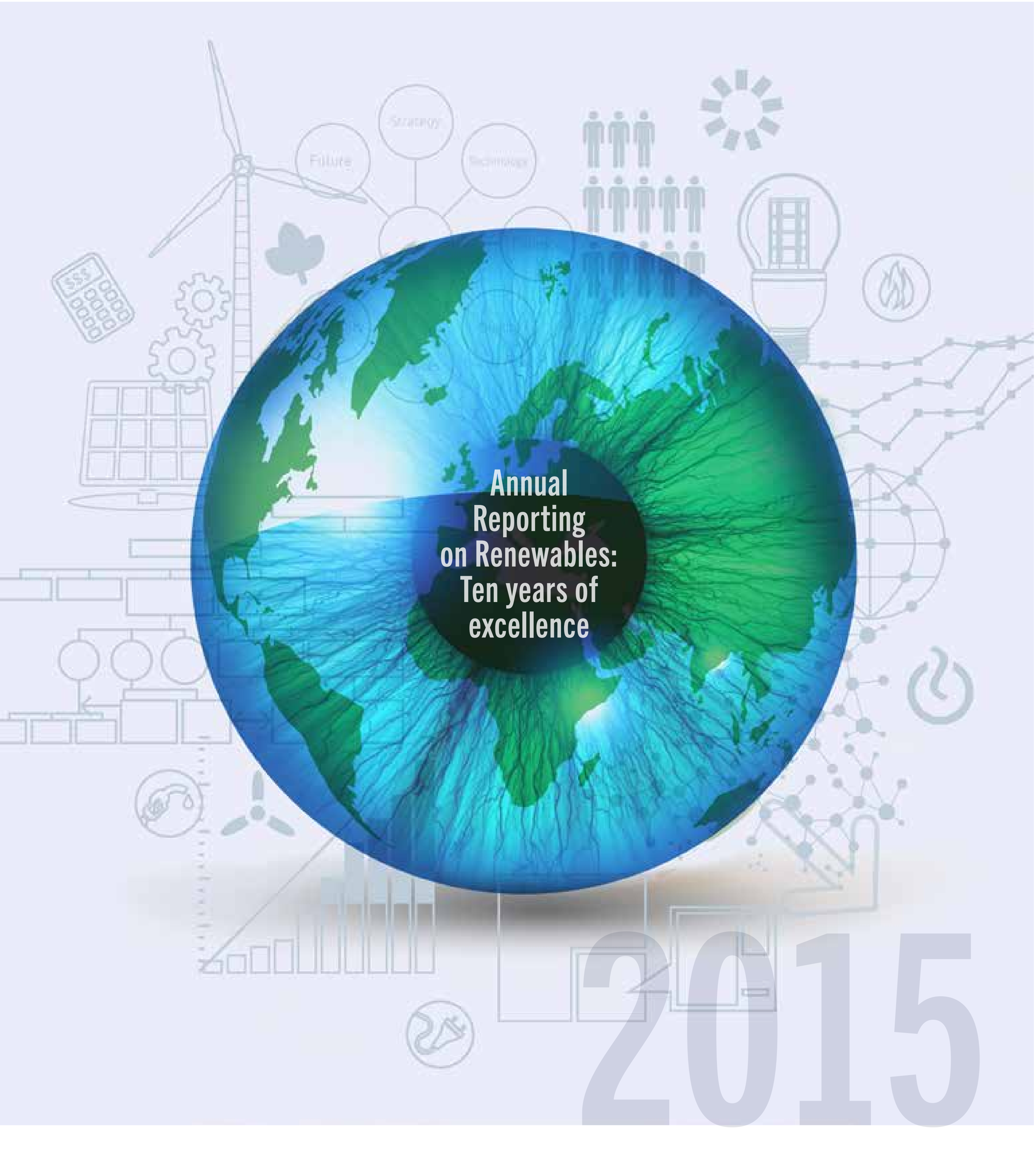
REN21 Renewable Energy Policy Network for the 21st Century

RENEWABLES 2015
GLOBAL STATUS REPORT



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REN21 releases issue papers and reports to emphasise the importance of renewable energy and to generate discussion on issues central to the promotion of renewable energy. While REN21 papers and reports have benefitted from the considerations and input from the REN21 community, they do not necessarily represent a consensus among network participants on any given point. Although the information given in this report is the best available to the authors at the time, REN21 and its participants cannot be held liable for its accuracy and correctness.

REN21 Renewable Energy Policy Network for the 21st Century

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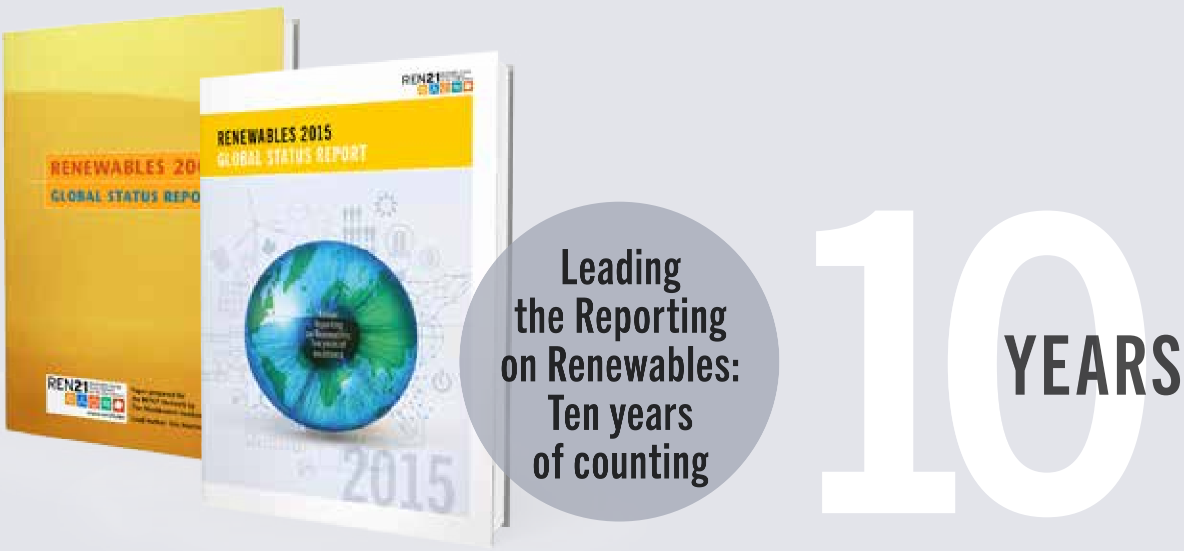
ANNUAL REPORTING ON RENEWABLES: TEN YEAR OF EXCELLENCE

The REN21 *Renewables Global Status Report (GSR)* provides an annual look at the tremendous advances in renewable energy markets, policy frameworks and industries globally. Each report uses formal and informal data to provide the most up-to-date information available. Reliable, timely and regularly updated data on renewable energy are essential as they are used for establishing baselines for decision makers; for demonstrating the increasing role that renewables play in the energy sector; and illustrating that the renewable energy transition is a reality.

This year's GSR marks 10 years of REN21 reporting. Over the past decade the GSR has expanded in scope and depth with its thematic and regional coverage and the refinement of data collection. The GSR is the product of systematic data collection resulting in thousands of data points, the use of hundreds of documents, and personal communication with experts from around the world. It benefits from a multi-stakeholder community of over 500 experts.

Ten years on, the GSR has established itself as the world's most frequently-referenced report on the global renewable energy market, industry and policy landscape.



FOREWORD

The *Renewables 2015 Global Status Report* marks the tenth report in the GSR series. Its evolution from a 35-page report to one that currently stands at over 250 pages reflects both the breadth and depth of renewable energy development over the past decade.

Renewable energy continued to grow in 2014 in parallel with global energy consumption and falling oil prices. Despite rising energy use, global CO_2 emissions associated with energy consumption remained stable over the course of the year while the global economy grew. The landmark "decoupling" of economic and CO_2 growth is due in large measure to China's increased use of renewable resources, and efforts by countries in the OECD to promote renewable energy and energy efficiency. This is particularly encouraging in view of COP21 later this year in Paris, where countries will announce and/or confirm actions to mitigate climate change, setting the stage for future investment in renewables and energy efficiency.

It is clear that renewables are becoming a mainstreamed energy resource. However while this year's report clearly documents advancements in the uptake of renewables, it also demonstrates that there remains untapped potential particularly in the heating and cooling and transport sectors. Nevertheless with the implementation of increasingly ambitious targets and innovative policies, renewables can continue to surpass expectations and create a clean energy future.

The *Renewables Global Status Report* relies on a robust, dynamic, international community of renewable energy experts. It is the collective work of REN21's contributors, researchers, and authors, which has helped make the GSR the most frequently referenced report on renewable energy market, industry and policy trends. Special thanks go to the ever-growing network of over 500 contributors, including authors, researchers, and reviewers who participated in this year's process and helped make the GSR a truly international and collaborative effort.

On behalf of the REN21 Secretariat, I would also like to thank all those who have contributed to the successful production of GSR 2015. These include lead author/research director Janet L. Sawin, the section authors, GSR project manager Rana Adib, and the entire team at the REN21 Secretariat, under the leadership of REN21's Executive Secretary Christine Lins.

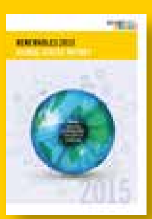
As 2014 demonstrated, the penetration and use of renewables are increasing as is the combination of renewables and energy efficiency. However the share of renewables in the overall energy mix is still under 20%. This needs to change if access to clean, modern renewable energy services for all to be assured by 2030.

Arthouros Zervos
Chairman of REN21

RENEWABLE ENERGY POLICY NETWORK FOR THE 21st CENTURY

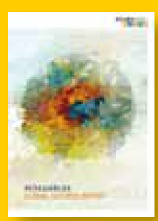
REN21 is the global renewable energy policy multi-stakeholder network that connects a wide range of key actors. REN21's goal is to facilitate knowledge exchange, policy development, and joint action towards a rapid global transition to renewable energy.

REN21 brings together governments, nongovernmental organisations, research and academic institutions, international organisations, and industry to learn from one another and build on successes that advance renewable energy. To assist policy decision making, REN21 provides high-quality information, catalyses discussion and debate, and supports the development of thematic networks.



Global Status Report: yearly publication since 2005

Regional Reports



Global Futures Report

www.ren21.net/map

REN21 Renewables Academy

REN21 Renewables Academy

	2004	2005	2006	2007	2008	2009	2010
REN21 publications:		First GSR published				Chinese Renewable Energy Status Report	Indian Renewable Energy Status Report
REN21 events:	renewables 2004, Bonn	BIREC, Beijing International Renewable Energy Conference			WIREC, Washington International Renewable Energy Conference		DIREC, Delhi International Renewable Energy Conference

REN21 facilitates the collection of comprehensive and timely information on renewable energy. This information reflects diverse viewpoints from both private and public sector actors, serving to dispel myths about renewable energy and to catalyse policy change. It does this through six product lines.

Renewables Global Status Report (GSR)

First released in 2005, REN21's *Renewables Global Status Report* (GSR) has grown to become a truly collaborative effort, drawing on an international network of over 500 authors, contributors, and reviewers. Today it is the most frequently referenced report on renewable energy market, industry, and policy trends.

Regional Reports

These reports detail the renewable energy developments of a particular region; their production also supports regional data collection processes and informed decision making.

Renewables Interactive Map

The Renewables Interactive Map is a research tool for tracking the development of renewable energy worldwide. It complements the perspectives and findings of REN21's Global and Regional Status Reports by providing continually updated market and policy information as well as providing detailed, exportable country profiles.

Global Future Reports (GFR)

REN21 produces reports that illustrate the credible possibilities for the future of renewables within particular thematic areas.

Renewables Academy

The REN21 Renewables Academy provides an opportunity for lively exchange among the growing community of REN21 contributors. It offers a venue to brainstorm on future-orientated policy solutions and allows participants to actively contribute on issues central to a renewable energy transition. The next REN21 Renewables Academy will take place in autumn 2016.

International Renewable Energy Conferences (IRECs)

The International Renewable Energy Conference (IREC) is a high-level political conference series. Dedicated exclusively to the renewable energy sector, the biennial IREC is hosted by a national government and convened by REN21. SAIREC 2015 will be held in South Africa on 4–7 October 2015.

2011	Global Status Report on Local Renewable Energy Policies	
2012		
2013	Global Futures Report MENA Renewable Energy Status Report	ADIREC, Abu Dhabi International Renewable Energy Conference
2014	ECOWAS Renewable Energy and Energy Efficiency Status Report	First REN21 Renewables Academy, Bonn
2015	SADC and UNECE Renewable Energy and Energy Efficiency Status Reports	SAIREC, South Africa International Renewable Energy Conference
2016	EAC Renewable Energy and Energy Efficiency Status Report	Second REN21 Renewables Academy

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SUSTAINABLE
ENERGY FOR ALL

The UN Secretary-General's initiative Sustainable Energy for All mobilises global action to achieve universal access to modern energy services, double the global rate of improvement in energy efficiency, and double the share of renewable energy in the global energy mix by 2030. REN21's *Renewables 2015 Global Status Report* contributes to this initiative by demonstrating the role of renewables in increasing energy access. A section on distributed renewable energy—based on input from local experts primarily from developing countries—illustrates how renewables are providing needed energy services and contributing to a better quality of life through the use of modern cooking, heating/cooling, and electricity technologies. As the newly launched Decade for Sustainable Energy for All (2014–2024) unfolds, REN21 will work closely with the SE4ALL initiative towards achieving its three objectives.

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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. The latest edition of this authoritative annual report tells the story of the most recent developments, signs, and signals in the financing of renewable power and fuels. It explores the issues affecting each type of investment, technology, and type of economy. 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 March 2015 and is available for download at **www.fs-unep-centre.org.**

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BIONICS means learning from nature to inspire technology development. **Biomimetics** or **biomimicry** is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems. **Access to sustainable energy** is one of the greatest challenges facing the world. Nature can inspire innovative solutions for future energy systems and technology design. Some **renewable energy technologies** already imitate processes found in nature; however, more can be learned to help us successfully address our future energy needs.

ES

bi·on·ic [bī-ŏn′ĭk]
From bi (as in "life") + onics (as in "electronics");
The design and production of materials, structures, and systems that are modelled on biological entities and processes.
Bionics means learning from the nature for the development of technology. The science of "bionics" itself is classified into several sections, from materials and structures

EXECUTIVE SUMMARY

Renewable energy continued to grow in 2014 against the backdrop of increasing global energy consumption, particularly in developing countries, and a dramatic decline in oil prices during the second half of the year. Despite rising energy use, for the first time in four decades, global carbon emissions associated with energy consumption remained stable in 2014 while the global economy grew; this stabilisation has been attributed to increased penetration of renewable energy and to improvements in energy efficiency.

Globally, there is growing awareness that increased deployment of renewable energy (and energy efficiency) is critical for addressing climate change, creating new economic opportunities, and providing energy access to the billions of people still living without modern energy services. Although discussion is limited to date, renewables also are an important element of climate change adaptation, improving the resilience of existing energy systems and ensuring delivery of energy services under changing climatic conditions.

Renewable energy provided an estimated 19.1% of global final energy consumption in 2013, and growth in capacity and generation continued to expand in 2014. Heating capacity grew at a steady pace, and the production of biofuels for transport increased for the second consecutive year, following a slowdown in 2011–2012. The most rapid growth, and the largest increase in capacity, occurred in the power sector, led by wind, solar PV, and hydropower.

Growth has been driven by several factors, including renewable energy support policies and the increasing cost-competiveness of energy from renewable sources. In many countries, renewables are broadly competitive with conventional energy sources. At the same time, growth continues to be tempered by subsidies to fossil fuels and nuclear power, particularly in developing countries.

Although Europe remained an important market and a centre for innovation, activity continued to shift towards other regions. China again led the world in new renewable power capacity installations in 2014, and Brazil, India, and South Africa accounted for a large share of the capacity added in their respective regions. An increasing number of developing countries across Asia, Africa, and Latin America became important manufacturers and installers of renewable energy technologies.

In parallel with growth in renewable energy markets, 2014 saw significant advances in the development and deployment of energy storage systems across all sectors. The year also saw the increasing electrification of transportation and heating applications, highlighting the potential for further overlap among these sectors in the future.

Power: more renewables capacity added than coal and gas combined

Renewables represented approximately 58.5% of net additions to global power capacity in 2014, with significant growth in all regions. Wind, solar PV, and hydro power dominated the market. By year's end, renewables comprised an estimated 27.7% of the world's power generating capacity, enough to supply an estimated 22.8% of global electricity.

Variable renewables are achieving high levels of penetration in several countries. In response, policymakers in some jurisdictions are requiring utilities to update their business models and grid infrastructure. Australia, Europe, Japan, and North America have seen significant growth in numbers of residential "prosumers"—electricity customers who produce their own power. Major corporations and institutions around the world made substantial commitments in 2014 to purchase renewable electricity or to invest in their own renewable generating capacity.

Heating and Cooling: slow growth but vast potential—key for the energy transition

About half of total world final energy consumption in 2014 went to providing heat for buildings and industry, with modern renewables (mostly biomass) generating approximately 8% of this share. Renewable energy also was used for cooling, a small but rapidly growing sector. The year saw further integration of renewables into district heating and cooling systems, particularly in Europe; the use of district systems to absorb heat generated by renewable electricity when supply exceeds demand; and the use of hybrid systems to serve different heat applications. Despite such innovations and renewables' vast potential in this sector, growth has been constrained by several factors, including a relative lack of policy support.

Transport: driven by biofuels, with e-mobility growing rapidly

In the transport sector, the primary focus of policies, markets, and industries has been on liquid biofuels. The share of renewables in transportation remains small, with liquid biofuels representing the vast majority. Advances in new markets and in applications for biofuels—such as commercial flights being fuelled by aviation biofuel—continued in 2014. Relatively small but increasing quantities of gaseous biofuels, including biomethane, also are being used to fuel vehicles. Increased electrification of trains, light rail, trams, and both two- and four-wheeled electric vehicles is creating greater opportunities for the integration of renewable energy into transport.

AN EVOLVING POLICY LANDSCAPE

Renewable energy developments in 2014 continued to be shaped largely by government policy. Renewables faced challenges in some countries resulting from policy changes or uncertainties, such as the imposition of new taxes on renewable generation in Europe and the expiration of the US federal production tax credit. However, the number of countries with renewable energy targets and policies increased again in 2014, and several jurisdictions made their existing targets more ambitious—including a rising number with 100% renewable energy or electricity targets. As of early 2015, at least 164 countries had renewable energy targets, and an estimated 145 countries had renewable energy support policies in place.

Policymakers continued to focus on adapting existing policies to keep pace with rapidly changing costs and circumstances. Recent trends include merging of components from different policy mechanisms; a growing linkage of support between the electricity, heat, and transport sectors; and development of innovative mechanisms to integrate rising shares of renewables into the energy mix.

RENEWABLE ENERGY POLICIES FOR ELECTRICITY

Combined policies to accompany structural changes

Policymakers have focused predominantly on the power sector, a trend that has shaped the current landscape. Feed-in and Renewable Portfolio Standards (RPS) policies remain the most commonly used support mechanisms. Feed-in policies have been enacted in 108 jurisdictions at the national or state/provincial level. Egypt was the only country to add a new national FIT, with policymakers—particularly in Europe—continuing the recent trend of amending existing policies. RPS policies are most popular at the state and provincial levels; they are in place in at least 26 countries at the national level and in 72 states/provinces. However, existing RPS policies continued to face opposition in several US States. Tendering has been utilised increasingly around the world; at least 60 countries had held renewable energy tenders as of early 2015. Net metering or net billing policies are in force in 48 countries, and some form of financial support for renewables is in place in an estimated 126 countries.

Traditional mechanisms also are being used to increase energy storage capacity and to modernise grid infrastructure. In addition to traditional support mechanisms, green banks and green bonds represent innovative options that are gaining support from policymakers. Despite the growing prominence of renewable energy support policies for power generation globally, however, charges or fees on renewable energy have been introduced in an increasing number of countries.

RENEWABLE ENERGY POLICIES FOR HEATING AND COOLING

Less-prevalent than policies for renewable power

Policies for renewable heating and cooling are slowly gaining attention from national policymakers. An estimated 45 countries worldwide had targets for renewable heating or cooling in place by early 2015. Financial incentives continued to be the most widely enacted form of policy support for renewable heating and cooling systems, with several schemes reintroduced and existing programmes strengthened. Other policy tools include solar-specific renewable heat mandates, which were in place in 11 countries at the national or state/provincial level, and technology-neutral mandates, which were in place in an additional 10 countries by early 2015.

RENEWABLE ENERGY TRANSPORT POLICIES

Renewable transport is on the move

The majority of transport-related policies continued to focus on the biofuel sector and on road transport, although other modes of transportation also are attracting attention. Policies promoting the linkage between electric vehicles and renewable energy have received little focus to date. As of early 2015, biofuel blend mandates were in place in 33 countries, with 31 national mandates and 26 state/provincial mandates. A number of countries strengthened existing blend mandates in 2014; however, the debate over the sustainability of first-generation biofuels continued.

CITY AND LOCAL GOVERNMENT RENEWABLE ENERGY POLICIES

Local municipalities take the lead

Cities continued to lead the way, setting and achieving ambitious targets and helping to drive the trends of national and regional governments. By early 2015, several jurisdictions had 100% renewable energy or electricity targets in place, with the vast majority of targets at the city/local level. Many municipalities already have achieved such targets.

To reach their goals, policymakers in cities around the world continued a growing trend of mandating the use of renewable power generation and renewable heat technologies through building codes. Development of district systems has emerged as an important measure to facilitate the scale-up of renewable energy for heating and cooling. Public-private partnerships are being used increasingly to advance renewable energy deployment, and thousands of US and European municipalities have created community power systems. Policymakers also continued to use their purchasing authority to support local deployment of renewable energy in all economic sectors, including integrating biofuel and electric vehicles into public transportation fleets and developing related support infrastructure.

RENEWABLE ENERGY INDICATORS 2014

		START 2004[1]	2013	2014
INVESTMENT				
New investment (annual) in renewable power and fuels[2]	billion USD	45	232	**270**
POWER				
Renewable power capacity (total, not including hydro)	GW	85	560	**657**
Renewable power capacity (total, including hydro)	GW	800	1,578	**1,712**
Hydropower capacity (total)[3]	GW	715	1,018	**1,055**
Bio-power capacity	GW	<36	88	**93**
Bio-power generation	TWh	227	396	**433**
Geothermal power capacity	GW	8.9	12.1	**12.8**
Solar PV capacity (total)	GW	2.6	138	**177**
Concentrating solar thermal power (total)	GW	0.4	3.4	**4.4**
Wind power capacity (total)	GW	48	319	**370**
HEAT				
Solar hot water capacity (total)[4]	GW_{th}	86	373	**406**
TRANSPORT				
Ethanol production (annual)	billion litres	28.5	87.8	**94**
Biodiesel production (annual)	billion litres	2.4	26.3	**29.7**
POLICIES				
Countries with policy targets	#	48	144	**164**
States/provinces/countries with feed-in policies	#	34	106	**108**
States/provinces/countries with RPS/quota policies	#	11	99	**98**
Countries with tendering/ public competitive bidding[5]	#	n/a	55	**60**
Countries with heat obligation/mandate	#	n/a	19	**21**
States/provinces/countries with biofuels mandates[6]	#	10	63	**64**

[1] Capacity data are as of the beginning of 2004; other data, such as investment and biofuels production, cover the full year. Numbers are estimates, based on best available information.

[2] 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, 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.

[3] The GSR 2014 reported a global total of 1,000 GW of hydropower capacity at the end of 2013; this figure has been revised upwards. Hydropower data do not include pumped storage capacity. For more information, see Methodological Notes, page 243.

[4] Solar hot water capacity data include water collectors only. The number for 2014 is a preliminary estimate.

[5] Data for tendering/public competitive bidding reflect the number of countries that had held tenders at any time up to the year in question, but not necessarily during that year.

[6] Biofuel policies include policies listed both under the biofuels obligation/mandate column in Table 3 (Renewable Energy Support Policies) and in Reference Table R18 (National and State/Provincial Biofuel Blend Mandates).

Note: All values are rounded to whole numbers except for numbers <15, and biofuels, which are rounded to one decimal point. Policy data for 2014 include all countries identified as of early 2015.

TOP FIVE COUNTRIES

ANNUAL INVESTMENT / NET CAPACITY ADDITIONS / PRODUCTION IN 2014

	1	2	3	4	5
Investment in renewable power and fuels (not including hydro > 50 MW)	**China**	United States	Japan	United Kingdom	Germany
Investment in renewable power and fuels per unit GDP[1]	**Burundi**	Kenya	Honduras	Jordan	Uruguay
Geothermal power capacity	**Kenya**	Turkey	Indonesia	Philippines	Italy
Hydropower capacity	**China**	Brazil	Canada	Turkey	India
Solar PV capacity	**China**	Japan	United States	United Kingdom	Germany
CSP capacity	**United States**	India	–	–	–
Wind power capacity	**China**	Germany	United States	Brazil	India
Solar water heating capacity[2]	**China**	Turkey	Brazil	India	Germany
Biodiesel production	**United States**	Brazil	Germany	Indonesia	Argentina
Fuel ethanol production	**United States**	Brazil	China	Canada	Thailand

TOTAL CAPACITY OR GENERATION AS OF END-2014

	1	2	3	4	5
POWER					
Renewable power (incl. hydro)	**China**	United States	Brazil	Germany	Canada
Renewable power (not incl. hydro)	**China**	United States	Germany	Spain / Italy	Japan / India
Renewable power capacity *per capita* (among top 20, not including hydro[3])	**Denmark**	Germany	Sweden	Spain	Portugal
Biopower generation	**United States**	Germany	China	Brazil	Japan
Geothermal power capacity	**United States**	Philippines	Indonesia	Mexico	New Zealand
Hydropower capacity[4]	**China**	Brazil	United States	Canada	Russia
Hydropower generation[4]	**China**	Brazil	Canada	United States	Russia
Concentrating solar thermal power (CSP)	**Spain**	United States	India	United Arab Emirates	Algeria
Solar PV capacity	**Germany**	China	Japan	Italy	United States
Solar PV capacity *per capita*	**Germany**	Italy	Belgium	Greece	Czech Republic
Wind power capacity	**China**	United States	Germany	Spain	India
Wind power capacity *per capita*	**Denmark**	Sweden	Germany	Spain	Ireland
HEAT					
Solar water collector capacity[2]	**China**	United States	Germany	Turkey	Brazil
Solar water heating collector capacity *per capita*[2]	**Cyprus**	Austria	Israel	Barbados	Greece
Geothermal heat capacity[5]	**China**	Turkey	Japan	Iceland	India
Geothermal heat capacity *per capita*[5]	**Iceland**	New Zealand	Hungary	Turkey	Japan

[1] Countries considered include only those covered by Bloomberg New Energy Finance (BNEF); GDP (at purchasers' prices) and population data for 2013 and all from World Bank. BNEF data include the following: all biomass, geothermal, and wind generation projects of more than 1 MW; all hydropower 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.

[2] Solar water collector (heating) rankings are for 2013 and are based on capacity of water (glazed and unglazed) collectors only; including air collectors would affect the order of capacity added, placing the United States slightly ahead of Germany rather than in sixth place, and would not affect the order of top countries for total capacity or per capita.

[3] Per capita renewable power capacity ranking considers only those countries that place among the top 20 worldwide for total installed renewable power capacity, not including hydropower. Several other countries, including Austria, Finland, Ireland, and New Zealand, also have high per capita levels of non-hydro renewable power capacity, with Iceland likely the leader among all countries.

[4] Country rankings for hydropower capacity and generation differ because some countries rely on hydropower for baseload supply whereas others use it more to follow the electric load and to match peaks in demand.

[5] Not including heat pumps.

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

MARKET AND INDUSTRY TRENDS

Markets for all renewable energy technologies advanced in 2014, with wind power and solar PV taking the lead for capacity additions.

BIOMASS ENERGY: BIOMASS FOR HEAT, POWER, AND TRANSPORT

Bio-heat production remained stable in 2014, increasing 1% over 2013. Composition of bio-heat portfolios continued to vary widely by region, ranging from large-scale production in industry (e.g., in the United States) to vast numbers of residential-scale bio-digesters (e.g., in China). Global bio-power production increased approximately 9%, with China, Brazil, and Japan leading for capacity additions, and the United States and Germany leading for generation (despite comparatively smaller capacity additions).

Liquid biofuel production was up 9% in 2014, reaching its highest level to date. Although the United States and Brazil dominated overall volume, Asia experienced particularly high production growth rates. Policy positively influenced biofuel markets where blending mandates increased demand, but policy uncertainty, particularly in Europe, the United States and Australia, had negative effects on industry. Low oil prices in the second half of the year had some positive effects, particularly in feedstock production, but reduced turnover for some bioenergy businesses.

Trade patterns in both solid and liquid fuels saw some shifts in 2014, with a considerable share of North American wood pellets flowing to Asia, reducing the domination of flows to European markets. The share of traded biofuels destined for Europe declined slightly, while new markets (particularly for fuel ethanol) expanded in other regions.

GEOTHERMAL ENERGY: SLOW BUT STEADY GROWTH

About 640 megawatts (MW) of new geothermal power generating capacity came on line, for a total approaching 12.8 gigawatts (GW), producing an estimated 74 terawatt-hours (TWh) in 2014. The largest share of new geothermal power capacity came on line in Kenya, underscoring the growing emphasis on geothermal energy in East Africa. An estimated 1.1 gigawatts-thermal (GWth) of geothermal direct use (heat) capacity was added in 2014 for a total of 20.4 GWth; output was an estimated 263 petajoules (PJ) in 2014 (73 TWh). Over the past five years, total power capacity has grown at an average annual rate of 3.6%, and heat capacity at an estimated 5.9%. The geothermal industry continues to face significant project development risk; various efforts are under way to ameliorate such risks in developed and developing countries.

HYDROPOWER: STILL GIANT AMONG ITS PEERS

An estimated 37 GW of new hydropower capacity was commissioned in 2014, bringing total global capacity to approximately 1,055 GW. Generation in 2014 is estimated at 3,900 TWh. China (22 GW) installed the most capacity by far, with significant capacity also added in Brazil, Canada, Turkey, India, and Russia. The industry continued innovation towards ever-more flexible, efficient, and reliable facilities. Demand for greater efficiency and lower generating costs have contributed to ever-larger generating units, including some 800 MW turbines. There also is significant demand for refurbishment of existing plants to improve the efficiency of output, as well as environmental performance in the face of new regulatory requirements. Innovations also include variable speed technology for new and refurbished pumped storage plants, which assist in further integration of variable renewable resources.

OCEAN ENERGY: TEMPERED PROGRESS BUT FULL OF PROMISE

Ocean energy capacity, mostly tidal power generation, remained at about 530 MW in 2014. Virtually all new installations were in some form of pilot or demonstration projects. Two prominent wave energy development companies faced strong headwinds. The EU Ocean Energy Forum was launched with the aim of bringing together stakeholders for problem solving and co-operation on ocean energy. Technology development continued in various test sites, with tidal and wave energy devices having advanced the most of all ocean energy technologies to date.

SOLAR PV: RAPID SPREAD TO NEW MARKETS

Solar PV is starting to play a substantial role in electricity generation in some countries as rapidly falling costs have made unsubsidised solar PV-generated electricity cost-competitive with fossil fuels in an increasing number of locations around the world. In 2014, solar PV marked another record year for growth, with an estimated 40 GW installed for a total global capacity of about 177 GW.

China, Japan, and the United States accounted for the vast majority of new capacity. Even so, the distribution of new installations continued to broaden, with Latin America seeing rapid growth, significant new capacity added in several African countries, and new markets picking up in the Middle East. Although most EU markets declined for the third consecutive year, the region—particularly Germany—continued to lead the world in terms of total solar PV capacity and contribution to the electricity supply.

The solar PV industry recovery that began in 2013 continued in 2014, thanks to a strong global market. Consolidation among manufacturers continued, although the flood of bankruptcies seen over the past few years slowed to a trickle. To meet the rising demand, new cell and module production facilities opened (or were announced) around the world.

CONCENTRATING SOLAR THERMAL POWER (CSP): DIVERSIFYING TECHNOLOGIES AND APPLICATIONS

The CSP market remains less established than most other renewable energy markets. Nonetheless, the sector continued its near-decade of strong growth with total capacity increasing 27% to 4.4 GW. Although parabolic trough plants continued to represent the bulk of existing capacity, 2014 was notable for the diversification of technologies in operation, with the world's largest linear Fresnel and tower plants coming on line.

Only the United States and India added CSP facilities to their grids in 2014. However, CSP activity continued in most regions, with South Africa and Morocco the most active markets in terms of construction and planning. Spain remained the global leader in existing capacity.

Stagnation of the Spanish market and an expected deceleration of the US market after a bumper year fuelled further industry consolidation. However, costs are declining, particularly in the global sunbelt, a large variety of technologies are under development, and thermal energy storage (TES) is becoming increasingly important and remains the focus of extensive research and development (R&D).

SOLAR THERMAL HEATING AND COOLING: NEW MARKETS GROWING, ESTABLISHED MARKETS SLOWER

Deployment of solar thermal technologies continued to slow, due largely to declining markets in Europe and China. Cumulative capacity of water collectors reached an estimated 406 GWth by the end of 2014 (with air collectors adding another 2 GWth), providing approximately 341 TWh of heat annually. China again accounted for about 80% of the world market for solar water collectors, followed by Turkey, Brazil, India, and Germany. The trend continued towards larger domestic water heating systems in hotels, schools, and other large complexes. There also was growing interest in the use of advanced collectors for district heating systems, solar cooling, and industrial applications, although advanced systems represent a small fraction of the global market.

In much of Asia, parts of Africa, and Latin America, domestic sales expanded, as did distribution channels, in response to strong market growth in certain segments. By contrast, it was a difficult year for the industry in Europe, where consolidation continued. China's industry was troubled by overcapacity due to weak demand in 2014, but China maintained its long-term lead.

WIND POWER: THE CHEAPEST OPTION FOR NEW POWER GENERATION

The global wind power market resumed its advance in 2014, adding a record 51 GW—the most of any renewable technology—for a year-end total of 370 GW. An estimated 1.7 GW of grid-connected capacity was added offshore for a world total exceeding 8.5 GW.

Wind energy is the least-cost option for new power generating capacity in an increasing number of locations, and new markets continued to emerge in Africa, Asia, and Latin America. Asia remained the largest market for the seventh consecutive year, led by China, and overtook Europe in total capacity. The United States was the leading country for wind power generation. Wind power met more than 20% of electricity demand in several countries, including Denmark, Nicaragua, Portugal, and Spain.

After years of operating in the red, most turbine makers pulled back into the black with all the top 10 companies breaking installation records. Turbine designs for use on- and offshore continued to evolve to improve wind's economics in a wider range of wind regimes and operating conditions.

INVESTMENT FLOWS

GLOBAL INVESTMENT UP IN ALL REGIONS

Global new investment in renewable power and fuels (not including hydropower >50 MW) was up 17% over 2013, to USD 270.2 billion. Including the unreported investments in hydropower projects larger than 50 MW, total new investment in renewable power and fuels reached at least USD 301 billion. Renewables outpaced fossil fuels for the fifth year running in terms of net investment in power capacity additions.

This first increase in three years was due in part to a boom in solar power installations in China and Japan, as well as to record investments in offshore wind projects in Europe. All regions of the world experienced an increase relative to 2013. Investment in developing countries was up 36% from the previous year to USD 131.3 billion. Developing country investment came the closest ever to surpassing the investment total for developed economies, which reached USD 138.9 billion in 2014, up only 3% from 2013.

The most significant dollar increase occurred in China, which accounted for almost two-thirds of developing country investment in renewable power and fuels. The Netherlands and Brazil saw the largest percentage increases. Other top countries included the United States, Japan, the United Kingdom, and Germany. Investment continued to spread to new markets throughout 2014, with Chile, Indonesia, Kenya, Mexico, South Africa, and Turkey each investing more than USD 1 billion in renewable energy.

Solar power and wind were the leading technologies by far in terms of dollars committed, with solar power (mostly solar PV) accounting for more than 55% of new investment in renewable power and fuels (not including hydro >50 MW), and wind power taking 36.8%. Both saw significant increases over 2013: solar power investments rose 25% to USD 149.5 billion, and wind advanced 11% (to USD 99.5 billion). Overall, in 2014, more than a quarter of new investment in renewable energy went to small-scale projects (particularly solar PV).

Geothermal power investment grew by 23%, and ocean energy (up 100%) also fared well although from a very low level. Other renewables did less well: biofuels declined 8% to a 10-year low, biomass and waste-to-energy dropped 10%, and small-scale hydropower slipped 17%.

All investment types saw increases over 2013, with asset finance of utility-scale projects accounting for the vast majority of total investment. The year 2014 also saw the creation of two new South-South development banks: the USD 100 billion New Development Bank created by the five BRICS countries, and the Asian Infrastructure Investment Bank created by 23 Asian countries. The expansion of new investment vehicles for renewables—such as green bonds, yield companies, and crowdfunding—have attracted new classes of capital providers and are helping to reduce the cost of capital for financing renewable energy projects.

DISTRIBUTED RENEWABLE ENERGY FOR ENERGY ACCESS

PROVIDING ESSENTIAL AND PRODUCTIVE SERVICES

More than 1 billion people, or 15% of the global population, still lack access to electricity. With a total installed capacity of roughly 147 GW, all of Africa has less power generation capacity than Germany. Moreover, approximately 2.9 billion people lack access to clean forms of cooking. Distributed renewable energy technologies are helping to improve these numbers by providing essential and productive energy services in remote and rural areas across the developing world. Renewable technologies are playing a large and growing role—via individual household systems and by powering a rapidly growing number of mini- and micro-grids—largely because renewables are cheaper and more convenient than conventional options.

In addition to the further spread of existing, well-established technologies (solar home systems, pico-hydro stations, solar thermal collectors, etc.), 2014 witnessed the evolution of new types of equipment, configurations, and applications. These include simple and inexpensive pico-wind turbines for powering remote telecommunications; solar-powered irrigation kits; and digitisation of ancillary services and monitoring, which allow for improved after-sales services and reduce costs so that companies can reach more people.

Several factors have resulted in increased funding (public and private) for distributed renewable energy. These include the increased recognition that isolated cooking and electricity systems, particularly renewable systems, are the most cost-effective options available for providing energy services and new economic opportunities to households and businesses in remote areas.

As such, renewables have become vital elements of rural electrification and clean cooking targets and policies in many countries. Peru was one of the first countries to prepare and implement a reverse auction for distributed renewable energy, finalising a contract in 2014. Several countries initiated new programmes in 2014 to expand energy access through renewables—including Chile, Myanmar, and Sri Lanka advancing renewables for electricity; and Ecuador, Guatemala, Bangladesh, and India launching initiatives to advance clean cooking.

Dozens of international actors were involved in advancing energy access with renewables in 2014, through international initiatives such as Sustainable Energy for All (SE4ALL), as well as through bilateral and multi-lateral government programmes. Multilateral financial institutions and development banks also continued to finance renewable energy projects in 2014. Alongside traditional actors, public-private partnerships and non-governmental organisations are promoting distributed renewables.

Involvement of the private sector is expanding, due largely to a growing awareness that off-grid, low-income customers represent fast-growing markets for goods and services. Distributed renewable systems continued to attract investment from venture capitalists, commercial banks, and companies in 2014, as well as from less-conventional sources.

ENERGY EFFICIENCY: RENEWABLE ENERGY'S TWIN PILLAR

Special synergies exist between energy efficiency and renewable energy sources in both technical and policy contexts, and across numerous sectors from buildings and electrical services to transportation and industry. Although energy intensity (primary energy consumption per unit of economic output) has improved globally and in almost all world regions since 1990, there are vast opportunities to improve energy efficiency further in all sectors and countries.

Drivers for policies to promote efficiency improvements include advancing energy security, supporting economic growth, and mitigating climate change. In poorer countries, increased efficiency can make it easier to provide energy services to those who lack access. To meet such goals, an increasing number of countries has adopted targets and policies to improve the efficiency of buildings, appliances, transport vehicles, and industry.

In 2014, targets were in place at all levels of government, and numerous countries introduced new policies or updated existing ones in order to achieve their targets. Several jurisdictions enacted performance requirements or incentives to improve building efficiency during 2013 and 2014. Standards and labelling programmes are the primary tools to improve the efficiency of appliances and other energy-consuming products, and, by 2014, 81 countries had such programmes. By the end of 2013, standards for electric motors used in industrial applications had been introduced in 44 countries. As of late 2014, vehicle fuel economy standards covered 70% of the world's light-duty vehicle market.

To date, there has been relatively little systematic linking of energy efficiency and renewables in the policy arena. However, a small but growing number of policies has begun to address them in concert, particularly through building-related incentives and economy-wide targets and regulations.

MAINSTREAMING RENEWABLES: KEY FINDINGS FOR POLICYMAKERS

Government support policies and increased cost-competitiveness, particularly for electricity generated from wind and solar photovoltaics (PV), have driven recent renewable energy development, resulting in changing market conditions for deployment. Future policies need to respond to emerging opportunities and challenges by addressing new developments, including: the spread of renewable energy deployment to new countries, particularly in the developing world; the need to improve existing energy infrastructure and markets in order to integrate high shares of renewable power; and the increasing electrification of non-power sectors (i.e., heating, cooling, and transport).

As the *Renewables Global Status Report* documents, renewables play an increasingly central role in the provision of energy services to people globally. The challenge now is to develop the necessary policy frameworks to drive the renewable energy transition to achieve sustainable and universal energy access for all.

DEVELOP STABLE AND PREDICTABLE POLICIES THAT CAN ADAPT TO A CHANGING ENVIRONMENT

Stability and predictability of policy frameworks are required to underpin sustained deployment of renewable energy. The renewable energy industry needs predictability in order to attract investment, build up production capacity, develop new technologies, and expand the number of sustainable jobs.

However, policies also need to have a degree of flexibility so that they can accommodate upcoming market developments and avoid unnecessary public spending. It is essential to avoid abrupt changes in the policy environment (for example, sudden reversal of feed-in policies can have major negative impacts for the industry).

Therefore, transitions towards new policy systems require full knowledge of coming changes and sufficient time for the industry to adapt its business models.

SHOWCASE AND COMMUNICATE THE ABILITY OF RENEWABLES TO PROVIDE LARGE-SCALE ELECTRICITY SUPPLY

Many developing countries are under pressure to rapidly increase energy generation capacities to address growing demand, to meet energy access challenges, and to foster economic development. Decision makers faced with such pressures often underestimate the potentially significant and rapid contribution that renewables can make. The successful integration of high shares of renewables in existing infrastructure in China, Denmark, Portugal, Spain, and the United States, for example, demonstrates that the right mix of renewable energy technologies, energy efficiency improvements, and smart management can provide an affordable and reliable power supply.

Communicating and learning from such successes and experiences is important to correct the misperception that baseload power cannot be provided by a mix of renewable energy sources.

CREATE A LEVEL PLAYING FIELD TO INCREASE COST-COMPETIVENESS

Global subsidies for fossil fuels and nuclear power remain high despite reform efforts. Estimates range from USD 550 billion (International Energy Agency) to USD 5.6 trillion per year (International Monetary Fund), depending on how "subsidy" is defined and calculated.

Growth in renewable energy (and energy efficiency improvements) is tempered by subsidies to fossil fuels and nuclear power, particularly in developing countries. Subsidies keep conventional energy prices artificially low, which makes it more difficult for renewable energy to compete. Artificially low prices also discourage energy efficiency and conservation.

Creating a level playing field can lead to a more-efficient allocation of financial resources, helping to strengthen initiatives to advance the development and implementation of energy efficiency and renewable energy technologies. Removing fossil fuel and nuclear subsidies globally would reflect more accurately the true cost of energy generation.

Where energy or fuel subsidies focus on consumers, particularly in developing countries, subsidies should be shifted towards energy efficiency and renewable energy options.

RENEWABLE POWER: ENERGY SYSTEM THINKING IS REQUIRED

To increase shares of variable solar and wind power generation, a variety of technologies must be integrated into one resilient power supply. Thus, policy programmes should shift away from single-technology support schemes towards measures that support a balanced combination of diverse technologies. Policy and regulatory mechanisms must: support/enable more flexible power grids; increase demand-side management; and integrate renewable energy-based power systems with the transport, buildings, industry, and heating and cooling sectors.

Utilities and grid system operators also play an important role in managing demand and generation in renewable energy-dominated energy systems. Demand-side management of industries, transport systems, and households, as well as the operation of distributed generation fleets, require different energy policies to support new business models. The deployment of new technologies to allow for mainstreaming higher shares of dispatchable renewable generation is also necessary and requires new incentives to drive infrastructure investment.

Policymakers should work with utilities and grid system operators, in addition to major energy consumers (e.g., energy-intensive industries), to define new policy mechanisms and regulatory structures.

INCREASE SUPPORT TO THE RENEWABLE HEATING AND COOLING SECTOR

Globally, heating and cooling accounts for almost half of total global energy demand. However, this sector continues to lag far behind the renewable power sector when it comes to policies that support technology development and deployment.

Building obligations (both for energy efficiency improvements and deployment of renewable technologies) are central to increasing the penetration of renewable heating and cooling technologies. In addition to buildings, it is important that there are requirements to integrate renewable energy into industrial and district heating systems. These support not only the development of renewable energy heating, but also the integration of variable power generation, relieving pressure on power grids.

Policymakers at all levels of government need to support the development of renewable heat given the large share of heat in final energy demand. Further development of integrated approaches for the heating and electricity sectors also can contribute to reducing grid pressure.

IMPROVE ACCESS TO FINANCE IN DEVELOPING COUNTRIES

In developing countries, access to financial resources is central to establishing a diversified, stable energy supply. With renewable energy, expansion of the energy supply for all customer groups is becoming increasingly a political and financial challenge, not a technical one. Deployment is often constrained by a lack of available financial resources, high costs of capital, or reluctance on the part of investors.

In order to expand energy markets to reach full energy access, the public sector needs to ensure political stability, which in turn sends a positive signal to investors. Public finance mechanisms such as preferential loans and grants as well as loan guarantees can be effective in leveraging private sector investment by overcoming the lack of private financial instruments, facilitating market development, and mitigating risk. Financial instruments can be implemented on both the supply and demand sides, supporting project developers and energy users to drive the evolution of projects to high-capacity deployment. Additionally, acquiring financing and buy-in necessitates trust in the technology, which requires the development of standards, certification, etc. to ensure quality. This is similarly important for developing local industries and the ability to export renewable energy products.

DRIVE GOOD DECISIONS WITH GOOD DATA

Reliable, timely, and regularly updated data are essential for establishing energy plans, defining targets, designing and continuously evaluating policy measures, and attracting investment. The data situation for renewable energy—especially in the power sector—has improved significantly in recent years. Nonetheless, data availability, accessibility, and quality remain limited for distributed renewable energy (including modern renewable heat), in particular. Improved and consolidated data are required to understand market potential, to drive policy development, and to attract investors.

Policymakers should pay particular attention to improving the data situation on distributed renewable energy in developing countries and on renewable energy heating and cooling; due to the decentralised nature of these sectors, both present major data challenges, but they are key to meeting energy access goals and driving the energy transition, respectively. Innovative and collaborative approaches to data collection, processing, and validation are necessary. Informal data are central to closing data gaps, but they require collaboration with new players from a variety of non-energy sectors (such as agriculture, industry, and health), as well as the integration of new methods and approaches for data collection.

There is a critical need to broaden the definition of renewable energy data, to collect data in a regular and more systematic manner, and to increase transparency.

For decentralised renewable energy for energy access, policymakers and donors need to build into their programmes and activities continuous data collection and reporting.

01

The most successful biological organisms avoid centralised control in favour of allowing multiple agents to sense independently and **respond quickly to environmental change. The OCTOPUS,** which has a powerful central brain, knows how to balance its advanced cognitive capabilities with quick responsiveness by decentralising the decision-making function. Similarly, **distributed and decentralised energy systems** using renewable energy can be designed to adapt more quickly to changing energy demands.

01 GLOBAL OVERVIEW

Renewable energy continued to grow in 2014 against the backdrop of increasing global energy consumption and a dramatic decline in oil prices during the second half of the year.[1] Global final energy consumption has increased by about 1.5% annually in recent years, driven primarily by rising demand in developing countries.[2]

Despite rising energy use, for the first time in four decades, global carbon emissions associated with energy consumption remained stable in 2014 while the global economy grew.[3] Whereas previous emissions decreases were associated with downturns in the global economy, the carbon stabilisation in 2014 has been attributed to increased penetration of renewable energy and improvements in energy efficiency.[4] Looking ahead, several countries—including China, Mexico, and the United States—as well as the European Union have announced climate change commitments that set the stage for future investment in renewables and energy efficiency.[5]

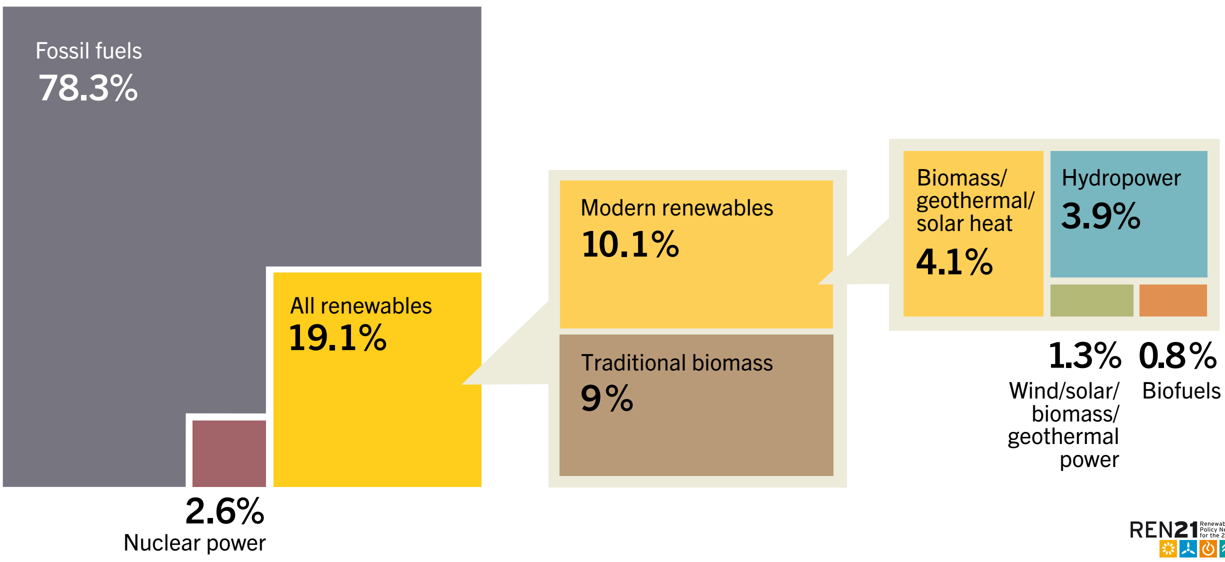
There is rising awareness worldwide that renewable energy and energy efficiency are critical not only for addressing climate change, but also for creating new economic opportunities, and for providing energy access to the billions of people still living without modern energy services.[i] Renewables are vital elements of rural electrification programmes in many countries, and dozens of international actors were involved in advancing energy access through renewables during 2014.[6]

In recognition of the importance of renewable energy and energy efficiency for sustainable development, the United Nations General Assembly declared 2014 the first year of a Decade of Sustainable Energy for All[ii] (SE4ALL).[7] SE4ALL aims to double the share of renewable energy in the global energy mix from a baseline share of 18% in 2010 to 36% in 2030.[8]

By 2013, the most recent year for which data are available, renewable energy provided an estimated 19.1% of global final energy consumption. Of this total share, traditional biomass, used primarily for cooking and heating in remote and rural areas of developing countries, accounted for about 9%, and modern renewables increased their share slightly over 2012 to approximately 10.1%.[9] (→ See Figure 1.)

Modern renewable energy is being used increasingly in four distinct markets: power generation, heating and cooling, transport, and rural/off-grid energy services. (→ See Distributed Renewable Energy section.) In 2013, hydropower accounted for an estimated 3.9% of final energy consumption; other renewable power sources comprised 1.3%; renewable heat energy accounted for approximately 4.1%; and transport biofuels provided about 0.8%.[10]

Figure 1. Estimated Renewable Energy Share of Global Final Energy Consumption, 2013



Source: See Endnote 9 for this section.

i - An estimated 1.2 billion people worldwide lack access to electricity, and 2.8 billion people rely on traditional biomass for cooking and heating. See United Nations Sustainable Energy for All (SE4ALL), "United Nations Decade of Sustainable Energy for All 2014-2024," http://www.se4all.org/decade/, viewed 10 April 2015.

ii - SE4ALL has three interlinked objectives: ensuring universal access to modern energy services, doubling the global rate of improvement in energy efficiency, and doubling the share of renewable energy in the global energy mix. See SE4ALL, "Our Objectives," http://www.se4all.org/our-vision/our-objectives/, viewed 10 April 2015.

In 2014, renewable energy overall expanded significantly in terms of capacity installed and energy produced. Some technologies experienced more rapid growth in deployment in 2014 than they have averaged over the past five years.[11] (→ See Figure 2.) In the heating sector, capacity installations continued at a steady pace; the production of biofuels for transport increased for the second consecutive year, following a slowdown in 2011-2012. The most rapid growth, and the largest increase in capacity, occurred in the power sector.

Although many renewable energy technologies have experienced rapid expansion, growth in capacity and improvements in energy efficiency are below the rates necessary to achieve the SE4ALL goal.[12] Further, the bulk of new capacity and investment has centred on just three technologies: solar PV, wind, and hydropower.

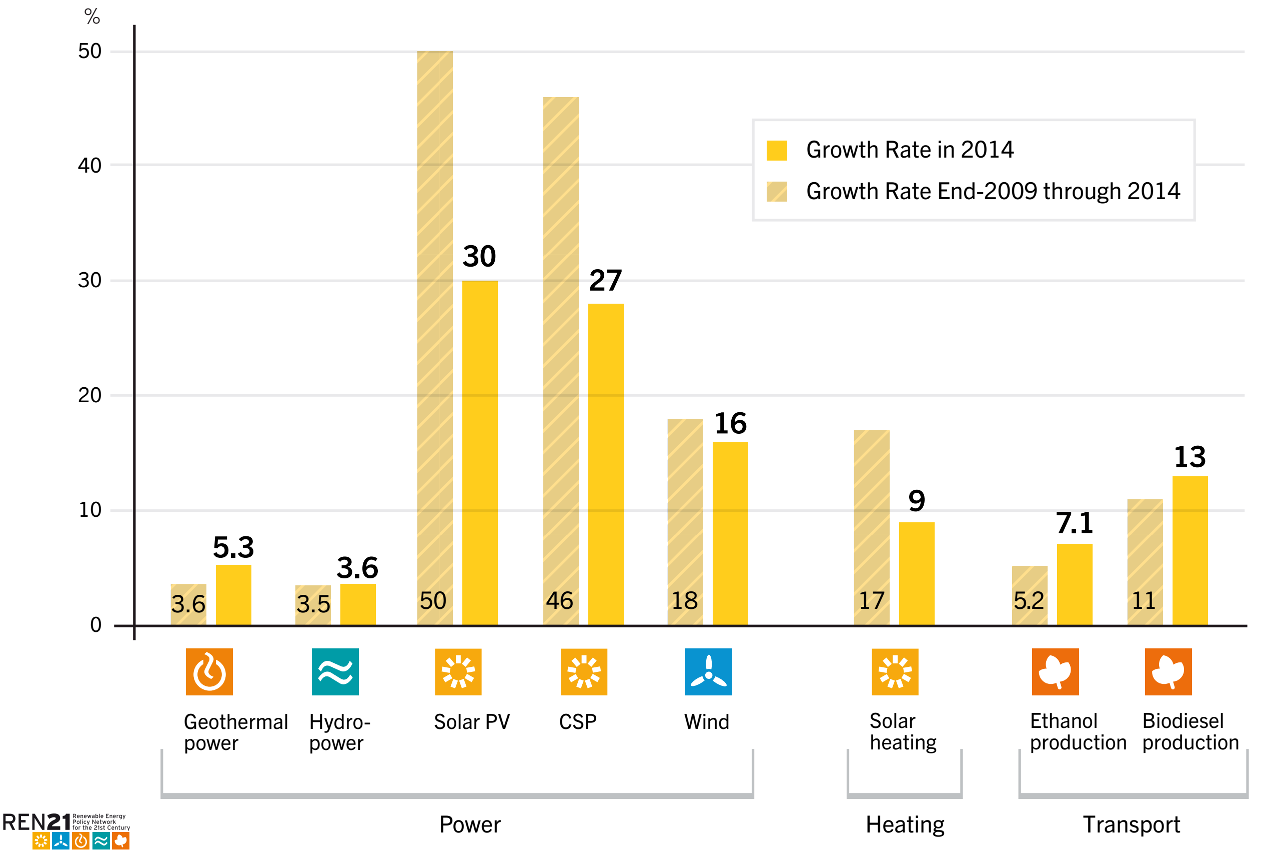
Renewable energy developments in 2014 continued to be driven largely by government policy.[13] (→ See Policy Landscape section.) Renewables faced challenges in some countries resulting from policy changes or uncertainties, such as the imposition of new taxes in Europe and the expiration of the US federal production tax credit. At the same time, the number of countries with renewable energy targets and policies increased again in 2014, and several jurisdictions made their existing targets more ambitious. Policymakers have focused predominantly on the power sector, with the least attention paid to heating and cooling and to transport beyond biofuels, a trend that has helped to shape the current landscape.

By early 2015, several jurisdictions had 100% renewable energy or electricity targets in place. The vast majority of such targets exist at the city/local level, with a growing number of state and provincial governments pursuing 100% goals.[14] Increasingly, 100% renewable energy and electricity goals also are being explored and deployed at the national level—for example, in countries such as Cabo Verde, Costa Rica, and Denmark.[15]

Growth also is driven by the increasing cost-competiveness of renewable energy. Renewable energy costs continued to decline in 2014, and in many countries renewables are broadly competitive with conventional energy sources.[16] In terms of cost and environmental performance, distributed renewable systems also are competitive with fossil fuels (especially diesel) for heat and electricity in islands and remote jurisdictions, and, in general, for providing access to modern energy services.[17] In remote and rural areas of developing countries—and increasingly deployed to power mini- and micro-grids—renewables are playing a large and growing role in providing essential and productive energy services, due largely to growing recognition of their cost-effectiveness.[18]

At the same time, growth in renewable energy (and energy efficiency improvements) continues to be tempered by subsidies to fossil fuels and nuclear power, particularly in developing countries. Subsidies keep conventional energy prices artificially low, which makes it more difficult for renewable energy to compete. Artificially low prices also discourage energy efficiency and conservation, which increases the amount of energy that renewables must produce in order to meet the SE4ALL goals.[19] In 2013, global subsidies for fossil fuels exceeded USD 550 billion.[20] In 2014, close to 30 countries reduced or eliminated their fossil fuel subsidies, with some doing so in response to low oil prices.[21]

Figure 2. Average Annual Growth Rates of Renewable Energy Capacity and Biofuels Production, End-2009–2014



Source: See Endnote 11 for this section.

SIDEBAR 1. REGIONAL SPOTLIGHT: EAST ASIA

As a region, East Asia has become the world's largest consumer and producer of renewable energy, as well as the largest investor in renewable technologies. East Asia comprises the major economies of Northeast Asia (China, Japan, South Korea, and Taiwan) and the fast-growing economies of Southeast Asia (such as Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam).

Renewable energy has become vital to East Asia for various reasons. The region is the world's largest emitter of carbon; many of its societies are highly susceptible to climate change risks; and pollution in its burgeoning cities is causing millions of premature deaths annually. Renewables not only bring greatly needed clean energy options to East Asia, but also help to mitigate energy supply security risk, especially due to the region's growing import dependence on fossil fuels. Most East Asian countries also view renewable energy as a key strategic component of new industrial policies.

By 2013, East Asia's total renewable power generating capacity was an estimated 457 GW (more than 29% of the global total), and China accounted for over 80% of this amount. Hydropower represented a significant proportion of the total (322 GW, with 260 GW in China), but wind energy has come to the fore as a major sector, driven predominantly by China. China and Japan were the world's top two solar PV markets; the Philippines and Indonesia were the world's second and third largest geothermal power generators, respectively; and South Korea led in tidal barrage energy.

East Asia also is a world leader in the renewable heat sector. China has been responsible for over 80% of solar water heater (SWH) capacity additions in recent years and currently hosts around two thirds of the global total. In biofuels, however, East Asia lags behind the big global players, accounting for just some 3% of world ethanol production and 12% of biodiesel production.

Similarly impressive figures can be found on equipment production. A decade ago, China made just 5% of the world's solar PV modules; now it makes two thirds. China manufactures around three quarters of global SWHs. The country also produces more wind turbines (large and small) than any other country. China has helped to drive down the costs of a range of renewable energy products. Japanese, South Korean, and Taiwanese firms are among the technology leaders in many sectors—including solar PV, ocean, and geothermal energy—and China is rapidly developing its indigenous capacity for technology innovation across the renewables spectrum.

A key trend across the region is for governments to integrate renewable energy into long-term, multi-sector strategies and policies. South Korea's Green Growth Strategy, Japan's New Growth Strategy, China's 12th Five-Year Plan, Vietnam's Green Growth Strategy, and the 10th Malaysia Plan all include ambitious programmes of renewables development. Furthermore, energy state-owned enterprises in the region are key players in renewables installation, equipment production, supporting infrastructure, new technology development, and investment.

The credibility of state plans has been called into question, however, as a result of underperformance. Some national targets have been missed repeatedly (e.g., South Korea and Japan), some governments have been accused (mainly domestically) of lacking ambition in key sectors (Japan, South Korea, Taiwan, Singapore), and some long-term plans have been frequently revised (e.g., Thailand has launched three long-term "alternative energy" strategies in just six years).

Nevertheless, these same plans have introduced well-funded policy incentives and other forms of state support, as well as improved legislative frameworks at the national, regional, and local levels; these developments have helped catalyse the rapid deployment of renewable energy in East Asia over the last decade. Feed-in tariffs, auctions, enabling building codes, and renewable portfolio standards have become increasingly popular policy instruments. A growing number of city and provincial governments are also devising their own strategies and policies on renewables, promoting deployment at the local level.

Fast-growing and substantial energy demand, diverse commercial opportunities, and dynamic entrepreneurism have further spurred renewable energy market and industry development. East Asia has a population of 2.2 billion and remains the world's fastest-growing regional economy. Its huge potential for both distributed generation and utility-scale renewable energy installations is being exploited in urban and rural areas alike. Although state-owned enterprises dominate most value-chain aspects of China's renewables industry, a dynamic private sector has emerged in solar and wind energy equipment manufacturing with firms such as Sinovel, Goldwind, Trina, and Yingli—all of which are now world leaders.

Various challenges lie ahead for further scaling up renewables in East Asia. Large-scale hydropower has proved highly controversial in China and Southeast Asia, and is reaching its exploitable potential. Transmission infrastructure bottlenecks continue to impede wind energy development in China and elsewhere in the region. And contentious issues concerning environmental sustainability and food security are arising in the bioenergy sector. Ongoing coal capacity expansion in the region might come at the expense of even greater renewable energy deployment.

In addition, recent trade disputes over China's exports of solar PV modules, wind turbines, and rare earth minerals have arisen due to claims of "unfair" state interventions, and future disputes appear likely as global competition intensifies in rapidly growing sectors such as wind and solar energy. Competitive East Asian firms are likely to benefit significantly, however, if the World Trade Organization's Environmental Goods Agreement is signed and its membership expanded. Finally, further engaging East Asian society in the clean energy revolution will be critical if the region is to rely less on the top-down, state-led promotion of renewables development.

Source: See Endnote 23 for this section.

As costs fall, renewable energy markets continue to diversify geographically.[22] While Europe remained an important regional market and a centre for innovation, activity continued to shift towards other regions. China again led the world in new renewable power capacity installations in 2014, and Brazil, India, and South Africa accounted for a large share of the capacity added in their respective regions.[23] (→ See Sidebar 1.) At the same time, the number of developing countries across Asia, Africa, and Latin America that were manufacturing and deploying renewable energy technologies continued to expand.[24]

Global investment in renewable power and fuels rebounded in 2014, with increased investment in all regions of the world. Renewables outpaced fossil fuels for the fifth year running in terms of net investment in power capacity additions, due almost entirely to increased investment in solar and wind power.[25] (→ See Investment Flows section.)

By dollars spent, the leading countries for investment were China, the United States, Japan, the United Kingdom, and Germany. However, considering investments made in new renewable power and fuels relative to annual GDP, top countries included Burundi, Kenya, Honduras, Jordan, and Uruguay.[i] The leading countries for investment per inhabitant were the Netherlands, Japan, Uruguay, the United Kingdom and Ireland and Canada (both about even).[26]

New investment vehicles for renewables—such as green bonds, yieldcos[ii], and securitisation—also expanded, as did the number and variety of crowdfunding platforms for renewable energy in developed and developing countries.[27] (→ See Distributed Renewable Energy section.) These innovations attract new classes of capital providers (e.g., institutional and retail investors) and help to reduce the cost of capital for financing renewable energy projects, which, in turn, further improves the competitiveness of renewable energy.

In parallel with growth in renewable energy markets, 2014 saw significant advances in the development and deployment of storage systems across all energy sectors. Energy storage (via pumped storage, batteries, thermal storage, and other means) is used primarily to provide peak shifting and frequency regulation services in the power sector, with very small but growing markets for the use of batteries for electric vehicle propulsion in the transportation sector, and for thermal energy storage in the heating and cooling sector.[28] Although batteries comprise only a small part of global storage capacity, several trends may signal future market ramp-up.[29] For example, innovative business and deployment models that integrate renewables and on-grid storage expanded in 2014, and massive manufacturing plants for the production of lithium-ion batteries were announced in China and the United States.[30]

Another trend that continued to emerge in 2014 is the increasing electrification of transportation and heating applications, highlighting the potential for further overlap among the sectors in the future. [31] The increasing electrification of personal vehicles and heating systems likely will require greater amounts of renewable capacity in order to meet existing power sector targets (e.g., RPS). At the same time, electric transportation and heating can be used to balance variable renewable power generation. Electric heating, for example, is being used for balancing both at the system level (e.g., using electricity from the grid to feed heat into district heating networks) and at the consumer level (e.g., the combination of solar PV and heat pumps).

POWER SECTOR

The most significant renewables growth in 2014 occurred in the power sector, with global renewable power capacity reaching an estimated 1,712 GW at year's end, an increase of 8.5% over 2013.[32] Hydropower capacity rose by 3.6% to approximately 1,055 GW, while other renewables collectively grew nearly 18% to an estimated total approaching 660 GW.[33] Globally, wind and solar PV each saw record capacity additions, each surpassing hydropower and together they accounted for more than 90% of non-hydro installations in 2014.[34] (**→ See Reference Table R1.**).

In 2014, renewables made up an estimated 58.5% of net additions to global power capacity and represented far higher shares of capacity added in several countries around the world.[35] By year's end, renewables comprised an estimated 27.7% of the world's power generating capacity.[36] This was enough to supply an estimated 22.8% of global electricity, with hydropower providing about 16.6%.[37] (→ See Figure 3.) Over the period 2007–2012, renewable power generation grew at an average rate of 5.9% per year.[38] In contrast, global electricity consumption increased by an annual average rate of 2.7% in the same period, with electricity consumption in non-OECD countries growing twice as rapidly.[39]

Variable renewables are achieving high levels of penetration in several countries. For example, throughout 2014, wind power met 39.1% of electricity demand in Denmark, 27% in Portugal, and 21% in Nicaragua; solar PV capacity in operation at the end of 2014 was enough to meet an estimated 7.9% of electricity demand in Italy, 7.6% in Greece, and 7% in Germany.[40]

By the end of 2014, China, the United States, Brazil, Germany, and Canada remained the top countries for total installed renewable electric capacity.[41] China was home to approximately one-fourth of the world's renewable power capacity, including about 280 GW of hydropower.[42] The top countries for non-hydro capacity were China, the United States, and Germany; they were followed by Italy, Spain, Japan, and India, which all ended the year with similar capacity levels.[43] (→ See Figure 4 and **Reference Table R2.**) Among the world's top 20 countries for non-hydro renewable power capacity, those with the highest capacity amounts per inhabitant were all in Europe. Denmark had a clear lead and was followed by Germany, Sweden, Spain, and Portugal.[iii 44]

- Regionally, **Asia** installed the most generating capacity–led by China, which added the most wind power, solar PV, and hydropower capacity of any country in the world.[45] There

i - Note that investments funds may have been sourced from outside of these countries. Others among the top 10 are Panama, Costa Rica, China, Fiji, and the Netherlands.

ii - A yield company is a corporate entity created specifically to hold high-yielding investments in operating-stage projects. Securitisation refers to the process of pooling assets with similar characteristics (e.g., solar PV systems) to reach scale sufficient for issuing a series of securities with different claim priorities on those assets, and selling the securities to investors.

iii - While there are other countries with high per capita amounts of renewable capacity and high shares of renewable electricity, the GSR focuses here on the top 20 countries for total installed capacity of non-hydro renewables. Several other countries, including Austria, Finland, Ireland, and New Zealand, also have high per capita levels of non-hydro renewable power capacity, with Iceland likely the leader among all countries. (See Reference Table R13 for country shares of electricity from renewable sources.)

also was significant market growth in Asia more broadly, with Thailand adding more solar PV (0.5 GW) than many European countries, and the Philippines and Pakistan each bringing on line significant amounts of wind power capacity.[46]

- Within the **European Union**, renewables accounted for the majority (78%) of new generating capacity for the seventh year running. Germany increased its share of non-hydropower renewable generation from 10.5% in 2010 to 24% by 2014, whereas Scotland supplied close to half of its electricity from renewables in 2014.[47]
- **North America** experienced significant solar PV and wind market growth, although the vast technical potential for both resources remains largely untapped. In the United States, more renewable energy capacity was built than natural gas capacity, and non-hydropower resources out-produced hydropower for the first time.[48]
- In **Latin America and the Caribbean**, Brazil continued to lead in terms of total new capacity additions. Brazil commissioned over 3 GW of hydropower and a record 2.5 GW of wind power capacity.[49] Both Chile and Mexico achieved significant increases in wind and solar PV, and Uruguay added the most wind capacity per capita globally.[50]
- **Africa** also saw a surge in new renewable energy installations. South Africa was among the top 10 solar PV markets for the first time (ranked 9th), ahead of India, and led the continent in new wind installations.[51] Kenya installed more than half of the world's new geothermal capacity, and Rwanda significantly increased its total generating capacity with the addition of new hydropower capacity (at least 30 MW) and an 8.5 MW solar PV plant.[52]

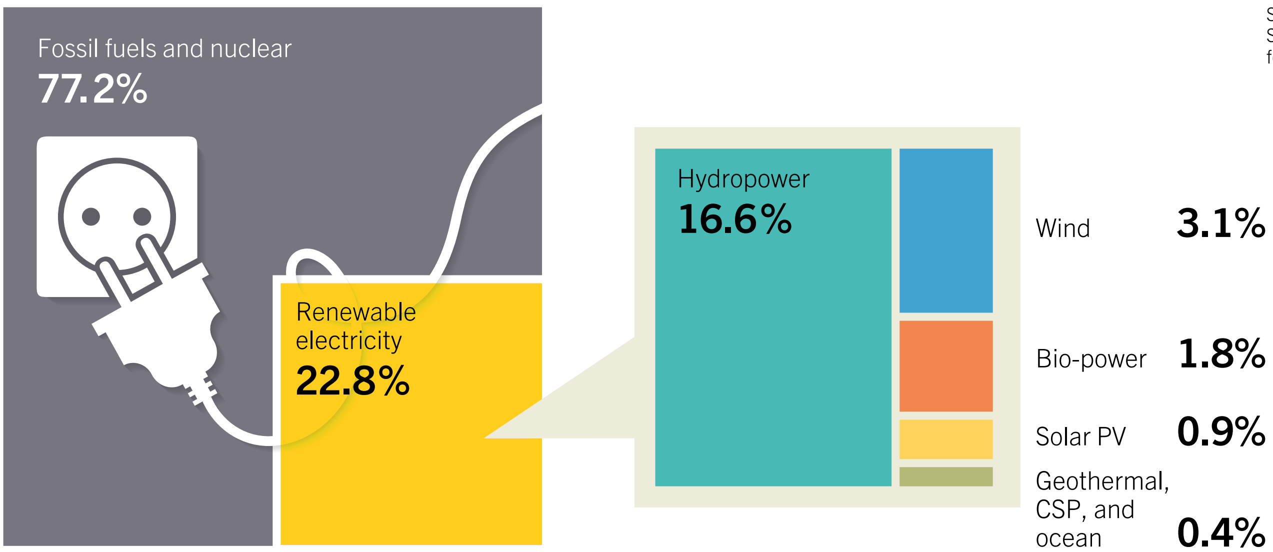
The rapid growth of renewable energy generation created both challenges and opportunities in 2014. In countries where energy consumption is expanding, both renewable energy and fossil fuel generation are developing in parallel to meet growing demand. In countries with slow or negative growth in electricity consumption (e.g., several OECD countries), renewable energy increasingly is displacing existing generation.[53] In response to this competition, some utilities and electricity suppliers in Europe and North America are repositioning by acquiring significant renewable energy assets, decreasing fossil fuel investments, and acquiring other utilities that already have significant amounts of renewable energy in their generation portfolios.[54]

At the same time, policymakers in some jurisdictions are requiring utilities to update their business models and grid infrastructure to support increased shares of renewable energy.[55] In addition, several countries and regions continued to strengthen their transmission systems in 2014, to increase capacity for higher penetrations of variable renewables, and to build transmission lines specifically to access strong renewable resources, for example in India and Africa.[56] Countries around the world also are exploring other new and innovative approaches to accommodating rising shares of renewable energy.[57] (→ See Sidebar 2.)

Globally, renewable electricity production in 2014 continued to be dominated by large (e.g., megawatt-scale) generators that are owned by utilities or large investors. Yet Australia, Europe, Japan, and North America also have seen significant growth in numbers of residential "prosumers"—electricity customers who produce their own power.[58] France held national dialogues on how to best support (and manage) prosumers, and the European Union began exploring guidance for member nations on self-consumption regulations.[59] In developed and developing countries, industrial prosumers also produced significant amounts of renewable generation from waste biomass associated with agriculture and forestry.[60]

Community and co-operative ownership of grid-connected renewables also expanded during 2014, particularly for solar PV. Feed-in tariffs supporting community-owned renewables continued to operate in jurisdictions such as Thailand and Nova Scotia.[61] Also, the first community-owned ocean energy system

Figure 3. Estimated Renewable Energy Share of Global Electricity Production, End-2014



Source: See Endnote 37 for this section.

Based on renewable generating capacity in operation at year-end 2014.

REN21 Renewable Energy Policy Network for the 21st Century

SIDEBAR 2. INNOVATING ENERGY SYSTEMS: POWER SYSTEM TRANSFORMATION

Power systems have been planned and operated in much the same way for generations. Today, however, a broad constellation of factors is driving significant change: growing concerns over the local and global impacts of fossil fuel emissions; a swiftly evolving energy security landscape; the imperative of universal energy access; rapidly changing technology costs; greater democratisation of energy supply; increased interactions with water and land-use sectors; and dramatic advances in network intelligence and system optimisation.

These forces call for significant power system transformation. Evidence from around the world shows that technical and institutional innovations are arising to unlock new system capabilities. Key innovations that have emerged and have begun to diffuse fall broadly into four categories: planning processes, operational practices, prices and tariffs, and enabling technologies. Examples include:

Planning Processes. As water, climate, and health impacts of energy production have become more widely understood and measured, they are being explicitly incorporated into integrated resource planning in some jurisdictions. For example, in the arid southwest of the United States, the Arizona Public Service (APS) utility planning process examines risks and benefits across a range of water and emissions scenarios, leading to greater emphasis on renewable energy technologies for supply. Several emerging markets also are shifting to more pro-active and comprehensive energy planning processes to account for unique characteristics such as energy access and economic development.

In jurisdictions with already high and growing shares of renewables, planning processes are evolving to include, among other things, better geospatial analysis of renewable energy resources, new approaches to co-ordinating transmission grid build-out with renewable generation, and more detailed reliability metrics to ensure reliable power systems as renewable shares grow. For example, the transmission system operator in Ireland (EirGrid) has developed a multi-phase process to maintain orderly deployment of transmission and wind generation, and it employs highly detailed reliability analyses to explore system operation under future wind generation scenarios.

Operational Practices. Balancing electricity supply and demand has always had an element of variability and uncertainty, and this grows along with the share of renewables. A variety of operational practices allow this growth to be managed cost-effectively and reliably, including improved weather forecasting, improved generator scheduling, and increased co-ordination with neighbouring grid systems. Better forecasting, for example, has diffused into nearly all major systems with significant amounts of wind power, such as in Canada, China, Germany, Ireland, Portugal, Spain, and the United States.

Prices and Tariffs. The design of prices and tariffs has been a linchpin of power system architecture. Today, prices and tariffs are increasingly important not only in driving renewable energy adoption but also in encouraging demand response, flexible performance from generators, energy efficiency, and investments in distributed generation. For example, various markets with high shares of renewables are witnessing general reductions in the wholesale market prices of electricity, as wind and solar bid with zero or near-zero incremental costs. These price reductions may reduce the profitability of those conventional generators that can provide essential grid services. In response, some market operators are implementing specific products—such as capacity payments or "pay-for-performance" mechanisms—to adequately compensate generators and demand-response providers for their services in providing dispatchable supply and in balancing the grid.

Enabling Technologies. To support power system transformation, investment is increasing in enabling technologies, including innovative water-saving generation technologies, "smart" inverters for new solar PV generation that can enable dynamic power output adjustments, smart meters and other technologies to enable demand response, battery and pumped hydro storage, and flexible thermal generators. For example, German utilities are retrofitting existing coal-fired power plants to enable them to ramp up and down more rapidly in order to integrate variable renewable resources more flexibly. In Denmark, CHP plants serve as a storage reservoir for variable wind power.

Together, these innovations give a sense of how broadly the landscape is changing in response to, and in support of, renewable energy deployment. The coming decades likely will bring even more change as the costs drop for renewables, storage, and network intelligence technologies. Strategic management of power system transformation will consequently become an increasingly important area of focus.[i]

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.

