas' prototype testing of the V164-8.0 MW turbine in Østerild" (Aarhus: 11 December 2011).

90 "REpower Commissions its Tallest Wind Turbine," *Renewable Energy Focus*, July/August 2012, p. 10; also getting higher from AWEA, cited in David Shaffer, "Wind Farm Towers Rise to New Heights, With More Power," IndependentMail.com, 12 September 2012; "Siemens Unveils 'World's Longest' Wind Turbine Blade," RenewableEnergyFocus.com, 14 June 2012.

91 In Europe, average water depth for new wind farms was slightly lower than in 2011, but these trends continue in general, from EWEA, op. cit. note 88.

92 Yoshinori Ueda, Japan Wind Energy Association and Japan Wind Power Association, personal communication with REN21, 14 February 2013. The United States and United Kingdom announced plans in 2012 to develop floating offshore turbines, per "Wind Updates – UK-US Boost Floating Tech," *Renewable Energy World*, Wind Technology Supplement, May-June 2012, p. 20.

93 EWEA, op. cit. note 88, p. 3.

94 Frank Wright, "Offshore Potential – Five Years to Grow Offshore Wind," *Renewable Energy World*, September-October 2012, pp. 85–88. Korea's largest ship builders—including Daewoo Shipbuilding and Marine Engineering, Hyundai Heavy Industries, Samsung Heavy Industries, and STX shipbuilding—are moving onto wind power, building five installation vessels for offshore wind facilities, per Korea Wind Energy Industry Association, cited in "Korea Shifts to a Wind Energy Powerhouse," 27 June 2012, at www.evwind.es/2012/06/27/korea-shifts-to-a-wind-energy-powerhouse/19402/.

95 Pike Research, op. cit. note 51. By the end of 2011, more than 330 manufacturers around the world offered commercial systems and more than 300 companies supplied parts and services, per WWEA, op. cit. note 49.

96 WWEA, op. cit. note 49.

97 Natalie Obiko Pearson, "RRB Energy Targets African Market with Smaller Wind Turbines," Bloomberg, 24 July 2012, at www.renewableenergyworld.com.

98 Bayar, op. cit. note 45.

99 **TABLE 2** based on the following:
POWER SECTOR
Bio-power: Bioenergy levelised costs of energy for power generation vary widely with costs of biomass feedstock (typically USD 0.50–9/GJ), complexity of technologies, plant capacity factor, size of plant, co-production of useful heat (CHP), regional differences for labour costs, life of plant (typically 30 years), discount rate (typically 7%), etc. In some non-OECD countries, lack of air emission regulations for boilers means capital costs are lower due to lack of control equipment. So before developing a new bioenergy plant, individual cost analysis is essential. Details of cost analyses can be found at: IRENA, *Renewable Power Generation Costs in 2012 – An Overview* (Abu Dhabi: 2013); Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2012* (Frankfurt: 2012); Intergovernmental Panel on Climate Change (IPCC), *Special Report on Renewable Energy Resources and Climate Change Mitigation* (Cambridge, U.K. and New York: 2011); Joint Research Centre of the European Commission (JRC), *2011 Technology Roadmap of the European Strategic Energy Technology Plan* (Petten, The Netherlands: 2011).
Geothermal power: Capacity factor and per kWh costs from IPCC, op. cit. this note, pp. 425–26 and 1004–06. Cost ranges are for greenfield projects, at a capacity factor of 74.5%, a 27.5-year economic design lifetime, assuming 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 USD 2012 dollars.) IRENA estimates the LCOE of a typical project to be USD 0.09–0.14/kWh, per IRENA, op. cit. this note, p. 17. In 2010, the International Energy Agency (IEA) estimated the LCOE of a binary plant to be USD 0.08–0.11/kWh, per IEA Energy Technology Systems Analysis Programme, *Geothermal Heat and Power*, Technology Brief E07 (Paris: May 2010), Table 5.
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 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 USD 0.021–0.129/kWh assuming a 7% discount rate. IRENA notes a LCOE range of USD 0.012–0.19/kWh for projects larger than 1 MW, with 80% of evaluated projects in the range of USD 0.018–0.085/kWh, and a median of USD 0.05/kWh, from IRENA, op. cit. this note, p. 46. Investment costs for hydropower projects