Source: See Endnote 57 for this section.

i - A deeper discussion of these changes and the road ahead can be found in the *Status Report on Power System Transformation* from the Clean Energy Ministerial, a forum of leading energy ministers that promotes policies and programmes that advance clean energy technology and encourages the transition to a global clean energy economy.

was installed in Scotland.[62] Both Denmark and Germany have a long tradition of community and local ownership of renewable energy systems.[63] In Germany, 47% of the renewable energy generation was owned by individuals or investor co-operatives as of 2012, although that percentage has declined in recent years.[64]

Major corporations and institutions around the world made substantial commitments in 2014 to purchase renewable energy, and a group of corporations committed to achieve 100% renewable energy under the RE100 Initiative.[65] Large companies also independently announced expenditures of several billion dollars to own (or purchase electricity from) renewable energy generators.[66] The mining industry is investing in renewable energy systems to improve reliability and reduce energy costs, with renewable energy systems to generate power and heat installed or under development at mines in Brazil, Canada, Chile, South Africa, and Tanzania.[67]

Voluntary purchases of renewable energy from traditional utilities continued to increase, primarily in the power sector. Germany remains one of the world's green power leaders, and other European countries have active green power markets as well.[68] Germany's market grew from 0.8 million residential customers in 2006 to 5.7 million in 2013, with 14.3% of all private households in the country purchasing a combined total of 19.5 TWh of renewable electricity. When commercial customers are included, green power purchases in Germany exceeded 29.6 TWh.[69]

Green power markets also exist in Australia, Canada, Japan, South Africa, and the United States. More than half of US electricity customers have the option to purchase green power directly from their local utility or electricity supplier. In 2013, US retail green power sales totalled 62 TWh (about 1.7% of total US electricity sales), purchased by approximately 5.4 million customers.[70]

HEATING AND COOLING SECTOR

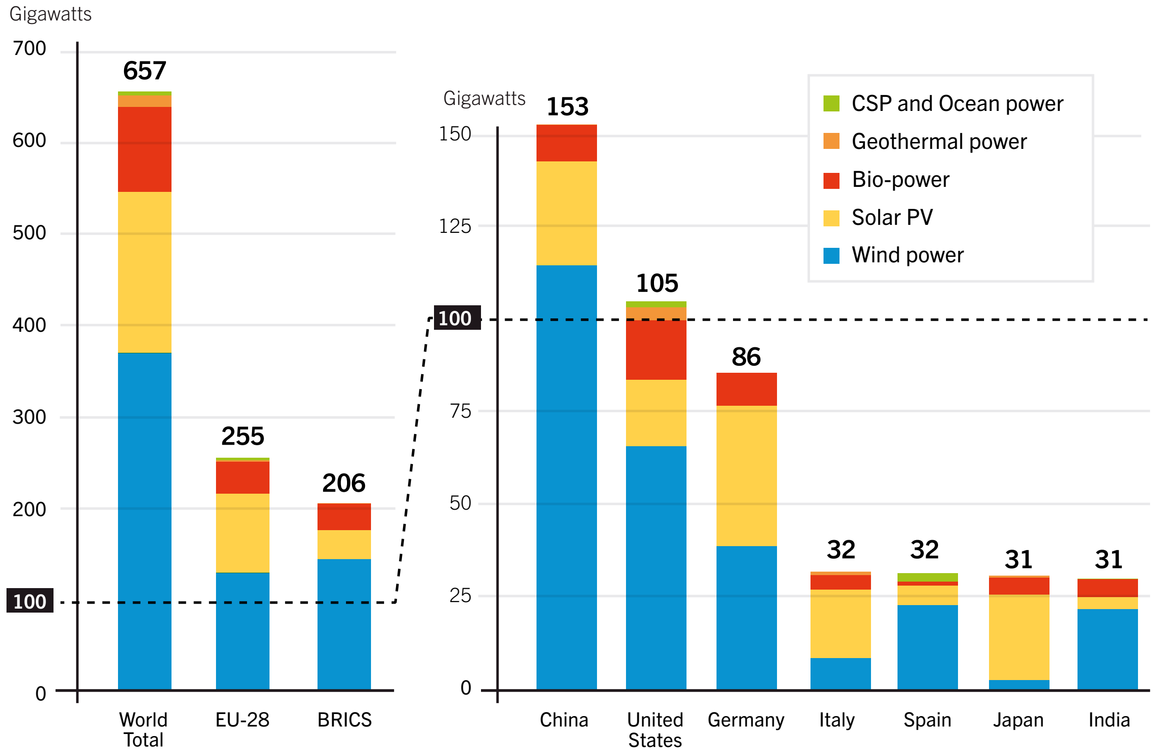
Energy use for heat accounted for about half of total world final energy consumption in 2014.[71] Renewable energy supplied more than 25% of final energy use in the heating sector, of which over two-thirds was traditional biomass.[72] Modern renewable energy supplied the remaining third—or approximately 8% of total heat. Therefore, modern renewable heating accounts for a significant share of renewable energy's total contribution to final energy use. Even so, there exists vast additional potential for the expansion of renewable heat, and for low-temperature heating applications in particular.[73]

In 2014, bioenergy accounted for over 90% of the modern renewable energy portion, with solar thermal and geothermal supplying the remainder.[74] About half of modern renewable heat is consumed by industry, where it meets an estimated 10% of total heat demand and is produced almost entirely from biomass.[75] Growth has been relatively slow in the industry sector in recent years.[76]

The other half of renewable heat consumption occurs in buildings for space heating, water heating, and cooking, and is derived primarily from biomass, with solar and geothermal contributing much smaller shares. Most growth of renewable energy use for heat in the buildings sector has been driven by support policies, although there are increasing numbers of locations and circumstances in which renewable heat technologies are cost-competitive with fossil fuels.[77]

Renewable energy also is used for cooling, and there is growing interest in regions around the world, including Asia, Europe, the Middle East, and North America, where it offers the potential to reduce electricity loads.[78] In recent years, the global solar cooling market has grown at an annual rate exceeding 40%.[79] However, the number of installations worldwide remains limited.[80]

Figure 4. Renewable Power Capacities* in World, EU-28, BRICS, and Top Seven Countries, 2014



Source:
See Endnote 43 for this section.

* not including hydropower (See Reference Table R2 for data including hydropower.)

Global demand for heat energy grew at an average annual rate of 2.6% between 2008 and 2012, driven primarily by increased demand for heat in industry and buildings in developing countries.[81] Cooling demand also has increased dramatically—up 60% during the decade from 2000 to 2010—as a result of improved energy access and rising global temperatures.[82]

In recent years, global growth in the use of traditional biomass for heating has begun to level off due to increasing urbanisation and access to modern energy sources in developing countries.[83] By contrast, global consumption of modern renewable energy in the heating sector increased by an average of 2.4% annually from 2007 to 2013.[84] Despite this increase, the total share of modern renewable energy in the heating sector has remained steady because of continuing growth in final energy use for heat.[85]

Renewable energy for heating is fairly evenly distributed around the world as a result of the use of industrial biomass in many countries. However, there are important differences in renewable heating trends at the regional level:

- **Asia** uses the largest amount of modern renewable energy in the heating sector overall, driven primarily by the amount of industrial bio-heat used in India and other Asian countries.[86] China continued to dominate the global solar heating market in 2014 and to lead the world in the direct use of geothermal, and in biogas for heat.[87]
- **Europe** leads the world in modern renewable energy as a share of heating energy (14.7% in 2013), and European countries such as Iceland, Norway, and Sweden have some of the highest renewable heating penetrations in the world (over 50%).[88] Europe also leads in innovations such as solar thermal combi-systems, the integration of solar heat into district energy networks as well as industrial processes, and the development of smaller-scale geothermal CHP and heating plants.[89]
- The **United States** continued to be a leader in solar water collector capacity during 2014, although this market has slowed in recent years.[90] Overall, total renewable energy for heating in North America declined from 2007 to 2013 due to decreases in biomass consumption in the industrial sector.[91]
- In **Latin America**, expansion of renewable thermal energy use in recent years has been driven primarily by biomass growth.[92] At the same time, Brazil has experienced strong growth in solar water heating, and Mexico also is becoming a notable market; several other countries in the region have experienced growth in solar water heating even without public incentives.[93]
- In **Africa**, modern renewable thermal energy plays a modest but important role, particularly in countries such as Mauritius, Ethiopia, and Kenya that have sugarcane industries fuelling co-generation plants with bagasse.[94] South Africa's solar water heating market led the continent, although markets across Africa continued to add solar heating capacity in 2014.[95]
- In the **Middle East**, solar hot water is an important resource in many countries. Israel leads for total capacity of solar water collectors, followed by the Palestinian Territories, Jordan, and Lebanon.[96] About 85% of Israeli households use solar water heaters.[97] Interest in solar cooling is also rising in the region.[98]

The year 2014 witnessed the continuation of several trends that are increasing renewable energy's potential to play a larger role in the heating and cooling sector. These included: energy efficiency improvements in industrial processes, in heating and cooling systems, and in building materials; rising interest in net zero energy buildings (NZE); and a growing number of countries with NZE mandates for 2020 and beyond. (→ See Energy Efficiency section and Sidebar 7.)

The expansion of district energy systems also may provide increased opportunities for renewable heating and cooling. District energy supplies approximately 12% of residential and commercial heating in Europe, and some countries in Europe and elsewhere have much higher percentages.[99] China, for example, doubled its district heating networks between 2005 and 2011 and supplies an estimated 30% of its heating demand from district systems.[100] Worldwide, an estimated 6% of modern renewable heat in buildings is provided through such networks.[101] A number of developed countries, especially in Europe, are integrating solar, biomass, and geothermal heat into district systems.[102] Denmark more than doubled the total solar thermal capacity in its district heating networks between 2012 and the end of 2014.[103]

A small number of countries, such as Denmark and Ireland, also has begun using district heat systems and other technologies to absorb heat generated by renewable electricity during periods of excess supply (e.g., through the use of heat pumps or resistance heaters).[104] China called on high-wind provinces to begin pilot testing of wind-to-heat technologies to ease the strain on local grids and reduce local air pollution.[105]

Another significant trend is a move towards the use of hybrid systems that integrate several energy resources (such as solar thermal or biomass with heat pumps) to serve different heat applications.[106] China's market for hybrid-heat pump products is double the size of Europe's, and both markets are expanding rapidly.[107] There is also growing interest in the use of larger-scale heat pumps for district heating as well as industrial processes.[108]

Despite these innovations in renewable heating, a limited awareness of the technologies, the distributed nature of consumption and fragmentation of the heating market, and a relative lack of policy support has constrained growth in the sector. Further, the sector has faced headwinds due to low fossil fuel prices, ongoing fossil fuel subsidies (especially for natural gas), as well as competition from other possible investments, such as energy efficiency improvements or other renewable energy systems (e.g., solar PV, heat pumps, and solar PV / heat pump hybrids).[109] Solar thermal has experienced the fastest growth among the modern renewable energy sources, but the pace of growth continued to slow in 2014 in response to such challenges.

TRANSPORT SECTOR

There are three main entry points for renewable energy in the transport sector: the use of 100% liquid biofuels or blended biofuels with conventional fuels; the growing role of natural gas; and the increasing electrification of transportation. Trends in each of these areas have contributed to the evolving landscape for renewable energy in the transport sector. To date, however, the primary focus of policies, markets, and industries in the transport sector has been on liquid biofuels.[110]

Demand for oil in transportation has increased significantly as a result of growth in private motorisation, primarily in developing countries. However, increased fuel economy in cars and other light-duty vehicles, as well as improved transportation strategies, have helped temper demand.[111] During the period 2008–2012, global demand for motor gasoline increased by 1.2% annually, with growth skewed towards non-OECD countries, at 5.1% annually.[112]

The share of renewables in transportation remains small. Renewable energy accounted for an estimated 3.5% of global energy demand for road transport in 2013, up from 2% in 2007.[113] (At the same time, transport fuels accounted for the second largest share of renewable energy jobs globally. → See Sidebar 3.) Liquid biofuels—primarily ethanol and biodiesel—represent the vast majority of the renewable share. Biofuels' contribution to the transport sector is considerably higher in some European countries, in the United States, and in Brazil—where the share of biofuels in road transport fuel exceeded 20% in 2014.[114] Liquid biofuels are used mainly for passenger vehicles and heavy-duty road vehicle applications.

Beyond liquid biofuels, relatively small but increasing quantities of gaseous biofuels, including biomethane (purified biogas), are being used to fuel vehicles. Renewables also are used in the form of electricity for trains, light rail, trams, and both two- and four-wheeled electric vehicles.

Although concerns about the environmental, economic, and social sustainability of biofuels constrained growth in some regions, almost all major producing nations increased their production of biofuels in 2014 relative to 2013.[115]

- The **United States** continued to lead the world in both biodiesel and ethanol production; ethanol output expanded from 2013 to 2014, despite policy uncertainties.[116] **Canada** also saw marginal increases in biofuels production in 2014 and was one of the world's top five producers of fuel ethanol.[117]
- Brazil's production of ethanol and biodiesel expanded in 2014, and output of smaller producers in **Latin America**, such as Argentina and Colombia, also increased. Argentina's output was up 28% in response to national incentives and a blend mandate, and it ranked fifth globally for production of biofuels in 2014.[118]
- The **European Union** considered capping the contribution of biofuels derived from sugars, starch, and oil crops due to sustainability concerns.[119] At the same time, EU countries struggled to meet their renewable energy targets for transportation.[120] Against this background, the amount of biofuel production increased during 2014, with Germany leading the region.[121]
- Biofuels production expanded rapidly in **Asia** during 2013–2014, where the region's top three producers (China, Indonesia, and Thailand) collectively increased their production by 16%.[122]
- Production levels in **Africa** remained small in 2014, although several sub-Saharan countries have national biofuel (mostly ethanol) blending mandates in place.[123]

There continue to be advances in new markets and in new applications for biofuels. In 2014, commercial flights in Norway and Sweden were fuelled by aviation biofuel, and airlines in Brazil, China, Indonesia, South Africa, the United Arab Emirates (UAE), the United Kingdom, and the United States announced aviation biofuel supply agreements or plans to integrate aviation biofuel into future flights.[124]

Around the world, militaries—including the navies of Australia, Chile, Italy, and the United States—continued to pursue biofuels development in 2014.[125] The US military announced the first successful supersonic flight fuelled by renewable isobutanol in December 2014.[126]

Beyond liquid biofuels, trends in the development of gaseous fuels and electricity continued to create pathways for the integration of renewables into transportation. The number of compressed natural gas vehicles and fuelling stations continued to expand in 2014, creating parallel opportunities for gaseous biofuels such as biomethane.[127] Limited but growing quantities of biomethane are fuelling cars, buses, and other vehicles in several EU countries (most notably Germany, Finland, and Sweden).[128] Although biomethane production is concentrated primarily in Europe, plans are under way in other regions—including Brazil, as well as countries in Asia and North America—to develop facilities for production and vehicle fuelling.[129]

The electrification of the transport sector expanded further during the year. The number of electric passenger vehicles on the road nearly doubled from 350,000 in 2013 to 665,000 in 2014.[130] The United States led the world in the size of its electric vehicle (EV) passenger fleet, but Norway led in the share of EVs in annual vehicle sales in 2014 (12%+).[131] As of early 2015, China was home to 97% of the world's 235 million electric two wheelers and 79% of the world's 46,000 electric buses.[132] In 2014, there also was continuous growth in electric public transport, including the expansion of electric passenger rail, light rail, and trolley systems.[133] In 2014, Bhutan announced that it would use its ample renewable resources to electrify its transportation sector, starting with government fleets and taxis.[134]

These trends enable greater integration of renewable energy into the transport sector, but only to the extent that the associated electricity demand is met with new renewables, as electric vehicles are only as "renewable" as their power source.[135] EVs can be connected directly to renewable energy charging stations, and also can have renewable energy integrated directly into their designs, but such direct links remain rare.[136] EV storage can also be utilised to balance variable renewable electricity, although this function remains at the demonstration stage.[137]

In Europe, a combination of on-site renewable energy and voluntary green power purchase programmes has enabled some rail systems to declare that their trains are, or soon will be, powered with renewable electricity and fuels. The Swedish passenger train company (SJ) has powered its trains with 100% renewable energy for a number of years, the Swiss Federal Railway (SBB) has a goal to move from 75% renewable energy to 100% by 2025, and Deutsche Bahn in Germany previously committed to achieve 100% renewable energy by 2050.[138] In 2014, the national rail system of the Netherlands established a goal to move to 50% renewable energy in 2015 and 100% by 2018, while the German region of Rhein-Hunsrück redirects its excess renewable energy generation to its transit system.[139] Beyond Europe, Indian Railways committed in 2014 to using up to 5% biofuels for its trains.[140]

SIDEBAR 3. JOBS IN RENEWABLE ENERGY

Renewable energy employment continues to be shaped by an array of industrial and trade policies, industry realignments, and technology developments, as well as an ongoing regional shift from Europe and North America to China and other Asian nations. According to IRENA[i], in 2014 an estimated 7.7 million people worked directly or indirectly in the sector, with an additional 1.5 million in large-scale hydropower (→ See Table 1.)

Solar PV is the largest employer, with 2.5 million jobs, most of which are concentrated in China due to its undisputed lead in manufacturing as well as a rapidly expanding domestic market. Japan, the United States, and Bangladesh have also boosted their solar PV employment. Jobs in the European PV industry have decreased by 35%, falling to 165,000 in 2013.

Liquid biofuels remains the second largest employer, with close to 1.8 million jobs. Brazil has the highest number of biofuels-related jobs, followed by the United States. Other important players, due to labour-intensive operations, include Indonesia, China, Colombia, and Thailand.

Global wind power employment crossed the 1 million jobs threshold in 2014. Growth has been especially strong in China and the United States, with Brazil and the European Union experiencing moderate increases.

Data for the remaining renewable energy technologies are sparse. In the solar heating sector, China accounts for the bulk of the estimated 764,000 jobs. Smaller, but noteworthy, employers include India, the United States, and Brazil.

In 2015, IRENA carried out the first-ever global estimate of employment in large-scale hydropower[ii], showing approximately 1.5 million direct jobs in the sector. The major employers in 2013 were China, Brazil, India, and Russia. Most jobs are found in construction and manufacturing, followed by operations and maintenance.

Renewable energy employment has been growing in off-grid sectors. The experience of Bangladesh illustrates the strong potential for solar PV to extend energy access and employment to rural areas in developing countries. Installations of solar home systems in the country had risen to 3.8 million units as of early 2015, and employment had expanded to an estimated 115,000 jobs, principally in sales, installations, and maintenance.

China has firmed up its position as the leading renewable energy employer, with 3.4 million jobs. It has a commanding position in solar PV, solar water heating, wind power, small hydro, and biogas.

In Europe, employment in renewables has declined for three years in a row, reflecting a decrease in overall investment resulting from adverse policy conditions. The total of 1.2 million jobs in 2013 (the most recent year available) was down 4% from the previous year; pronounced solar PV job losses were not offset by smaller gains in biomass (heat and power) and wind power. Germany had by far the highest level of employment in 2013, followed by France, the United Kingdom, Spain, and Italy.

The United States saw strong jobs growth in 2014 in the solar industries (up 22% since 2013) and in the ethanol industry (up 34%). Biodiesel employment declined slightly along with falling production. Wind manufacturers recovered from the downturn in 2013, and new wind installations helped increase total wind-related employment by 45% in 2014.

Brazil's employment profile continues to be dominated by bioenergy. Although mechanisation is shrinking the sugarcane harvesting workforce, the trend is more than offset by the expanding biodiesel sector. The number of people employed in wind power and solar water heating is also on the rise.

India has ambitious solar PV installation goals, but its manufacturers have faltered in the face of cheap imports; in 2014, only about a quarter of India's 2.3 GW module production capacity was operational. The solar water heater industry also has faced strong competition from Chinese imports.

A number of Asian countries have fared well in their solar PV development. Driven by strong growth in installations, solar PV jobs in Japan more than doubled in 2013. Malaysia has attracted a range of solar PV manufacturers with a favourable investment environment, employing 18,000 people in 2014. For South Korea, a 2013 figure of 7,500 solar PV jobs in manufacturing is the latest available estimate.

i - This sidebar is drawn from IRENA, *Renewable Energy and Jobs – Annual Review 2015* (Abu Dhabi: May 2015), www.irena.org/publications/rejobs-annual-review-2015.pdf. Data are principally for 2013–2014, with years varying by country and technology, including some instances where only dated information is available. IRENA's 2013 estimate of 6.5 million jobs (excluding large-scale hydropower) was updated to 6.9 million following a revision by the China National Renewable Energy Centre for solar water heating employment in China.

ii - Definitions for large-scale hydropower vary across countries. Large hydropower was not included in previous editions of IRENA's *Annual Review* and of this sidebar due to lack of data.

JOBS IN RENEWABLE ENERGY

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

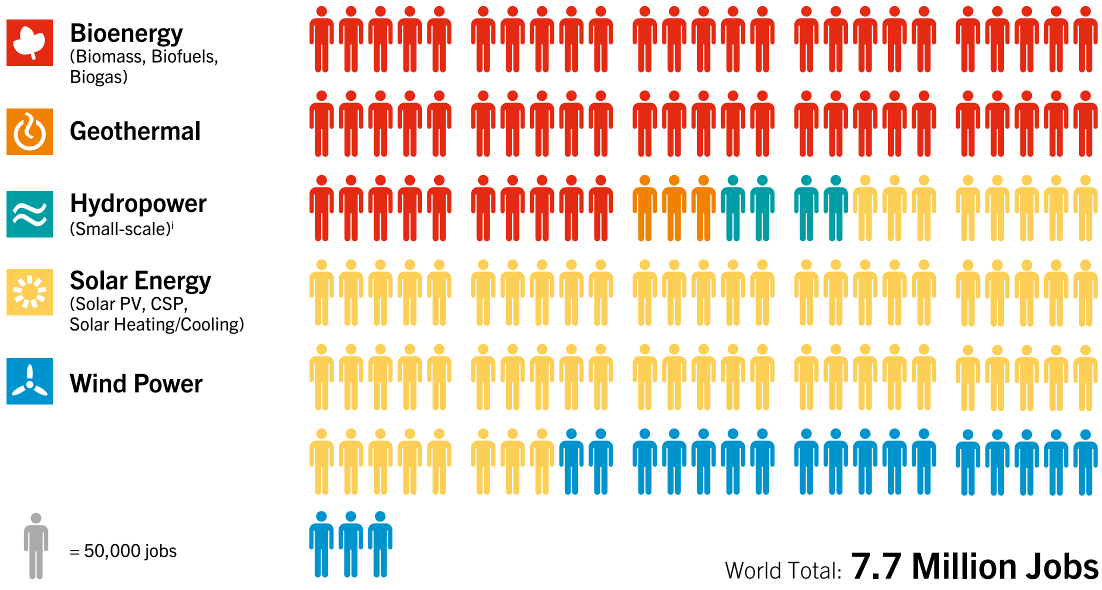
	World	China	Brazil	United States	India	Japan	Bangladesh	European Union[j]		
								Germany	France	Rest of EU
	THOUSAND JOBS									
Biomass[a,b]	822	241		152[f]	58			52	53	238
Biofuels	1,788	71	845[d]	282[g]	35	3		26	30	42
Biogas	381	209			85		9	49	3	14
Geothermal[a]	154			35		2		17	33	54
Hydropower (Small)[c]	209	126	12	8	12		5	13	4	24
Solar PV	2,495	1,641			125	210	115	56	26	82
CSP	22			174[h]				1		14
Solar heating / cooling	764	600	41[e]		75			11	7	19
Wind power	1,027	502	36	73	48	3	0.1	138	20	162
Total	**7,674[i]**	**3,390**	**934**	**724**	**437**	**218**	**129**	**371[k]**	**176**	**653**

Data source: IRENA

Note: Figures provided in the table are the result of a comprehensive review of primary (national entities such as ministries, statistical agencies, etc.) and secondary (regional and global studies) data sources and represent an ongoing effort to update and refine available knowledge. Totals may not add up due to rounding.

a) Power and heat applications (including heat pumps in the case of the European Union). **b)** Traditional biomass is not included. **c)** Although 10 MW is often used as a threshold, definitions are inconsistent across countries. **d)** About 304,400 jobs in sugarcane and 199,600 in ethanol processing in 2013; also includes 200,000 indirect jobs in equipment manufacturing, and 141,200 jobs in biodiesel in 2014. **e)** Equipment manufacturing and installation jobs.
f) Biomass power direct jobs run only to 15,500. **g)** Includes 232,633 jobs for ethanol and 49,525 jobs for biodiesel in 2014. **h)** All solar technologies combined.
i) The total for 'World' is calculated by adding the individual totals of the technologies, with 3,600 jobs in ocean energy and 8,300 jobs in publicly funded R&D and administration in Germany. **j)** All EU data are from 2013 and the two major EU countries are represented individually. **k)** Includes 8,300 jobs in publicly funded R&D and administration; not broken down by technology.

Figure 5. Jobs in Renewable Energy

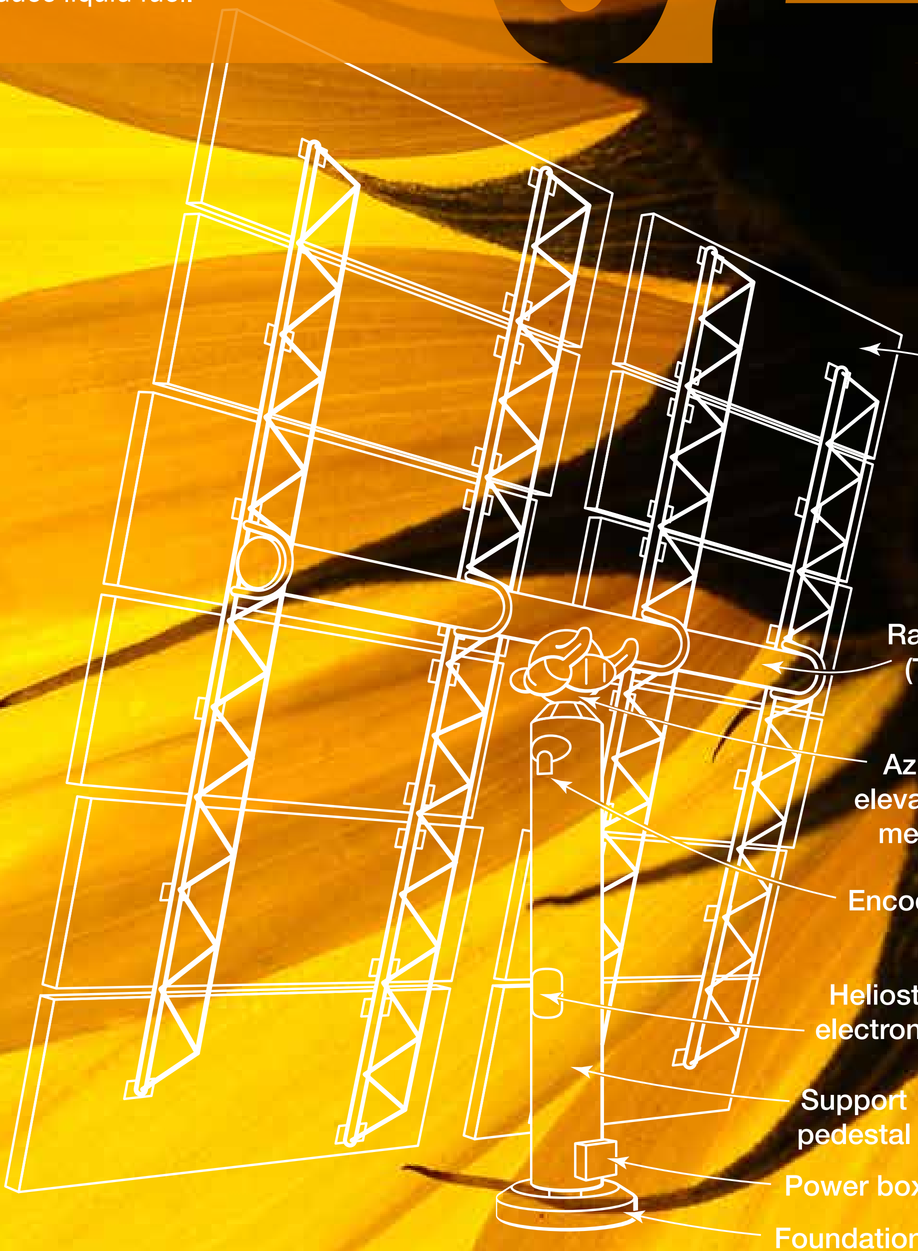


Source: IRENA

i - Employment information for large-scale hydropower not included.

02

Innovations from the past, innovations for the future. Nature offers new ways to think about renewable energy: using the tracking mechanism in **SUNFLOWERS** to inform the design of heliostats to track the sun; mimicking the human body's blood cooling system to increase the performance of solar PV systems; examining the aerodynamics of an owl's wing to compose more efficient wind turbine blades and harnessing the chemical process of photosynthesis to develop bionic/artificial leaves that produce liquid fuel.



(a)

02 MARKET & INDUSTRY TRENDS

BIOMASS ENERGY

Biomass use for energy is multi-faceted: many different raw and/or processed types of biomass can be transformed via numerous conversion technologies for use in energy sectors (residential, commercial, and industrial heating, electricity, or transport).[1] (→ See Figure 6.)

Because of its multi-faceted nature and the complexities lying therein—paired with the widely dispersed sources and the difficulty of co-ordinating data collection across institutions—production and demand for biomass and bioenergy are relatively difficult to measure, and large data gaps often exist.[2] (→ See Sidebar 4.)

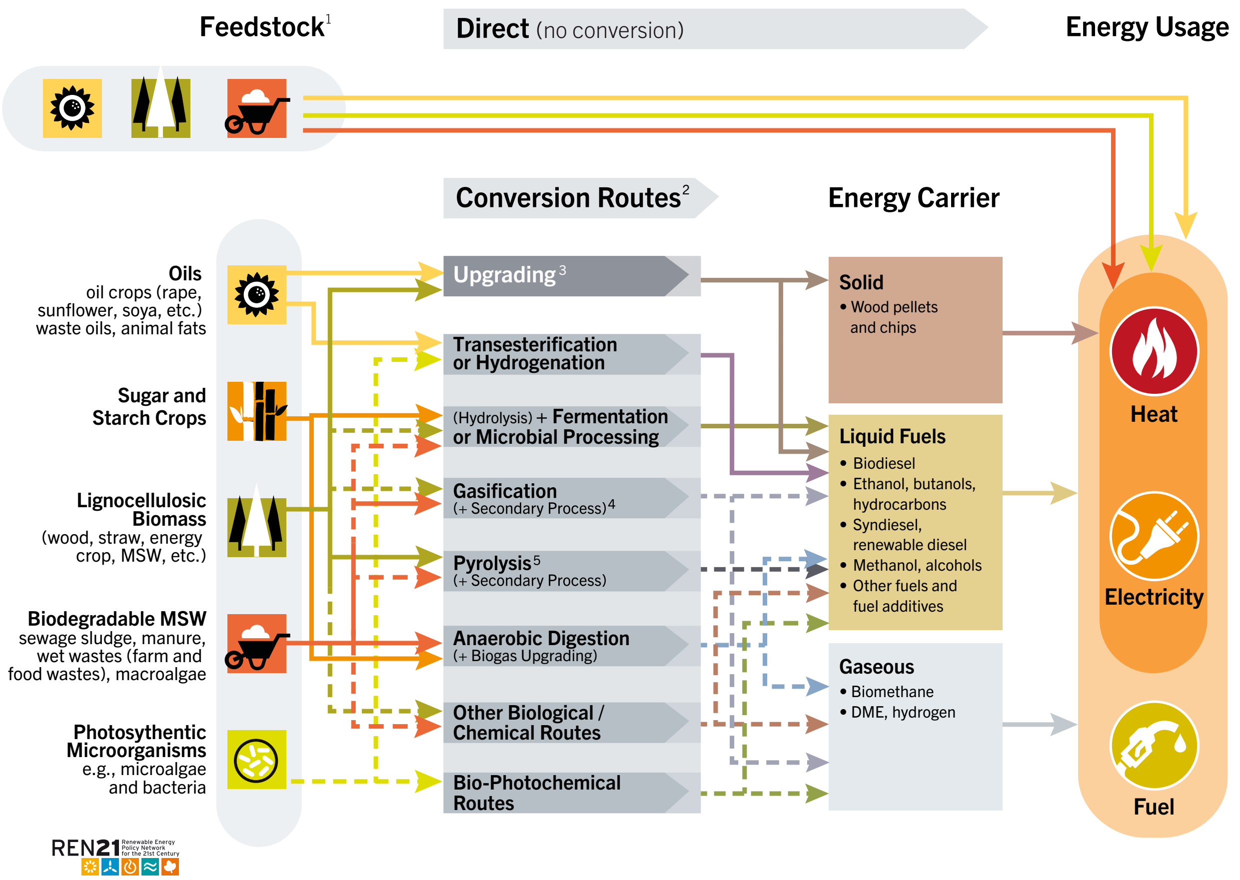
BIOENERGY MARKETS

Total primary energy demand from biomass in 2014 was approximately 16,250 TWh (58.5 EJ). The bioenergy share in total global primary energy consumption has remained steady since before the year 2000, at around 10%.[3]

In recent years, estimates for the share of traditional biomass in total bioenergy use have ranged from 54% to 60%.[4] This large volume of traditional biomass—consisting of fuelwood, charcoal, agricultural residues, and animal dung—is burned in open fires, kilns, and ovens for cooking and heating applications.[5] (→ See Distributed Renewable Energy section.)

After traditional biomass, modern heating accounts for the next-largest share of biomass use for energy purposes.

Figure 6. Bioenergy Conversion Pathways



Source: See Endnote 1 for this section.

Note: Solid lines represent commercial pathways, and dotted lines represent developing bioenergy routes.

¹ Parts of each feedstock, e.g., crop residues, could also be used in other routes. ² Each route also gives co-products. ³ Biomass upgrading includes any one of the densification processes (pelletisation, pyrolysis, torrefaction, etc.). ⁴ Anaerobic digestion processes release methane and CO_2, and removal of CO_2 provides essentially methane, the major component of natural gas; the upgraded gas is called biomethane. ⁵ Could be other thermal processing routes such as hydrothermal, liquefaction, etc. DME = dimethyl ether.

SIDEBAR 4. RENEWABLE ENERGY DATA: DISTRIBUTED CAPACITY AND PRODUCTION

Timely, accurate, and accessible data on renewable energy are essential for good policymaking. As deployment of renewable energy technologies increases and their geographical spread widens, the complexity of data collection, verification, and harmonisation also increases. (→ See Sidebar 1, GSR 2014.) A problem of data aggregation has long existed for traditional uses of biomass for heating and cooking, and data on direct consumption of biomass have always been estimated. This challenge now extends to modern renewables, and particularly to distributed and small-scale renewable energy installations, which are difficult to track and often are considered insignificant for inclusion in national energy statistics.

In the aggregate, distributed small-scale systems can represent a significant share of a renewable technology's total capacity and generation on a national or even global level. In Germany, for example, where the regulator requires central registration of all solar PV systems and where very detailed data are available, systems below 1 MW accounted for 68% of all solar PV capacity added to the country's grid in 2014. Due to the rapidly growing number of distributed renewable energy producers worldwide, some account should be made to avoid omitting significant amounts of renewable capacity and generation while ensuring greater accuracy in the aggregate picture. New methods of energy accounting are needed to complete the picture of renewable energy production and consumption.

Challenges of accounting for distributed energy production occur mainly in the electricity and heating and cooling sectors (renewable transport fuels, in contrast, typically are produced at larger facilities and are easier to track). Distributed electricity and heating or cooling often are generated on-site for self-use. Except where financial support mechanisms (such as feed-in tariffs) require production accounting, generation data must be estimated based on installed capacity. In many jurisdictions, however, the authorities responsible for energy data collection lack information on the scale of the market, a problem that is particularly acute in developing countries.

To overcome these challenges, authorities at the local and national levels are furthering their efforts to improve data surveys and other means of data collection, and international agencies and non-governmental organisations are pursuing innovative approaches to data collection and collaboration.

International agencies that long relied solely on official government data have identified differences in accounting methods from country to country and are adjusting their data collection and estimation accordingly. In addition to publishing official national renewable energy statistics, the International Energy Agency (IEA) supplements these statistics with data obtained from multiple non-governmental sources as well as its own estimates, for publication in its annual *Medium-Term Renewable Energy Market Report*. The International Renewable Energy Agency (IRENA) is improving existing datasets through its Renewable Energy Statistics Questionnaire by collecting detailed data on distributed systems from countries that are able and willing to supply such information.

Additional methodological efforts focus on international trade data (extracted from customs and import tax declaration forms) related to solid and liquid biomass fuels and renewable energy equipment, such as solar PV systems. Such information can be used to identify newly installed capacities and to improve renewable energy consumption data. However, international trade codes are harmonised only up to a six-digit level, which is not explicit enough to clearly identify many types of renewable energy carriers or equipment. Additional challenges include the need to convert from the monetary value of the equipment to the respective capacity, and uncertainty around the date of installation and operation of the imported equipment.

There is also a potential opportunity to extract renewable energy statistics from broader surveys and datasets. The World Bank is piloting a new multi-tier approach to measuring energy access. The Bank's methodology includes information on the equipment used to supply electricity and heat for comfort and cooking, which in turn could provide indirect estimates of renewable energy use. For example, the electricity access survey includes data on solar PV systems (e.g., solar lanterns), which make it possible to estimate associated capacity and generation based on assumed size and load hours. In the heating survey, data gathered according to the type of cookstove used could enable estimates of wood consumption based on stove efficiencies. However, extracting renewable energy-specific information from this survey could be labour-intensive and would provide only a partial picture of small-scale renewable installations.

Collaboration among organisations and countries can play a significant role in improving data on distributed renewable energy. Points of collaboration include agreements on common methodologies for improving the comparability of datasets, and contributions to freely accessible knowledge portals that bring together data and analysis from multiple sources. Such portals allow for feedback channels that offer the potential to improve data accuracy significantly.

Examples include the REN21 Interactive Map (as well as the annual *Renewables Global Status Report* and regional status reports), which relies on a large network of international contributors, and IRENA's newly launched REsource portal. The portal currently references only IRENA's own work, but, in the next phase, it will include the work of multiple trusted renewable energy actors. Overarching initiatives such as the UN Secretary-General's Sustainable Energy for All also are bringing stakeholders together and improving the understanding of synergies (such as between energy access and small-scale renewable energy systems) in data collection.

Source: See Endnote 2 for this section.

Applications range from residential to industrial scales and may be decentralised or grid-connected, for example through district heating systems. Modern bio-heat is followed by transport biofuels and bio-power.[6] Solid biomass represents the largest share of biomass used for heat and electricity generation, whereas liquid biofuel represents the largest source in the transport sector.[7] (→ See Figure 8.)

The vast majority of biomass used for energy is derived locally, or at least domestically. There is also significant informal trade in solid biomass that occurs regionally and across national borders. However, international trade in biomass is rising rapidly. Wood pellets and wood chips, as well as fuel ethanol and biodiesel, all are now commonly traded in large volumes; in addition, some biomethane is traded in Europe through gas grids.

Some shifts in trading patterns were observed in 2014. Wood pellets, for example, saw a dramatic shift in export routes. The largest international trade flows are from North America (the United States and Canada) to the European Union. In 2014, shipments of wood pellets from Canada to Europe declined to 2011 volumes, whereas Canadian shipments to Asia (notably South Korea) increased significantly.[8] (→ See Figure 7 and Reference Table R3.) While the volume of wood pellets shipped to Asia is increasing, the primary supply for Asian markets continues to be sourced either domestically or from within the region—for example, South Korean imports from Vietnam.[9]

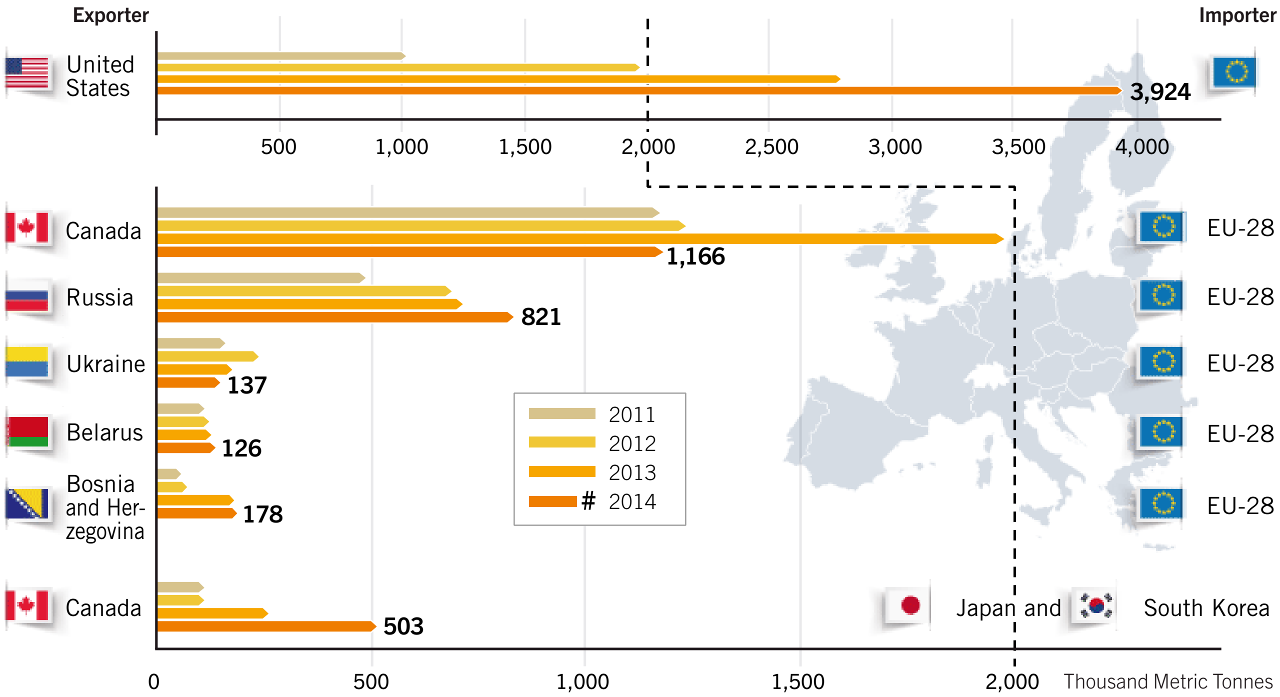
US fuel ethanol exports soared to 2.4 billion litres in 2014, up 37% over 2013 and representing 4% of US output.[10] Factors behind this expansion included low production costs, which temporarily made US ethanol more cost-competitive; a saturated US national market; and rising demand for imports in new markets such as India, the Philippines, South Korea, Tunisia, and the United Arab Emirates.[11]

By contrast, Brazilian exports decreased 42% from 2013 for several reasons, including unfavourable exchange rates. The result was an increase in domestic ethanol sales.[12]

The volume of EU imports of (un-denatured[i]) ethanol dropped 3% to just under 600 million litres in 2014. Some ethanol passes through third states that are exempt from EU import duties (e.g., in Latin America) before entering the EU market.[13] The European ethanol industry has begun to address this situation, and the European Commission and individual Member States (e.g., Sweden and the United Kingdom) have successfully closed several trade loopholes in recent years.[14] Key countries that export to the European Union include Brazil, Peru, Guatemala, and the United States.[15]

Traditionally, the EU has represented the largest destination market for biodiesel. In 2014, however, the region's imports reached an all-time low, at just over 1 million litres (down from an already small volume of 35.6 million litres in 2013).[16] The decline is due to anti-dumping duties placed by the EU on imports from Argentina, Indonesia, and Malaysia, which have made imported biodiesel more expensive.[17]

Figure 7. Global Wood Pellet Trade Flows, 2014



Source: See Endnote 8 for this section.

The figure represents some major trade flows in wood pellets but is not exhaustive. There is also some documented trade within Europe (e.g., between Norway, Switzerland, and EU Member States) as well as among Asian countries.

i - Fuel ethanol labelled "denatured" has been rendered unfit for human consumption by the addition of a petroleum denaturant, typically pentanes plus or conventional motor petrol blending components. Fuel ethanol usually is denatured prior to transport from the ethanol production facility.

Bio-heat Markets

Solid, liquid, and gaseous biomass fuels can be combusted to provide higher-temperature heat (200–400 °C) for use by industry, in district heating schemes, in agricultural processes, and in combined heat and power (CHP) plants. They also can be combusted for use at lower-temperature heat (<100 °C) for drying; for heating water for domestic, commercial, or industrial use; and for heating space in individual buildings.

Globally, biomass was used to produce an estimated 12,500 TWh (45 EJ) of heat in 2014, up from 12,360 TWh (44.5 EJ) in 2013 and accounting for nearly 77% of total global primary bioenergy demand.[18] Roughly 70% (8,805 TWh) of this was generated from traditional biomass, which is used for heat primarily in Asia (5,305 TWh or 19.1 EJ) and Africa (3,222 TWh or 11.6 EJ).[19]

Modern biomass heat generation occurs mainly in Europe (861 TWh or 3.1 EJ), developing countries in Asia (750 TWh or 2.7 EJ), and North America (roughly 722 TWh or 2.6 EJ).[20] Approximately 9 GW_{th} of modern biomass heat capacity was added in 2014, increasing total global capacity to about 305 GW_{th}.[21]

In 2014, Europe remained the world's largest consumer of modern bio-heat, most of which was in Sweden, Finland, Germany, France, and Italy.[22] A large portion of Europe's bio-heat is produced for district heating networks, where the share of heat derived from bioenergy has grown steadily in recent years; as of 2014, this share reached an estimated 12–23%.[23] Solid biomass heat consumption is rising sharply in countries that promote the use of wood fuel through policies such as France's tax credit and the UK Renewable Heat Incentive (non-domestic).[24] Heating with split roundwood remains common in residential heat markets. In addition, roughly 50% of total biogas consumption in Europe, amounting to more than 92 TWh, is attributed to heat production.[25]

Biogas also accounts for a significant amount of heat production in Asia[i]. In 2014, China had an estimated 100,000 large-scale modern biogas plants and 43 million residential-scale biodigesters (the fuel is used primarily for cooking).[26] China produces significant amounts of heat from individual and farm-scale biogas plants, generating roughly 400 GWh per day.[27] India installed more than 82,730 family biogas digesters in 2014, bringing its total to 4.75 million.[28] In South Korea, roughly 24% (roughly 0.62 TWh) of biogas production was utilised to generate heat during the year.[29]

In the United States, most heat produced from biomass is used by the industrial sector (primarily the pulp and paper industry), which hosts 420 large-scale boilers and over 11,000 small-scale boilers.[30] However, the residential sector drives US demand for pellets, which are burned in more than 800,000 individual pellet stoves.[31] Heating with split roundwood is also common in US residential markets. In 2014, more than 2.71 million homes were heated primarily with wood, an increase of almost 4% over 2013.[32]

Bio-power Markets

Bio-power capacity increased by an estimated 5 GW in 2014, bringing the global total to approximately 93 GW.[33] Bio-power generation also increased, from an estimated 396 TWh in 2013 to about 433 TWh in 2014.[34] By country, the leaders for bio-power generation were the United States (69.1 TWh), Germany (49.1 TWh), China (41.6 TWh), Brazil (32.9 TWh), and Japan (30.2 TWh).[35]

Although the United States continued to lead global bio-power generation and capacity, with 16.1 GW in operation at year's end, only 0.3 GW was added in 2014 (down about 50% from 2013).[36] Growth has slowed in recent years because of limited policy incentives for new installations.[37] US bio-power is derived primarily from wood and agricultural residues burned in co-generation plants; as with bio-heat, most of this is consumed in the industrial sector, particularly by the pulp and paper industry.[38] In 2014, electricity generation based on woody biomass increased 6% to 42 TWh, while generation based on waste biomass dropped 2% to 19.7 TWh.[39]

In 2014, China's bio-power capacity increased by 1.5 GW to 10 GW. Most of the total (about 53%) was from agricultural and forestry products, and from municipal solid waste (about 45%).[40] China is one of Asia's major consumers of wood pellets and chips.[41]

Elsewhere in the region, Japan added more than 0.9 GW of new solid biomass capacity (mostly MSW[ii]) and 6 MW of new biogas capacity, for an estimated total of 4.7 GW.[42] India added only 0.5 GW in 2014 for a year-end total of 5 GW of capacity. The market was down relative to 2012 and 2013 due in part to uncertainty about feedstock supplies.[43] While India leads the region for consumption of wood pellets and chips for bio-power production, most of India's bio-power is produced from bagasse and other agricultural waste.[44] In South Korea, roughly 59% of biogas produced annually is used to generate about 1.5 TWh per year of electricity.[45]

By region, Europe leads for both bio-power generation and capacity, with roughly 36.5 GW in operation at the end of 2014.[46] Countries that added capacity during 2014 include the United Kingdom, which increased its capacity by 0.5 GW thanks largely to the partial conversion of the second 0.66 GW unit (out of a total of six) of the coal-fired Drax Power plant to solid biomass, and Germany, which installed 0.4 GW of new capacity, most of which relies on biogas and biomethane.[47]

Total EU electricity generation from solid biomass was approximately 81.6 TWh in 2014.[48] The EU's top five producers combined—Germany, Finland, the United Kingdom, Sweden, and Poland—made up about 63% of the region's bio-power production.[49] Although a number of countries use biomass primarily in electricity-only plants (e.g., the United Kingdom, Ireland, and Hungary), about 65% of the EU's bio-power was generated in CHP plants, up from 63% in 2013.[50]

In addition, roughly 50% of the total biogas produced in Europe during 2014 (92.3 TWh) was used to generate electricity.[51] More than 14,560 biogas power plants were operating in Europe, with total capacity approaching 7.9 GW.[52] Germany accounted for

i - Most available information on bioenergy in Asia is limited to biogas.

ii - Municipal solid waste. The GSR strives to report only the renewable portion of MSW. However, oftentimes MSW information reported in the literature includes both renewable and non-renewable values.

BIOMASS ENERGY

Figure 8. Shares of Biomass Sources in Global Heat and Electricity Generation, 2014

Source: See Endnote 7 for this section.

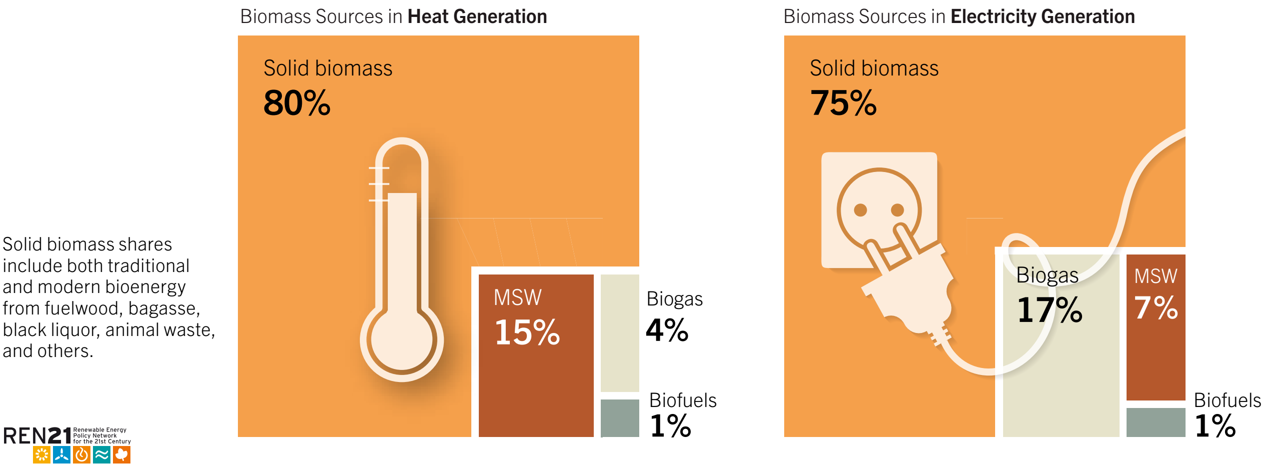


Figure 9. Ethanol, Biodiesel, and HVO Global Production, 2004–2014

Source: See Endnote 60 for this section.

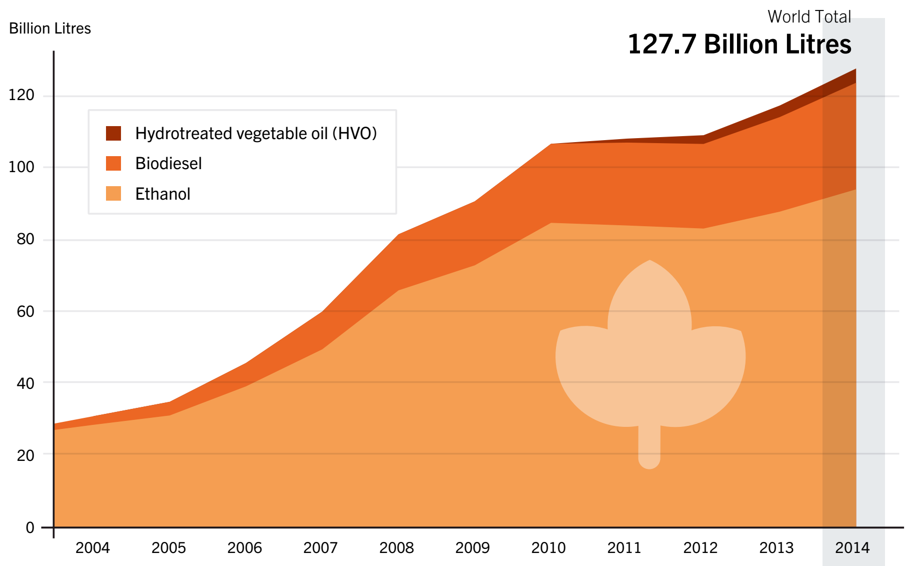
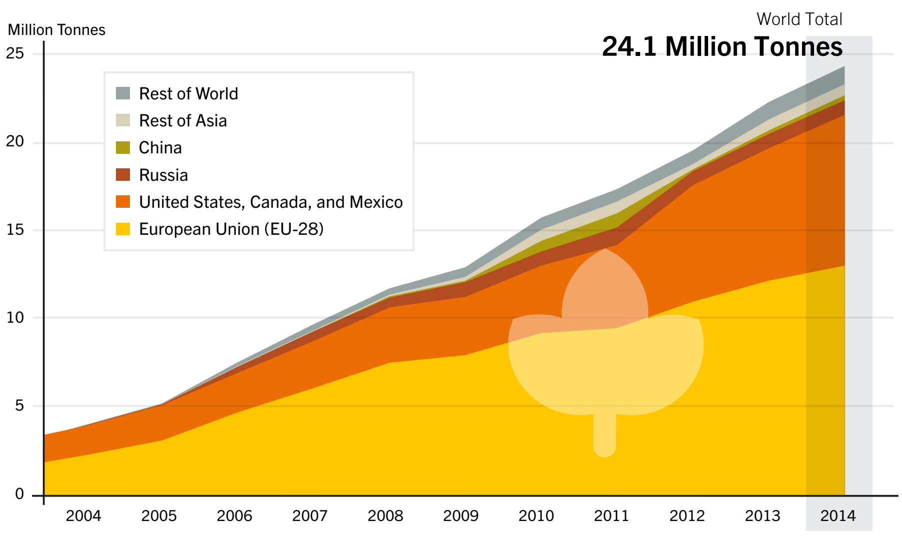


Figure 10. Wood Pellet Global Production, by Country or Region, 2004–2014

Source: See Endnote 107 for this section.



half of this capacity (almost 3.9 GW) and for annual electricity generation from biogas of around 29 TWh, followed by Italy (1,391 plants), Switzerland (620), and France (610).[53]

Brazil's bio-power sector has seen continuous market growth. An estimated 1.49 GW of new capacity brought Brazil's total to 12.3 GW in 2014.[54] Electricity production from biomass—primarily sugarcane bagasse and black liquor—in thermoelectric plants remained stable at 7.6% of Brazil's total electricity generation.[55] In addition, 22 grid-connected biogas plants (mostly at landfills) generated electricity in 2014.[56] Policies that require local utility service providers to obtain at least 2 GW of new renewable capacity through auctions annually between 2007 and 2017 have not been favourable to biomass because most providers have opted instead for wind power installations that receive government incentives.[57]

There is also some modest bio-power production in Africa. All sugarcane mills produce electricity from bagasse in co-generation facilities for their own use, while some—including mills in Ethiopia, Kenya, Mauritius, Sierra Leone, Sudan, and Uganda—sell excess electricity into the national grid.[58] Some pilot installations were installed in 2014, including a waste-to-energy plant in Nigeria.[59]

Transport Biofuel Markets

Global biofuel production increased 9% in 2014, to a total of 127.7 billion litres, with each type of biofuel reaching its highest level to date. Fuel ethanol accounted for 74% of the total, biodiesel largely from fatty acid methyl ester (FAME) for 23%, and hydrotreated vegetable oil (HVO) for limited but increasing quantities.[60] (→ See Figure 9.) The top countries for total production of biofuels were the United States, Brazil, Germany, China, and Argentina.[61] (**→ See Reference Table R4.**)

Global fuel ethanol production was up 7% to 94 billion litres.[62] The increase was due largely to good corn and sugarcane harvests and low crude oil prices, all of which kept production costs low. The United States accounted for 58% of ethanol production, followed by Brazil (28%), China (3%), Canada (2%), and Thailand (1%); the European Union accounted for 6% of global production, led by France and Germany.[63]

US fuel ethanol production increased 8% to 54 billion litres, following two years of decline.[64] By the end 2014, nearly 100 fuel stations in 16 states sold the blend E15 (15% fuel ethanol and 85% petrol), and vehicle manufacturers were specifying increasingly that their vehicles were compatible with ethanol blends up to 15%.[65] To the north, Canada saw marginal increases in production that have been attributed to improved operational efficiency because domestic production capacity was not expanded.[66]

Production in Brazil was up 4% to 27 billion litres, nearly 88% of which was consumed domestically.[67] Brazil's 25% blend mandate was increased to E27 in early 2015.[68] (**→ See Reference Table R18.**)

China's production increased 5% in 2014, for a total of almost 3 billion litres.[69] Ethanol blending in China ranges from 8% to 12%.[70] In Thailand, production of fuel ethanol is being driven by government subsidies that make ethanol blends (of 12–40%) cheaper than other petrol, as well as an increasing number of fuel stations that sell E20 and E85 blends.[71] Some other Asian countries experienced rapid growth during 2014, although from low levels: for example, production increased 67% in the Philippines and 46% in India.[72]

Europe also saw a significant expansion in 2014, with ethanol production up 13% over 2013 to 5.2 billion litres.[73] Most of the increase occurred in Belgium (up 22%) and the Netherlands (35%).[74] Australia was one of the few countries to see a decrease in fuel ethanol production in 2014. Production declined 16% relative to 2013 as motorists shifted from E10 to higher octane grades of petrol.[75]

Although production levels remain small, several countries in Africa support blends of roughly 10%, including Ethiopia (E10), Kenya (10%), Malawi (varying between 10% and 20%), and Zimbabwe (varying between 5% and 15%).[76]

Global production of biodiesel (most of which is FAME) increased 13% to 30 billion litres.[77] The top producers were the United States, which accounted for 16% of the global total, Brazil and Germany (both with 11%), Indonesia (10%), and Argentina (9.7%). Europe accounted for 39% of global biodiesel production in 2014.[78]

Europe produced 11.5 billion litres of biodiesel, up 9% relative to 2013.[79] US production (FAME) fell 5% relative to 2013, to 4.7 billion litres, due to policy uncertainty.[80] US production and consumption of HVO also were up, although still at very low volumes.[81]

Brazil's blending mandate, which was raised from B5 to B7 in 2014, helped drive production increases, and output rose 17% to 3.4 billion litres.[82] As with ethanol, most biodiesel produced in Brazil is consumed domestically.[83] To the south, Argentina's output increased by about 28% in response to national incentives and to a 10% blend mandate.[84]

Biodiesel production in Asia was up substantially in 2014. Indonesia led the region, with production up 41% to 3.1 billion litres.[85] Malaysia's production also increased significantly (141%), although from comparatively low levels.[86] In India, biodiesel production declined slightly, despite the deregulation of diesel prices, allowances for producers to sell directly to end consumers, and initiatives for blending biodiesel in Indian railways.[87]

China's biodiesel production rose 5% to 1.13 billion litres. This increase was due largely to a crackdown on the illegal use of recycled cooking oil for human consumption, which freed substantial cooking oil feedstocks for biodiesel production. Nonetheless, capacity utilisation in China is only 28% due to a lack of large-scale collection of this feedstock.[88] By the end of 2014, China had more than 50 biodiesel production plants with a capacity of over 3.5 million tonnes (roughly 4 billion litres), and many more facilities were under construction.[89]

In Australia, biodiesel FAME production went the same direction as ethanol. Only about 30% of the country's production capacity was in operation, with a total of 50 million litres produced during the year. However, HVO production in Australia was up 33% to 20 million litres.[90] Globally, HVO production increased 23% in 2014, to 4 billion litres.[91] Most HVO production is in the Netherlands, the United States, and Singapore.[92]

The use of biomethane[i] as a transport fuel is increasing as well. The largest markets are in Europe, where roughly 10% of the biomethane produced is used in the transport sector.[93] Market growth has been steady and, by 2014, was expected to exceed 1 TWh in Sweden, 0.55 TWh in Germany, and nearly 0.02 TWh in Finland (up almost 15%).[94] Italy supports a strong infrastructure for natural gas-based vehicles (roughly 31% of all natural gas refuelling stations in Europe are in Italy), and most Swedish cities fuel their commuter bus fleets with locally produced biogas.[95]

Important infrastructure changes to advance the use of biomethane are occurring in other regions as well. South Korea, for example, supports six biomethane fuelling stations, and 600 buses in the country run on biomethane.[96]

BIOENERGY INDUSTRY

The bioenergy industry includes feedstock suppliers and processors; 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 designed to convert biomass to useful energy carriers and 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).

Biomass industries were affected by a number of factors in 2014, including volumes of agricultural harvest (which affected feedstock costs), trade measures, and public concerns related to sustainability, especially in Europe. The most important factors were crude oil prices and policies, which had mixed effects on the industry in 2014. For example, in some countries, biofuel blending mandates helped increase demand for biofuels, whereas in others, policy uncertainty (particularly in Australia and the United States) and discussions indicating a cap to be placed on the percentages of biofuel that could come from food crops in Europe had countering impacts.[97]

The low crude oil price in the second half of 2014 reduced costs associated with feedstock production and transport. However, it reduced turnover for some actors in the supply chain, with some businesses reporting 30% declines for the second half of the year, and resulted in project suspensions.[98]

Industry initiatives to address sustainability concerns continued to operate by sector (e.g., for solid biomass in the EU, for power and heat through the Sustainable Biomass Partnership); by feedstock (e.g., the Roundtable for Sustainable Palm Oil); and by fuel (e.g., the Renewable Fuels Association).[99] Many bioenergy companies continued to participate voluntarily in sustainability certification schemes, using best management practices (as endorsed by the industry) for feedstock supply and processing, and absorbing associated costs into their operations.

Bio-refining practices (producing co-products from biomass feedstocks, such as chemicals and animal feeds) also continued. In 2014, the United States counted some 213 biorefinery facilities that were producing a range of co-products with ethanol; another 100 were expanding or under construction.[100] Biorefineries also exist in many other countries. For example, the Netherlands supports 5 commercial biorefineries and 12 demonstration and pilot facilities.[101]

i - Biomethane has the same specifications and characteristics as natural gas and can be used in natural gas fleets (either in CNG- or LNG-compatible vehicles).

Solid Biomass Industry

During 2014, a large number of companies was actively engaged in supplying equipment and bioenergy plants that convert solid biomass into upgraded fuels (mainly wood chips and pellets) and then into heat and electricity.

Although the focus of sustainability criteria continued to be on biofuels, there was some discussion related to solid biomass. The European Commission confirmed that it would not publish criteria for solid biomass, leaving this responsibility to individual Member States. As of March 2015, the United Kingdom, the Netherlands, and Denmark were the only nations to publish sustainability criteria, although Germany and Belgium continued to debate the matter.[102]

Roughly 1.9 billion m[103] of wood fuel (roundwood and wood chips—excluding wood residues from forest processing, black liquor, or recovered wood waste) have been produced annually in recent years, with only small annual increases. Most wood fuel is produced in the Asia-Pacific region (41%) and Africa (35%), with minor shares produced in Latin America, Europe, and North America.[104]

Charcoal is used for cooking in many countries and by industries such as steel in Brazil.[105] (**→ See Reference Table R21.**) Charcoal production has increased roughly 9% since 2009. Africa accounts for the bulk of production (61%) and is the only region where production is increasing in both absolute and relative terms.[106] Increased use of charcoal for more-traditional applications is due largely to the removal of subsidies for liquefied petroleum gas (LPG), which has made charcoal a more cost-competitive fuel in Nigeria, for example.[107]

In 2014, global production of wood pellets rose by 9% to just over 24 million tonnes, continuing a strong upwards trend.[108] (→ See Figure 10.) The main wood pellet-producing regions continued to be Europe (roughly 62%) and North America (roughly 34%). The top national producers were the United States (26% of total production), Germany (10%), Canada (8%), Sweden (6%), and Latvia (5%).[109]

The United States had an estimated 184 plants producing wood pellets in 2014.[110] Enviva LP, German Pellets GmbH, and Biomass Secure Power Inc. have the most wood pellet production capacity in the country, although many smaller companies exist as well.[111] In Europe, the major operators of solid biomass power plants include the Drax Group plc (UK), UPM/Pohjolan Volma Oy (Finland), E.ON (Germany), Fortum (Finland), and Vattenfall (Sweden).[112]

Torrefaction, which is a thermochemical treatment of biomass that provides a product of a better fuel quality, also saw some expansion in 2014. Solvay and New Biomass Energy (NBE) launched a joint venture to expand a Mississippi plant that was built and developed by NBE, with the goal of tripling the plant's production to 250,000 tonnes per year.[113]

Liquid Biofuels Industry

Global investment in biofuels production capacity continued to fall in 2014, down 8% from 2013 and reaching a near 10-year low of USD 5.1 billion. Manufacturing capacity increases have slowed in key markets, including Brazil, Europe, and the United States. However, investment in biofuels in developing countries (mostly China) grew 23% in 2014.[114]

Global prices of most key biofuel feedstocks declined in 2014.[115] (→ See Figure 11.) Relative to 2013, global prices fell for corn (down 26%), soybean oil (-14%), palm oil (-4%), and sugar (-4%); the exception was coconut oil.[116] Feedstock generally accounts for around 70% of production costs, with processing, transportation, and other costs making up the remainder.[117] Therefore, declining feedstock prices helped industry by reducing overall production costs.

In 2014, most fuel ethanol was produced from sugar crops (roughly 61%), with the remainder from grains (roughly 39%).[118] Feedstocks vary significantly depending on the country or region. For example, fuel ethanol production in the United States is based largely on corn, whereas Brazil relies primarily on sugar crops, and China on sweet sorghum, cassava, and other non-grain crops.[119]

In the United States during 2014, corn production surpassed 378 million tonnes (14 billion bushels) for the first time, helping to bolster US ethanol production.[120] In Brazil, sugarcane harvests recovered somewhat from a drought-induced drop in production in 2013, rising by roughly 3% in 2014.[121] However, informal temporary mandates in place in 2014 (and subsequently revoked) placed a cap on retail fuel pump prices, which had a negative impact on the industry because the price that could be charged for fuel ethanol did not match the costs of sugarcane production, leading 12 (out of a total of 370) Brazilian sugar mills to halt production.[122]

Sugar crop supply constraints and competition for the crop from chemical and beverage industries suppressed fuel ethanol production in a number of countries, such as Malawi.[123] India prohibits the use of refined sugar for ethanol production, relying instead on molasses, a byproduct of sugar manufacturing. Therefore, even a surplus of refined sugar during 2014 could not compensate for the country's shortage of sugar cane for ethanol production.[124] In Thailand, tight supplies of molasses have meant that cassava is being used increasingly as a feedstock.[125]

Some of the major players in the global ethanol industry in 2014 included: US producer Archer Daniels Midland (ADM), which owns the five largest ethanol mills in the world and has a total production capacity of 5 billion litres per year; Novozymes (Denmark), which provides enzymes for about 60% of global corn ethanol production; DuPont, which has most of the remaining market; and Odebrecht Agroindustrial (Brazil), Abengoa Bioenergy (Spain), and Henan Tianguan Group (China).[126]

Global biodiesel production is based largely on vegetable oils, mostly from rapeseed (Europe) and soybeans (United States, Brazil, Argentina), with smaller shares from palm (Indonesia) and other sources such as jatropha and coconut.[127] Biodiesel production also includes industrial by-products such as used cooking oils (the main feedstock in China) and animal fat. In Europe, the relative share of cooking oil and tallow in biodiesel production is increasing as EU policy allows these feedstocks to be double-counted in transportation targets.[128]

In the United States, the largest biodiesel production facility is owned by RBF Port Neches LLC.[129] Diester Industrie of France was Europe's largest biodiesel producer, with a capacity of 2.5 million tonnes (2.8 billion litres).[130]

Constraints in biofuel production in 2014 (especially biodiesel) included high production costs, unstable feedstock supplies (e.g., in China), logistical challenges (e.g., high costs of inter-island shipping in Indonesia), and policy uncertainty (e.g., in the United States, Brazil, and Europe).[131]

US biodiesel producers began idling production in the face of policy uncertainty, including a lapse of the US biodiesel tax incentive (roughly USD 0.26/litre) and delays in the announcement of renewable fuel standard volumes.[132] Oil price declines and European import duties had a notable negative effect on Argentina's biodiesel export contracts.[133] In China, only 20–25% of biodiesel production capacity was utilised due to the shortage of feedstock supply, and in Australia, a number of biodiesel plants closed.[134]

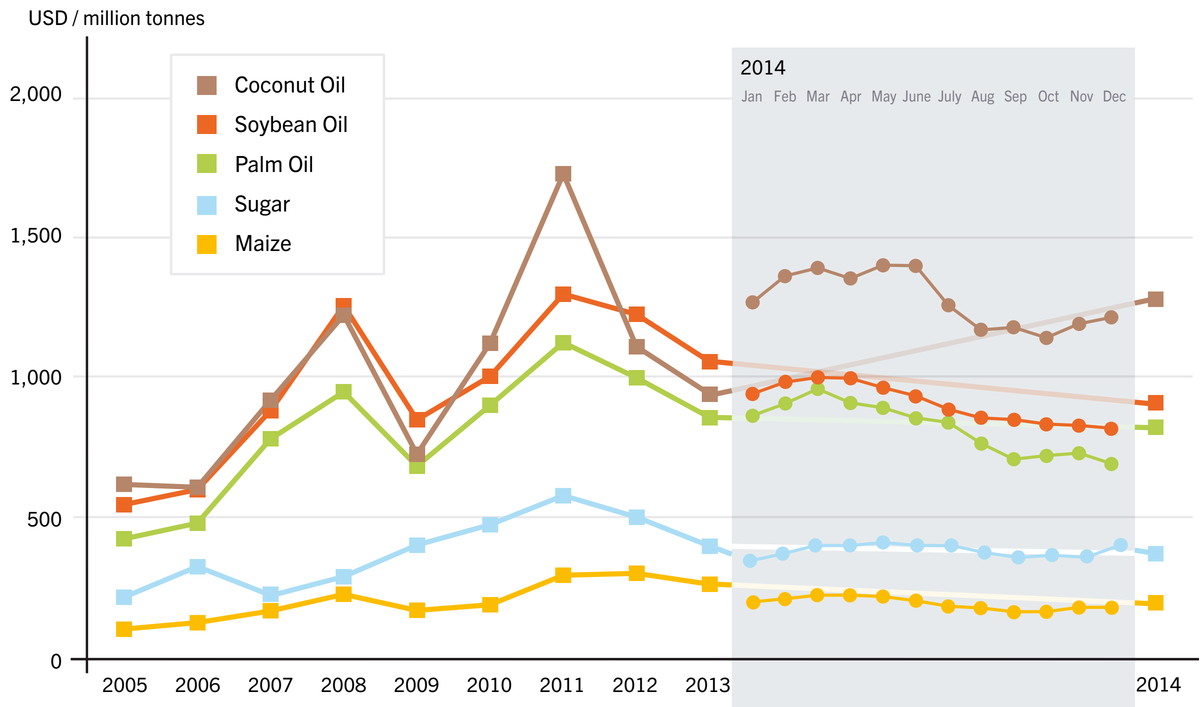
In Europe, EU policy requires that every Member State obtain 10% of its transport fuel from renewable sources by 2020; however, new legislation discussed over the course of 2014 and likely to be implemented in 2015 would limit the contribution of biofuels derived from sugars, starch, and oil crops due to sustainability concerns, which are mainly about indirect land-use change. This, in combination with amendments to some national biofuel policies, has raised uncertainty among producers.[135]

Even as several conventional biofuel production facilities closed their doors, several advanced biofuel production facilities came on line in 2014. These included three new biorefineries using cellulosic plant material (predominantly corn stover) in the United States: POET-DSM, DuPont, and Abengoa.[136] In Brazil, three commercial, second-generation biofuel projects started operation: GranBio commercial cellulosic ethanol plant, Raizen/Iogens plant, and Solazyme-Bunge plant.[137]

The advanced biofuels industry also faced challenges, however. US-based Kior filed for bankruptcy and decommissioned its commercial-scale cellulosic biofuel plant in Mississippi.[138] In Europe, development of advanced biofuels has lagged due to the lack of EU-wide policy support, although some Member States have started to enact national policies (e.g., Italy announced a mandate of 0.6% advanced biofuels by 2018).[139]

Aviation biofuels made strong strides forward in 2014. In Europe (Norway and Sweden), supplies of aviation biofuels at airports became more readily available, and new contracts were signed in the United States to begin supplies in the coming years.[140] In addition, some of the first commercial biofuel-based flights were completed in Europe and Brazil.[141] In the United States, Boeing completed the world's first flight using "green diesel", which is chemically distinct from the biodiesel used in ground transportation.[142] In October 2014, a Chinese subsidiary of the state-owned Sinopec Corp. partnered with Boeing to launch a pilot project in Hangzhou, China that will turn used cooking oil into an estimated 1.8 billion litres per year of jet fuel.[143]

Figure 11. Global Biofuel Feedstock Prices, 2005–2014, with 2014 by Month



Source: See Endnote 114 for this section.

Gaseous Biomass Industry

Worldwide manufacture and installation of residential, farm, and community-scale biogas plants continued in 2014, as did expansion of facilities to upgrade biogas, sewage gas, and landfill gas to higher-quality biomethane for use as a vehicle fuel or for injection into the natural gas grid for power, transport, and heat generation.

In Europe, biogas is derived from agricultural waste, manure, and energy crops (accounting for 5.1 GW of power production capacity), landfill gas (1.4 GW), and smaller amounts of sewage sludge and other sources. Production capacities and feedstock vary from country to country.[144] Europe's leading biogas manufacturers are based in Germany and include Schmack Biogas GmbH, MT-Energie, PlanET, and EnviTec.[145]

Growth was particularly strong in the Czech Republic (+15%) and the United Kingdom (+15.4%).[146] The increase in UK biogas production was due primarily to an increase in agricultural biogas plants, from 39 to 62 plants (up 59%), driven largely by new support schemes.[147] By contrast, a German policy amendment[i] that signaled a shift away from biogas-based bio-power has raised concern that other EU countries and/or regional policy may follow suit.[148]

Europe is the world's leading producer of biomethane, with 282 plants producing an estimated 9.4 TWh annually. Most biomethane production plants are in Germany (154 plants), Sweden (54 plants), and the Netherlands (23 plants).[149] During 2014, 18 new production plants were completed.[150]

Elsewhere in the world, biogas is produced primarily by landfill-based plants or small-scale family digesters. The United States has more than 170 anaerobic digesters on farms (100 MW), 1,500 digesters at wastewater treatment plants (250 of which use the energy on site), and more than 560 landfill plants.[151] In Brazil, six landfill plants are responsible for 68% of the country's biogas production; two industrial plants account for an additional 26% share, and the remainder is produced by smaller agricultural, bio-waste, and sewage plants.[152]

In Asia, China generated about 15 billion m^3[153] of biogas in 2014 (90 TWh of calorific energy).[154] India has an estimated 4.75 million family biogas digesters and 12 bio-CNG plants.[155] In South Korea, as of early 2014, a total of 82 biogas plants were producing 2.58 TWh annually; just over half of the production was from landfills (52%), with large contributions from sewage sludge (37%) and bio-waste (food waste and digestible co-substrates) (10%).[154]

Despite some small-scale attempts, there has been little experience with biogas in Africa. Great distances, as well as a lack of infrastructure and cultural uptake, have impeded development.[155] Production of biomethane is rare in Africa, but in 2014 Kenya began to construct its first grid-connected biomethane plant, which was expected to begin producing power in 2015.[156]

GEOTHERMAL POWER AND HEAT

GEOTHERMAL MARKETS

Geothermal resources provide energy in the form of electricity and direct heating and cooling, totalling an estimated 528 PJ (147 TWh) in 2014.[1] Geothermal electricity generation is estimated to be half of the total final geothermal output (74 TWh), with the remainder representing direct use.[ii 2] Some geothermal plants produce both electricity and thermal output for various heat applications.

Approximately 640 MW of new **geothermal power** generating capacity was completed in 2014, bringing total global capacity close to 12.8 GW.[3] Countries that added capacity in 2014 were (in order of new capacity brought on line) Kenya, Turkey, Indonesia, the Philippines, Italy, Germany, the United States, and Japan.[4] (→ See Figure 12.) Kenya accounted for more than half of new installations. At the end of 2014, the countries with the largest amounts of geothermal electric generating capacity were: the United States (3.5 GW), the Philippines (1.9 GW), Indonesia (1.4 GW), Mexico (1.0 GW), New Zealand (1.0 GW), Italy (0.9 GW), Iceland (0.7 GW), Kenya (0.6 GW), Japan (0.5 GW), and Turkey (0.4 GW).[5] (→ See Figure 13.)

Global geothermal power generation in 2014 was 74 TWh.[6] Total capacity in operation has grown at an average annualised rate of 3.6% for the last five years, while the average annualised growth in generation has been lower, at 1.8%.[7] The global average capacity factor (utilisation) for geothermal power production has declined over this period, from about 71% in 2009 to about 66% in 2014. Average capacity factors were notably above-average in both Europe and Oceania, at around 80%, possibly explained in part by newer-than-average plant fleets.[8] In addition to ageing plants, reasons for lower capacity factors may include the growing market share of binary[iii] plants, ageing geothermal fields in some areas that have lower productive capacity than before, and variations in the accuracy of stated plant capacity.[9]

Kenya added 358 MW in 2014, more than doubling its stock to about 600 MW. Two 13 MW binary units were completed in February, expanding the Olkaria III complex to 110 MW.[10] The 140 MW Olkaria IV was commissioned in October, and two more 70 MW units came on line at Olkaria I in December.[11] Also of note, five mobile wellhead power plants, totalling 52 MW of capacity, began operations in 2014.[12] These units are valued for their ability to enable rapid deployment of geothermal power resources.[13]

Turkey added an estimated 107 MW of geothermal generating capacity in 2014, increasing its capacity by about a third to 0.4 GW. All the units added were binary units in the range of 6–26 MW each.[14] Turkey aims to deploy 1 GW of geothermal power by 2023.[15]

Indonesia increased its geothermal power capacity by about 5%, to 1.4 GW, as three new units came on line in 2014, the largest being the 55 MW Patuha Unit 1.[16] Licensing for new

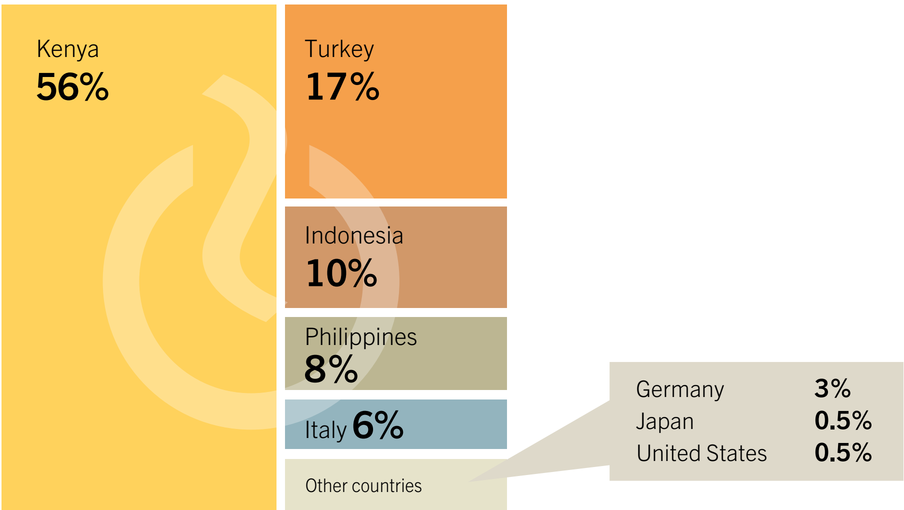
i - Germany's amendment to the FIT sets a cap on new biogas power capacity, per Agata Przadka and Erneszt Kovacs, *Biogas Report 2014* (Brussels: European Biogas Association, 2014), http://european-biogas.eu/2014/12/16/4331/.

ii - This does not include the renewable final energy output of ground-source heat pumps, which was estimated at 325 PJ (90 TWh) in 2014.

iii - In a binary plant, the geothermal fluid heats and vaporises a separate working fluid, which drives a turbine for power generation. Each fluid cycle is closed, and the geothermal fluid is re-injected into the heat reservoir. In a conventional thermal power plant, the working fluid is water. Organic Rankine Cycle (ORC) binary geothermal plants use an organic fluid with a lower boiling point than water, allowing effective and efficient extraction of heat for power generation from relatively low-temperature geothermal fields. The Kalina cycle is another variant for implementing a binary plant.

GEOTHERMAL POWER

Figure 12. Geothermal Power Global Capacity Additions, Share by Country, 2014



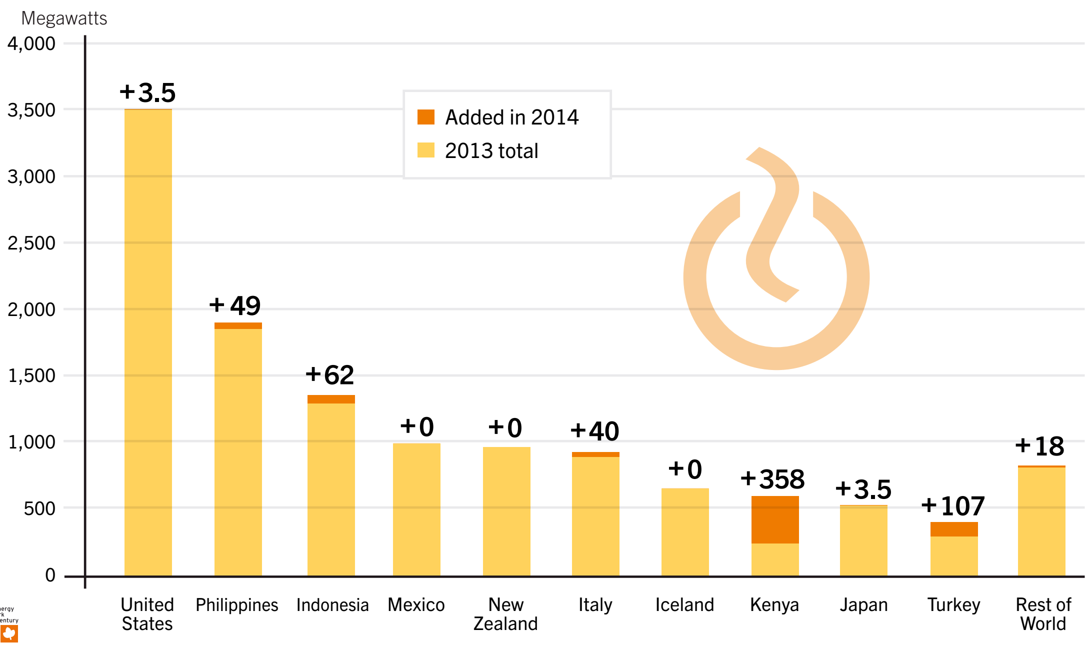
Source: See Endnote 4 for this section.