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99 Table 2 (continued)
can be as low as USD 400–500/kW, but most realistic projects today are in the range of USD 1,000–3,000 per kW, per IPCC, op. cit. this note, p. 1006. 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 project. Normally, small-scale hydro projects last 20–50 years compared to large-scale hydro plants, which may last 30–80 years. Hydro facilities that are designed to be load-following (rather than baseload) have lower capacity factors and therefore higher generation costs per kWh, on average.
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. Electricity generation costs are in the range of USD 0.31–0.39/kWh (EUR 0.24–0.30/kWh), from Sarasin, *Working Towards a Cleaner and Smarter Power Supply: Prospects for Renewables in the Energy Revolution* (Basel, Switzerland: December 2012), p. 11.
Solar PV: *Rooftop solar systems:* peak capacities are based on Europe and drawn from European Photovoltaic Industry Association (EPIA), *Market Report 2011* (Brussels: January 2012), and from EPIA, personal communication with REN21, 3 April 2012. Capacity factor from IRENA, op. cit. this note, p. 56. Note that values outside of this range are possible for exceptional sites (higher) or where siting is suboptimal (lower); adding tracking systems can raise these capacity factors significantly, from IRENA, idem. Capital costs based on: average of EUR 1,750/kW (using exchange rate of EUR 1 = USD 1.3) for residential systems up to 10 kWp, in fourth quarter of 2012, from German Solar Industry Association (BSW-Solar), "Statistic Data on the German Solar Power (Photovoltaic) Industry," February 2013, at www.solarwirtschaft.de; U.S. range of 4,300–5,000 by end of 2012, with low end being average cost for non-residential systems (USD 5.04/W) and high end being average cost for residential systems (USD 4.27/W), from U.S. Solar Energy Industries Association (SEIA) and GTM Research, "U.S. Solar Market Grows 76% in 2012; Now an Increasingly Competitive Energy Source for Millions of Americans Today," press release (Washington, DC and Boston, MA: 14 March 2013); Japan based on average of about 437,000 JPY/kW for systems of 10–50 kW, and about 375,000 JPY/kW (converted using JPY 1 = USD 0.099) for systems of 50–500 kW, from Japanese Ministry of Economy, Trade and Industry (METI), "Procurement Prices Calculation Committee," www.meti.go.jp/committee/gizi_0000015.html (in Japanese); typical global range for industrial systems based on EUR 1,150–2,000/kW (converted using EUR 1 = USD 1.3), from Gaëtan Masson, EPIA and IEA Photovoltaic Power Systems Programme (IEA-PVPS), personal communication with REN21, April 2013. Note that costs were down significantly from the second quarter of 2012, when capital costs in Germany for fixed-tilt rooftop systems averaged USD 2,200/kW, and in the United States average prices for residential systems were USD 5,500/kW, with a range of USD 4,000–8,000, per IRENA, op. cit. this note, pp. 7, 54, 55. Note that the IEA puts capital costs for small-scale systems in the range of USD 2,400–6,000/kW, per IEA, *Tracking Clean Energy Progress 2013* (Paris: OECD/IEA, 2013), p. 30. LCOE costs for OECD and non-OECD are 2012 USD, from lowest to highest, and based on 7% cost of capital, from IRENA, op. cit. this note, from IRENA Renewable Cost Database, 2013, and from Michael Taylor, IRENA, personal communication with REN21, May 2013; Europe based on costs in the range of EUR 0.12–0.29/kWh (converted using EUR 1 = USD 1.3) for residential, commercial, and industrial projects in the south and north of France, Germany, Italy, Spain, and the United Kingdom, from EPIA database, provided by Masson, op. cit. this note. *Ground-mounted utility-scale systems*: peak capacity from EPIA, *Market Report 2011*, op. cit. this note, from David Renne, International Solar Energy Society (ISES), personal communication with REN21, April 2013, and from Denis Lenardic, pvresources.com, personal communication with REN21, April 2013; also see relevant section and endnotes in Market and Industry Trends by Technology. Conversion efficiency low of 10% is for amorphous silicon and high of 30% is for concentrating PV, from Gaetan Masson, EPIA and IEA-PVPS, personal communication with REN21, 21 March 2013. Note that conversion efficiency for ground-mounted utility-scale was noted as 15–27% in EPIA, *Market Report 2011*, op. cit. this note. Capital costs based on the following: typical global costs based on 1,000–1,500 Euros/kW (converted using EUR 1 = USD 1.3) from Masson, April 2013, op. cit. this note; USD 2,270/kW was the weighted average in the United States at the end of 2012, from SEIA and GTM Research, op. cit. this note; Japan based on average capital cost of 280,000 JPY/kW (converted using JPY 1 = USD 0.099) for systems over 1 MW, from Japanese METI, op. cit. this note; and China (USD 2,200/kW) and India (USD 1,700/kW) from IRENA, op. cit. this note, pp. 54–55. Note that the U.S. range in the second quarter of 2012 was USD 2,000–3,600, with a capacity weighted average of USD 2,900/kW, from IRENA, op. cit. this note. Also note that the IEA puts capital costs for large-scale systems in the range of USD 1,300–3,500/kW, from IEA, *Tracking Clean Energy…*, op. cit. this note, p. 30. LCOE based on the following: OECD and non-OECD cost ranges are 2012 USD, with 7% discount rate, from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, from IRENA Renewable Cost Database, 2013, and from Michael Taylor, IRENA, personal communication with REN21, May 2013; Europe based on LCOE in the range of EUR 0.11–0.26/kWh (using exchange rate of EUR 1 = USD 1.3) for ground-mounted systems in the south and north of France, Germany, Italy, Spain, and the United Kingdom, from EPIA database, provided by Masson, op. cit. this note. Note that the LCOE in Thailand is estimated to be in the range of USD 0.15–0.18/kWh, based on input from project developers and former Thai Minister of Energy Piyasvasti Amranand, per Chris Greacen, Palang Thai, personal communication with REN21, April 2013. While PV module prices are global, balance of system costs are much more local. Also, note that prices have been changing rapidly.
CSP: Characteristics including plant sizes from European Solar Thermal Electricity Association (ESTELA), personal communication with REN21, 22 March 2012 and 24 January 2013; from Protermosolar, the Spanish Solar Thermal Electricity Industry Association, April 2012; and based on parabolic trough plants that 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). Note that multiple systems can be combined for higher-capacity plants. Capacity factors based on ESTELA, op. cit. this note, and on Michael Mendelsohn, Travis Lowder, and Brendan Canavan, *Utility-Scale Concentrating Solar Power and Photovoltaics Projects: A Technology and Market Overview* (Golden, CO: U.S. National Renewable Energy Laboratory (NREL), April 2012); on 20–28% capacity factor for plants without storage and 40–50% for plants with 6–7.5 hours storage, from U.S. Department of Energy, *SunShot Vision Study*, prepared by the NREL (Golden, CO: February 2012), p. 105; on 20–30% for parabolic trough plants without storage and 40% to as high as 80% for tower plants with 6–15 hours of storage, from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 19; and on the capacity factor of parabolic trough plants with six hours of storage, in conditions typical of the U.S. Southwest estimated to be 35–42%, per IPCC, op. cit. this note, pp. 1004, 1006. Note that the Gemasolar plant, which began operation in Spain in 2011, has storage for up to 15 hours, per Torresol Energy, "Gemasol," www.torresolenergy.com/TORRESOL/gemasolar-plant/en. Capital costs based on: U.S. parabolic trough and tower plants without storage in the range of USD 4,000–6,000/kW, and trough and towers with storage in the range of USD 7,000–10,000/kW, from U.S. Department of Energy, Loans Programs Office, www.lgprogram.energy.gov, provided by Fred Morse, Abengoa Solar, personal communication with REN21, April 2013; and on parabolic trough plants with storage capital costs of USD 4,700–7,300/kW in OECD countries, and 3,100–4,050/kW in non-OECD (based on costs of five projects), and costs with storage all from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, pp. 19, 59–60; and on range of about 3,900–8,000/kW from IEA, *Tracking Clean Energy…*, op. cit. this note. LCOE estimates in table all assume a 10% cost of capital and come from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 65. Other LCOE estimates include: range of USD 0.12–0.16/kWh from GTM Research, *Concentrating Solar Power 2011: Technology, Costs and Markets* (Boston: 15 February 2011); range of USD 0.19–0.29/kWh (assuming a 7% discount rate) from IPCC, op. cit. this note, p. 1004, assuming 7% discount rate; and EUR 0.15–0.20/kWh per ESTELA, *The Essential Role for Solar Thermal Electricity* (Brussels: October 2012), p. 3.
Wind power: Characteristics based on the following: turbine sizes from JRC, *2011 Technology Map…*, op. cit. this note; on- and offshore capacity factors from IPCC, op. cit. this note, p. 1005; and from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 36. Note that weighted average capacity factors range from around 25% for China to an average 33% in the United States (with a range of 18–53%); ranges in Africa and Latin

America are similar to the United States, whereas ranges in Europe are closer to China. Curtailments in China due to grid constraints put the average capacity factor for dispatched generation closer to 20%, all from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 36. Capital costs for onshore wind based on: range of USD 1,750–2,200/kW in major OECD markets in 2011, and average U.S. costs in the first half of 2012 around USD 1,750/kW (and as low as USD 1,500/kW), from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, pp. 18, 32–37; on Navigant's BTM Consult, *International Wind Energy Development: World Market Update 2012* (Copenhagen: 2013); on a range of about USD 1,250–2,300/kW from IEA, *Tracking Clean Energy…*, op. cit. this note; and on R. Wiser and M. Bolinger, *2011 Wind Technologies Market Report* (Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2012). LCOE for onshore wind assume 7% discount rate and are from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 37; IRENA Renewable Cost Database, 2013, and from Michael Taylor, IRENA, personal communication with REN21, May 2013; also based on range of USD 0.04–0.16 U.S. cents/kWh from IEA, *Deploying Renewables…*, op. cit. this note. Note that the lowest-cost onshore wind projects have been installed in China; higher costs have been experienced in Europe and the United States. Offshore capital costs based on: average costs in the range of USD 4,000–4,500/kW from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 18; on Navigant's BTM Consult, op. cit. this note; and on range of USD 3,000–6,000/kW from IEA, *Tracking Clean Energy…*, op. cit. this note. Offshore LCOE based on USD 0.15–0.17 assuming a 45% capacity factor, USD 0.035/kWh operations and maintenance cost, and 10% cost of capital, and on USD 0.14-0.15/kWh assuming a 50% capacity factor, from IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 38; also from the low LCOE for offshore wind in the OECD is about USD 0.15/kWh and the high is USD 0.23/kWh, assuming a 7% discount rate, per IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 37; IRENA Renewable Cost Database, 2013, and from Michael Taylor, IRENA, personal communication with REN21, May 2013. All small-scale wind data from World Wind Energy Association (WWEA), *2012 Small Wind World Report* (Bonn: March 2012). Note that in 2011, installed costs of the top 10 small wind turbine models in the United States were in the range of USD 2,300–10,000/kW in 2011, and the average installed cost of all small-scale wind turbines was USD 6,040/kW; in China, the average was USD 1,900/kW, per WWEA, *Small Wind World Report 2013* (Bonn: March 2013).

HEAT AND COOLING SECTOR

Biomass heat: Cost variations between heat plants are wide for reasons similar to those listed above for bio-power. Further details can be found at: Fachagentur Nachwachsende Rohstoff e.V. (FNR), "Faustzahlen Biogas," www.biogasportal.info/daten-und-fakten/faustzahlen/, viewed May 2013; and Pellet Fuels Institute, "Compare Fuel Costs," http://pelletheat.org/pellets/compare-fuel-costs/, viewed May 2013. Bioenergy CHP includes small-scale biogas engine generating sets and biomass medium-scale steam turbines. Data converted using USD 1 GJ = 0.36 U.S. cents/kWh.

Geothermal heat: Geothermal space heating from IPCC, op. cit. this note, pp. 427 and 1010–11 (converted from USD 2005 to 2012), assuming 7% discount rate, and using USD 1 GJ = 0.36 U.S. cents/kWh. 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, a lifetime of 25 years, and transmission and distribution costs are not included. For ground-source heat pumps (GHP), IPCC shows capital costs of USD (2012) 1,095–4,370/kW, and USD 20–65/GJ assuming 25–30% as the load factor and 20 years as the operational lifetime. In 2011, IEA indicated a range of USD 439–4,000/kW based on 2007 data and operating efficiency of 250–500% (COP of 2.5–5.0), from IEA, *Technology Roadmap Energy – Efficient Buildings: Heating and Cooling Equipment* (Paris: OECD/IEA, 2011), Table 5. It is worth taking into account that actual LCOE for GHP are influenced by electricity market prices. Drilling costs are included for commercial and institutional installations, but not for residential installations.

Solar thermal heating: Solar heating plant sizes and efficiency rates for hot water systems and combi systems, based on 2007 data, from IEA, Technology Roadmap…, op. cit. this note, pp. 12–13, and district heat plant sizes from Werner Weiss, AEE – Institute for Sustainable Technologies (AEE-INTEC), Gleisdorf, Austria, personal communication with REN21, April 2012. Capital costs for OECD new-build and for OECD retrofit (for year 2007) from IEA, *Technology Roadmap…*, op. cit. this note; LCOE for domestic hot water (low end), and capital costs and LCOE for China (all converted from USD 2005 to USD 2012; and LCOE assuming 7% discount rate, and converted using USD 1/GJ = 0.36 U.S. cents/kWh) from IPCC, op. cit. this note, p. 1010; and LCOE for domestic hot water (high end) from Andreas Häberle, PSE AG, Freiburg, personal communication with REN21, 29 May 2013. European district heat capital costs from Weiss, op. cit. this note, and from Häberle, 25 April 2013. Note that the low of USD 470/kW is for district heat systems in Denmark, where costs start at about USD 370/kW (EUR 200/m^2) and storage costs a minimum of USD 100/kW. LCOE for district heat in Denmark based on low of EUR 0.03/kWh (converted using EUR 1 = USD 1.3), from Häberle, op. cit. this note. According to the IEA, the most cost-effective solar district heating systems in Denmark have had investment costs in the USD 350–400/kW range, resulting in heat prices of USD 35–40/MWh, from IEA, *Technology Roadmap – Solar Heating and Cooling* (Paris: OECD/IEA, 2012), p. 21. Industrial process heat data all from Häberle, 25 April 2013.

Solar thermal cooling: Capacity data, efficiency, and capital cost in the range of USD 2,925–5,850/kW from Uli Jakob, "Status and Perspective of Solar Cooling Outside Australia," in Proceedings of the Australian Solar Cooling 2013 Conference, Sydney, 12 April 2013. Efficiency based on coefficient of performance (COP) ranging from 0.50 to 0.70, depending on the system used and on driving, heat rejection, and cold water temperatures. Capital cost ranges based on EUR 2,250/kW for large-scale kits to EUR 4,500/kW for small-scale kits. Low-end of capital costs based on range of USD 1,600–3,200/kW for medium- to large-scale systems from IEA, *Technology Roadmap – Solar Heating and Cooling*, op. cit. this note, p. 21.

TRANSPORT SECTOR

Biofuel costs vary widely due to fluctuating feedstock prices (see, for example, Agriculture Marketing Resource Center (AgMRC), "Tracking Ethanol Profitability," www.agmrc.org/renewable_energy/ethanol/tracking_ethanol_profitability.cfm). Costs quoted exclude value of any co-products. Data sources include: Ernst and Young, Renewable Energy Attractiveness Indices (London: November 2012); IRENA analysis (forthcoming 2013); JRC, 2011 Technology Roadmap ..., op. cit. this note.

RURAL ENERGY

Wind capital cost data based on what is representative for Africa, from B. Klimbie, "Small and Medium Wind for Off-Grid Electrification," presentation at International Off-Grid Renewable Energy Conference and Exhibition (IOREC), 2 November 2012, cited in IRENA, *Renewable Power Generation Costs in 2012…,* op. cit. this note, p. 34; LCOE from Alliance for Rural Electrification, cited in Simon Rolland, "Campaigning for Small Wind: Facilitating Off-Grid Uptake," *Renewable Energy World*, March–April 2013, pp. 47–49. All other data from past editions of REN21, *Renewables Global Status Report* (Paris: REN21 Secretariat, various years).

INVESTMENT FLOWS

1 Sidebar 5 from the following sources: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2013* (Frankfurt: 2013); C. Mitchell et al., "Policy, Implementation and Financing," Chapter 11 in O. Edenhofer et al., eds., *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K. and New York: Cambridge University Press, 2012); International Energy Agency (IEA), *Harnessing Variable Renewables – A Guide to the Balancing Challenge* (Paris: 2011), pp. 877–78. Figure 21 from FS-UNEP and BNEF, op. cit. this note.