GLOBAL OUTPUT

POWER **74 TWh**

HEAT **73 TWh**

Figure 13. Geothermal Power Capacity and Additions, Top 10 Countries and Rest of World, 2014



Source: See Endnote 5 for this section.

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geothermal capacity in Indonesia has been held back by several barriers, including fossil fuel subsidies in power generation and unsustainably low payments for geothermal power in recent years.[17] Restrictions on projects in protected forest areas, nature reserves, and national parks may have played a role as well; at the same time, the industry acknowledges the need to protect the forest environment and hydrology to sustain geothermal installations.[18] To simplify the complex licensing requirements for developing Indonesia's 29 GW of potential, a new law was enacted in 2014 to consolidate licensing under the central government and to institute new pricing rules. The law also reclassified geothermal development as outside the scope of mining activity, thereby lifting restrictions on developing fields within forest conservation areas, but also requiring developers to share revenues with local communities.[19]

After successful testing and grid-connection in 2013, the Philippines began commercial operations at the 20 MW Maibarara geothermal power plant in early 2014.[20] Later in the year, the 49.4 MW Nasulo facility was inaugurated, raising the country's total capacity to about 1.9 GW.[21] The Renewable Energy Act of 2008 is considered instrumental in paving the way for recent and ongoing geothermal development, in part by making investment more attractive.[22]

In Italy, two 20 MW units at the Bagnore 4 plant were operating by year's end. The plant joined forces with the 17-year-old 20 MW Bagnore 3 at Mt. Amiata in Tuscany.[23] Germany brought several geothermal co-generation plants on line in Bavaria, all producing power and heat, for a total addition of 18 MW/51 MW_{th}.[24]

The United States and Japan each added a handful of binary units of 2 MW or less.[25] Japan has the third largest geothermal potential in the world, after the United States and Indonesia, but it ranks only eighth in power generation, as little new capacity growth has occurred for two decades. However, government support for geothermal power has increased since the 2011 nuclear disaster, and, as a result, industry had over 40 exploration and development projects running in 2014.[26]

The 166 MW Te Mihi plant was completed in New Zealand in 2013 and was counted among additions for 2013 (→ See GSR 2014.), although this plant was not officially delivered until 2014.[27] Its two 83 MW Toshiba turbines replaced some existing capacity at the old Wairakei field for a net increase of approximately 115 MW.[28]

There is great anticipation for expanded geothermal activity in East Africa, beyond Kenya. Ethiopia hopes to overcome structural barriers and lack of funding to exploit its geothermal resources to meet rapidly growing electricity demand.[29] Recently, Icelandic and Japanese development agencies have provided assistance for new geothermal plans in Ethiopia, but development has been slow, due not only to high upfront costs and project risk but also to limited local technological capacity.[30] In 2014, the World Bank committed USD 200 million in funding for development of Ethiopia's Aluto and Alalobad geothermal sites.[31] In Djibouti, international development agencies are helping to re-launch exploration and development, including a 50 MW development in the Asal-Fiale field.[32]

The Central American market also shows promise.[33] Honduras continued development of the Platanares geothermal site in 2014 with the aim of producing power by 2016.[34] In Costa Rica, construction is under way to expand capacity at the Las Pailas plant with an additional 55 MW.[35]

Geothermal direct use refers to direct thermal extraction for heating and cooling, excluding heat pumps.[i] Geothermal direct use stood at an estimated 263 PJ in 2014 (73 TWh). An estimated 1.1 GW_{th} was added in 2014, for a total capacity of 20.4 GW_{th}.[36] Over the past five years, the average annualised growth in direct use capacity has been 5.9%, while the average annualised growth in direct heat consumption has been 3.3%. The average global capacity factor (utilisation) for direct geothermal heat plants was an estimated 41% in 2014.[37]

The single largest direct use sector is estimated to be swimming pools and other public baths (9.1 GW_{th} of capacity, and 33.2 TWh of use); however, this category is difficult to quantify due to differences in methods of operation.[38] The second largest sector is space heating, including district heat networks (7.6 GW_{th}; 24.5 TWh). Market penetration can be very high in locations where resources are particularly plentiful and where district heat systems are well developed, such as Iceland, where nine out of ten buildings rely on direct geothermal heat.[39] Other uses include domestic hot water supply, greenhouse heating, industrial process heat, aquaculture, snow melting, and agricultural drying.[40]

Much of the thermal activity during the year took place in Europe, including some district heat schemes in countries that have relatively few traditional high-temperature resources.[41] Italy saw completion of two small thermal plants: a 6.5 MW_{th} installation in Tuscany and a 0.7 MW_{th} installation in Vicenza.[42] In addition, Germany completed the two co-generation plants noted above, Hungary completed two new facilities (2 and 3 MW_{th} respectively), and France advanced development of a 10 MW_{th} plant in Arcueil-Gentilly, near Paris.[43] Drilling for the Paris basin project, which combines geothermal and natural gas-derived heat, started in late 2013 and is expected to be fully completed in 2015.[44] In all, there are plans for five new district heating systems in the Paris region in the near future.[45] In Finland, plans are under way for a 40 MW_{th} closed-loop district heat plant to be completed in 2016, utilising a direct heat exchanger.[46]

The countries with the largest geothermal direct use capacity at the end of 2014 were China (6.1 GW_{th}), Turkey (2.8 GW_{th}), Japan (2.1 GW_{th}), Iceland (2.0 GW_{th}), India (1.0 GW_{th}), Hungary (0.9 GW_{th}), Italy (0.8 GW_{th}), and the United States (0.6 GW_{th}). Together, these eight countries account for about 80% of global capacity.[47]

In line with installed capacity, China utilised the largest amount of direct geothermal heat (20.6 TWh). Other top users of direct geothermal heat are Turkey (12.2 TWh), Iceland (7.4 TWh), Japan (7.1 TWh), Hungary (2.7 TWh), the United States (2.6 TWh), and New Zealand (2.4 TWh). These countries accounted for approximately 70% of direct geothermal use in 2014. On a per capita basis, direct use is by far most significant in Iceland, at 22 MWh per person each year, followed by New Zealand, Hungary, Turkey, and Japan, all at 0.5 MWh per person or less.[48]

i - Direct use refers here to deep geothermal resources, irrespective of scale, as distinct from shallow geothermal resource utilisation, specifically ground-source heat pumps. (See heat pumps discussed in Sidebar 4 of GSR 2014.)

GEOTHERMAL INDUSTRY

The Global Geothermal Alliance was launched at the UN Climate Summit in 2014 to address the high upfront cost and investment risks that continue to be the main obstacles to more rapid deployment of geothermal energy. The Alliance also is charged with promoting innovative financing, risk mitigation, regulatory and institutional reform, and capacity building and technical assistance for geothermal systems development.[49]

To address some of these challenges in developing countries, the World Bank has mobilised funds, totalling USD 235 million by the end of 2014, for critical early-stage investment in geothermal energy projects. These resources are to support project development in several countries including Armenia, Chile, Djibouti, Dominica, Ethiopia, Indonesia, Kenya, Mexico, Nicaragua, St Lucia, and Turkey, with further expansion envisioned at 36 geothermal fields across 16 countries.[50]

Lack of funding and the exposure to project risk are challenges not limited to developing countries. In Europe, the industry is concerned that the geothermal power market is not developing as quickly as it should be due to general lack of awareness of the potential and value of geothermal energy, perceived low public financial support relative to other technologies, and the lack of a transnational risk insurance fund for Europe to spread the risk beyond national economies.[51]

In the United States, government research programmes are aimed at overcoming some of the technical and risk barriers associated with geothermal development. For example, the advancement of enhanced geothermal systems (EGS) may reduce the risk of drilling what otherwise might be unproductive or sub-commercial wells.[52] EGS enhances extraction of heat by fracturing subsurface rock for greater permeability, allowing production similar to naturally occurring conventional geothermal fields.[53] Because this technology is not limited to conventional hydrothermal resources, the potential is significant and is estimated to be 100 GW in the United States alone.[54]

A further challenge in some locations can be the release of potentially harmful air emissions from geothermal plants.[55] For example, the Puna geothermal plant on the US Island of Hawaii was fined for uncontrolled emissions of hydrogen sulphide in early 2015.[56] Hydrogen sulphide emissions at the 303 MW Hellisheidi power plant on the outskirts of Reykjavik, Iceland, also have raised concerns. To address this issue, plant operators at Hellisheidi started hydrogen capture and re-injection protocols in 2014.[57]

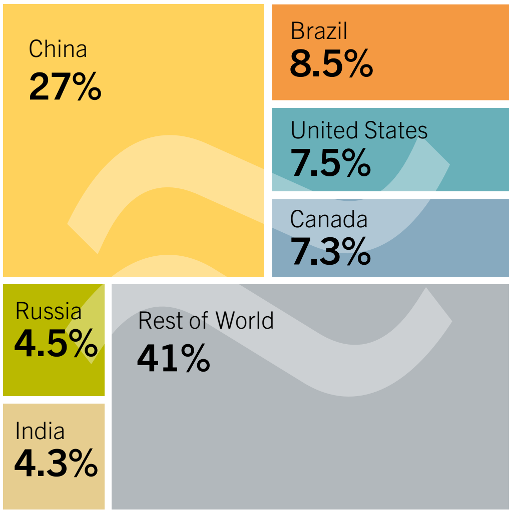
One industry innovation in 2014 is geothermal-solar thermal hybrid systems. Enel Green Power (Italy), in co-operation with US partners, explored the benefits of using concentrated solar power to supplement geothermal heat for power production at the Stillwater binary plant in Nevada.[58] In Italy, Enel started construction of another hybrid configuration, combining geothermal power with biomass sourced from local forests. The system is expected to return higher steam temperatures than otherwise, for greater efficiency and output.[59]

There were 612 geothermal power plants operating worldwide by the end of 2014. The majority of installed capacity—7.8 GW and 63% of global geothermal generation—is represented by 237 flash plants. Flash plants separate steam from the water stream before driving a turbine, and they are used in fields that have plentiful steam at temperatures above 180 °C. More numerous, but representing less capacity (1.8 GW and 12% of generation), are the 286 binary-cycle plants, which typically operate at resource temperatures of 100–180 °C. There are also 63 dry steam plants (2.9 GW and 22% of generation), the oldest type of geothermal power plant, implemented where water/steam phase separation is not required.[60]

The main geothermal field/plant operators in 2014 were US-based Chevron and Calpine (1.3 GW each), followed by EDC of the Philippines (1.2 GW), the Mexican state utility CFE and Italy's Enel Green Power (1 GW each), and the US-based Ormat (0.9 GW).[61] The market leaders for new turbine installations were Mitsubishi, Ormat, and Fuji Electric, which together represented 60% of new units and 75% of existing capacity in 2013.[62] For all existing capacity, the market leaders have been mostly Japanese, with Toshiba, Mitsubishi, and Fuji Electric each accounting for 2.6–3.0 GW. They are followed by Ormat (binary technology) and Ansaldo-Tosi (1.7 GW each), and General Electric-Nuovo Pignone, which ranks sixth (500 MW); all others represent significantly less.[63] In addition to Ormat, other (mostly binary) turbine manufacturers include Exergy, Atlas Copco, Electra Therm, TAS Energy, Cryostar, and Turboden.[64]

HYDROPOWER

Figure 14. Hydropower Global Capacity, Shares of Top Six Countries and Rest of World, 2014

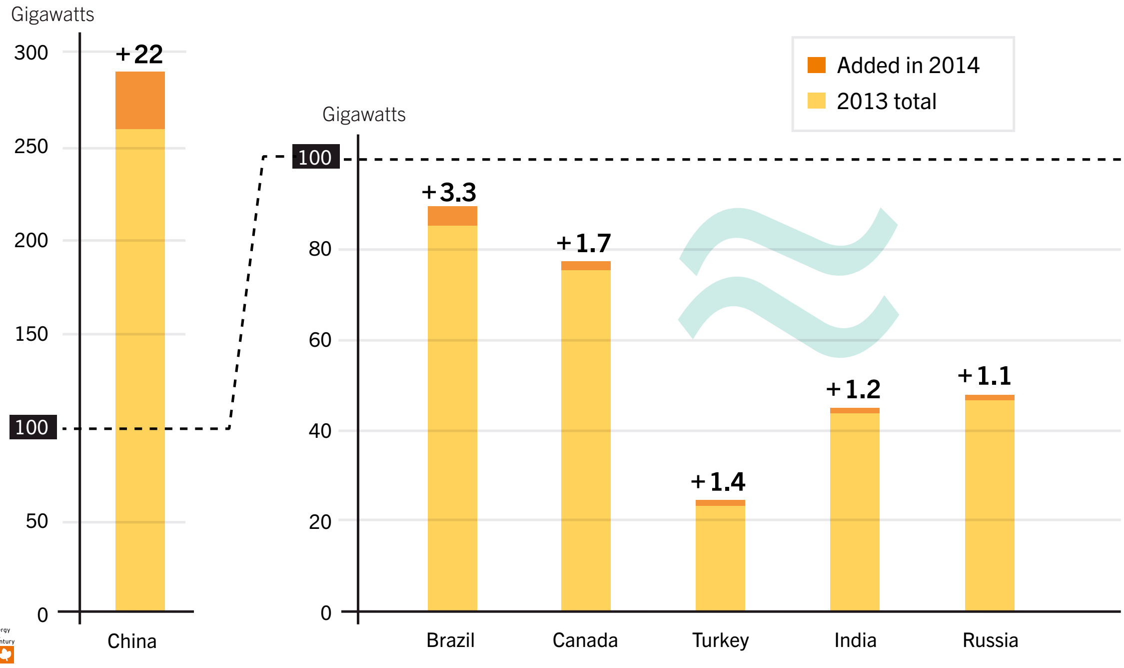


Source: See Endnote 2 for this section.

Global capacity reached 1,055 GW

Figure 15. Hydropower Capacity and Additions, Top Six Countries for Capacity Added, 2014

Source: See Endnote 5 for this section.



HYDROPOWER

HYDROPOWER MARKETS

An estimated 37 GW of hydropower capacity was commissioned in 2014, increasing total global capacity by 3.6% to approximately 1,055 GW.[i1] The top countries for hydropower capacity and generation remained China, Brazil, the United States, Canada[ii], Russia, and India, which together accounted for about 60% of global installed capacity at the end of 2014.[2] (➔ See Figure 14 and **Reference Table R6**.) Global hydropower generation, which varies each year with hydrological conditions, was estimated at 3,900 TWh in 2014, an increase of more than 3% from 2013.[3] Hydropower generation declined in many countries due to droughts, but it recovered significantly in China following a drop in 2013. Global pumped storage capacity was estimated to be as high as 142 GW at year's end.[4]

A significant portion of new capacity in 2014 was installed in China; substantial additional capacity also was commissioned by Brazil, Canada, Turkey, India, and Russia.[5] (→ See Figure 15.) China commissioned almost 22 GW for a year-end total of 280 GW. Despite the significant increase in capacity from new completions, China's additions were down 29% relative to 2013.[6] Hydropower generation in China increased by almost 20%, due to better hydrological conditions, exceeding 1,000 TWh for the first time (at 1,070 TWh).[7] The Xiluodu plant (13.86 GW), which started operations with two-thirds of its full capacity in 2013, was completed in 2014, becoming the third largest hydropower plant in the world after China's Three Gorges and Brazil's Itaipu.[8] Downstream from Xiluodu on the Jinsha River, the 6.4 GW Xiangjiaba plant came on line, becoming China's third largest hydropower plant.[9] It houses eight 800 MW turbines, which are the highest capacity hydro units in the world.[10] In addition, the last generating units of the 5.85 GW Huaneng Nuozhadu station were put into service in June, making it the fourth largest hydropower facility in China.[11] Investment in the country's hydropower infrastructure was USD 15.6 billion (CNY 96 billion) for the year, down 21.5% from 2013.[12]

Brazil added 3.3 GW in 2014, including 138 MW of small-scale[iii] hydro (<30 MW) capacity, for a year-end total of 89.2 GW.[13] Brazil's hydropower output (393 TWh in 2014) has been severely affected by prolonged droughts, with some reservoirs at all-time lows in 2014.[14] Despite annual increases in generating capacity, the share of hydropower in total generation dropped from 91% in 2011 to 73% in 2014.[15] At the Madeira River complex, the Jirau plant (the largest single renewable energy Clean Development Mechanism project) saw 24 of its 75 MW turbines in commercial operation by the end of 2014; this will be a 3.75 GW facility when completed.[16] Jirau and its sister plant Santo Antonio (3.57 GW when completed), also along the Madeira River, were ordered to revisit their environmental impact assessments in 2014 following floods in upstream Bolivia after heavy rains.[17] Neighbouring Colombia completed the 820 MW Sogamoso hydropower plant, which is expected to supply 10% of the country's power needs.[18]

Another country where hydropower generation has suffered due to drought is the United States. In 2014, the country experienced its third consecutive year of decline in output, with generation of 259 TWh, and a drop of 5.3% relative to the annual average over the preceding nine years.[19] The United States had 79.2 GW of hydropower capacity at year-end.[20]

Third for new installations was Canada, which completed 1.7 GW of new hydropower capacity in 2014, raising its total generating stock to 77.4 GW.[21] However, output dropped by 3.1% to 375 TWh.[22] By early 2015, Ontario's Lower Mattagami River redevelopment project was completed, almost doubling capacity to 924 MW at four generating units.[23] The 195 MW Forrest Kerr facility came on line in British Columbia in 2014.[24] Both projects are notable, among others, for being developed in co-operation with aboriginal First Nations people, whose native lands are affected by reservoir development. Such partnerships are becoming quite frequent for new hydropower development in Canada.[25]

Turkey added 1.35 GW of hydropower capacity in 2014, for a total of 23.6 GW. Hydropower generated 40.1 TWh during the year, representing a 32% decline from 2013, and the result of drought in recent years.[26]

India added about 1.2 GW of capacity in 2014, 228 MW of which was classified as small-scale hydro (<25 MW per facility), bringing the country's total capacity to 44.9 GW. Annual generation was estimated at 144 TWh; generation from large hydropower facilities (>25 MW) was 131 TWh, which is virtually unchanged from 2013.[27] The 240 MW Uri II project was completed in early 2014 after experiencing technical difficulties during commissioning, including limited water availability.[28]

In Russia, net capacity additions in 2014 were 1.1 GW, increasing installed capacity to 47.7 GW. Even as capacity rose, hydropower generation (164 TWh) declined 4.4% from the previous year.[29] The last of ten 640 MW turbines was installed at the Sayano-Shushenskaya facility (6.4 GW) in late 2014, finally completing the restoration of the plant, which suffered a severe accident in 2009.[30] At the Boguchanskaya plant, the last of nine 333 MW units was commissioned; the station is expected to reach its full capacity of 3 GW once its reservoir is full later in 2015.[31]

The Grand Renaissance project (6 GW when completed) on the Abbay River (Blue Nile) in Ethiopia continued to advance in 2014. However, downstream neighbours have raised concerns about the project's impact. In 2014, Ethiopia, Egypt, and Sudan agreed to jointly carry out further studies on the project, and in early 2015, they issued a joint Declaration of Principles for co-operation on the sustainable and fair use of the Nile Basin water resources.[32]

Elsewhere in Africa, Rwanda brought on line its new Nyaborongo plant (28 MW). While relatively small in the global context, the facility is significant for this nation of 11.8 million people. This project increased Rwanda's power capacity by 25% and is expected to reduce electricity deficits in a country where only 19% of the population had access to electricity in late 2014.[33] Even smaller was Rwanda's 2.2 MW Rukarara 2 hydropower

i - Global data reflect an upwards adjustment of 18 GW to year-end 2013 capacity noted in GSR 2014. Unless otherwise specified, all capacity numbers exclude pure pumped storage capacity if possible. Pumped hydro plants are not energy sources but means of energy storage. As such, they involve conversion losses and are powered by renewable and/or non-renewable electricity. Pumped storage plays an important role in balancing power, in particular for variable renewable resources.

ii - Despite slightly lower total capacity, Canada's baseloaded output exceeds the more load-following output in the United States.

iii - Brazil reports hydropower capacity separately by size category, at the threshold of 30 MW. India does the same, at the threshold of 25 MW.

plant that came on line in 2014, which is one of many examples of small hydropower projects expected to advance rural electrification in developing countries.[34] As of 2012, global installed capacity of small plants of 10 MW or less was estimated at 75 GW.[35] Small hydropower has been credited for its suitability for improved rural electrification and for its potential for socially inclusive and sustainable development.[36]

Global pumped storage capacity at the end of 2014 was estimated to be as high as 146 GW, with as much as 2.4 GW of capacity added in 2014.[37] One project completed during the year was on the island of El Hierro, the smallest of the Canary Islands. The 6 MW project is small in scale but large in significance. The island is now self-sufficient in power thanks to the combination of wind power (11.5 MW) and the pumped storage facility, which together displaced a diesel plant.[38] In Austria, the 430 MW Reisseck II pumped storage facility was completed in early 2015.[39]

As of early 2015, several new variable-speed pumped storage plants were planned or under construction in Europe, and one existing plant was being retrofitted for variable-speed operation. Variable speed capability for new and refurbished pumped storage plants improves pumping efficiency; it also provides the flexibility to match the level of pumping at any given facility with conditions on the grid, as it enables power regulation capabilities in both generation and pumping modes.[40] The 1,000 MW Linthal plant under construction in Switzerland will be the first high-capacity variable speed pumped storage dam when completed in 2015.[41] Other notable pumped storage facilities on the horizon include the 1.3 GW Ingula pumped storage facility in South Africa, to be operational in 2015, and a 2.1 GW plant to be built in Egypt.[42]

Pumped storage is not the only way to use hydropower for active reserve power. Norway, the United Kingdom, and Germany agreed in 2014 to build two 1.4 GW interlinks to enable Norway's significant hydropower capacity to function as a balancing reserve for its southern neighbours, particularly in the context of variable renewable power.[43]

The topic of sustainability remains prominent in the context of hydropower development. In 2014, the World Bank acknowledged the Hydropower Sustainability Assessment Protocol, launched in 2011, as a useful and complementary tool for developing sustainable hydropower projects, but it noted that it did not replace the Bank's own policies and safeguards in this regard.[44] The US Congress acted in 2014 to require improved social and environmental safeguards for project funding, and the World Bank Group announced in early 2015 that it sought to improve safeguards related to resettlement practices.[45] In early 2015, the US government registered its opposition to the Bank's funding of the 108 MW Gulpur project in Pakistan on grounds of inaccurate and inadequate environmental risk assessment.[46]

A number of projects have been delayed or cancelled due to concerns about social and environmental impacts. In Turkey, the 1.2 GW Ilisu dam on the Tigris River continued to be stymied by geopolitical factors in 2014, due in part to controversy over the eventual flooding of ancient archaeological sites.[47] In India, local opposition caused further delays for the 2 GW Lower Subansiri project.[48] In Vietnam, allegations of illegal land acquisitions and mismanagement prompted authorities to consider revoking investor licences.[49] Among the complaints is the impact of dams on downstream agriculture as well as failure by developers to plant trees to compensate for deforestation.[50]

HYDROPOWER INDUSTRY

Industry continued innovation towards ever more flexible, efficient, and reliable hydropower facilities. Hydro equipment manufacturers responded to the growing need for pumped storage, in part to integrate rising shares of variable renewable power.[51] Likewise, there is a growing demand, particularly in North America and Europe, for refurbishment of power plants—not only to increase their efficiency and power output, but also to improve their environmental performance to meet new regulatory requirements.[52] Another driver for innovation is the demand for lower generating costs, which has contributed to the development of very large machines to achieve high operating efficiencies. Examples include the two 800 MW units installed at China's Xiangjiaba plant in 2014.[53]

The hydropower sector is responding to growing climate change risk with increased research into associated vulnerabilities and is, in some instances, incorporating climate change resilience into project design and operations.[54] Such considerations include potential and projected changes in river flows, dam safety in the face of extreme floods, projected variability in electricity generation, and optimisation of turbines and other design parameters for greater variability in river flow.[55]

The most significant providers of hydropower equipment are Alstom (France), Andritz Hydro (Austria), and Voith Hydro (Germany), each with about equal market shares. Together they account for about one-half of the global market.[56] Other notable manufacturers include Harbin (China), Dongfang (China), and Power Machines (Russia).

Andritz Hydro reported that both sales and new orders were down for the second consecutive year because the global market has shrunk in recent years. However, the company said that it was looking forward to some large projects in South America and Africa, along with global growth in refurbishment of existing plants and small-scale hydropower facilities in emerging countries where lower absolute investment costs may be particularly important.[57]

For Voith Hydro, 2014 sales were down 5% relative to 2013, but new orders were up 24% over the same period.[58] However, Voith saw significant opportunities in refurbishment of existing plants, particularly in North America, Russia, and Eastern Europe.[59] The one weak spot in the market, according to Voith, was the Latin American market, where projects were delayed on account of political and economic conditions.[60] Voith also noted the continuing concern that revenue to pumped hydro facilities for peak power may not be adequate in the current context of growing peak solar PV generation.[61]

Alstom's proposed merger with General Electric in 2014 raised preliminary concerns from the European Commission in relation to potential loss of competition in some market segments, but the Commission expressed no concerns about the joint company's hydropower activities.[62]

OCEAN ENERGY

OCEAN ENERGY MARKETS

Ocean energy refers to any energy harnessed from the ocean by means of ocean waves, tidal range (rise and fall), tidal streams, ocean (permanent) currents, temperature gradients, and salinity gradients.[1] At the end of 2014, global ocean energy capacity remained at about 530 MW, with most of this coming under the category of tidal power, and specifically tidal barrages across bays and estuaries.[2] Most of the development effort in ocean power technologies is focused on tidal, current, and wave power in open waters.

The largest ocean energy facilities in operation are all tidal barrage projects and are used for electricity generation. They include the 254 MW Sihwa plant in South Korea (completed in 2011), the 240 MW Rance station in France (1966), the 20 MW Annapolis plant in Nova Scotia, Canada (1984), and the 3.9 MW Jiangxia plant in China (1980).[3] Other projects are smaller in capacity, and many are pre-commercial demonstration projects, with a notable concentration (totalling several megawatts) of tidal stream and wave energy development installations in the United Kingdom.

Little capacity was added globally during 2014. Virtually all new installations were in some form of pilot or demonstration projects, and most activity that did occur was in European waters. Among significant developments on the horizon is the 398 MW MeyGen tidal stream project in Scotland.[4] The UK's Crown Estate, as manager of the UK seabed, announced its commitment to invest USD 15.5 million (GBP 10 million) for the first phase of the MeyGen development in an effort to catalyse investments by others, and to advance other projects towards construction and operation.[5] The Crown Estate also opened up leases for further wave and tidal current technology test and demonstration zones in UK waters, some being designated for locally based organisations.[6] There are also significant tidal development plans in the Alderney Race between Alderney (UK) and France, where the tidal resource is estimated at 1.4 GW.[7]

OCEAN ENERGY INDUSTRY

The year was notable for continued innovation and progress towards commercialisation in ocean energy. But the industry also faced some tangible headwinds, particularly for Pelamis Wave Power and Aquamarine Power, two Scottish wave energy firms.

Pelamis faced bankruptcy administration in late 2014, after failing to secure the funding necessary to continue further development of its wave energy converters.[8] The Scottish government stepped forward with plans to continue the work of Pelamis and to retain some of the company's staff under Scottish Wave Energy, funded by the Scottish energy budget.[9] Subsequently, Wave Energy Scotland acquired the intellectual property and physical assets of Pelamis along with funding of USD 22 million (GBP 14.3 million).[10]

Also in late 2014, Aquamarine Power announced plans to downsize its business while retaining a core team to continue operations and maintain its Oyster 800 wave machine at the European Marine Energy Centre (EMEC) in Orkney. The decision was said to be the result of financial, regulatory, and technical challenges that are faced by the entire ocean energy sector.[11]

To address development risk, a new ocean simulation facility was opened at the University of Edinburgh in 2014. The FloWave test tank can simulate real ocean conditions to aid technology developers by potentially "de-risking" the development process before they incur the greater cost of going offshore.[12] FloWave and other government-supported test facilities and research can help ameliorate technology-specific risk. Other risks include uncertainties regarding long-term funding as well as adequate interconnection given that the best ocean energy resources are generally not close to grid infrastructure.[13]

In addition, the EU Ocean Energy Forum was launched in 2014 with the aim of bringing together stakeholders for problem solving and co-operation on ocean energy. The ultimate aim is to forge public-private partnerships to enhance the impact of innovative research and development and to provide a platform for sharing investment risk.[14]

Most deployments in 2014 were pre-commercial projects that developers hope may be expanded further. Among these is Carnegie Wave Energy's (Australia) Perth Project, which passed a significant milestone with the deployment of three of its interconnected CETO 5 wave energy devices in late 2014 and early 2015. The devices, which are entirely submerged during operation, are configured for desalinating seawater in addition to power production.[15]

Among other notable projects was the installation of a 30 kW tidal device by Nova Innovation (Scotland) in the Bluemull Sound in Shetland (Scotland) in April 2014. With funding support from the Scottish government, the project has been called the world's first community-owned tidal turbine.[16] Subsequently, Nova and its partner ELSA (Belgium) secured further funding for a 500 kW array in the same location, using 100 kW devices.[17] In early 2015, three grid-connected tidal turbines were installed in a Dutch sea defense dike by Tocardo (Netherlands), in co-operation with the Dutch Tidal Testing Center, with plans to expand this 300 kW installation up to 2 MW upon further evaluation.[18] The project was generating electricity for about 100 households.[19] The company was also chosen to develop a future 28 MW tidal energy project in the Mokpo Jeonnam region of South Korea, and another one in the United Kingdom, off the Isle of Man.[20]

In spite of the challenges faced, in early 2015 Aquamarine reported operating data for its Oyster 800 device, noting that it has operated as expected and even exceeded expectations at high sea states[i]. The company's plan is to continue development of the next generation of the device along with the WavePOD, a subsea generating unit for wave energy generators that is being developed in co-operation with several other parties.[21]

Atlantis Resources (UK/Singapore) announced in early 2014 that it had reached an agreement with Dongfang Electrical Machinery (China) for testing in preparation for deployment of Atlantis's 1 MW AR1000 tidal stream turbine at an offshore demonstration project in Zhejiang Province in China. Dongfang also would provide low-cost manufacturing for the new 1.5 MW AR1500 turbine, which was developed by Atlantis in co-operation with Lockheed Martin (United States). [22]

Having acquired a majority stake in the MeyGen project in Scotland in 2013, Atlantis Resources announced in early 2015 that it had commenced construction of onshore facilities, including directional drilling for subsea cables for turbine interconnection.[23] Atlantis also announced a construction contract with Lockheed Martin to build Atlantis's AR1500 turbines for the project, scheduled for delivery in 2016. The turbines feature active rotor pitch control and full nacelle yawing capability.[24] In addition, Atlantis signed a contract with Andritz Hydro Hammerfest (Norway) to supply three 1.5 MW tidal turbines to the first phase of the MeyGen Project.[25]

OpenHydro (a subsidiary of DCNS, France, since 2013) partnered with Alderney Renewable Energy in plans to develop a 300 MW tidal array. The joint venture, called Race Tidal Ltd., would use 150 of the company's 2 MW turbines.[26] Following tests in Brittany (France), OpenHydro and EDF (France) committed to deploying two new turbines as a pilot project in 2015, with an eye towards pre-commercial farms in subsequent years.[27]

Alstom (France) also has plans in the area. In late 2014, together with GDF Suez (France), Alstom was chosen by the French government to supply four of its new turbines for the Raz Blanchard (Alderney Race) tidal pilot project, to begin operation in 2017, with an expected operational lifespan of 20 years.[28] The company will deploy its improved tidal turbine technology, the 1.4 MW Oceade 18, featuring variable pitch blades and rotating nacelle to best face the oncoming tide.[29]

Nautricity (Scotland) tested its 500 kW dual-rotor contra-rotating marine turbine (CoRMaT) during 2014 at EMEC's test bed in Shapinsay Sound (Scotland). In early 2015, the company secured an alternate grid-connected testing berth at EMEC's Fall of Warness site, where stronger tides allow further testing under the harshest sea conditions.[30] Magallanes Renovables (Spain), supported by the EU-funded Marinet project, launched a prototype of its floating ATIR turbine at EMEC in late 2014 for its first testing at sea. A full-scale version would have a capacity of 2 MW.[31] OpenHydro also continued to test and develop its technology at EMEC, installing a new generation of its device in early 2014.[32]

New tidal projects were planned at Canada's Fundy Ocean Research Center for Energy (FORCE) in the Bay of Fundy. OpenHydro and its local partner Emera were given a green light at FORCE for their plan to deploy two 2 MW tidal turbines in 2015 as a first phase towards a commercial-scale project known as Cape Sharp Tidal.[33] Black Rock Tidal Power (Canada), a subsidiary of marine propulsion manufacturer Schottel (Germany), was offered a demonstration berth to deploy its technology, which combines a Triton platform developed by TidalStream (UK) with 16 of Schottel's 70 kW "floating" tidal generators (STG).[34] Schottel also saw its STG turbines deployed at another test site by Sustainable Marine Energy (UK) off the Isle of Wight.[35] Later in 2014, the newly formed Schottel Hydro announced its new instream turbine (SIT). The company's technology is based on the premise that reducing turbine size leads to a better ratio of power and material use.[36]

The ocean power industry saw some acquisitions in 2014, in addition to Wave Energy Scotland's purchase of Pelamis' assets. Fortum (Finland) acquired a minority stake in Finnish wave energy developer Wello.[37] Wello's single device, called the Penguin, is said to contain all original parts from the time of construction in 2011, establishing confidence in the durability of its design.[38] The Penguin is a floating platform that encapsulates a rotating eccentric mass that is actuated by waves, driving a generator typically used in wind turbines.[39] Tocardo acquired fellow Dutch company IHC Tidal Energy from Royal IHC. In doing so, Tocardo supplemented its horizontal-axis turbines with a vertical-axis technology that is nearing commercialisation.[40] In early 2015, Tocardo also acquired the intellectual property of Swanturbines (UK), including its subsea tidal turbine technology.[41]

In recent years, tidal and wave technologies have advanced the most of all ocean energy technologies, with tidal power expected to be commercially viable earlier than wave technologies.[42] While tidal technologies show a greater convergence in design, wave energy devices are more varied and generally have not reached the same stage of development. The differentiation in wave energy devices is due in part to variability in wave resource characteristics at different water depths.[43]

i - A sea state is a general condition of the ocean surface with respect to waves and swell as generated by tidal forces and wind.

SIDEBAR 5. SUSTAINABILITY SPOTLIGHT: THE WATER-ENERGY-FOOD NEXUS

In a world with growing demand and constraints on resources, managing the interlinkages among water, energy, and food systems—the nexus—has become a key to ensuring sustainability as well as security of supply. Population growth, economic development, and urbanisation are driving up the consumption of fresh water, energy, and food, each of which is expected to experience significant long-term growth. Meeting these growing demands will become progressively difficult as resource scarcity, the impacts of climate change, and conflicting needs within the nexus intensify.

As demand for fresh water increases and as supply becomes scarcer, more energy will be required for pumping, desalination, treatment, and distribution. Annual water withdrawals in the energy sector—for mining, processing, refining, and electricity generation—account for nearly 15% of global freshwater use and are expected to grow significantly over the coming decades. The agri-food sector alone accounts for 30% of global energy use and 70% of freshwater withdrawals. As food demand grows, the associated energy and water inputs likely will increase as well, putting more pressure on the other two sectors.

Nexus-based policies and solutions can help to mitigate or avoid these trade-offs and to leverage potential synergies. Renewable energy represents one such solution. Despite the challenges associated with some renewable technologies[i], renewables offer great potential to reduce demand pressures and enhance water, food, and energy security—if deployed sustainably.

Increasing the deployment of renewable energy technologies with relatively low water inputs—such as most solar technologies and wind—can help to reduce water demand in the energy sector. A recent IRENA study found that countries such as Germany, India, and the United Kingdom would be able to greatly reduce water withdrawals and use in the electricity sector by increasing the share of renewables. Renewables-based technologies also can enhance water security. Pumps and irrigation systems powered by renewable energy are used widely in both developed (e.g., the United States and Australia) and developing countries (e.g., India). The use of desalination plants driven by renewables is also increasing, particularly in the Middle East, where the largest solar desalination plant is under construction in Saudi Arabia.

Renewable energy can enhance food security by reducing the agri-food sector's vulnerability to fossil fuel price spikes and volatility, which have been linked to the 2007–08 global food crisis. The use of renewables also can increase product value while reducing food losses in developing countries, where 30–40% of food produced is lost due to insufficient energy for processing and cooling. Solar dryers are being used to preserve fruit in northern Pakistan, and biogas-powered cooling has been introduced in the Ugandan dairy industry. Bioenergy, produced from organic waste and non-food crops, can raise the productivity of local farms, thus increasing disposable income.

To appropriately address the current and future nexus challenges, policy formulation needs to take an integrated approach that considers all three sectors. The first step towards an integrated approach is the further development of appropriate assessment tools and methodologies, which can inform decision making and implementation. Existing nexus tools model resource flows and impacts, analyse local environments, and evaluate policy options. Methodologies take either a "fully integrated" approach—accounting for all linkages among the resources, or an "entry point" approach—focusing on the impact of a single resource. The Stockholm Environment Institute's WEAP-LEAP[ii] model, for example, uses a fully integrated quantitative approach to analyse and model water and energy systems. The UN Food and Agriculture Organization and IRENA use food and renewable energy entry point approaches, respectively, relying on both quantitative and qualitative methods.

Research and non-profit organisations already are employing nexus assessment tools—for example to evaluate potential nexus trade-offs pertaining to Ethiopia's Growth and Transformation Plan and to assess alternative agricultural patterns and the potential for biofuel production in Madagascar. Some groups, such as the German Development Agency, GIZ[iii], and the Economic Community of West African States (ECOWAS), are working to integrate the nexus approach and tools on a broader policy level. Additionally, the water-energy-food nexus has been identified as a High Impact Opportunity by the Sustainable Energy for All (SE4ALL) initiative.

Despite the progress made and the increasing availability of assessment tools to facilitate the integration of this approach, however, governments, industry, academia, and civil society still have a long way to go to fully integrate nexus thinking into policymaking and project development.

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 68 for the Solar PV section.

i - For further information on sustainability challenges, see Sidebar 7 in GSR 2010 (bioenergy), Sidebar 4 in GSR 2012 (water impacts of renewable energy technologies), and Sidebar 3 in GSR 2013 (hydropower).

ii - Water Evaluation and Planning system (WEAP) and Long-range Energy Alternatives Planning system (LEAP)

iii - Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

SOLAR PHOTOVOLTAICS (PV)

SOLAR PV MARKETS

The year 2014 marked the 60th anniversary of the first public demonstration of a solar PV cell.[1] It also marked another record year for growth, with about 40 GW of capacity added, for a global total of about 177 GW.[i,2] The strong market in 2014 came despite the substantial decline in new installations in the European Union, challenges reaching targets (particularly for distributed systems) in China, and slower-than-expected emergence of promising new markets.[3] More than 60% of all PV capacity in operation worldwide at the end of 2014 was added over the past three years.[4] (→ See Figure 16 and **Reference Table R7**.)

Once again, the top three markets were China, Japan, and the United States, followed by the United Kingdom and Germany. Others in the top 10 for additions were France, Australia, South Korea, South Africa, and India.[5] Five countries added more than 1 GW of solar PV to their grids in 2014, down from nine countries in 2013.[6] While the vast majority of capacity was added in a handful of countries, the distribution of new installations continued to broaden, and plans for deployment are rising rapidly as prices fall.[7] All countries in the world have some solar PV in operation.[8] By the end of the year, 20 countries had at least 1 GW of capacity (up from 17 countries in 2013).[9] The leaders for solar PV per inhabitant were Germany, Italy, Belgium, Greece, the Czech Republic, and Japan.[10]

Asia eclipsed all other markets, accounting for almost 60% of global additions.[11] China increased its cumulative capacity by 60%, adding a reported 10.6 GW for a total exceeding 28 GW.[12] (→ See Figure 17.) Over 80% of China's new capacity was in large-scale power plants, and the remainder was in distributed rooftop systems and other installations for small-scale use.[13] Transmission infrastructure has not kept up with the rapid growth in capacity, leaving solar farms in sunny western regions without infrastructure to transmit power to demand centres in the south and east.[14]

In 2014, Inner Mongolia, Qinghai, and the coastal province of Jiangsu were at the forefront of additions, each installing more than 1 GW.[15] Although the market grew quickly, China struggled to meet self-imposed targets, particularly for distributed installations.[16] China generated about 25 billion kWh of electricity with solar PV in 2014, an increase of more than 200% over 2013.[17]

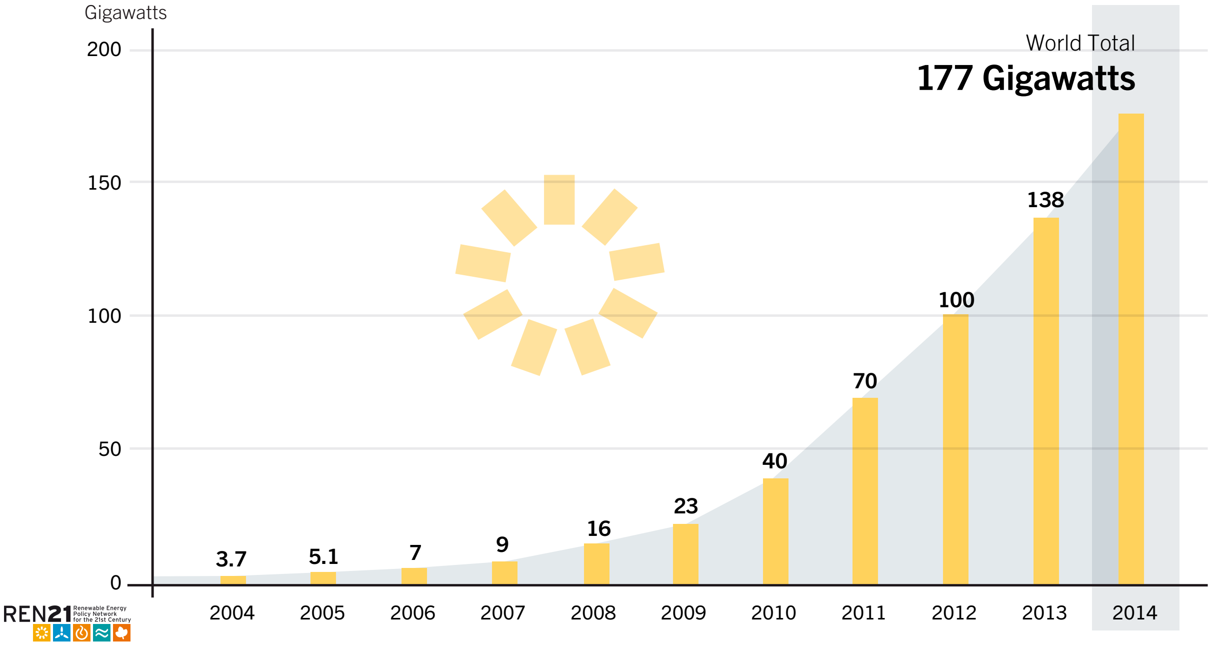
Japan's market continued its rapid expansion in 2014, with an estimated 9.7 GW added to the grid, raising total capacity to 23.3 GW.[18] Despite the record growth, the residential market saw its first decline since 2007, with 0.9 GW added for a total of 7.5 GW.[19] Commercial and utility-scale projects drove demand for the second consecutive year, and Japan saw a rapid expansion in the number of companies (including restaurants and home builders) registering to sell retail power.[20] Constraints limiting grid connections and difficulties finding suitable land are leading developers to use industrial parks, empty lots, and rooftops.[21]

In late 2014, due to concerns about their ability to absorb additional variable power, four utilities in Japan suspended new grid connections for solar PV projects.[22] The government responded by setting capacity limits for new grid connections; further changes made to Japan's FIT allow utilities to ask producers of solar power to reduce output once the capacity of the utilities' grid reaches its peak for variable electricity, and they remove the utilities' obligation to compensate these producers.[23] In January 2015, the four utilities resumed grid connections under the new rules (which did not yet apply to three major utilities, including TEPCO).[24]

i - Note that global additions and year-end capacity in 2013 were lower than reported in GSR 2014 because official Chinese numbers for 2013 additions were revised downwards after publication by about 2 GW (from 12.92 GW to 10.95 GW), for a year-end total of 17.45 GW, per China's National Energy Board, cited in National Energy Administration (NEA), "2014 PV Statistics," 9 March 2015, http://www.nea.gov.cn/2015-03/09/c_134049519.htm (using Google Translate).

SOLAR PV

Figure 16. Solar PV Global Capacity, 2004–2014

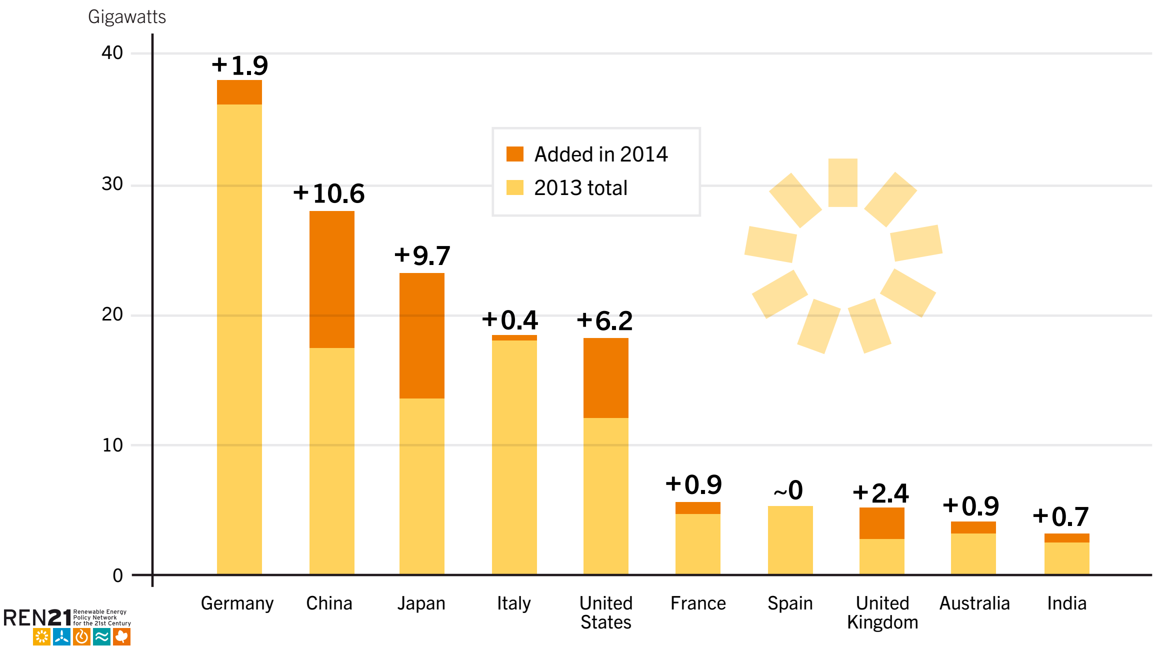


Source:
See Endnote 4
for this section.

40 GW

added in 2014

Figure 17. Solar PV Capacity and Additions, Top 10 Countries, 2014



Source:
See Endnote 12
for this section.

02

Elsewhere in Asia, the largest market was South Korea (0.9 GW), followed by India (0.7 GW) and Thailand (0.5 GW).[25] India's market shrank relative to 2012 and 2013.[26] Policy uncertainty has raised significant roadblocks, making it difficult to secure financing, as have delays associated with the national subsidy process.[27] By the end of 2014, India had 3.2 GW in operation, and the situation was looking brighter thanks to the announcement of new government support policies as well as financial commitments from international financial institutions.[28]

Most of the 15–16 GW installed outside of Asia was added in North America and the EU.[29] North America added 6.7 GW in 2014.[30] Canada accounted for about 0.5 GW, for a year-end total of 1.7 GW, with the rest brought on line in the United States.[31]

US installations were up 30% over 2013 to 6.2 GW, for a total of 18.3 GW.[32] The market was driven by a continued decline in installed costs (particularly balance of systems), innovative financing, and stable policies.[33] For the first time, each of the three major market segments (residential, commercial, and utility) installed more than 1 GW, although commercial sector demand declined slightly.[34] The ramp-up in utility procurement (3.9 GW added) was driven by Renewable Portfolio Standard (RPS) requirements and by solar PV's growing economic competitiveness in the broader electricity market (e.g., against natural gas).[35] By early 2015, the solar PV pipeline exceeded 14 GW for utility projects expected to come on line before scheduled changes to a federal tax credit at end-2016.[36]

US residential demand (1.2 GW) grew by more than 50% for the third consecutive year, thanks to falling prices and to an increasing number of financing and ownership options.[37] Several large employers launched a bulk corporate purchasing programme to reduce significantly the installation costs for their employees, and states also began implementing such programmes.[38] California remained the leader for capacity additions (3.5 GW), followed distantly by North Carolina (0.4 GW). At year's end, California also led the country for total capacity (8.7 GW), while Hawaii was the top state for per capita installations.[39]

The EU continued to lead the world in total regional operating capacity (87 GW) and in solar PV's contribution to electricity supply.[40] However, EU markets declined for the third year running, with an estimated 6.3 GW added, down from a peak of 22 GW in 2011.[41] Demand was down in most EU markets due to reductions in policy support and to retroactive taxes in some countries, which have hurt investor confidence.[42] Several countries, including France, Germany, Italy, and the United Kingdom, are moving to more market-based policy mechanisms such as premium payments, particularly for larger projects.[43] (→ See Policy Landscape section.)

Italy and Spain saw precipitous declines in 2014, and Germany's market shrank 43% relative to 2013.[44] Former GW-sized markets—including Belgium, Bulgaria, Czech Republic, Greece, and Spain—installed little capacity in 2014.[45] Exceptions to this trend included France, the Netherlands, Switzerland, and the United Kingdom.[46]

The United Kingdom and Germany were the EU's top installers and ranked fourth and fifth, respectively, for global capacity additions in 2014. The United Kingdom installed 2.4 GW for a year-end total of 5.2 GW.[47] More than 125,000 UK households put solar panels on their roofs in 2014, and the country was the EU's only significant (remaining) market for large-scale ground-mounted projects.[48] Germany added 1.9 GW, below the Renewable Energy Law (EEG) target of 2.5 GW, for a total of 38.2 GW.[49] The marked decline reportedly resulted from the falling FIT payment for solar PV (down more than 70% since 2006) and concerns about the surcharge on self-consumption.[50] Smaller rooftop systems (<10 kW) have not experienced the same rate of deceleration as larger ones because their self-consumption is not subject to EEG surcharges.[51] Germany generated about 33 TWh with solar PV in 2014, and, at year's end, it had the most solar PV capacity of any country by far.[52]

Australia ranked seventh globally for new capacity in 2014, adding 0.9 GW for a total surpassing 4.1 GW.[53] About 14% of households have solar rooftop installations, with the highest proportion (24%) in South Australia, and more than 15,000 businesses have installed on-site solar systems.[54] Policy uncertainty has led to suspension of some large projects, but at least two were under construction by early 2015 and were scheduled to go on line during the year.[55]

Latin America is the fastest growing regional market, although growth is uneven from country to country.[56] Chile added 395 MW to its existing 12 MW, and accounted for the vast majority of the region's installations.[57] Much of Chile's growth is in large-scale projects that supply the mining industry, as well as large merchant plants that rely on the spot market for revenue.[58] Mexico also saw substantial growth (64 MW), and Brazil granted the first contracts for large-scale solar PV projects (totalling 1 GW from 31 solar parks) in late 2014.[59] Challenges to future growth in the region range from grid access to securing financing.[60]

In developing and emerging economies, obtaining financing—and at affordable rates—is a common challenge, and deployment of solar PV is driven largely by decisions of large banks to support specific projects that they consider to pose relatively low risk.[61] Even so, some new markets are starting to install measurable capacities of solar PV, both on- and off-grid. South Africa, for example, installed about 0.8 GW in 2014 to rank ninth globally for capacity added; most of this was in large parks and the result of South Africa's tender programme.[62] Kenya has focused on increasing off-grid solar in isolated areas, with large plants (several MW) also under development, and Rwanda commissioned a solar PV farm (8.5 MW) in 2014 that represents 7% of national installed power capacity.[63] (→ See the Distributed Renewable Energy section for more on off-grid solar PV in developing countries.) Also in 2014, Egypt announced a procurement programme under its FIT for a total of 2.3 GW of solar PV.[64]

Markets also are picking up in the Middle East, where many countries have established targets for solar PV.[65] (**→ See Reference Table R15.**) Israel led the region for 2014 installations (up almost 50% to 0.7 GW), and Jordan became the region's first country to successfully launch and complete a solar procurement programme.[66] The United Arab Emirates continued to emerge as an important centre for demand and manufacturing, and announced large tenders for solar PV.[67] Interest in the region is driven by several factors, including high solar insolation rates, rapidly increasing energy demand, solar PV's low water demand, and its potential to desalinate water.[68] (→ See Sidebar 5.)

By early 2015, at least 70 solar PV plants larger than 50 MW were operating in at least 14 countries.[69] The top 10 were all in China, India, and the United States, where the world's largest plants—Topaz Solar and Desert Sunlight (each 550 MW)—went on line in late 2014 and early 2015.[70] The world's 50 biggest plants reached cumulative capacity approaching 7.1 GW by early 2015 and accounted for about 4% of global capacity.[71] At least 17 of these came on line (or achieved full capacity) in 2014 and early 2015, including one (100 MW) in Chile and six plants (totalling over 500 MW) in South Africa, representing the largest solar PV plants on their respective continents.[72] China added 160 MW to its hybrid solar PV-hydro plant in Qinghai Province.[73] Globally, the total capacity of projects of 4 MW and larger increased an estimated 65%, to 35.9 GW, with capacity split fairly evenly among Asia, Europe, and North America.[74] By the end of 2014, large-scale projects were completed or under construction in several countries, including Australia, France, Japan, Pakistan, the Philippines, and Russia.[75]

Even as the share of utility-scale projects increased, utilities in several countries continued to push back against the expansion of distributed solar PV, due to concerns about a shrinking customer base and lost revenue. In many US states, debates continued over net metering laws and rate design; in Australia, major utilities concerned about their future business models acted to slow or halt the advance of solar PV; in Japan, utilities curbed access to the grid; and, in Europe, discussions continued about retail tariff design in the context of increasing decentralised generation (including growing shares of self-consumption).[76] However, many utilities in these countries and elsewhere have expanded their roles in developing and operating solar PV.[77]

Community-owned solar PV projects are emerging with a variety of models in an increasing number of countries, including Australia, Japan, Poland, the United Kingdom, and Thailand, which has a community solar target under its national FIT.[78] US community solar gardens, which sell power to local utilities in exchange for monthly credits to investors, continued to spread in 2014, and several US states actively promote community solar.[79] Community-owned micro-utilities relying on solar PV also are becoming more common in developing countries.[80]

The market for concentrating PV (CPV)—which includes an optical system to focus large areas of sunlight onto each cell—is young and remains small, but there is interest in niche markets due greatly to higher efficiency levels in locations with high direct normal insolation and low moisture.[81] The key countries are Australia, China, Italy, South Africa, and the United States, with small plants (1–2 MW) operating in Mexico, Saudi Arabia, and several other countries.[82] An estimated 70 MW of capacity was installed from January through November 2014, including South Africa's 44 MW Touwsrivier Plant.[83] By late 2014, global capacity totalled at least 330 MW.[84] Several large plants (20 MW and larger) were under construction, although plans for even larger facilities were scrapped or suspended.[85]

Solar PV is starting to play a substantial role in electricity generation in some countries, meeting by year's end an estimated 7.9% of annual electricity demand in Italy, 7.6% in Greece, and 7% in Germany.[86] By the end of 2014, Europe had enough solar PV capacity to meet an estimated 3.5% of total consumption (up from 0.3% in 2008) and 7% of peak demand; global capacity in operation was enough to produce at least 200 TWh of electricity per year.[87]

SOLAR PV INDUSTRY

The solar PV industry recovery, which began in 2013, continued in 2014 thanks to strong global demand.[88] Most top tier companies were back in the black (or at least had reduced losses) by year's end.[89] It was a challenging year in Europe, however, where shrinking markets left many installers, distributors, and others struggling to stay afloat, and companies diversified risk by focusing on markets elsewhere.[90] Low module prices continued to challenge many thin film companies and the concentrating solar industries, which have struggled to compete.[91] International trade disputes also continued.[92] (→ See Policy Landscape section.)

Average module prices fell during 2014, with multicrystalline silicon module spot prices down about 14% year-over-year to USD 0.6/Watt.[93] The drop in spot price was driven by incremental module production cost reduction, lower regional price levels, and weaker-than-expected demand (especially in China).[94]

The industry continued to focus on reducing soft costs (non-hardware). Total installed costs fell worldwide in 2014, with significant differences in soft costs depending on project location and scale—soft costs are higher in the United States and Japan than in Australia or Germany, for example.[95]

As costs fall, solar PV-generated electricity has become cost-competitive with fossil fuels without subsidies in an increasing number of countries.[96] The year 2014 saw extremely low bids for solar PV in several countries including Brazil, India, and the United Arab Emirates—where low bids (the top six were below USD 0.06/kWh) encouraged the government utility to double its contracted capacity.[97]

Production of crystalline silicon cells and modules rose in 2014. Estimates of cell and module production, as well as of production capacity, vary widely; increasing outsourcing and rebranding render the counting of production and shipments more complex every year.[98] Preliminary estimates of production capacity in 2014 ranged from around 45 GW to 60 GW for cells, and from about 50 GW to more than 70 GW for modules.[99] Thin film production also increased, by an estimated 25%, with its share of total global PV production remaining at about 10%.[100]

Over the past decade, module production has shifted from the United States, to Japan, to Europe, and back to Asia, with China dominating shipments since 2009.[101] By 2014, Asia accounted for 87% of global production (up from 85% in 2013), with China producing 64% of the world total (same in 2013).[102] Europe's share continued to fall, to about 8% in 2014 (10% in 2013), and the US share held at about 2%.[103]

Among the leading module manufacturers in 2014 were several Chinese companies including Trina, Yingli, Canadian Solar, and Jinko Solar; other top manufacturers included Hanwha Solar One (South Korea) and First Solar (United States).[104] Sharp Solar and Kyocera (both Japan) bought and rebranded a large number of Chinese modules, and were among the top sellers for the year.[105]

To meet rising demand in an increasing number of markets, numerous Asian, US, and some European-based manufacturers restored idled capacity, opened new cell and module production facilities, or announced plans to expand capacity around the world.[106] A major driver for Chinese panel makers to build factories in Malaysia and elsewhere overseas has been avoidance of anti-dumping tariffs imposed by the United States on goods produced in China.[107] US-based manufacturers have responded to competition—especially from China—by increasing volume at home and investing in automation and efficiency.[108] At the same time, several manufacturers closed facilities in Europe to concentrate on other markets.[109] For example, Solaria Energia (Spain) shuttered its manufacturing plant in Puertollano to focus on new markets in Latin America and the Asia-Pacific region.[110]

Consolidation among manufacturers continued into 2014, but at a slower pace.[111] Despite being the largest market, China's industry saw some of the greatest challenges as the government took steps to avoid worsening of overcapacity and to drive consolidation of manufacturers.[112] Chinese cell maker LDK Solar became the fourth major Chinese solar company in just over a year to seek bankruptcy and restructure its debt.[113]

The year also saw several mergers and acquisitions. Some manufacturers expanded into markets downstream or in new regions, and some took over their competition, while non-solar companies took steps to enter the industry.[114] For example, developer, financier, and installer SolarCity purchased module manufacturer Silevo (both United States) and began moving into energy efficiency and storage; Sunrun (developer and financier) made several acquisitions including distributor AEE Solar and racking hardware manufacturer SnapNrack (all United States); Chinese building materials and glass company CNBM acquired German CIGS manufacturer Avancis; and, in early 2015, Canadian Solar (China) purchased US-based Recurrent Energy from Sharp (Japan) to expand its US project pipeline, while the largest US utility, Duke, acquired a majority stake in US developer REC Solar.[115]

Many companies furthered strategic partnerships to advance technologies and expand their reach. For example, SunEdison (United States) announced a joint venture agreement with JIC Capital (China) to facilitate financing to develop, construct, and own up to 1 GW of projects in China; Hanergy and Suntech (both China) expanded into Switzerland and the Benelux countries, respectively, with new partnerships; LG Electronics (South Korea) teamed up with Borrego Solar (United States) to supply modules to the US commercial market; and Trina, Yingli, and Canadian Solar announced initiatives to partner with financial backers to develop new large-scale plants.[116] Several partnerships focused on energy storage options for commercial and residential markets in Japan, the United States, some European countries, and elsewhere: for example, Kyocera and Sharp began marketing innovative storage options with solar PV; and Siemens (Germany) announced plans to offer its VersiCharge home-charging system to Sunrun customers who own electric vehicles.[117]

New business models and innovative financing options continued to emerge, and 2014 saw the launch of several solar PV yield companies (or yieldcos[i]), which facilitate access to relatively low-cost capital for project development, a major driver for reducing generation costs.[118] New online investment platforms are enabling people around the world to invest in solar PV projects.[119] In the United States, an increasing number of firms—including solar developers and installers, investment companies, and major banks—have entered the solar financing

i - See Glossary.

market.[120] For example, US-based module manufacturer Sunpower began selling and financing solar systems in 2014.[121] Internet-service company Google launched new funds in 2014 and early 2015 to help finance residential solar projects.[122]

Practices such as solar leasing are spreading beyond the United States to Europe, India, the Pacific, and elsewhere.[123] In China, Canadian Solar partnered with investment management firm Sichuan Development to launch a fund for financing development, construction, and ownership of solar power projects in China, and Trina Solar acquired a stake in Shuntai Leasing.[124] (→ See the Distributed Renewable Energy section for financing innovations in the off-grid sector of the developing world.)

Innovations also focused on making solar products more efficient, as well as more durable and resistant to a broader range of conditions (e.g., high temperatures, humidity, dust and sand deposition) as their use spreads to new environments.[125] Solar cell efficiencies increased, with new records announced during 2014.[126] Perovskites[i] continued to break records for efficiencies in laboratories, but hurdles remain before they can be brought to market.[127] For the near term, Passivated Emitter Rear Cell (PERC) coating technology shows promise for increasing cell efficiency in standard production processes.[128] The European Gigawatt Fab (xGWp) project, which aims to maintain competitiveness of the region's manufacturing industry, continued its work to develop a new generation of technologies and to exploit the potential of gigawatt-scale production.[129] And a new generation of solar cooling systems based on solar PV-driven reversible heat pumps is emerging, although still in the R&D phase.[130]

Even as technologies have advanced, concerns about the quality of some installations and components have arisen over the past few years.[131] In 2014, a significant share of panels made for use only in China was found to have significant defects; the result is that some Chinese solar farms are producing far less power than expected.[132] The revelation in China feeds into concerns that cost cuts in response to falling prices in recent years might have led to quality problems.[133] In some developing and emerging countries, uncertainty about energy yield has contributed to reluctance to provide financing, which is holding back development.[134]

On the positive side, solar inverters are becoming more sophisticated to actively support grid management.[135] As a result, they are increasingly important for adding value to solar PV system architecture—enhancing communications, control, and interaction with the grid.[136] Originally considered a niche product for shaded rooftops, microinverters in particular comprise one of the fastest growing sectors in the solar industry.[137] New inverter products provide more functions, such as safety and storage management, to appeal to a broader customer base.[138]

Rising competitiveness in the inverter industry has reduced prices (as well as global net revenue), which continued to fall in 2014.[139] One result has been consolidation, with a host of mergers and acquisitions, some downsizing (including German inverter giant SMA Solar), and at least one major bankruptcy during the year.[140] Also in 2014, several companies expanded manufacturing capabilities or broadened their services, and solar panel makers moved into the inverter business.[141]

The CPV industry had another challenging year in 2014. Companies continued to go bankrupt, close down, or leave the industry.[142] Despite record module and cell efficiencies of CPV technologies, CPV has not achieved economies of scale and has been unable to compete with falling prices of conventional solar PV.[143] Leading company Soitec (France) reached full production capacity at its new factory in California in 2013 and, in 2014, launched a new off-grid CPV product, completed its 44 MW plant in South Africa, and achieved efficiency milestones.[144] However, in early 2015, following years of delay, modification, and ultimately cancellation of utility contracts for large-scale projects in southern California, Soitec announced plans to exit the solar industry.[145] Other leading companies were acquired by new owners in 2014.[146] Those remaining in the industry are working to improve products and expand their focus, including actively marketing in the Middle East and North Africa (MENA) region and China, and forming partnerships to expand project pipelines.[147]

i - Perovskite solar cells include perovskite (crystal) structured compounds that are simple to manufacture and are expected to be relatively inexpensive to produce. They have experienced a steep rate of efficiency improvement in laboratories over the past few years.

CONCENTRATING SOLAR THERMAL POWER (CSP)

CSP MARKETS

The concentrating solar thermal power (CSP) market remains less established than most other renewable energy markets. Nonetheless, in 2014 the sector continued nearly a decade of strong growth. During the course of the year, four new projects totalling over 0.9 GW increased total global capacity by 27% to nearly 4.4 GW.[1] (→ See Figure 18 and **Reference Table R8**.) In the five years from end-2009 to end-2014, global operating capacity rose by an annual average of 46%.[2] The United States was the global market leader for the second consecutive year, with India the only other country to bring new capacity into commercial operation during 2014.[3] South Africa continued to emerge as a major market, with further development and interest in CSP in other new markets with high direct normal irradiance (DNI)[i].[4]

Although parabolic trough plants represent the bulk of existing capacity, 2014 was a notable year in terms of the diversification of the CSP technology landscape. Capacities of newly deployed parabolic trough and tower plants drew closer, with 46% of added capacity based on parabolic trough technology, and 41% based on tower technology. The increase in tower capacity was due to commissioning in the United States of the Ivanpah plant, the largest CSP plant in the world. The world's largest linear Fresnel plant (125 MW), equivalent to 13% of global added capacity, came on line in India, further diversifying the mix of added technologies. By early 2015, parabolic trough plants accounted for just over half of the capacity under construction, while towers/central receivers represented approximately 40%.[5]

The United States had a record year, increasing operating CSP capacity from 0.9 GW to just over 1.6 GW.[6] Plants that came on line included the Ivanpah tower plant (377 MW) as well as the Mojave plant (250 MW) and the second (125 MW) phase of the Genesis plant (total 250 MW), both using parabolic trough technology.[7] The United States will see significantly less capacity added in 2015, with the Crescent Dunes parabolic trough project (100 MW) the only plant expected to come on line.[8]

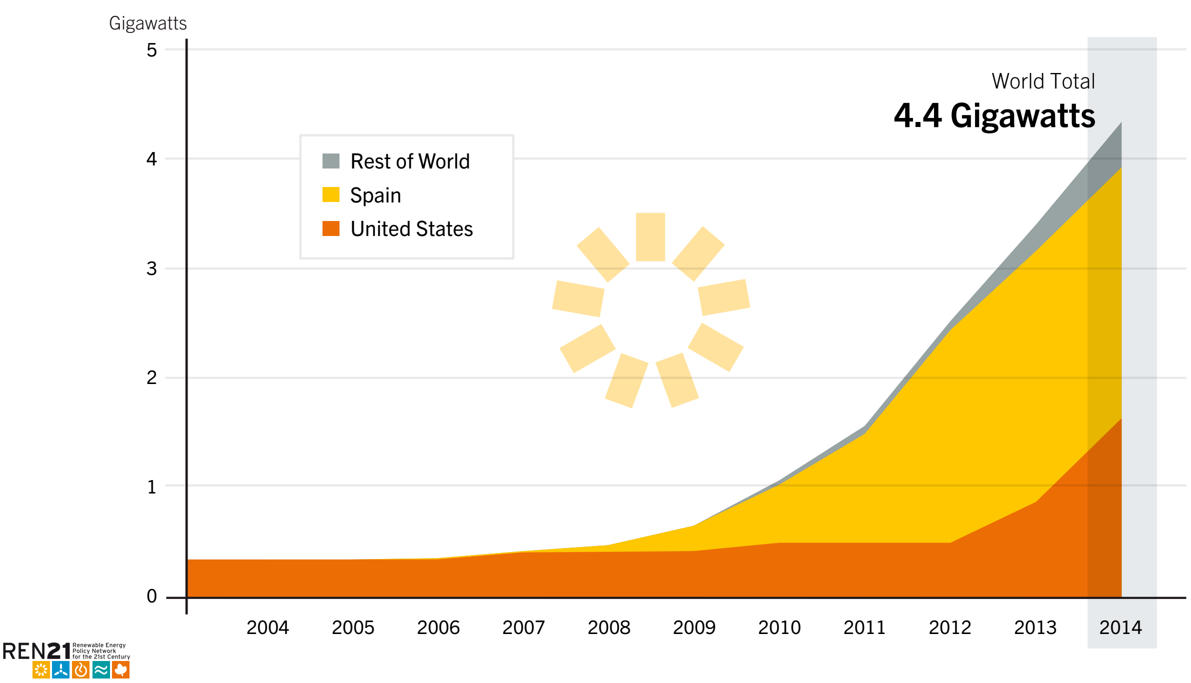
India saw the opening of the Dhursar CSP plant (125 MW) and the Megha plant (50 MW), increasing the country's installed capacity more than fourfold to 225 MW.[9] The Dhursar plant in Rajasthan is Asia's largest CSP installation.[10] The Megha plant, located in Andhra Pradesh, was the third CSP plant to be commissioned under the first phase of India's Jawaharlal Nehru National Solar Mission.[11]

Spain remains the global leader in cumulative capacity with 2.3 GW of CSP, despite the fact that it added no new capacity in 2014.[12] The paralysis of the Spanish market follows policy changes implemented in recent years, including a 2012 moratorium on feed-in tariffs for new plants and the severe curtailment in 2014 of tariff rates for plants already in operation.[13]

The South African market continued to expand rapidly. At the end of 2014, four plants totalling 300 MW were under construction. These included a 100 MW facility which came on line in early 2015, two 50 MW plants expected later in the year, and a 100 MW plant expected on line in 2017. A range of other plants are under planning, with two 100 MW facilities expected to finalise funding for construction in late 2015.[14]

Morocco also was a centre of activity in 2014. Construction continued on Morocco's Noor I plant (160 MW), which is expected to begin commercial operation in 2015.[15] Contractors were selected in early 2015 for the further phases of the project, totalling an additional 350 MW.[16]

Figure 18. Concentrating Solar Thermal Power Global Capacity, by Country or Region, 2004–2014



i - DNI refers to the amount of solar radiation per unit area that is received directly from the sun and strikes a given surface.

Other countries with existing CSP capacity that did not bring new facilities on line in 2014 include the United Arab Emirates (100 MW), Algeria (25 MW), Egypt (20 MW), Morocco (20 MW), Australia (13 MW), and Thailand (5 MW).[17] Several additional countries had small pilot plants[i] in operation, including China, France, Germany, Israel, Italy, South Korea, and Turkey.[18]

The year saw tangible progress for CSP in new markets, including in Africa, Asia, Latin America, and the Middle East. China, for example, started construction on its first commercial CSP project: the 50 MW Qinghai Delingha plant, based on parabolic trough technology.[19]

CSP activity continued in the Middle East where, in 2014, Kuwait selected preferred bidders for a 50 MW plant and advanced the development of further capacity based on Integrated Solar Combined Cycle technology (ISCC)[ii].[20] An ISCC plant also was at an advanced planning stage in Saudi Arabia.[21] In Israel, as of early 2015, a 121 MW plant was being planned, as was a 10 MW hybrid CSP-biomass plant with thermal storage.[22]

Farther south, in Namibia, CSP planning remains in a preliminary phase, while elsewhere in the Southern Hemisphere, construction commenced on Chile's first grid-scale CSP facility.[23] The Cerro Dominador plant (110 MW) in Chile's Atacama Desert is expected to be on line in 2017; with its 18 hours of thermal storage capacity, it is expected to provide baseload power to mining operations.[24] Australia is home to a handful of potential CSP projects, although they faced an uncertain funding and policy landscape in 2014.[25]

Further examples of hybridised CSP technologies appeared in 2014, including the planned ISCC plants in Kuwait and Saudi Arabia.[26] In the United States, construction is under way on the world's first CSP-geothermal plant, while construction of the Cogan Creek Solar Boost project in Australia (which will supplement existing coal-based power generation capacity) continues to advance, although on a delayed schedule.[27] A small pilot CSP-biomass hybrid system came on line in Italy, and another was under planning in India.[28] Hybridisation of CSP is being driven by a range of motivations, including the reduction of emissions at fossil fuel plants and the improved economics and reduced variability provided by CSP with thermal energy storage.[29]

CSP INDUSTRY

The industrial consolidation experienced in 2013 continued in 2014, fuelled in part by the ongoing stagnation of the previously dominant Spanish market and by an expected deceleration in the United States after a bumper year.[30]

French linear Fresnel specialist AREVA confirmed plans to close its CSP business, after experiencing significant losses.[31] The move was seen as a blow to the wider commercial advancement of linear Fresnel technology. Schott Solar announced a re-organisation of its production set-up and a halt in receiver manufacturing at its Mitterteich plant in Germany due to low demand; production of glass-metal seals at the facility will continue.[32]

The top companies in 2014 included Abengoa, Acciona, ACS Cobra, Elecnor, Sener/Torresol Energy and FCC (all Spain); Brightsource and Solar Reserve (both United States); ACWA Power International (Saudi Arabia); and Schott Solar (Germany). All were involved in either one or a combination of activities including project development, construction, ownership, operations and maintenance, and manufacturing.[33] Abengoa Solar maintained the world's largest portfolio of plants in operation or under construction, with equity in 25% of the capacity that was added in 2014, and in around 60% of the capacity under construction at year's end.[34]

Swiss company ABB exited the CSP market in 2013 with the sale of its shares in Novotec Solar, but its French counterpart, Alstom, became increasingly involved in the sector during 2014.[35] Also in 2014, the Saudi Arabian government and privately owned Saudi conglomerates continued a range of strategic acquisitions of international CSP companies and established strategic alliances with research organisations.[36]

Thermal energy storage (TES) using molten salt is in commercial use in Spain and the United States. Given the growth of variable solar PV and wind power, and the role that CSP with TES can play in grid reliability, CSP research continued to focus heavily on the improvement of TES systems, and on the evaluation of alternative heat transfer media.[37] TES solutions under development and/or evaluation in 2014 included: solid-state concrete heat storage; high- and low-temperature metal hydride beds for low-pressure heat storage (potentially allowing longer material life cycles and avoiding freezing of the heat-transfer fluid); the use of sand in a fluidised bed for heat storage; and the use of phase-change materials to achieve higher energy densities.[38]

Solar forecasting also is becoming an increasingly important research focus at a number of laboratories and research institutes, which are developing and refining methodologies for predicting short- and medium-term weather patterns and operating plants accordingly.[39] The development of cost-effective methods for accurately measuring solar resources is also a high-priority research area.[40]

CSP continued to face challenges from falling solar PV prices in 2014, and it remains more expensive than many other renewable power generation technologies.[41] However, cost reduction and optimisation strategies (including a trend towards larger plants and greater economies of scale, as evidenced by the opening of two of the largest CSP plants in the world, Ivanpah and Mojave) are leading to improvements in overall costs of deployment. Abengoa reported an approximate halving in electricity costs at new plants in South Africa, relative to older plants operating in Spain, while ACS Cobra noted its experience that CSP with storage has the potential to compete with natural gas, given the right DNI levels.[42] ACWA also reported competitive pricing for its parabolic trough and tower plants under construction, or due to enter construction, in Morocco.[43]

i - Note that CSP market capacity data in this report are based on commercial plants only, and do not include demonstration/pilot facilities.
ii - ISCC technology uses both CSP and natural gas.

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 2013[i], global market growth slowed due largely to declining markets in Europe and China.[1] The world installed 55 GW_{th} (789.6 million m²) of solar heat capacity, up from 54.1 GW_{th} (77.3 million m³) in 2012.[4] Cumulative capacity of all collector types in operation rose by a net 44 GW_{th} for a year-end total of 374.7 GW_{th}[ii].[5] An estimated 53.3 GW_{th} (96.8%) of the new installations in 2013 was glazed water systems, and the rest was unglazed water systems mainly for swimming pool heating (3.1%), as well as unglazed and glazed air collector systems (0.1%).[6] Globally, solar thermal accounts for about 1.2% of water and space heating in buildings.[7]

Glazed and unglazed water collectors provided an estimated 313.7 TWh (1,129 PJ) of heat in 2013.[8] The vast majority of solar heat capacity is in China, which accounted for nearly 81% of the world market for water collectors and 70% of total capacity that year.[iii9] (→ See Figure 19.) The top five countries for capacity added in 2013, including both glazed and unglazed water systems, were China, Turkey, Brazil, India, and Germany (with the United States close behind); including air collectors, the United States was slightly ahead of Germany.[10] The top five countries for total capacity in operation remained China, the United States, Germany, Turkey, and Brazil.[11] (➔ See Figure 20 and **Reference Table R9**.)

Most countries focus on glazed water collectors, with both China and India primarily installing evacuated tube water collectors (ETC), and other key markets relying mainly on flat plate collectors (FPC).[12] In the United States, the majority of systems use unglazed water collectors for pool heating. The only other markets of note for unglazed water collectors are Australia and Brazil.[13] About three-fourths of all solar thermal systems installed are thermosyphon systems, and the rest are pumped systems (common mainly in North America and Central and Northern Europe).[14]

The slowdown in market growth continued in 2014, when total capacity of water collectors increased by an estimated 33 GW_{th} (47.6 million m[15]), bringing operating global solar thermal capacity to about 406 GW_{th}[16] (→ See Figure 21.) There was enough capacity by year's end to provide approximately 341 TWh (1,228 PJ) of heat annually.[17] Domestic hot water systems for single-family homes remained the most important market segment.[18]

China was again the primary driver of demand for new solar thermal capacity in 2014. However, following several years of rapid growth, China's market was down nearly 18% relative to 2013.[19] About 36.7 GW_{th} (52.4 million m[20]) was installed, of which about 27 GW_{th} was additional (about 26% of the new collectors replaced existing capacity), bringing China's total operating capacity to 289.5 GW_{th}.[21]

China is seeing a trend away from the retail market to commercial projects. Retail business, including in the rural residential sector, has slowed due to some market saturation in several provinces and to competition with heat pumps.[22] Provincial and municipal solar thermal obligations and construction of new residential (including government-supported low-income) buildings are driving demand for FPCs and more-sophisticated building-integrated installations.[23] Also notable is the share of projects to provide hot water in schools, universities, and hotels—where the preference is for large-scale centralised rooftop systems with large water tanks.[24] Growth in these sectors, however, did not offset losses in the rural residential market, which remains significant but is stable or declining.[25]

India and Japan are the largest Asian markets outside of China. After an exceptional 2012 due to a generous investment subsidy, India's market declined in 2013 because of a delay in incentive payments.[26] In 2014, the country added 0.8 GW_{th} (1.1 million m[27]), a market increase of 8% relative to 2013, for a total of 4.7 GW_{th} (6.8 million m[28]).[29] India is seeing increased interest in ETCs (mostly from China), which cost less than FPCs (the dominant technology a decade ago).[30] Japan's market declined about 9% during 2012 and 2013, and cumulative capacity is declining due to decommissioning of old systems.[31]

Turkey continues to be an important market and ranked second in 2013 for new installations. (As of publication, data for 2014 were not available.) In 2013, Turkey saw another year of market expansion (up 18% over 2012), adding 1.3 GW_{th} to end the year with nearly 11 GW_{th} and to retain its fourth-place ranking for total operating capacity.[32] The fastest-growing market segments in 2014 appeared to be multi-family houses, although this remains a small segment.[33] The market for residential solar water heaters with ETC is expanding as well.[34]

Brazil ranked third for new installations in 2013; in 2014, the market expanded by an estimated 4.5% relative to 2013, for a year-end capacity of 7.7 GW_{th} (11 million m[35]).[36] Demand is driven largely by the economic competitiveness of solar thermal in Brazil and by municipal building regulations and social housing programmes—such as Minha Casa, Minha Vida ("My House, My Life")—that mandate solar water heaters in new buildings for very poor families.[37] The residential sector is the largest market (about 60%), followed by social housing (19%), the commercial sector (18%), and process heat (3%).[38] Elsewhere in the region, Mexico is starting to play a role, ranking eleventh globally for new capacity in 2013, and Colombia, El Salvador, and Guatemala have seen growth even without public incentives.[39]

The European Union (EU-28) continues to support a greater diversity of uses for solar thermal heat technologies than any other market.[40] At the same time, the region's market has continued to contract. In 2013, Europe's annual market declined 11% to 2.14 GW_{th}, down one-third from the 2008 peak, for a year-end total of 30.2 GW_{th}.[41] All large markets shrank—including Denmark and Poland, which saw significant growth in 2012.[42] The exception was Spain, where the market began to stabilise

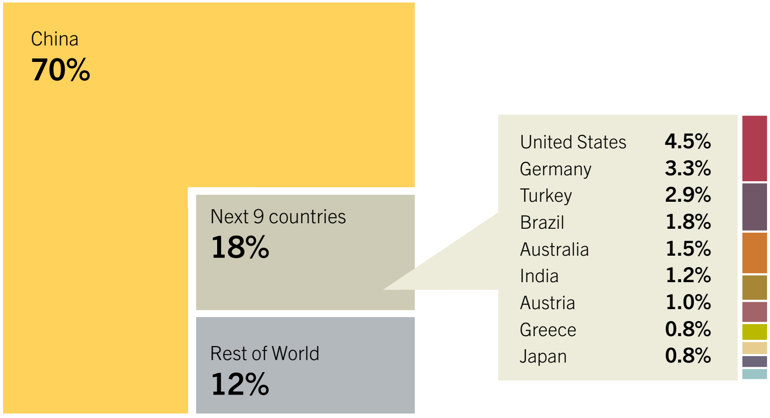
i - The year 2013 is the most recent year for which firm global data and most country statistics are available. This section includes a mix of 2013 and 2014 data, depending on what was available at time of publication, and the text specifies the relevant year.

ii - Data include air collectors; gross water heating collector capacity additions in 2013 were just under 55 GW_{th}, for a year-end total of 373 GW_{th}. Note that, in 2014, China settled on a new methodology for calculating cumulative capacity, which assumes a 10-year lifetime for Chinese-made systems. Because China is such a large market, this change has a significant effect on the global total. Data have been adjusted to reflect this change: China's total for end-2012 was adjusted upwards to 226.2 GW_{th}, and the 2013 total was 262.3 GW_{th}; the world total for 2012 was adjusted upwards to 330.7 GW_{th} including air collectors, and 329 GW_{th} without them. (See Endnote 3 for this section.)

iii - China's shares for all solar collectors (including air) are only a fraction lower.