2 Figure 22 from FS-UNEP and BNEF, op. cit. note 1.

3 Figure 23 from ibid.

4 Figure of 80% for 2011 from FS-UNEP and BNEF, *Global Trends in Renewable Energy Investment 2012* (Frankfurt: 2012).

5 Ibid.

6 Estimates of 55.4 GW_{th} and 80% based on data from Franz Mauthner, AEE – Institute for Sustainable Technologies, Gleisdorf, Austria, personal communication with REN21, 14 May 2013, and from Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2011*, edition 2013 (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme, May 2013). Weiss and Mauthner estimate of 52.6 GW_{th} was derived from available market data from Austria, Brazil, China, Germany, and India; data for the remaining countries were estimated according to their trends for the previous two years. The Weiss and Mauthner report covers 56 countries and is assumed to represent 95% of the global market, so data were adjusted upwards by REN21 from an estimated 95% of the global market to 100% (i.e., 52.6 GW_{th}/0.95) to reach 55.4 GW_{th} of gross additions. 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 BNEF estimate includes only the actual devices or panels; it does not include installed costs.

7 BNEF estimate for investment in large hydropower (>50 MW) is based on 22 GW of capacity commissioned during 2012 and a capital cost per megawatt of USD 1.5 million, bringing the total investment in large hydropower to USD 33 billion. The figure USD 1.5 billion per GW is the average value based on numbers provided by developers of large hydro projects in applications for the Clean Development Mechanism. 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 commissioned in 2012 was actually invested in prior years; in addition, there was investment during 2012 for projects that are currently under construction and are not included in the BNEF estimates. Note that data for hydropower projects larger than 50 MW differ somewhat between this GSR and the *Global Trends in Renewable Energy Investment 2013* due to different methodologies and data sources. This *GSR* estimates that 30 GW of total hydropower capacity was commissioned worldwide during 2012, and a significant portion of this was projects larger than 50 MW, whereas BNEF estimates that 26 GW of hydro capacity was commissioned in 2012, including 22 GW of large projects (>50 MW).

8 Data are from the IEA and 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 IEA database.

POLICY LANDSCAPE

1 This section is intended to be only 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 also may 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 regional- and 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. Table 3 based on idem and numerous sources cited throughout this section. Figures 25 and 26 from idem and from Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2005 Global Status Report* (Washington, DC: Worldwatch Institute, 2005), and from REN21, *Renewables Global Status Report 2006 Update* (Paris: REN21 Secretariat and Washington, DC: Worldwatch Institute, 2006).

2 Sidebar 6 is based on the following sources: IEA estimate from International Energy Agency (IEA), *World Energy Outlook 2012* (Paris: 2012), p. 69. Of this total, about 54% went to oil products and 25% to the underpricing of fossil-based electricity (p. 70); IMF estimate from International Monetary Fund (IMF), *Energy Subsidy Reform: Lessons and Implications* (Washington, DC: January 2013); Birol statement made at European Wind Energy Association 2013 Annual Event, Vienna, Austria, 4 February 2013, as quoted in Zoë Casey, "Fossil Fuel Subsidies Are 'Public Enemy Number One'," European Wind Energy Association, 4 February 2012, at www.ewea.org/blog/2013/02/fossil-fuel-subsidies-are-public-enemy-number-one/; estimate of USD 88 billion and sectoral/country breakdowns from IEA, *World Energy Outlook 2012*, op. cit. this note, pp. 234–35. Heating and cooling subsidies include, for example the U.K. Renewable Heat Incentive, see https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi; cost and benefits from IEA, "How Big Are Energy Subsidies and Which Fuels Benefit?" World Economic Outlook 2011 Factsheet (Paris: 2011), and from Intergovernmental Panel on Climate Change (IPCC), *Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K.: Cambridge University Press, 2011), Chapter 9; reduced export earnings from IEA, *World Energy Outlook 2012*, op. cit. this note, p. 69; G20 from G20, "Leaders Statement: The Pittsburgh Summit, 24–25 September 2009," paragraph 24 of Preamble; APEC commitments from IEA, *World Energy Outlook 2012*, op. cit. this note, p. 71; G20 finance meeting from International Institute for Sustainable Development (IISD), "G20 Finance Ministers Call for Phase-out of Inefficient Fossil Fuel Subsidies," 16 February 2013, at http://climate-l.iisd.org/news/g20-finance-ministers-call-for-phase-out-of-inefficient-fossil-fuel-subsidies/. In the communiqué, G20 Finance Ministers agreed to develop methodological recommendations and to undertake a voluntary peer review process for fossil fuel subsidies in order to promote broad participation and report on the outcomes to G20 leaders at the September 2013 G20 Summit in St. Petersburg, Russia. The language was not changed from the previous communiqué in 2009; two joint reports from IEA, "Input to the G20 Initiative on Rationalizing and Phasing Out Inefficient Fossil Fuel Subsidies," www.iea.org/publications/worldenergyoutlook/resources/energysubsidies/inputtog20initiative/; IMF report from IMF, op. cit. this note; lack of timeline and organisation from Natural Resources Defense Council, "Governments Should Phase Out Fossil Fuel Subsidies or Risk Lower Economic Growth, Delayed Investment in Clean Energy and Unnecessary Climate Change Pollution," Fuel Facts, 2012, at www.nrdc.org/energy/files/fossilfuel4.pdf; subsidy reform in non-OECD countries from IEA, *World Energy Outlook 2012*, op. cit. this note, pp. 71–72; an increasing number of civil society observers and research organisations are monitoring and reporting on the global fossil fuel subsidies burden, a reflection of its rising public profile. One such effort is led by IISD's Global Subsidies Initiative (GSI), designed to put the spotlight on subsidies and the corrosive effects they can have on environmental quality, economic development, and governance; see www.iisd.org/gsi/.

3 India from Global Wind Energy Council (GWEC), *India Wind Energy Outlook 2012* (Brussels: November 2012), and from M. Ramesh, "Wind power capacity addition down 40% in first-half," The *Hindu Business Line*, 13 October 2012; Tonga from Z. Shahan, "Kingdom of Tonga Plans for 50% Renewable Energy by 2015," CleanTechnica.com, 23 February 2012.

4 Philippe Lempp, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), personal communication with REN21, 25 February 2013.

5 To meet the overall target, India has also outlined technology-specific electricity targets for wind (15 GW additional), solar (10 GW), biomass and biofuels (2.7 GW), and small-scale hydro (2.1 GW), per Bloomberg New Energy Finance (BNEF), "Energy: Week in Review Vol. VI – Issue 136" (London: 29 May 2012).

6 The Palestinian Territories set installed capacity targets for wind (44 MW), solar PV (45 MW), CSP (20 MW), and waste to energy (21 MW) by 2020. Hatem Elrefaai, Regional Centre for Renewable Energy and Energy Efficiency (RCREEE), personal communication with REN21, 23 March 2013.

7 In addition to the targets for on-grid renewable electricity, the ECOWAS Regional Energy Policy aims to serve 25% of the rural population via off-grid systems (e.g., stand-alone systems, mini-grids). It further includes a regional biofuel blending target of 15% of gasoline consumption by 2030, and stipulates that 50% of health centres and schools, 25% of agro-food industries, and 25% of hotels shall be equipped with solar thermal systems by 2030, per ECOWAS. *ECOWAS Renewable Energy Policy* (Cape Verde: 2012).

8 Qatar from Abdulaziz Al-Shalabi, OME, France, personal communication with REN21, 20 May 2013; Iraq from Amel Bida, RCREEE, personal communication, 19 February 2013. Saudi Arabia's 54.1 GW renewable energy target is designed to be met by capacity additions from a range of technologies. The target calls for 16 GW of solar PV, 25 GW of solar thermal, and a combined 13 GW of wind, geothermal, and waste-to-energy by 2032. King Abdullah City for Atomic and Renewable Energy, *Proposed Competitive Procurement Process for the Renewable Energy Program* (Saudi Arabia: 2013); "Saudi Arabia Reveals Plans for 54 GW of Renewable Energy, White Paper Provides Details," CleanTechnica.com, 25 February 2013; B. Stuart, "Saudi Arabia targets 41 GW of solar by 2032," PV Magazine, 9 May 2012; G. Clercq, "Saudi Arabia hopes to export solar electricity to Europe," *Reuters*, 11 April 2013.

9 "Energy Community Ministerial Council Adopts Renewable Energy 2020 targets," www.energy-community.org, 18 October 2012. Note that Sweden, Austria, Denmark, Spain, Greece, Hungary, and the Czech Republic have set national targets in addition to those set under EU Directive 2009/28/EC. The Directive sets targets at 49% in Sweden, 34% in Austria, 30% in Denmark, 20% in Spain, 18% in Greece, and 13% in Hungary and the Czech Republic. Figure 24 from the following sources: targets for 2020 and share in 2005 from European Commission, "Renewable Energy Targets by 2020," http://ec.europa.eu/energy/renewables/targets_en.htm; share in 2011, except where otherwise noted, from Observ'ER, The State of Renewable Energies in Europe 2012 (Paris: 2012), at www.energies-renouvelables.org/observ-er/stat_baro/barobilan/barobilan12.pdf; Germany 2011 share from Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), "Erneuerbare Energien 2012" (Bonn: February 2013); Portugal 2011 share from Luisa Silverio, Direcção Geral de Energia e Geologia (DGEG), personal communication, 14 December 2012.

10 Ibid. Maged Mahmoud, RCREE, personal communication with REN21, 20 February 2013.

11 Austria from Ministry of Economy, Family, and Youth, "Mitterlehner: Neues Ökostromgesetz stärkt Österreichs Position als Europameister bei Erneuerbaren Energien," press release (Vienna: 29 June 2012); Denmark from Danish Energy Agency, "Danish Climate and Energy Policy," www.ens.dk/en-US/policy/danish-climate-and-energy-policy/Sider/

danish-climate-and-energy-policy.aspx; France from T. Patel, "France Doubles Solar Energy Target, Seeks to Promote European Equipment," RenewableEnergyWorld.com, 8 January 2013; Germany from DB Climate Change Advisors, *The German Feed-in Tariff: Recent Policy Changes* (New York: Deutsche Bank Group, 2012); Netherlands from Government of the Netherlands, "III. Sustainable growth and innovation," www.government.nl/government/coalition-agreement/sustainable-growth-and-innovation; Poland from Steve Sawyer, GWEC, personal communication with REN21, 18 September 2012; Russian Federation from Government of the Russian Federation, "Order No 1839-r," 4 October 2012; Scotland from V. Font, "Scotland Schools the States on Offshore Wind Initiatives," RenewableEnergyWorld.com, 22 November 2012.

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6 For more on the limitations of marginal cost based power markets and potential alternatives (such as capacity markets, capacity payments, etc.), see Bundesverband Erneuerbare Energie e.V. (BEE, German Renewable Energy Federation), *Die Zukunft des Strommarktes* (Bochum: 2011), and BEE, *Kompassstudie Marktdesign. Leitideen für ein Design eines Strommarktsystems mit hohem Anteil fluktuierender Erneuerbarer Energien* (Bochum: 2012).

7 The Danish government has decided that the country's electricity and heating needs should be fully sourced from renewables by 2050; see Danish Energy Agency, "Danish Climate and Energy Policy," www.ens.dk/EN-US/POLICY/DANISH-CLIMATE-AND-ENERGY-POLICY/Sider/danish-climate-and-energy-policy.aspx. In its 2010 energy concept, the German government's objective was set to reach a renewables share of 60% in final energy consumption and to reach 80% in the electricity sector. These targets were underlined in 2011, when—after the Fukushima catastrophe—the government committed to the complete phase-out of nuclear power by 2022. The Energy Concept of 2010, revised in 2012, can be found at Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "The Federal Government's energy concept of 2010 and the transformation of the energy system of 2011," www.bmu.de/fileadmin/bmu-import/files/english/pdf/application/pdf/energiekonzept_bundesregierung_en.pdf.

8 An estimated 15% of PV and 30% of wind in Europe in 2030 would require around 100 GW of storage systems (out of which 80 GW of pumped hydro), according to European Photovoltaic Industry Association, *Connecting the Sun: Solar Photovoltaics on the Road to Large-Scale Grid Integration* (Brussels: September 2012).

9 The cost reduction in Germany amounted to USD 0.007/kWh (EUR 0.005/kWh) in 2011, and is expected to increase to more than USD .01/kWh (EUR 0.008/kWh) in 2013, per German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Häufig gestellte Fragen," www.erneuerbare-energien.de/fileadmin/ee-import/files/pdfs/allgemein/application/pdf/faq_eeg-umlage_2013_bf.pdf (exchange rate as of 31 December 2012). The effect has also been seen in Denmark, Spain, and other countries.

10 Sensfuss, op. cit. note 5; EWEA, op. cit. note 5.

11 BEE, op. cit. note 6, both references.

12 Ibid.

13 Based on data for January through September 2012, from Danish Energy Agency, "Monthly Energy Statistics," www.ens.dk/EN-US/INFO/FACTSANDFIGURES/ENERGY_STATISTICS_AND_INDICATORS/MONTHLY%20STATISTIC/Sider/Forside.aspx, viewed 15 April 2013.

14 Data for 2011 from Danish Energy Agency, "Renewables now cover more than 40% of electricity consumption," press release (Copenhagen: 24 September 2012); end of 2012 from Global Wind Energy Council, *Global Wind Report – Annual Market Update 2012* (Brussels: April 2013).

15 In March 2012, the Danish Parliament enacted the decision to phase out fossil fuels for power production and in the heating and cooling sector at the latest by 2050, from "Denmark Passes Legislation: 100% Renewable Energy by 2050!" SustainableBusiness.com, 30 March 2012, and from Danish Ministry of Climate, Energy and Building, *Accelerating Green Energy Towards 2020: The Danish Energy Agreement of March 2012* (Copenhagen: 2012).

16 Energinet.dk, "Infrastructure Projects—Electricity," www.energinet.dk/EN/ANLAEG-OG-PROJEKTER/Anlaegsprojekter-el/Sider/default.aspx, viewed 26 December 2012.

17 All 27 EU progress reports can be found at European Commission, "Renewable Energy: 2011 Progress Reports," http://ec.europa.eu/energy/renewables/reports/2011_en.htm, viewed 26 December 2012.

18 This statement should not be misunderstood to be celebrating recent policy changes such as the moratorium for all new renewables capacities, but CECRE remains a good example for how to deal with high shares of variable renewables. CECRE was established in 2006 by RED Eléctrica de España, the Spanish transmission system operator, as a special section of the central power control. For details of the operation as well as actual data about power flows within the country and between Spain and neighbours, see RED Eléctrica de España, "Centro de control de régimen especial," www.ree.es/operacion/cecre.asp, viewed 26 December 2012.