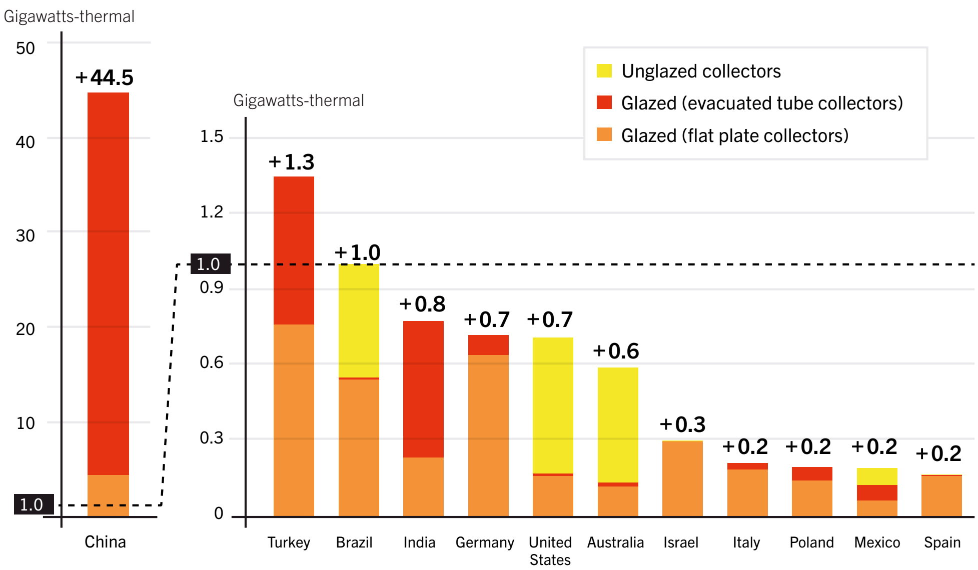
SOLAR THERMAL HEATING AND COOLING

Figure 19. Solar Water Heating Collectors Global Capacity, Shares of Top 10 Countries and Rest of World, 2013



Source: See Endnote 7 for this section.

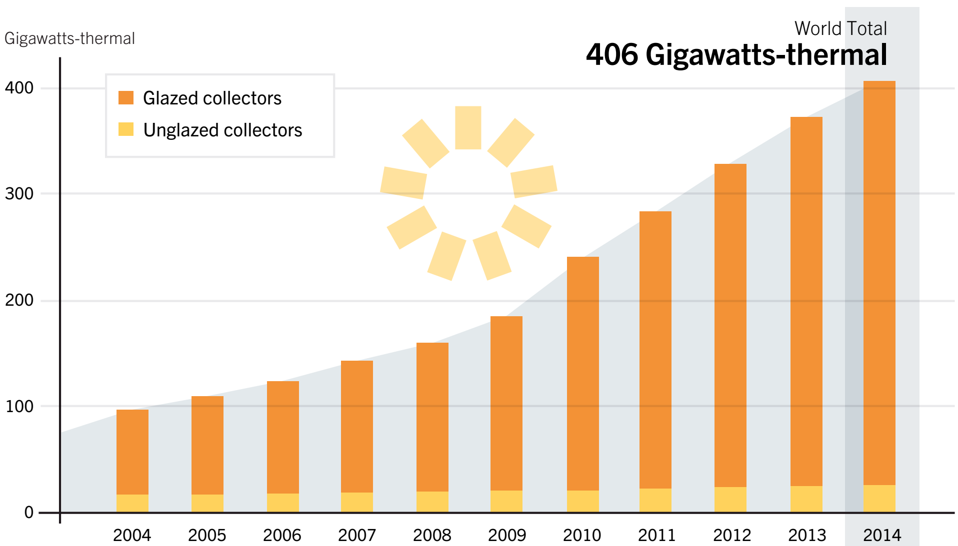
Figure 20. Solar Water Heating Collectors Additions, Top 12 Countries for Capacity Added, 2013



Additions represent gross capacity added.

Source: See Endnote 9 for this section.

Figure 21. Solar Water Heating Collectors Global Capacity, 2004–2014



Source: See Endnote 13 for this section.

Data are for solar water collectors only (not including air collectors).

because of the upturn in construction and new incentives at the municipal and regional levels.[43]

In 2014, Europe saw its sixth consecutive year of market decline.[44] The reasons were as varied as the countries and included a lack of stable and effective support schemes, a dearth of installers, a large number of rules and requirements, and competition with other "green" investment options.[45] Germany was again the largest EU installer and saw its two-millionth system enter into operation; however, the market was down about 12% to its lowest level since 2007.[46] About 0.6 GW_{th} (900,000 m[47]) was added for a total of 12.9 GW_{th} (18.4 million m[48]).[49] Solar thermal systems in Germany generated 7.3 TWh of heat during 2014.[50]

While the United States placed fifth for 2013 additions (0.7 GW_{th}), it continued to rank second for total collector area, with 16.7 GW_{th} at the end of 2013 (14.6 GW_{th} of which was unglazed collectors for pool heating).[51] About 58% of all unglazed water collector area operates in the United States.[52]

Australia is home to much of the remaining unglazed collector area—more than 13% of the world total.[53] In 2013, Australia ranked sixth for new installations of solar water collectors, just behind the United States.[54] In 2014, the country added an estimated 0.6 GW_{th} (78% unglazed) and retired about 0.2 GW_{th} for a year-end total of nearly 6 GW_{th} (60% unglazed).[55] This amounted to about 50,000 new solar water heating systems, for an end-2014 total exceeding 900,000.[56]

Solar thermal systems are used to heat water in several African countries, including Egypt, Kenya, Morocco, Mozambique, Namibia, Tunisia, Zimbabwe, and South Africa, the most mature market in sub-Saharan Africa.[57] South Africa has experienced market growth approaching 18% annually in recent years.[58] However, markets in many developing countries in Africa and elsewhere are challenged by a lack of quality assurance measures and skilled labour, leading to use of inferior products and poor installations, which have undermined solar thermal's reputation.[59]

In the Middle East, Israel leads for total capacity, followed by the Palestinian Territories, Jordan, and Lebanon (with 255 MW_{th} operating at end-2014).[60] About 85% of Israeli households use solar water heaters, and the Palestinian Territories also have a high per capita ratio.[61] In Jordan, almost 95% of international hotel chains along the Dead Sea coast use solar thermal technology; however, while overall demand rose in 2014, the market for small systems declined due to a greater interest among investors in the country's new FIT for solar PV.[62]

Globally, Cyprus remained the world leader on a per capita basis considering all water collectors, with 423 kilowatts-thermal (kW_{th}) per 1,000 inhabitants at the end of 2013.[63] It is estimated that more than 93% of Cyprus' households and 52% of its hotels have solar water heating systems.[64] Cyprus was followed by Austria (385 kW_{th}), Israel (374 kW_{th}), Barbados (319 kW_{th}), and Greece (271 kW_{th}).[65] Considering capacity added during 2013, the leading countries per capita for new installations were Israel (38 kW_{th}), China (33 kW_{th}), the Palestinian Territories (19 kW_{th}), Turkey (17 kW_{th}), and Austria (15 kW_{th}).[66]

Most solar thermal systems are used for domestic water heating, and they typically meet 40–80% of demand.[67] There is a trend towards larger domestic water heating systems for hotels, schools, multi-family homes, and other big complexes.[68] The use of solar thermal water collectors for space heating is also gaining ground, particularly in Central Europe, where 100% solar-heated

buildings have been demonstrated (although typically solar meets 15–30% of space heating demand).[69] Such "combi-systems", which provide water and space heating, account for about 4% of the global solar thermal heat market.[70] They are most common in Europe (particularly in Austria, Germany, Italy, and Poland); in Austria and Germany, they represent about 40% of installed systems and a far larger share of the capacity market.[71] Solar thermal can be combined with various backup heat sources, and hybrid systems with heat pumps are gaining popularity in Europe.[72]

In contrast to solar water collectors, **solar air collectors** absorb solar radiation and use it to heat building ventilation air (rather than a liquid) or to provide drying air for industrial applications.[73] They can reduce by 20–50% the amount of conventional energy consumed for heating a building, or for agricultural or process drying.[74] At the end of 2013, solar air collectors (both glazed and unglazed) represented less than 1% of global solar thermal capacity in operation, or just under 1.7 GW_{th}.[75]

Japan is the largest market for glazed air collectors.[76] The largest markets for unglazed air collectors are Australia and the United States, although production in North America has been flat in recent years due largely to discontinuation of incentives.[77] The country with the most unglazed collectors installed is Switzerland, where they are used to dry hay, but there has been little market for new capacity in recent years.[78]

Whereas domestic hot water and space heating are provided by conventional flat plate and evacuated tube collectors, which typically supply heat at temperatures below 60 °C, **advanced collectors** can be used for solar-assisted district heating as well as for industrial and commercial applications with operating temperatures generally in the 60–120 °C range; they also can drive some cooling systems.[79] Concentrating systems—including parabolic trough, dish, and Fresnel collectors—provide heat at higher temperatures (typically 120–250 °C, and up to 400 °C) for industrial processes or to drive double- or triple-stage absorption chillers.[80]

An increasing number of district heating systems relies on solar thermal technology, often combined with other heat sources such as biomass, and increasingly with seasonal storage.[81] Although the market for such systems remains relatively small, interest has increased in recent years. Most capacity is operating in northern Europe, with recent movement to the south.[82] Interest is rising in other regions as well, with large systems operating in Canada, China, and South Africa, for example.[83]

At the end of 2014, an estimated 227 solar thermal district heating plants (totalling 551 MW_{th}) were operating in about 20

EU countries, up from 216 plants (433 MW_{th}) in 2013.[84] Austria, Germany, and Sweden had more than 20 systems each.[85] All of Europe's 11 new plants in 2014 were installed in Denmark, where the market is driven by high taxes for fossil fuels and solar thermal systems are cost-competitive.[86] Denmark saw capacity rise 43% in 2014 to 61 plants in 2014 totalling 389 MW_{th} (557,000 m[87]).[88] In addition, four existing plants in Europe were enlarged in 2014, including one in Austria and three in Denmark.[89] An expanded facility in Vojens, Denmark, became the world's largest plant (49 MW_{th}) with seasonal storage when it was commissioned in May 2015.[90]

The still-modest global solar cooling market has grown at an average annual rate exceeding 40% since 2004, and nearly 1,200 systems of all technology types and sizes were installed by 2014.[91] While more than 75% of these systems were in Europe, including at least 17 large-scale district systems, use of solar cooling is rising in many regions with sunny dry climates, including Australia, India, Mediterranean islands, and the Middle East.[92]

One of the market drivers for solar cooling is the potential to reduce peak electricity demand, particularly in countries with significant cooling needs.[93] The availability of small (<20 kW) cooling kits for residential use has increased interest in the residential sector in Central Europe and elsewhere, and large-scale systems are gaining appeal due to their more favourable economics.[94] Most solar cooling installations range in scale from 15 kW to 500 kW, with systems of 1 MW and larger being installed since 2011.[95] In 2014, one of South Africa's first solar thermal cooling projects was installed in Johannesburg, and the world's largest installation (3.4 MW_{th}) was completed at a school in the US state of Arizona.[96] The latter project was financed by private investors and is operated as an energy service company (ESCO).[97]

Solar thermal technologies are being used increasingly for industrial applications, providing heat and steam, as well as refrigeration, although their uptake has been limited by relatively high costs, integration challenges, and lack of standardised equipment.[98] Major industrial applications include food processing, cooking, and textile manufacturing.[99] By late 2014, there were at least 138 plants worldwide totalling 95 MW_{th} (collector area of 136,182 m[100]), and these figures probably miss several plants in China, India and Mexico, where deployment has increased substantially in recent years.[101] Solar dryers adapted for drying foods represent a small but growing niche market in many developing countries.[102]

Solar process heat projects added in 2014 included a fodder pellet facility in Mexico, a kibbutz in Israel, and a manufacturer of fabricated metals products in Portugal. The largest (1,500 m[103]) was installed at a concrete component manufacturing facility in Austria.[104] India leads in the use of concentrating solar thermal systems (mostly for cooking).[105] The major limiting factor in a number of countries, including some in the MENA region, is the low price of conventional energy, which is still heavily subsidised.[106]

Although interest is growing around the world, district heating networks, solar air conditioning, and solar process heat for industrial purposes account for only about 1% of global solar thermal capacity.[107] There also exists a large untapped potential for new applications such as water treatment and sea water desalination.[108]

SOLAR THERMAL HEATING/COOLING INDUSTRY

Health of the industry in 2014 depended largely on location. In much of Asia, parts of Africa, and Latin America—particularly Brazil—domestic sales expanded, as did distribution channels, in response to strong demand growth in certain segments.[109] By contrast, 2014 was a difficult year for the industry in Europe as well as in Chile, parts of Russia, and the United States.[110] In Europe, in order to survive years of declining demand, many small manufacturers have had to optimise cost structures, shift their focus to exports, expand their business profiles, or leave the solar thermal sector.[111]

Experiences also varied according to the type of solar thermal system. In China, for example, production volumes and sales have increased much faster for flat plate collector manufacturers in recent years, and FPC manufacturers in Brazil, Jordan, and Turkey profited in 2014 from public-sector orders.[112] In India, FPCs have faced challenges because evacuated tube collectors have captured a clear edge in the market, and the largest manufacturer at the end of 2014 was an ETC assembler (Supreme Solar).[113] Turkey's three evacuated tube manufacturers, established in response to high import taxes on Chinese evacuated tubes, have experienced a market boom and have plans to become significant exporters, making Turkey the first to compete with China on the world market.[114]

The top manufacturers of FPCs (based on collector area produced in 2013) were Greenonetec (Austria), Soletrol (Brazil), Prosunpro (China), Five Star (China), Bosch Thermotechnik (Germany), and Ezinç (Turkey).[115] The largest ETC manufacturers were Linuo Group, South East Corporation (Sunrain and Micoe brands), and Himin (all China).[116] Over the past three years, several companies that specialised in solar thermal FPC systems have dropped from the rankings of the world's largest manufacturers, having lost market share or left the sector entirely.[117]

China's industry was troubled by overcapacity due to weak demand in 2014.[118] Even so, China maintained its multi-year lead in the global solar heating industry, producing an estimated 36.7 GW_{th} (52.4 million m[119]) of collectors in 2014.[120] China's industry consists of more than 500 system suppliers (including very small ones), making the market fragmented, but several large players are increasing their market shares through aggressive marketing.[121] Export volume remained negligible compared to the industry's total turnover—at an estimated USD 300 million, about even with 2013.[122]

In Europe, consolidation continued during 2014.[123] The most prominent insolvency was Wagner & Co Solartechnik, a collector producer since 1979, which was purchased by former customer Sanderink Holding (Netherlands).[124] Europe also saw a further concentration of turnkey large-scale suppliers; most notable was that VKR Holding purchased Sunmark Solutions (both Denmark) and merged it with the subsidiary Arcon Solar in early 2015.[125] Arcon Solar has dominated large-scale solar installations over the past 10 years.[126]

System quality and prices vary significantly from country to country, and solar heat prices have not fallen as quickly as system prices.[127] In Europe, the industry is working to reduce the final price of solar heat, rather than simply hardware prices, by improving technology and the plug-and-play ease of system installation.[128] (In China, Israel, and several other countries, hot water from solar systems is already cost-competitive with that produced from fossil fuels.[129]) Innovation efforts also aim to make solar thermal collectors thinner and to make systems more durable and easier to integrate into rooftops.[130]

New technologies continued to emerge in 2014, including Chinese solar water heating systems with forced circulation, driven by provincial and municipal obligations for building-integrated technologies.[131] Other advancements include membrane liners and insulated floating covers for seasonal storage with solar district heat systems, and large solar fields with storage for district heat are becoming a proven technology with minimal risk.[132] A new generation of system controllers in Europe is enabling solar thermal systems to be better integrated into home automation systems.[133] Photovoltaic/solar thermal hybrid (PVT) systems, which convert sunlight to electricity and absorb heat from the solar PV panel and use it to heat water, also advanced in 2014.[134]

The air collector industry has faced significant challenges, with companies moving in to test the market and withdrawing when earnings targets are not met.[135] Several companies left the industry in 2013–2014, while others entered, including Brassolar (Brazil), Elsol (Serbia), and Sammler (Greece) in 2014.[136]

The cost of solar cooling kits continues to fall, declining by 45–55% (depending on system size) over the period 2007–2012.[137] The variety of thermal chillers continued to increase in 2014, as did their standardisation.[138] Several European companies released new chillers for small systems down to 5 kW.[126] Alternative heat rejection systems (which remove waste heat generated by the system) are under development to reduce costs and planning time.[127]

In addition to new chillers, innovative technologies continue to emerge, particularly for large-scale and industrial systems.[128] Due to improved efficiencies of chillers and increasing temperature range for solar thermal technologies, flat plate and evacuated tube collectors can drive air-conditioning and slab cooling systems in the 10 to -20 °C range, and solar concentrators such as parabolic trough and Fresnel collectors can drive refrigeration up to -20° C.[129] As systems become larger, solar thermal ESCOs offer a promising business model for overcoming financial and other long-term risks.[130]

A growing number of manufacturers around the world specialises in concentrating collectors for industrial applications.[131] Indian manufacturing companies dominate the area of solar parabolic dishes, while leaders for parabolic trough and linear Fresnel concentrators are in Europe and the United States.[132] Solar process heat is competitive in niche markets today, and economics are improving as these technologies provide increasing temperature ranges and as costs associated with fossil fuels and their price volatility rise.[133] The technologies offer significant potential for applications from low temperature (<100 °C) to high (up to 400 °C), but they are not widely known.[134]

Attention to quality standards and certification continued in 2014 with further development of a global certification network for solar heating, to increase production quality while reducing testing and certification costs.[135] Latin America and the MENA region continued to develop regional standards for solar thermal heat systems, while Brazil postponed mandatory quality assurance labelling for solar heaters to late 2015, and India opened two test centres for solar thermal technologies.[136] The trend is towards adapting existing standards (as in Europe, for example) to other countries or regions, and it is driven in part by the use of solar thermal systems in public housing (e.g., in Brazil, Jordan, and Turkey) and to support international trade.[137] Industry standards for solar cooling also advanced in 2014.[138]

WIND POWER

WIND POWER MARKETS

Following a slowdown in 2013, the wind power market resumed its advance with another record year. Over 51 GW was added in 2014, representing a 44% increase over the 2013 market and bringing the global total to around 370 GW.[1] (➔ See Figure 22 and **Reference Table R10.**) The top 10 countries accounted for 84% of year-end global capacity, but there are dynamic and emerging markets in most regions.[2] By the end of 2014, at least 85 countries had seen commercial wind activity, while at least 74 had more than 10 MW of capacity in operation, and 24 had more than 1 GW.[3] This compares with 2005, when the global market was 11.5 GW and 11 countries had cumulative capacity exceeding 1 GW.[4]

Asia remained the largest market for the seventh consecutive year, accounting for half of added capacity, followed by the European Union (23% in 2014, compared with about 32% in 2013) and North America (13% in 2014, compared with less than 8% in 2013).[5] Non-OECD countries were responsible for the majority of installations, as has been the case since 2010 (except for 2012).[6] China alone accounted for about 45% of global additions, followed distantly by Germany, the United States, Brazil, and India.[7] Others in the top 10 were Canada, the United Kingdom, Sweden, France, and Turkey.[8] (→ See Figure 23.) Growth in some of the largest markets was driven by uncertainty about future policy changes and on-off policies.[9]

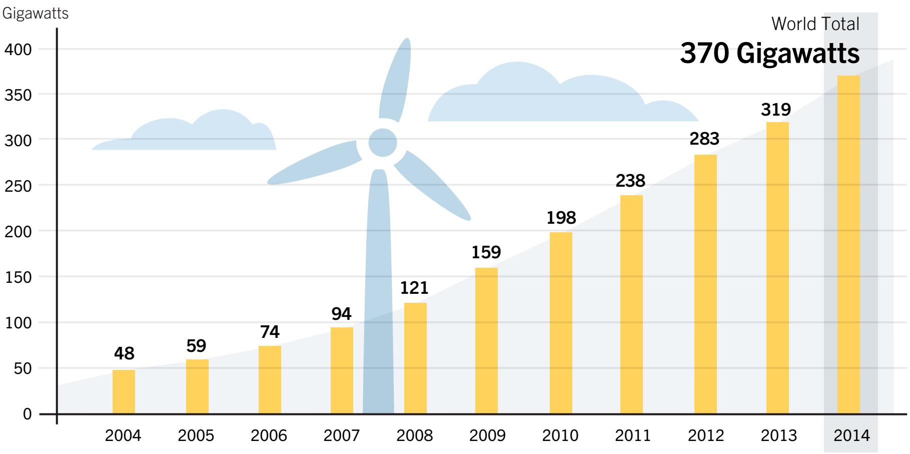
Wind has become the least-cost option for new power generating capacity in an increasing number of markets, and new markets continued to emerge during 2014 in Africa, Asia, and Latin America.[10] Uruguay, for example, added more capacity per capita than any other market.[11] The leading countries for total wind power capacity per inhabitant were Denmark, Sweden, Germany (which moved up from sixth), Spain, and Ireland.[12]

China saw a rush of installations due in part to anticipation of a reduced feed-in tariff for onshore wind power.[13] China added an estimated 23.2 GW, more than any country has ever installed in one year, for a total approaching 115 GW.[14] About 20.7 GW was integrated into the national grid and started receiving the FIT premium during 2014, with approximately 95.8 GW considered officially grid-connected by year's end.[15] Wind generated 156.3 TWh in 2014, accounting for 2.8% of China's total generation (up from 2.6% in 2013).[16] Inner Mongolia had 21.1% of cumulative capacity at year's end, followed by Gansu (10.3%), Hebei (9.2%), and Xinjiang (8.1%) provinces, with Gansu and Hebei both benefitting from new transmission lines and improved grid management.[17]

Difficulties continued in transmitting China's wind power from turbines to population centres. However, new transmission lines and turbine deployment in areas with better grid access, as well as incentives for wind farm development in less-windy areas nearer to demand centres, are reducing the number of idled turbines.[18] As a result, the rate of curtailment dropped four percentage points relative to 2013, to 8% (down from a high of 17% in 2012)—meaning that 14.9 TWh of potential generation was curtailed.[19] Trials are under way to feed "surplus" wind-generated electricity into central and district heating systems in the northeast, an additional measure that could help solve the curtailment problem.[20]

WIND POWER

Figure 22. Wind Power Global Capacity, 2004–2014

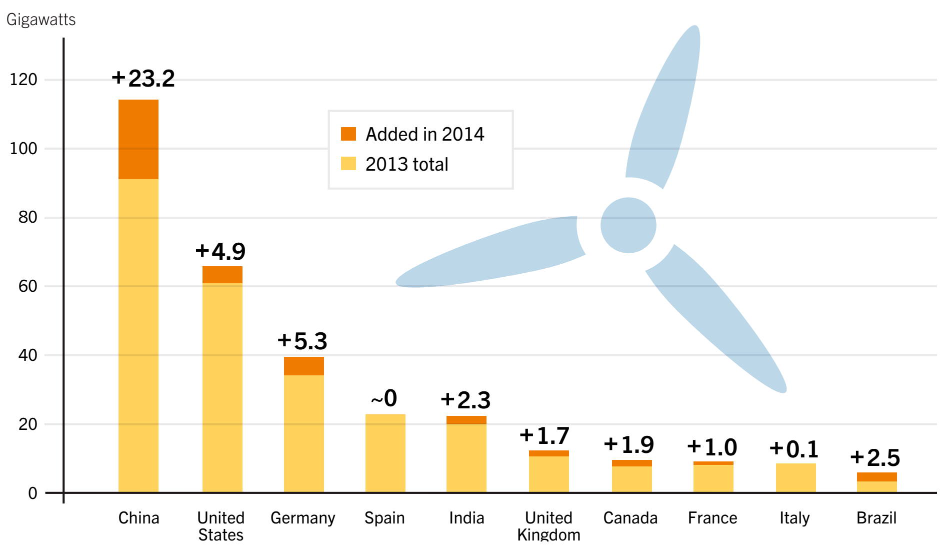


Source: See Endnote 1 for this section.

51 Gigawatts added in 2014

Wind generated more than **20%** of electricity in several countries, including: **Denmark, Nicaragua, Portugal and Spain**

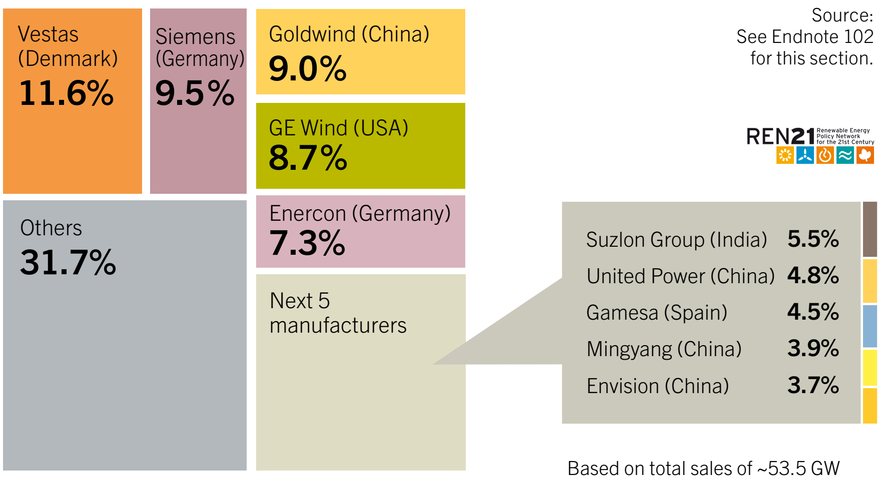
Figure 23. Wind Power Capacity and Additions, Top 10 Countries, 2014



Source: See Endnote 8 for this section.

Additions are net of repowering.

Figure 24. Market Shares of Top 10 Wind Turbine Manufacturers, 2014



Source: See Endnote 102 for this section.

Based on total sales of ~53.5 GW

02

New and vital markets are developing elsewhere in Asia, including in Indonesia, Mongolia, Pakistan, the Philippines, Thailand, and Vietnam.[21] The Philippines completed Southeast Asia's largest individual wind project (150 MW) to date, and commissioned a second large project (81 MW) in 2014.[22] Pakistan added 150 MW for a year-end total of 256 MW, followed in the region by Japan (130 MW), where wind development has been delayed by cumbersome environmental impact assessment procedures.[23] India was the world's fifth largest market (2.3 GW, up 34% over 2013) and remained fifth globally for cumulative capacity (22.5 GW).[24]

The European Union yielded its position as the top region for cumulative wind capacity to Asia in 2014, although the EU market was up 4% over 2013.[25] The region saw its second highest installations ever (after 2012), due largely to Germany.[26] Wind accounted for the largest share of new EU power capacity (nearly 44%) in 2014, followed by solar PV.[27] More than 11.8 GW of wind capacity (a net increase of 11.4 GW) was added to the EU's grids, for a total approaching 129 GW.[28] By year's end, 16 EU countries had more than 1 GW in operation.[29]

Even so, investments in wind power in the region are being undermined by regulatory and political uncertainty, leading to increased concentration in the few countries with stable frameworks.[30] Germany and the United Kingdom accounted for 59% (46% in 2013) of new EU installations.[31] Germany surpassed its 2013 record, adding nearly 5.3 GW to the grid in 2014.[32] Considering decommissioned onshore capacity (nearly 0.4 GW), Germany's capacity increased by 4.9 GW for a year-end total of 39.2 GW (including offshore capacity not yet grid-connected, it totalled 40.5 GW).[33] The strong market onshore was driven at least in part by the availability of new wind priority areas in several regions and by revisions to the Renewable Energy Sources Act (EEG), including an end to the repowering bonus after 2014.[34] More than 1.1 GW, or at least 24% of onshore installations in 2014, was for repowering.[35] Germany's gross generation from wind power was 56 TWh (up from 51.7 TWh in 2013).[36]

The United Kingdom added 1.7 GW to the grid for a year-end total of 12.4 GW; 36% of the total operates offshore.[37] UK wind capacity generated 31.5 TWh in 2014, accounting for 9% of total electricity supply.[38] Other top markets included Sweden (1.1 GW) and France (1 GW), both seeing significant increases over 2013 and closing the year with 5.4 GW and 9.3 GW, respectively.[39] Several previously important markets—such as Denmark, Italy, and Spain—saw declines relative to 2013.[40]

The United States ranked third for additions (nearly 4.9 GW), second for cumulative capacity at year's end (65.9 GW), and first for wind power generation (181.8 TWh) during 2014.[41] The US market rebounded with a record 13 GW under construction as of early 2015.[42] Texas led for capacity added (more than 1.8 GW), followed by Oklahoma, Iowa, Washington, and Colorado.[43] The federal Production Tax Credit (PTC), which expired at the end of 2013, was reinstated retroactively in mid-December 2014, and expired again at year's end.[44] Canada also had a strong year, surpassing its 2013 record. It added nearly 1.9 GW, for a total of 9.7 GW, led by Ontario (adding 1 GW), Quebec (0.5 GW), and Alberta (0.4 GW).[45]

To the south, wind power is picking up speed in several new markets across Latin America and the Caribbean. The region added about 4.3 GW during 2014, with Mexico (0.6 GW), Chile (0.5 GW), Uruguay (0.4 GW), and Peru (adding 146 MW to its previous 2 MW) the top markets after Brazil.[46] Brazil installed a record 2.5 GW, double its 2013 market, to rank fourth globally for newly added capacity.[47] Growth has been so rapid that Brazil is facing challenges similar to China's, with mismatched timing of project construction and development of the necessary transmission links; it is hoped that new auction systems for transmission will resolve this issue.[48] Other challenges include bottlenecks for the supply of wind turbines due to rapid growth and national content rules.[49] Brazil ended the year with 5.9 GW of commissioned capacity, of which 5.6 GW was grid-connected and in commercial operation.[50]

Australia added nearly 0.6 GW of wind capacity, bringing its total to 3.8 GW.[51] Wind energy provided 4% of Australia's electricity in 2014.[52] By early 2015, however, most investment and projects were on hold due to policy uncertainty.[53] The only other country in the Pacific to add capacity was Samoa, which installed its first wind farm (550 kW).[54]

Turkey moved into the top 10 markets by adding 0.8 GW (after installing about 0.5 GW annually since 2010) for a total approaching 3.8 GW.[55] The Middle East saw little new operating capacity of note in 2014.[56] The African continent, however, installed nearly 1 GW during the year thanks to Algeria (10 MW), which commissioned its first large-scale wind farm; Egypt (60 MW); Morocco (300 MW); and South Africa, which increased its capacity from 10 MW to 570 MW in a single year.[57] Morocco, with a total approaching 0.8 GW, surpassed Egypt (0.6 GW) to lead the African continent for total wind power capacity at year's end, and both countries entered 2015 with significant amounts of capacity under construction.[58] After a three-year delay due to difficulty securing financing, Kenya's Lake Turkana (310 MW) project was moving ahead by year's end, and projects also were under way in Ghana, Senegal, and Tanzania.[59]

Offshore, an estimated 1.7 GW of grid-connected capacity was added in 2014, for a world total exceeding 8.5 GW.[60] The vast majority added (88%) was in Europe, where another 1.5 GW was installed for a total of 8 GW of grid-connected capacity off the coasts of 11 countries.[61] The United Kingdom accounted for nearly 48% of new grid-connected installations (813 MW)—followed by Germany (529 MW), and Belgium (141 MW)—and by end-2014 the UK had more capacity connected offshore than the rest of the world combined.[62] UK development is slowing, however, and developers cancelled several GW of potential projects in 2014 due to challenging conditions.[63]

Germany's offshore grid-connected capacity exceeded 1 GW by year's end, with another 1.3 GW awaiting grid connection.[64] Denmark held on to second place for cumulative capacity (1.3 GW) and brought additional capacity on line in early 2015.[65] Offshore development has begun in Japan, South Korea, Taiwan, and Vietnam.[66] Beyond Europe, however, the only significant market is China, which added about 200 MW to its grids (nearly 230 MW installed) for a grid-connected total of 440 MW (660 MW installed).[67] As of early 2015, about 6 GW of capacity was under construction in seven countries (in Asia and Europe), with construction of the first US offshore project slated to begin mid-year.[68]

Offshore and on land, independent power producers and energy utilities remained the most important clients in terms of capacity installed. However, there is growing interest in other sectors. The number of large corporate purchasers of wind-generated electricity and turbines continued to increase during 2014.[69] In addition, interest in community- and citizen-owned wind power projects is growing in Australia, Canada, Japan, the United States, parts of Europe, and elsewhere.[70]

Worldwide capacity of small-scale[i] turbines rose 12% in 2013, significantly below the 18% increase in 2012.[71] At least 870,000 small-scale turbines, or more than 755 MW, were operating worldwide at the end of 2013 (up from 678 MW at end 2012).[72] By one estimate, another 255 MW was added during 2014.[73] Applications include defence, rural electrification, water pumping, battery charging, and telecommunications, with small turbines used increasingly to displace diesel in remote locations.[74]

While most countries have some small-scale turbines in use, the majority of capacity operating at the end of 2013 was in China (305 MW) and the United States (221 MW).[75] Other leaders include the United Kingdom (113 MW), Italy (29.1 MW), Germany (21.8 MW), Canada (12.6 MW), and Ukraine (12.5 MW)[ii].[76] In 2013, the three biggest markets saw a decrease in the number of units installed; in 2014, US and UK markets slowed substantially due to reduced incentives and competition with solar PV, but US momentum is building around new leasing models.[77] In general, the market is evolving towards larger turbines, which are easier to finance.[78] Small-scale vertical axis turbines are gaining attention but remain a small share of the market.[79]

Repowering—the replacement of old turbines with fewer, larger, taller, and more-efficient and reliable machines—is a rapidly developing new line of business, particularly in Europe and, to a lesser extent, in Japan.[80] During 2014, an estimated 444 MW of old turbines was dismantled in Europe (over 430 MW), Japan (11 MW), and Taiwan (2 MW).[81] The largest market was Germany, which dismantled at least 544 turbines with capacity totalling almost 0.4 GW; at least 413 turbines, with capacity of 1,148 MW, were installed in repowering projects.[82] There is also a thriving international market for used turbines in several developing and emerging economies.[83]

Wind power is playing a major role in power supply in an increasing number of countries. In the EU, wind's share of the electricity mix was about 7.5% in 2014, and, at year's end, capacity in operation was enough to cover more than 10% of electricity consumption in a normal wind year.[84] Several EU countries—including Denmark (39.1%), Ireland (19%), Portugal (27%), and Spain (over 20%)—met higher shares of their demand with wind.[85] Four German states had enough wind capacity at year's end to meet over 55% of their electricity needs, and the Australian state of South Australia generated approximately 40% of its electricity from wind.[86] In the United States, wind power represented 4.4% of total electricity generation and accounted for more than 12% of generation in nine states.[87] Nicaragua, which added 40 MW for a total of 186 MW, generated almost 21% of its electricity with the wind.[88] Globally, wind power capacity by the end of 2014 was enough to meet at least 3.1% of total electricity consumption.[89]

i - Small-scale wind systems generally are considered to include turbines that produce enough power for a single home, farm, or small business (keeping in mind that consumption levels vary considerably across countries). The International Electrotechnical Commission sets a limit at approximately 50 kW, and the World Wind Energy Association (WWEA) and the American Wind Energy Association define "small-scale" as up to 100 kW, which is the range also used in the GSR; however, size varies according to needs and/or laws of a country or state/province, and there is no globally recognised definition or size limit. For more information see, for example, Stefan Gsänger and Jean-Daniel Pitteloud, *2015 Small Wind World Report* (Bonn: WWEA and New Energy Husum, March 2015), Summary, http://small-wind.org/wp-content/uploads/2014/12/Summary_SWWR2015_online.pdf.

ii - Data are for end-2013 with the exceptions of Canada (year 2010) and Ukraine (2011).

WIND POWER INDUSTRY

After years of running in the red—and the loss of a quarter of businesses across the supply chain due to economic recession and policy uncertainty—most turbine makers pulled back into the black in 2014 and ended the year with fairly full order books.[90] In this more streamlined industry, major manufacturers have outsourced extensively to remain profitable and have advanced value-added products and services (including advanced materials, innovative designs for blade extension, after-market service solutions) to further reduce levelised energy costs to compete with fossil energy sources.[91]

Over the past few years, the capital costs of wind power have declined, primarily through competition as well as through technological advances that have increased capacity factors.[92] Onshore wind power is now cost-competitive, or nearly so, on a per kWh basis with new coal- or gas-fired plants, even without compensatory support schemes, in more and more markets (including Australia, Brazil, Chile, Mexico, New Zealand, Turkey, South Africa, much of the EU, and some locations in India and the United States).[93] By one estimate, global levelised costs per MWh of onshore wind fell about 15% between 2009 and late 2014.[94] After a period of rising costs offshore due to the use of new machines in deeper waters farther from shore, there is growing evidence that costs are coming down.[95]

Most of the world's turbine manufacturers are in China, Denmark, France, Germany, India, Japan, Spain, and the United States, and components are supplied from many countries.[96] An increasing number of manufacturers is in Brazil, with South Korea also emerging as a producer of wind technology.[97] Blade manufacturing, for example, has shifted from Europe to North America, South and East Asia, and, most recently, Latin America to be closer to new markets.[98]

The world's top 10 turbine manufacturers captured 68% of the market in 2014 (down from 70% in 2013).[99] Vestas (Denmark) retained the top spot, followed by Siemens (Germany), which climbed two steps.[100] Goldwind (China) dropped one to third, GE (United States) stepped up from fifth to fourth, doubling its 2013 installations, and Enercon (Germany) fell from third place to fifth.[101] Other top manufacturers were Suzlon Group (India), Gamesa (Spain), as well as United Power, Mingyang and Envision (all China).[102] (→ See Figure 24.) All companies in the top 10 broke installation records in 2014.[103]

As the amount of wind output and its share of total generation have increased, so have grid-related challenges in several countries. Challenges include lack of transmission infrastructure, delays in grid connection, the need to reroute electricity through neighbouring countries, and curtailment where regulations and current management systems make it difficult to integrate large amounts of wind and other variable renewables.[104] Curtailment remains the largest challenge facing China's industry, where it is hurting profit margins.[105]

Overcapacity of most key components and material continued during 2014, with many facilities running at partial capacity.[106] In most areas of the supply chain, overcapacity is providing greater choice, flexibility, and cost control.[107] In some countries, however, the industry has struggled as a result. In China, for example, several manufacturers have fought for survival, with the number of turbine manufacturers falling from more than 80 in 2009 to about 30 in late 2014 (although the situation improved for some in 2014).[108] In Europe, declining markets due to regulatory instability and the protracted recession have forced manufacturers to devise new growth scenarios and to consider moving factories overseas.[109] In the United States, a number of facilities opened during 2006–2009, when companies were optimistic about future federal policy support. In 2014, however, several top-tier manufacturers closed operations and cut jobs, and the number of US-based wind components factories dropped to 500, down from 550 in 2013.[110]

Elsewhere, manufacturing capacity is increasing despite global oversupply. In Brazil, major manufacturers are scrambling to meet local content requirements, adding capacity to overcome components shortages.[111] For example, Suzlon (India) announced plans to build its first plant in Latin America, in Brazil, and to develop a supply chain there; and, in early 2015, Alstom and Andrade Gutierrez (Brazil) launched a joint venture to build Alstom's third factory in Brazil.[112] Vestas also announced an investment plan in Brazil, and, in early 2015, the company planned to begin producing 80-metre (260-foot) blades for offshore use at its new factory on the Isle of Wight (UK).[113]

Industry restructuring continued, with some significant acquisitions and joint ventures.[114] The year's top disclosed transaction (USD 2.4 billion) was SunEdison's acquisition of First Wind (both United States), a developer of wind projects.[115] Large-scale wind projects also changed hands, with a total of 24.6 GW being acquired, and activity offshore was at about the same level as onshore activity for the first time.[116] Vestas and Mitsubishi (Japan) formed a joint venture to focus on Vestas's 8 MW offshore turbine; the French government approved GE's proposed takeover of Alstom's (France) power division; Areva (France) and Gamesa created a joint venture to work in the offshore sector; and Suzlon sold Senvion (formerly Repower) to focus on India and high-growth markets including Brazil, China, Mexico, South Africa, and Turkey.[117]

Turbine designs continued to evolve, with trends towards larger machines (longer blades, higher hub height to reach stronger winds, greater nameplate capacity), developments to reduce operations and maintenance costs, and shifts in technologies and strategies to improve wind's economics in a wider range of wind regimes and operating conditions.[118] Such advances are improving reliability and efficiency and reducing costs.[119] Blades have become an area of strategic innovation, with significant changes under way in design, materials, and manufacturing processes.[120] This trend is particularly notable in the offshore sector, where high-tech blades exceed 80 metres in length.[121] Expanding rotor area has increased capacity factors and resulted in higher energy yields at lower wind speeds, which is increasingly important as countries run low on space with good winds (as in Europe) or develop projects closer to load areas (as in China).[122] Several new turbines were launched in 2014, many designed for low-wind sites.[123]

The trend towards ever-larger turbines continued in 2014, with the average size delivered to market rising to 2 MW (from 1.9 MW in 2013).[124] Average turbine sizes were 2.9 MW in Germany, 2.1 in Brazil and Canada, 2 MW in the United States, 1.8 MW in China, and 1.5 MW in India.[125] The average size installed offshore in Europe, about 3.7 MW, was down from 2013 due to the increased share of the Siemens 3.6 MW machine.[126] New machines in the 5–8 MW range are being tested for offshore use in Europe and Asia, and the highest-capacity turbine installed offshore as of early 2015 was Vestas's 8 MW turbine.[127]

The offshore industry differs technologically and logistically from onshore wind.[128] In addition to bigger turbines, the offshore industry is seeing larger projects and is moving farther out, into deeper waters.[129] The distance from shore and water depth of completed or partially completed European wind farms in 2014 averaged 32.9 kilometres and 22.4 metres, respectively.[130] To access winds in even deeper waters—in the Atlantic and Mediterranean, and just off Japan's shore—the industry continues to invest in the development of floating turbines.[131]

While sites are becoming more challenging—resulting in rising costs in recent years—the development of offshore-specific machines, foundations, electrical infrastructure, vessels, and operation and management practices have resulted in better, cheaper, and safer construction techniques.[132] Most historical supply chain bottlenecks have been overcome, and remaining challenges include a general shortage of skilled labour, serial production of jacket foundations (for deep waters), high-voltage direct and alternating current transmission systems, and availability (particularly in Japan and Taiwan) of vessels to transport ever-larger and heavier turbines, foundations, and cables.[133]

The main challenge, however, is reducing costs—a reasoning behind the move towards larger machines.[134] Offshore costs generally are about 50–60% higher than onshore and range from about USD 204/MWh[i] (EUR 168/MWh) in the United Kingdom (including transmission infrastructure) to USD 170/MWh (EUR 140/MWh) in Germany, with the winning tender for Denmark's Horns Rev 3 (to be completed in 2020) coming in at USD 125/MWh (EUR 103/MWh).[135] In Europe, the industry is targeting producing electricity at USD 122/MWh (EUR 100/MWh) by 2020.[136] Manufacturers MHI-Vestas and Siemens, and developer DONG Energy signed a joint declaration in early 2015 for a united industry goal to drive the cost of offshore wind energy below that level by 2020.[137]

In the small-scale wind industry, five countries (Canada, China, Germany, the United Kingdom, and the United States) accounted for more than 50% of turbine manufacturers as of 2013; aside from China, developing countries played a minor role.[138] The year 2013 was challenging for UK and US manufacturers due to declining domestic demand. Exports of US-made machines increased 70% from 2012 (8 MW) to 2013 (13.6 MW) as manufacturers worked to compensate for the drop in domestic sales.[139] Nine US-based manufacturers and one exporter reported sales over USD 1 million in 2013, down from a total of 17 in 2012.[140] In early 2014, small-scale turbine maker Quiet Revolution (UK) filed for bankruptcy in London.[141] To increase the competitiveness of small-scale wind, several leading US small-scale and distributed wind companies have begun offering long-term leases to build on the success of third-party financing for solar PV.[142]

→ See **Table 2** on pages 75–77 for a summary of the main renewable energy technologies and their characteristics and costs.[143]

i - Note that throughout the GSR, currency conversions are calculated as of 31 December 2014, and are sourced from http://www.oanda.com/currency/converter/.

TABLE 2. STATUS OF RENEWABLE TECHNOLOGIES: CHARACTERISTICS AND COSTS

TECHNOLOGY	TYPICAL CHARACTERISTICS	CAPITAL COSTS USD / kW	TYPICAL ENERGY COSTS LCOE – US cents / kWh[1]
POWER GENERATION			
Bio-power from solid biomass (including co-firing and organic MSW)	Plant size: 0.5–200 MW Conversion efficiency: 25–35% Capacity factor: 25–95%	800–4,500 (Global) Co-fire: 200–800 (Global) Up to 1,000 (China and India)	3–22 (Global) Co-fire: 4–12 (Global) 14 (Europe) 5–6 (China)
Bio-power from gasification	Plant size: 0.03–40 MW Conversion efficiency: 30–40% Capacity factor: 40–80%	2,050–5,500 (Global)	6–24 (Global)
Bio-power from anaerobic digestion	Plant size: 0.075–20 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: 1,900–3800 Binary: 2,250–5,500	Condensing flash: 4–14 Binary: 7–24
Hydropower: Grid-based	Plant size: 1 MW to multi-GW Plant type: reservoir, run-of-river Capacity factor: 20–80%	Projects ≥20 MW: 750–2,500 Projects ≤20 MW: 750–4,000	Projects >20 MW: 2–8 Projects <20 MW: 3–23
Ocean power: Tidal range	Plant size: <1 to >250 MW Capacity factor: 23–29%	5,290–5,870 (Global)	21–28 (Global) 35–42 (Europe)
Solar PV: Rooftop	Peak capacity: 3–5 kW (residential); 100 kW (commercial); 500 kW (industrial) Capacity factor: 10–25% (fixed tilt)	Residential costs: 2,200 (Germany); 3,500–7,000 (United States); 4,260 (Japan); 2,150 (China); 3,380 (Australia); 2,400–3,000 (Italy) Commercial costs: 3,800 (United States); 2,900–3,800 (Japan)	21–44 (OECD) 28–55 (non-OECD) 16–38 (Europe)
Solar PV: Ground-mounted utility-scale	Peak capacity: >1–250+ MW Capacity factor: 10–25% (fixed tilt)	1,200–3,000 (Global) Weighted capital costs (2014): 1,670 (China), 2,710 (Japan) 1,495 (Germany) 2,080 (United Kingdom) 2,218 (United States) Concentrating PV (CPV): 1,480–2,330 (10 MW)	10–38 (OECD) 7–40 (non-OECD) 14–34 (Europe) 11 (China) 25 (Japan) 11 (United States) CPV: 10–15
Concentrating solar thermal power (CSP)	Types: parabolic trough, tower, dish Plant size: 50–250 MW (trough) 20–250 MW (tower) 10–100 MW (Fresnel) Capacity factor: 20–35% (no storage) 35–80% (with storage)	Trough, no storage: 5,000–7,000 (OECD) 3,100–4,050 (non-OECD) Trough, 6 hours storage: 6,000–8,000 Tower: 6,000 (United States, without storage); 9,000 (United States, with storage)	Trough and Fresnel: 19–38 (no storage); 17–37 (6 hours storage Tower: 12.5–16.4 (United States; high end of range is with storage)
Wind: Onshore	Turbine size: 1.5–3.5 MW Capacity factor: 20–50%	925–1,470 (India) 660–1,290 (China) 2,300–10,000 (United States) 5,873 (United Kingdom)	4–16 (Global) 6–7 (Asia, Eurasia, North America) 5–10 (Central and South America)
Wind: Onshore small-scale	Turbine size: up to 100 kW Average: 0.85 kW (global) 0.5 kW (China) 1.4 kW (United States) 4.7 kW (United Kingdom)	2,300–10,000 (United States) 1,900 (China) 5,870 (United Kingdom)	15–20 (United States)
Wind: Offshore	Turbine size: 1.5–7.5 MW Capacity factor: 35–45%	4,500–5,500 (Global) 2,250–6,250 (OECD)	15–23 (Global)

02

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

TECHNOLOGY	TYPICAL CHARACTERISTICS	INSTALLED COSTS OR LCOE USD / kW or US cents / kWh
DISTRIBUTED RENEWABLE ENERGY IN DEVELOPING COUNTRIES		
Biogas digester	Digester size: 6–8 m^3	Unit cost: USD 612 / unit (Asia); USD 886 / unit (Africa)
Biomass gasifier	Size: 20–5,000 kW	LCOE: 8–12 (Global) LCOE: 5–6 (China)
Solar home system	System size: 20–100 W	LCOE: 160–200 (Global) LCOE: 4 (Bangladesh)
Household wind turbine	Turbine size: 0.1–3 kW (off-grid, residential) 1.1–2.5 MW (industrial, institutional)	Capital cost: 10,000 / kW (1 kW turbine) 5,000 / kW (5 kW) 2,500–3,500 / kW (250 kW) LCOE: 15–35+
Hydropower: Off-grid/rural	Plant size: 0.1–1,000 kW Plant/storage type: run-of-river, diurnal storage, hydrokinetic	Capital costs: 1,175–6,000 LCOE: 5–40
Village-scale mini-grid	System size: 10–1,000 kW	LCOE: 25–100

TECHNOLOGY	FEEDSTOCKS	FEEDSTOCK CHARACTERISTICS	ESTIMATED PRODUCTION COSTS US cents / litre[1]
TRANSPORT FUELS			
Biodiesel	Soy, rapeseed, mustard seed, palm, jatropha, waste vegetable oils, 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: 56–72 (Argentina); 100–120 (Global average) Palm oil: 100–130 (Indonesia, Malaysia, and other) Rapeseed oil: 105–130 (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: 82–93 (Brazil) Corn (dry mill): 85–128 (United States)

TECHNOLOGY	TYPICAL CHARACTERISTICS	CAPITAL COSTS USD / kW	TYPICAL ENERGY COSTS LCOE – US cents / kWh
HOT WATER / HEATING / COOLING			
Biomass heat plant	Plant size: 0.1–15 MW_{th} Capacity factor: ~50–90% Conversion efficiency: 80–90%	400–1,500	4.7–29
Wood pellet heater (domestic)	Plant size: 5–100 MW_{th} Capacity factor: 15–30% Conversion efficiency: 80–95%	360–1,400	6.5–36
Biomass 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 Direct Use: Space heating in buildings	Plant size: 0.1–1 MW_{th} Capacity factor: 25–30%	1,865–4,595	10–27
Geothermal Direct Use: District heating	Plant size: 3.8–35 MW_{th} Capacity factor: 25–30%	665–1,830	5.8–13

[1] Litre of diesel or petrol equivalent.

TECHNOLOGY	TYPICAL CHARACTERISTICS	CAPITAL COSTS USD / kW	TYPICAL ENERGY C. LCOE – US cents / kWh
HOT WATER / HEATING / COOLING			
Heat Pump: Ground-source (residential and commercial)	Plant size: 10–350 kW_{th} Conversion efficiency: 280-500%	500–2,250	7–13
Heat Pump: Domestic water heaters	Plant size: 1–2 kW_{th} Conversion efficiency: 250–300%	300–350	6–7
Heat Pump: Water-source (residential, including multi-family)	Plant size: 4–40 kW_{th} Conversion efficiency: 300–400%	500–700	5–7
Heat Pump: Air-source	Plant size: 1–2 kW_{th} Conversion efficiency: 300–400%	350–400	5–7
Solar thermal: Domestic hot water systems	Collector type: flat-plate, evacuated tube (thermosyphon and pumped systems Plant size: 2.1–4.2 kW_{th} (single-family); 35 kW_{th} (multi-family) Efficiency: 100%	Single-family: 1,100–2,140 (OECD, new build); 1,300–2,200 (OECD, retrofit); 147–634 (China) Multi-family: 950–1,850 (OECD, new build); 1,140–2,050 (OECD, retrofit) Thermosyphon direct: 100–250 (China, India, Turkey); 630–650 (South Africa); 1,100 (Australia) Thermosyphon indirect: 2,300 (United States) Pumped direct: 1,700 (United States); 760–820 (South Africa) Pumped indirect: 2,300 (United States); 850-1,900 (Central Europe); 1,600-2,400 (Northern Europe) Integral collector storage: 450–800 (United States) Large-scale SWH: 350–1,040 (Europe)	1.5–28 (China) 5–8 (Australia)
Solar thermal: Domestic heat and hot water systems (combi-systems)	Collector type: same as water only Plant size: 7–10 kW_{th} (single-fam.); 70–130 kW_{th} (multi-family); 70–3,500 kW_{th} (district heating); >3,500 kW_{th} (district heat with seasonal storage) Efficiency: 100%	Single-family: same as water only Multi-family: same as water only District heat (Europe): 460–780 (350–400 in Denmark); with storage: 470–1,060	Domestic hot water: 5–50 District heat: 4 and up (Denmark)
Solar thermal: Industrial process heat	Collector type: flat-plate, evacuated tube, parabolic trough, linear Fresnel Plant size: 100 kW_{th}–20 MW_{th} Temperature range: 50–400 °C	470–1,000 (without storage) 265–1,060 (Europe) 210–320 (India, Turkey, S. Africa, Mexico) Concentrated systems: 420–1,900 (parabolic dish, India) 640–2,120 (parabolic trough) 1,270–1,900 (linear Fresnel) Solar concentrated systems: 980–1,400 (China) 1,800 and up (Germany)	4–16 (Global) 2.6–8.5 (Europe) Concentrated systems: 6.4–9.6
Solar thermal: Cooling	Capacity: 10–1,000 kW (absorption chillers) 5–430 kW (adsorption chillers) Efficiency: 50–75% (single-effect absorption/adsorption chiller) 120–140% (double-effect absorption chiller)	1,600–3,200	Not available

Note: To the extent possible, costs provided are indicative economic costs, levelised, and exclusive of subsidies or policy incentives. Several components determine the levelised costs of energy/heat (LCOE/H), 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. 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.

Source: See Endnote 143 in the Wind Power text for sources and assumptions.

03

The **DANDELION** uses the multiplier effect to ensure its survival. Its flower head is composed of hundreds of seeds that scatter with the smallest gust of wind and contain the necessary material to generate and form a new flower. Populating the landscape with **efficient financial instruments** can support the implementation of renewable energy systems to meet energy needs, cleanly and sustainably.

03 INVESTMENT FLOWS

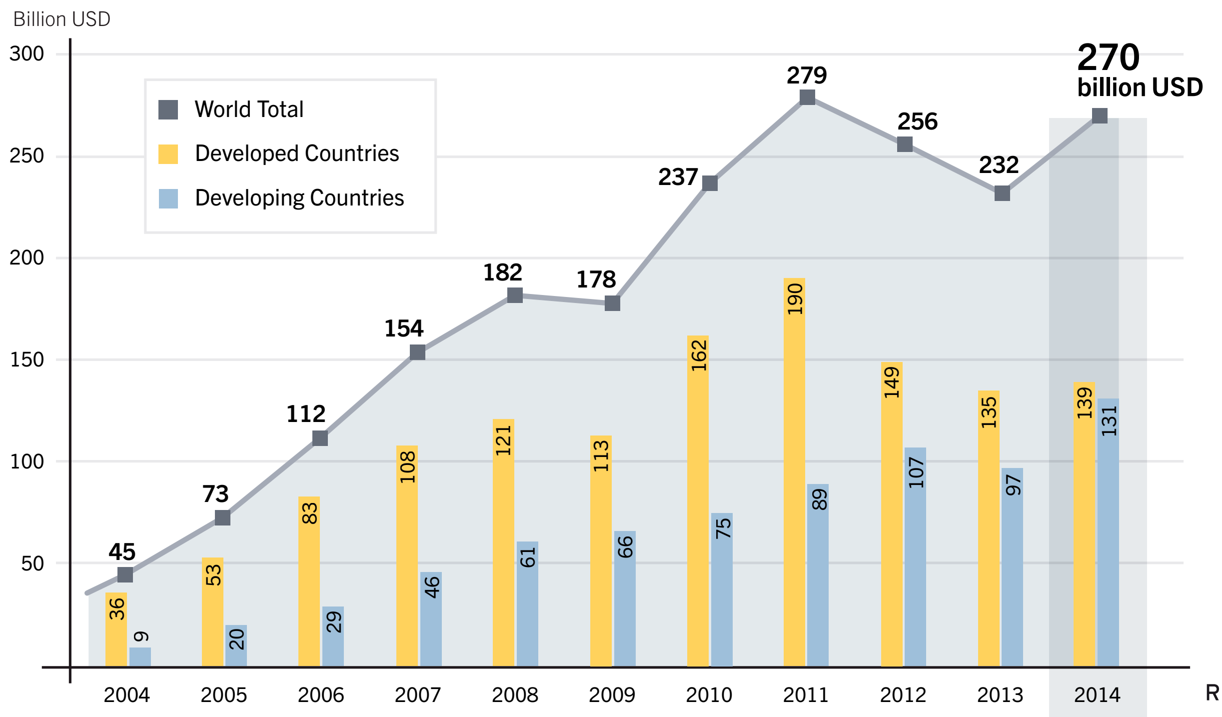
Global new investment in renewable power and fuels (not including hydropower projects >50 MW) was USD 270.2 billion in 2014, as estimated by Bloomberg New Energy Finance (BNEF).[i] This represents a rise of 17% compared to the previous year and the first increase in three years. (→ See Figure 25.) Including investments in hydropower projects larger than 50 MW, total new investment in renewable power and fuels was at least USD 301 billion in 2014.[ii 1] Note that these estimates do not include investment in renewable heating and cooling technologies.

This increase in investment was due in part to a boom in solar power installations in China and Japan, totalling USD 74.9 billion between those two countries, as well as to a record USD 18.6 billion of final investment decisions for offshore wind projects in Europe. Overall, more than a quarter of new investment in renewable energy—some USD 73.5 billion—went to small-scale projects in 2014. Small-scale distributed solar PV is gaining ground in developing countries around the world as an immediate and affordable alternative to centralised, grid-based power systems.

Investment in developing countries continued to rise during 2014: it was up 36% from the previous year to USD 131.3 billion. Developing country investment came the closest ever to surpassing the investment total for developed economies, which reached USD 138.9 billion in 2014, up only 3% from 2013.

Throughout 2014, renewable energy investment continued to spread to new markets. Chile, Indonesia, Kenya, Mexico, South Africa, and Turkey each invested more than USD 1 billion in renewable energy. Other developing countries—including Jordan, Myanmar, Panama, the Philippines, and Uruguay—were in the USD 500 million to USD 1 billion range.

Figure 25. Global New Investment in Renewable Power and Fuels, Developed and Developing Countries, 2004–2014



Source: See Footnotes i and ii for this section.

i - This section is derived from UNEP's *Global Trends in Renewable Energy Investment 2015* (Frankfurt: 2015), the sister publication to the GSR, prepared by the Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP) in co-operation with Bloomberg New Energy Finance (BNEF). Data are based on the output of the Desktop database of BNEF, unless otherwise noted, and reflect the timing of investment decisions. The following renewable energy projects are included: all biomass and waste-to-energy, geothermal, and wind generation projects of more than 1 MW; all hydropower 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 information, please refer to the FS-UNEP/BNEF *Global Trends* report. Where totals do not add up, the difference is due to rounding.

ii - Investment in large hydropower (>50 MW) is not included in the overall total for investment in renewable energy. BNEF tracks only hydropower projects of between 1 MW and 50 MW, but it does make estimates for hydro >50 MW.

Overall investment in solar power was up 25% to USD 149.6 billion, while investment in wind power advanced 11% to a record USD 99.5 billion. Investment in geothermal power capacity also rose, by 23% to USD 2.7 billion. Other renewables did less well: biofuels saw an 8% decline to USD 5.1 billion (a 10-year low), biomass and waste-to-energy dropped 10% to USD 8.4 billion, and small-scale hydropower slipped 17% to USD 4.5 billion.

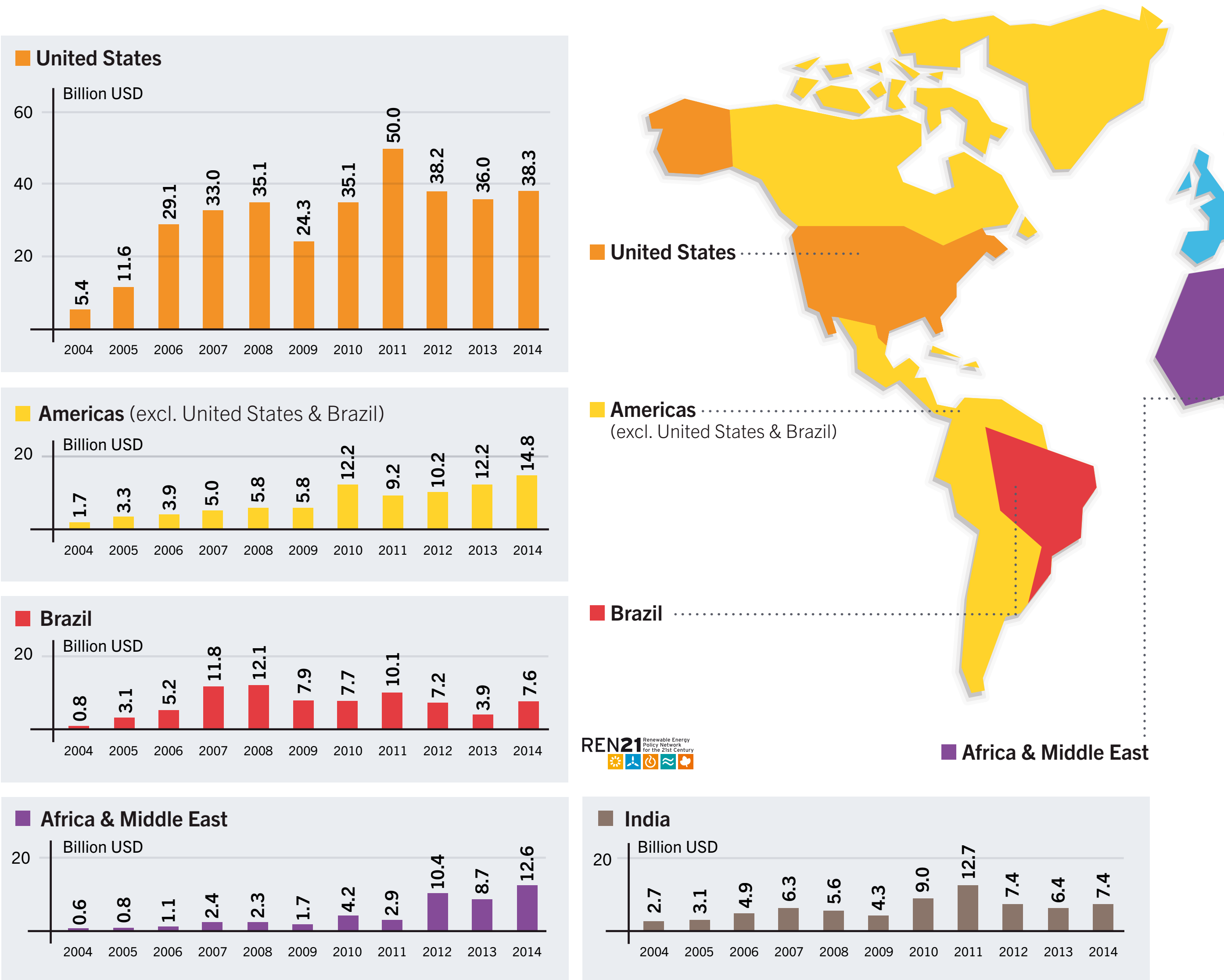
New investment in renewable power capacity—USD 242.5 billion, excluding large-scale hydropower—was below the gross investment in fossil fuel capacity, at some USD 289 billion. However, it was far above the total for net investment in additional fossil fuel capacity, which came to USD 132 billion in 2014. Including investment in large-scale hydropower, global investment in renewable power capacity was more than twice the investment in net fossil fuel power capacity during 2014.

INVESTMENT BY ECONOMY

Developed and developing countries alike saw increases in renewable energy investments in 2014 relative to previous years. While developed countries noted a modest increase of 3%, to USD 138.9 billion, developing economies as a group (including China, Brazil, and India) saw an increase of 36%, to USD 131.3 billion. As a result, the share of global investment from developing countries increased by six percentage points to 49% in 2014, setting a new record. China accounted for 63% of developing country investment, up from 61% in 2013, and was responsible in large part for boosting the developing economies' share of the world total.

All regions of the world experienced an increase in renewable energy investment relative to 2013. (→ See Figure 26.) China's investment was up 39% on 2013, and India's investment rose USD 1 billion to USD 7.4 billion. The rest of the Asia-Oceania region saw annual investment in renewable energy continue its uninterrupted rise to USD 48.7 billion (up almost 9%). Investment in Europe was up less than 1%, to USD 57.5 billion. The United States invested USD 38.3 billion, an increase of 7% compared to 2013 but still well below the all-time high reached in 2011. In the rest of the Americas (excluding Brazil and the United States),

Figure 26. Global New Investment in Renewable Power and Fuels, by Region, 2004–2014



investment was up over 21% to USD 14.8 billion in 2014. The Middle East and Africa region also experienced a significant increase in investment, from USD 8.7 billion in 2013 to USD 12.6 billion in 2014.

The top 10 national investors consisted of four developing countries (all of which are BRICS[i] countries) and six developed countries. China was again in the lead, accounting for nearly one-third of global investment in renewable energy, followed by the United States, Japan, the United Kingdom, and Germany. The next five were Canada, Brazil, India, the Netherlands, and South Africa. The most significant increase in dollar terms occurred in China, with the total rising USD 20.7 billion relative to 2013. The Netherlands and Brazil saw the largest percentage increases, with investment up more than threefold to USD 7.4 billion in the Netherlands, and almost doubling to USD 7.6 billion in Brazil.

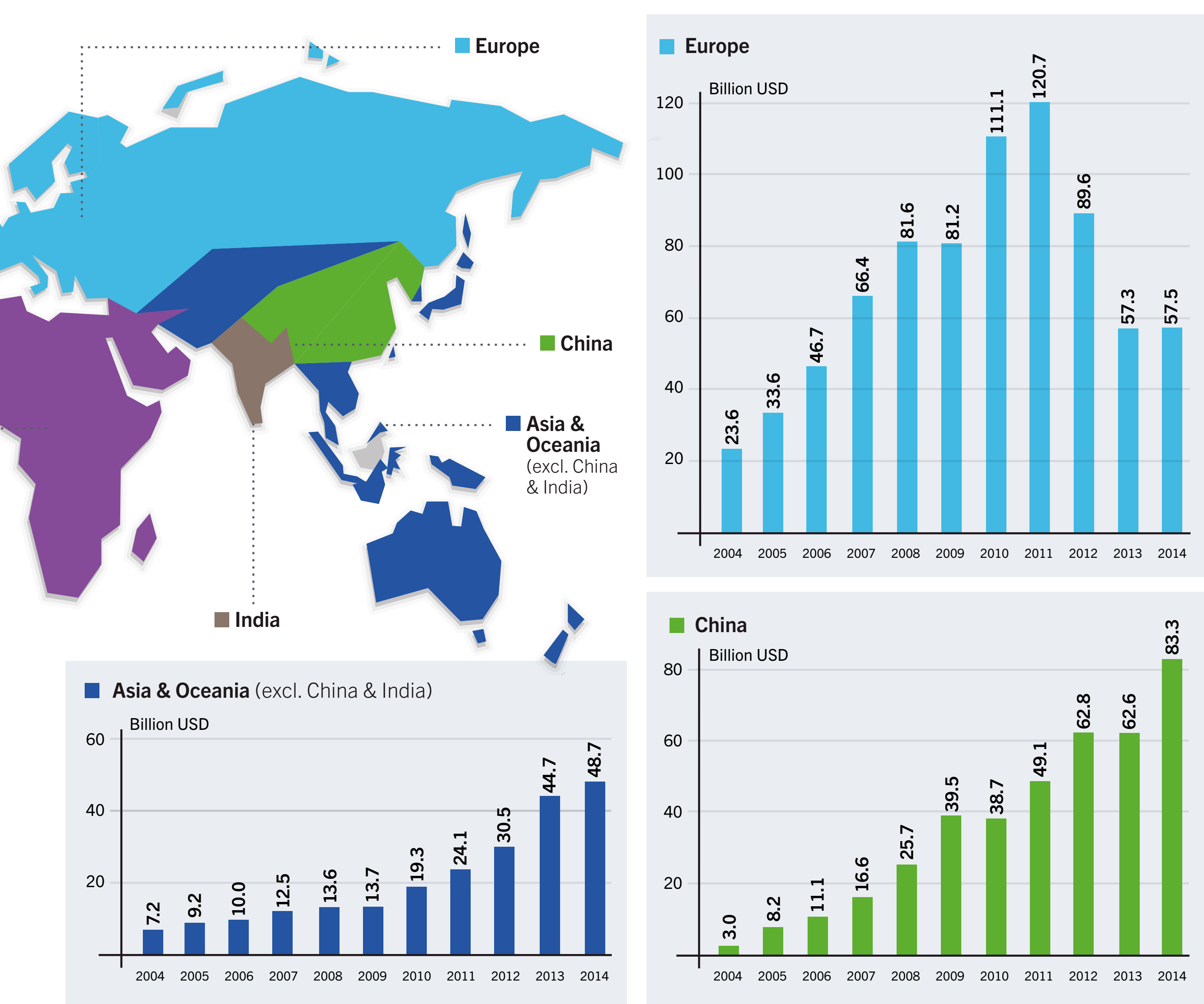
China accounted for USD 83.3 billion (including R&D) of new investment in renewable energy, more than double the investment of its nearest country competitor, the United States. In utility-scale[ii] projects, wind power retained the sector lead, attracting USD 37.9 billion of asset finance, compared with USD 29.7 billion for solar power. Within the solar power sector, investment in small-scale solar PV rose again in 2014 to USD 7.6 billion, up from USD 1.2 billion in 2013. China was one of the few countries to see significant investment in small-scale hydropower, at USD 2.4 billion. The country also invested significant sums in large-scale hydropower, bringing a total of about 22 GW of new hydropower capacity into operation during the year, a large portion of which was projects >50 MW.[iii] [2] (→ See Hydropower section.)

The United States, which invested USD 38.3 billion (including R&D), continued to be the largest individual investor among the

i - The five BRICS countries are Brazil, Russia, India, China, and South Africa.

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

iii - The Chinese government estimates that China invested USD 15.6 billion (CNY 96 billion) in hydropower during 2014, including hydropower facilities of all sizes, per China Electricity Council, "An Overview of China's Power Industry in 2014" (Beijing: 10 March 2015), http://www.cec.org.cn/yaowenkuaidi/2015-03-10/134972.html (using Google Translate). This figure may include investment in pumped storage.



Data include government and corporate R&D.

Source: BNEF.

developed economies. In terms of finance types, venture capital and private equity in solar power increased from USD 373 million in 2013 to USD 1.3 billion in 2014. US public market activity in solar power also did well in 2014, with a 76% increase to USD 5.9 billion. The US wind power sector faced a difficult year in 2014, with investment (excluding R&D) decreasing by half to USD 6.9 billion; funding was delayed due to uncertainty over whether the Production Tax Credit would be extended.

Japan was not far behind the United States at USD 34.3 billion (excluding R&D). About 82% of the country's total investment volume was spent on small-scale solar PV projects, driven by the country's generous solar feed-in tariff.

The United Kingdom saw a modest rise (1%) in renewable energy investments to USD 13.9 billion (excluding R&D). Wind power was again the country's star sector, with USD 8 billion, 86% of which was for offshore projects. This compared with USD 2.7 billion invested in solar power. In addition, the United Kingdom was one of the few countries to attract ocean energy investment.

The other leading investor in offshore wind projects, Germany, saw overall financing (excluding R&D) increase by 4% to USD 11.4 billion. Wind power attracted more than 2.5 times as much investment as in 2013. However, the solar power market of this former leader for investment in small-scale PV almost halved for the second year running. The decline was due largely to the decrease in feed-in tariff rates as well as to the self-consumption surcharge that was introduced in August 2014.

Canada has been a steady investor in renewable energy in recent years. In 2014, the country attracted USD 8 billion in investment (excluding R&D), up almost 31% from the preceding year. Most of this increase was in asset finance, principally for large-scale wind projects in Ontario and Quebec, and for solar PV.

Brazil climbed back into the top 10 countries in 2014, investing USD 7.4 billion (excluding R&D) in renewables, with wind power attracting 84% of the total. Brazil's second biggest renewable energy sector, biofuels, saw USD 574 million invested, a long way from the USD 8.3 billion invested in 2007. Outside of Brazil, but still in the region, investment in renewable energy was widely distributed, with Mexico up 19% to USD 2 billion, followed by Chile (USD 1.4 billion), Uruguay, Panama, and Costa Rica.

Investment in India rose 14% in 2014, to USD 7.4 billion. Solar power was the only sector to see growth during the year, with financing doubling to USD 3 billion. In contrast to 2013, capacity auctions in 2014 were fully subscribed, indicating that investor confidence has risen. Wind power attracted nearly half of India's total investment, with USD 3.4 billion. The second largest investor in the Asia-Oceania region was Indonesia (USD 1.8 billion), followed by Myanmar, the Philippines, Sri Lanka, and Thailand.

Of the top 10 countries for renewable energy investment, the Netherlands experienced the fastest growth relative to 2013. Investment rose from USD 1.9 in 2013 to USD 6.5 billion in 2014, with most of this going to offshore wind projects.

South Africa led the African continent and retained its place among the top 10 countries. The country saw renewable energy investment increase 5% in 2014, to USD 5.5 billion. South Africa's principal driver of renewables financing is the national tender programme. Approximately USD 1.6 billion (under 30%) was spent on wind in 2014, with 71% of total investment going to solar PV and CSP. The second largest investor in Africa was Kenya (USD 1.3 billion), followed by Algeria, Egypt, Nigeria, and Tanzania.

INVESTMENT BY TECHNOLOGY

Solar power was again the leading sector by far in terms of money committed during 2014, accounting for USD 149.6 billion, or more than 55% of total new investment in renewable power and fuels (not including hydropower >50 MW). Wind power followed with USD 99.5 billion, or 36.8% of the total (up 11% from 2013, to a new record). The remaining 8% was made up of biomass and waste-to-energy[i] (USD 8.4 billion), biofuels (USD 5.1. billion), small-scale hydropower (<50 MW) (USD 4.5 billion), geothermal power (USD 2.7 billion), and ocean energy (USD 0.4 billion). Of these technologies, geothermal (up 23%) and ocean (up 110%) saw increases in 2014, while investment declined in biofuels (-8%), biomass and waste-to-energy (-10%), and small-scale hydropower (-17%). (→ See Figure 27.)

Developing economies continued to represent the majority of investments in wind power, small-scale hydro, and geothermal power, whereas developed countries outweighed them in all other technologies.

About 90% of solar power investment went to solar PV (USD 134.8 billion), with the remaining shares going to CSP (2.5%) and unspecified solar (7.4%). Solar power investment was up 25% compared with investment in the sector during 2013. Developed countries retained the majority in solar power investment, but their share shrank by nine percentage points to 58% due largely to a surge in China, which attracted more than one-quarter of the global total. The top developed country investor in solar was Japan, accounting for 23% of the total, followed by the United States (19%).

The top investors in wind power were China, driven in part by anticipated reductions in the feed-in tariff, followed distantly by the United Kingdom, Germany, Netherlands, Brazil, and India. Other renewable energy technologies showed contrasting trends, with investment in small-scale hydropower up in developed economies but down significantly in developing countries, and biofuels and geothermal down in developed economies but up in developing economies. Biomass decreased in developed and developing countries, whereas ocean energy investment increased in developed and developing countries.

Detailed statistics are not tracked by BNEF for large hydropower projects over 50 MW in size, although they represent the third most important sector for renewable energy investment after solar and wind power. Translating hydropower capacity additions into asset finance dollars per year is not straightforward because the average project takes four years to build. However, BNEF estimates that asset financing for large-scale hydro projects commissioned in 2014 totalled at least USD 31 billion. Considering hydropower data provided by the industry and reported elsewhere in this GSR, investment in hydropower >50 MW may have been considerably higher.[3]

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

Figure 27. Global New Investment in Renewable Energy by Technology, Developed and Developing Countries, 2014

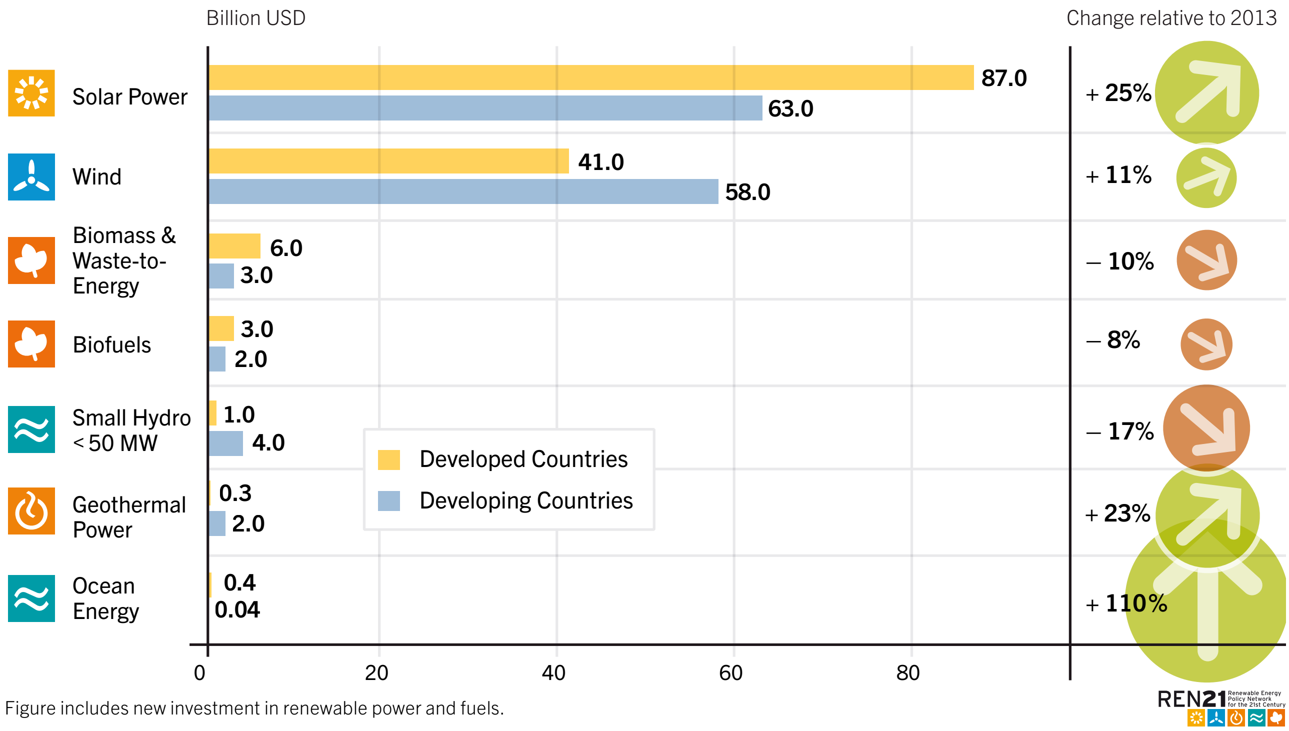


Figure includes new investment in renewable power and fuels.