19 For details on the development of the Renewable Energy Law since 2000, and the recent 2012 amendment, see BMU, "Renewable Energy Sources Act (EEG) 2009," www.erneuerbare-energien.de/en/topics/acts-and-ordinances/renewable-energy-sources-act/eeg-2009/.

20 BMU, "Further growth in renewable energy in 2012," 2013, at www.erneuerbare-energien.de/en/topics/data-service/renewable-energy-in-figures/further-growth-in-renewable-energy-in-2012/.

21 See, for example, BMU, "Chronology of the Transformation of the Energy System," www.bmu.de/en/topics/climate-energy/transformation-of-the-energy-system/chronology/, updated October 2011.

22 For capacity markets and other measures with the intention of securing sufficient power capacities, see IEA, op. cit. note 1; BEE, *Die Zukunft des Strommarktes. Anregungen für den Weg zu 100 Prozent Erneuerbare Energie* (Berlin: 2011); and BEE, *Kompassstudie Marktdesign* (Berlin: December 2012).

23 See M. Fischedick et al., "Mitigation Potential and Costs," Chapter 10 in O. Edenhofer et al., op. cit. note 1. The report analyses 164 scenarios with regard to renewables potentials, costs, contribution to greenhouse gas mitigation and various other aspects, and provides an in-depth analysis of four model scenarios.

24 Ibid. The scenario highlighted is Greenpeace International and European Renewable Energy Council, *Energy [R]evolution* (Amsterdam and Brussels: 2012).

REFERENCE TABLES

1 **TABLE R1** **Bio-power** based on the following sources: International Energy Agency (IEA) Energy Statistics online data services, 2013; REN21, *Renewables 2012 Global Status Report* (Paris: 2012); U.S. Federal Energy Regulatory Commission, Office of Energy Projects Energy Infrastructure Update for December 2012; German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources 2012," with data from Working Group on Renewable Energy-Statistics (AGEE-Stat), provisional data, 28 February 2013, at www.erneuerbare-energien.de; State Electricity Regulatory Commission, National Bureau of Statistics, National Energy Administration, Energy Research Institute, and China National Renewable Energy Center, "China Renewables Utilization Data 2012," March 2013, at www.cnrec.org.cn/english/publication/2013-03-02-371.html; ANEEL – National Electric Energy Agency, "Generation Data Bank," (in Portuguese); U.K. Department of Energy and Climate Change (DECC), "Energy Trends section 6 – Renewables," and "Renewable electricity capacity and generation ET6.1," https://www.gov.uk/government/publications/renewables-section-6-energy-trends, updated 9 May 2013; Électricité Réseau Distribution France (ERDF), "Installations de production raccordées au réseau géré par ERDF a fin décembre 2012," at www.erdfdistribution.fr; Red Eléctrica de España (REE), *The Spanish Electricity System, Preliminary Report 2012* (Madrid: December 2012), at www.ree.es; Indian Ministry of New and Renewable Energy (MNRE), "Achievements," http://mnre.gov.in/mission-and-vision-2/achievements/, viewed May 2013; Institute for Sustainable Energy Policy (ISEP), *Renewables 2013 Japan Status Report*, www.isep.or.jp/jsr2013; Directorate General for Energy and Geology (DGEG), Portugal, 2013, at www.precoscombustiveis.dgeg.pt. **Geothermal power** additions and total global installed capacity in 2012 of 11.65 GW based on global inventory of geothermal power plants compiled by Geothermal Energy Association (GEA) (unpublished database), per Benjamin Matek, GEA, personal communication with REN21, May 2013. **Hydropower** based on 955 GW at the end of 2011 and 26–30 GW added during 2012 from International Hydropower Association, London, personal communication with REN21, February 2013; more than 975 GW in operation in 2011, including a limited number of pumped storage facilities, from International Journal on Hydropower & Dams, *Hydropower & Dams World Atlas 2012* (Wellington, Surrey, U.K.: 2012); 35 GW of capacity added in 2012 from Hydro Equipment Association, Brussels, personal communication with REN21, April 2012. Based on these figures, a best estimate of non-pumped storage hydro capacity at year-end 2012 is about 990 GW. **Ocean power** total capacity in 2011 was 526,704 kW, per IEA Implementing Agreement on Ocean Energy Systems (OES), *Annual Report 2011* (Lisbon: 2011), Table 6.2. Little capacity to speak of was added in 2012. See Ocean Energy section and related endnotes for more information. **Solar PV** from sources in Endnote 5 in this section. **CSP** from sources in Endnote 6 in this section. **Wind power** from sources in Endnote 8 in this section. **Modern bio-heat** based on 290 GW_{th} in GSR 2012, which was estimated based on the average of the capacity obtained from secondary modern bioenergy for heat in the year 2008 (297 GWth) presented in Helena Chum et al., "Bioenergy," Chapter 2 in Intergovernmental Panel on Climate Change (IPCC), *Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K.: Cambridge University Press, 2011), assuming a growth rate of 3%, and the heat capacity in the year 2009 (270 GWth) from W.C. Turkenburg et al., "Renewable Energy," in T.B. Johansson et al., eds., in *Global Energy Assessment – Toward a Sustainable Future* (Cambridge, U.K. and Laxenburg, Austria: Cambridge University Press and the International Institute for Applied Systems Analysis, 2012), and assuming a 3% growth rate for 2012. No more-accurate data currently exist. **Geothermal heating** estimates are based on values for 2010 (50.8 GW_{th} of capacity providing 121.6 TWh 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 communications with REN21, March, April, and June 2011. Since use of ground-source heat pumps is growing much faster than other direct-use categories, historical average annual growth rates for capacity and energy-use values for nine sub-categories of direct heat use were calculated for the years 2005–10 and used to project change for each category. The resulting weighted average annual growth rate for direct-heat use operating capacity is 13.8%, and for thermal energy use is 11.6%. The resulting estimated aggregate average capacity factor is 26.8%. **Solar collectors for water heating** estimates based on data from Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2011*, edition 2013 (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme, May 2013); and from Franz Mauthner, AEE – Institute for Sustainable Technologies, Gleisdorf, Austria, personal communication with REN21, 14 May 2013. Weiss and Mauthner estimate that total year-end 2012 capacity for all solar collectors was 268.1 GW_{th}, counting 95% of the global market, based on available market data from Austria, Brazil, China, Germany, and India; data for remaining countries were estimated according to the trends for the previous two years. Data were adjusted upwards by REN21 from 95% to 100% of the global market, for a total of 282.2 GW_{th}, and then 90.2% of this total was taken to arrive at the total year-end capacity for glazed water collectors only (254.55 GW_{th}). Net additions in 2012 were calculated by subtracting the 2011 year-end total from the 2012 total estimate for glazed water collectors. The 2011 year-end total was calculated by adjusting up to 100% (from 95%) the 211.5 GW_{th} in operation to 222.63 GW_{th}, per Mauthner, op. cit. this note. **Ethanol and biodiesel production in 2012** from sources in Endnote 4 in this section.