Source: BNEF.

INVESTMENT BY TYPE

Global research and development [i] (R&D) increased by a modest 2% in 2014 to USD 11.7 billion, with government R&D steady at USD 5.1 billion, and corporate R&D at USD 6.6 billion. Europe remains the biggest investor in renewable energy R&D by far, spending 36% of the total (USD 4.3 billion)—almost equal to the combined outlay of the United States and China.

Total R&D spending on solar power rose 2% to USD 6.1 billion. Solar power attracted more than all other sectors combined for the fourth year running. R&D investment in wind power decreased slightly, to USD 2 billion, while R&D spending for biofuels, biomass, and ocean energy technologies increased in 2014.

Asset finance of utility-scale projects accounted for the vast majority of total investment in renewable energy. It totalled USD 170.7 billion during the year, an increase of 10% relative to 2013.

Small-scale distributed capacity investment, largely rooftop solar PV, was USD 73.5 billion. This represented an increase of 34% compared to 2013.

Public market investment in renewable energy companies and funds increased 42%, to USD 15.1 billion. In its second year of strong recovery, public market investment was almost four times greater than it was in 2012. Funds raised by initial public offerings (IPOs) fell by 20% relative to 2013, to USD 3.1 billion. However, secondary issues and private investment in public equity rose by two-thirds to a record USD 6.2 billion, and convertible bond issues more than doubled to a record USD 5.8 billion.

Investment via public markets in "yield companies"[ii] continued to increase, with investors seeing this model as providing steady dividend income at relatively low risk, at a time of record-low interest rates. Solar power investment increased by 73% to USD 8.3 billion, while wind power grew 120% to USD 5.4 billion. Small-scale hydropower and ocean energy saw their public market equity raising increase in 2014 from a tiny base; however, biofuels and biomass declined, and geothermal fell to zero after a major privatisation in 2013.

The WilderHill New Energy Global Innovation Index (NEX), which tracked 106 clean energy companies in 2014, fell 3% over the course of the year. The decline was due mainly to investor reaction to falling oil prices and to policy uncertainties facing the wind and solar power sectors.

Venture capital and private equity investment (VC/PE) in renewable energy increased by more than one-fourth to USD 2.8 billion in 2014; even so, it remained at less than a third of the peak reached in 2008. Investors continued to be hesitant about early-stage opportunities and were only marginally more interested in financing later-stage ventures.

The United States remained the global centre for venture capital investment in renewable energy, while there was a significant decline in the volume of equity-raising in Europe. Private equity expansion capital grew 20% due to a number of substantial deals involving US residential solar firms. A number of next-generation biofuel manufacturers attracted investment, as the first wave of these technologies approached commercialisation.

Acquisition activity—which is not counted as part of the USD 270.2 billion in new investment—also rose in 2014. It was up by USD 2 billion to USD 68.8 billion in 2014, a 3% increase over 2013. These figures include corporate mergers and acquisitions (M&A); power infrastructure acquisitions and debt refinancing; private equity buy-outs; and the purchase of stakes in specialist companies by trade buyers.

i - See Sidebar 5 in GSR 2013, "Investment Types and Terminology," for an explanation of investment terms used in this section.

ii - A yield company (or yieldco) is a corporate entity created specifically to hold high-yielding investments in operating-stage projects. (→ See Glossary.)

Corporate M&A—the buying and selling of companies—fell by 35% in 2014 to USD 9.8 billion. Asset acquisitions and refinancing rebounded from the only contraction in the past decade, rising 11% to establish a new record of USD 54.5 billion. Public market investor exits were almost unchanged at USD 1.9 billion, but private equity buy-outs were four times higher than in 2013, at USD 2.5 billion. Acquisition activity was, as usual, dominated by wind (almost USD 41 billion) and solar (just over USD 20 billion). Wind and solar power combined made up almost 89% of all activity, up from 83% in 2013.

RENEWABLE ENERGY INVESTMENT IN PERSPECTIVE

In 2014, gross investment in new renewable electric generating capacity (not including hydro >50 MW) amounted to USD 242.5 billion[i], up 17% from 2013.[4] Despite the increase, renewable energy investment was again below gross investment in fossil fuel capacity, which went up by 7% to USD 289 billion.

However, much of the investment in fossil fuels went to replacing existing coal-, oil-, and gas-fired power stations, while only USD 132 billion went to establishing additional fossil fuel capacity. By contrast, almost all investment in renewable capacity is net, meaning that it adds to overall generating capacity. Considering only net investment in 2014, renewable power was ahead for the fifth consecutive year, with its USD 242.5 billion taking a wide lead over fossil fuels' estimated USD 132 billion. Taking into account investment in hydropower projects >50 MW, global investment in renewable power capacity in 2014 was again well over twice the year's net investment in fossil fuel power capacity.

SOURCES OF INVESTMENT

Clean energy funds saw declining sector share prices in 2014, influenced partly by the oil price decline. The value of assets managed by clean energy funds was down 13.5% relative to 2013. However, newer types of innovative yield-oriented financing vehicles continued to attract interest, with three US yield companies floated in 2014, raising a combined USD 1.6 billion. Listed project funds, the UK equivalent of US yield companies, saw their number grow to six in 2014, attracting investors with dividend yields of 6%, compared with the 2% offered by 10-year government bonds. Overall, US yieldcos, UK-quoted project funds, and one German equivalent raised USD 5 billion from stock market investors in 2014.

Crowdfunding continued to become a more mainstream means of raising money in an increasing number of countries. Crowdfunding enables small companies and start-ups to raise capital from many small investors in exchange for an equity stake, structured payments, and/or products. Possibly the largest renewables crowdfunding platform by US dollars invested is De WindCentrale based in the Netherlands. By September of 2014, it had amassed over USD 17 million of capital.

Issuance of **green bonds** hit a new record of USD 39 billion in 2014, some 2.6 times the preceding year's total. The record volume was driven by a doubling of issuance from development lenders, such as the World Bank, and from national government agencies, in addition to a fivefold increase in self-labelled corporate bonds from issuers.

In contrast, **clean energy project bonds**[ii] were not so successful, seeing an 82% drop to USD 630 million. This was due to the fact that there was no repeat of the very large issues for solar PV parks seen in 2013 because bank debt remained a compelling alternative in Europe. Nonetheless, 2014 saw the first clean energy project bond in Latin America, the first green bond from Asia's private sector, and the world's first project bond explicitly labelled as "green".

Institutional investors—including pension funds, insurance companies, and wealth managers—continued to play an increasing role. This has been reflected in the emergence of green bonds, as a fixed-interest product linked to clean energy, and of yieldcos and quoted project funds, as equity products exposed to the cash flows from renewable power projects. Another increasingly important conduit for the deployment of institutional money in clean energy is direct investment in projects, which hit a record USD 2.8 billion in 2014, up from USD 1.8 billion in 2013.

Development banks remained crucial to clean energy investment in 2014.[iii] Brazil's BNDES featured as the top player for utility-scale asset finance transactions with a credit of USD 2.7 billion, up from USD 1.5 billion in 2013. The European Investment Bank (EIB) dropped to second place with a credit of USD 1.5 billion, nearly 20% below its 2013 total.

i - This number is for renewable power asset finance and small-scale projects. It differs from the overall total for renewable energy investment (USD 270.2 billion) provided elsewhere in this section because it excludes biofuels and types of non-capacity investment such as equity-raising on public markets, and development R&D.

ii - Clean energy bonds are fixed-interest securities linked to clean energy. In contrast, green bonds are fixed-interest securities linked to clean energy as well as energy efficiency, and also other sustainability goals.

iii - Note that investment data were not available for most development banks when the UNEP/BNEF *Global Trends* report was published.

The year 2014 also saw the creation of two new South-South development banks: in July 2014, the five BRICS countries created the USD 100 billion New Development Bank, to which each country will initially contribute USD 10 billion with the primary focus on infrastructure and sustainable development projects, and with lending to begin in 2016. A few months later, 23 Asian countries (excluding Japan and South Korea) agreed to create the Asian Infrastructure Investment Bank. The initial USD 50 billion was provided mostly by China, and operations are expected to start by the end of 2015.

EARLY INVESTMENT TRENDS IN 2015

Global investment in renewable energy was USD 50.2 billion in the first quarter (Q1) of 2015, as dealmaking slowed in big markets such as Brazil, China, and in Europe. The first quarter tends to be the weakest of the year, but this total was down 10% from Q1 in 2014 (USD 55.9 billion). However, the US dollar had strengthened 15% against several currencies over the interim, and 29% against the euro, accounting for at least part of this decline.

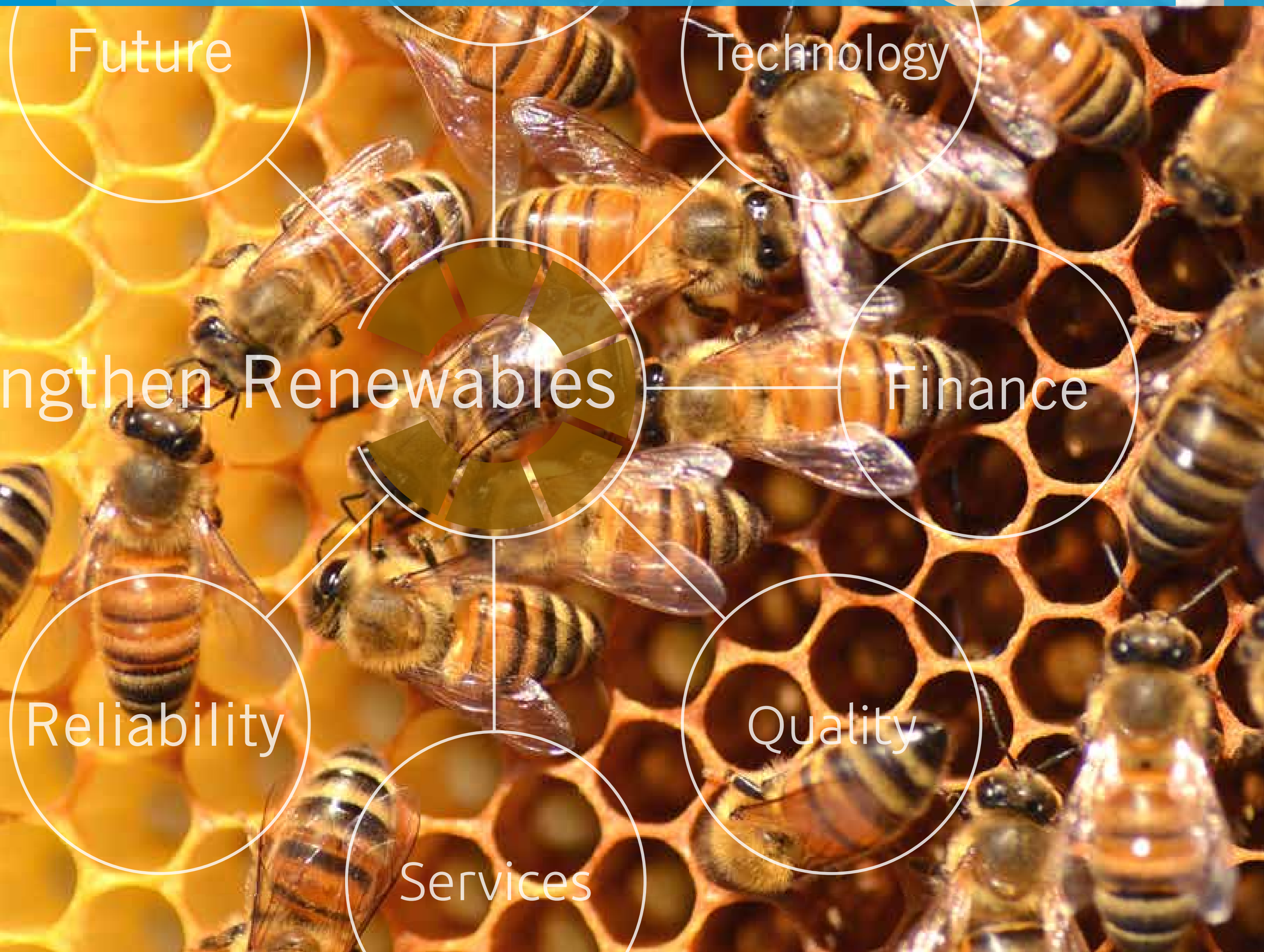
Figures for Q1 of 2015 show that investment fell 29% in Europe compared to the first quarter of 2014, and also declined in China (-23%), Brazil (-62%), and the rest of the Americas (-18%) outside of the United States, where it was up 46%. It also was down slightly in Japan (-3%) and in the rest of the Asia-Oceania region (-43%), with the exception of India, where investment rose 59% compared with Q1 in 2014. South Africa saw the strongest performance, with investment surging to USD 3.1 billion, from almost nothing in the same quarter of 2014, as financing flowed to a series of large solar PV, CSP, and wind power projects that were contracted under the country's tendering process.

All types of investment were down relative to Q1 in the previous year, except for small distributed capacity—primarily rooftop solar PV—which rose 11% to USD 20.3 billion. By sector, investment in Q1 2015 increased relative to Q1 in 2014 for solar power (up 7% to USD 31.8 billion) and biomass and waste-to-energy (up 94% to USD 1.7 billion). However, it declined for wind power (-30%; USD 15.1 billion) and biofuels (-64%; USD 447 million).

Despite the declines, the numbers indicate that the slump in oil and natural gas prices has not had much of an impact on investment in renewable energy.

04

Collective behaviour and nest architecture of **SOCIAL INSECTS**, like bees, can inspire **innovative policy design** for future energy systems. While individual social insects exhibit relatively simple behaviours, collectively, the colony can address complex issues. **Future energy systems** will be based on renewables which often can be both distributed and decentralised. Policy design will need to adapt to changing conditions, integrating the different specificities of the renewables, the changing energy demands and the behaviour patterns of a wide variety of players.



04 POLICY LANDSCAPE

Renewable energy technologies have become mainstream sources of energy, supported by targets and policies. Most countries have enacted policies to regulate and promote renewables in the power generation, heating and cooling, and transport sectors, driven by the need to mitigate climate change, reduce dependence on imported fuels, develop more flexible and resilient energy systems, and create economic opportunity.

As of early 2015, renewable energy support policies could be found in 145 countries. This number is up from 138 countries in 2014, and is over nine times higher than the 15 countries reported in GSR 2005.[i 1] (→ See Table 3 and Figures 28 and 29.) Adoption of new policies has slowed in recent years because the vast majority of countries already have adopted some form of renewable energy support. Policymakers have focused their attention on adapting existing policies to keep pace with rapidly changing costs and circumstances. Recent trends include merging of components from different policy mechanisms, a growing linkage of support between the electricity, heat, and transport sectors, and development of innovative mechanisms to integrate growing shares of renewables into the energy mix.

Strategies to promote renewable energy also have continued to evolve and expand at the regional level. In 2014, the European Union established new regulations governing the energy sector beyond 2020, setting a region-wide goal of a 27% renewable energy share by 2030.[2] Also in 2014, with the adoption of the Arab Renewable Energy Framework (AREF), the Arab League and its 22 member states joined other regions around the world—including the EU and the Caribbean Community (CARICOM)—in establishing a regional framework for renewable energy development and deployment.[ii] The AREF builds on the Pan-Arab Strategy for the Development of Renewable Energy Applications: 2010–2030, which was adopted in 2013.[3]

Targets for renewable energy deployment were identified in 164 countries as of early 2015, up from 144 countries in 2014.[i] The majority of targets focus on growth in specific sectors—power, heating and cooling, and transportation—although several countries have set economy-wide targets for renewable energy deployment. (→ See subsequent sub-sections of the Policy Landscape section as well as **Reference Tables R12–R18.**) Examples of new or revised system-wide targets from 2014 include France's target of 32% of final energy consumption from renewables by 2030, and Ukraine's target of 11% renewables in the national energy mix by 2020.[4]

Many targets are being expressed within the process of establishing a specific policy mechanism or procurement framework. For example, the renewable portfolio standard (RPS) policies at the state level in the United States mandate specific shares of renewable electricity (or capacity) to be reached. Renewable energy tendering mechanisms, which are gaining prominence around the globe, establish fixed capacity goals under the procurement process.

This section highlights various policy types, such as mandates, incentives, and enabling mechanisms, that were added or revised in 2014 and early 2015 in the power, heating and cooling, and transport sectors. Developments related to each type of policy mechanism are described independently, although a variety of policies often are implemented in conjunction. This section does not attempt to assess or analyse the effectiveness of specific policy mechanisms.

POWER GENERATION

Targets and supporting policy tools to promote renewable energy for power generation continued to receive the majority of attention from policymakers, outpacing those set for the heating and cooling and transportation sectors. Targets remain the most prevalent indication of support to renewable energy in the power sector. The targets covered in this section were established in a variety of ways, including through energy policy frameworks, national energy planning documents, and official declarations by heads of state.

Several countries added or revised power generation targets during 2014. Japan and Nicaragua both added new share targets. Japan's fourth Basic Energy Plan, released in 2014, adopted a national electricity goal of 13.5% by 2020 and 20% by 2030, adding to the country's other renewable energy targets.[5] Nicaragua's new Generation Expansion Plan targets a 90% renewable electricity share by 2027.[6] In addition, Bolivia and Singapore added new renewable technology capacity targets. Bolivia set a goal of developing 160 MW of additional solar, wind, geothermal, and bio-power capacity over the next 10 years, while Singapore established its first renewable energy target, seeking to deploy 350 MW of solar PV by 2020.[7]

Seven jurisdictions revised or built on existing goals. Algeria revised its energy plan to adopt a slate of new renewable energy goals to be achieved by 2030.[8] China adjusted its power

i - All GSR estimates for numbers of countries with policies and targets are based on what was the best information available to REN21 at the time.

ii - The League of Arab States includes Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, the Palestinian Territories, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, and Yemen.

generating capacity targets upwards, and, as of early 2015, the country aimed to deploy 150 GW of wind, 70 GW of solar PV (35 GW of utility-scale and 35 GW of distributed), and 330 GW of hydropower by 2017; it also aimed to install 17.8 GW of solar PV during 2015.[9] India established an overall goal of 170 GW of renewable energy by 2022; increased its solar power target to 100 GW by 2022, which is five times the original goal; and also inaugurated the National Mission on Small Hydro, which includes hydropower targets.[10] St. Lucia raised its renewable power generation target from 20% to 35% by 2020.[11] Turkey added cumulative capacity targets for biomass (1 GW), geothermal (1 GW), hydropower (34 GW), and solar PV (5 GW) to its existing wind energy target (20 GW), all to be met by 2023.[12] At the sub-national level, the emirate of Dubai increased its renewable electricity target from 5% by 2030 to 15% by 2030.[13] While other countries increased their targets, Saudi Arabia pushed back its target to source 33% of its electricity from solar power by eight years, from 2032 to 2040.[14]

Feed-in policies[i] have long been the most popular form of renewable energy regulatory support policy worldwide. (→ See Figure 30.) As of early 2015, feed-in policies were in place in 73 countries at the national level and in 35 states/provinces in Australia, Canada, China, India, and the United States. Feed-in tariff (FIT) policies continued to be adjusted in response to shifting market conditions and policy priorities. Many FIT payment rates were adjusted downwards (some retroactively), and some FIT designs have integrated elements of other policy types (e.g., competitive bidding or on-site consumption[ii]). (**→ See Reference Table R16.**)

Trends and developments related to feed-in policies vary from one income group and region to the next. (→ See Figure 31.) Countries in Africa have turned increasingly to feed-in policies to promote renewable energy deployment. A decade ago, Algeria was the only country on the continent with a feed-in policy in place, whereas, as of early 2015, eight African countries had enacted such policies.[15] (→ See Figure 32.) Egypt was the only country to introduce a new feed-in policy in 2014. The country adopted solar power (solar PV and CSP) rates that differ based on installation size (with ranges set in five different categories and capped at 50 MW), and wind power rates that are determined by total hours of production.[16] Elsewhere in Africa, Algeria revised its FIT programme to provide additional support for the deployment of wind and solar PV projects.[17] As of early 2015, new FIT policies also were under discussion in The Gambia, Senegal, and Zimbabwe.[18]

In Asia, Kazakhstan's 2013 FIT came into force in 2014, and several other Asian countries revised existing policies. Existing FIT programmes were expanded to include new technologies in both China (small-scale distributed PV and offshore wind) and Vietnam (waste-to-energy).[19] New lower rates were introduced in China (a reduction in tariffs for onshore wind) and the Philippines (for hydro, biomass, wind, and solar power).[20] Japan doubled the consumer surcharge placed on all consumers' electricity bills to fund the FIT scheme, expressed its intention to revise eligibility requirements, and reduced rates for solar PV (starting in April 2015).[21] Malaysia's FIT was expanded to cover new regions, while degression rates were revised downwards in early 2014 and subsequently raised later in the year.[22] By early 2015, India's new government was considering abandoning the country's tendering scheme in favour of FITs in an effort to increase investment and to scale up deployment of solar power.[23]

A number of countries in Latin America and the Caribbean had feed-in policies in place by early 2015. The US territory of the Virgin Islands adopted a new feed-in policy to support solar PV systems 10–500 kW in size.[24] Costa Rica, which utilises a hybrid FIT and tendering-based mechanism, revised its FIT in 2014 and approved FIT rates for PV systems in early 2015. Costa Rica provides differentiated payments for excess electricity exported to the grid from self-consumption installations up to 1 MW in size, as well as for plants operated by independent power producers (IPPs) of up to 20 MW.[25]

In North America, feed-in policies continue to be found only at the sub-national level. For the second year in a row, no US states added new FITs, and the number of states with feed-in policies remained at five. No Canadian provinces added FITs in 2014, although Ontario completed its third round of applications under its FIT programme.[26]

European countries—at the forefront of the development of feed-in policy mechanisms—continued their recent trend of revising existing policies. Unlike in recent years, however, these changes are now being formalised in a continent-wide shift away from FITs through guidance from the European Commission. The Commission's new State Aid guidelines, issued in 2014, instruct EU countries to begin using tendering to allocate support to new renewable energy projects in 2015–16, with all new project support to be allocated through renewable energy tenders by 2017.[27] (→ See Sidebar 6 for more details on tender mechanisms.)

Meanwhile, EU countries enacted a host of revisions to existing FIT schemes in 2014. Denmark and Poland established new tariffs to support the development of small-scale wind projects (up to 25 kW in Denmark and up to 10 kW in Poland).[28] In response to a 2013 European Commission ruling that France's FIT programme constituted illegal state aid under EU regulations, France revised the text of its FIT to remain in compliance; as a result, its previously suspended wind tariffs were permitted to resume.[29]

Also in 2014, many European countries at the national level—including Bulgaria, Germany, Greece, Italy, and Switzerland—made FIT rate cuts, with most reductions focused primarily on solar PV and wind power.[30] In a small but growing number of cases, including in Greece and Spain, these revisions were made retroactively. In addition, Malta approved a slate of new seasonally adjusted solar PV FIT rates, and Russia enacted domestic content requirements, with reduced tariffs for systems not including 70% local content.[31] At the sub-national level, FIT rates were reduced in Crimea.

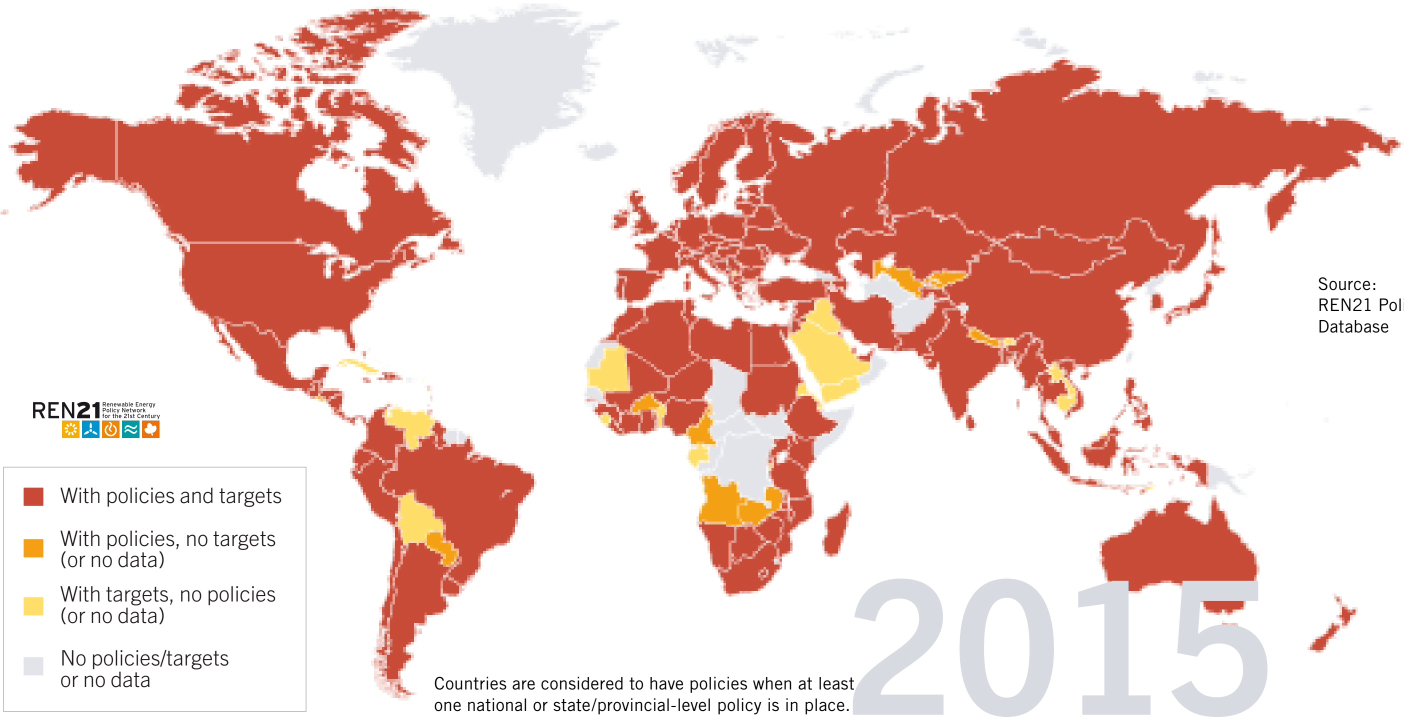
Degression mechanisms are now in place in some European countries, including Germany, Italy, and Switzerland. In the United Kingdom, the minimum degression rate of 3.5% was triggered for all new renewable power installations as of January 2015 (the total volume of installations failed to trigger the higher automatic reduction rates).[32]

i - See Glossary for policy definitions.

ii - On-site consumption refers to mechanisms, such as taxes and fees, governing electricity consumed at the site of generation.

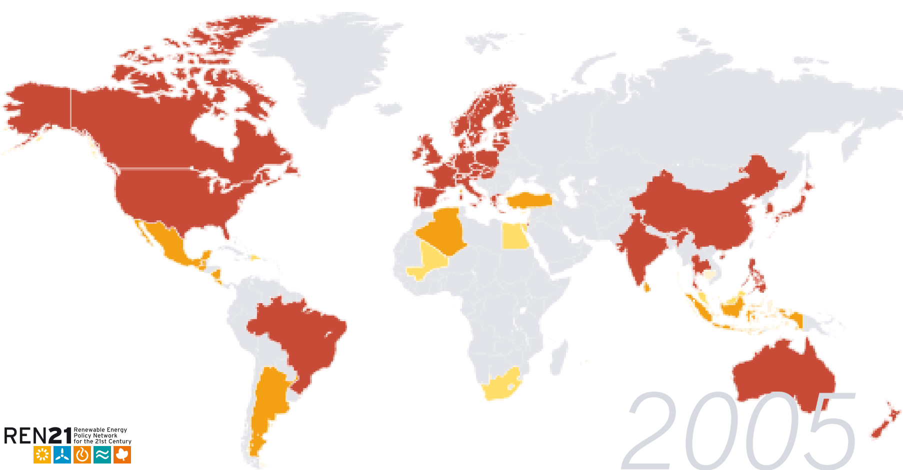
POLICY MAPS

Figure 28. Countries with Renewable Energy Policies and Targets, Early 2015



Source: REN21 Policy Database

Figure 29. Countries with Renewable Energy Policies and Targets, 2005



164 COUNTRIES HAD DEFINED RENEWABLE ENERGY TARGETS BY EARLY 2015

Figure 30. Number of Countries with Renewable Energy Policies, by Type, 2011–Early 2015

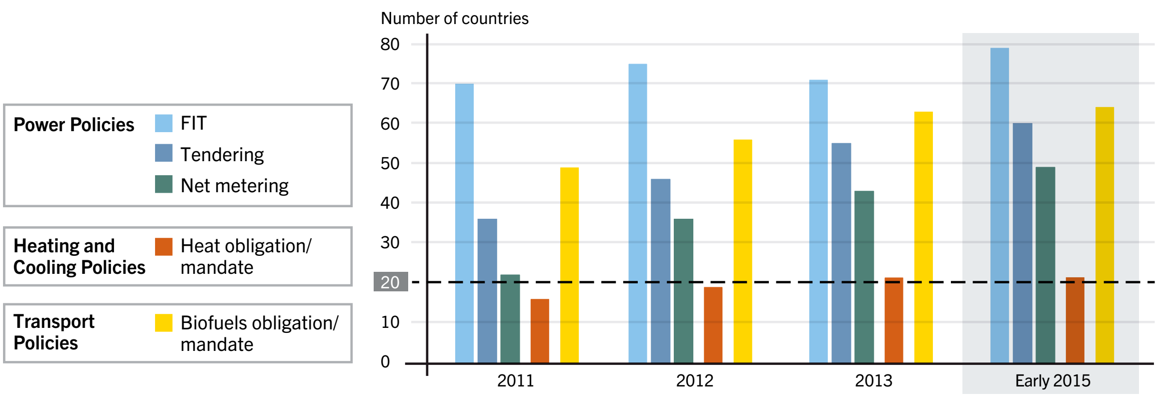


Figure does not show all policy types in use. Countries are considered to have policies when at least one national or state/provincial-level policy is in place.

Source: REN21 Policy Database

SIDEBAR 6. COMPETITIVE BIDDING / TENDERING: TRENDS IN POLICY DESIGN

Competitive bidding, or tendering, has been used to procure and incentivise renewable energy generation for decades, starting in North America and Europe in the 1980s and 1990s. In recent years, use of competitive bidding has spread to all regions of the world.

A wide range of options exists for designing competitive bidding, relating to the requirements for participation, whether the bids are awarded based on price or other factors, how many winners there are, and what is actually awarded (e.g., a long-term incentive or the right to negotiate a long-term contract). These and other design options can result in dramatically different outcomes and results.

Some of the largest competitive procurements in recent years have occurred in emerging economies (e.g., India, Russia, South Africa), with a heavy concentration of recent activity in Latin America. Argentina, Brazil, Chile, and Peru have awarded contracts for over 13,000 MW of capacity through tendering since 2007, and Uruguay has used competitive bidding to increase its wind power capacity from 40 MW in 2012 to its target of 1 GW by 2015. In Central America, El Salvador, Guatemala, Honduras, and Panama each released bids for renewable energy in 2014.

A noteworthy trend from recent tenders in Latin America and other regions is a sharp decrease in renewable energy contract prices, especially for solar PV. The recent solar PV tender in Brazil, for example, awarded contracts to 890 MW of capacity, with an average bid price of USD 0.087 per kWh. In Dubai, a tender for 100 MW of solar PV received bids as low as USD 0.06 per kWh in November 2014. Panama awarded contracts to 172 MW of solar PV with an average price of USD 0.088 per kWh, whereas wholesale spot market prices in Panama spiked above USD 0.30 per kWh in 2014.

The recent low solar PV contract pricing in some countries has raised questions as to whether these prices are high enough to support viable projects. A key issue for policymakers to consider is how many of the recently awarded contracts worldwide will lead to projects that are built. Competitive bidding can place downward pressure on renewable energy prices. However, it also can result in high levels of contract failure[i] if pricing is unrealistically low due to speculative behaviour or inexperienced bidders. Careful design can help mitigate these risks.

As competitive bidding continues to diffuse internationally, an important question is how bidding intersects with other policy frameworks. Since the early 2000s, there have been debates on the comparative merits of bidding and other policy types, such as feed-in tariffs (FITs) and short-term certificate trading. Tendering has replaced FITs as the primary renewable energy procurement mechanism in some countries (e.g., South Africa), whereas FITs have replaced tendering in others (e.g., China and Ireland).

Increasingly, policymakers are deploying FITs and competitive bidding in combination. In some jurisdictions, bidding and FITs have been deployed in parallel to support different market segments. In France and Taiwan, FITs are used to support small-scale solar PV systems, whereas bidding is used to support large-scale systems. In Uganda, bidding is used to support solar PV, and FITs are used to support other resources.

In other jurisdictions, elements of FIT and competitive bidding design are used in hybrid policies. Alternately, competitive bidding outcomes can be used to set FIT rates. These policy combinations have given policymakers greater flexibility, but they also may make it more difficult, going forward, to draw distinctions between policy types using the traditional labels.

Source: See Endnote 27 for this section.

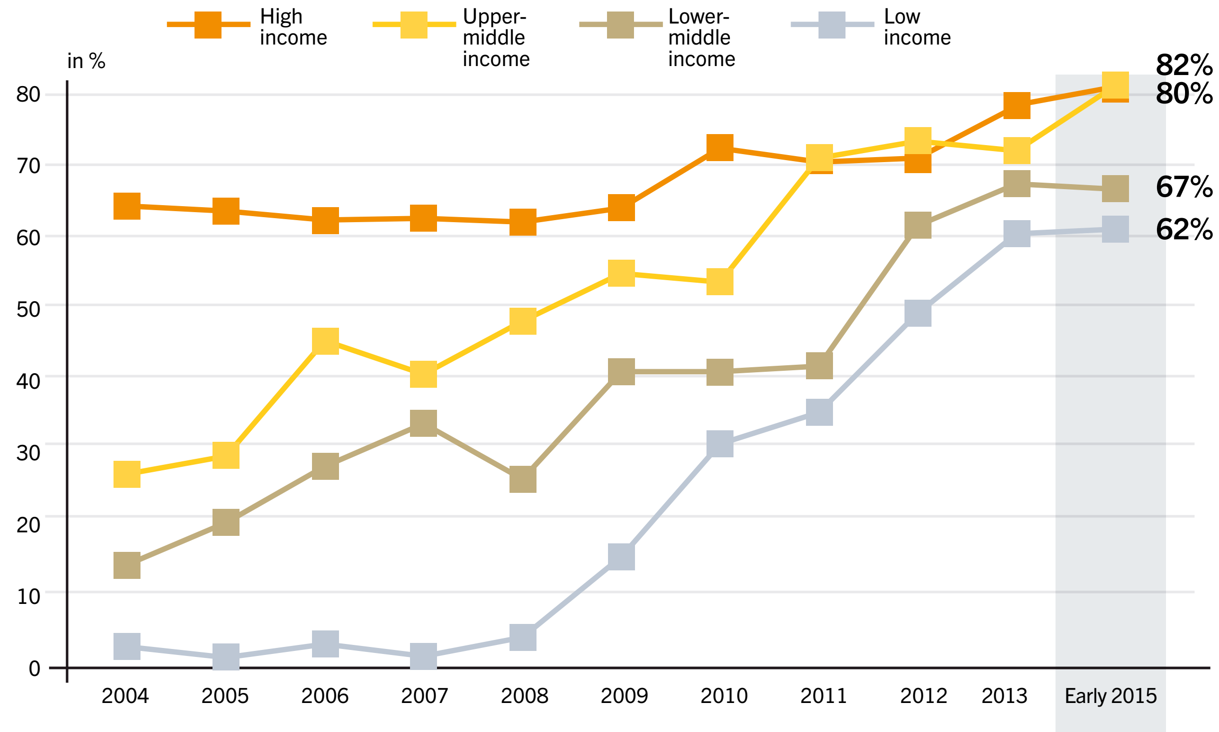
i - Contract failure occurs when renewable energy projects are not built after they are awarded contracts. For example, competitive tenders in France, Ireland, and the United Kingdom resulted in contract failure rates of 68–78% in the 1990s.

Renewable energy tendering—also referred to as public competitive bidding or auctioning—is being adopted by an increasing number of countries. As of early 2015, 60 countries had held both technology-neutral and single-technology renewable energy tenders. (→ See Sidebar 6.) Countries such as Jordan, Russia, and Uganda used multi-technology tenders during 2014, while examples of countries holding single technology tenders include Argentina, Egypt, India, Morocco, and Rwanda. Other countries, such as Brazil and South Africa, held both single and multi-technology auctions.[33]

Specific multi-technology auctions include Jordan's allocation of 12 solar PV and two wind projects in its first renewable energy tender, and Uganda's third tendering round for hydro, biomass, and bagasse power project developers.[34] Examples of single-technology auctions include Argentina, which launched a geothermal tender in early 2015; India, which used tendering to advance its solar PV sector at the national level, and where six states held solar PV tenders; and Rwanda, which held a solar PV auction.[35] In North Africa, both Egypt and Morocco held wind actions.[36] At the sub-national level, the Australian Capital Territory held a tender for large-scale wind power.[37] Highlighting the growing shift towards tendering, Poland's new renewable energy law, adopted in early 2015, established a new tendering system designed to replace the existing system of green certificate trading.[38]

Policymakers have begun to enact a number of revisions to existing tendering mechanisms in order to make their tendering schemes more attractive. In Europe, countries such as Denmark and France began implementing a dialogue with the private sector to foster close collaboration on the design of tenders.[39] Elsewhere, policymakers have implemented new regulations governing the management of tenders. Brazil revised its tender

Figure 31. Share of Countries with Renewable Energy Policies, by Income Group, 2004–Early 2015



Source: REN21 Policy Database

Declines in income group shares in specific years are due primarily to countries moving into new income groups. Over the period 2004–2014, 80 countries made a total of 108 changes in income groups.

requirements to mandate that all projects secure guaranteed grid access prior to bidding, and China strengthened transparency mechanisms to avoid interference with tender results.[40]

Net metering or net billing policies were in force in 48 countries as of early 2015. Three countries—Colombia, Costa Rica, and Honduras—adopted new net metering policies in 2014.[41] At the sub-national level, Dubai established a solar rooftop net metering programme, the second such programme in the region after Jordan's.[42] In recent years, countries such as Denmark—which limited its net metering credit carry-forward provision to one hour (instead of one month or one year as in other countries)—have revised net metering policies to respond to rapid market growth.

A number of additional countries and territories revised existing net metering/billing policies in 2014. The US Virgin Islands instituted a temporary hold on solar PV development after reaching its 15 MW cap for capacity under its net metering and FIT regulations ahead of schedule.[43] An increasing number of island states moved away from the practice of crediting excess electricity at retail rates and began crediting it at below the retail rate. The Seychelles' net metering programme, for example, credits excess generation at 88% of the avoided fuel cost.[44] Barbados and Saint Vincent and the Grenadines each introduced new policies under which small systems can consume their own power and can receive below-retail compensation for any power delivered to the grid. Larger systems in both countries are not allowed to consume power on-site, however, and must sell all of their power into the grid.[45]

Quotas or RPS establish mandatory shares of renewable power capacity or generation to be sourced by utilities. These policies traditionally have included a mandated target and a compliance mechanism, such as tradable renewable energy credits (RECs). As of early 2015, RPS or quota policies were in place in 26 countries at the national level—including China, Israel, and the United Kingdom—and in 72 states/provinces, including in Belgium (2), Canada (4), India (27 states and 7 union territories), and the United States (29 states, the District of Columbia, and two territories).

In the United States, RPS policies have been the preferred regulatory method for renewable energy promotion at the state level. Mandates vary widely from state to state, with California's requirement of 33% renewable power ranking among the country's most ambitious mandates.[46] State-level RPS policies continued to face opposition in 2014 and early 2015, and Ohio became the first US state to freeze its RPS, putting it on hold until 2017.[47] In early 2015, West Virginia became the first state to remove its RPS policy entirely.[48] Other states—such as Colorado, Kansas, New Mexico, Oklahoma, and Texas—continued to consider reducing or eliminating their RPS policies.[49]

As of early 2015, an estimated 126 countries around the world had adopted some form of financial support policy, including tax reductions, grants, and low-interest loans. A host of new support schemes and revisions to existing programmes was seen throughout 2014. Colombia's new Renewable Energy Law included a slate of new tax incentives for the promotion of renewable energy, including import duty exemptions, value-added tax (VAT) exemptions, accelerated depreciation, and an income tax deduction.[50] Malaysia eliminated its VAT on solar PV panels in its 2014 budget, and Pakistan removed import duties and the general sales tax on the import of solar PV panels.[51]

In the United States, the production tax credit (PTC), which covers several renewable technologies (and expired at the end of 2013) was re-enacted temporarily for a period of two weeks in December 2014, to provide retroactive support to projects that started construction prior to 1 January 2015.[52] At the state level, California revised its rebate system to encourage more solar PV power generation to match late-day demand. The revised incentive provides rebates that are 15% higher for the installation of west-facing systems instead of the typically installed south-facing panels.[53]

In addition to traditional support mechanisms, green banks—such as those in place in the United Kingdom, as well as the New York Green Bank inaugurated in 2014—and green bonds represent innovative options that are gaining support from policymakers.

While several national and state governments extended financial support to the renewable power sector, some rolled back incentives in 2014. For example, Ukraine removed its income tax exemption for companies that sell renewable electricity.[54] In the United States, Florida regulators acted to allow the state's solar PV rebate programme to close at the end of 2015.[55]

Charges or fees on renewable electricity are being levied in an increasing number of countries. These charges come in varying forms and are used to recover a range of costs (including utilities' fixed costs). In recent years, several European countries (such as the Czech Republic, Greece, and Spain) established fees for grid connection and/or taxes on renewable energy output, including generation for self-consumption and for sales back to the grid. Bulgaria enacted a 20% tax on income derived from solar PV and wind power generation; subsequently, the country's top court deemed the tax unconstitutional and overturned it.[56] Germany extended the FIT surcharge to apply to electricity from solar PV installations larger than 10 kW that is consumed on-site, and Italy imposed a 5% charge on self-consumed electricity from solar PV.[57]

In the Americas, Costa Rica imposed a fee for grid interconnection of renewable energy systems. By early 2015, 8 US states had enacted charges on new and existing solar PV systems, and an additional 11 states were discussing doing the same.[58]

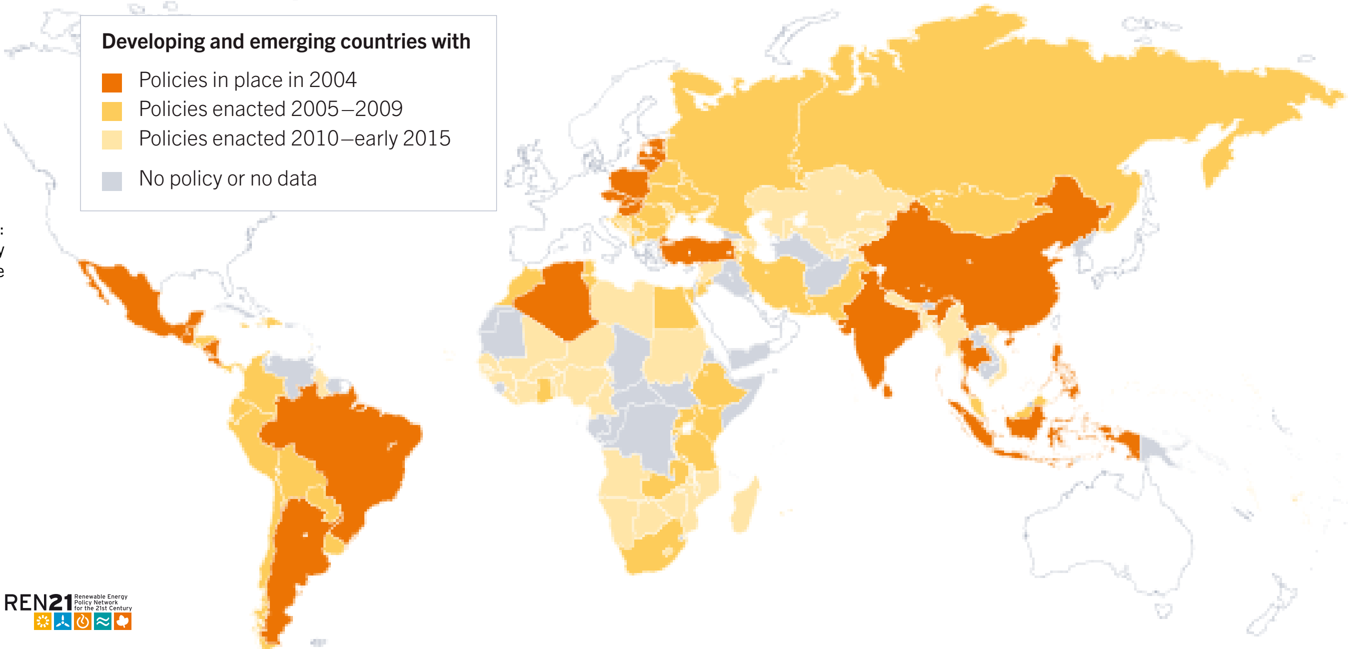
Several countries have instituted fees on imported renewable energy components in an effort to protect domestic manufacturers. The US-China dispute over solar PV components continued, and, in January 2015, the United States instituted 91% duties on solar modules or cells imported from China and Taiwan.[59] Meanwhile, China imposed 42% anti-dumping duties on EU polysilicon.[60] In 2014, the United States launched an official challenge at the World Trade Organization (WTO) to India's domestic content requirements, and, in early 2015, Canada imposed duties on imported Chinese solar equipment.[61]

Despite these contentious international trade issues, some agreements were reached in 2014. For example, the United States and India agreed on bilateral commitments to scale up renewable energy development, with the former pledging USD 2 billion to support India's renewable energy and climate goals.[62] In addition, the United States and China reached agreement on mutual commitments to combat climate change, which include a number of clean energy promotion provisions.[63]

As renewable energy has achieved substantial shares in the electricity mix, efforts to find technical solutions to mitigate integration challenges, while simultaneously simplifying project development and reducing the associated soft costs (non-hardware), are being integrated into policy schemes. The United Kingdom revised requirements on rooftop solar PV and solar thermal heating systems on commercial properties to exempt projects up to 1 MW in size from permitting requirements.[64] At the state level, California simplified permitting and review processes for solar PV projects.[65]

Traditional mechanisms also are being used to increase energy storage capacity and to modernise grid infrastructure. Examples include Kenya's VAT revisions, which eliminated the VAT on certain batteries used exclusively to store solar power, and Japan's pledge of USD 700 million (JPY 81 billion) in incentives

Figure 32. Developing and Emerging Countries with Renewable Energy Policies, 2004, 2009, and Early 2015



Source: REN21 Policy Database

Countries are considered to have policies when at least one national or state/provincial-level policy is in place.

for energy storage development.[66] By contrast, Pakistan levied import duties and taxes on the import of solar batteries.[67]

At the sub-national level in the United States, several states have been actively promoting new grid and storage infrastructure projects. California contracted 264 MW of storage capacity in 2014 through competitive bidding to meet the state's energy storage mandate that was set the previous year.[68] Also in 2014, Hawaii mandated several provisions to enhance the state's grid network, requiring grid operators to improve the solar PV interconnection process and to invest in demand-response programmes, among other things.[69] Massachusetts ordered utilities to modernise the state grid over the next decade and pledged USD 18 million to support a slate of projects—including battery storage and microgrids—intended to develop a more resilient energy infrastructure.[70] New Jersey awarded USD 3 million to 13 energy storage projects.[71]

HEATING AND COOLING

Historically, national policymakers have afforded little attention to renewable heating and cooling technologies, despite their potential to play an important role in national energy systems. However, this situation is beginning to change.

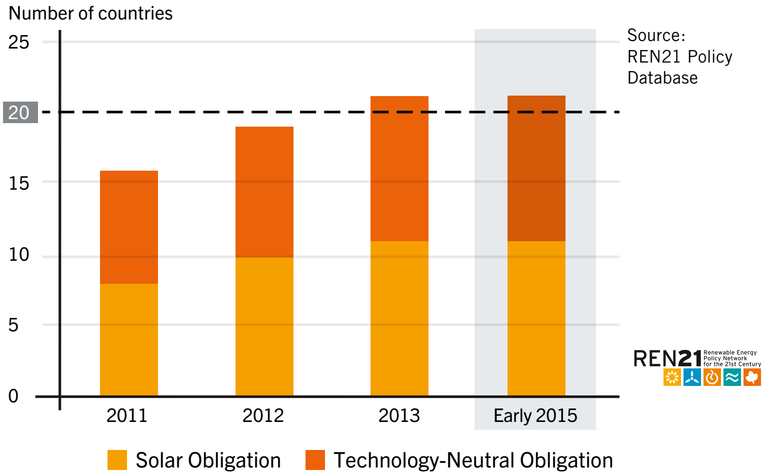
Renewable heating technologies have received more policy attention than renewable cooling technologies. Of the heating technologies, solar thermal—primarily solar water heaters—is the main focus of public policy. Policies also have focused mostly on residential and commercial buildings, rather than on the industrial sector, although, in recent years, attention has turned towards industrial heat in some countries. For example, Austria, Denmark, Germany, India, Mexico, Thailand, and Tunisia all have incentive schemes that support utility-scale and/or industrial renewable heat.[72] Public finance mechanisms have received the most attention from policymakers in the sector. As with the electricity sector, policymakers promote renewable heating and cooling through a mix of targets, rate-setting and incentives policies, regulatory mandates, and public finance mechanisms.[73] (→ See Sidebar 7.)

Although renewable heating and cooling targets continue to be limited primarily to Europe, an estimated 45 countries worldwide had targets in place by early 2015. (**→ See Reference Table R14.**) No new targets were added in 2014. At the sub-national level, the German state of Baden-Württemberg revised its heat target, increasing its renewable heat mandate for residential buildings (in force since 2010) from 10% to 15%.[74]

Traditionally, targets have established specific shares of total heating and cooling demand to be supplied by renewable technologies, or have focused on the installation of specified capacity or new renewable heating systems. In Europe, the majority of targets in EU and Energy Community Member States have been introduced through each country's National Renewable Energy Action Plan (NREAP).

Mandates to promote renewable heating and cooling, often included in building codes, have advanced slowly at the national level relative to the municipal level. (→ See Cities subsection.) Policymakers generally have adopted two varying forms of mandates: solar obligations, which have been enacted in 11 countries at the national or state/provincial level, and technology-neutral renewable heat obligations, which were in place in 10 countries by early 2015. (→ See Figure 33.)

Figure 33. Number of Countries with Renewable Energy Heating and Cooling Obligations, by Type, 2011–Early 2015



Source: REN21 Policy Database

Countries are considered to have policies when at least one national or state/provincial-level policy is in place.

South Africa was the only country to institute a new mandate during 2014. The mandate (first enacted in 2011 but not in effect until September 2014) requires that a minimum of 50% of all hot water in new and retrofitted buildings come from renewable sources, including solar, geothermal, and biomass heating, as well as heat recovery systems.[75] Most of the national-level policies are in Europe, where renewable heat mandates have been enacted to ensure compliance with the building efficiency requirements introduced through the EU's Energy Performance of Buildings Directive.

Many renewable heating and cooling mandates focus on solar water heating, such as those in Greece, Jordan, Kenya, and Uruguay. However, with the exception of Greece, mandates across most of Europe—such as those in France, Germany, and Ireland—are generally technology-neutral, offering support to a wide range of renewable heat technologies.

Existing mandates remained largely unchanged in 2014. A few governments have begun to integrate renewable heat requirements into existing renewable power mandates placed on electric utilities. In 2014, Massachusetts became the fifth jurisdiction in the United States—after the District of Columbia, Maryland, New Hampshire, and North Carolina—to mandate renewable heat to qualify for credits under the state's existing RPS.[76]

A limited number of performance-based policy mechanisms have been adapted for use in the heat sector. In 2014, the United Kingdom launched its domestic Renewable Heating Incentive (dRHI)—a long-term incentive programme that provides production-based payments—to complement the existing non-domestic RHI scheme. The new dRHI pays rates for heat generated by solar water heaters, biomass boilers and stoves, and ground- and air-source heat pumps for use by single domestic properties.[77] Also in 2014, tariffs under the UK's existing RHI scheme were increased.[78]

Financial incentives continued to be the most widely enacted form of policy support for renewable heating and cooling systems during 2014.[79] These mechanisms generally help to reduce

SIDEBAR 7. INTEGRATED RENEWABLES HEATING AND COOLING POLICIES FOR BUILDINGS AND DISTRICT HEATING NETWORKS

Thermal energy makes up about 50% of worldwide energy use, although only 8% of the heating and cooling load is served by modern renewables. Widespread deployment of renewable heating and cooling (RE-H/C) will be necessary to achieve goals for energy security, greenhouse gas emissions reduction, and economic development. To scale up renewable heating and cooling, jurisdictions are developing innovative and integrated energy policies that incorporate RE-H/C into new and existing buildings as well as smart district heating networks. Several new policies—including incentives, mandates, building exhibitions, and planning initiatives—have been deployed recently to align RE-H/C with broader energy and climate goals.

RE-H/C IN NEW AND EXISTING BUILDINGS

Aside from a few global leaders (such as Upper Austria and Denmark), most of the world has overlooked the need for RE-H/C policies in buildings. This is starting to change. For example, in 2012, the United Kingdom launched the Renewable Heating Incentive (RHI) for commercial and industrial consumers, the first comprehensive performance-based incentive for heat; in 2014, it was expanded to include the residential sector. The RHI pays a set tariff to residential, commercial, public, and industrial consumers for every unit of renewable heat generated on a pence per kWh basis.

In 2008, Germany established a legally binding RE-H/C target of 14% by 2020. German policymakers seek to achieve this mandate by requiring all new building construction to incorporate RE-H/C, including solar hot water, biomass, ground-source heat pumps[i], and other RE-H/C technologies. The German state of Baden-Württemberg took this mandate a step further, requiring that existing residential buildings supply at least 10% of their heat from renewable energy sources when central heating systems are replaced. Starting in July 2015, Baden-Württemberg is increasing this requirement to 15%. In 2012, Kenya issued legislation mandating that within five years, all existing buildings using over 100 litres of hot water a day must install solar water heating systems to cover 60% of demand, a mandate that applies to all new buildings.

While these policies have sought to encourage use of RE-H/C in buildings directly, RE-H/C also is receiving a boost from policies designed to promote construction of net zero energy (NZE) buildings. Because heating and cooling is the number one energy user in buildings, RE-H/C technologies are essential to achieve NZE building status. As a result, NZE targets, mandates, and other programmes serve as *de facto* policies that drive adoption of RE-H/C.

For example, under the EU Energy Performance of Buildings Directive (2002/91/EC, EPBD), EU member states are required to achieve near zero energy status for all new construction by 2020. In the United States, California has a robust planning process in place to make all new buildings NZE by 2020 for residences and 2030 for commercial buildings. Other US states, including Massachusetts and New York, are implementing pilot building grants or building competitions, respectively, to explore potential for NZE development. Japan aims for all new public buildings to be NZE by 2020, and private buildings by 2030. In every case, policymakers, building owners, developers, and designers are considering the role of RE-H/C technologies as part of the integrated energy system to achieve building energy goals.

RENEWABLE HEATING AND SMART DISTRICT ENERGY NETWORKS

Historically, conventional district heating networks have consisted of a few large, centralised generators that distribute heat one-way to end-users. Smart heating networks, by contrast, enable many decentralised generators to feed energy back into the grid. This provides thermal networks with greater flexibility and reliability. It also enables greater use of RE-H/C and energy efficiency technologies in district heating networks. However, widespread deployment of smart district heating networks is prevented by numerous technical and market barriers, which policymakers and grid operators (especially in Europe) are just beginning to tackle.

Conventional district heating networks traditionally have supplied consumers using high- or medium-temperature heat (in high-pressure systems). These systems typically are served by only biomass, CHP, or fossil fuel boilers, and have hindered the widespread integration of low-temperature RE-H/C technologies such as solar hot water or advanced heat pumps.

To address this technical barrier, district heating providers and energy planners are preparing to pilot (or, as in the cases of Canada and Denmark, already are piloting) low-temperature district heating grids. Due to their lower operating temperatures, such networks are much more efficient and can enable end-users to deliver low-temperature surplus heat from buildings back into the thermal grid. Low-temperature networks are expected to “serve as the backbone of smart cities,” increasing communities’ flexibility to integrate RE-H/C and energy efficiency technologies into buildings.

New interconnection, dispatch, and tariff policies are needed to address market barriers and to incentivise decentralised generators to feed heat into smart heating grids. To that end, the International Building Exhibition in Hamburg recently developed a pilot project in the district of Wilhelmsburg that showcased new regulatory policies. The regulatory structure enabled operation of a smart heating grid that incorporates centralised heat generation, decentralised RE-H/C generation, and thermal storage.

The community association overseeing the Wilhelmsburg project applied principles from Germany’s renewable feed-in tariff to heating. In 2012, the regulations gave decentralised heat

i - The energy output of heat pumps is at least partially renewable on a final energy basis. (See Sidebar 4, GSR 2014.)

exporters priority dispatch for up to 10% of the grid's annual heat requirement. The grid operator pays decentralised generators a fixed fee for every kWh of renewable heat that they export. Over time, it is expected that the limit will be increased so that distributed heating generators can provide up to 25% of the heat required to serve the Wilhelmsburg central grid.

Solar-cooled bus stop in Dubai

PLANNING AND TECHNICAL ASSISTANCE FOR DISTRICT COOLING

Some governments are using their authority to help plan for, regulate, finance, or develop district cooling. For example, the city of Dubai (UAE) has a goal to use district cooling to meet 40% of its cooling capacity through district cooling by 2030. For Dubai, a major driver has been the need to reduce air conditioning load, which represents approximately 70% of total electricity consumption. Dubai has leveraged city assets and regulatory authority to support district cooling installations, including providing anchor loads to alleviate load risk and facilitate investment. In particular, all public sector buildings and new developments are required to connect to the district cooling system.

In Europe, the European Commission is co-funding the Renewable Smart Cooling Urban Europe (RESCUE) project. RESCUE provides technical support to help local policymakers address challenges to the development and implementation of low-carbon district cooling systems. This includes provision of support packages, which provide energy planners and technical staff with development guidelines from project conceptualisation and feasibility to implementation. It is anticipated that a number of cities will initiate feasibility studies with RESCUE support to assess district cooling potential as a means to achieve carbon reductions in response to the EU Covenant of Mayors' Sustainable Energy Action Plans (SEAP).

Source: See Endnote 73 for this section.

investment costs through grants, soft loans, or tax incentives. In 2014, four countries—Algeria, Chile, Romania, and Slovenia—re-introduced incentive schemes that had expired in previous years. Algeria launched its second national programme to promote solar water heaters, providing grants to support up to 35% of system costs.[80] Chile re-enacted a tax credit for residential solar thermal systems and extended it to include social housing developments.[81] Romania restarted its Casa Verde programme to provide grant support for the deployment of solar thermal and biomass systems.[82] Slovenia extended its Environmental Public Fund to continue to provide grants and low-interest loans to solar thermal systems and wood boilers.[83]

Existing financial incentives were revised in 2014. The Czech Republic, India, and Kenya strengthened incentives. The Czech Republic opened the second financing round of its Green Savings programme amid private sector concerns about its low level of financial support and relatively high administrative burden.[84] India revised its existing customs duty exemptions on solar power components to provide excise and import tax exemptions for components used in the manufacturing of solar thermal systems; previously, customs duties on solar thermal equipment stood at 14–21%.[85] Kenya revised its existing tax code to eliminate the VAT on solar water heaters.[86] In contrast, South Africa and Italy reduced their incentives. South Africa removed all support for imported solar water heaters and limited rebates to high-pressure systems with 70% domestically manufactured content.[87] Italy instituted a subsidy cap on its Conto Termico incentive scheme, limiting the programme's subsidy to 65% of the investment cost.[88]

At the sub-national level in the United States, Massachusetts increased rebates for solar water heaters, doubling the maximum rebate offered for commercial systems and increasing incentives for residential systems and public or non-profit investors.[89] In addition, Minnesota inaugurated a 10-year rebate programme for residential and commercial solar water heaters in 2014, and New York established a USD 27 million rebate fund for residential and commercial consumers that install high-efficiency, low-emission wood heating systems during 2015.[90]

Policymakers also have begun to integrate renewable heat more broadly into energy permitting and planning processes. For example, Scotland launched several provisions in 2014 to scale up the domestic renewable heat market. To simplify the deployment of renewable heat technologies, Scotland established new provisions that govern the planning and permitting of district heating systems and provided training for local authorities on a renewable heat data set for its Renewable Heat Map, which outlines heat demand and supply and showcases opportunities for connection.[91]

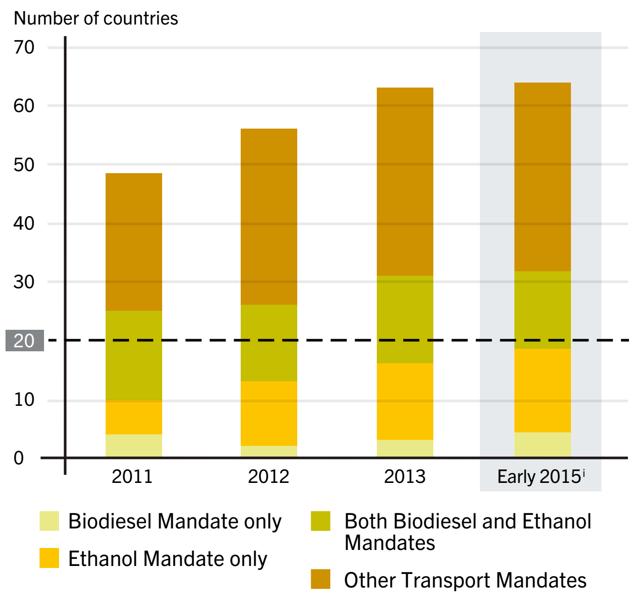
TRANSPORT

Renewable transport fuels are being promoted through a mix of regulatory measures and fiscal incentives. Electric vehicles also are drawing increased attention, although they are being promoted in connection with renewable energy to a far more limited extent. As in recent years, the majority of transport-related policies continued to focus on developments in the biofuel sector and in road transport; however, other modes of transportation are attracting attention as well.

Biofuel blend mandates—which require that specific shares or volumes of biodiesel, ethanol, and/or advanced biofuels be mixed with petroleum-based transportation fuel—are now in place in 33 countries, with 31 national mandates and 26 state/provincial mandates. Within these policy frameworks, 44 jurisdictions mandate specified shares of bioethanol, and 27 mandate biodiesel blends, with many countries enacting mandates for both fuels. (→ **See Reference Table R18** and Figure 34.)

Several countries strengthened existing mandates in 2014. Argentina increased its existing ethanol blend mandate, raising the previous 7% (E7) mandate to a required 10% ethanol (E10), and introduced a separate 10% biodiesel (B10) mandate in December 2014.[92] Brazil raised its biodiesel blend mandate twice in 2014, from 5% to 6% starting 1 July, and to 7% starting 1 November. Brazil also raised the cap on the maximum ethanol blend from 25% to 27.5%.[93] Malaysia upped its existing mandate from 5% to 10% biodiesel.[94] Panama's ethanol mandate was raised from 2% to 5% in 2014, and subsequently increased to 7% in early 2015.[95] Vietnam issued a national mandate that requires seven cities to begin distribution of 5% ethanol blends.[96] At the state level, Minnesota became the first US state to mandate a 10% biodiesel blend.[97]

Figure 34. Number of Countries with Renewable Energy Transport Obligations, by Type, 2011–Early 2015



Countries are considered to have policies when at least one national or state/provincial-level policy is in place.

With a growing number of mandates in place to utilise renewable fuels, the debate over the sustainability of the first-generation biofuels that are often used to meet those mandates continued in many countries. In 2014, European energy ministers agreed to cap at 7% the contribution of biofuels and bioliquids produced from cereals and other starch-rich crops, sugars, and oil crops to the EU-wide renewable transport fuel target (10% of total transport fuel); this compares with the European Commission's 2013 recommendation of a 5% cap.[98] A final decision on the 7% cap is expected in 2015. At the national level, Italy became the first country in Europe to set a specific mandate for advanced biofuels, enacting a mandated blend of 0.6% advanced biofuels by 2018.[99] In early 2014, Spain revised regulations governing which biofuel raw materials qualify towards meeting the national biofuel mandate.[100]

Countries continued to provide financial support to biofuel development and production as an additional means of promoting renewable fuels. For example, Brazil approved tax reductions for ethanol exports in 2014.[101] India deregulated the sale of biodiesel, allowing producers to sell directly to consumers in an effort to expand the biodiesel market, and India's state-owned rail company, India Railways, now aims to include up to 5% biodiesel in its locomotive fuel.[102] Other countries reduced their support for biofuels: for example, Australia's 2014 budget included provisions to end the Ethanol Production Grant programme by mid-2015, and Ukraine imposed a national excise tax on alternative transportation fuels.[103]

International biofuel trade continued to draw the attention of policymakers in 2014. South Africa concluded a new economic partnership agreement with the European Union that provides the former with a quota of 80,000 tonnes of duty-free ethanol exports to the latter.[104] However, a number of countries filed international trade complaints centred around developments in the biofuels sector. Indonesia filed a formal complaint to the WTO against anti-dumping tariffs lodged by the EU on Indonesian biodiesel exports.[105] Argentina filed a similar challenge against the EU on behalf of its biofuel industry.[106]

Electric vehicles (EVs) represent a small but increasing share of the global vehicle market. While a number of incentives exist across the globe to expand sales of EVs, irrespective of power source, countries rarely are focusing on the intersection of renewable power generation and EVs. If developed in parallel, EVs and renewables offer the potential to decrease greenhouse gas emissions more than either could alone. Further, EVs offer the potential to balance grid networks by providing energy storage capacity.[107] In 2014, China mandated that EVs make up at least 30% of all vehicles purchased for government fleets by 2016.[108] At the sub-national level, the US state of Maryland enacted a USD 2 million grant programme to support the installation of solar PV for EV charging at parking lots.[109]

i - Italy's advanced biofuel blend mandate is included in "Other transport mandates".

CITY AND LOCAL GOVERNMENTS

Cities and municipalities are on the leading edge of integrating renewable energy into power infrastructure, buildings, and transportation systems. Thousands of cities and towns around the world have used their unique purchasing and regulatory authority to enact policies and targets to promote the deployment of renewables. Local governments have used a mix of direct support mechanisms and indirect support through broader eco-development or climate programmes.[110]

Targets and policies introduced by city governments are often among the most ambitious and innovative of any seen worldwide. Local-level policies—such as local FITs in Germany and solar obligations in Spain—have served as blueprints for state and national policies. Local officials also have taken leading roles in developing private sector partnerships to scale up renewable energy technologies. Support for expanding the deployment of renewable energy technologies in the electricity sector remains a primary component of city-level policy development.

Policy support has expanded beyond the electricity sector, however. In contrast to the slow adoption of policies for promoting renewable heating technologies at the national level, numerous municipalities have used their planning and regulatory authority to increase the uptake of renewable heat technologies. In Europe and South America, for example, the renewable heat sector has benefitted from the unique regulatory authority that cities often hold, leading to the development of district heating and cooling networks that integrate renewables, and to the widespread deployment of solar water heaters. Cities also have promoted renewable transportation alternatives, integrating biofuel and EVs into public transportation fleets and developing supporting infrastructure, such as EV charging stations. This section attempts to provide an overview of actions taken by cities around the world and does not provide a comprehensive list of municipal policy actions.

Numerous local governments across the globe, including in many of the world's largest cities, have set targets for local renewable energy deployment. Although most such cities are in developed countries, an increasing number of cities in developing countries are establishing targets. Targets vary widely in size and scope and are often more ambitious than those set at the national level. Notable examples of cities that enacted targets in 2014 include: Austin, Texas (United States), which mandated that its city utility achieve a 65% renewable energy share by 2025; New York City (United States), which targets the deployment of 350 MW of new solar PV in 10 years; and Tokyo (Japan), which aims to generate 20% of its electricity with renewables by 2024.[111] In the renewable heat sector, Vienna (Austria) established a new goal to cover half of its heat demand with solar thermal energy by 2050.[112]

There is also a worldwide movement for municipalities to achieve 100% renewable energy in the electricity sector or economy-wide. In Germany alone, 140 municipalities have committed to 100% renewable energy or electricity goals.[113] New 100% renewable targets set in 2014 include the Japanese region of Fukushima, which set a goal of acquiring 100% of its energy from renewable sources by 2040, and the three islands of Maui County, Hawaii (United States), which seek to become the first American islands to be powered entirely by renewable energy.[114]

Many cities and municipalities around the world, including 74 in Germany, have reached 100% renewable energy goals already, with most focusing on reaching 100% renewable electricity.[115] In 2014, the US city of Burlington, Vermont, achieved its 100% renewable electricity goal.[116] Collaborative efforts such as the 100% RES Communities and RES Champions League in Europe, and the Global 100% RE initiative, have brought additional attention to efforts aimed at achieving 100% renewable energy at the municipal level.[117]

Mandates are gaining prominence as tools for renewable energy promotion. Mandates often are enacted through the development of new building code regulations to require the inclusion of renewable energy systems in building construction and renovation. Mandates also have become a common means for promoting renewable heating technologies, with the majority of city mandates focusing on the deployment of solar water heaters. Major Brazilian cities, including São Paulo, have taken a leading role in adopting building codes that promote renewable heat technologies.[118] Chinese cities also have been particularly active in using such provisions to promote the use of solar water heaters; for example, as of 2014, 10 cities in Shandong Province had adopted mandates for the use of solar water heaters in residential buildings.[119] Mandates also have been used to promote the use of renewable electricity generating technologies. In 2014, several European cities were joined by Dubai (UAE) and Guragon (India) in mandating the use of solar PV.[120]

Local governments have enacted regulatory instruments to spur renewable energy deployment as well. Net metering has been an important tool used by local policymakers where national or state/provincial policies are not in place. The Indian cities of Delhi and Bengaluru (Bangalore) approved new net metering programmes in 2014.[121] And Dubai became the first city in the Middle East to adopt a comprehensive legislative framework allowing any customer to install PV generation systems and inject surplus solar PV power into the grid.[122]

Feed-in policies also have been used at the local level—often offering higher rates than national or state/provincial policies (e.g., Los Angeles, California)—or are being put in place (e.g., multiple German cities) prior to national or state/provincial FITs. Worldwide, however, feed-in policies have not been adopted as widely at the city level as at the national level. Where they are in place, local FITs often face challenges similar to those at the national level. In 2014, city FITs saw a mix of positive and negative revisions. For example, Banff in Alberta launched the first municipal FIT in Canada; Palo Alto, California (United States) raised the capacity cap on its FIT programme; and Gainesville, Florida (United States)—a pioneer in local feed-in tariffs in the United States—suspended its FIT to limit overcapacity and manage electricity rates.[123]

Public financing policies remain an important driver of deployment, supporting renewable power systems, solar thermal technologies, and alternative transportation options. For example, in 2014, Barcelona (Spain) approved a USD 13.7 million (EUR 11.3 million) subsidy scheme to promote rooftop renovation, including the installation of solar water heaters.[124] In Melbourne (Australia), the government offers rebates to businesses for the purchase and installation of solar PV systems to stimulate demand.[125] Cities have enacted financial support mechanisms to spur the development of private purchases of EVs. In China, Shenzhen enacted a new programme aimed at increasing the number of EVs used in the city's taxi fleet, offering taxi drivers the ability to lease EVs with no down-payments.[126]

Public-private partnerships are also a tool for implementing renewable energy projects in municipalities that are rich in renewable resources but have limited budgets. In China, Xiong County (under governance of Baoding City) adopted a partnership approach to harness its geothermal resources, which now cover 90% of heat demand within the county's district heating areas.[127] The City of Melbourne is trialling a "group purchasing model" where large energy users across the city can aggregate their energy demand to benefit from economies of scale.[128]

In addition to supporting the deployment of renewable energy technologies by private parties, local governments often lead the charge directly by purchasing renewable energy systems for municipal buildings or public infrastructure improvements. Cities have created innovative means for integrating renewable energy technologies as well as electric vehicles into public procurement. Similar to national-level EV policy, policymakers are still slow to adopt mechanisms directly linking EV promotion to renewable energy. Building on the transition of San Francisco's public bus fleet to all biofuel and EVs, in 2014 a coalition of city government agencies made the largest-ever purchase of EVs in the United States.[129] Increasing the use of EVs in public fleets also has been key in a number of city-wide efforts to reduce fossil fuel consumption in the transportation sector. For example, Paris (France) announced the purchase of USD 12–49 million (EUR 10–40 million) of electric buses for its city bus fleet as part of a pilot electric bus programme.[130]

Another instrument that has had a positive impact on the deployment of renewable electricity at the local level has been municipalities taking over control or ownership of local utilities. To enable greater integration of renewable sources in Europe, the Community Power (CO-POWER) project was developed to support the creation of community power systems across 12 European countries.[131] In the United States, as of early 2015, more than 2,000 communities had created community power systems to enable the uptake of renewable energy, including in Austin, Texas, where Austin Energy is responsible for meeting the city's renewable energy target.[132] An additional 800 or more electrical co-operatives (co-ops) in the United States have helped extend the benefits of consumer-owned power systems.[133]

District heating and cooling systems have emerged as another measure helping to facilitate the scale-up of renewable energy. At the city level, district energy networks have been promoted through municipal oversight of planning and regulation. A few notable examples of systems relying on renewable energy—in addition to Xiong County in China—include Dubai, which has developed the world's largest district cooling network as part of

a plan to meet 40% of the city's cooling demand by 2030 utilising technologies such as water chillers, and Paris, which is home to Europe's first district cooling network, deriving its cooling power from the water of the Seine River.[134] Additional European cities such as Copenhagen (Denmark), Helsinki (Finland), and Vilnius (Lithuania) source nearly all of their heating and cooling supply from district energy networks.[135] Large-scale solar thermal heating plants have been developed to feed in to district energy networks across the EU (particularly in northern Europe). Total installations are led by Denmark, while cities and towns in countries such as Austria, Germany, and Sweden also have taken a leading role in developing large-scale systems.[136]

Policymakers in many cities have focused on reducing administrative hurdles to renewable energy deployment by simplifying permitting procedures. In 2014, several Chinese cities, including Shanghai, simplified their administrative processes for solar PV installations.[137] In the United States, the city of Los Angeles began implementing a new online permitting procedure for solar PV to reduce costs for homeowners who install new systems, and the US federal SunShot initiative has partnered with a number of communities to reduce the total installed cost of solar energy systems to USD 0.06 per kWh by 2020.[138]

Cities are increasingly working collaboratively to spur renewable energy deployment more effectively while making the most of limited resources. The Compact of Mayors was launched on a global scale in September 2014 at the United Nations Climate Summit hosted by the UN Secretary-General. The group brings together over 2,000 cities to promote and support city-level climate actions, including the deployment of renewable energy and energy efficiency technologies.[139] The Covenant of Mayors is a European-based initiative through which authorities commit to increasing renewable energy and energy efficiency in their municipalities or regions. By end-2014, it had expanded to 6,149 signatories, and, by early 2015, 71 groups of small municipalities had adopted Joint Sustainable Energy Action Plans under guidance of the Covenant in order to aggregate their resources and benefit from economies of scale.[140] The Energy-safe Cities East Asia Program was launched in 2014 to help cities in China, Japan, South Korea, and Mongolia achieve their goals of 100% renewable energy by 2030.[141]

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES

COUNTRY	Renewable energy targets	REGULATORY POLICIES: Feed-in tariff / premium payment	Electric utility quota obligation / RPS	Net metering	Biofuels obligation/ mandate	Heat obligation/ mandate	Tradable REC	Tendering	FISCAL INCENTIVES AND PUBLIC FINANCING: 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
HIGH INCOME COUNTRIES													
Andorra		○										○	
Australia	○	●	○		●	●	○	★*	○				○
Austria	○	○			○		○		○	○			○
Bahrain	○												○
Barbados[140]	○			○							○		○
Belgium	○		●	●	○		○	○	●	○	○		
Canada	●	R*	●	●	○			○	○	○	○		○
Chile	○		○	○				★	○	★	○		○
Croatia	○	○			○								
Cyprus	○	○		○	○			○	○				
Czech Republic	○				○		○		○	○	○		R
Denmark	○	R		R	○		○	○	○	○	○		○
Estonia	○	○			○							○	○
Finland	○	○			○		○		○		○	○	
France	R	R			○	○	○	○	○	○	○		○
Germany	○	R			○	○			○	○	○		○
Greece	○	R		○	○	○			○	○	○		○
Ireland	○	○			○	●	○	○					
Israel	○	○	○	○		○		○			○		○
Italy	○	R		○	★	○	○	○	○	R	○		○
Japan	R	R	○	○			○	○	○				○
Kuwait	○							○					
Latvia	○	○		○	○			○			○		
Liechtenstein		○											
Lithuania	○	○	○		○								○
Luxembourg	○	○			○				○				
Malta	○	R		○					○		○		
Netherlands	○	○		○	○		○		○	○	○	○	○
New Zealand	○								○				○
Norway	○		○		○		○	○	○		○		○
Poland	○	R	○		○		○	R			○		○
Portugal	○	○	○	○	○	○		○	○	○	○		○
Russia	○	R						★	○				
San Marino		○											
Singapore	★			○				○					○
Slovakia	○	○			○		○				○		
Slovenia	○	○					○	○	○	○	○		R
South Korea	○		○	○	○	○	○		○	○	○		○
Spain[141]	○			○	R	○	○		○	○		○	
Sweden	○	○	○		○		○		○	○	○		○
Switzerland	○	R				○			○		○		
Trinidad and Tobago	○									○	○		
United Arab Emirates	R*		●			●		●				●	●
United Kingdom	○	○	○		○		○		○		○	○	○
United States[3]	R*	R*	R*	R*	○	●	●		○	R	○		○
Uruguay	○	○		○	○	○		○	○		○	○	○

○ – existing national (could also include state/provincial), ● – existing state/provincial (but no national), ★ – new (* indicates state/provincial), R – revised (* indicates state/provincial), ✕ – removed/expired

[1] Certain Caribbean countries have adopted hybrid net metering and feed-in policies whereby residential consumers can offset power, while commercial consumers are obligated to feed 100% of the power generated into the grid. These policies are defined as net metering for the purposes of the Global Status Report.

[2] Spain removed FIT support for new projects in 2012. Incentives for projects that previously had qualified for FIT support continue to be revised.

[3] State-level targets in the United States include RPS policies.

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES (continued)

COUNTRY	Renewable energy targets	REGULATORY POLICIES							FISCAL INCENTIVES AND PUBLIC FINANCING				
		Feed-in tariff / premium payment	Electric utility quota obligation / RPS	Net metering	Biofuels obligation/ mandate	Heat obligation/ mandate	Tradable REC	Tendering	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
UPPER-MIDDLE INCOME COUNTRIES													
Albania	○	○	○		○		○	○		○	○	○	○
Algeria	R	R						○	○				★
Angola					○								○
Argentina	○	○		○	R			★	○	○	○	○	○
Azerbaijan	○												○
Belarus	○	○	○								○		○
Belize	○							○					
Bosnia and Herzegovina	○	○						○	○				
Botswana	○								○		○		
Brazil	○			○	R	●		★		○	○		○
Bulgaria	○	R			○								○
China	R	R	○		○	○		○	○	○	○	○	○
Colombia	○			★	○					★	R		★
Costa Rica	○	R		★	○			○			○		
Dominican Republic	○	○		○				○	○	○	○		○
Ecuador	○	○			○			○			○		○
Fiji	○									○	○		
Grenada	○			○							○		
Hungary	○	○			○				○		○		○
Iran	○	○								○		○	○
Jamaica	○			○	○			○		○	○		
Jordan	○	○		○	○	○		★			○		○
Kazakhstan	○	★					○		○				
Lebanon	○			○							○		○
Libya	○										○		
Macedonia, Republic of	○	○											
Malaysia	○				○						☼		○
Maldives	○	○						○					
Marshall Islands	○										○		
Mauritius	○							○	○		○		○
Mexico	○			○				○		○			○
Montenegro	○	○											
Namibia	○					○							
Palau	○		○										
Panama	○	○		○	○			○		○	○	○	
Peru	○	○	○		○			○			○		○
Romania	○		○		○		○						R
Serbia	○	○							○				
Seychelles	○			★						○	○		○
South Africa	R		○		○	○		★	R		R		○
St. Lucia	R			○							○		
St. Vincent and the Grenadines[1]	○			○									
Thailand	○	R			○						○	○	○
Tunisia	○			○					○		○		R
Turkey	R	○			○				○				○

○ – existing national (could also include state/provincial), ● – existing state/provincial (but no national), ★ – new (* indicates state/provincial), R – revised (* indicates state/provincial), ✕ – removed/expired

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

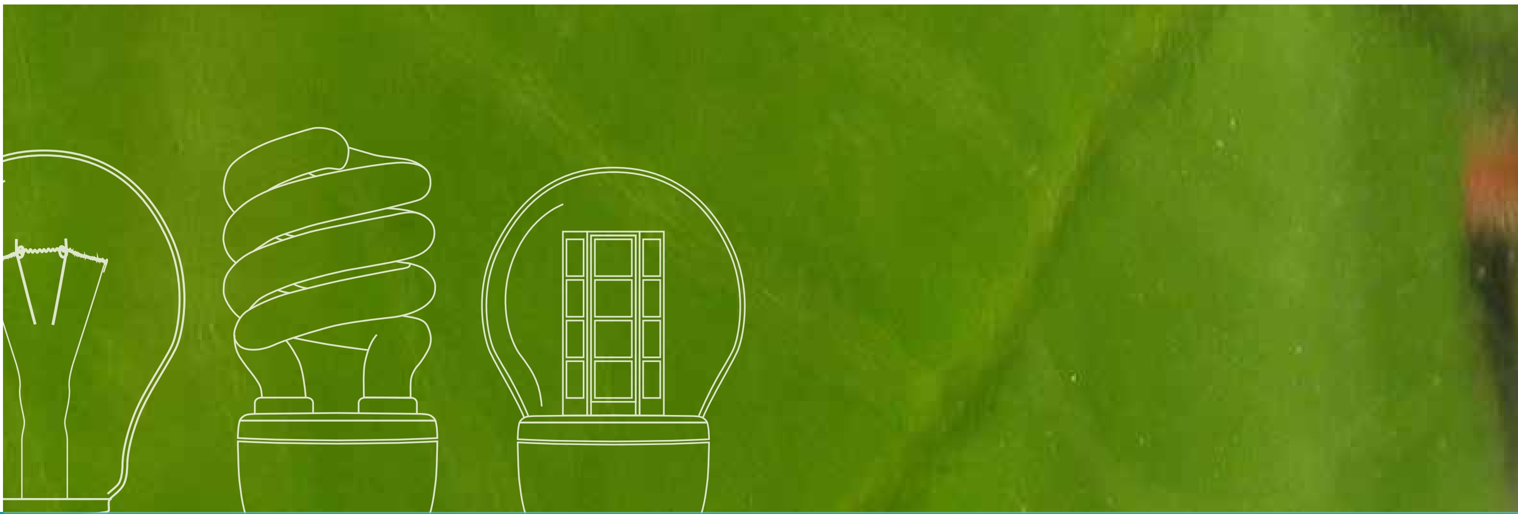
Note: Countries are organised according to annual gross national income (GNI) per capita levels as follows: "high" is USD 12,746 or more, "upper-middle" is USD 4,125 to USD 12,745, "lower-middle" is USD 1,046 to USD 4,125, and "low" is USD 1,045 or less. Per capita income levels and group classifications from World Bank, "Country and Lending Groups," accessed March 2015. 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)

COUNTRY	Renewable energy targets	REGULATORY POLICIES: Feed-in tariff / premium payment	Electric utility quota obligation / RPS	Net metering	Biofuels obligation/ mandate	Heat obligation/ mandate	Tradable REC	Tendering	FISCAL INCENTIVES AND PUBLIC FINANCING: 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
LOWER-MIDDLE INCOME COUNTRIES													
Armenia	○	○											
Cabo Verde	○			○				○		○		○	
Cameroon											○		
Côte d'Ivoire	○							○			○		
Egypt	○	★		○				○	○		○		
El Salvador								○		○	○	○	○
Ghana	○	○	○		○		○		○		○		○
Guatemala	○			○	○			○		○	○		
Guyana	○										○		
Honduras	○	○		★				○		○	○		
India	○	○	○	●	○	●	○	★	○	○	★	○	○
Indonesia	○	○	○		○			○	○	○	○		○
Kyrgyz Republic			○						○		○		
Lesotho	○			○				○	○	○		○	○
Micronesia, Federated States of	○			●									
Moldova	○	○											○
Mongolia	○	○						○					
Morocco	○			○				○					○
Nicaragua	○	○									○		
Nigeria	○	○			○				○		○		○
Pakistan	○	○		○	○		○		●		★		○
Palestinian Territories[4]	○	○		○							○		
Paraguay					○						○		
Philippines	○	○	○	○	○			○	○	○	○	○	○
Senegal	○	○	○	○				○			○		
Sri Lanka	○	○	○	○	○				○		○	○	○
Sudan	○				○								
Syria	○	○		○				○		○			
Ukraine	○	○		○	○				○		×		○
Uzbekistan								○					
Vanuatu	○										○		
Vietnam	○	○			○		○		○	○	○		
Zambia									○		○		○
LOWER INCOME COUNTRIES													
Bangladesh	○							○	○		○		○
Burkina Faso								○		○	○	○	
Ethiopia	○				○						○		○
Gambia	★										○		
Guinea	○										○		
Haiti	○												○
Kenya	○	○				○		○			R	○	○
Liberia	○										○		
Madagascar	○										○		
Malawi	○										○		○
Mali	○				○						○		○
Mozambique	○				○						○		○
Myanmar	○										○		
Nepal	○	○					○	○	○	○	○		○
Niger	○										○		
Rwanda	○	○						★		○	○		○
Tajikistan	○	○									○		○
Tanzania	○	R							○		○	○	○
Togo	○										○		
Uganda	○	○						★	○		○		○
Zimbabwe	○				○						○		○

04



05

Bioluminescence in **FIREFLIES** is nearly 100 percent efficient, meaning that little energy is wasted to produce their light. The process of bioluminescence and the structure of firefly lanterns is being used to improve the design of a standard light-emitting diode (LED) to significantly increase its efficiency. This new design could be employed in the near future to produce low-cost LED bulbs and ensure better lighting services. Using energy more efficiently reduces overall energy costs, making energy services more accessible in developing countries.

05 DISTRIBUTED RENEWABLE ENERGY FOR ENERGY ACCESS

In sub-Saharan Africa, girls are more likely to die from breathing the fumes and smoke from indoor cooking fires than from malaria or malnutrition.[1] In South Asia, a woman living in a rural area typically spends about 40 hours per month collecting cooking fuel.[2] In parts of northern Asia, some villagers are too poor to purchase charcoal in the winter for cooking.[3] And, in many regions, the lack of electricity and modern energy services can hamper healthcare and educational services.[4]

Roughly one in every seven people worldwide lack access to electricity, and more than two in five depend on traditional biomass to meet their household energy needs.[5] For many people, it remains a daily struggle to access energy required to meet very basic needs. In many rural areas of developing countries, connections to central electric grids are economically prohibitive and may take decades to materialise, if at all. Moreover, grid connectivity does not fully address the need for access to sustainable heating and cooking options.

Distributed renewable energy[i] (DRE) systems offer an unprecedented opportunity to accelerate the transition to modern energy services in remote and rural areas, by increasing access to sustainable cooking and heating devices; affordable lighting, communications, and refrigeration; education; improved public health; and energy for processing and other productive activities. These objectives can be achieved by establishing and strengthening institutional, financial, legal, and regulatory support mechanisms for renewable energy deployment. In turn, these mechanisms can help by improving access to financing, developing the necessary supply-chain infrastructure, and building awareness about the challenges posed by a lack of access to sustainable energy sources and the potential of renewable energy.[6]

An array of viable and cost-competitive options can provide reliable and sustainable energy services. Technologies available include isolated small-scale electricity generation systems and mini-grids for lighting, battery charging, communications, water pumping, and other productive uses. They also cover renewable energy systems for space and water heating, cooling, and clean cooking. Innovative, modular, sustainable, and locally relevant DRE solutions are available to meet the energy needs of individuals and communities, while also increasing energy security, lowering fuel-related costs (including fossil fuel subsidies), enhancing the educational skills of the labour force, easing the burden of collecting fuelwood, and avoiding harmful emissions from kerosene lamps and inefficient stoves.[7]

This section seeks to provide a picture of the current status of DRE markets in developing countries and to present an overview of the major networks and programmes that were operational in 2014.

STATE OF ENERGY ACCESS IN RURAL AREAS

According to the most recently available data (as of early 2015), approximately 1 billion people, or 15% of the global population, still lack any access to an electricity grid.[8] Approximately 2.9 billion people lack access to cleaner forms of cooking.[9] Those living without electricity and clean cooking options are scattered around the world; however, more than half of those without electricity live in sub-Saharan Africa, and the region with the largest share lacking clean cooking is South America.[10] (→ See Figures 35 and 36.)

The lack of electricity and clean cooking solutions remains primarily a rural issue, with 139 million people in urban areas lacking electricity, compared to 941 million in rural areas. Likewise, about 400 million people who lack clean cooking are in urban areas, compared to 2.4 billion in rural areas.[11] (**→ See Reference Tables R20 and R21**.) The raw numbers portray little about emerging trends, however. While the figures look bleak, the situation of electrification is improving. From 1990 to 2012, the global electrification rate climbed from 75% to 85%.[12]

Numbers and trends also differ by region. In sub-Saharan Africa, more than 620 million people, or more than two-thirds of the population, live without electricity, and 730 million people depend on polluting forms of cooking.[13] While the African continent is home to about 1 billion people, only 4% of global electricity is generated there. With a total installed capacity of roughly 147 GW, Africa has less power generation capacity than Germany.[14] All 47 sub-Saharan countries (excluding South Africa) have a combined installed renewable generation capacity of only 23 GW, which is less than one-third of the total renewable power capacity installed in India..[15] In addition, as the population is rising, the number of people in sub-Saharan Africa without access to clean cooking also has risen—by about 2.7% per year between 1995 and 2012—despite increases in GDP per capita. This trend is expected to continue.[16]

Northern Africa and the Middle East have made notable progress in electrification and access to modern energy services. Apart from Yemen (where 40% of the population lacks access), countries in the region are fully or almost fully electrified. Yet the provision of access to electricity is a challenge particularly

i - For the purpose of this section, "distributed renewable energy" refers to energy systems 1) that are relatively small and dispersed (such as small-scale solar PV on rooftops), rather than relatively large and centralised; and 2) for which generation and distribution occur independent from a centralised grid. DRE includes energy services for electrification, cooking, heating, and cooling that are generated and distributed independent of any centralised system, in urban and rural areas of the developing world. (→ See Sidebar 9, GSR 2014.)

Figure 35. World Electricity Access and Lack of Access by Region, 2012

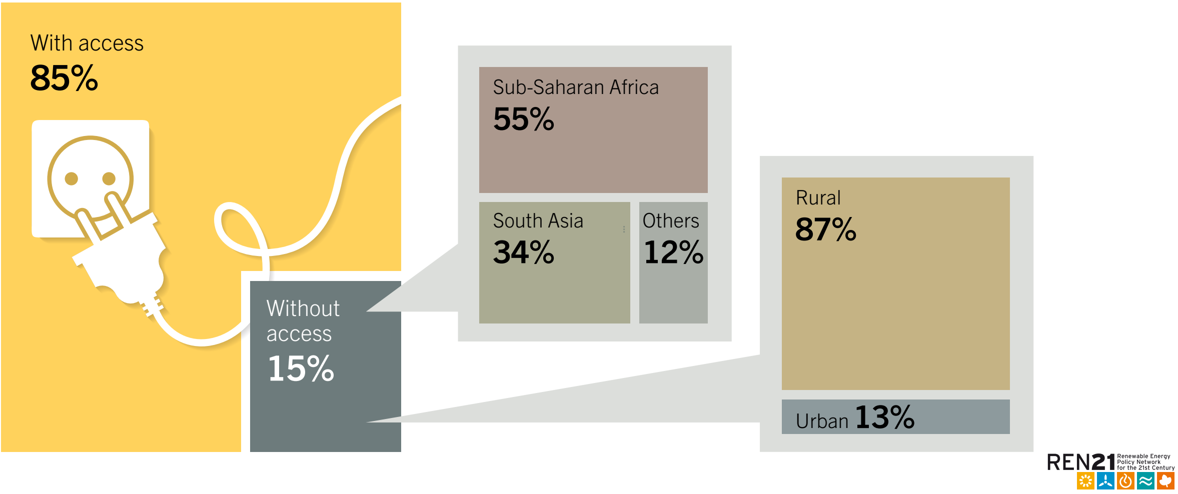
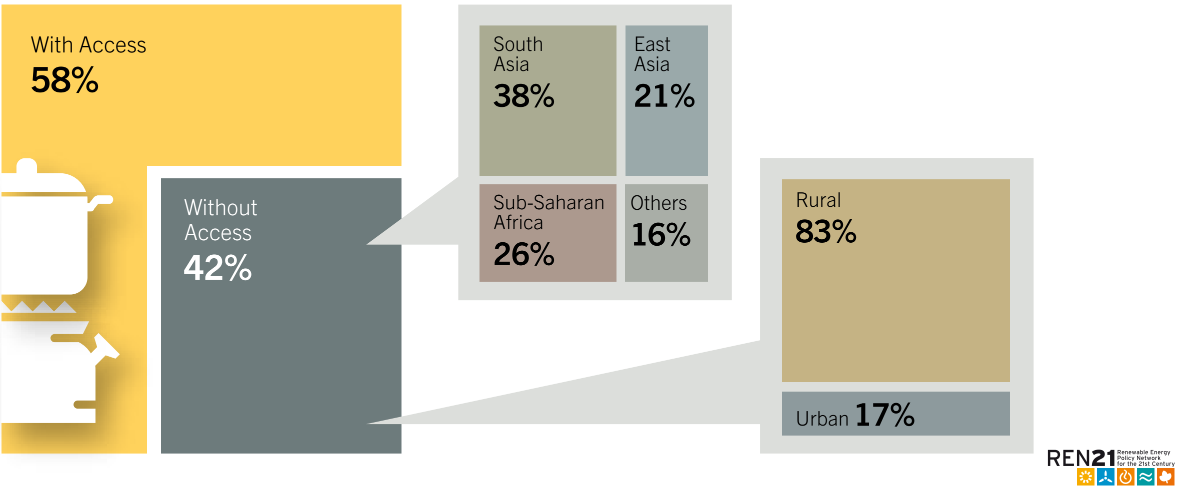


Figure 36. World Clean Cooking Access and Lack of Access by Region, 2012



Source: See Endnote 10 for this section.

in mountainous and rural areas of North Africa and the Levant, and large segments of the rural population continue to rely on traditional uses of biomass.[17]

People concentrated in South Asia (in Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka) consume less energy per capita than the average continental African.[18] India is home to large numbers of people who depend on solid fuels for cooking (778 million) and lack an electricity connection (263 million).[19] China's electrification rate is close to universal, but an estimated 607 million people in the country still rely on solid fuels for cooking.[20]

It is also difficult and costly to supply modern energy services to people living in small-island developing states in Oceania, such as Fiji and Vanuatu. These countries remain heavily dependent on diesel imports and have small electricity grids and high tariffs.[21]

Across Latin America and the Caribbean, overall rates of electrification are high, although they range from the worst in the Western Hemisphere (Haiti at less than 30%) to near-universal coverage (Brazil has achieved more than 99%).[22] The situation is different when it comes to clean cooking, however. It is estimated that more than 50% of people in Central America use firewood for cooking, but only about 10% of firewood users have improved cookstoves.[23] In rural areas of the Amazonian basin—in Bolivia, Brazil, Colombia, Ecuador, and Peru—people still rely heavily on firewood for cooking and heating.[24]

DISTRIBUTED RENEWABLE ENERGY TECHNOLOGIES

People in rural and remote regions generally acquire improved access to energy in three ways: 1) through use of isolated devices and systems for power generation at the household level, and for heating and cooking; 2) through community-level mini-grid systems; and 3) through grid-based electrification, where the grid is extended beyond urban and peri-urban areas. This section focuses on the first two (distributed) means of improving energy access. (→ See Sidebar 9, GSR 2014.)

Reliable quantitative data regarding DRE markets and installed capacity are relatively limited. However, at the household and non-residential levels, DRE technologies—including small-scale solar PV and stand-alone lighting systems, wind, biodiesel, and micro- and pico-hydro stations for electricity, heating and cooling units, and cooking devices—appear to have a significant and growing market presence. (**→ See Reference Table R22**.)

The dramatic price reductions of solar PV cells, combined with the availability of affordable and efficient appliances such as LED lights and new lithium-based batteries, have rendered solar PV systems more affordable, even for very small-scale applications (although prices vary across markets). The popularity of solar lanterns, solar-pico PV systems (1–10 W capacity), and slightly larger solar home systems (SHS) (10–200 W) continued to rise in 2014. One of the most successful SHS programmes has been carried out in Bangladesh, where more than 3 million systems were operational at the end of May 2014 (with 65,000 units being sold every month), serving 13 million beneficiaries, or 9% of the total population.[25]

Stand-alone lighting systems—including solar lanterns, flash-lights, and battery-powered LED devices—have begun to proliferate, especially in sub-Saharan Africa.[26] In addition, during 2014, small-scale wind turbines were being used predominantly for battery charging, telecommunications, irrigation, and water pumping.[27]

Micro- and pico-hydro stations as small as 1 kW continue to be adopted in many countries, providing local communities with affordable electricity. Typically, such hydro systems operate reliably for at least 20 years and require minimal maintenance (other than keeping the intake screen free of debris). Nepal had more than 2,600 micro- and pico-hydro systems installed by the end of 2013, with a total capacity of more than 45 MW.[28]

Increasingly, biomass and biogas systems are being used to supply electricity. To fuel engine-powered generators, people in a rising number of countries are using vegetable oils from palm, coconut, jatropha, and other sources to displace diesel. In Thailand, biodiesel for electricity generation is being produced on a small scale from used cooking oil.[29] In Cambodia, India, Vietnam, and elsewhere, biogas produced from dry wood, weeds, and rice husks is used increasingly to fuel engines, driving generator sets to supply electricity to mini-grids.[30]

The rural cooking and heating sector has progressed due to advances in technology and increased awareness of problems associated with deforestation. The rising popularity of educational programmes also has played a role by raising awareness among rural populations about the benefits of using modern biomass and solar thermal systems for clean cooking and for water and space heating.[31] Programmes to promote modern biomass stoves have reached a significant number of households, due largely to historic government efforts in China and to international efforts of the Global Alliance for Clean Cookstoves.[32]

Other fuels used for household cooking purposes, although at far smaller volumes, include ethanol, biogas, wood pellets, and solar energy, as well as non-renewable fuels such as coal, kerosene, and liquefied petroleum gas (LPG). Ethiopia is home to a cookstove programme that relies on liquid biofuel rather than biomass.[33] In Nigeria, SMEFunds has distributed roughly 200,000 cleaner-burning stoves that use ethanol gel as a fuel.[34] Simple anaerobic digester technology can produce clean biogas fuel for cooking from animal manure, crop residues, and other organic waste feedstocks.[35] Biogas is best suited for the estimated 155 million households and commercial farms where sufficient animal manure (and human waste) can be collected on a daily basis.[36] Nepal has one of the most successful biogas programmes in the world, with more than 330,000 plants installed under the Biogas Support Program.[37]

Other applications relying on DRE, such as street lighting and energy for productive uses, continued to emerge in 2014. For instance, solar-powered public lighting has proliferated in several countries, and it is becoming a first step in rural electrification programmes. In Haiti, the government supported the installation of as many as 14,000 solar-powered streetlights in 2014, and countless others were erected by private actors.[38] Abuja, Nigeria, also has more than 100 streets with solar-powered lighting.[39]

In addition, numerous DRE systems can provide a variety of other energy services connected to productive energy or mechanical energy.[40] (→ See Table 4.) DRE is playing a large and growing role in energising schools, health clinics, and some urban residences in developing countries, largely because it is cheaper and more convenient than diesel generators.[41] Other DRE applications include powering remote telecommunications towers and sending excess energy back into community micro-grids.[42]

Another distinct type of configuration of DRE systems relates to micro- and mini-grids. When configured properly, they can operate more cost effectively than centralised power grids.[43] SunEdison signed an agreement with India-based Omni-grid Micropower Company to set up solar powered micro-grids in 5,000 Indian villages (cumulative capacity of 250 MW).[44] A company in Gabon (Meagle Sun) has developed and installed 100 community SHS units with batteries (called "solar cupboards"), configured as a single micro-grid.[45] The Indian government launched a very ambitious target in 2014 to install a cumulative 40 GW of rooftop solar PV power plants, which will be set up over the next five years in community micro-grids ranging from 1 kW to 500 kW in capacity.[46]

Other micro-grids are deployed in urban areas. Gham Power in Nepal, for example, developed a business model for urban diesel-solar micro-grids as an answer to unreliable electricity supplies from the public grid. It is building about 4 MW of hybrid solar PV-diesel generators to serve about 30 organisations, including hospitals, banks, hotels, and factories.[47]

In addition to existing, well-established technologies, 2014 witnessed the evolution of new types of DRE equipment, configurations, and applications.[48] (→ See Sidebar 8.)

TABLE 4. DISTRIBUTED RENEWABLE ENERGY FOR PRODUCTIVE ENERGY SERVICES AND ECONOMIC DEVELOPMENT

ENERGY SERVICE	TECHNOLOGY	NEW INCOME OPPORTUNITIES	IMPROVEMENT OF EXISTING ACTIVITIES	ADDITIONAL BENEFITS
Lighting	Smaller-scale solar PV, stand-alone lighting systems; pico-wind, biodiesel, and micro- and pico-hydro stations; biodiesel engines	Street lighting enables night-time stalls and entertainment	Later closing of restaurants, cafés, and shops; education and reading; manufacturing at night time	Creating opportunity for night-time activities, increased safety, and enhanced socialisation
Cooking	Cleaner biomass cookstoves, biogas, solar cookers	Sales and distribution of commercial modern fuels and stoves	Cleaner and more cost-effective cooking	Time saved in wood collection, cooking, and pot cleaning; improved health
Cooling/ refrigeration	Larger-scale solar PV and wind, biodiesel, and micro- and pico-hydro stations; biodiesel engines	New markets for refrigerated products, e.g., milk, cheese, yoghurt and curd; fresh instead of dried fish	Less waste of agricultural and fishery products, more income creation, safe storage of medications	Reduced time and energy spent keeping goods fresh; lives saved with medications
Heating	Solar thermal water heaters, biogas, biomass	Process heat for new industrial processes and other activities such as agro-processing	Improved comfort in homes, commercial buildings	Time saved in collecting wood for heating
Information and communication technologies (mobile phones, radios)	Solar PV, pico-wind	Internet cafés, mobile phone charging, radio stations	Enabled access to real-time market prices	Reduced travel time and expense associated with communication, banking, and bill paying
Irrigation	Diesel pumping systems fuelled with biofuel, micro-hydro, solar PV, wind	Growing more / new kinds of crops	Better yields on existing land compared with rain-fed agriculture	Less time spent watering crops
Agro-processing	Biodiesel pumps, micro-hydro, micro-grids, solar dryers	Adding value by refining agricultural products	Increased throughput and lower costs	Less time spent manually grinding, pounding, drying, etc.
Mechanical energy	Biodiesel pumps, micro-hydro	Enabling welding and metalwork	Improved quality and speed of carpentry	Time saved by mechanisation of repetitive designs

POLICY DEVELOPMENTS

Because the expansion of energy access cannot be done through grid extension alone, policymakers are supporting DRE with a variety of specific policies, regulations, and targets. To date, most policy frameworks developed for improving energy access have emphasised electrification, with less of a focus on clean cooking, heating, and cooling.[49]

Brazil, China, India, and South Africa have taken the lead in developing large-scale, off-grid renewable energy programmes that are making significant inroads into addressing the dual challenges of energy access and sustainability.[50] An important factor in the success of renewable energy initiatives in these countries has been their inclusion in broader long-term rural electrification programmes that are supported politically and backed by substantial and sustained public resource allocations.[51]

The most popular policy tools involve energy market mechanisms, which seek to harness the power of market competition among project developers to spur development. Peru, for instance, was one of the first countries to prepare and implement a DRE reverse auction, where those offering the lowest price win contracts. The auction was prepared in 2013, and a contract was awarded in late 2014 for the provision of 500,000 off-grid solar PV systems through a 15-year contract that includes construction, installation, operation, maintenance, and any replacements required.[52]

In 2014, some countries established or were in the process of forming their own ministries or departments related to DRE. For example, the Bangladesh Renewable Energy Policy of 2014 created a Sustainable and Renewable Energy Development Authority (SREDA).[53] Chad also was in the process of creating an autonomous agency to regulate developments related to energy access and to promote investment in the DRE sector.[54]

Other countries initiated new programmes to expand energy access to rural and remote regions. Chile launched the Energy Access Fund in 2014 to finance small-scale renewable energy

SIDEBAR 8. EMERGING INNOVATIVE DISTRIBUTED RENEWABLE ENERGY TECHNOLOGIES

A number of recent innovations offer the potential to radically improve the future DRE landscape. For example:

Thermoelectric generator (TEG) stoves utilise their own heat to produce power that operates a blower or fan, eliminating the need for an external source of electricity and increasing the efficiency of combustion. Alternatively, the electricity that they generate can be used to charge small devices such as mobile phones. TEG stoves are becoming cost-competitive. They have been shown to reduce harmful pollutants significantly compared to traditional stoves. In 2014, multiple models backed by dozens of companies were field-tested and piloted in Haiti, India, Malawi, Nepal, and Nicaragua.

Flexi-biogas systems use balloon (or tube) digesters made from a polyethylene or plastic bag, making them mobile and extremely lightweight. They have several advantages over traditional units: they typically can be constructed in one day; they can be carried by bicycle or motorcycle; they cost less and use fewer materials; they require less manure for start-up; and they take less time to convert waste into energy. The International Fund for Agricultural Development (IFAD) and Biogas International distributed 500 systems in Kenya during 2011–14. Flexi-biogas systems also are being piloted by IFAD in India, Rwanda, and São Tomé and Príncipe, and by the Multilateral Investment Fund in Mexico.

Pico-wind turbines offer a very low-cost technology for powering remote telecommunications. Founded only a few years ago, the company Fairwind has designed small wind machines made from plastic bottles that can be constructed in a matter of minutes with a simple knife and scissors. The units require only a "gentle breeze" to charge a mobile phone and can complete the charge in about three to four hours. Fairwind is piloting its systems in South Africa and is targeting more of sub-Saharan Africa and South Asia (India and Nepal) for expansion in 2015.

Solar-powered irrigation kits enable farmers to grow high-value fruits and vegetables. One irrigation kit made by SunCulture combines cost-effective solar pumping technology with a high-efficiency drip irrigation system. The systems help farmers in Africa realise yield gains of up to 300% and water savings of up to 80%. In Benin, the Solar Electric Light Fund (SELF) has promoted "solar market gardens." The SELF project couples solar PV units (1.5–3 kW) with drip irrigation systems. The drip irrigation systems are drilled into boreholes and are able to water half-hectare farming plots. In Bangladesh, Infrastructure Development Company Limited distributed 160 MW of off-grid solar irrigation pumps in 2014 to replace 18,700 diesel-based irrigation pumps. The Renewable Energy and Energy Efficiency Partnership (REEEP) also has invested in solar-powered irrigation in Ethiopia and Kenya.

Ancillary services and monitoring are making use of digitisation, and the "internet of things" is making its way into the DRE sector with remote monitoring systems that enable collection of data on system use and status, allowing for improved after-sales service, better customer service, and lower costs that enable companies to reach more people. As a service to DRE companies, Product Health collects and analyses data on the battery status and use patterns of remote solar units. The SparkMeter micro-grid metering system enables micro-grid operators to implement pre-payment for electricity and to achieve real-time monitoring and control. The low-cost system consists of four hardware components, a cloud-based operator interface, and a mobile money (or cash-based) pre-payment system.

Also in 2014, the Multilateral Investment Fund started developing a solar charge controller for Latin America and the Caribbean that combines remote system monitoring via cellular signal, compatibility with mobile payment services, and an extra input for the integration of additional sources of energy, such as a connection to a mini-grid or a national grid. In the realm of cooking, Project Surya has developed a "Cookstove Temperature Monitoring System" that utilises a wireless sensor to enable remote verification of the number of times a stove is used for cooking and the duration of each use.

Solar direct current (DC) micro-grids offer superior compatibility with certain electric appliances (such as LED lamps, battery-operated phones and computers, televisions, etc.) and can obviate the need for an inverter. Schneider Electric has been developing DC micro-grid systems that integrate solar PV units with low-voltage radial distribution lines. A Bangladeshi company developed a charge controller with an embedded DC converter to distribute electricity at higher DC voltages with reduced line losses.

Bundling of products and services together into hybridised or integrated packaged systems—especially bundles that promote electricity and appliance usage, telecommunications, and/or cooking—could be another high-impact innovation. Super-efficient DC appliances that can be connected directly to a solar home system are emerging, a trend that started recently with LEDs and that is expanding to other appliances, such as televisions that run on 12 V systems, as well as radios, shavers, and fans. In India, TERI has designed a new "Integrated Domestic Energy System" that provides access to basic solar energy systems for lighting, charging mobile phones, and operating a fan in a forced-draft cookstove. As of March 2015, TERI had distributed 7,793 units in India.

Source: See Endnote 48 for this section.

projects to improve access for rural communities.[55] Myanmar, which has a strong commitment to achieve universal access to electricity, continued with its plans to complete a National Electrification Plan (NEP) by 2015.[56] In addition, Sri Lanka created its Sunithyalokaya programme, which aims to provide access to electricity for 1,200 off-grid households through DRE units and targets 100% of remaining off-grid households.[57]

Numerous countries have electrification targets, with Barbados, China, Ghana, South Africa, South Sudan, and Sri Lanka all aiming for 100% of their citizens to have electricity access within the next one to six years (depending on the country).[58] The Philippines Expanded Rural Electrification Program aims to achieve 90% household electrification by 2017; as of April 2014, it had reached 99.98% of potential *barangays* (villages).[59]

Many programmes focus on the rollout of specific technologies, such as solar home systems. Costa Rica continued its initiative to deploy stand-alone solar PV installations in rural areas. In early 2014, a tender was published that called for the provision of more than 800 solar PV systems for households.[60] Ghana continued with its Solar Lantern Distribution Programme, launched in 2013, which aims to provide 200,000 lanterns over five years to replace kerosene use in rural off-grid communities. The programme targets communities on islands or without road access and aims to establish a local assembly plant and to build awareness.[61]

There were also new initiatives related to clean renewable cooking during 2014. In July, Ecuador started executing a plan to introduce 3 million solar induction cooktops by 2016.[62] Guatemala established a Cluster of Improved Cookstoves and Clean Fuels, representing individuals and organisations who work in these two areas, with the aim of providing technical, social, and economic solutions to the problems of household air pollution and the excessive use of firewood, as well as targeting fuel efficiency improvements, the appropriation of technology, and social responsibility.[63] Bangladesh announced a Country Action Plan for Clean Cookstoves with a target to disseminate 30 million units and make all kitchens smoke-free by 2030.[64] Also in 2014, India launched the Unnat Chulha Abhiyan Programme to develop and deploy 2.75 million clean stoves by 2017.[65] India continued its National Biogas and Manure Management Programme and plans to install 110,000 biogas plants from 2014 to 2019.[66] Some African countries, including Nigeria and Senegal, also have programmes to distribute millions of clean cookstoves.[67]

Fiscal incentives—such as loans, grants, and tax reductions—have been used successfully by many countries in their off-grid renewable electricity programmes to address the barrier of high upfront costs. While approaches vary by country, the most common practice is to provide subsidies to encourage operators to adopt renewable energy technologies when developing electrification schemes in remote communities.[68]

Beyond the level of individual nation states, dozens of international actors—including at least 30 programmes and 20 global networks—were involved in deploying DRE in 2014. **(→ See Reference Tables R23 and R24.)** One of the most visible international efforts is Sustainable Energy for All (SE4ALL), launched by United Nations Secretary-General Ban Ki-moon in 2012 and co-led by the president of the World Bank.[69] The SE4ALL initiative has several aims, one of which is to help achieve universal access to modern energy services by 2030. The SE4ALL initiative continued to build momentum in 2014, and the UN Decade of Sustainable Energy for All 2014–2024 was launched at the First Annual Sustainable Energy for All Forum in June.[70]

The SE4ALL initiative works at the country level to help governments prepare their action agendas, and is spearheading work in several high-impact opportunity areas—including clean energy mini-grids and energy for women and children's health—where there is potential to provide scale and impact.[71] Under the SE4ALL initiative, the Alliance for Rural Electrification (ARE) and Partners for Euro-African Green Energy (PANGEA) announced a partnership in late 2014 to support the development of biomass-based DRE systems to advance energy access.[72] As the renewable energy hub in the SE4ALL process, the International Renewable Energy Agency (IRENA) helps countries establish political and regulatory frameworks for deployment of DRE, providing a platform to strengthen investor confidence in developing countries, and also helps support regular exchange among key stakeholders in the DRE field.[73]

Other efforts have been driven primarily by national governments that provide bilateral or multilateral aid. One of the largest programmes is Power Africa, a US initiative that addresses access to electricity in sub-Saharan Africa. As of August 2014, the United States had leveraged more than USD 26 billion in financial support and loan guarantees, and Norway, Sweden, and the United Kingdom pledged an additional combined USD 12 billion.[74] Energising Development (EnDev), an initiative of Australia, Germany, the Netherlands, Norway, Switzerland, and the United Kingdom, aims to provide sustainable access to modern energy services to at least 15 million people by the end of 2018. By year-end 2014, EnDev had helped 12.9 million people in Africa, Asia, and Latin America.[75] Some programmes involve working with governments to establish and implement policy and regulatory frameworks that support the sustainable deployment of DRE. Germany's GIZ, for example, supports such programmes in several countries including India, Kenya, Madagascar, and Pakistan.[76]

Alongside traditional actors such as governments and international organisations, public-private partnerships and nongovernmental organisations are also promoting DRE. For instance, the Global Alliance for Clean Cookstoves mobilises high-level national and private donor commitments to promote the adoption of clean cookstoves and fuels in 100 million households by 2020. In 2014, it ended its first phase (2010–2014) and had engaged 30 countries in developing International Organization for Standardization (ISO) requirements for cookstoves. The second phase (2015–2017) focuses on driving investment, furthering innovation, and scaling up the project.[77] The Global Lighting and Energy Access Partnership (Global LEAP) works to catalyse the development of commercial markets for energy access solutions. In 2014, Global LEAP continued its support of the Lighting Africa programme, which has enabled the sale of 2.7 million quality-assured off-grid lighting systems in Africa, benefitting over 7 million people in 29 countries.[78]

FINANCING AND INVESTMENT

Historically, governments and international organisations took the lead in advancing energy access. However, in the last decade or so there has been a simultaneous evolution from a centralised, public-led approach towards public-private partnerships and private ventures, and towards a greater focus on renewables. Increased involvement of the private sector is due largely to a growing awareness that (as in the mobile phone market) off-grid, low-income customers represent fast-growing markets for goods and services.[79] Renewables are playing a greater role due to increased recognition that isolated cooking and electricity systems, particularly renewable systems, are the most cost-effective options available for providing energy services to households and businesses in remote areas; this is increasingly the case as technologies continue to improve and as costs decline.[80] All of these factors have resulted in increased funding (public and private) for DRE.

DRE systems continued to attract investment from venture capitalists, commercial banks, and companies. For example, energy companies such as Khosla Impact and Solar City invested about USD 63.9 billion in off-grid solar PV in 2014.[81] Bank of America (United States) pledged USD 1 billion to help finance DRE projects that normally would not pass risk assessments, and to seed a Catalytic Finance Initiative to stimulate at least USD 10 billion of new investment in high-impact clean energy projects.[82] Such initiatives will help develop innovative financing mechanisms to reduce investment risk and attract a broader range of institutional investors to the DRE sector.

Other financing streams were less conventional. Persistent Energy Capital, a boutique investment bank pursuing a commercial approach to energy access for all in Africa, has invested in companies that provide renewable energy products and services in Ghana, Tanzania, Uganda, and elsewhere.[83] The Renewable Energy and Energy Efficiency Partnership (REEEP) started a competitive incubator programme that provided small and medium-sized enterprises with seed-level grants or convertible loans to adopt DRE systems, as well as offering coaching, advisory, and matchmaking services to investors.[84]

Multilateral financial institutions and development banks continued to make their mark on DRE in 2014. While also still supporting fossil fuels, the World Bank invested at least USD 3.6 billion in renewable energy in 2014 (it did not disaggregate its data by DRE or non-DRE).[85] The Asian Development Bank raised some USD 400 million for energy access in 2014 under its Energy for All Initiative, which will benefit about 8.25 million people.[86] The Inter-American Development Bank continued to support its Multilateral Investment Fund, whose total cumulative lending topped USD 2 billion in 2014 and was spread across more than 1,800 separate DRE projects.[87] The African Development Bank directed USD 60 million into its Sustainable Energy Fund for Africa, with individual projects focused on cookstoves in Nigeria, solar PV in Cameroon, and solar-diesel mini-grids in Tanzania.[88] The Islamic Development Bank launched its USD 125 million Renewable Energy for Poverty Reduction programme, which promoted low-cost DRE sources across six countries, most of them in sub-Saharan Africa.[89] And in 2014, the German Development Bank KfW committed funds for energy projects to provide more than 2 million people with access to modern energy.[90]

Some of these banks rely on competitive prizes as a novel financing mechanism. For instance, the Inter-American Development Bank runs an "Energy Innovation Contest" every year that supports the implementation of innovative projects in the areas of renewable energy, energy efficiency, and energy access in Latin America and the Caribbean. In 2014, it gave awards to a hydro kinetic (ocean and rivers) project for isolated communities of Tierra del Fuego and Patagonia Austral in Chile, and to a scheme that provides remote service and maintenance for household solar systems in Nicaragua.[91] Also in 2014, Global LEAP held two off-grid product award competitions, with awards presented for the most efficient off-grid LED lights and televisions.[92]

Furthermore, the Green Climate Fund (GCF) has started to leverage billions of dollars of financing through the Conference of Parties process at the United Nations Framework Convention on Climate Change. The GCF aims to harmonise ongoing global financing efforts related to energy and transport infrastructure (among others) from the World Bank, the Global Environment Facility, the Adaptation Fund, the Clean Development Mechanism of the Kyoto Protocol, and the G8, with DRE systems and technology transfer being two of the core areas of focus. As of late 2014, the GCF had raised USD 10.2 billion in pledges.[93]

In parallel with increases in financing volumes are new mechanisms such as crowdfunding. Crowdfunding continued to increase in popularity in 2014, with a number of entities initiating campaigns to release new products or expand into new areas. The UN Foundation's Energy Access Practitioner Network used crowdfunding to raise USD 200,000 for various SE4ALL efforts.[94] Other actors have installed micro-grids using crowdfunded loans to facilitate access to energy for off-grid communities in Kenya, and to support DRE entrepreneurs in Haiti.[95]

BUSINESS MODELS

The use of innovative business models continued to gain momentum in 2014. These include: energy service companies (ESCOs), microfinance and credit, pay as you go, and one-stop-shops.

The energy services company (ESCO) model, or "fee for service", is one in which a customer pays regular fees for use of a renewable energy system that is owned, operated, and maintained by a supplying company.[96] Benefits include good service delivery, professional maintenance, and system replacement in case of default; the downside is that lack of ownership by users can lead to careless handling and damage.[97] Increasing numbers of ESCOs[i] are establishing training academies to increase staff retention, facilitate maintenance, and create local jobs.[98]

Under the microcredit model (microfinance), purchasers (households, small businesses) take out a small loan from a bank to cover the cost of DRE equipment. This model avoids the high upfront costs usually associated with renewable energy systems since users pay for them in instalments over time.[99] Microfinance has proven to be one of the most popular models for disseminating energy systems in the developing world over the past decade.[100] In 2014, Haiti, India, and Uganda all relied on microfinance enterprise programmes to expand the availability of consumer financing for solar lanterns and cleaner cookstoves, and Bangladesh continued utilising such programmes to improve the affordability of clean cookstoves, biogas digesters, and SHS.[101]

i - Such as Off Grid Electric, BBOXX, EarthSpark International, etc.

SIDEBAR 9. WOMEN AND DISTRIBUTED RENEWABLE ENERGY

DRE systems can make a significant contribution to improving the lives of people living in energy poverty, particularly women. The consequences of energy poverty for women are poor health, a life of repetitive, physically demanding tasks, and a shortage of time available for rest, their children, and income-generating activities.

Having a smokeless wood or biogas stove provides a clean kitchen while also reducing the time required to collect fuelwood, the burden of carrying heavy loads, and the associated health risks. In Uganda, biogas is reported to reduce the time that women spend on cooking by as much as an hour a day, while also encouraging men to become more involved in preparing snacks and drinks. The good-quality light provided by solar PV and light bulbs (rather than kerosene lanterns or candles) allows women flexibility in managing their days for household chores, reduces energy expenses, and enables children to study in healthier and safer conditions. In Sri Lanka, the lighting provided by solar home systems enabled women to shift certain chores to the night-time, allowing greater flexibility in managing their days. Women in East Africa who replace kerosene with solar lamps save up to 30% of their household expenditure.

DRE technologies bring electricity to remote locations, enabling people to use televisions, radios, and mobile phones, and providing other services. These devices and services help women keep in contact with family members working elsewhere, enable them to receive money or pay bills more quickly and less expensively than through traditional banks, and help them to feel a part of the modern world.

There is growing recognition in the renewable energy technology supply chain that women are more than consumers in developing countries—they also have a role to play in sales teams and as entrepreneurs. In a survey of 42 renewable energy companies from Asia, Africa, and Latin America, a number of entrepreneurs considered that involving women in the design of equipment (such as improved cookstoves) to be used in the home was an important factor in the ultimate success of their products. In some circumstances, women can be better positioned than their male counterparts to sell products to other female consumers. In Bangladesh, Grameen Shakti (which sells solar home systems, improved cookstoves, and biogas digesters) recruits and trains local women engineers and technicians who are able to build rapport with potential female clients in their own homes, something that would not always be possible for their male colleagues.

Unfortunately, women in developing countries face more barriers than men in their efforts to become renewable energy entrepreneurs. For example, women entrepreneurs lack start-up capital and collateral required as security to obtain loans. They also are more likely than men to lack technical and financial knowledge, as well as necessary business skills. In some countries, working with renewable energy technologies is considered to be "men's work".

Furthermore, if employers are to hire women, they must ensure that their premises and hiring practices are women-friendly. Greenway Grameen Infra in India aimed for women to represent at least 25% of employees selling their stoves, and realised that they needed appropriate sanitation facilities and a flexible hiring policy based on "group hiring", which enables women to support and substitute for one another when an individual's family duties prevent her from working.

A number of programmes, using a range of different business models, are orientated towards supporting women's involvement in the renewable energy supply chain. ENERGIA's Women's Economic Empowerment (WEE) Programme supports 3,000 women entrepreneurs who work in the area of energy services delivery; these women aim to reach over 2 million consumers spread across five countries. One of the organisations in the programme is Solar Sister, a social enterprise in East Africa that provides female entrepreneurs with a "business in a bag": a start-up kit of inventory, training, and marketing support for bringing portable solar technology to households in their communities. Another example is Kopernik (also WEE) in Indonesia, which uses existing kiosks run by women to distribute their solar lanterns.

Women working together find solidarity and support to overcome the barriers they face. For example, Khulumani Gogos Going

Under pay-as-you-go (PAYG) schemes, customers typically provide a small upfront fee for a solar charger kit, a portable system, and a control unit that can be used for powering LED lights and charging devices such as mobile phones. They then pay for the energy they need, either in advance or on a regular basis depending on consumption. Such micro-payment schemes have become one of the most popular categories of business models.[102] They are especially effective for solar technologies such as solar-powered charger kits because price levels and schedules are set to match customers' variable cash flows and their energy consumption patterns. One PAYG model operating in Africa had 30,000 solar PV units in the distribution channel as of 2014, and 15,000 units had been installed in customers' homes by year's end.[103] Kenya is already using PAYG for SHS on a large scale, and India announced the launching of similar PAYG schemes for solar lamps.[104]

One-stop-shop models are also expanding in use. Under this model, a single organisation both sells the renewable energy home systems and provides loans to pay for them (in essence, the company acts as supplier and micro-financier). This is common in Bangladesh, where one organisation sells SHS with a 15% down-payment and provides customers with three-year loans at 6%, after-sale services, and long-term product warranties. It also provides technical training across rural Bangladesh and trains entrepreneurs, particularly women, to become owners of their own renewable energy businesses.[105] (→ See Sidebar 9.)

Green is a small enterprise initiated by elderly women living in rural South Africa who form savings clubs to enable them to gain access to solar lighting and electricity. Community schemes, such as a micro-hydro scheme in the Western Solomons, often give responsibility for financial control to women, as they consider women to be more reliable than men at managing money. In Bangladesh's remote island community of Char Montaz, 40 women have a co-operative in which they assemble and sell solar home kits, and they employ 15 additional people in remote satellite offices. The success of the business model can be seen by its spread to neighbouring islands.

The policy environment is also important for supporting women's involvement in the renewable energy supply chain, as entrepreneurs as well as users. For example, Uganda's Renewable Energy Policy has special strategies, including promoting micro-finance, to ensure that women are able to benefit from renewable energy technologies in their household tasks. India's national biofuels programme mentions specifically the role of women in cultivation of biodiesel crops. As a result, women in the Hassan district in Karnataka are able to grow the crops in their backyards, which fits well with carrying out their household tasks and earns them much-needed and welcome income.

Recognising the achievements of women through award schemes such as the SEED and Ashden awards can inspire women to get involved in renewable energy-related businesses. However, women need encouragement to apply for awards. The Tanzanian Rural Energy Agency (REA) realised that most organisations and institutions that apply to win the Lighting Rural Tanzania Competition (LRTC) are led by men, even though there are women-led companies that are potential winners; therefore, they now announce the competition with gender-neutral language to encourage women to apply. An additional benefit for women entrepreneurs from the Ashden Awards is that winners in India have established the Ashden India Renewable Energy Collective for small-scale sustainable energy organisations to promote renewable energy solutions. Women play a leading role in the collective, and doing so gives women a stronger voice in influencing government policy.

Source: See Endnote 105 for this section.

06

JELLYFISH have one of the most **efficient means of propulsion** on the planet: the recoil drive. Through an ingenious design of elastic-type material, jellyfish can recover and reuse energy previously used for forward movement. This **energy-saving capability** allows them to move quickly for short periods of time. Called “passive energy recapture”, this mechanism can be used to increase significantly the efficiency of engines or other mechanical devices when long-term motor speed is not important.

06 ENERGY EFFICIENCY: RENEWABLE ENERGY'S TWIN PILLAR

Renewable energy and energy efficiency are twin pillars of a sustainable energy future.[1] As energy services are delivered more efficiently, renewables can more quickly become an effective and significant contributor to the primary energy supply. Concurrently, as the share of renewables increases, less primary energy is needed to provide the same level of energy services.

Energy efficiency measures and renewable energy options can work together to reduce system-wide environmental and economic costs. For example, distributed renewable energy systems[i] together with energy efficiency improvements can reduce peak electricity demand on the grid while easing transmission losses and bottlenecks. Non-fuel renewables—such as wind, solar, and hydropower—can improve system efficiencies on their own, as they remove the losses inherent in the thermal conversion of fossil fuels. The two pillars support each other to enable applications that otherwise might not be technically or economically practical, thereby rendering the outcome greater than the sum of the parts.

The total amount of energy required to deliver basic services depends on both the energy source and the losses that occur at each step (i.e., primary energy extraction, transformation, transportation, transmission, and end-use). Each of these steps presents an opportunity to improve the energy efficiency of the overall system, which is advantageous irrespective of the primary energy source. However, special synergies exist between energy efficiency and renewable energy sources, in both technical and policy contexts. Examples of these synergies include:

- **Synergies for greater system benefits**. Efficient building systems and designs, combined with on-site renewable energy generation, reduce end-use energy demand, electrical grid congestion and losses, and the monetary and energy expenditures associated with fuel transportation.
- **Synergies for greater renewable energy share in the energy mix.** Improving end-use efficiency and increasing use of on-site renewables reduce primary energy demand. With lower end-use energy requirements, the opportunity increases for renewable energy sources of low energy density to meet full energy-service needs. Targets to increase the share of renewables in total energy consumption can be achieved through both increasing the amount of renewable energy and reducing total energy consumption.
- **Synergies for greater investment in renewables and efficiency.** Improvements in end-use energy efficiency reduce the cost of delivering end-use services by renewable energy, and the money saved through efficiency can help finance additional efficiency improvements and/or deployment of renewable energy technologies.

These synergies exist across numerous sectors, from buildings and electrical services to transportation and industry.[2] (→ See Feature, GSR 2012.)

This section was produced in collaboration with the Copenhagen Centre on Energy Efficiency (C2E2).

i - In this section and the rest of the GSR (with the exception of the section on Distributed Renewable Energy for Energy Access), "distributed renewable energy systems" refers to energy systems 1) that are relatively small and dispersed (such as small-scale solar PV on rooftops), rather than relatively large and centralised; and/or 2) for which generation and distribution occur independent from a centralised grid.

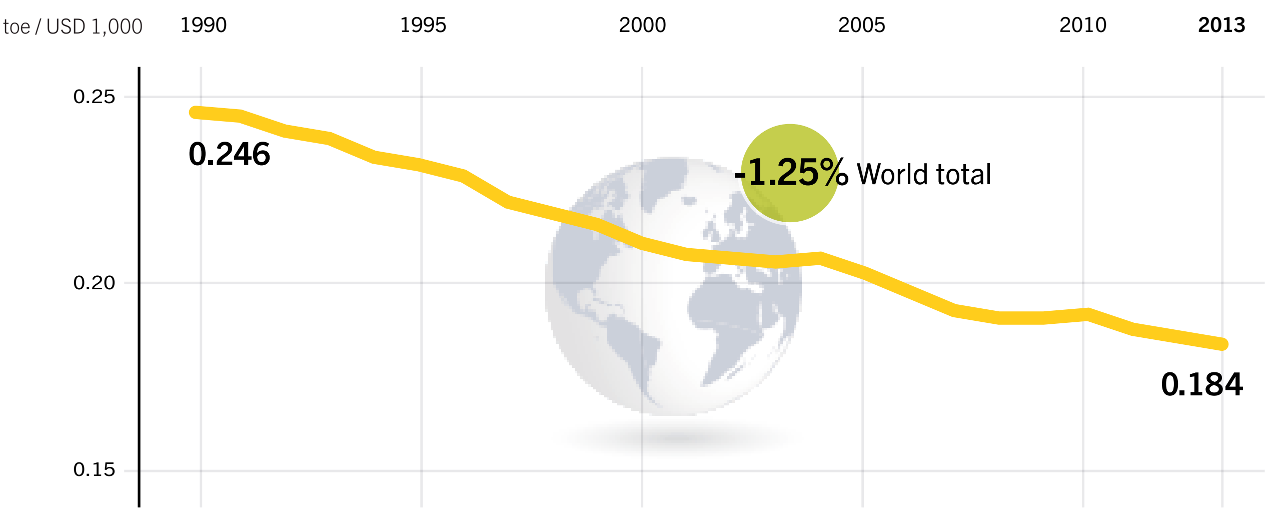
Energy intensity (i.e., primary energy consumption per unit of economic output) is typically used as a proxy for energy efficiency in macro-level analyses. This is due to the lack of an internationally agreed-upon high-level indicator for measuring energy efficiency.[3] (→ See Sidebar 10.) Energy intensity at the global level decreased at a compounded annual rate averaging about 1.25% between 1990 and 2013, and most world regions achieved improvements in aggregated energy intensity during this period.[4] (→ See Figure 37.) The most significant reductions in energy intensity were seen in the Commonwealth of Independent States (CIS) region, North America, and Europe; however, it is likely that structural changes in these economies contributed to reduced energy intensity. The Middle East is the only world region that experienced an increase in overall energy intensity.[5]

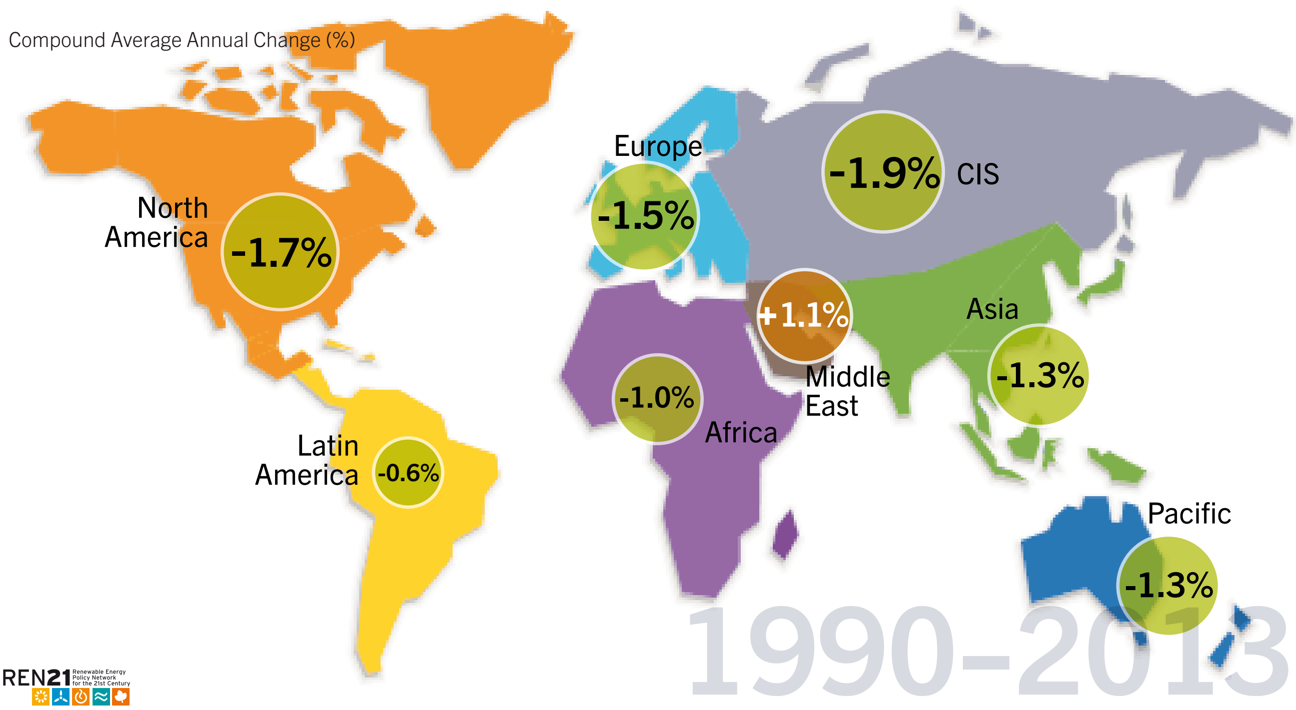
Some countries use energy more efficiently than others (in some cases by substantial margins), and potential savings vary greatly across countries and regions. Nevertheless, in all countries and economic sectors, improvements in energy efficiency are possible.[6]

The subsections that follow discuss the status, trends, and developments related to energy efficiency in buildings and appliances, transport, and industry. Each of these sectors accounts for approximately one-third of global final energy demand. The remaining text covers the current status of policies to advance energy efficiency and synergies between energy efficiency and renewable energy. While this section focuses on some emerging technologies within each sector and recent policy developments, it is not intended to be comprehensive.

In recognition of the important linkages between energy efficiency and the advancement of renewable energy, this section of the *Renewables 2015 Global Status Report* marks the first of what will be an annual chapter on the subject.

Figure 37. Global Energy Intensity, 1990–2013





Source: See Endnote 4 for this section.

SIDEBAR 10. THE STATUS OF ENERGY EFFICIENCY DATA

Although improving energy efficiency is a policy priority in many countries, there is no internationally agreed upon high-level indicator for measuring and tracking energy efficiency trends at the national or global level.

One of the most aggregated indicators commonly used to illustrate the rate of improvement in energy efficiency is energy intensity. However, the effectiveness of this indicator is limited because changes in energy intensity can be caused by factors other than energy efficiency, such as structural changes in the economy (e.g., shifting from energy-intensive industries towards services). Other approaches—such as energy efficiency indices, indicators, and scorecards—usually require detailed sectoral and/or policy data, which often are not available across different sectors and countries.

In the building sector, one of the most crucial types of data is building energy performance. Although several databases exist and are publicly available, they typically are limited geographically and cover only a small number of buildings. Examples include the U.S. National Buildings Performance Database, the U.S. High Performance Building Database, the Net Zero-Energy Buildings Map of International Projects supported by the German government, and the New Building Institute's "Case Studies of NZE Verified and NZE Emerging Projects". Databases also exist to track the developments of passive houses.

To address the lack of necessary data, the EU ZEBRA2020 project was launched in 2014 to monitor the market uptake of low-energy buildings across Europe (covering 17 Member States) and to generate data and evidence for policy evaluation and optimisation. Other efforts are taking advantage of the potential to collect building energy performance data through building certification and labelling schemes. In 2013, New Zealand launched a voluntary scheme (NABERSNZ) to measure and rate the energy performance of commercial buildings by adapting the successful National Australian Built Environment Rating System (NABERS). Under NABERSNZ, the energy performance of commercial buildings is evaluated and a star rating is applied.

The collection of performance data in various sectors can be used for comparative studies and information campaigns to demonstrate energy savings and other benefits of more energy-efficient solutions. For example, in 2014, Algeria launched a pilot project, Ecobat, to measure energy efficiency in buildings and to assess energy savings in heating and cooling in several provinces. As part of the assessment, the energy performance of houses subject to energy efficiency standards is being compared to the performance of conventional buildings.

Improved quality and accessibility of energy efficiency data is an important prerequisite and foundation for sound decision making across sectors and regions. Although there have been improvements in data collection efforts and in the development of indicators, in general the quality and coverage of energy efficiency data still lag in comparison to data on renewable energy sources.

There are several reasons for this problem. First, energy efficiency is much less tangible than renewable energy, and uncertainties remain about how to define and measure energy efficiency improvements. Second, the demand for energy efficiency data is still low in most countries, due mainly to the lack of understanding of its importance, as well as to a lack of resources and capacities to establish robust data collection. Finally, in the countries where data collection efforts do exist, they often take place at different levels (e.g., national, sub-national, municipal, etc.) and have different methodologies and quality, which creates further difficulty in achieving consistency.

Source: See Endnote 3 for this section.

BUILDINGS AND APPLIANCES

The building sector accounts for about one-third of global final energy demand.[7] About 40% of the energy consumed in buildings is used to provide space heating and cooling, with the remainder going to other end-uses, such as water heating, lighting, and operating appliances.[8] Vast opportunities exist to reduce energy use in buildings while improving comfort, such as: optimisation of building orientation and design to maximise the benefits of passive solar energy (e.g., for heating and daylighting); reduced thermal bridging; advanced glazing; improved air tightness; increased thermal mass, which improves a building's ability to absorb and store heat; and improved ventilation.[9]

In recent years, more focus has been placed on taking a holistic approach to improving building energy performance, rather than on raising the efficiency of individual systems.[10] This means addressing all the aspects of efficient building design in a way that best optimises overall performance in a given geographical location and in the most cost-effective manner. Examples of building standards include Energy Star in the United States and the Passivhaus Standard, which is a common benchmark for high building energy performance, predominantly in Europe. By definition, passive houses have very low energy demand and provide high levels of thermal comfort without the use of conventional heating or cooling technologies.[11] In Europe alone, the number of such buildings tripled between 2000 and 2012, with Germany and Austria leading this growth.[12]

Net zero energy buildings (NZEBs) and nearly zero energy buildings (nZEBs) are those in which energy demand is greatly reduced through efficiency improvements, and all (or nearly all, in the case of nZEBs) remaining energy needs are satisfied with renewable energy.[13] New NZEBs are inaugurated every day in numerous countries, providing evidence that NZE performance is achievable in a variety of locations and climates.[14] Emerging NZEB-related trends and lessons include:

- Public buildings are being used increasingly to demonstrate the feasibility of nZE and NZE, helping to educate people about potential benefits. In North America, public buildings account for two-thirds of existing NZE projects, and US public benefits programmes have resulted in successful pilot NZEBs in Oregon and California.[15]
- Large NZE buildings (with floor area of 5,000 m[16] or greater) are becoming more common.[17]
- Architects around the world are becoming more familiar with nZE design. In 2014, the International Union of Architects agreed unanimously to adopt the 2050 Imperative, committing member organisations (which represent more than 1.3 million architects in 124 countries) to 100% nZE design by 2050.[18]
- North America has demonstrated that NZE performance is not restricted to new construction; 24% of verified NZE buildings in the region comprise renovation projects.[19] The focus on existing buildings for NZE/nZE projects and targets is rising, most notably in several EU countries.
- Projects are more frequently expanding beyond single buildings, with the overall energy balance measured for a portfolio of neighbouring buildings or an entire district under a common NZE target. In North America, for example, there are 18 NZE districts, including U.S. Army facilities and several universities.[20]
- Although most of the existing NZEB projects are located in developed countries, pilot NZEBs have been built in several developing countries and emerging economies, including China, Kenya, Malaysia, and Taiwan.[21]
- Additional investment costs for NZEBs (in comparison to similar conventional buildings) are estimated in the range of 5–19%. Return on investment for energy efficiency, without subsidy, is estimated to be 5–12%.[22]

The efficiency of a building is determined predominantly by its design and systems, including heating and cooling. Heat pumps—whether air-, ground-, or water-sourced—can be an efficient technology for meeting heating and cooling needs. Between 2011 and 2014, the global market for heat pumps grew from approximately 1.5 million units to 2 million units, driven largely by Asia, and in particular China.[23] Heat pumps have the potential to provide some renewable energy content for heating and cooling in buildings. (→ See Sidebar 4, GSR 2014.) Synergies exist, as it is far easier to meet heating and cooling demand with heat pumps if buildings have efficient envelopes; the same applies for solar thermal and modern biomass systems.

Appliances and electronics used within a building complete the picture. Large appliances—such as refrigerators, washing machines, and dryers—are responsible for a significant share of residential electricity consumption.[24] Due to efficiency improvements, the energy consumption of large appliances has declined rapidly. Energy use in refrigerators, for example, decreased from a range of 450–800 kWh per year in 1996 to 250–400 kWh per year in 2011 (refrigerators in the EU demonstrated the highest efficiency throughout this period).[25]

Televisions (and computer monitors) also have experienced significant efficiency advances over the past decade, including the replacement of cathode ray tubes (CRTs) with flat panel technologies (liquid crystal display (LCD) and plasma display panel (PDP)); the transitions from analog to digital and from cold cathode fluorescent lamp (CCFL) backlights to light-emitting diode (LED) backlights; and the adoption of power management systems for televisions.[26] Among technologies commercially available in 2015, the most efficient models have demonstrated energy savings in the range of 32–71% compared to conventional CCFL backlit LCD televisions.[27] Between 2010 and 2014, global shipments of less-efficient CCFL-LCDs decreased by almost 90%, while those of LED-LCDs increased eightfold.[28]

The global lighting market is in the process of transitioning from energy-intensive incandescent lamps to LEDs.[29] LED lamps consume up to 90% less energy than traditional incandescent bulbs to produce the same light output, and can provide an estimated six times as many hours of illumination.[30] In recent years, LED technology has advanced rapidly, while costs have dropped significantly; the cost of a 60-watt-equivalent LED bulb fell nearly 40% between 2011 and 2012.[31] National bans on incandescent light bulbs have led to a proliferation of LED products on the market in a number of countries, resulting in rapid deployment.[32] Leading LED markets include Europe (23% of the global market), China (21%), the United States (19%), and Japan (9%).[33]

Appliances and equipment consume energy when they are in active operation. In addition, many also consume energy when they are not performing their main function, as they draw "standby power" to maintain signal reception, power an internal clock, or for other purposes. In most developed countries, standby power typically represents 5–10% of residential electricity use; in developing countries (particularly in cities), standby consumption represents a smaller but growing share. In commercial buildings, standby consumption makes up a smaller but still significant share of total electricity use. Standby consumption per unit has declined in recent years due to regulations that were in place in most developed countries by 2010.[34]

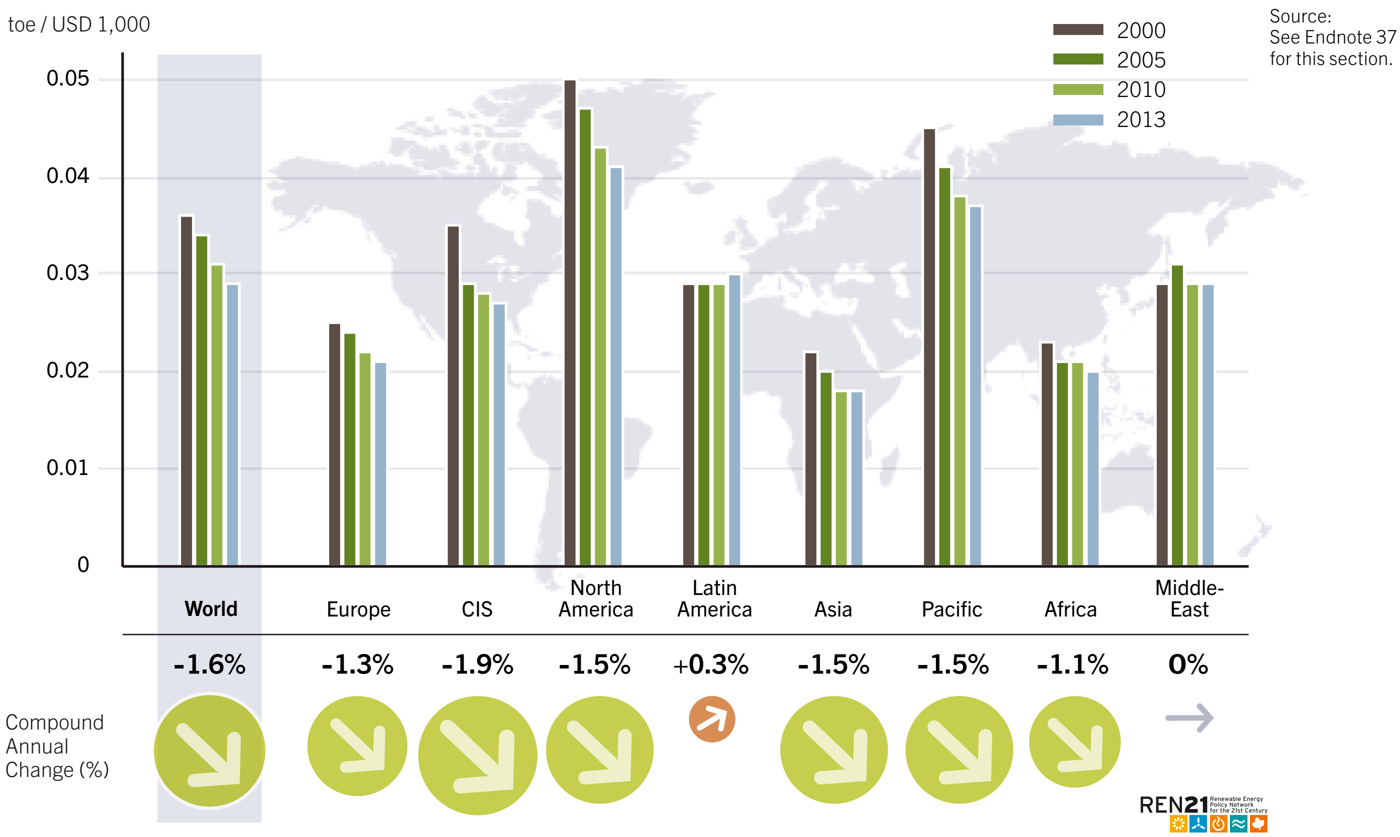
TRANSPORT

Transport accounts for just under 30% of global final energy demand.[35] Of that total, road transport (including light vehicles, buses, and heavy trucks) accounts for 81.4% of transportation energy use, compared to 8% for air transport, 4.5% for water, 3.8% for pipeline, and 2.3% for rail.[36] Most emphasis on efficiency improvements to date has been in the area of road transport.

Key trends in the road transport sector have included fuel-economy improvements in private vehicles, increased penetration of electric (EV) and hybrid (HEV) vehicles, and shifts to more sustainable modes of passenger travel (e.g., public transportation, rail, and bus rapid transit (BRT) systems[i]). As a result, fuel economy performance has improved steadily over the past 15 years. Both globally and in several regions (the exceptions being Latin America and the Middle East), average energy intensity[ii] in this sector declined substantially from 2000 to 2013.[37] (→ See Figure 38.)

In the United States, for example, the fuel economy of cars and light trucks has improved by approximately 25% during the past decade, and by 85% since 1975. The most advanced diesel and gasoline model cars available on the US market in 2014—all gasoline hybrid vehicles—had fuel economy values in the range of 30–32 kilometres per litre (70–76 miles per gallon).[38]

Figure 38. Energy Intensity in Transportation by Country and Region, 2000, 2005, 2010, and 2013



i - BRT is a high-quality bus-based transit system that delivers fast, comfortable, and cost-effective services at metro-level capacities.

ii - The energy intensity of the transport sector is calculated as the ratio of the energy consumption of transport to GDP. It is not related to the value added of the sector, as this value added reflects only the activity of transport companies, which represent only a part of the total consumption of the sector (e.g., usually less than 60% in EU countries).

Electric vehicles convert about 59–62% of electrical energy from the grid to power at the wheels; this compares to conventional gasoline vehicles that convert only about 17–21% of the energy stored in gasoline to power at the wheels[i].[39] Between 2008 and 2013, global sales of EVs rocketed from approximately 10,000 vehicles to more than 400,000 vehicles, with a growth rate averaging more than 100% annually.[40] The share of EVs in the global and national markets is still small, however. In 2013, the highest market share was achieved by Norway (6.1%), followed by the Netherlands (5.6%) and California (4%, compared with 1.3% in the United States as a whole).[41]

Switching from private cars to public transport, such as BRT systems, also can help to increase efficiency of mobility. As of 2013, more than 150 cities around the world had implemented some kind of BRT system, providing mobility to an estimated 28 million passengers each weekday.[42]

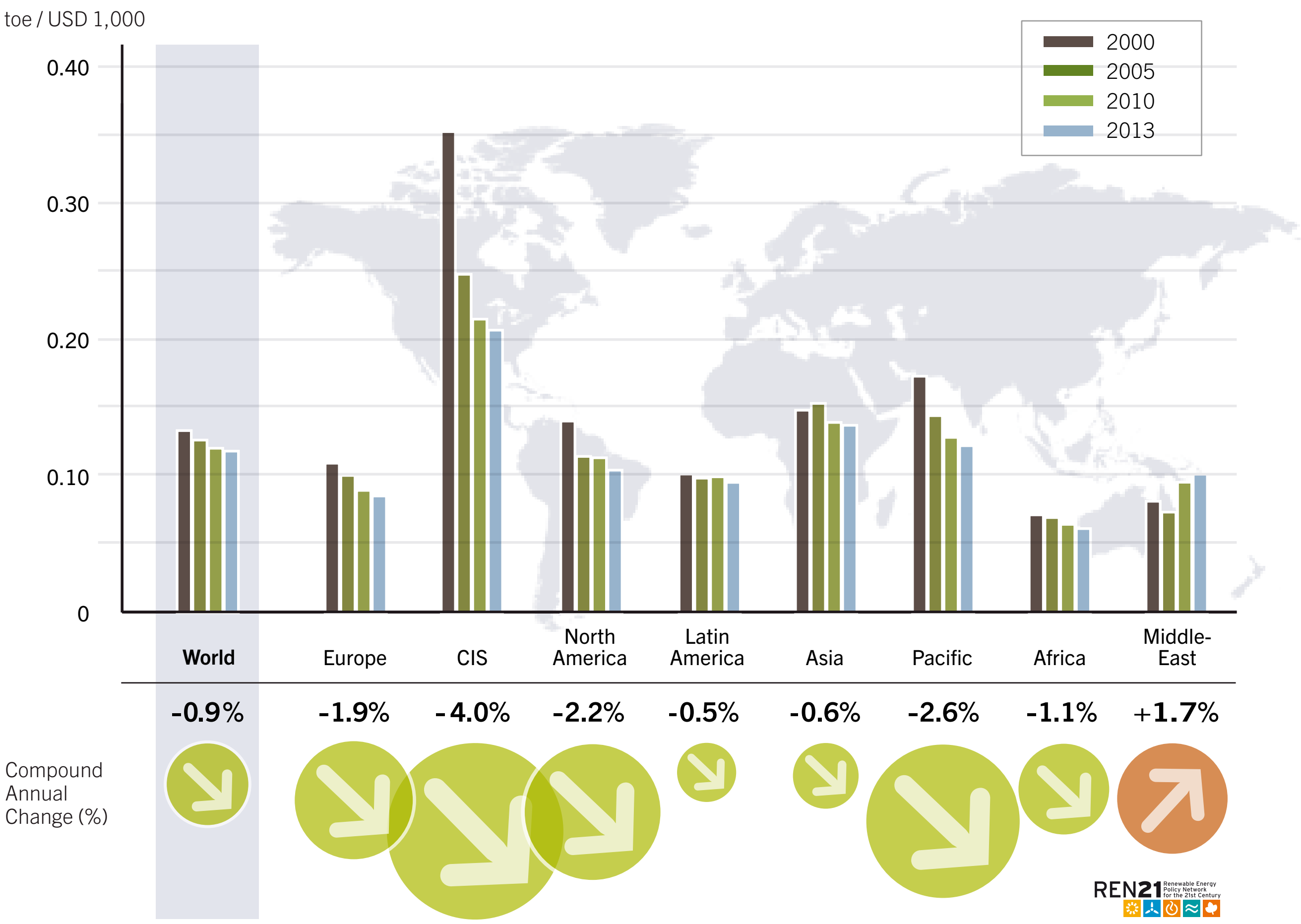
INDUSTRY

Approximately 40% of global final energy consumption occurs in the industrial sector in the forms of electricity, heat, and mechanical energy.[43] Between 2000 and 2013, global energy intensity of this sector declined steadily; energy intensity dropped in most of the world's regions as well, with the exception of the Middle East.[44] (→ See Figure 39.)

The most energy-intensive industries are chemical (including refineries), metals and alloys, pulp and paper, and cement.[45] Each of these industries offers substantial potential for energy efficiency improvements through the application of existing best practices. The technical potential to reduce energy use at the global level is estimated to be 26% in the pulp and paper industry, 24% in the chemical industry, 21% for iron and steel, 18% in the cement industry, and 11% for aluminium production.[46]

A positive trend that is improving energy efficiency in this sector is the expanded implementation of energy management systems (EnMS) at industrial facilities, particularly under the International Organization for Standardization (ISO) standard 50001[ii]. EnMS was implemented at more than 7,300 sites worldwide between 2011 (when ISO 50001 was established) and May 2014.[47]

Figure 39. Energy Intensity in Industry by Country and Region, 2000, 2005, 2010, and 2013



Source: See Endnote 44 for this section.

i - For a full accounting of well-to-wheel energy use in internal combustion engines, it would be necessary to calculate the energy involved in extracting, refining, and transporting fuel; likewise, for EVs, one must account for extracting and transporting fuel to power plants, energy loss in power generation, and losses associated with power transmission. EV efficiency increases significantly if the electricity source is renewable, particularly if generated on-site.

ii - EnMS enable manufacturers, corporations, utilities, energy service companies, and other organisations to reduce energy costs and carbon emissions. An increasing number of facilities is operating under ISO 50001, an energy management framework for organisations and facilities to manage their energy consumption, covering various aspects of energy procurement and use.

POLICIES TO ADVANCE ENERGY EFFICIENCY

Drivers for policies to promote energy efficiency improvements include advancing energy security, supporting economic growth, and mitigating climate change.[48] Energy efficiency improvements also are important for economic competitiveness.[49] In poorer countries, increased efficiency (in appliances and light bulbs, for example) can make it easier to provide energy services to those who lack access.[50] To that end, an increasing number of countries has enacted policies to improve the energy efficiency of buildings, appliances, transport vehicles, and industry.

Targets to advance energy efficiency have been established at all levels of government, including the regional level. In late 2014, the European Union set a non-binding target to achieve an efficiency improvement of at least 27% by 2030 (in relation to the 1990 level), up from its 2020 target of 20%. To achieve the initial 2020 EU-wide target, several Member States have established national indicative targets for 2020. During 2013–14, 14 Member States[i] set targets for country-wide energy savings, and 20 EU countries submitted National Energy Efficiency Action Plans (NEEAP) outlining how they would achieve their targets.[51]

Beyond the EU, other countries and regions that have adopted energy efficiency targets include China, India, South Africa, Thailand, the United States, and all ECOWAS[ii] countries in Africa. In early 2015, China's premier announced government plans to reduce the nation's energy intensity by 3.1% during 2015 (compared with a 4.8% reduction in 2014).[52]

To achieve their targets, governments are introducing new regulations or updating existing ones to drive efficiency improvements in all sectors of the economy. In the building sector, recent developments include: British Columbia's (Canada) introduction of more-stringent energy efficiency requirements for single-family houses and small buildings in 2014; Belgium and Lithuania's adoption of new building energy performance requirements in 2013; the United Kingdom's 2013 Energy Companies Obligation scheme, which aims to reduce national energy consumption while also providing support for people living in fuel poverty; and Vietnam's introduction, also in 2013, of a new building code that includes energy efficiency requirements.[53]

Standards and labelling programmes are the primary tools used to improve the efficiency of appliances and other energy-consuming products. By 2014, 81 countries had such programmes, and mandatory energy performance standards covered 55 product types, with refrigerators, room air conditioners, lighting, and televisions the most commonly regulated. The number of all types of standards and labelling measures (related to energy performance) around the world has nearly tripled over the past decade, exceeding 3,600 in 2014.[54]

Several standard and labelling schemes were extended or strengthened over the past two years. For example, Poland, Japan, and South Korea each expanded coverage to all energy-consuming products (previously they targeted only domestic appliances). Germany introduced a voluntary labelling scheme, "TOP 100 – Eco-label for Climate-Relevant Products", to identify and label the most energy-efficient products.[55] Other countries are in the process of developing standards and labelling programmes. For example, Côte d'Ivoire is developing standards and labels for household appliances under its Strategic Development Plan for 2011–2030.[56]

Particularly in developing and emerging economies, energy efficiency of cooking technology has become important, and several countries have begun to adopt related regulations and standards. For example, Iran implemented energy performance standards (EPS) for cookstoves and hobs/cooktops in 2013, and Vietnam adopted mandatory labelling in 2013 and EPS for rice cookers the following year. Other countries in the process of considering or developing similar instruments include Bangladesh, Chile, Indonesia, and Mexico.[57] Furthermore, several developing countries have programmes to promote efficient cookstoves, including Burkina Faso, the Gambia, Ghana, Guinea, Mali, Niger, Senegal, and Togo.[58]

Energy efficiency standards and labelling also focus increasingly on the transport and industrial sectors. In transport, recent

i - They include Belgium, Bulgaria, Cyprus, Estonia, France, Hungary, Italy, Latvia, the Netherlands, Poland, Portugal, Romania, Slovenia, and the United Kingdom.

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

developments include: the United States and Canada set fuel economy standards to 2025; Mexico set its first standards; the European Union, China, and Japan tightened and extended light-duty fuel economy standards; India developed standards and is approaching their implementation; Chile introduced its first fuel economy labelling policy; and Mauritius developed and implemented the developing world's first fuel economy/CO_2-based feebate system (with fees and rebates based on vehicle fuel efficiency).[59] As of late 2014, vehicle fuel economy standards covered 70% of the world's light-duty vehicle market.[60]

In the industrial sector, energy performance standards often target specific equipment. By the end of 2013, standards for electric motors used in industrial applications had been introduced in 44 countries, including Brazil, China, South Korea, and the United States.[61] In 2013, China mandated the implementation of provincial-level energy management programmes targeting large energy users across the country.[62] In the United States, 41 states operate ratepayer-funded energy efficiency programmes, and state energy offices in 35 states have industrial energy efficiency programmes that are separate from, or in support of, ratepayer-funded programmes.[63]

Fiscal incentives—such as rebates, tax reductions, and low-interest loans—also have been used to stimulate improvements in energy efficiency. For example, several European countries have enacted fiscal incentives in the building sector. In 2014, Italy and the Netherlands established revolving funds to help finance energy efficiency projects in buildings (also covering industrial installations and production processes in Italy); the Czech Republic established a green investment scheme, New Green Savings 2014+, which will allocate USD 83 million (CZK 1.9 billion) from revenues of emissions allowances (EU-ETS) auctions for efficiency improvements in buildings; and, in 2013, Poland launched two grant programmes to encourage efficiency in buildings.[64] This Energy Efficiency Housing Programme provides performance-based grants to homeowners for renovations or highly efficient construction, and a similar programme for public buildings offers grants in the range of 30–70% of investment depending on the energy efficiency class of the building.[65]

In the transport sector, fiscal incentives have included tax credits and rebates for energy-efficient vehicles, including EVs. In 2013, Poland introduced a financing scheme to support projects with the goal of reducing energy consumption in urban transport. Beneficiaries include municipalities, utility companies that serve local public transport authorities, and other urban transport service providers under contract with municipalities.[66] The United States and France offer rebates for fuel-efficient HEVs and EVs.[67]

Fiscal incentives also are used in the industry sector. In 2014, Turkey announced amendments to its investment incentive scheme with the aim of encouraging energy efficiency in industrial facilities.[68] Germany introduced two subsidy programmes to support company investment, certification, and measuring related to energy efficiency.[69] As of 2014, more than 40% of EU Member States had incentives in place to encourage the use of EnMS, around 15% of Member States had incentives for environmental management systems, and almost 35% of Member States had voluntary agreements. [70] Furthermore, market mechanisms exist to promote energy efficiency such as white certificate schemes, the energy efficiency equivalent of green certificate schemes used for renewables.