2 **TABLE R2** from the following sources: **For all global data**, see Endnote 1 for this section and other relevant reference tables. For more specific data and sources by country or region, see Global Market and Industry Overview section and related endnotes; for more specific technology data, see Market and Industry Trends by Technology section. **Bio-power** from sources in Endnote 1 for this section. Russia and South Africa from IEA, *Medium-Term Renewable Energy Market Report 2013* (Paris: OECD/IEA, forthcoming 2013); EU-27 based on the following sources: REN21, *Renewables 2012 Global Status Report* (Paris: 2012); German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources 2012," based on information supplied by the Working Group on Renewable Energy-Statistics (AGEE-Stat), provisional data, 28 February 2013, p. 18, at www.erneuerbare-energien.de; Gestore Servizi Energetici (GSE), "Impianti a fonti rinnovabili in Italia: Prima stima 2012," 28 February 2013; U.K. Government, Department of Energy and Climate Change, "Energy trends section 6: renewables," and "Renewable electricity capacity and generation (ET6.1)," 9 May 2013, at https://www.gov.uk/government/publications/renewables-section-6-energy-trends; Électricité Réseau Distribution France (ERDF), "Installations de production raccordées au réseau géré par ERDF à fin décembre 2012," www.erdfdistribution.fr/medias/Donnees_prod/parc_prod_decembre_2012.pdf; Red Eléctrica de España, *The Spanish Electricity System: Preliminary Report 2012* (Madrid: 2012); Directorate General for Energy and Geology (DGEG), Portugal, 2013, www.precoscombustiveis.dgeg.pt. Note that IEA Energy Statistics online data services, 2013, were used to check against OECD country data from other references used, and 2011 capacity data for Austria, Belgium, Canada, Denmark, the Netherlands, and Sweden were assumed to have increased by 2%. **Geothermal power** from global inventory of geothermal power plants by Geothermal Energy Association (GEA) (unpublished database), provided by Benjamin Matek, GEA, personal communication with REN21, May 2013. **Ocean power** from IEA Implementing Agreement on Ocean Energy Systems, *Annual Report 2011* (Lisbon: 2011), Table 6.2. **Solar PV** EU-27 from Gaëtan Masson, European Photovoltaic Industry Association and IEA Photovoltaic Power Systems Programme (IEA-PVPS), personal communications with REN21, February–May 2013; China, Germany, India, and Spain from IEA-PVPS, *PVPS Report: A Snapshot of Global PV 1992–2012* (Paris: 2013); United States from GTM Research and U.S. Solar Energy Industries Association, *U.S. Solar Market Insight Report, 2012 Year in Review* (Washington, DC: 2013), p. 21; Italy from GSE, *Rapporto Statistic 2012 – Solare Fotovoltaico*, 8 May 2013, at www.gse.it. Other BRICS include: Brazil (7.6 MW) from ANEEL – National Electric Energy Agency, "Generation Data Bank" (in Portuguese), viewed February 2013; Russia (no capacity to speak of); and South Africa (30 MW) from EScience Associates, Urban-Econ Development Economists, and Chris Ahlfeldt, *The Localisation Potential of Photovoltaics (PV) and a Strategy to Support Large Scale Roll-Out in South Africa*, Integrated Report, Draft Final v1.2, prepared for the South African Department of Trade and Industry, March 2013, p. x, at www.sapvia.co.za. **CSP** from sources in Endnote 6 for this section. **Wind power** global total from Global Wind Energy Council (GWEC), *Global Wind Report – Annual Market Update 2012* (Brussels: April 2013); from from Navigant's BTM Consult, *International Wind Energy Development: World Market Update 2012* (Copenhagen: March 2013); and from World Wind Energy Association (WWEA), *World Wind Energy Report 2012* (Brussels: May 2013); EU-27, Spain, Italy, and Russia from European Wind Energy Association, *Wind in*

Power: 2012 European Statistics (Brussels: February 2013); Brazil, China, India, Japan, and South Africa from GWEC, op. cit. this note; China also from Chinese Wind Energy Association, provided by Shi Pengfei, personal communication with REN21, 14 March 2013; United States from American Wind Energy Association, *AWEA U.S. Wind Industry Annual Market Report, Year Ending 2012* (Washington, DC: April 2013), Executive Summary; Germany from BMU, op. cit. this note. **Hydropower** from sources in Endnote 1 for this section. **Population** data for 2011 from World Bank, "Population, total," http://data.worldbank.org/indicator/SP.POP.TOTL.

3 **TABLE R3** from the following sources: P. A. Lamers, Ecofys/Utrecht University, Netherlands, personal communication with REN21, 14 May 2013.

4 **TABLE R4** from the following sources: Ethanol and biodiesel production and comparison with 2011 based on data from F.O. Licht, "Fuel Ethanol: World Production, by Country," 2013, and from F.O. Licht, "Biodiesel: World Production, by Country," 2013. Ethanol data were converted from cubic metres to litres using 1,000 litres/cubic metre. Biodiesel data were reported in 1,000 tonnes and converted using a density value for biodiesel to give 1,136 litres per tonne based on U.S. National Renewable Energy Laboratory (NREL), *Biodiesel Handling and Use Guide*, Fourth Edition (Golden, CO: 2009). The other major sources of biofuel production data are the International Energy Agency and the United Nations Food and Agriculture Organization; note that data can vary considerably among sources. For further details, see Bioenergy section in Market and Industry Trends by Technology, and related endnotes.

5 **TABLE R5** from the following sources: European Photovoltaics Industry Association (EPIA), *Global Market Outlook for Photovoltaics 2013–2017* (Brussels: 8 May 2013); EPIA database, May 2013; International Energy Agency Photovoltaic Power Systems Programme (IEA-PVPS), *PVPS Report, A Snapshot of Global PV 1992–2012* (Paris: April 2013); Gaëtan Masson, EPIA and IEA-PVPS, personal communications with REN21, February–May 2013; German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources 2012," based on information supplied by the Working Group on Renewable Energy-Statistics (AGEE-Stat), provisional data, 28 February 2013, at www.erneuerbare-energien.de; Gestore Servizi Energetici, *Rapporto Statistico 2012 Solare Fotovoltaico*, 8 May 2013, at www.gse.it; GTM Research and U.S. Solar Energy Industries Association, *U.S. Solar Market Insight Report, 2012 Year in Review* (Washington, DC: 2013); Commissariat Général au Développement Durable, Ministère de l'Écologie, du Développement durable et de l'Énergie, "Chiffres et statistiques," No. 396, February 2013, at www.statistiques.developpement-durable.gouv.fr. EPIA data for Europe and world total were adjusted based on differences between EPIA numbers and those used from other sources.

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7 **TABLE R7** from the following sources: Werner Weiss and Franz Mauthner, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2011*, edition 2013 (Gleisdorf, Austria: International Energy Agency (IEA) Solar Heating & Cooling Programme, May 2013); Franz Mauthner, AEE – Institute for Sustainable Technologies, Gleisdorf, Austria, personal communications with REN21, February–May 2013. The Weiss and Mauthner report covers 56 countries and accounts for an estimated 95% of the global market. Data provided were 48.1 GW_{th} added (68.6 million m^2) in 2011 for a year-end total glazed water collector capacity of 234.6 GW_{th}; these data were adjusted upwards to 100% for the GSR. Rest of world data were calculated by subtracting the sums of the top 12 countries from world totals. Note that 2011 collector area (and respective capacity) in operation were estimated by Weiss and Mauthner based on official country reports regarding the lifetime basis used; where such reports were not available, a 25-year lifetime was assumed except in the case of China, where the Chinese Solar Thermal Industry Federation considers lifetime to be below 10 years. Also, note that in 2004 the represented associations from Austria, Canada, Germany, the Netherlands, Sweden, and United States, as well as the European Solar Thermal Industry Federation (ESTIF) and the IEA Solar Heating and Cooling Programme agreed

to use a factor of 0.7 kW_{th}/m^2 to derive the nominal capacity from the area of installed collectors; this conversion rate is also used in the GSR.