POLICIES TO ADVANCE THE RENEWABLE ENERGY–ENERGY EFFICIENCY LINK

Although a large and increasing number of countries has established policies to support energy efficiency and renewable energy separately, to date there has been relatively little systematic linking of the two in the policy arena. In some cases, energy efficiency and renewables are even put in competition with each other.[71] However, a small but growing number of policies has begun to address efficiency and renewable energy in concert, particularly through building-related incentives and economy-wide targets and regulations.

Three main approaches have been taken thus far: encouraging renewables and energy efficiency in parallel on an economy-wide basis (e.g., parallel targets for both); integrating renewables and energy efficiency under the same economy-wide basis (e.g., Renewable Portfolio Standards, RPS, that can be met with either/both); and requiring the joint implementation of renewables and energy efficiency (e.g., energy efficiency upgrades required before renewables can be implemented).

Recent targets that combine efficiency and renewables have been adopted by several individual countries as well as at the EU level. For example, alongside its energy efficiency targets for 2020 and 2030, the European Union has committed to increasing the renewable share in the overall energy mix (to 27% by 2030).[72] In 2013, India introduced its 12th Five-Year Plan (2012–17), which focuses on actions required to achieve its targets to reduce energy intensity 20–25% by 2020, and to add 30 GW of renewable energy capacity during 2012–17.[73] Also in 2013, Japan adopted a Low Carbon Technology Plan to develop and diffuse energy efficiency and renewable energy technologies through innovation and government support policies.[74]

To achieve an EU Directive requiring all Member States to ensure that public buildings and all new construction are nZE by the end of 2018 and 2020, respectively, several EU states—including Belgium, Denmark, France, Germany, Italy, and the United Kingdom—have established intermediate targets for public buildings.[75] These targets vary by country according to factors such as building size and the target year.[76] Targets have been used to promote efficiency and renewables in the transport sector as well. The Czech Republic, for example, adopted a target in 2014 to increase the share of renewables in total transport energy consumption to 10% by 2020, while also reducing energy consumption and emissions.[77]

Some policymakers are using regulations to advance efficiency and renewables in combination. In early 2015, Switzerland established rules for building energy codes that include nZEB standards from 2020 onwards (similar to EU requirements under the EU Energy Performance of Buildings Directive) and a 10% renewable requirement for heating system retrofits.[78] In 2014, the US state of California began implementing its revised building code, which requires that all new residential and commercial buildings be NZE by 2020 and 2030, respectively.[79]

Although building regulations are set at the federal level in Australia, Sydney provides an example of an integrated approach to energy efficiency and renewable energy planning in buildings at the local level. As of early 2015, the city was in the process of consulting on its draft Energy Efficiency Master Plan, which is intended to reduce energy use in buildings (and associated greenhouse gas emissions) and will be implemented alongside the city's Renewable Energy Master Plan and its Trigeneration Master Plan.[80]

In addition to targets and regulations, several countries have used fiscal incentives to advance renewables and efficiency in parallel. In early 2014, California took steps to address mortgage lenders' concerns in order to revive its successful PACE financing programme that has supported energy efficiency improvements in buildings and rooftop solar PV installations.[81] In early 2015, 38 California cities and three counties launched a new PACE programme.[82]

Also in early 2015, Germany revised subsidy guidelines to boost the renewable share of heat in buildings in order to meet its climate targets; the incentive programme supports solar heat as well as energy efficiency.[83] Colombia enacted Law 1715 in 2014 to promote the development of renewable energy sources and their integration into the power market, while also establishing the legal framework and financial instruments to promote energy efficiency, including the creation of a Non-Conventional Energy and Efficient Energy Management Fund to help finance these initiatives.[84] In 2013, Luxembourg adopted a scheme that provides grants for projects that improve energy savings and increase the use of renewable energy sources in existing and new high-performance structures.[85] That same year, Italy introduced an incentive that covers up to 40% of investments in energy efficiency improvements in existing buildings, small-scale high-efficiency systems, and/or renewable thermal energy technologies.[86]

In other sectors, examples of fiscal incentives for renewables and efficiency combined exist but appear to be more limited. Poland, for example, introduced a five-year programme in 2013 to provide investment grants (up to 45%) for projects that reduce emissions from urban transport, including the use of energy efficiency and renewable energy.[87]

Despite the actions taken towards improving energy efficiency and combining these efforts with renewable energy applications, there is still the risk of the rebound effect. Rebound occurs when cost savings from greater efficiency stimulate greater utilisation (e.g., running an individual appliance or vehicle for more hours, or operating more units, such as larger numbers of light bulbs or appliances). However, the still-limited number of studies makes it impossible to draw conclusions regarding rebound impacts in a typical energy efficiency project.[88]

07

Natural ecosystems can provide lessons about adaptability and system resilience. **MANGROVES** demonstrate considerable resilience in a dynamic environment, adapting constantly to changing water levels, fluctuating levels of salinity, and shifting landforms. Due to their structure and functionality, **renewable energy systems** can improve the resilience of existing energy systems and ensure the delivery of energy services under **changing climatic conditions**.

07 FEATURE: USING RENEWABLES FOR CLIMATE CHANGE ADAPTATION

Laura E. Williamson (REN21 Secretariat)

There is unequivocal scientific evidence that the earth's climate is warming and that recent observed changes in the climate are very likely due to a rise in greenhouse gases produced by human activity. While uncertainty remains about the precise extent of climate change and its effects, the most recent assessment of the Intergovernmental Panel on Climate Change (IPCC) concludes that climate change will affect both the frequency and severity of extreme weather.[1]

Examples of increased climate variability include: heightened intensity of rainfall (leading to flooding), storm surges, landslides, extreme winds, freezing conditions, heat waves, and seasonal droughts. Each of these will have an impact on a country's infrastructure, such as roads, bridges, tunnels, food and water supply, sewers, telecommunications, and energy systems.

Although modern energy systems are susceptible to multiple factors unrelated to weather—such as war, earthquakes, fuel supply shortages, and terrorism—extreme weather and other impacts associated with climate change will further increase the vulnerability of energy infrastructure. Natural disasters that interrupt fuel supply chains and disrupt service are on the rise.[2] Moreover, many developing countries depend heavily on traditional biomass for energy; climate-related declines in vegetation can lead to resource scarcity, reducing basic energy access for vulnerable populations. Given the central role that energy plays in economic development and in the overall functioning of society, it is important that energy systems continue to function regardless of varying weather conditions. The use of renewable energy sources (as opposed to fossil fuels) can play a central role.

Adaptation refers to adjustments in a system in response to actual or expected stimuli and their effects or impacts in order to moderate or avoid harm.[3] In the context of climate change, adaptation refers to changes in processes, practices, and structures that moderate potential damages or capture benefits created by shifts in weather patterns.[4] The United Nations Framework Convention on Climate Change (UNFCCC) notes that adaptation to the adverse effects of climate change, responding to changes that are happening already while simultaneously preparing for future impacts, is vital. Even with a decrease in carbon emissions, societies will still need to adapt to changes caused by past and future emissions.[5]

It is widely recognised that the use of renewable energy is critical in mitigation—efforts to reduce the scale and rate of climate change.[6] However, renewable energy is also an important component of climate change adaptation: 1) in improving the resilience of existing energy systems in the face of the impacts of a changing climate; and 2) in ensuring the delivery of energy services—including lighting, heating, and cooling—under changing climatic conditions.[7]

INCREASING RESILIENCE WITH RENEWABLES

An element of climate change adaptation is to increase the resilience of energy systems to meet demand despite climate-related threats.[8] All energy systems are susceptible to climate variability and extremes. For example, decreasing water levels and droughts can lead to the shutdown of thermal power plants that depend on water-based cooling systems.[9] Dry periods, alternating with floods, can shift erosion and deposition patterns, altering growth rates of biomass and affecting the quality and quantity of the potential fuel output.[10] The melting of glaciers, induced by temperature increases, can have a negative effect on hydropower systems by causing infrastructure damage from flooding and siltation, as well as affecting generation capacity. The efficiency of solar PV declines with high temperatures and dust accumulation, and most of today's wind turbines shut down in winds exceeding 100 to 120 kilometres per hour[i].[11]

Typical responses to reducing system vulnerability involve reinforcing existing infrastructure (including strengthening transmission towers and lines); ensuring redundancy of critical systems; building seawalls around power plants; reducing the need for power plant cooling water; and storing larger quantities of fuel at plants.[12] More-innovative strategies include local generation and storage, diversification of energy sources, use of a combination of smart grids and technologies, and improving capabilities to couple and decouple individual systems from the central grid system during emergencies.

Although renewable energy systems are also vulnerable to climate change, they have unique qualities that make them suitable both for reinforcing the resilience of the wider energy infrastructure and for ensuring the provision of energy services under changing climatic conditions. System modularity, distributed deployment, and local availability and diversity of fuel sources—central components of energy system resilience—are key characteristics of most renewable energy systems.[13] Ultimately, renewable energy systems improve the resilience of conventional power systems, both individually and by their collective contribution to a more diversified and distributed asset pool.

i - New technologies are coming onto the market to address the issue of wind turbine shutdown at high wind speeds.

Modularity: Numerous renewable energy technologies are modular in design[i]; they are scalable, allowing for units to be added (or brought on line) as changes are required in energy services. The relatively short planning cycle for many renewable energy technologies provides a level of flexibility not found in fossil fuel- or nuclear-powered generation—months versus years. This can be particularly important when populations are uprooted by climate change, as is occurring in many low-lying island states.[14]

The modularity of renewables (especially for some solar technologies) also allows for the quick provision of services in emergency situations.[15] Hurricane Sandy was a devastating storm that affected the entire Atlantic coastline of the United States, as well as inland communities, and left 8.5 million people without power.[16] In the New York area of Long Island, 90% of Long Island Power Authority's (LIPA's) 1.1 million customers had no power for days and in some cases weeks. In the interim, renewables provided needed power. The Solar Sandy Project, for example, supplied mobile solar generators[ii] to an area where LIPA had struggled to restore power, providing critical energy services to people affected by the outage.[17]

Distributed and Decentralised Deployment: Renewable energy technologies can be distributed; hence, weather-related events are less likely to adversely affect large portions of the power supply infrastructure to a great extent.[18] Moreover, distributed systems can continue to perform even if the connection of one or more of the units to the grid is disrupted. The systems have the potential to recover function, reduce cascading blackouts, restore critical services faster, and ensure overall security of supply.[19] However, most grid-connected renewable energy power today needs a grid to synchronise. Thus, in the case of a central power system failure, distributed generation also fails. This limitation is not due to the technology itself, but rather is a result of how the grid is managed. Some countries, such as Germany, are seeking to address this issue by implementing methods to stabilise the grid in extreme events.[20]

Redundancy: The traditional way to increase system resilience is to build redundancy into the system. This entails having multiple distribution systems available so that if one form of delivery—for example, transmission lines—is not functioning, there is an alternative way to ensure access to energy, either from the initial power source or by bringing an alternative system on line. A common way to establish electric power redundancy is to install backup generation. In many countries, regulations require critical facilities (refineries, hospitals, data and communication centres, etc.) to have backup power systems, which are typically diesel-powered. Renewables may be suitable in many instances to replace these diesel generation backup systems, which are dependent on a regular fuel supply, costly, and often polluting.[21]

Availability: Renewable resources in one form or another are available wherever people live, albeit with greater variety and/or better resources in some areas than others.[iii] Whichever are in greatest abundance in a particular location can be used to power renewable energy technologies to meet energy needs. Moreover, fuel storage and transport are vulnerable when infrastructure—road, rail, docks—is damaged through sea-level rise, storm surge, landslides, flooding, and high winds. Using locally available renewable resources avoids potential disruptions in the fuel delivery chain.[22]

Diversity: A diverse portfolio of renewable resources can help to hedge the climatic stresses that individual resource types may face. Several regions of the world rely heavily on large-scale hydropower for electricity supply: for example, it accounts for 50–60% of electricity in Latin America. Complementing existing hydro-dependent energy systems with non-hydro systems is one approach to reducing vulnerabilities.[iv] In response to hydropower shortfalls, Brazil, Kenya, and Uruguay, among other countries, are expanding other renewable energy capacity to hedge hydropower risks.[23]

i - Examples include solar PV, wind, solar water heating and cooling, and biomass digesters.

ii - The generators were used to charge phones, heat food, and run other critical equipment. The area also was served by Rolling Sunlight, a massive, mobile, solar power array strapped to a truck. Run by Greenpeace, the system is able to store 50 kWh of energy. The solar panels charge an array of batteries inside the truck, which then feeds an inverter, generating 120/240 AC. The system can run enough lights to keep a decently sized area lit through the night.

iii - For example, the availability of modern (sustainably produced) biomass can vary significantly by region.

iv - For example, in drought-stricken Brazil, a severe drop in water availability has reduced hydropower generation and has led to blackouts across the country.

RENEWABLES FOR ENSURING ENERGY SERVICES

In addition to being resilient—as individual, often distributed units, or as part of a larger diversified energy system—renewable energy can ensure the delivery of energy services in direct response to climate change impacts.

In Ghana, electricity demand is increasing by 10% annually; however, changing climatic conditions in western Africa have reduced annual precipitation rates and raised average temperatures, thereby reducing hydropower output.[24] The result is a national power crisis. The Ghanaian Energy Commission recently indicated that solar energy can help respond to electricity needs while simultaneously addressing concerns about system resilience and independence from fossil fuel imports.[25] There also is an emerging discussion that the relationship between climate change and a stable energy supply should be part of the larger discussion on national energy security.[26]

In the lowlands of Nepal, the changing frequency and intensity of rainfall has forced communities to complement local water supply with pumped groundwater. Solar PV pumps draw up groundwater, which then is purified using solar water-purification systems. The motivation for a renewable-powered system is to ensure stable and resilient energy supply to the water system, to respond to changing rainfall patterns, and to mitigate carbon emissions.[27]

As noted earlier, climate change can create the conditions for temperature extremes. Larger-scale applications, such as district cooling and heating systems, can use renewable resources to help meet increased load. Situated in wind-swept, cloud-covered northern Europe, Copenhagen, Denmark, is not the first city to come to mind in need of air conditioning, particularly as summer temperatures rarely exceed mid-20° C. However, the City of Copenhagen expects cooling demand to increase in the coming decades. Peak summer high temperatures, mild compared to warmer climes, are expected to rise 2–3% by 2050, with average daily temperatures rising as well. Using sea water drawn from the city's harbour in a district cooling system allows the city to adapt to these anticipated temperature rises without increasing carbon emissions.[28]

MOVING FORWARD

There is increasing awareness that in order to provide needed energy services in a climate-constrained environment, future energy systems need to be resilient and to maintain service even under extreme, changing, or unpredictable conditions by being robust, yet flexible and adaptive.[29]

However, discussion about the specific role of renewables in energy system resilience, and in adaptation activities more broadly, is still relatively limited. Most literature focuses on power infrastructure and looks primarily at how renewable energy can contribute to disaster recovery, as well as at the backup functions that renewables can provide in cases of increased demand or grid failure. Although the impact of climate variability on energy systems is being discussed increasingly (at the national and local levels, in various research fora, through regional initiatives and international bodies such as the UNFCCC, and in an expanding number of documents and studies), the focus primarily is on identifying the impacts currently being witnessed and anticipating future impacts.[30] Little is written about the proactive role that renewable energy can play in increasing energy system resilience, and how these technologies can provide services as part of larger adaptation activities.

Nonetheless, there are signs that renewables should be considered as an integral part of a climate adaptation strategy. A 2014 US White House report on climate preparedness clearly states that when opportunities arise for planning and investment in the energy sector, climate-resilient, energy-efficient, and clean energy systems should be prioritised.[31]

The role of renewables has been proven in climate mitigation. As the effects of extreme weather are felt increasingly, more attention will need to be paid to how renewable energy can support adaptation activities so that energy services can be assured. Mitigation and adaptation responses to climate change cannot remain independent of each other. Rather, both responses need to occur simultaneously, illustrating their complementary nature and their collective role in meeting climate change challenges.[32]

TABLE R1. GLOBAL RENEWABLE ENERGY CAPACITY AND BIOFUEL PRODUCTION, 2014

	ADDED DURING 2014	EXISTING AT END-2014
POWER GENERATION (GW)		
Bio-power	5	93
Geothermal power	0.6	12.8
Hydropower	37	1,055
Ocean power	~0	0.5
Solar PV	40	177
Concentrating solar thermal power (CSP)	0.9	4.4
Wind power	51	370
HEATING / HOT WATER (GW_{th})		
Modern bio-heat	9	305
Geothermal direct use[1]	1.1	20
Solar collectors for water heating[2]	33	406
TRANSPORT FUELS (billion litres / year)		
Ethanol production	6.2	94
Biodiesel production	3.3	30
Hydrotreated vegetable oil (HVO)	0.8	4

[1] Estimates for 2014 do not include ground-source heat pumps in the geothermal direct use total.

[2] Solar collector capacity is for glazed and unglazed water systems only. Additions are net.

Note: Numbers are rounded to the nearest GW/GW_{th}/billion litres, except for numbers <15, which are rounded to the 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 Reference Tables R2–R10, Market and Industry Trends section, and related endnotes.

Source: See Endnote 1 for this section.

TABLE R2. RENEWABLE ELECTRIC POWER GLOBAL CAPACITY, TOP REGIONS/COUNTRIES, 2014

TECHNOLOGY	World	EU-28	BRICS	China	United States	Germany	Italy	Spain	Japan	India
	GW			GW						
Bio-power	93	36	29	10	16.1	8.8	4	1	4.7	5
Geothermal power	12.8	1	0.1	~0	3.5	~0	0.9	0	0.5	0
Hydropower	1,055	124	463	280	79	5.6	18	17.3	22	45
Ocean power	0.5	0.2	~0	~0	~0	0	0	~0	0	0
Solar PV	177	87	32	28	18	38	18.5	5.4	23	3.2
Concentrating solar thermal power (CSP)	4.4	2.3	0.2	~0	1.6	0	~0	2.3	0	0.2
Wind power	370	129	144	115	66	39	8.7	23	2.8	22
Total renewable power capacity (including hydropower)	**1,712**	**380**	**668**	**433**	**185**	**92**	**50**	**49**	**54**	**76**
Total renewable power capacity (not including hydropower)	**657**	**255**	**206**	**153**	**105**	**86**	**32**	**32**	**31**	**31**
Per capita capacity (Watts / inhabitant, not including hydropower)	90	500	70	110	330	1,070	530	680	250	20

Note: Global total reflects additional countries not shown. Table shows the top seven countries by total renewable power capacity, not including hydropower; if hydro were included, countries and rankings would differ somewhat (the top seven would be China, United States, Brazil, Germany, Canada, India, and Japan). Numbers are based on best data available at time of production. 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. Capacity amounts of <50 MW (including pilot projects) are designated by "~0." For more precise data, see Global Overview and Market and Industry Trends sections and related endnotes. Numbers 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 243.

Source: See Endnote 2 for this section.

TABLE R3. WOOD PELLETS GLOBAL TRADE, 2014

EXPORTER	IMPORTER	VOLUME (kilotonnes)	
		2013	2014
United States	EU-28	2,776	3,924
Canada	EU-28	1,963	1,166
Russia	EU-28	702	821
Ukraine	EU-28	165	137
Belarus	EU-28	116	126
Bosnia and Herzegovina	EU-28	171	178
Serbia	EU-28	70	71
Australia	EU-28	31	0
Norway	EU-28	48	18
Egypt	EU-28	17	20
Other	EU-28	23	33
EU-28	Switzerland	87	59
EU-28	Norway	30	27
EU-28	Japan	6	6
Canada	South Korea, Japan	250	503

Source: See Endnote 3 for this section.

TABLE R4. BIOFUELS GLOBAL PRODUCTION, TOP 16 COUNTRIES AND EU-28, 2014

COUNTRY	FUEL ETHANOL	BIODIESEL	HVO	TOTAL	CHANGE RELATIVE TO 2013
			billion litres		
United States	54.3	4.7	1.1	**60.1**	+ 3.9
Brazil	26.5	3.4		**29.9**	+ 1.6
Germany	0.9	3.4		**4.3**	+ 0.6
China	2.8	1.1		**3.9**	+ 0.3
Argentina	0.7	2.9		**3.6**	+ 0.8
Indonesia	0.1	3.1		**3.2**	+ 0.9
France	1.0	2.1		**3.1**	+ 0.1
Netherlands	0.4	0.7	1.7	**2.5**	+ 0.2
Thailand	1.1	1.2		**2.3**	+ 0.4
Canada	1.8	0.3		**2.1**	+ 0.1
Belgium	0.6	0.7		**1.3**	+ 0.2
Spain	0.4	0.8		**1.2**	+ 0.1
Singapore	0	0	1.0	**1.0**	+ 0.1
Poland	0.2	0.8		**1.0**	+ 0.1
Colombia	0.4	0.6		**1.0**	no change
Australia	0.2	0.1		**0.3**	- 0.1
EU-28	**5.2**	**11.6**	**1.8**	**18.6**	**1.9**
World	**94**	**29.7**	**4**	**127.7**	**10.4**

Note: All figures are rounded to the 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 2014, and not by energy content. Where numbers do not add up, it is due to rounding.

Source: See Endnote 4 for this section.

TABLE R5. GEOTHERMAL POWER GLOBAL CAPACITY AND ADDITIONS, TOP SIX COUNTRIES, 2014

	ADDED 2014	TOTAL END-2014
	MW	GW
TOP COUNTRIES BY TOTAL CAPACITY		
United States	4	3.5
Philippines	49	1.9
Indonesia	62	1.4
Mexico	-	1.0
New Zealand	-	1.0
Italy	40	0.9
TOP COUNTRIES BY NET ADDITIONS		
Kenya	358	0.6
Turkey	107	0.4
Indonesia	62	1.4
Philippines	49	1.9
Italy	40	0.9
Germany	18	0.03
World Total	**640**	**12.8**

Source: See Endnote 5 for this section.

TABLE R6. HYDROPOWER GLOBAL CAPACITY AND ADDITIONS, TOP SIX COUNTRIES, 2014

	ADDED 2014	TOTAL END-2014
	GW	GW
TOP COUNTRIES BY TOTAL CAPACITY		
China	22	280
Brazil	3.3	89
United States	0.0	79
Canada	1.7	77
Russia	1.1	48
India	1.2	45
TOP COUNTRIES BY ADDITIONS		
China	22	280
Brazil	3.3	89
Canada	1.7	77
Turkey	1.4	24
India	1.2	45
Russia	1.1	48
World Total	**37**	**1,055**

Note: Capacity additions are rounded to the nearest 0.1 GW and totals are rounded to the nearest 1 GW. Data reflect a variety of sources, some of which differ quite significantly, reflecting variations in accounting and methodology. For more information and statistics, see Hydropower text and related endnotes in Markets and Industry Trends section.

Source: See Endnote 6 for this section.

TABLE R7. SOLAR PV GLOBAL CAPACITY AND ADDITIONS, TOP 10 COUNTRIES, 2014

	TOTAL END-2013	ADDED 2014	TOTAL END-2014
		GW	
TOP COUNTRIES BY ADDITIONS			
China	17.5	10.6	28.2
Japan	13.6	9.7	23.3
United States	12.1	6.2	18.3
United Kingdom	3.4	2.4	5.2
Germany	36.3	1.9	38.2
France	4.7	0.9	5.7
Australia	3.2	0.9	4.1
South Korea	1.5	0.9	2.4
South Africa	0.1	0.8	0.9
India	2.5	0.7	3.2
TOP COUNTRIES BY TOTAL CAPACITY			
Germany	36.3	1.9	38.2
China	17.5	10.6	28.2
Japan	13.6	9.7	23.3
Italy	18.1	0.4	18.5
United States	12.1	6.2	18.3
France	4.7	0.9	5.7
Spain	5.3	~0	5.4
United Kingdom	2.8	2.4	5.2
Australia	3.2	0.9	4.1
India	2.5	0.7	3.2
World Total	**138**	**40**	**177**

Note: Country data are rounded to the nearest 0.1 GW; world totals are rounded to the 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 for Japan and Spain are converted to direct current (DC) from official data reported in alternating current (AC). Data reflect a variety of sources, some of which differ quite significantly, reflecting variations in accounting or methodology. "~0" denotes capacity additions of below 50 MW. For more information, see Solar PV text and related endnotes in Market and Industry Trends section.

Source: See Endnote 7 for this section.

TABLE R8. CONCENTRATING SOLAR THERMAL POWER (CSP) GLOBAL CAPACITY AND ADDITIONS, 2014

COUNTRY	TOTAL END-2013	ADDED 2014	TOTAL END-2014
		MW	
Spain	2,300	0	2,300
United States	882	752	1,634
India	50	175	225
United Arab Emirates	100	0	100
Algeria	25	0	25
Egypt	20	0	20
Morocco	20	0	20
Australia	12	0	12
China	10	0	10
Thailand	5	0	5
World Total	**3,425**	**925**	**4,350**

Note: Table includes all countries with operating commercial CSP capacity at end-2014. Several additional countries had small pilot plants in operation by year's end, including China (3.5 MW), France (at least 0.75 MW), Germany (1.5 MW), Israel (6 MW), Italy (5 MW), and South Korea (0.2 MW). National data are rounded to the nearest 1 MW, and world totals are rounded to the nearest 5 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 8 for this section.

TABLE R9. SOLAR WATER HEATING COLLECTORS GLOBAL CAPACITY AND ADDITIONS, TOP 12 COUNTRIES, 2013

	ADDED 2013			TOTAL END-2013		
	MW_{th}			GW_{th}		
COUNTRY	**Glazed**	**Unglazed**	**Total**	**Glazed**	**Unglazed**	**Total**
China[1]	44,492	0	44,492	262.3	0	262.3
United States	165	540	705	2.1	14.6	16.7
Germany	714	0	714	11.9	0.4	12.3
Turkey	1,344	0	1,344	11.0	0	11.0
Brazil	530	435	965	4.7	2.1	6.7
Australia	130	455	585	2.3	3.3	5.6
India[2]	770	0	770	4.3	0	4.3
Austria	125	1	126	3.2	0.4	3.5
Greece	159	0	159	2.9	0	2.9
Israel	294	2	296	2.9	0	2.9
Japan	102	0	102	2.9	0	2.9
Italy	208	0	208	2.6	0	2.6
Rest of World	**5,286**	**337**	**5,623**	**35.1**	**4.2**	**39.3**
World Total[1]	**53,260**	**1,690**	**54,950**	**348**	**25**	**373**

[1] In 2014, China settled on a new methodology for calculating cumulative capacity, which assumes a 10-year lifetime for Chinese-made systems. China and world data reflect this change.

[2] India data are by fiscal year rather than by calendar year.

Note: Countries are ordered according to total installed capacity. The order of top countries for additions in 2013 was: China, Turkey, Brazil, India, Germany, United States (slightly ahead of Germany if air collectors are included), Australia, Israel, Italy, Poland, Mexico, and Spain. Data are for glazed and unglazed water collectors; air collectors add almost 1.7 GW_{th} to the year-end world total. Additions represent gross capacity added; total end-2013 numbers include allowances for retirements. Numbers are rounded: added data for countries and rest of world are rounded to the nearest 1 MW_{th}, and for world are rounded to the nearest 10 MW_{th}; end-2013 data for countries and rest of world are rounded to the nearest 0.1 GW_{th}, and for world are rounded to the nearest 1 GW_{th}. 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 2013 is the most recent one for which firm global data and most country statistics are available. It is estimated, however, that 406 GW_{th} of solar thermal capacity (water collectors only) was in operation worldwide by the end of 2014. For 2014 details and source information, see Solar Thermal Heating and Cooling text and related endnotes in Market and Industry Trends section.

Source: See Endnote 9 for this section.

TABLE R10. WIND POWER GLOBAL CAPACITY AND ADDITIONS, TOP 10 COUNTRIES, 2014

	TOTAL END-2013	ADDED 2014	TOTAL END-2014
		GW	
TOP COUNTRIES BY ADDITIONS			
China[1]	75.5 / 91.4	20.7 / 23.2	95.8 / 114.6
Germany[2]	34.3	5.3	39.2
United States	61.1	4.9	65.9
Brazil	3.5	2.5	5.9
India	20.2	2.3	22.5
Canada	7.8	1.9	9.7
United Kingdom	10.7	1.7	12.4
Sweden	4.4	1.1	5.4
France	8.2	1	9.3
Turkey	3	0.8	3.8
TOP COUNTRIES BY TOTAL CAPACITY			
China[1]	75.5 / 91.4	20.7 / 23.2	95.8 / 114.6
United States	61.1	4.9	65.9
Germany[2]	34.3	5.3	39.2
Spain	23	~0	23
India	20.2	2.3	22.5
United Kingdom	10.7	1.7	12.4
Canada	7.8	1.9	9.7
France	8.2	1	9.3
Italy	8.6	0.1	8.7
Brazil	3.5	2.5	5.9
World Total	**319**	**51**	**370**

[1] For China, data to the left of the "/" are the amounts officially classified as connected to the grid and operational (receiving FIT premium) by year's end; data to the right are total installed capacity, most, if not all, of which was connected to substations by year's end. The world and rest-of-world totals include the higher figures for China. (See Wind Power text and related endnotes for more details.)

[2] For Germany, note that in 2013, 236 MW of onshore capacity was removed for repowering, and about 355 MW of capacity that was added offshore was not connected to the grid by year's end. In 2014, nearly 0.4 GW of onshore capacity was removed for repowering, and 1.3 GW of capacity (not included above) was installed offshore and awaiting grid-connection at year's end. (See Wind Power text and related endnotes for more details.)

Note: Additions represent gross capacity. Country data are rounded to nearest 0.1 GW; world data 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 or repowering/removal of existing projects. Data reflect a variety of sources, some of which differ quite significantly, reflecting variations in accounting or methodology. For more information, see Wind Power text and related endnotes in Market and Industry Trends section.

Source: See Endnote 10 for this section.

TABLE R11. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT, 2004–2014

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Billion USD										
NEW INVESTMENT BY STAGE											
Technology Research											
Government R&D	1.9	2.0	2.2	2.7	2.8	5.3	4.7	4.6	4.5	4.9	5.1
Corporate R&D	3.2	2.9	3.1	3.5	4.0	4.1	4.2	5.1	5.0	6.6	6.6
Development / Commercialisation											
Venture capital	0.4	0.6	1.2	2.1	3.2	1.6	2.5	2.5	2.4	0.7	1.0
Manufacturing											
Private equity expansion capital	0.3	1.0	3.0	3.6	6.8	2.9	3.1	2.5	1.7	1.4	1.7
Public markets	0.3	3.7	9.1	20.7	10.9	13.1	11.4	10.1	3.9	10.5	15.1
Projects											
Asset finance	30.4	52.5	84.7	110.4	135.4	120.0	154.6	181.2	163.2	154.6	170.7
(re-invested equity)	0.0	0.2	0.7	3.1	3.7	1.9	5.6	3.3	2.9	1.9	3.6
Small distributed capacity	8.6	10.3	9.5	14.1	22.3	33.4	62.2	76.1	78.8	54.9	73.5
Total New Investment	**45.1**	**72.9**	**112.1**	**153.9**	**181.8**	**178.5**	**237.2**	**278.8**	**256.4**	**231.8**	**270.2**
Merger & Acquisition Transactions	8.8	26.2	36.0	58.5	59.3	64.2	58.4	73.5	67.7	66.8	68.8
Total Transactions	**53.9**	**99.1**	**148.1**	**212.5**	**241.1**	**242.7**	**295.7**	**352.3**	**324.1**	**298.6**	**339.0**
NEW INVESTMENT BY TECHNOLOGY											
Solar power	12.0	16.3	22.1	38.0	60.8	63.7	103.3	155.7	144.3	119.8	149.6
Wind power	17.9	29.1	39.6	61.6	75.2	81.2	98.9	84.2	84.1	89.3	99.5
Biomass and waste-to-energy	7.4	9.6	12.1	15.8	16.9	13.9	16.0	17.4	12.4	9.3	8.4
Biofuels	3.9	9.6	28.4	28.7	19.2	10.2	10.1	10.4	7.0	5.5	5.1
Hydropower <50 MW	2.6	7.2	7.6	7.1	7.8	6.3	5.7	7.2	6.4	5.5	4.5
Geothermal power	1.2	1.0	1.5	2.0	1.7	2.9	3.0	3.7	1.8	2.2	2.7
Ocean energy	0.0	0.1	0.9	0.8	0.2	0.3	0.3	0.3	0.3	0,2	0.4
Total New Investment	**45.1**	**72.9**	**112.1**	**153.9**	**181.8**	**178.5**	**237.2**	**278.8**	**256.4**	**231.8**	**270.2**

Note: Data are based on the output of the Desktop database of Bloomberg New Energy Finance and reflect the timing of investment decisions.
The following renewable energy projects are included: all biomass, geothermal, and wind generation projects of more than 1 MW; all hydropower projects of between 1 and 50 MW; all solar power projects, with those less than 1 MW estimated separately and referred to as small distributed capacity; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more. Where totals do not add up, this is due to rounding.
For more information about the investment stages in this table, see Sidebar 5 in GSR 2013.

Source: See Endnote 11 for this section.

TABLE R12. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2012 / 2013 AND TARGETS

COUNTRY	PRIMARY ENERGY		FINAL ENERGY	
	Share	Target	Share	Target
EU-28			15%	→ 20% by 2020
Albania		→ 18% by 2020		→ 38% by 2020
Algeria				→ 40% by 2030
Armenia		→ 21% by 2020 → 26% by 2025		
Austria[1]			33%	→ 45% by 2020
Azerbaijan		→ 9.7% by 2020		
Barbados		→ 20% by 2016		
Belarus				→ 28% by 2015 → 32% by 2020
Belgium			7.9%	→ 13% by 2020
Bosnia and Herzegovina				→ 40% by 2020
Botswana				→ 1% by 2016
Brazil	41% (2014)			
Bulgaria			19%	→ 16% by 2020
Burundi				→ 2.1% by 2020
China				→ 11.4% by 2015 → 13% by 2017
Costa Rica			37%	
Côte d'Ivoire		→ 5% by 2015 → 15% by 2020 → 20% by 2030		
Croatia			18%	→ 20% by 2020
Cyprus			8.1%	→ 13% by 2020
Czech Republic[1]			12%	→ 13.5% by 2020
Denmark			27%	→ 35% by 2020 → 100% by 2050
Ecuador	9.3%			
Egypt		→ 14% by 2020		
Estonia			26%	→ 25% by 2020
Fiji				→ 23% by 2030
Finland			37%	→ 25% by 2015 → 38% by 2020 → 40% by 2025
France	9.5%		14%	→ 23% by 2020 → 32% by 2030
Gabon				→ 80% by 2020
Germany[1]			11% (2014)	→ 18% by 2020 → 30% by 2030 → 45% by 2040 → 60% by 2050
Greece[1]			15%	→ 20% by 2020
Grenada		→ 20% by 2020		
Guatemala				→ 80% by 2026
Hungary[1]			9.8%	→ 14.65% by 2020
India	2%			
Indonesia		→ 25% by 2025		

TABLE R12. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2012 / 2013 AND TARGETS (continued)

COUNTRY	PRIMARY ENERGY		FINAL ENERGY	
	Share	Target	Share	Target
Ireland			7.8%	→ 16% by 2020
Israel				→ 50% by 2020
Italy			17%	→ 17% by 2020
Jamaica			8%	→ 15% by 2020 → 20% by 2030
Japan	7.2%	→ 10% by 2020		
Jordan		→ 7% by 2015 → 10% by 2020		
Kosovo				→ 25% by 2020
Laos				→ 30% by 2025
Latvia			37%	→ 40% by 2020
Lebanon				→ 12% by 2020
Lesotho			3%	
Libya		→ 10% by 2020		
Lithuania		→ 20% by 2025	23%	→ 23% by 2020
Luxembourg			3.6%	→ 11% by 2020
Macedonia				→ 28% by 2020
Madagascar				→ 54% by 2020
Malawi		→ 7% by 2020		
Mali		→ 15% by 2020		
Malta			3.8%	→ 10% by 2020
Mauritania		→ 15% by 2015 → 20% by 2020		
Mauritius	4.2%	→ 35% by 2025		
Moldova		→ 20% by 2020		→ 17% by 2020
Mongolia		→ 20–25% by 2020		
Montenegro				→ 33% by 2020
Nauru				→ 50% by 2015
Nepal		→ 10% by 2030		
Netherlands[1]			4.5%	→ 16% by 2020
Nicaragua			75% (2014)	
Niger		→ 10% by 2020		
Norway			65.5%	→ 67.5% by 2020
Palau		→ 20% by 2020		
Palestinian Territories				→ 25% by 2020
Panama		→ 18.3% by 2023		
Philippines	38%			
Poland		→ 12% by 2020	11%	→ 15.5% by 2020
Portugal			26%	→ 31% by 2020
Romania			24%	→ 24% by 2020
Samoa		→ 20% by 2030		
Serbia				→ 27% by 2020
Slovakia			9.8%	→ 14% by 2020
Slovenia			22%	→ 25% by 2020

TABLE R12. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2012 / 2013 AND TARGETS (continued)

COUNTRY	PRIMARY ENERGY		FINAL ENERGY	
	Share	Target	Share	Target
South Korea		→ 4.3% by 2015 → 6.1% by 2020 → 11% by 2030		
Spain[1]			15%	→ 20.8% by 2020
St. Lucia		→ 20% by 2020		
Swaziland	17%			
Sweden[1]			52%	→ 50% by 2020
Switzerland		→ 24% by 2020		
Syria		→ 4.3% by 2030		
Tanzania			29%	
Thailand				→ 25% by 2021
Ukraine		→ 18% by 2030		→ 11% by 2020
United Kingdom			5.1%	→ 15% by 2020
Uruguay	49%	→ 50% by 2015		
Vietnam		→ 5% by 2020 → 8% by 2025 → 11% by 2050		
Zambia			10%	

[1] Final energy targets for all EU-28 countries are set under EU Directive 2009/28/EC. The governments of Austria, the Czech Republic, Germany, Greece, Hungary, Spain, and Sweden have set higher targets, which are shown here. The government of the Netherlands has reduced its more ambitious target to the level set in the EU Directive.

Note: Actual percentages are rounded to the nearest whole decimal for numbers over 10% except where associated targets are expressed differently. Some countries shown have other types of targets. (See Tables R13, R14, and R15.)

Source: See Endnote 12 for this section.

TABLE R13. SHARE OF ELECTRICITY GENERATION FROM RENEWABLES, EXISTING IN 2013 AND TARGETS

COUNTRY	SHARE	TARGET
EU-28	25.4%	
Algeria		→ 5% by 2017 → 27% by 2030
Antigua and Barbuda		→ 5% by 2015 → 10% by 2020 → 15% by 2030
Argentina		→ 8% by 2016
Australia		→ 20% by 2020
Austria	68.1%	→ 70.6% by 2020
Azerbaijan		→ 20% by 2020
Bahamas		→ 15% by 2020 → 30% by 2030
Bahrain		→ 5% by 2030
Bangladesh		→ 5% by 2015 → 10% by 2020
Barbados		→ 29% by 2029
Belgium	12.3%	→ 20.9% by 2020
Belize		→ 50% (no date)
Brunei Darussalam		→ 10% by 2035
Bulgaria	18.9%	→ 20.6% by 2020
Cabo Verde		→ 50% by 2020
Cambodia		→ 15% by 2015
Chile[1]	8.6% (2014)	→ 20% by 2025
Costa Rica	90%	→ 100% by 2021
Croatia	39%	→ 39% by 2020
Cuba		→ 24% by 2030
Cyprus	6.6%	→ 16% by 2020
Czech Republic	12.8%	→ 14.3% by 2020
Denmark[2]	43%	→ 50% by 2020 → 100% by 2050
Djibouti		→ 100% by 2020
Dominica		→ 100% (no date)
Dominican Republic		→ 10% by 2015 → 25% by 2025
Ecuador	48%	→ 85% by 2017
Egypt		→ 20% by 2020
Eritrea		→ 50% (no date)
Estonia	13%	→ 18% by 2015
Fiji		→ 100% by 2030
Finland	31%	→ 33% by 2020
France	20% (2014)	→ 27% by 2020
Gabon		→ 70% by 2020
Gambia		→ 35% by 2020
Germany	28% (2014)	→ 40–45% by 2025 → 55–60% by 2035 → 65% by 2040 → 80% by 2050
Ghana		→ 10% by 2020
Greece	21%	→ 40% by 2020
Guatemala		→ 80% by 2027
Guinea-Bissau		→ 2% by 2015
Guyana		→ 90% (no date)
Haiti		→ 50% by 2020
Honduras		→ 60% by 2022 → 80% by 2038
Hungary	6.6%	→ 10.9% by 2020
Indonesia		→ 26% by 2025
Iraq		→ 10% by 2030
Ireland	20.9%	→ 42.5% by 2020
Israel		→ 5% by 2014 → 10% by 2020
Italy	31%	→ 26% by 2020
Jamaica	7% (2012)	→ 30% by 2020
Japan	12% (2014)	→ 13.5% by 2020 → 20% by 2030
Kazakhstan		→ 3% by 2020 → 50% by 2030
Kiribati		→ 3% by 2020
Kuwait		→ 10% (no date)
Latvia	49%	→ 60% by 2020
Lebanon		→ 12% by 2020
Liberia		→ 30% by 2021
Libya		→ 7% by 2020 → 10% by 2025
Lithuania	13%	→ 21% by 2020
Luxembourg	5.3%	→ 11.8% by 2020
Macedonia		→ 24.7% by 2020
Madagascar	63%	→ 75% by 2020
Malaysia		→ 5% by 2015 → 9% by 2020 → 11% by 2030 → 15% by 2050
Maldives		→ 16% by 2017
Mali[3]		→ 10% by 2015 → 25% by 2033
Malta	1.6%	→ 3.8% by 2020
Marshall Islands		→ 20% by 2020
Mauritius		→ 35% by 2025
Mexico		→ 25% by 2026
Moldova		→ 10% by 2020
Mongolia		→ 20–25% by 2020
Myanmar		→ 15–18% by 2020
Namibia		→ 10% by 2020
Netherlands	10%	→ 37% by 2020
New Zealand	80% (2014)	→ 90% by 2025
Nicaragua	51% (2014)	→ 90% by 2027

TABLE R13. SHARE OF ELECTRICITY GENERATION FROM RENEWABLES, EXISTING IN 2013 AND TARGETS (continued)

COUNTRY	SHARE	TARGET
Nigeria[4]		→ 10% by 2020
Pakistan	1.7% (2014)	→ 10% by 2015
Palestinian Territories		→ 10% by 2020
Peru		→ 60% by 2025
Philippines	29% (2012)	→ 40% by 2020
Poland	10.7%	→ 19.3% by 2020
Portugal	49%	→ 45% by 2020
Qatar		→ 2% by 2020 → 20% by 2030
Romania	38%	→ 43% by 2020
Russia[5]		→ 2.5% by 2015 → 4.5% by 2020
Senegal		→ 20% by 2017
Seychelles		→ 5% by 2020 → 15% by 2030
Sierra Leone		→ 18% by 2015 → 33% by 2020 → 36% by 2030
Slovakia	21%	→ 24% by 2020
Slovenia	32.8%	→ 39.3% by 2020
Solomon Islands		→ 50% by 2015
South Africa		→ 9% by 2030
Spain	36.4%	→ 38.1% by 2020
Sri Lanka		→ 10% by 2016 → 20% by 2020
St. Kitts and Nevis		→ 20% by 2015
St. Lucia		→ 15% by 2015 → 35% by 2020
St. Vincent and the Grenadines		→ 30% by 2015 → 60% by 2020
Sudan		→ 11% by 2031
Sweden	61.8%	→ 62.9% by 2020
Tanzania		→ 14% by 2015
Thailand[6]		→ 10% by 2021
Timor-Leste		→ 50% by 2020
Togo		→ 15% by 2020
Tonga		→ 50% by 2015
Tunisia		→ 11% by 2016 → 30% by 2030
Turkey		→ 30% by 2023
Tuvalu		→ 100% by 2020
Uganda	91%	→ 61% by 2017
Ukraine	1% (2014)	→ 12.4% by 2020 → 20% by 2030
United Kingdom	19%	→ 50% by 2015
Uruguay	84%	→ 92% by 2015
Vanuatu		→ 23% by 2014 → 40% by 2015 → 65% by 2020
Vietnam		→ 5% by 2020
Yemen		→ 15% by 2025

TABLE R13. SHARE OF RENEWABLE ELECTRICITY PRODUCTION IN 2013 IN COUNTRIES WITHOUT TARGET SHARES

COUNTRY	SHARE
Brazil	79% (2014)
Burundi	70%
Cameroon	60%
Colombia	72%
Ethiopia	99%
Georgia	78% (2014)
India[7]	12% (2014)
Iran	21%
Kenya	65%
Mozambique	95% (2014)
Rwanda	60% (2014)
Suriname	40% (2014)
Tanzania	38% (2014)
United States	13% (2014)

[1] Chile's target excludes hydropower plants over 40 MW.

[2] In March 2012, Denmark set a target of 50% electricity consumption supplied by wind power by 2020.

[3] Mali's target excludes large hydropower.

[4] Nigeria's target excludes hydropower plants over 30 MW.

[5] Russia's targets exclude hydropower plants over 25 MW.

[6] Thailand does not classify hydropower installations larger than 6 MW as renewable energy sources, so large-scale hydro >6 MW is excluded from national shares and targets.

[7] India does not classify hydropower installations larger than 25 MW as renewable energy sources, so large-scale hydro >25 MW is excluded from national shares and targets.

Note: Unless otherwise noted, all targets and corresponding shares represent all renewables including hydropower. A number of state/provincial and local jurisdictions have additional targets not listed here. The United States and Canada have *de facto* state- and provincial-level targets through existing RPS policies, but no national targets. (See Tables R15 and R17.) Some countries shown have other types of targets. (See Tables R12–R18.) See Policy Landscape section (Section 4) and Table R19 for more information about city and local targets. Existing shares are indicative and may need adjusting if more accurate national statistical data are published. Sources for reported data often do not specify the accounting method used; therefore, shares of electricity are likely to include a mixture of different accounting methods and thus are not directly comparable or consistent across countries. Where shares sourced from Observ'ER differed from those provided to REN21 by country contributors, the latter were given preference.

Source: See Endnote 13 for this section.

TABLE R14. SHARE OF HEATING AND COOLING FROM MODERN RENEWABLE TECHNOLOGIES, EXISTING IN 2013 AND TARGETS

COUNTRY	SHARE	TARGET
Austria	33.5%	32.6% renewables in total heating and cooling supply by 2020
Belgium	8.1%	11.9% renewables in total heating and cooling supply by 2020
Bhutan		Solar heating and cooling: 3 MW equivalent by 2025
Bulgaria	29.2%	24% renewables in total heating and cooling supply by 2020
China		Solar water heating: 280 GW_{th} (400 million m^2) by 2015
Croatia	18.1%	19.6% renewables in total heating and cooling supply by 2020
Cyprus	21.7%	23.5% renewables in total heating and cooling supply by 2020
Czech Republic	15.3%	14.1% renewables in total heating and cooling supply by 2020
Denmark	34.8%	39.8% renewables in total heating and cooling supply by 2020
Estonia	43.1%	17.6% renewables in total heating and cooling supply by 2020
Finland	50.9%	47% renewables in total heating and cooling supply by 2020
France	18.3%	33% renewables in total heating and cooling supply by 2020
Germany	10.6%	14% renewables in total heating and cooling supply by 2020
Greece	26.5%	20% renewables in total heating and cooling supply by 2020
Hungary	13.5%	18.9% renewables in total heating and cooling supply by 2020
India		Solar water heating: 5.6 GW_{th} (8 million m^2) of new capacity to be added between 2012 and 2017
Ireland	5.7%	15% renewables in total heating and cooling supply by 2020
Italy	18%	17.1% renewables in total heating and cooling supply by 2020 Bioenergy: 5,670 ktoe for heating and cooling by 2020 Geothermal: 300 ktoe for heating and cooling by 2020 Solar water and space heating: 1,586 ktoe by 2020
Jordan	13% (2010)[1]	Solar water heating: 30% of households by 2020
Kenya		Solar water heating: 60% of annual demand for building using over 100 litres of hot water per day (no date)
Latvia	49.7%	53.4% renewables in total heating and cooling supply by 2020
Lebanon		Solar water heating: 133 MW_{th} (190,000 m^2) newly installed 2009–2014
Libya		Solar water heating: 80 MW_{th} by 2015; 250 MW_{th} by 2020
Lithuania	37.7%	39% renewables in total heating and cooling supply by 2020
Luxembourg	5.6%	8.5% renewables in gross final consumption in heating and cooling by 2020
Malta	23.7%	6.2% renewables in total heating and cooling supply by 2020
Moldova		27% renewables in total heating and cooling supply by 2020
Montenegro		38.2% renewables in total heating and cooling supply by 2020
Morocco		Solar water heating: 1.2 GW_{th} (1.7 million m^2) by 2020
Mozambique		Solar water and space heating: 100,000 systems installed in rural areas (no date)
Netherlands	3.6%	8.7% renewables in total heating and cooling supply by 2020
Poland	13.9%	17% renewables in total heating and cooling supply by 2020
Portugal	34.5%	30.6% renewables in total heating and cooling supply by 2020
Romania	26.2%	22% renewables in total heating and cooling supply by 2020
Serbia		30% renewables in total heating and cooling supply by 2020
Sierra Leone		1% penetration of solar water heaters in hotels, guest houses, and restaurants by 2015; 2% by 2020; 5% by 2030 1% penetration of solar water heaters in the residential sector by 2030
Slovakia	7.5%	14.6% renewables in total heating and cooling supply by 2020
Slovenia	31.7%	30.8% renewables in total heating and cooling supply by 2020
Spain	14.9%	18.9% renewables in total heating and cooling supply by 2020 Bioenergy: 4,653 ktoe by 2020 Geothermal: 9.5 ktoe by 2020 Heat pumps: 50.8 ktoe by 2020 Solar water and space heating: 644 ktoe by 2020
Sweden	67.2%	62.1% renewables in total heating and cooling supply by 2020
Thailand		Bioenergy: 8,200 ktoe by 2022 Biogas: 1,000 ktoe by 2022 Organic MSW[2]: 35 ktoe by 2022 Solar water heating: 300,000 systems in operation and 100 ktoe by 2022
Uganda		Solar water heaters: 21 MW_{th} (30,000 m^2) by 2017
United Kingdom	2.6%	12% renewables in total heating and cooling supply by 2020

[1] Jordan's share refers to the share of households with solar water heaters.

[2] It is not always possible to determine whether municipal solid waste (MSW) data include non-organic waste (plastics, metal, etc.) or only the organic biomass share.

Note: Table R14 includes targets established under EU National Renewable Energy Action Plans. Because heating and cooling targets are not standardised across countries, the table presents a variety of targets for the purpose of general comparison.

Source: See Endnote 14 for this section.

TABLE R15. OTHER RENEWABLE ENERGY TARGETS

COUNTRY	SECTOR / TECHNOLOGY	TARGET
EU-28	Transport	10% of EU-wide transport final energy demand by 2020
Albania	Transport	10% of transport final energy demand by 2020
Algeria	Electricity	22 GW by 2030
	Bio-power from waste-to-energy	1 GW by 2030
	Geothermal power	15 MW by 2030
	Solar PV	13.5 GW by 2030
	CSP	2 GW by 2030
	Wind power	5 GW by 2030
Argentina	Electricity	3 GW by 2016
	Geothermal power	30 MW by 2016
Armenia	Hydropower (small-scale)	377 MW by 2020; 397 MW by 2025
	Geothermal power	50 MW by 2020; 100 MW by 2025
	Solar PV	40 MW by 2020; 80 MW by 2025
	Wind power	50 MW by 2020; 100 MW by 2025
Austria	Bio-power from solid biomass and biogas	200 MW added 2010–2020
	Hydropower	1 GW added 2010–2020
	Solar PV	1.2 GW added 2010–2020
	Wind power	2 GW added 2010–2020
	Transport	11.4% of transport final energy demand by 2020
Azerbaijan	Electricity	1 GW by 2020
Bangladesh	Bio-power from solid biomass	2 MW by 2014; 100,000 plants of 2.6 m^3 capacity capable of producing 40 MW of electricity
	Bio-power from biogas	4 MW by 2014; 7 MW by 2017
	Biogas digesters	150,000 plants by 2016
	Solar PV	500 MW by 2015
	Solar PV (off-grid and rural)	6 million solar home systems by 2016 (240 MW_p total); 50 minigrids of 150 kW_p each; 1,550 solar irrigation pumps by 2017
Benin	Electricity (off-grid and rural)	50% by 2025
Bhutan	Electricity	20 MW by 2025
	Bio-power from solid biomass	5 MW by 2025
	Solar PV	5 MW by 2025
	Wind power	5 MW by 2025
Bolivia	Electricity	160 MW renewable energy capacity added 2015–2025
Brazil	Bio-power	19.3 GW by 2021
	Hydropower (small-scale)	7.8 GW by 2021
	Wind power	15.6 GW by 2021
Bulgaria	Hydropower	Three 174 MW plants commissioned by 2017–2018
	Solar PV	80 MW solar PV park operational by 2014
	Transport	11% of transport final energy demand by 2020
Burundi	Bio-power from solid biomass	4 MW
	Hydropower	212 MW
	Solar PV	40 MW
	Wind power	10 MW

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
China	Bio-power	13 GW by 2015
	Hydropower	330 GW by 2017
	Solar PV	70 GW by 2017 (35 GW utility-scale and 35 GW distributed generation)
	CSP	1 GW by 2015; 3 GW by 2020
	Wind power	150 GW by 2017
Colombia	Electricity (grid-connected)[1]	3.5% of generation by 2015; 6.5% by 2020
	Electricity (off-grid)	20% of generation by 2015; 30% by 2020
Croatia	Transport	10% of transport final energy demand by 2020
Cyprus	Transport	4.9% of transport final energy demand by 2020
Czech Republic	Transport	10.8% of transport final energy demand by 2020
Denmark	Wind power	50% share of generation by 2020
	Transport	10% of transport final energy demand by 2020
Djibouti	Solar PV (off-grid and rural)	30% by 2017
Dominican Republic	Distributed power	20% by 2016
Egypt	Hydropower	2.8 GW by 2020
	Solar PV	220 MW by 2020; 700 MW by 2027
	CSP	1.1 GW by 2020; 2.8 GW by 2017
	Wind power	12% of generation and 7.2 GW by 2020
Eritrea	Wind power	50% of generation (no date)
Estonia	Transport	2.7% of transport final energy demand by 2020
Ethiopia	Bio-power from bagasse	103.5 MW (no date)
	Geothermal power	75 MW by 2015; 450 MW by 2018; 1 GW by 2030
	Hydropower	10.6 GW (>90% large-scale) by 2015; 22 GW by 2030
	Wind power	770 MW by 2014
Finland	Bio-power	13.2 GW by 2020
	Hydropower	14.6 GW by 2020
	Wind power	884 MW by 2020
	Transport	20% of transport final energy demand by 2020
France	Ocean power and wind power (offshore)	6 GW by 2020
	Wind power (onshore)	25 GW by 2020
	Transport	10.5% of transport final energy demand by 2020
Germany	Wind power	2.5 GW per year onshore through 2020; 6.5 GW offshore by 2020; 15 GW offshore by 2030
	Transport	20% of transport final energy demand by 2020
Greece	Solar PV	2.2 GW by 2030
	Transport	10.1% of transport final energy demand by 2020
Guinea	Solar power	6% of electricity by 2025
	Wind power	2% of electricity by 2025
Guinea-Bissau	Solar PV	2% of primary energy by 2015
Hungary	Transport	10% of transport final energy demand by 2020
India	Electricity	3.77 GW installed in 2014–2015; 30 GW added 2012–2017; 170 GW by 2022
	Bio-power	400 MW installed in 2014–2015; 2.7 GW added 2012–2017
	Hydropower (small-scale)[2]	250 MW installed in 2014–2015; 2.1 GW added 2012–2017
	Solar PV	1.1 GW solar PV and 60 MW small-scale PV installed in 2014–2015; 20 million solar lighting systems added 2010–2022
	Solar PV and CSP	100 GW by 2022
	Wind power	2 GW installed in 2014-2015; 60 GW by 2022

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
Indonesia	Hydropower, solar PV, wind power	1.4% share in primary energy (combined) by 2025
	Biofuels	10.2% share of primary energy by 2025
	Geothermal power	12.6 GW by 2025
	Hydropower	2 GW by 2025, including 0.43 GW micro-hydropower
	Pumped storage[3]	3 GW by 2025
	Solar PV	156.8 MW by 2025
	Wind power	100 MW by 2025
Iran	Solar and wind power	5 GW (no date)
Iraq	Solar PV	240 MW by 2016
	CSP	80 MW by 2016
	Wind power	80 MW by 2016
Ireland	Transport	10% of transport final energy demand by 2020
Italy	Bio-power	19,780 GWh / year generation from 3.8 GW capacity by 2020
	Geothermal power	6,760 GWh / year generation from 920 MW capacity by 2020
	Hydropower	42,000 GWh / year generation from 17.8 GW capacity by 2020
	Solar PV	23 GW by 2017
	Wind power (onshore)	18,000 GWh / year generation and 12 GW capacity by 2020
	Wind power (offshore)	2,000 GWh / year generation and 680 MW capacity by 2020
	Transport	10.1% transport final energy demand (2,899 ktoe) from biofuels by 2020
Japan	Bio-power	3.3 GW by 2020; 6 GW by 2030
	Geothermal power	0.53 GW by 2020; 3.88 GW by 2030
	Hydropower	49 GW by 2020
	Ocean power (wave and tidal)	1.5 GW by 2030
	Solar PV	28 GW by 2020
	Wind	5 GW total by 2020; 8.03 GW offshore by 2030
Jordan	Electricity	1 GW by 2018
	Solar PV	300 MW by 2020
	CSP	300 MW by 2020
	Wind power	1.2 GW by 2020
Kazakhstan	Electricity	1.04 GW by 2020
Kenya	Geothermal power	1.9 GW by 2016; 5 GW by 2030
	Hydropower	794 MW by 2016
	Solar PV	423 MW by 2016
	Wind power	635 MW by 2016
Kuwait	Solar PV	3.5 GW by 2030
	CSP	1.1 GW by 2030
	Wind power	3.1 GW by 2030
Latvia	Bio-power from solid biomass	8% of generation by 2016
Lebanon	Bio-power from biogas	15–25 MW by 2015
	Hydropower	40 MW by 2015
	Wind power	60–100 MW by 2015; 400–500 MW by 2020
Lesotho	Electricity	260 MW by 2030
	Electricity (off-grid and rural)	35% of rural electrification by 2020
Liberia	Biofuels	5% of total transport fuel by 2015
Libya	Solar PV	129 MW by 2015; 344 MW by 2020; 844 MW by 2025
	CSP	125 MW by 2020; 375 MW by 2025
	Wind power	260 MW by 2015; 600 MW by 2020; 1 GW by 2025

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
Lithuania	Transport	10% of transport final energy demand by 2020
Luxembourg	Transport	10% of transport final energy demand by 2020
Macedonia	Bio-power from solid biomass	50 GWh by 2020
	Bio-power from biogas	20 GWh by 2020
	Hydropower (small-scale)	216 GWh by 2020
	Solar PV	14 GWh by 2020
	Wind power	300 GWh by 2020
Malawi	Hydropower	346.5 MW by 2014
Malaysia	Electricity	2.1 GW (excluding large-scale hydropower), 11.2 TWh / year, or 10% of national supply (no date given) 6% of total capacity by 2015; 11% by 2020; 14% by 2030; 36% by 2050
Malta	Transport	10.7% of transport final energy demand by 2020
Micronesia	Electricity	10% of generation in urban centres and 50% in rural areas by 2020
Moldova	Transport	20% of transport final energy demand by 2020
Morocco	Electricity	42% of capacity by 2020
	Hydropower	2 GW by 2020
	Solar PV and CSP	2 GW by 2020
	Wind power	2 GW by 2020
Mozambique	Bio-digesters for biogas	1,000 systems installed (no date)
	Hydropower, solar PV, wind	2 GW each (no date)
	Solar PV	82,000 solar home systems installed (no date)
	Wind turbines for water pumping	3,000 stations installed (no date)
	Renewable energy-based productive systems	5,000 installed (no date)
Netherlands	Transport	10% of transport final energy demand by 2020
Nigeria	Bio-power	50 MW by 2015; 400 MW by 2025
	Hydropower (small-scale)[4]	600 MW by 2015; 2 GW by 2025
	Solar PV (large-scale, >1 MW)	75 MW by 2015; 500 MW by 2025
	Wind power	20 MW by 2015; 40 MW by 2025
	CSP	1 MW by 2015; 5 MW by 2025
Norway	Electricity	30 TWh / year generation by 2016
	Electricity	26.4 TWh common electricity certificate market with Sweden by 2020
Palestinian Territories	Bio-power	21 MW by 2020
	Solar PV	45 MW by 2020
	CSP	20 MW by 2020
	Wind power	44 MW by 2020
Philippines	Electricity	Triple the 2010 capacity by 2030
	Bio-power	277 MW added 2010–2030
	Geothermal power	1.5 GW added 2010–2030
	Hydropower	5,398 MW added 2010–2030
	Ocean power	75 MW added 2010–2030
	Solar PV	284 MW added 2010–2030
	Wind power	2.3 GW added 2010–2030
Poland	Wind power (offshore)	1 GW by 2020
	Transport	20% of transport final energy demand by 2020
Portugal	Electricity	15.8 GW by 2020
	Bio-power from solid biomass	769 MW by 2020
	Bio-power from biogas	59 MW by 2020

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
Portugal (continued)	Geothermal power	29 MW by 2020
	Hydropower (small-scale)	400 MW by 2020
	Ocean power (wave)	6 MW by 2020
	Solar PV	670 MW by 2020
	CSP	50 MW by 2020
	Wind power	5.3 GW onshore by 2020; 27 MW offshore by 2020
	Transport	10% of transport final energy demand by 2020
Qatar	Solar PV	1.8 GW by 2014
	Transport	10% of transport final energy demand by 2020
Romania	Transport	10% of transport final energy demand by 2020
Russia	Hydropower (small-scale)[5], solar PV, wind power	6 GW combined by 2020
Rwanda	Biogas power	300 MW by 2017
	Geothermal power	310 MW by 2017
	Hydropower	340 MW by 2017
	Hydropower (small-scale)	42 MW by 2015
	Electricity (off-grid)	5 MW by 2017
Samoa	Final energy	Increase by 20% the current share of final energy supply by 2030
Saudi Arabia	Electricity	54 GW by 2040
	Solar PV and CSP	41 GW by 2040 (25 GW CSP, 16 GW PV)
	Geothermal, waste-to-energy, wind power	13 GW combined by 2040
Serbia	Solar PV	150 MW by 2017
	Wind power	1.4 GW (no date)
Sierra Leone	Electricity	1 GW (no date)
Singapore	Solar PV	350 MW by 2020
Slovakia	Transport	10% of transport final energy demand by 2020
Slovenia	Transport	10.5% of transport final energy demand by 2020
South Africa	Electricity	17.8 GW by 2030; 42% of new generation capacity installed 2010–2030
South Korea	Electricity	13,016 GWh / year (2.9% total generation) by 2015; 21,977 GWh / year (4.7%) by 2020; 39,517 GWh / year (7.7%) by 2030 supplied by a mix of renewable technologies, including:
	Bio-power from solid biomass	2,628 GWh / year by 2030
	Bio-power from biogas	161 GWh / year by 2030
	Bio-power from landfill gas	1,340 GWh / year by 2030
	Geothermal power	2,046 GWh / year by 2030
	Hydropower (large-scale)	3,860 GWh / year by 2030
	Hydropower (small-scale)	1,926 GWh / year by 2030
	Ocean power	6,159 GWh / year by 2030
	Solar PV	2,046 GWh / year by 2030
	CSP	1,971 GWh / year by 2030
	Wind power	900 MW by 2016; 1.5 GW by 2019; 16,619 GWh / year by 2030 2.5 GW offshore by 2019
Spain	*Final energy*	
	Bioenergy from solid biomass, biogas, and organic MSW[6]	0.1% by 2020
	Geothermal energy, ocean power, and heat pumps[7]	5.8% by 2020
	Hydropower	2.9% by 2020

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
Spain (continued)	Solar PV	3% by 2020
	Wind power	6.3% by 2020
	Electricity	
	Bio-power from solid biomass	1.4 GW by 2020
	Bio-power from organic MSW[6]	200 MW by 2020
	Bio-power from biogas	400 MW by 2020
	Geothermal power	50 MW by 2020
	Hydropower	13.9 GW by 2020
	Pumped storage[3]	8.8 GW by 2020
	Ocean power	100 MW by 2020
	Solar PV	7.3 GW by 2020
	CSP	4.8 GW by 2020
	Wind power (onshore)	35 GW by 2020
	Wind power (offshore)	750 MW by 2020
	Transport	
	Biodiesel	11.3% of transport final energy demand by 2020
	Ethanol/bio-ETBE[8]	2,313 ktoe by 2020
	Electricity in transport	4.7 GWh / year by 2020 (501 ktoe from renewable sources by 2020)
Sri Lanka	Transport	20% of transport final energy demand from biofuels by 2020
Sudan	Bio-power from solid biomass	54 MW by 2031
	Bio-power from biogas	68 MW by 2031
	Hydropower	63 MW by 2031
	Solar PV	667 MW by 2031
	CSP	50 MW by 2031
	Wind power	680 MW by 2031
Sweden	Electricity	25 TWh more renewable electricity annually by 2020 (base year 2002)
	Electricity	26.4 TWh common electricity certificate market with Norway by 2020
	Transport	Vehicle fleet that is independent from fossil fuels by 2030
Switzerland	Electricity	12 TWh / year by 2035; 24.2 TWh by 2050
	Hydropower	43 TWh / year by 2035
Syria	Bio-power	140 MW by 2020; 260 MW by 2025; 400 MW by 2030
	Solar PV	45 MW by 2015; 380 MW by 2020; 1.1 GW by 2025; 1.8 GW by 2030
	CSP	50 MW by 2025
	Wind power	150 MW by 2015; 1 GW by 2020; 1.5 GW by 2025; 2 GW by 2030
Tajikistan	Hydropower (small-scale)	100 MW by 2020
Thailand	*Transport*	
	Ethanol	9 million litres / day consumption by 2022
	Biodiesel	6 million litres / day consumption by 2022
	Advanced biofuels	25 million litres / day production by 2022
	Electricity	
	Bio-power from solid biomass	4.8 GW by 2021
	Bio-power from biogas	600 MW by 2021
	Bio-power from organic MSW[6]	400 MW by 2021
	Geothermal power	1 MW by 2021
	Hydropower	6.1 GW by 2021
	Ocean power (wave and tidal)	2 MW by 2021
	Solar PV	1 GW by 2014; 3 GW by 2021
	Wind power	1.8 GW by 2021

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
Trinidad and Tobago	Electricity	5% of peak demand (or 60 MW) by 2020
	Wind power	100 MW (no date given)
Tunisia	Electricity	1 GW (16% of capacity) by 2016; 4.6 GW (40% of capacity) by 2030
	Bio-power from solid biomass	40 MW by 2016; 300 MW by 2030
	Solar PV	140 MW by 2016; 1.5 GW by 2030
	CSP	500 MW by 2030
	Wind power	430 MW by 2016; 1.7 GW by 2030
Turkey	Bio-power from solid biomass	1 GW by 2023
	Geothermal	1 GW by 2023
	Hydropower	34 GW by 2023
	Solar PV	5 GW by 2023
	Wind power	20 GW by 2023
Uganda	Bio-power from organic MSW[6]	30 MW by 2017
	Geothermal power	45 MW by 2017
	Hydropower (large-scale)	1.2 GW by 2017
	Hydropower (mini- and micro-scale)	85 MW by 2017
	Solar PV (solar home systems)	700 kW by 2017
	Biofuels	2,200 million litres / year consumption by 2017
United Kingdom	Wind power (offshore)	39 GW by 2030
	Transport	5% of transport final energy demand by 2014; 10.3% by 2020
Uruguay	Bio-power	200 MW by 2015
	Wind power	1.3 GW by 2015
Venezuela	Electricity	613 MW new capacity installed 2013–2019, including:
	Wind power	500 MW new capacity installed 2013–2019
Vietnam	Bio-power	200 MW by 2015
	Hydropower	19.2 GW by 2020
	Wind power	1 GW by 2020
	Biofuels	1% of transport petroleum energy demand by 2015; 5% by 2025
Yemen	Bio-power	6 MW by 2025
	Geothermal power	200 MW by 2025
	Solar PV	4 MW by 2025
	CSP	100 MW by 2025
	Wind power	400 MW by 2025
Zimbabwe	Transport	10% of transport final energy demand by 2015

[1] Colombia's target is to be met by "non-conventional sources of energy".

[2] India does not classify hydropower installations larger than 25 MW as renewable energy sources. Therefore, national targets and data for India do not include hydropower facilities >25 MW. India 2014–2015 targets are for the national fiscal year which runs from April 2014 through March 2015.

[3] Pumped hydro plants are not energy sources but a means of energy storage. As such, they involve conversion losses and are powered by renewable or non-renewable electricity. Pumped storage is included here because it can play an important role as balancing power, in particular for variable renewable resources.

[4] Nigeria's target excludes hydropower plants over 30 MW.

[5] Russia's targets exclude hydropower plants over 25 MW.

[6] It is not always possible to determine whether municipal solid waste (MSW) data include non-organic waste (plastics, metal, etc.) or only the organic biomass share. Uganda utilises predominantly organic waste.

[7] The energy output of heat pumps is at least partially renewable on a final energy basis, which is why they are included in this table. For more information, see Sidebar 4, GSR 2014.

[8] ETBE is a form of biofuel produced from ethanol and isobutylene.

TABLE R15. OTHER RENEWABLE ENERGY TARGETS: STATE / PROVINCIAL LEVEL

COUNTRY	SECTOR / TECHNOLOGY	TARGET
Australia		
South Australia	Electricity	33% of generation by 2020
Tasmania	Electricity	100% of generation by 2020
Belgium		
Wallonia	Transport	10.14% of transport final energy demand by 2020
	Final energy	20% share from renewables by 2020
	Electricity	8 TWh / year by 2020
Canada		
New Brunswick	Electricity	Increase renewable share 10% by 2016; 40% by 2020
Nova Scotia	Electricity	25% of generation by 2015; 40% by 2020
Prince Edward Island	Wind power	30 MW increase by 2030 (base year 2011)
Ontario	Electricity	10.7 GW by 2022 supplied by a mix of renewable technologies, including:
	Hydropower	1.5 GW by 2025
	Solar PV	40 MW by 2025
	Wind power	5 GW by 2025
China		
Taiwan	Geothermal power	4 MW by 2015; 66 MW by 2020; 150 MW by 2025; 200 MW by 2030
	Ocean power	1 MW by 2015; 30 MW by 2020; 200 MW by 2025; 600 MW by 2030
	Solar PV	420 MW by 2015; 1.02 GW by 2020; 2.5 GW by 2025; 3.1 GW by 2030
	Wind power	881 MW by 2015; 1.8 GW by 2020; 3 GW by 2025; 4.2 GW by 2030
India		
Andaman and Nicobar	Electricity	3% (0.4% solar) of generation
Andhra Pradesh	Electricity	7% (0.2% solar) of generation
Arunchal Pradesh	Electricity	7% (0.2% solar) of generation
Assam	Electricity	7% (0.25% solar) of generation
Bihar	Electricity	5% (0.75% solar) of generation; 3% solar by 2022
Chandigarh	Electricity	3% (0.4% solar) of generation
Chattisgarh	Electricity	6.75% (0.75% solar) of generation; 7.25% by 2016
Dadra and Nagar Haveli	Electricity	3% (0.4% solar) of generation
Daman and Diu	Electricity	3% (0.4% solar) of generation
Delhi	Electricity	6.2% (0.25% solar) of generation; 9% by 2017
Goa	Electricity	3.3% (0.6% solar) of generation; 6% by 2022
Gujarat	Electricity	9% (1.5% solar) of generation; 10% by 2017
Haryana	Electricity	3.25% (0.25% solar) of generation; 5.5% by 2022
Himachal Pradesh	Electricity	10.25% (0.25% solar) of generation; 19% by 2022
Jammu and Kashmir	Electricity	6% (0.75% solar) of generation; 9% by 2017
Jharkhand	Electricity	4% (1% solar) of generation; 4% by 2016
Karnataka	Electricity	10.25% (0.25% solar) of generation
Kerala	Electricity	4.5% (0.25% solar) of generation; 6.6% by 2022
Lakshadweep	Electricity	3% (0.4% solar) of generation
Madhya Pradesh	Electricity	7% (1% solar) of generation
Maharashtra	Electricity	9% (0.5% solar) of generation
Manipur	Electricity	5% (0.25% solar) of generation
Meghalaya	Electricity	1% (0.4% solar) of generation
Mizoram	Electricity	7% (0.25% solar) of generation
Nagaland	Electricity	8% (0.25% solar) of generation

TABLE R15. OTHER RENEWABLE ENERGY TARGETS: STATE / PROVINCIAL LEVEL (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
India (continued)		
Orissa	Electricity	6.5% (0.25% solar) of generation
Pondicherry	Electricity	3% (0.4% solar) of generation
Punjab	Electricity	4% (0.19% solar) of generation
Rajasthan	Electricity	9% (1.5% solar) of generation
Tamil Nadu	Electricity	11% (2% solar) of generation
Tripura	Electricity	2.5% (1.05% solar) of generation
Uttar Pradesh	Electricity	6% (1% solar) of generation
Uttarakhand	Electricity	7.075% (0.075% solar) of generation
West Bengal	Electricity	4.5% (0.15% solar) of generation
Kosovo		
	Heating and cooling	45.65% renewables in total heating and cooling supply by 2020
New Zealand		
Cook Islands	Electricity	50% by 2015; 100% by 2020
Niue	Electricity	100% by 2020
Tokelau	Electricity	100% (no date given)
United Arab Emirates		
Abu Dhabi	Electricity	7% of capacity by 2020
Dubai	Electricity	7% of capacity by 2020; 15% by 2030
United Kingdom		
Scotland	Electricity	100% by 2020
United States		
Arizona	Electricity	15% of supply by 2025
California	Electricity	25% of supply by 2015; 33% by 2020
Colorado	Electricity	30% of supply by 2020 (IOUs[9]) 10% or 20% for munis and electric co-ops[10]
Connecticut	Electricity	27% of supply by 2020
Delaware	Electricity	25% of supply by 2025–2026
Hawaii	Electricity	25% of supply by 2020; 40% by 2030
Illinois	Electricity	25% of supply by 2015–2016
Iowa	Electricity	105 MW of generating capacity for IOUs[9]
Kansas	Electricity	15% of supply by 2015-2019; 20% by 2020
Maine	Electricity	40% of supply by 2017
Maryland	Electricity	20% of supply by 2020
Massachusetts	Electricity	15% of supply by 2020 and additional 1% each year after
Michigan	Electricity	10% of supply by 2015
Minnesota	Electricity	26.5% of supply by 2025 (IOUs[9]); 25% by 2025 (other utilities)
Missouri	Electricity	15% of supply by 2021 (IOUs[9])
Montana	Electricity	15% of supply by 2015
Nevada	Electricity	25% of supply by 2025
New Hampshire	Electricity	24.8% of supply by 2025
New Jersey	Electricity	24.5% of supply by 2020
New Mexico	Electricity	20% of supply by 2020 (IOUs[9]); 10% by 2020 (co-ops[10])
New York	Electricity	29% of supply by 2015
North Carolina	Electricity	12.5% of supply by 2021 (IOUs[9]); 10% by 2018 (munis and co-ops[10])
Ohio	Electricity	25% of supply by 2024

TABLE R15. OTHER RENEWABLE ENERGY TARGETS: STATE / PROVINCIAL LEVEL (continued)

COUNTRY	SECTOR / TECHNOLOGY	TARGET
United States (continued)		
Oregon	Electricity	25% of supply by 2025 (utilities with 3% or more of state's load) 10% by 2025 (utilities with 1.5–3% of state's load) 5% by 2025 (utilities with less than 1.5% of state's load)
Pennsylvania	Electricity	18% of supply by 2020–2021
Rhode Island	Electricity	16% of supply by 2019
Texas	Electricity	5,880 MW by 2015
Washington	Electricity	9% of supply by 2016; 15% by 2020
Wisconsin	Electricity	10% of supply by 2015
District of Columbia	Electricity	20% of supply by 2020
Northern Mariana Islands	Electricity	80% of supply by 2015
Puerto Rico	Electricity	20% of supply by 2035

[9] Investor-owned utilities (IOUs) operate under private control, rather than government or co-operative operation.

[10] Municipal utilities (munis) are publicly owned and operated. Co-operative utilities (co-ops) are owned and operated by members who also make up the utility's customer base.

Note: All capacity targets are for cumulative capacity unless otherwise noted. Targets are rounded to the nearest tenth decimal. Renewable energy targets are not standardised across countries; therefore, the table presents a variety of targets for the purpose of general comparison. Many sub-national targets have been enacted under RPS policies. (➔ See Table R17.). Countries on this list may also have primary/final energy, electricity, or heating/cooling targets. (➔ See Tables R12–R14.) Table R15 lists transport energy targets; biofuel blend mandates can be found in Table R16: National and State/Provincial Biofuel Blend Mandates. It is not always possible to determine whether transportation targets are limited to road transportation. Additionally, targets may cover only the use of biofuels or a wider array of renewable transport options (i.e., renewable electricity with electric vehicles, hydrogen).

Source: See Endnote 15 for this section.

TABLE R16. CUMULATIVE NUMBER OF COUNTRIES / STATES / PROVINCES ENACTING FEED-IN POLICIES, AND 2014 POLICY REVISIONS

YEAR	CUMULATIVE[1] #	COUNTRIES / STATES / PROVINCES ADDED THAT YEAR
1978	1	United States[2]
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; Slovak Republic; South Korea; Maharashtra (India)
2004	34	Israel; Nicaragua; Prince Edward Island (Canada); Andhra Pradesh and Madhya Pradesh (India)
2005	41	China; Ecuador; Ireland; Turkey; Karnataka, Uttar Pradesh, and Uttarakhand (India)
2006	46	Argentina; Pakistan; Thailand; Ontario (Canada); Kerala (India)
2007	55	Albania; Bulgaria; Croatia; Dominican Republic; Finland; Macedonia; Moldova; Mongolia; South Australia (Australia)
2008	71	Iran; Kenya; Liechtenstein; Philippines; San Marino; Tanzania; Ukraine; Queensland (Australia); Chhattisgarh, Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu, and West Bengal (India); California (USA)
2009	81	Japan; Serbia; South Africa; Australian Capital Territory, New South Wales, and Victoria (Australia); Taiwan (China); Hawaii, Oregon, and Vermont (USA)
2010	87	Belarus; Bosnia and Herzegovina; Malaysia; Malta; Mauritius; United Kingdom
2011	94	Ghana; Montenegro; Netherlands; Syria; Vietnam; Nova Scotia (Canada); Rhode Island (USA)
2012	99	Jordan; Nigeria; Palestinian Territories; Rwanda; Uganda
2013	101	Kazakhstan; Pakistan
2014	103	Egypt; Virgin Islands (USA)
Total[3]	**108**	

[1] "Cumulative" refers to number of jurisdictions that had enacted feed-in policies as of the given year.

[2] The US PURPA policy (1978) is an early version of the feed-in tariff, which has since evolved.

[3] "Total" excludes nine countries that are known to have subsequently discontinued policies (Brazil, Czech Republic, Mauritius, Norway, South Africa, South Korea, Spain, Sweden, and the United States) and adds nine countries (Andorra, Honduras, Maldives, Peru, Panama, Russia, Senegal, Tajikistan, and Uruguay) and five Indian states (Bihar, Himachal Pradesh, Jammu and Kashmir, Jharkhand, and Orissa) that are believed to have FITs but with an unknown year of enactment.