8 **TABLE R8** from the following sources: Year-end world and country data for 2011 from *Global Wind Energy Council, Global Wind Report—Annual Market Update 2012* (Brussels: April 2013), except as noted below. Data for 2012 from ibid. and from the following sources: Navigant's BTM Consult, *International Wind Energy Development: World Market Update 2012* (Copenhagen: March 2013); WWEA, *World Wind Energy Report 2012* (Brussels: May 2013); China Electricity Council (commercial operation) and Chinese Wind Energy Association (installed capacity), provided by Shi Pengfei, personal communication with REN21, 14 March and 20 April 2013; American Wind Energy Association, *AWEA U.S. Wind Industry Annual Market Report, Year Ending 2012* (Washington, DC: April 2013), Executive Summary; German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), "Renewable Energy Sources 2012," data from Working Group on Renewable Energy-Statistics (AGEE-Stat), provisional data (Berlin: 28 February 2013), p. 18; European Wind Energy Association (EWEA), *Wind in Power: 2012 European Statistics* (Brussels: February 2013); France had 6,809 MW at the end of 2011 and added 753 MW in 2012 for a year-end total of 7,562 MW, per French Ministry of Ecology, Sustainable Development and Energy, *Chiffres & Statistiques*, No. 396 (Paris: February 2013) (data differ by only a few MW from EWEA, op. cit. this note); Portugal had 4,379 MW at the end of 2011 and added 880 MW in 2012 for a year-end total of 4,525 MW, per EWEA, op. cit. this note. See Wind Power text and related endnotes for further world and country statistics and details.

9 **TABLE R9** from the following sources: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2013* (Frankfurt: 2013).

10 **TABLE R10** from the following sources: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER, *The State of Renewable Energies in Europe* (Paris: 2013). For online updates, see the "Renewables Interactive Map" at www.ren21.net.

11 **TABLE R11** from the following sources: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER, *Worldwide Electricity Production from Renewable Energy Sources: Stats and Figures Series* (Paris: 2013). For online updates, see the "Renewables Interactive Map" at www.ren21.net.

12 **TABLE R12** from the following sources: REN21 database compiled from all available policy references plus submissions from report contributors. For online updates, see the "Renewables Interactive Map" at ww.ren21.net.

13 **TABLE R13** from the following sources: all available policy references, including the IEA/IRENA online Global Renewable Energy Policies and Measures database, published sources as given in the endnotes for the Policy Landscape Section of this report, and submissions from report contributors.

14 **TABLE R14** from ibid.

15 **TABLE R15** from ibid.

16 **TABLE R16** from the following sources: For selected targets and policies see the EU Covenant of Mayors, REN21, *Renewables 2011 Global Status Report* (Paris: 2011); *REN21 Global Futures Report* (Paris: 2013) and the REN21/ISEP/ICLEI 2011 *Global Status Report on Local Renewable Energy Policies* (latest edition May 2011). Selected Examples in Urban Planning: Glasgow from: City of Glasgow, Environment, "Sustainable Glasgow Report" (Glasgow: January 2010), at http://www.glasgow.gov.uk/chttphandler.asx?id=10159&p=0); Hong Kong from: City of Hong Kong, Blueprint for Sustainable Use of Resources 2013 – 2022 (Hong Kong: May 2012), at http://www.enb.gov.hk/en/files/WastePlan-E.pdf and Green Hong Kong (Hong Kong: May 2012), at http://www.brandhk.gov.hj/en/facts/factsheets/pdf/05_green_hongkong_en.pdf; Malmo from: Environmental Programme for the City of Malmö 2009-2020, (Malmo: 2009) at http://www.malmo.se/download/18.6301369612700a2db9180006227/Environmental-Programme-for-the-City-of-Malmo-2009-2020.pdf; IRENA, "Renewable Energy Policy in Cities: Selected Case Studies - Malmo, Sweden"(Abu Dhabi: January 2013), at www.irena.org/Publications/RE_Policy_Cities_CaseStudies/IRENA%20cities%20case%207%20Malmo.pdf; Seoul from: City of Seoul, City Initiatives, "Overview of Seoul City's Administration Plan" (Seoul: 2011) at, http://english.seoul.go.kr/gtk/cg/policies.php and "City planning of Seoul" (Seoul: 2013) at http://english.seoul.go.kr/library/common/download.php?fileDir=/community/&fileName=04_City_Planning_of_Seoul.pptx; Sydney from: City of Sydney, Sydney Sustainable Sydney 2030, (Sydney: 2011) at http://www.cityofsydney.nsw.gov.au/2030/makingithappen/documents/Building_Water_Energy_Retrofit_EOI.pdf; Vancouver from: City of Vancouver, Green Vancouver, "Greenest City 2020 Action Plan" (Vancouver: November 2012), at http://vancouver.ca/files/cov/greenest-city-action-plan.pdf; Yokohama from: City of Yokohama, "Climate Change Policy-related pages of the Mid-Term Plan of the City of Yokohama" (Yokohama: 2013), at http://www.city.yokohama.lg.jp/ondan/english/pdf/policies/mid-term-plan-of-the-city-of-yokohama.pdf.

17 **TABLE R17** from the following sources: REN21 database; submissions from report contributors; International Energy Agency (IEA), *World Energy Outlook 2012* (Paris: 2012); IEA, *World Energy Outlook 2011* (Paris: 2011); Latin America Energy Organisation (SIEE OLADE), http://siee.olade.org. Additional sources include: Developing Asia from Division of Developing Asia into China & East Asia and South Asia, as per IEA, *World Energy Outlook 2011*, op. cit. this note; Malawi from Institute of Developing Economies, Japan External Trade Organization (IDE-JETRO), African Growing Enterprises File, "Electricity Supply Commission of Malawi (ESCOM)," 2009, at www.ide.go.jp/English/Data/Africa_file/Company/malawi05.html#anchor4; Mexico from Comisión Federal de Electricidad (CFE), "What is CFE?" www.cfe.gob.mx/lang/ en/Pages/thecompany.aspx, viewed 29 February 2012; South Sudan from World Bank, "Terms of Reference for an Electricity Sector Strategy for South Sudan," posted in International Development Business, 2011, at www.devex.com/en/ projects/electricity-sector-strategy-note-for-south-sudan; ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), "Draft Technical Discussion Paper on General Energy Access in ECOWAS," prepared for Regional Workshop: Accelerating Universal Energy Access Through the Use of Renewable Energy and Energy Efficiency," Accra, Ghana, 24–26 October 2011, at http://ecreee.org/sites/default/files/event-att/working_paper_3_-_general_energy_access_0.pdf; Information Office of the State Council, *China's Energy Policy 2012* (Beijing: 2012), at www.scio.gov.cn/zxbd/wz/201210/t1233774.htm.

18 **TABLE R18** from the following sources: IEA, *World Energy Outlook 2012* (Paris: 2012).

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