TABLE R16. CUMULATIVE NUMBER OF COUNTRIES / STATES / PROVINCES ENACTING FEED-IN POLICIES, AND 2014 POLICY REVISIONS (continued)

2014 FIT RATE ADJUSTMENTS	
Bulgaria	Hydropower: Reduced 5% Solar PV: Reduced 28% Wind: Reduced 22%
China	Solar PV: Reduced 10% Offshore wind: USD 0.12 / kWh (RMB 0.75–0.85 / kWh)[4] [New] Onshore wind: Reduced by USD 0.003–0.006 / kWh (RMB 0.02–0.04 / kWh)
Crimea	Wind and solar power: Reduced to USD 0.09 / kWh
Denmark	Wind (<10 kW): USD 0.4 / kWh (EUR 0.33 / kWh) [New] Wind (10 kW–25 kW): USD 0.24 / kWh (EUR 0.2 / kWh) [New]
Germany	Solar PV: 1% per month reduction Wind: 1.5% annual rate reduction
Greece	Solar PV: Reduced from USD 209 / MWh (EUR 171.9 / MWh) to USD 115.4 / MWh (EUR 95 / MWh)
Japan	Solar PV: Reduced 19% to USD 0.24 / kWh (JPY 29 / kWh)
Kazakhstan	Solar PV: USD 0.176 / kWh [New] Wind: USD 0.115 / kWh [New]
Malta	Solar PV (<40 kW): May 1–October 31 USD 0.2 / kWh (EUR 0.165 / kWh); November 1–April 30 USD 0.19 / kWh (EUR 0.155 / kWh) Solar PV (> 40 kW): May 1–October 31 USD 0.19 / kWh (EUR 0.16 / kWh); November 1–April 30 USD 0.18 / kWh (EUR 0.15 / kWh)
Philippines	Biomass: Reduced to USD 0.15 / kWh (PHP 6.63 / kWh) Run-of-river hydro: Reduced to USD 0.13 / kWh (PHP 5.9 / kWh) Solar: Reduced to USD 0.22 / kWh (PHP 9.68 / kWh) Wind: Reduced to USD 0.19 / kWh (PHP 8.53 / kWh)
Poland	Wind (<3 kW): USD 0.21 / kWh (EUR 0.17 / kWh) [New] Wind (3–10 kW): USD 0.18 / kWh (EUR 0.15 / kWh) [New]
Russia	Non-technology specific: Revised FIT to institute a reduction of more than 50% if failing to meet 70% domestic content requirement
Switzerland	Solar PV (up to 29.9 kW): Reduced 23% Solar PV (30 kW to 1 MW): Reduced 18% Solar PV (> 1 MW): Reduced 12%
U.S. Virgin Islands	Solar PV: 0.26 USD / kWh [New]
Vietnam	Waste-to-energy: Rates more than 25% higher than those allocated to wind projects [New]

[4] All currencies are converted to USD with exchange rates of 31 December 2014, using http://www.oanda.com/currency/converter/.
Source: See Endnote 16 for this section.

TABLE R17. CUMULATIVE NUMBER OF COUNTRIES / STATES / PROVINCES ENACTING RPS/QUOTA POLICIES

YEAR	CUMULATIVE[1] #	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	Italy; New Jersey and Texas (USA)
2000	13	New Mexico (USA)
2001	15	Australia; Flanders (Belgium)
2002	18	United Kingdom; Wallonia (Belgium); California (USA)
2003	21	Japan; Sweden; Maharashtra (India)
2004	34	Poland; Nova Scotia, Ontario, and Prince Edward Island (Canada); Andhra Pradesh, Karnataka, Madhya Pradesh, and Orissa (India); Colorado, Hawaii, Maryland, New York, and Rhode Island (USA)
2005	38	Gujarat (India); Delaware, District of Columbia, and Montana (USA)
2006	39	Washington State (USA)
2007	45	China; Illinois, New Hampshire, North Carolina, Northern Mariana Islands, Oregon (USA)
2008	52	Chile; India; Philippines; Romania; Michigan, Missouri, and Ohio[2] (USA)
2009	53	Kansas (USA)
2010	56	South Korea; British Columbia (Canada); Puerto Rico (USA)
2011	58	Albania; Israel
2012	59	Norway
2013	59	[None identified]
2014	59	[None identified]
Total[3]	**98**	

[1] "Cumulative" refers to the number of jurisdictions that had enacted RPS/Quota policies as of the given year. Jurisdictions are listed under the 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.

[2] Ohio's RPS policy was put on hold in 2014. It has not been officially revoked.

[3] "Total" adds 40 jurisdictions believed to have RPS/Quota policies but whose year of enactment is not known (Belarus, Ghana, Indonesia, Kyrgyzstan, Lithuania, Palau, Peru, Portugal, Senegal, South Africa, Sri Lanka, United Arab Emirates, the Indian states of Arunchal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttarakhand, Uttar Pradesh, and West Bengal and the Indian Union Territories of Andaman and Nicobar Islands, Chandigarh, Dadra and Nagar Haveli, Daman and Diu, Delhi, Lakshadweep, and Puducherry) and excludes Italy, which phased out its RPS in 2012. In the United States, there are 10 additional states and territories with policy goals that are not legally binding RPS policies (Guam, Indiana, North Dakota, Oklahoma, South Carolina, South Dakota, U.S. Virgin Islands, Utah, Vermont, and Virginia). West Virginia's non-binding goal was repealed in 2015. Three additional Canadian provinces also have non-binding policy goals (Alberta, Manitoba, and Quebec).

Note: The latest RPS mandated targets at the sub-national level can be found in Table R15.

Source: See Endnote 17 for this section.

TABLE R18. NATIONAL AND STATE / PROVINCIAL BIOFUEL BLEND MANDATES

COUNTRY	MANDATE
Angola	E10
Argentina	E10 and B10
Australia	*State*: E6 and B2 in New South Wales; E5 in Queensland
Belgium	E4 and B4
Brazil	E27.5 and B7
Canada	*National:* E5 and B2 *Provincial:* E5 and B2 in Alberta; E5 and B4 in British Columbia; E8.5 and B2 in Manitoba; E5, B2, and B3 by 2016 in Ontario; E7.5 and B2 in Saskatchewan
China	E10 in nine provinces
Colombia	E8
Costa Rica	E7 and B20
Ecuador	B5
Ethiopia	E10
Guatemala	E5
India	E5
Indonesia	E3 and B5
Italy	0.6% advanced biofuels blend by 2018; 1% by 2022
Jamaica	E10
Malaysia	B5
Mozambique	E10 in 2012–2015; E15 in 2016–2020; E20 from 2021
Norway	B3.5
Panama	E7; E10 by April 2016
Paraguay	E25 and B1
Peru	E7.8 and B2
Philippines	E10 and B2; B5 in 2015
South Africa	E2 and E5 as of October 2015
South Korea	B2; B2.5 by August 2015; B3 by 2018
Sudan	E5
Thailand	E5 and B5
Turkey	E2
Ukraine	E5; E7 by 2017
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. The RFS for 2013 was reduced 49.21 billion litres (13 billion gallons). *State:* E10 in Hawaii; E2 and B2 in Louisiana; B5 in Massachusetts; E20 and B10 in Minnesota; E10 in Missouri and Montana; B5 in New Mexico; E10 and B5 in Oregon; B2 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	E5 and B5
Vietnam	E5
Zimbabwe	E5, to be raised to E10 and E15 (no date given)

Note: 'E' refers to bioethanol and 'B' refers to biodiesel. Chinese provincial mandates include Anhui, Heilongjian, Henan, Jilin, and Liaoning. Chile has targets of E5 and B5 but has no current blending mandate. The Dominican Republic has targets of B2 and E15 for 2015 but has no current blending mandate. Fiji approved voluntary B5 and E10 blending in 2011 with a mandate expected. Mexico has a pilot E2 mandate in the city of Guadalajara. Nigeria has a target of E10 but no current blending mandate.

Table R18 lists only biofuel blend mandates; transport and biofuel targets can be found in Table R15.

Source: See Endnote 18 for this section.

TABLE R19. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES

TARGETS FOR RENEWABLE SHARE OF ENERGY CONSUMPTION, ALL CONSUMERS	
Austin, Texas, USA	65% of total energy by 2025
Boulder, Colorado, USA	30% of total energy by 2020
Calgary, Alberta, 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
Howrah, India	10% of total energy by 2018
Nagano Prefecture, Japan	70% of total energy by 2050
Oaxaca, Mexico	5% of total energy by 2017
Paris, France	25% of total energy by 2020
Skellefteå, Sweden	Net exporter of biomass, hydro, or wind energy by 2020
Växjö, Sweden	100% of total energy by 2030

TARGETS FOR RENEWABLE SHARE OF ELECTRICITY, ALL CONSUMERS	
Amsterdam, Netherlands	25% by 2025; 50% by 2040
Aspen, Colorado, USA	100% by 2015
Austin, Texas, USA	35% by 2020
Cape Town, South Africa	15% by 2020
Lancaster, California, USA	100% by 2020
Malmö, Sweden	100% by 2020
Munich, Germany	100% by 2025
Nagano Prefecture, Japan	10% by 2020; 20% by 2030; 30% by 2050
San Francisco, California, USA	100% by 2020
San Jose, California, USA	100% by 2022
Skellefteå, Sweden	100% by 2020
Taipei City, Taiwan	12% by 2020
Tokyo, Japan	20% by 2024
Ulm, Germany	100% by 2025
Wellington, New Zealand	78–90% by 2020

TARGETS FOR RENEWABLE ELECTRIC CAPACITY OR GENERATION	
Adelaide, Australia	2 MW of solar PV on residential and commercial buildings by 2020
Esklistuna, Sweden	48 GWh of wind power, 9.5 GWh of solar PV by 2020
Los Angeles, California, USA	1.3 GW of solar PV by 2020
New York, New York, USA	350 MW of solar PV by 2024
San Francisco, California, USA	100% of peak demand (950 MW) by 2020

TARGETS FOR GOVERNMENT OWN-USE PURCHASES OF RENEWABLE ENERGY	
Cockburn, Australia	20% of final energy in city buildings by 2020
Ghent, Belgium	50% of final energy by 2020
Hepburn Shire, Australia	100% of final energy in public buildings; 8% of electricity for public lighting
Kristianstad, Sweden	100% of final energy by 2020
Malmö, Sweden	100% of final energy by 2030
Portland, Oregon, USA	100% of final energy by 2030
Sydney, Australia	100% of electricity in buildings; 20% for street lamps

TABLE R19. 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, woody biomass, and waste heat)
Chandigarh, India	Mandatory use of solar water heating in industries, hotels, hospitals, prisons, canteens, housing complexes, and government and residential buildings as of 2013
Loures, Portugal	Solar thermal systems mandated as of 2013 in all sports facilities and schools that have good sun exposure
Munich, Germany	80% reduction of heat demand by 2058 (base 2009) through passive solar design (includes heat, process heat, and water heating)
Nantes, France	Extend the district heating system to source heat from biomass boilers for half of city inhabitants by 2017
Vienna, Austria	50% of total heat demand with solar thermal energy by 2050

Note: Table R19 provides a sample of local renewable energy commitments worldwide. It does not aim to present a comprehensive picture of all municipal renewable energy goals.

Source: See Endnote 19 for this section.

TABLE R20. ELECTRICITY ACCESS BY REGION AND COUNTRY

REGION / COUNTRY	ELECTRIFICATION RATE IN 2012	PEOPLE WITHOUT ACCESS TO ELECTRICITY IN 2012	TARGETS
	Share of population with access	Millions	Share of population with access
Africa	**43%**	**622**	
North Africa	**99%**	**1**	
Sub-Saharan Africa	**32%**	**620**	
Developing Asia	**83%**	**620**	
Latin America	**95%**	**23**	
Middle East	**92%**	**18**	
Africa			
Algeria	99%	0.4	
Angola	30%	15	
Benin	28%	7	
Botswana	66%	1	→ 80% by 2016
Burkina Faso	16%	14	
Burundi	10%	9	
Cabo Verde	94%	0.03	
Cameroon	54%	10	
Central African Republic	3%	4	
Chad	3%	12	
Comoros	45%	0.4	
Congo	35%	3	
Côte d'Ivoire	26%	15	
Democratic Republic of the Congo	9%	60	
Djibouti	50%	0.1	
Egypt	99.6%	0	
Equatorial Guinea	66%	0.3	
Eritrea	32%	4	
Ethiopia	23%	70	
Gabon	60%	1	
Gambia	35%	1	
Ghana	72%	7	→ 100% by 2016
Guinea	12%	10	
Guinea-Bissau	20%	1	
Kenya	20%	35	→ 70% by 2020
Lesotho	28%	2	→ 40% by 2020
Liberia	2%	4	
Libya	99.8%	0	
Madagascar	19%	15	
Malawi	9%	15	
Mali	27%	11	→ 55% by 2015 (urban) → 15% by 2015 (rural)
Mauritania	21%	3	
Mauritius	100%	0	
Morocco	99%	0.4	
Mozambique	39%	15	

TABLE R20. ELECTRICITY ACCESS BY REGION AND COUNTRY (continued)

REGION / COUNTRY	ELECTRIFICATION RATE IN 2012	PEOPLE WITHOUT ACCESS TO ELECTRICITY IN 2012	TARGETS
	Share of population with access	Millions	Share of population with access
Middle East (continued)			
Namibia	30%	2	
Niger	14%	15	→ 15% by 2020
Nigeria	45%	93	→ 75% by 2020
Rwanda	19%	9.5	
São Tomé and Príncipe	59%	0.1	
Senegal	55%	6	→ 60% by 2016
Seychelles[1]	99%	0	
Sierra Leone	5%	6	→ 30% by 2015 → 75% by 2025 → 100% by 2030
Somalia	15%	9	
South Africa	85%	8	→ 100% by 2019
South Sudan	1%	11	
Sudan	35%	24	
Swaziland	27%	1	
Tanzania	24%	36	→ 75% by 2035
Togo	27%	5	
Tunisia[2]	100%	0	
Uganda	15%	31	
Zambia	26%	10	
Zimbabwe	40%	8	→ 66% by 2030 → 90% (urban) → 51% (rural)
Developing Asia			
Bangladesh	60%	62	→ 100% by 2021
Brunei	99.7%	0	
Cambodia	34%	10	
China	99.8%	3	→ 100% by 2015
Democratic People's Republic of Korea	26%	18	
India	75%	304	
Indonesia	76%	60	
Laos	78%	1	
Malaysia	99.5%	0	
Mongolia	90%	0.3	
Myanmar	32%	36	
Nepal	76%	7	
Pakistan	69%	56	
Philippines[1]	79%	21	→ 90% by 2017
Singapore	100%	0	
Sri Lanka	89%	2	
Thailand	99%	1	
Vietnam	96%	4	

TABLE R20. ELECTRICITY ACCESS BY REGION AND COUNTRY (continued)

REGION / COUNTRY	ELECTRIFICATION RATE IN 2012	PEOPLE WITHOUT ACCESS TO ELECTRICITY IN 2012	TARGETS
	Share of population with access	Millions	Share of population with access
Latin America			
Argentina	96%	1.5	
Barbados[3]	98%	0.0	→ 100% by 2021
Bolivia	88%	1.2	→ 100% by 2015 (urban) → 100% by 2025 (rural)
Brazil	99.5%	1.0	
Chile[1]	98%	0.4	
Colombia	97%	1.4	→ 97.45% by 2017
Costa Rica	99%	0.0	→ 100% by 2015
Cuba	98%	0.2	
Dominican Republic	96%	0.4	
Ecuador	94%	0.9	→ 98.92% by 2022 (urban) → 96.29% by 2022 (rural)
El Salvador	93%	0.5	
Guatemala	86%	2.2	
Haiti	28%	7.3	
Honduras[1]	89%	0.9	
Jamaica[4]	98%	0.1	
Mexico[3]	98%	3.7	
Nicaragua[4]	75%	1.6	
Panama[1]	91%	0.3	
Paraguay	99%	0.1	
Peru	91%	2.7	
Suriname[3]	90%	0.1	
Trinidad and Tobago	97%	0.0	
Uruguay	99%	0.0	

TABLE R20. ELECTRICITY ACCESS BY REGION AND COUNTRY (continued)

REGION / COUNTRY	ELECTRIFICATION RATE IN 2012	PEOPLE WITHOUT ACCESS TO ELECTRICITY IN 2012	TARGETS
	Share of population with access	Millions	Share of population with access
Middle East			
Bahrain[2]	100%	0.0	
Iran	98%	1.2	
Iraq	98%	0.6	
Jordan[2]	100%	0.0	
Kuwait	100%	0.0	
Lebanon	100%	0.0	
Oman	98%	0.1	
Palestinian Territories[1, 5]	99%		
Qatar	100%	0.0	
Saudi Arabia	99%	0.3	
Syria	93%	1.6	
United Arab Emirates	100%	0.0	
Yemen	42%	13.8	
Oceania			
Federated States of Micronesia[3, 6]	4%	0.0	→ 75% by 2015
All Developing Countries	**76%**	**1,283**	
World[7]	**82%**	**1,285**	

[1] Data are for 2013.
[2] Countries that achieved an electrification rate of 100% in 2012.
[3] Data are for 2011.
[4] Data are for 2014.
[5] The Palestinian Territories rate is defined by the number of villages connected to the national electricity grid.
[6] 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).
[7] Includes countries in the OECD and economies in transition.
Note: Rates and targets are national unless otherwise specified. For other targets that relate to off-grid and rural electrification, see Table R15.
Source: See Endnote 20 for this section.

TABLE R21. POPULATION RELYING ON TRADITIONAL BIOMASS FOR COOKING

REGION / COUNTRY	SHARE OF POPULATION IN 2012	POPULATION (MILLIONS)
Africa	**67%**	**728**
Sub-Saharan Africa	**80%**	**727**
North Africa	**1%**	**1**
Developing Asia	**51%**	**1,875**
Latin America	**15%**	**68**
Middle East	**4%**	**8**
Africa		
Angola	56%	12
Benin	94%	9
Botswana	37%	1
Burkina Faso	95%	16
Burundi	98%	10
Cabo Verde	31%	0.2
Cameroon	75%	16
Central African Republic	97%	4
Chad	93%	12
Comoros	71%	1
Congo	76%	3
Côte d'Ivoire	79%	16
Democratic Republic of the Congo	93%	61
Djibouti	14%	0.1
Equatorial Guinea	78%	1
Eritrea	63%	4
Ethiopia	95%	87
Gabon	21%	0.3
Gambia	95%	2
Ghana	84%	21
Guinea	96%	11
Guinea-Bissau	98%	2
Kenya	84%	36
Lesotho	62%	1
Liberia	98%	4
Madagascar	98%	22
Malawi	97%	15
Mali	98%	15
Mauritania	56%	2
Morocco	3%	1
Mozambique	96%	24
Namibia	55%	1
Niger	94%	16
Nigeria	68%	115
Rwanda	98%	11
São Tomé and Príncipe	71%	0
Senegal	56%	8
Sierra Leone	98%	6
Somalia	96%	10
South Africa	13%	7
South Sudan	97%	11

TABLE R21. POPULATION RELYING ON TRADITIONAL BIOMASS FOR COOKING (continued)

REGION / COUNTRY	SHARE OF POPULATION IN 2012	POPULATION (MILLIONS)
Africa (continued)		
Sudan	72%	27
Swaziland	62%	1
Tanzania	96%	46
Togo	95%	6
Uganda	97%	35
Zambia	83%	12
Zimbabwe	70%	10
Developing Asia		
Bangladesh	89%	138
Cambodia	89%	13
China	33%	448
Democratic People's Republic of Korea	47%	12
India	66%	815
Indonesia	42%	105
Laos	65%	4
Mongolia	70%	2
Myanmar	93%	49
Nepal	80%	22
Pakistan	62%	112
Philippines	49%	47
Sri Lanka	74%	15
Thailand	24%	16
Vietnam	51%	45
Latin America		
Argentina	1%	0.6
Bolivia	25%	2.7
Brazil	6%	12.5
Colombia	15%	7.1
Costa Rica	6%	0.3
Cuba	7%	0.8
Dominican Republic	8%	0.9
Ecuador	4%	0.6
El Salvador	21%	1.3
Guatemala	64%	9.6
Haiti	93%	9.4
Honduras	51%	4.1
Jamaica	13%	0.4
Nicaragua	54%	3.2
Panama	17%	0.7
Paraguay	46%	3.1
Peru	36%	10.7
Middle East		
Iraq	1%	0.3
Yemen	33%	7.8
All Developing Countries	**49%**	**2,679**
World[1]	**38%**	**2,679**

[1] Includes countries in the OECD and economies in transition.

Source: See Endnote 21 for this section.

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
AFRICA				
Angola	Solar powerpack[1]		299 kW_p	- 897 residents electrified - Installed by ARE members
Benin	Solar PV (pico)	100 units	100 units	Implemented under the EnDev Programme[2]
	Solar lamps	1,500 units	2,825 units	Implemented under the SNV-funded Off-grid Solar Market Development Programme
	Solar powerpack[1]		50 kW_p	- 250 people electrified - Installed by ARE members
	Hybrid mini-grid		30 kW_p (2013)	Implemented in North Benin under an Energias Sin Fronteras (EsF) project
	Biogas digesters	100 units	107 units	Implemented by SNV with government funding
	Improved cookstoves	60,900 units	214,600 units	Implemented under the EnDev Programme[2]
Burkina Faso	Solar home systems (SHS)	159 kW_p	342 kW_p	- 3,365 people electrified - Installed by ARE members (FRES)
	Solar lamps	3,000 units	3,325 units	Implemented under the SNV-funded Pico PV for Africa Project
	Solar PV (pico)	21,352 units		Implemented under a joint GOGLA and World Bank project[3]
	Hybrid mini-grid (PV / diesel)		45 kW_p	- Three hybrid PV-diesel mini-grid projects, each with an installed capacity of 15 kW_p (as of July 2014) - Consolidated at country level
	Biogas digesters	1,448 units	5,462 units	- 4,741 households - Implemented by SNV/HIVOS under the African Biogas Partnership Programme funded by the Directorate General for International Cooperation, Netherlands (DGIS)
	Improved cookstoves	24,500 units	124,700 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	845 units	966 units	- For productive use in agricultural SMEs[4] - Implemented under the SNV-funded Energy, Poverty and Gender in Agro Processing (EPGAP) project
Burundi	Solar lanterns	250 units	500 units	Consolidated at country level
	Solar PV (pico)	5,300 units	9,800 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	900 units	1,700 units	Implemented under the EnDev Programme[2]
Cameroon	Hybrid mini-grids		23 MW	- 30 hybrid mini-grids operating - Consolidated at country level
	Biogas digesters	104 units	302 units	Implemented under an SNV-funded project
Congo	Solar PV		60 kW_p	Consolidated at country level
Côte d'Ivoire	Solar streetlights		9 kW_p	- 45 solar streetlights installed - Installed by ARE members
Democratic Republic of the Congo	Solar lamps	508 units	508 units	Implemented under the SNV-funded Pico PV for Africa Project
	Solar PV (pico)	37,452 units		Implemented under a joint GOGLA and World Bank project[3]
	Mini-grid (biofuel)	16 kW_p	16 kW_p	- Palm oil biofuel-based mini-grid run by co-operative - 100 households electrified - Implemented by SNV under a DGIS and FACT Foundation project
	Improved cookstoves	1,528 units	1,728 units	Implemented under the SNV-funded Improved Cookstove Programme
Ethiopia	Solar PV		5 MW	- 60% installed for rural telecom applications, 20% for water pumping, and 20% for solar home systems - Consolidated at country level

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES (continued)

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
AFRICA				
Ethiopia (continued)	Solar PV		5 MW	- 60% installed for rural telecom applications, 20% for water pumping, and 20% for solar home systems - Consolidated at country level
	Solar PV (pico)	44,300 units	71,700 units	Implemented under the EnDev Programme[2]
	Solar PV (pico)	580,930 units		Implemented under a joint GOGLA and World Bank project[3]
	Solar water pumping systems		15 units (2012)	Implemented by Plan International under the ACP–EU Energy Facility Programme
	Solar lanterns		9,000 units	Installed by ARE members
	Solar powerpacks[1]		500 kWp	- 1,500 people electrified - Installed by the ARE network
	Solar home systems	1,600 units	3,200 units	Implemented under the EnDev Programme[2]
	Solar home systems		500 units	Installed by ARE members
	Biogas digesters	1,465 units	10,678 units	- 3,136 households from 2012 to 2014 - Implemented by SNV/HIVOS under the DGIS-funded Africa Biogas Partnership Program
	Improved cookstoves	15,100 units	352,200 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	3,200 units	3,200 units	Implemented under the SNV-funded Integrated Renewable Energy Services project
Eritrea	Solar PV		310 kW_p	Installed in 429 community courts by ARE members
Gambia	Solar water pumping systems		26 kW_p	- 16 solar water pumping systems for community water supply and irrigation - Installed by ARE members
	Mini-grid (wind)		350 kW_p	Consolidated at country level
Ghana	Solar PV		3.2 MW	Consolidated at country level
	Solar lamps	1,033 units		Implemented under an SNV-funded project
	Solar outdoor microstation		6 kW_p	- Two outdoor microstations providing electricity to 1,800 people - Installed by ARE members
	Mini-grid (solar)		6 kW_p	- Two compact mini-grids - Installed by ARE members
	Improved cookstoves	1,200 units	1,233 units	- For productive use in agricultural SMEs[4] - Implemented through the SNV-funded EPGAP project
Guinea-Bissau	Solar PV		127 units	Consolidated at country level
	Solar home systems	138 kW_p	279 kW_p	- 2,041 people electrified - Installed by ARE members (FRES)
Kenya	Solar PV (pico)	36,900 units	56,800 units	Implemented under the EnDev Programme[2]
	Solar PV (pico)		695 units (2012)	Implemented under an SNV-funded project
	Solar PV (pico)	599,052 units	1,574,078 units	Implemented under a joint GOGLA and World Bank project[3]
	Solar kits	150 units	150 units	Implemented by Oolux under a REPIC co-funded project
	Solar kits	100 units	100 units	Implemented by Oolux under a SYMPHASIS co-funded project
	Solar lanterns		7,155 units (2012)	Implemented under an SNV-funded project
	Solar powerpack[1]		430 kW_p	- 1,290 residents electrified - Installed by ARE members
	Solar home systems		100 units	Implemented by Mobisol under a REPIC co-funded project

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES (continued)

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
AFRICA				
Kenya (continued)	Isolated home systems		320,000 units	- 6–8 MW installed - Consolidated at country level
	Hybrid mini-grid		19 MW	- 18 systems installed - Consolidated at country level
	Mini-grid (solar)		113 kW_p	A mini-grid (45 kW), 25 compact mini-grids (58 kW), and 4 containerised mini-grids (10 kW) installed by ARE members
	Biogas digesters	2,533 units	14,112 units	- 10,873 households - Implemented by SNV/HIVOS under the DGIS-funded African Biogas Partnership Program
	Improved cookstoves		917,700 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	839 units		Implemented under an SNV-funded project
Lesotho	Solar home systems		1,537 units	Implemented under the Lesotho Renewable Energy Based Rural Electrification Programme (closed in March 2013)
Liberia	Solar PV (pico)	7,000 units	7,500 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	600 units	1,100 units	Implemented under the EnDev Programme[2]
Madagascar	Solar PV	150 kW_p		- A 75 kW solar plant installed in two villages - Consolidated at country level
	Solar water pumping systems		10 kW_p	- Four solar water pumping systems for community water supply and irrigation installed - Installed by ARE members
	Micro-grid (PV)		3.2 kW_p	- Micro-grid of 2 kW - Implemented under a project funded by REPIC and Agena Energies (private company)
	Hydro	3 units	3 units	- Three units of 5 kW installed - Implemented under a co-funded REPIC project
Malawi	Solar water heaters		1,500 units	- Capacity of 200 litres per solar water heater - Consolidated at country level
	Isolated home systems		700 kW_p	- 5,000 systems installed - Consolidated at country level
	Improved cookstoves	10,200 units	14,400 units	Implemented under the EnDev Programme[2]
Mali	Solar PV		13 units	- Off-grid units that range from 20 kW to 240 kW - Consolidated at country level
	Solar PV		902 kW_p	- Solar home systems and mini-grid providing electricity to 6,314 people - Installed by ARE members
	Solar PV		2 units	- Off-grid systems installed in schools - Implemented under a Plan International project
	Solar PV (pico)	700 units	1,800 units	Implemented under the EnDev Programme[2]
	Solar lamps	2,275 units	2,867 units	Implemented under an SNV-funded project
	Solar water heating systems		3 kW_p	Implemented under a Plan International project
	Solar kiosks	9 kW_p	30 units	Recharging stations implemented by Plan International under the ACP-EU Energy Facility Programme
	Solar home systems	86 kW_p	280 kW_p	- 2,286 systems installed - Installed by FRES
	Isolated home systems		216 kW_p	Consolidated at country level
	Mini-grids (solar)		622 kW_p	Installed by FRES

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES (continued)

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
AFRICA				
Mali (continued)	Hybrid mini-grid (PV / diesel)		2.1 MW	- 21 hybrid mini-grids installed - Consolidated at country level
	Improved cookstoves	17,529 units	25,459 units	- Domestic and productive stoves - Implemented under the SNV-funded EPGAP project
	Improved cookstoves		3,100 units	Implemented under a Plan International project
Mauritania	Solar water pumping systems		16 kW_p	- Eight solar water pumping systems for community water supply and irrigation installed - Installed by ARE members
	Hybrid mini-grid (PV / diesel)		6 units	PV / diesel power plants (three systems of 15–20 kW_p and three systems of 25 kW_p)
Morocco	Solar home systems		51,599 units (2013)	Implemented under the Governmental Rural Electrification Programme
Mozambique	Solar PV (pico)		6,600 units	Implemented under the EnDev Programme[2]
	Solar outdoor micro-station		6 kW_p	- 1,800 residents electrified - Installed by ARE members
	Mini-grid (solar)		9 kW_p	- Three compact mini-grids installed - Installed by ARE members
	Improved cookstoves	4,500 units	4,700 units	Implemented under the EnDev Programme[2]
Niger	Solar PV		4 MW	Consolidated at country level
	Solar lamps	7,600 units		Implemented under an SNV-funded project
	Mini-grid (solar)		27.5 kW_p	- 105 households electrified and electricity for productive use - Implemented by Plan International under the ECREEE EREF II
Nigeria	Solar PV (pico)	147,396 units		Implemented under a joint GOGLA and World Bank project[3]
	Solar outdoor microstation		23 kW_p	- 6,900 residents electrified - Installed by ARE members
	Solar streetlights		5.4 kW_p	- 40 solar streetlights installed - Consolidated at country level
	Isolated home systems		5 units	Consolidated at country level
	Hybrid mini-grid		6 units	Consolidated at country level
	Mini-grid (hydro)		4 kW_p	- 150 residents electrified - Installed by ARE members
	Mini-grid (solar)		16 kW_p	- 12 compact mini-grids - Installed by ARE members
Rwanda	Solar PV (pico)	80,111 units		Implemented under a joint GOGLA and World Bank project[3]
	Solar home systems	400 kW_p		- 4,000 installations; 21,200 people electrified - Installed by Mobisol
	Mini-grid (hydro)		1,000 kW_p	Implemented under the EnDev Programme[2]
	Hybrid mini-grid (PV / diesel)		50 units	- 50 minigrids of 3–6 kW_p for health care centres - Consolidated at country level
	Biogas systems	200 units	1,700 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	24,769 units	24,769 units	- Clay-based, efficient Canarumwe stoves - Implemented by SNV under the World Bank-funded Improved Cook Stoves project

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES (continued)

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
AFRICA				
Senegal	Solar PV		21 MW	Implemented under a joint GOGLA and World Bank project[3]
	Solar PV (pico)	14,930 units		Consolidated at country level
	Isolated home systems		50,000 units	Consolidated at country level
	Solar home systems	700 units	2,600 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	30,200 units	110,400 units	Implemented under the EnDev Programme[2]
Sierra Leone	Hybrid mini-grid (PV / hydro)		1 unit	Consolidated at country level
Somalia	Solar PV		5 kW_p	- Used for cooling purposes - Installed by ARE members
South Africa	Solar powerpack[1]		504 kW_p	- 1,640 people electrified - Installed by ARE members
	Solar home systems		1,317 kW_p	- 18,065 resident electrified - Installed by ARE members (FRES)
Sudan	Solar home systems		100 units	Consolidated at country level
Tanzania	Solar outdoor microstation		66 kW_p	- 1,800 people electrified - Installed by ARE members
	Solar PV (pico)	1,800 units	1,800 units	Implemented under the EnDev Programme[2]
	Solar PV (pico)	787,488 units		Implemented under a joint GOGLA and World Bank project[3]
	Solar lamps	750 units	1,050 units	Implemented under the SNV-funded International Renewable Energy Services Programme
	Solar home systems		900 kW_p	- 7,500 residents electrified - Installed by ARE members
	Solar home systems	1,000 kW_p		- 56,000 people electrified in 2014 - 10,000 systems installed by Mobisol
	Isolated home systems		4 MW	- 4,000–8,000 units installed - Consolidated at country level
	Mini-grid (solar)		6 kW_p	- Two compact mini-grids - Installed by ARE network
	Biogas digesters	2,304 units	11,103 units	- 8,532 households - Implemented by SNV/HIVOS under the DGIS-funded African Biogas Partnership Program
	Improved cookstoves	2,200 units	2,800 units	Implemented under the EnDev Programme[2]
	Improved cookstoves		960 units	Implemented through an SNV-funded project
Uganda	Solar PV (pico)	5,900 units	14,000 units	Implemented under the EnDev Programme[2]
	Solar PV (pico)	70,022 units		Implemented under a joint GOGLA and World Bank project[3]
	Solar kits	200 units	200 units	Implemented by Oolux under a REPIC co-funded project
	Solar kits	130 units	130 units	Implemented by Oolux under a SYMPHASIS co-funded project
	Solar home systems	600 units	1,700 units	Implemented under the EnDev Programme[2]
	Solar home systems	114 kW_p	544 kW_p	- 3,482 people electrified - Installed by ARE members (FRES)
	Isolated home systems		400 kW_p	- 15,000 systems installed - Consolidated at country level
	Hybrid mini-grid		5 kW_p	Consolidated at country level

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES (continued)

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
AFRICA				
Uganda (continued)	Improved cookstoves	5,200 units	12,400 units	Implemented under the EnDev Programme[2]
	Improved cookstoves	3,847 units	3,847 units	Implemented under the SNV-funded International Renewable Energy Services programme
	Biogas digesters	527 units	5,695 units	- 3,793 households - Implemented by SNV/HIVOS under the DGIS-funded African Biogas Partnership Program
Zimbabwe	Solar powerpacks[1]		550 kW_p	- 1,650 residents electrified - Installed by ARE members
	Solar lamps	25,000 units	25,803 units	Implemented under an SNV-funded project
DEVELOPING ASIA				
Bangladesh	Solar PV		630 kW_p	- 3,600 residents electrified - Installed by ARE members
	Solar PV		550 kW_p	- 2,500 people electrified by solar PV rooftop solutions - Installed by ARE members
	Solar lanterns		106 units	Consolidated at country level
	Solar home systems	271,200 units	3,600,000 units	- Information as of April 2014 - 13 million people have access to solar electricity - Installed in 2014 under the EnDev Programme[2]
	Solar home systems		28,800 kW_p	- 720,000 residents electrified - Installed by ARE members
	Mini-grid (solar)		300 kW_p	- 7,500 residents electrified - Installed by ARE members
	Biogas systems	5,173 units	37,059 units	- 37,059 households - Implemented by SNV under the DGIS / KfW-funded Biogas Program
	Improved cookstoves	87,200 units	382,100 units	Implemented under the EnDev Programme[2]
Bhutan	Biogas systems	581 units	1,420 units (2013)	Implemented by SNV under an ADB-funded project
Cambodia	Solar lanterns		10,000 units	Consolidated at country level
	Biogas systems	700 units	1,100 units	Implemented under the EnDev Programme[2]
	Biogas systems		22,119 units	- 22,119 households - Implemented by SNV under the DGIS-funded Biogas Program
India	Solar PV (pico)	1,054,051 units		Implemented under a joint GOGLA and World Bank project[3]
	Solar lanterns		27,913 units	Consolidated at country level
	Hybrid mini-grid		1,123 MW	Consolidated at country level
	Biogas digesters	82,733 units	4,750,000 units	Consolidated at country level
Indonesia	Solar PV (pico)	54,473 units		Implemented under a joint GOGLA and World Bank project[3]
	Mini-grid (hydro)	500 kW_p	5,000 kW_p	Implemented under the EnDev Programme[2]
	Mini-grid (solar)	2,000 kW_p	3,700 kW_p	Implemented under the EnDev Programme[2]
	Biogas systems	1,000 units	1,700 units	Implemented under the EnDev Programme[2]
	Biogas systems	2,861 units	14,192 units	- 14,192 households - Implemented by SNV/HIVOS under the DGIS-funded Biogas Program
Laos	Biogas systems		2,888 units	Implemented by SNV under a DGIS-funded project
	Improved cookstoves	21,240 units	28,000 units	Implemented by SNV under a project funded by EU/Oxfam/ Blue Moon Fund

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES (continued)

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
DEVELOPING ASIA				
Mongolia	Solar PV		100,000 households	Implemented under the 100,000 Solar Ger project
Myanmar	Solar PV (pico)	26,764 units		Implemented under a joint GOGLA and World Bank project[3]
Nepal	Mini-grid (hydro)	500 kW_p	600 kW_p	Implemented under the EnDev Programme[2]
	Hybrid mini-grid (solar and wind)	7 kW_p		- 5 kW_p from wind turbines and 2 kW_p from solar PV - Implemented under the ADB Energy for All initiative
	Biogas systems	35,108 units	70,526 units	- 70,526 households - Implemented by SNV under the DGIS-funded Biogas Program
	Improved cookstoves	19,046 units	32,246 units	- 32,246 households - Implemented under a project funded by OPEC Fund for International Development (OFID) and SNV
Philippines	Solar powerpack[1]		406 kW_p	- 2,030 people electrified - Installed by ARE members
	Solar lanterns		34 kW_p	- 20,000 solar lanterns installed - Installed by ARE members
Pakistan	Solar PV (pico)	17,411 units		Implemented under a joint GOGLA and World Bank project[3]
	Solar powerpack[1]		26 kW_p	- 80 people electrified - Installed by ARE members
	Biogas systems	2015 units	5,360 units	- 5,360 households - Implemented by SNV under the DGIS-funded Biogas Program
Sri Lanka	Solar home systems		30,000 units	Consolidated at country level
Vietnam	Biogas systems	5,300 units	8,900 units	Implemented under the EnDev Programme[2]
	Biogas systems		173,905 units (2013)	Implemented under a project funded by DGIS/ADB/World Bank/JICA/Blue Moon Fund
LATIN AMERICA				
Bolivia	Solar PV (pico)	260 units	260 units	Implemented under the EnDev Programme[2]
	Solar lanterns		5,705 units	Implemented under the Household and Social PV Systems Global Partnership Output Based Aid (EDAU-GPOBA)
	Biogas systems		500 units	Implemented under the EnDev Programme[2]
	Improved cookstoves		44,400 units	Implemented under the EnDev Programme[2]
Colombia	Hybrid mini-grid (PV / hydro)		4 kW_p	- 90 residents electrified - Installed by ARE members
Costa Rica	Solar PV		2,800 households	Consolidated at country level
Guatemala	Solar home systems		335 households	Implemented under the IDB-funded Rural Electrification Program with the goal of 3,335 SHS
Honduras	Solar home systems	1,100 units	4,100 units	Implemented under the EnDev Programme[2]
	Biogas systems		4 units	- Biogas for productive use in agricultural SMEs[4] (coffee and pig) - Implemented by SNV under a DANIDA/U.S. Embassy-funded project
	Improved cookstoves		9,800 units	Implemented under the EnDev Programme[1]
Nicaragua	Solar home systems		406 households	Implemented under the IDB-funded Rural Electrification Program with the goal of 4,218 SHS
	Biogas systems	279 units	283 units	Implemented by SNV under a project funded by IDB/Nordic Funds/HIVOS

TABLE R22. DISTRIBUTED RENEWABLE ENERGY MARKETS AND INSTALLED CAPACITIES: EXAMPLES (continued)

COUNTRY	TECHNOLOGY/ SYSTEM	CAPACITY ADDED IN 2014	CUMULATIVE AT END-2014	ADDITIONAL INFORMATION (including programme, financing partner and project developer)
LATIN AMERICA				
Panama	Solar home systems		1,425 households	Implemented under the IDB-funded Rural Electrification Program
Peru	Solar PV (pico)	2,200 units	3,000 units	Implemented under the EnDev Programme[2]
	Solar home systems	1,100 units	4,900 units	Implemented under the EnDev Programme[2]
	Mini-grid (biogas)	16 kW_p		- 50 households electrified - Implemented by SNV under a Government/Dutch Foundation-funded project
	Hybrid mini-grid (hydro / solar)	4 kW_p		- 192 residents electrified - Installed by ARE members
	Improved cookstoves	20,000 units	124,800 units	Implemented under the EnDev Programme[2]
Venezuela	Solar PV		2.5 MW	3,139 PV systems installed under the Government "Sowing Light" Program
MIDDLE EAST				
Saudi Arabia	Solar powerpack[1]		14 kW_p	- 50 residents electrified - Installed by ARE members
United Arab Emirates	Solar PV		80 kW_p	Consolidated at country level
OCEANIA				
Australia	Solar PV		275 kW_p	Installed by ARE members
Papua New Guinea	Solar PV (pico)	23,833 units		Implemented under a joint GOGLA and World Bank project[3]

[1] A solar powerpack is a solar array that consists of a solar PV module, a maintenance-free battery, a solar inverter/charge controller, and safety switches/relays, mounting hardware, and interconnecting cables.

[2] All Energising Development (EnDev) data are based on reported figures as of end-2014, and they have been corrected to account for a "sustainability" factor, a "windfall gain" factor, and replacement. The sustainability factor applies when the renewable energy technology being used may not be repaired or when a household returns to its previous energy source at end-of-life of the renewable energy system. The windfall gain factor refers to people who, in the same period and in the absence of the project, still might have gained access to an equivalent service. The replacement factor accounts for systems that had to be replaced during the duration of a project due to their lifespan (applies mainly to cookstoves and pico solar PV systems).

[3] All Global Off-Grid Lighting Association (GOGLA) data represent units sold by GOGLA members in 2014 (partly only during the second half of 2014); data are only for countries where more than three member companies have reported sales; all stand-alone solar lanterns and systems that are under 15 kW_p are referred to as "Solar PV (pico)".

[4] SME = small and medium-sized enterprise.

Note: This reference table represents a first attempt to compile DRE data based on available information and contributions from key stakeholders. As such, it is non-exhaustive and should not be considered comprehensive. This table does not include all countries, and it might be missing some systems or/and technologies that are present in a specific country. Data are derived from the REN21 database and are compiled from all available submissions from report contributors, in particular country contributors and topical DRE contributors. It includes information only from those development banks and organisations that contributed to the REN21 database. All data in column "cumulative at end-2014" are for 2014 unless otherwise noted.

Source: See Endnote 22 for this section.

TABLE R23. PROGRAMMES FURTHERING ENERGY ACCESS: SELECTED EXAMPLES

NAME	BRIEF DESCRIPTION
ACP-EU Energy Facility	A co-financing instrument that works to increase access to sustainable and affordable energy services in impoverished rural and peri-urban areas of African, Caribbean and Pacific (ACP) countries by involving local authorities and communities.
Africa-EU Renewable Energy Cooperation Programme (RECP)	A programme that contributes to the African EU Energy Partnership's political targets of increasing renewable energy use and bringing modern access to at least an additional 100 million people by 2020. It provides policy advice, private sector co-operation, project preparation support activities, and capacity development.
African Renewable Energy Fund (AREF)	A private equity fund that invests in small to medium-sized renewable energy projects in sub-Saharan Africa, excluding South Africa. It aims to assist governments in meeting their renewable energy and carbon emission targets, while creating jobs. AfDB and SE4ALL are co-sponsors and anchor investors.
Asian Development Bank – Energy for All Initiative	An initiative that strengthens ADB's investments on energy access. From 2008 to 2014, ADB's aggregate investment was around USD 5.2 billion, which is expected to benefit 86.4 million people.
Capital Access for Renewable Energy Enterprises Programme (CARE2)	A USD 7 million programme that aims to expand renewable energy markets in Kenya, Rwanda, Tanzania, and Uganda through interventions designed to increase the supply of capital to businesses. CARE2 is supported by the Swedish International Development Cooperation Agency.
Central America Clean Cooking Initiative (CACCI)	An initiative that aims to help scale up clean cooking solutions in countries such as Guatemala, Honduras, Nicaragua, and possibly El Salvador. Activities to be financed by the grant include development of a roadmap to achieve universal clean cooking access by 2030. The roadmap will build on the regional Sustainable Energy Strategy 2020.
CleanStart	Developed by the UN Capital Development Fund and UNDP to help poor households and micro-entrepreneurs access micro-financing for low-cost clean energy. It aims to help lift at least 2.5 million people out of energy poverty by 2017, in ways that can be replicated and scaled up by others.
Energising Development (EnDev)	A multilateral initiative supported by the governments of Australia, Germany, the Netherlands, Norway, Switzerland, and the United Kingdom. It operates in 24 countries in Asia, Africa, and Latin America with the aim of facilitating the sustainable access to modern energy services for at least 15 million people by the end of 2018. So far, EnDev has facilitated energy access for 12.9 million people.
Energy Environment Resiliency in Africa (EERA)	A project that supports energy decision makers in assessing national energy policy frameworks and in identifying how energy policies can support climate resilience and sustainable energy objectives in Benin, Mali, and Togo.
EU-Africa Infrastructure Trust Fund (ITF)	A fund that combines grants and loans from the EU and its Member States and banks to support local infrastructure projects, notably in electricity generation. By end-2013, 36 grants had been approved for projects totalling EUR 240 million in investments.
GIZ – HERA Basic Energy Supply	A project that works on facilitating the access of poor households, social institutions, and small businesses to renewable energy and its sustainable and efficient use. HERA develops and disseminates strategies and concepts for poverty-oriented basic energy services and assists energy access projects conducted by GIZ on behalf of the German government worldwide.
Global Alliance for Clean Cookstoves	A public-private partnership that works to save lives, improve livelihoods, empower women, and protect the environment by creating a thriving global market for clean and efficient household cooking solutions. Its goal is to provide 100 million households with clean cookstoves and fuels by 2020.
Global Energy Efficiency and Renewable Energy Fund (GEEREF)	A sustainable development tool sponsored by the EU, Germany, and Norway, advised by the European Investment Bank Group. It aims to mobilise public and private capital to support small and medium-sized renewable energy and energy efficiency projects.
Global LEAP Awards for Outstanding Off-Grid Products	An international competition to identify the world's best-quality low-voltage, direct-current appliances for off-grid use (including LED appliances for room lighting and flat-panel colour televisions). The first round was awarded in May 2014.

TABLE R23. PROGRAMMES FURTHERING ENERGY ACCESS: SELECTED EXAMPLES (continued)

NAME	BRIEF DESCRIPTION
Global Lighting and Energy Access Partnership (Global LEAP)	An initiative of the Clean Energy Ministerial that includes more than 10 governments and development partners. It provides support for quality assurance frameworks and programmes that encourage market transformation towards super-efficient technologies for off-grid use.
Global Sustainable Energy Islands Initiative (GSEII)	An initiative that works with NGOs and multilateral institutions to help small-island developing states (SIDS) address energy security and climate change issues. It has helped nine SIDS to build human capacity, increase awareness, and implement energy efficiency and renewable energy projects. It has spent about USD 1 million on the preparation of national energy plans, biofuel feasibility studies, energy efficiency training, and renewable energy projects.
Green Climate Fund (GCF)	A fund emerging from the COP climate change discussions in Copenhagen, Denmark, and Durban, South Africa, to co-ordinate and consolidate funding on climate change mitigation and adaptation. It attempts to harmonise ongoing global financing efforts related to energy and transport infrastructure (among others) from the World Bank, the GEF, the Adaptation Fund, the CDM of the Kyoto Protocol, and the G8.
IDEAS – Energy Innovation Contest	A contest that supports the implementation of innovative projects in the areas of renewable energy, energy efficiency, and energy access in Latin America and the Caribbean by promoting innovative energy solutions that can be replicated and scaled up in the region.
IRENA – Abu Dhabi Fund for Development (ADFD)	A fund to support renewable energy projects that offer innovative and replicable approaches to broaden energy access; address several socio-economic issues identified in the Millennium Development Goals and SE4ALL objectives; and address energy security issues.
Lighting a Billion Lives	A global initiative launched in 2008, steered by The Energy and Resources Institute, to facilitate access to clean lighting and cooking solutions for energy-starved communities. The programme operates on an entrepreneurial model of energy service delivery to provide innovative, affordable, and reliable off-grid solar solutions. As of March 2015, it had facilitated access to clean lighting and cooking solutions for more than 3.5 million people in India, sub-Saharan Africa, and South Asia.
Lighting Africa	An IFC and World Bank programme to accelerate the development of sustainable markets for affordable, modern off-grid lighting solutions for low-income households and micro-enterprises across Africa. As of early 2014, Lighting Africa had provided access to clean, safe lighting for more than 7.7 million people.
Lighting Asia	An IFC market transformation programme aimed at increasing access to clean, affordable energy in rural Bangladesh and India by promoting modern off-grid lighting products, systems, and mini-grid connections. The programme works with the private sector to remove market entry barriers, provide market intelligence, foster business to business linkages, and raise consumer awareness on modern lighting options. It aims to reach 3 million people in India and 2.3 million people in Bangladesh by 2016.
Power Africa	A US government initiative to address access to electricity in sub-Saharan Africa, with a commitment of USD 26 billion in financial support and loan guarantees. It has a target to double energy access in sub-Saharan Africa, using renewable energy, by adding more than 60 million new household and business connections. In August 2014, an additional combined USD 12 billion was pledged by Norway, Sweden, and the United Kingdom.
Readiness for Investment in Sustainable Energy (RISE)	A new World Bank Group project providing indicators that compare the investment climate of countries across the three focus areas of the SE4ALL initiative: energy access, energy efficiency, and renewable energy.
Renewable Energy and Energy Efficiency Partnership (REEEP)	A partnership that invests in clean energy markets in developing countries to reduce CO_2 emissions and build prosperity. Based on a strategic portfolio of high-impact projects, it works to generate energy access, improve lives and economic opportunities, build sustainable markets, and combat climate change. REEEP has formed partnerships with more than 120 governments, banks, businesses, nongovernmental organisations, and inter-governmental organisations, and has invested about USD 20 million (EUR 16.4 million) in more than 145 projects.

TABLE R23. PROGRAMMES FURTHERING ENERGY ACCESS: SELECTED EXAMPLES (continued)

NAME	BRIEF DESCRIPTION
Scaling Up Renewable Energy in Low Income Countries (SREP)	A Strategic Climate Fund (SCF) programme that was established to expand renewable energy markets and scale up renewables' deployment in the world's poorest countries. It initially piloted in Ethiopia, Honduras, Kenya, Liberia, the Maldives, Mali, Nepal, and Tanzania, and added 14 additional countries in 2014.
SNV Netherlands Development Organisation – Biogas Practice	A multi-actor sector development approach that supports the preparation and implementation of national biogas programmes throughout the world. In co-operation with its partners, SNV had installed 579,000 biogas plants in 18 developing countries in Asia, Africa, and Latin America by end-2013 (with 74,000 in 2013 alone).
Sustainable Energy for All Initiative (SE4ALL)	A global initiative of UN Secretary-General Ban Ki-moon with three objectives for 2030: achieving universal access to electricity and clean cooking solutions; doubling the share of the world's energy supplied by renewable sources; and doubling the rate of improvement in energy efficiency.
Sustainable Energy Fund for Africa (SEFA)	A fund administered by the African Development Bank and anchored by a Danish government commitment of USD 57 million to support small- and medium-scale clean energy and energy efficiency projects in Africa through grants for technical assistance and capacity building, investment capital, and guidance.

TABLE R24. NETWORKS FURTHERING ENERGY ACCESS: SELECTED EXAMPLES

NAME	BRIEF DESCRIPTION
African Bioenergy Development Platform	A platform launched by UNCTAD to help interested African countries develop their bioenergy potentials for advancing human and economic development through interactive, multi-stakeholder analytical exercises.
African Center for Renewable Energy and Sustainable Technologies (ACREST)	A centre established in 2005 for information, demonstration, awareness, production, and research on renewable energy and sustainable technologies in Africa. Its mission is to promote renewable energy technologies and sustainable technologies to improve people's living conditions and to fight poverty.
African Renewable Energy Alliance (AREA)	A global multi-stakeholder platform to exchange information and consult about policies, technologies, and financial mechanisms for the accelerated uptake of renewable energy in Africa.
AKON Lighting Africa	An initiative launched in February 2014 that seeks to provide a concrete response at the grassroots level to Africa's energy crisis and to lay the foundations for future development. It aims to develop an innovative solar-powered solution that will provide African villages with access to a clean and affordable source of electricity.
Alliance for Rural Electrification (ARE)	An international business association that represents the decentralised energy sector and works towards the integration of renewables into rural electrification markets in developing and emerging countries. It has more than 80 members along the whole value chain of DRE systems.
Clean Energy for Africa (CLENA)	A five-year action plan (2012–2016) to promote sustainable energy and alleviate energy poverty in Africa.
Climate Technology Initiative Private Financing Advisory Network (CTI PFAN)	A multilateral, public-private partnership initiated by the Climate Technology Initiative (CTI) in co-operation with the UNFCCC Expert Group on Technology Transfer. PFAN operates to bridge the gap between investments and clean energy businesses. It is designed to be an "open source" network to fit seamlessly with existing global and regional initiatives and to be inclusive of all stakeholders with an interest in clean energy financing.
Consultative Group to Assist the Poor (CGAP)	A global partnership of 34 leading organisations, housed at the World Bank, that seeks to advance financial inclusion. It develops innovative solutions through practical research and active engagement with financial service providers, policy makers, and funders to enable approaches at scale.
CTI – Private Financing Advisory Network	A network that identifies promising clean energy projects at an early stage and provides mentoring for development of a business plan, investment pitch, and growth strategy, etc.
ENERGIA International	An international network focused on gender issues, women's empowerment, and sustainable energy. By early 2014, it included 22 organisations working in Africa and Asia.
Energy Access Practitioner Network	A 2,000-strong global network of businesses and non-profits operating in 170 countries that focuses on decentralised low-carbon household and community-level electrification. It supports innovative financial and business models in predominantly market-based applications that help address development issues such as income generation, health, agriculture, education, small business, and telecommunications.
Global Network on Energy for Sustainable Development (GNESD)	A network oriented to address energy access issues and promote renewable energy technologies that reduce poverty. It mainly conducts workshops and publishes reports on energy and poverty in Asia, Africa, and Latin America.
Global Renewable Energy Islands Network (GREIN)	A network created to help islands accelerate their renewable energy uptake. It will serve as a platform for pooling knowledge, sharing best practices, and seeking innovative solutions for the accelerated update of clean and cost-effective renewable energy technologies in island states and territories.
HEDON Household Energy Network	A network aimed at empowering practitioners to unlock barriers to household energy access by addressing knowledge gaps, facilitating partnerships, and fostering information sharing.

TABLE R24. NETWORKS FURTHERING ENERGY ACCESS: SELECTED EXAMPLES (continued)

NAME	BRIEF DESCRIPTION
International Network for Sustainable Energy (INFORSE)	A network of 140 NGOs operating in 60 countries that was established as part of the Rio Convention. It is dedicated to promoting sustainable energy and social development and is funded by a mix of national governments, multilateral institutions, and civil society organisations. INFORSE focuses on four areas: raising awareness about sustainable energy use; promoting institutional reform among national governments; building local and national capacity on energy related issues; and supporting research and development.
La Via Campesina (LVC)	Informally known as the "international peasants' movement", a group of about 150 organisational members that co-ordinate migrant workers, farmers, rural women, and indigenous communities on rural development issues. The "sustainable agriculture", "water", and "women and human rights" programmes deal with various aspects of rural energy use, especially the connections between food security and biofuels.
RedBioLAC	A multinational network of institutions involved in research and dissemination of anaerobic bio-digestion and the treatment and management of organic waste in Latin America and the Caribbean.
Small-Scale Sustainable Infrastructure Development Fund (S3IDF)	A fund that promotes a Social Merchant Bank approach to help local entrepreneurs create micro-enterprises that provide infrastructure services to the poor. As of early 2015, it had a portfolio of almost 200 small investments and associated enterprises in India, and an additional 100 projects in the pipeline.
WindEmpowerment	A global association for the development of locally built small-scale wind turbines for sustainable rural electrification.

1 U.S. Energy Information Administration (EIA), "Short-term Energy Outlook: Global Crude Oil Prices," 12 May 2015, http://www.eia.gov/forecasts/steo/report/prices.cfm; Grant Smith and Anthony Dipaola, "Saudis' Oil Price War Is Paying Off," *Bloomberg*, 26 February 2015, http://www.bloomberg.com/news/articles/2015-02-27/saudis-bold-gambit-paying-off-just-three-months-later-energy; Grant Smith, "Oil-Price Rout Seen Deepening by IEA as Pressure on OPEC Mounts," *Bloomberg*, 14 November 2014, http://www.bloomberg.com/news/articles/2014-11-14/oil-price-rout-seen-deepening-by-iea-as-pressure-on-opec-mounts; Ehren Goossens, "Cheap Oil Unlikely to Slow Growth of Renewables, Citigroup Says," *Bloomberg*, 30 March 2015, http://www.bloomberg.com/news/articles/2015-03-30/cheap-oil-unlikely-to-slow-growth-of-renewables-citigroup-says; Ole Mikelson, "Vestas Wind Chairman Say Low Oil Price Not a Big Problem," *Reuters*, 30 March 2015, http://af.reuters.com/article/energyOilNews/idAFL6N0WW3UQ20150330; Tom Randall, "While You Were Getting Worked Up Over Oil Prices, This Just Happened to Solar," *Bloomberg*, 29 October 2014, http://www.bloomberg.com/news/articles/2014-10-29/while-you-were-getting-worked-up-over-oil-prices-this-just-happened-to-solar; University of Cambridge and PwC, *Financing the Future of Energy* (Abu Dhabi: March 2015), http://www.pwc.com/m1/en/publications/documents/financing-the-future-of-energy-executive-summary-english.pdf. Decreased oil prices may dampen the markets for renewable energy in transportation and heating and cooling going forward, from Jacob Bunge and Jesse Newman, "Falling Crude Prices Force Ethanol Makers to Take It on the Chin," *Wall Street Journal*, 2 January 2015, http://www.wsj.com/articles/falling-crude-prices-force-ethanol-makers-to-take-it-on-the-chin-1420238100.

2 Growth in final energy consumption for years 2007 through 2012, from International Energy Agency (IEA), *World Energy Statistics and Balances*, 2014 edition (Paris: OECD/IEA, 2014).

3 Carbon emissions remained stable in 2014 compared to 2013, while the global economy grew by 3%. IEA, "Global Energy-related Emissions of Carbon Dioxide Stalled in 2014," 13 March 2015, http://www.iea.org/newsroomandevents/news/2015/march/global-emissions-of-carbon-dioxide-stalled-in-2014.html.

4 Ibid.

5 Together, China and the United States emitted 40% of global carbon dioxide emissions in 2014, from Leigh Phillips, "How Big a Deal Is the US-China Climate Deal?" Road to Paris, 16 November 2014, http://roadtoparis.info/2014/11/16/big-deal-us-china-climate-deal/; The White House, "U.S.-China Joint Announcement on Climate Change," press release (Washington, DC: 11 November 2014), https://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change; Alex Nussbaum and Eric Martin, "Mexico Pledges to Cut Emissions 25 Percent in Climate Change Milestone," Renewable Energy World, 30 March 2014, http://www.renewableenergyworld.com/rea/news/article/2015/03/mexico-pledges-to-cut-emissions-25-percent-in-climate-change-milestone; Government of the Republic of Mexico, "Mexico's Intended Nationally Determined Contribution," press release (Mexico City: 27 March 2015); European Commission for Climate Action, "2030 Framework for Climate and Energy Policies," 26 March 2015, http://ec.europa.eu/clima/policies/2030/index_en.htm.

6 See section on Distributed Renewable Energy in Developing Countries and Reference Tables R22–R24.

7 United Nations Sustainable Energy for All (SE4ALL), "United Nations Decade of Sustainable Energy for All 2014-2024," http://www.se4all.org/decade/.

8 SE4ALL, "Tracking Progress," http://www.se4all.org/tracking-progress/, viewed 10 April 2015.

9 Estimated shares based on the following sources: Total 2013 final energy consumption (estimated at 8,332 Mtoe) is based on 8,170 Mtoe for 2012 from IEA, op. cit. note 2, and escalated by the 1.98% increase in global primary energy demand from 2012 to 2013, derived from BP, *Statistical Review of World Energy 2014* (London: 2014). Traditional biomass use in 2013 of 31.5 EJ from IEA, *Medium-Term Renewable Energy Market Report 2014* (Paris: OECD/IEA, 2014), p. 208. Elsewhere, traditional biomass use in 2012 was estimated at 758 Mtoe (31.74 EJ), and expected to decline by 2020, from IEA, *World Energy Outlook 2014* (Paris: OECD/IEA, 2014), p. 242. 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, UK and New York: Cambridge University Press, 2011), Table 2.1, http://srren.ipcc-wg3.de/report. Modern bio-heat energy values for 2013 (industrial, residential, and other uses, including heat from heat plants) of 310.5 Mtoe (13 EJ) from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. this note, p. 212. Bio-power generation of 34 Mtoe (396 TWh), from idem, p. 144. Wind power generation of 54.3 Mtoe (631 TWh) from idem, pp. 159, 164. Solar PV generation of 11.3 Mtoe (131 TWh), from idem, Electronic Databook. Concentrated solar thermal power (CSP) was 0.5 Mtoe (6.3 TWh), from idem. Ocean power was 0.1 Mtoe (1 TWh), from idem. Geothermal electricity generation of 6.3 Mtoe (73 TWh), from idem. Hydropower of 325 Mtoe (3,782 TWh) from BP, op. cit. this note. Solar thermal heating/cooling estimated at 27 Mtoe (1.13 EJ), from Franz Mauthner, AEE-Institute for Sustainable Technologies (AEE-INTEC), Gleisdorf, Austria, personal communications with REN21, March–May 2015; Franz Mauthner and Werner Weiss, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2013* (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme (SHC), 2015). Note that the estimate does not consider air collectors. Geothermal heat (excluding heat pumps) was estimated at 6.3 Mtoe (0.26 EJ), based on 2014 value from John W. Lund and Tonya L. Boyd, "Direct Utilization of Geothermal Energy: 2015 Worldwide Review," in *Proceedings of the World Geothermal Congress 2015* (Melbourne, Australia: 19–25 April 2015). For liquid biofuels, ethanol use was estimated at 45.4 Mtoe (1.9 EJ) and biodiesel use at 20.4 Mtoe (0.85 EJ), based on 89.6 billion litres and 26.6 billion litres, respectively, from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. this note, Electronic Databook; and conversion factors from U.S. Department of Energy Alternative Fuels Data Center, http://www.afdc.energy.gov/fuels. Nuclear power generation was assumed to contribute 214 Mtoe (2,489 TWh) of final energy, from BP, op. cit. this note. **Figure 1** based on the sources in this note.

10 Ibid.

11 **Figure 2** based on the following: See relevant sections and endnotes for more details regarding 2014 data and sources. **Geothermal** based on 10.7 GW in operation at the end of 2009, about 12.1 GW at the end of 2013, and nearly 12.8 GW at the end of 2014, from U.S. Geothermal Energy Agency (GEA), unpublished database, provided by Benjamin Matek, GEA, personal communication with REN21, March 2014; and from Ruggero Bertani, "Geothermal Power Generation in the World: 2010-2014 Update Report," in *Proceedings of the World Geothermal Congress 2015* (Melbourne, Australia: 19–25 April 2015). **Hydropower** based on an estimated 888 GW (not including pumped storage) in operation at the end of 2009 based on data from EIA, "International Energy Statistics," http://www.eia.gov/countries/data.cfm, viewed 14 May 2014; 37 GW of new capacity in 2014 and 1,055 GW of total capacity at the end of 2014 from International Hydropower Association (IHA) Hydropower Database, from IHA, personal communication with REN21, May 2015. Additions in 2014 are lower than the IHA value of 39 GW published in May 2015 to reflect lower actual capacity additions in Malaysia of 0.8 GW compared to 3.3 GW, with much of the difference installed in prior years. **Solar PV** based on 23.2 GW in operation at the end of 2009, and 138 GW at the end of 2013, from Gaëtan Masson, IEA Photovoltaic Power Systems Programme (IEA-PVPS) and Becquerel Institute, personal communication with REN21, 7 May 2015, from European Photovoltaic Industry Association (EPIA), *Market Report 2014* (Brussels: 2014), and from EPIA, *Global Market Outlook for Photovoltaics 2015-2019* (Brussels: forthcoming 2015), and on 177 GW at the end of 2014. **CSP** based on 663 MW in operation at the end of 2009, from Fred Morse, Abengoa Solar, personal communication with REN21, 4 May 2012, and from Red Eléctrica de España (REE), "Potencia Instalada Peninsular (MW)," updated 29 April 2013, http://www.ree.es/es/publicaciones/indicadores-y-datos-estadisticos/series-estadisticas; on 3,424 MW at the end of 2013, from REN21, *Renewables 2014 Global Status Report* (Paris: 2014); Elisa Prieto Casaña, Frederick H. Morse, and Francisco Javier Martínez Villar, Abengoa Solar, personal communications with REN21, 28 April 2015; Eduardo Garcia Iglesias, Protermosolar, personal communication with REN21, 29 April 2015; U.S. National Renewable Energy Laboratory (NREL), "Concentrating Solar Power Projects," http://www.nrel.gov/csp/solarpaces/, viewed 24 April 2015; "CSP Today Global Tracker," CSP Today, http://social.csptoday.com/tracker/projects, viewed 27 April 2014; and on 4,364 MW at the end of 2014. **Wind power** based on 159.1 GW at the end of 2009 and 318.6 GW at the end of 2013, from Global Wind Energy Council (GWEC), *Global Wind Report – Annual Market Update 2014* (Brussels: 2015), and

approximately 370 GW at the end of 2014. **Solar water heaters** based on 185.1 GW_{th} capacity (not including air collectors) in operation at the end of 2009, 373.1 GW_{th} at the end of 2013, and an estimated 406.4 GW_{th} at the end of 2014, from Franz Mauthner and Werner Weiss, AEE-INTEC, Gleisdorf, Austria, personal communication with REN21, April and May 2015, and on Mauthner and Weiss, op. cit. note 9. **Ethanol and Biodiesel** based on 72.9 billion litres of fuel ethanol and 17.8 billion litres of biodiesel produced in 2009, on 87.8 billion litres of fuel ethanol and 26.3 billion litres of biodiesel in 2013, and on 94.0 billion litres of fuel ethanol and 29.7 billion litres of biodiesel in 2014, all from F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," various years, and F.O. Licht, "Biodiesel: World Production, by Country (1000 T), various years, with permission from F.O. Licht / Licht Interactive Data.

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13 Countries have enacted renewable energy policy in response to drivers such as carbon emissions reductions, environmental conservation, energy access, rapidly rising energy demand, energy security, and economic development, among others; see IPCC, op. cit. note 9; China's recent large-scale renewable energy commitments, for example, have been driven by its desire to reduce its reliance on coal and mitigate environmental pollution, per Feifei Shen, "China Targets 70 Gigawatts of Solar to Cut Coal Reliance," Renewable Energy World, 16 May 2014, http://www.renewableenergyworld.com/rea/news/article/2014/05/china-targets-70-gigawatts-of-solar-power-to-cut-coal-reliance?cmpid=SolarNL-Saturday-May17-2014.

14 See Policy Landscape section.

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18 IRENA, *Off-Grid Renewable Energy Systems: Status and Methodological Issues* (Abu Dhabi: 2015), http://www.irena.org/DocumentDownloads/Publications/IRENA_Off-grid_Renewable_Systems_WP_2015.pdf; Giles Parkinson, "Solar Costs Will Fall Another 40% In 2 Years," Clean Technica, 29 January 2015, http://cleantechnica.com/2015/01/29/solar-costs-will-fall-40-next-2-years-heres/.

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32 See Reference Table R1 and related endnote for details and references.

33 Ibid.

34 Based on total non-hydropower additions of approximately 100 GW, including an estimated 40 GW of solar PV and about 51 GW of wind power capacity. For details and references see Reference Table R1, Market and Industry Trends section, and related endnotes.

35 Figure of 58.5% based on a total of approximately 134.5 GW of renewable capacity added, as noted in this report, and on assumed net additions of 93–98 GW (average of 95.5 GW) nuclear and fossil fuel capacity, for a total of 230 GW global net additions, of which renewables account for 58.5%. Nuclear and fossil fuel estimate based on net capacity additions from all sources totalling 216 GW, renewables excluding "large hydro" (>50 MW) totalling additions of 103 GW, and large hydro additions of 15–20 GW, (and therefore the assumption that net additions of nuclear and fossil fuel capacity in 2014 were 93–98 GW), all from Angus McCrone, BNEF, personal communication with REN21, 22 April 2015, and from FS-UNEP Centre and BNEF, op. cit. note 25; European Wind Energy Association (EWEA), *Wind in Power: 2014 European Statistics* (Brussels: February 2015), pp. 7–8, http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA-Annual-Statistics-2014.pdf.

36 Renewable share of total global electric generating capacity is based on an estimated renewable total of 1,712 GW (see Reference Table R1 and related endnote for details and sources) and on total global electric capacity in the range of 6,180 GW. Estimated total world capacity for end-2014 is based on 2013 total of 5,950 GW, from IEA, *World Energy Outlook 2014*, op. cit. note 9, p. 201; on about 230 GW of net power capacity additions in 2014, as outlined in Endnote 35.

37 Share of generation based on the following: Total global electricity generation in 2014 is estimated at 23,480 TWh, based on 23,127 TWh in 2013 from BP, op. cit. note 9, and an estimated 1.52% growth in global electricity generation for 2014. The growth rate is based on the weighted average actual change in total generation for the following countries (which together account for two thirds of global generation in 2013): United States (+0.66% net generation), EU-28 (-2.93% gross generation), Russia (+0.1%), India (+9.45%), China (+3.6%), and Brazil (+2.1%). Sources for 2013 and 2014 electricity generation are: EIA, *Electric Power Monthly*, February 2015, Table 1.1; European Commission, Eurostat database, http://ec.europa.eu/eurostat; System Operator of the Unified Power System of Russia, 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), 10 February 2015, http://www.cec.org.cn/yaowenkuaidi/2015-03-10/134972.html; National Operator of the Electrical System of Brazil (ONS), http://www.ons.org.br/historico/geracao_energia.aspx. Hydropower generation in 2014 is estimated at 3,900 TWh, based on 2013 hydropower output of 3,782 TWh from BP, op. cit. note 9, as well as observed average year-on-year change in output (+3.77%) for top producing countries (China, Brazil, Canada, the United States, the EU-28, Russia, India, Norway, and Turkey), which together accounted for about three-fourths of global hydropower output. The combined hydropower output of these countries was up by 3.77% relative to 2013. Hydropower generation by country: United States from EIA, op. cit. this note; Canada from Statistics Canada, http://www5.statcan.gc.ca; EU-28 from European Commission, op. cit. this note; Norway from Statistics Norway, www.ssb.no; Brazil from ONS, op. cit. this note; System Operator of the Unified Power System of Russia, op. cit. this note; Government of India, op. cit. this note; CEC, op. cit. this note; Turkey from Enerji Atlasi, 12 January 2015, http://www.enerjiatlasi.com/haber/elektrik-kurulu-gucu-2014-te-8-61-artti, and from Turkish Ministry of Energy and Natural Resources, "Hidrolik," http://www.enerji.gov.tr/tr-TR/Sayfalar/Hidrolik. Non-hydro renewable generation of 1,455 TWh was based on 2014 year-end generating capacities shown in Reference Table R1 and representative capacity factors in the relevant endnotes, or other specific estimates as detailed by technology in the Market and Industry section and Table 2. **Figure 3** based on sources in this endnote.

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39 Growth in global electricity output of 2.7%, and non-OECD electricity output of 5.6%, for years 2007 through 2012, from IEA, op. cit. note 2.

40 Denmark and Portugal from Feng Zhao et al., *Global Wind Market Update—Demand & Supply 2014* (London: FTI Consulting LLP, March 2015), p. 117; Denmark met 39% of electricity demand with

wind, from Jesper Nørskov, "Wind Turbines Reached Record Level in 2014," Energinet.com, 20 January 2015, http://www.energinet.dk/EN/El/Nyheder/Sider/Vindmoeller-slog-rekord-i-2014.aspx; in Nicaragua, wind power generated 833.7 TWh and total net generation in 2014 was 4,050.2 TWh, from Dirección de Estudios Económicos y Tarifas (Directorate of Economic Studies and Tariffs), Instituto Nacional de Energía, "Generación Neta Por Tipo De Empresa Sistema Eléctrico Nacional Año 2014 (MWh)," http://www.ine.gob.ni/DGE/estadisticas/2014/GeneracionNeta_2014_actAbr15.pdf, viewed 30 April 2015; Spain also had high shares of generation from the wind, from REE, *The Spanish Electricity System: Preliminary Report: 2014* (Madrid: 23 December 2014), p. 9, http://www.ree.es/sites/default/files/downloadable/preliminary_report_2014.pdf; solar PV in Italy, Greece, and Germany based on IEA-PVPS, *Snapshot of Global PV Markets 2014* (Brussels: 2015), http://www.iea-pvps.org/index.php?id=trends0.

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33 Ibid. Note that module prices remained relatively flat, but balance of system (BOS) "prices fell precipitously, leading to average 10% annual decline in system prices, depending on market segment," from idem.

34 Three market segments from SEIA, "U.S. Installs 6.2 GW of Solar PV in 2014, Up 30% Over 2013," press release (Boston and Washington, DC: 10 March 2015), http://www.seia.org/news/us-installs-62-gw-solar-pv-2014-30-over-2013. Commercial sector declined, from GTM Research and SEIA, op. cit. note 30, p. 5.

35 An estimated 3,934 MW of utility PV was added in 2014, up 38% from 2013, from SEIA, op. cit. note 34; drivers from GTM Research and SEIA, op. cit. note 30, p. 10.

36 GTM Research and SEIA, op. cit. note 30, pp. 6, 10. Very large projects came on line in 2014, but general anxiety over upcoming changes to incentives (the Investment Tax Credit expires at end-2016) is affecting development of large projects, from Paula Mints, "Despite Energy, 2014 Is Another Growth Year for Solar PV," Renewable Energy World, 4 November 2014, http://www.renewableenergyworld.com/rea/news/article/2014/11/despite-everything-2014-is-another-growth-year-for-solar-pv.

37 Figure of 1.2 GW from SEIA, op. cit. note 34. More than 50% from GTM Research and SEIA, op. cit. note 30, p. 9. Falling prices and financing options from Renewable Energy World Editors, "Analyst: US Residential Demand Could Approach 1 GW Annually," Renewable Energy World, 15 October 2014, http://www.renewableenergyworld.com/rea/news/article/2014/10/analyst-us-residential-demand-could-approach-1-gw-annually.

38 A nationwide solar purchase programme sponsored by several large employers (3M, Cisco, Kimberley-Clark, National Geographic Society, WWF) enables employees to install solar PV systems on their homes for about one-third less than the national average; Internet marketer Geostellar works with local utilities and installers to aggregate parts, from Heather Hansman, "The Newest Benefits Perk: Cheap Solar Power for Your Home," *Grist*, 26 November 2014, http://grist.org/climate-energy/the-newest-benefits-perk-cheap-solar-power-for-your-home/. In Massachusetts there is a bulk purchase programme called Mass Solar Connect for Universities and nonprofits with at least 5,000 associates, and Connecticut is planning a similar program for universities, from "Massachusetts Lights the Way on Solar Energy Policy," *Boston Globe*, 2 November 2014, http://www.bostonglobe.com/opinion/editorials/2014/11/02/massachusetts-lights-way-solar-energy-policy/HGSFF66Bqjrb70SgZ4efWN/story.html.

39 California added 3,549 MW and North Carolina added 397 MW, from GTM Research and SEIA, op. cit. note 30, pp. 6–8. About 10% of Hawaii's residential customers have solar PV systems on their roofs, compared with about 0.5% nationally. National figure from US Solar Electric Power Association (SEPA), and all data cited in Erica Gies, "Will New Obstacles Dim Hawaii's Solar Power Surge?" *Yale Environment360*, 16 February 2015, http://e360.yale.edu/feature/will_new_obstacles_dim_hawaiis_solar_power_surge/2847/.

40 IEA-PVPS, op. cit. note 2; Masson, op. cit. note 2; Zachary Shahan, "Europe Is Still Leading the Solar Charge, Relatively Speaking," Sustainnovate.ae, 13 October 2014, http://sustainnovate.ae/en/innovators-blog/detail/europe-is-still-leading-the-solar-charge-relatively-speaking. All Europe, including Turkey, added about 88.5 GW from EPIA, op. cit. note 2. In 2014, more than 31 GW of new capacity was installed outside of Europe, based on data from IEA-PVPS, op. cit. note 2, and from Masson, op. cit. note 2; an estimated 33 GW was installed outside of Europe in 2014 (but the number could have been a bit higher) from Manoël Rekinger, EPIA, personal communication with REN21, 23 April 2015, and from EPIA, op. cit. note 2. This compares with 10 GW in 2010, from EPIA, op. cit. note 4, p. 17.

41 Figure of 6.3 GW added in EU (and 6.8 GW in all of Europe) from Masson, op. cit. note 2; Europe added 7 GW from EPIA, op. cit. note 2; 22 GW in 2011 based on 22.4 GW from EPIA, *Market Report 2013* (Brussels: March 2014), p. 4, http://www.epia.org/uploads/tx_epiapublications/Market_Report_2013_02.pdf, and on 22 GW from IEA-PVPS, op. cit. note 6.

42 Gaëtan Masson, "Where Is the European PV Market Going?" Becquerel Institute, 22 January 2015, http://becquerelinstitute.org/2014-pv-european-back-2009-levels/.

43 Rekinger, op. cit. note 40.

44 Italy and Spain from Masson, op. cit. note 3; Italy added 386 MW for a total of 18,460 MW, from IEA-PVPS, op. cit. note 2. Despite its relatively weak market, Italy's production increased from 21,228 GWh in 2013 to 23,229 GW in 2014, from TSO Terna SpA, cited in "Italy Installed Up to 1.38 GW of PV Capacity in 2014," Photon, 4 February 2015, http://www.photon.info/photon_news_detail_en.photon?id=90982. Germany based on data from Bundesministerium für Wirtschaft und Energie (BMWi), *Marktanalyse Photovoltaik-Dachlagen* Berlin: BMWi, 2015, http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/bmwi_de/marktanalysen-photovoltaik-photovoltaik.pdf; and BMWi, *Entwicklung der Erneuerbaren Energien in Deutschland im Jahr 2014* (Berlin: 2015) data from Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), as of February 2015, http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/entwicklung_der_erneuerbaren_energien_in_deutschland_im_jahr_2014.pdf; Germany added 1.9 GW in 2014, down from 3.3 GW in 2013, from Bundesverband Solar Wirtschaft e.V. (BSW-Solar), "Statistische Zahlen der deutschen Solarstrombranche (Photovoltaik)," March 2015, http://www.solarwirtschaft.de/fileadmin/media/pdf/2015_3_BSW_Solar_Faktenblatt_Photovoltaik.pdf.

45 Belgium added 65 MW for a total of 3,074 MW; Bulgaria (1.6 MW; 1,022 MW); Czech Republic (1.7 MW; 2,134 MW), Greece (16 MW; 2,959 MW); and Spain (25.3 MW; 5,361.5 MW), from IEA-PVPS, op. cit. note 2. Spain officially reports data in alternating current (AC); these sources have converted them to direct current (DC) for consistency across countries. Spain

added 7 MW to the grid in 2014 for a total of 4,672 MW at year's end, after commissioning 105 MW in 2013, from Red Electric de España, cited in Veselina Petrova, "Spain to Add 8.5 GW of Renewables by 2020 – Report," Renewables SeeNews, 9 February 2015, http://renewables.seenews.com/news/spain-to-add-8-5-gw-of-renewables-by-2020-report-462314.

46 France, the Netherlands, and the United Kingdom, from Masson, op. cit. note 42. Note that France's high number was due largely to past commitments (projects committed prior to 2014). France added 927 MW for a total of 5,660 MW, the Netherlands added 400 MW for a total of 1,123 MW, from IEA-PVPS, op. cit. note 2; Switzerland's market expanded and about 250 MW was added, bringing total capacity to about 1 GW from Ilias Tsagas, "Swiss PV Grows But FIT Cuts Push Market Towards Self-Consumption," *PV Magazine*, 24 November 2014, http://www.pv-magazine.com/news/details/beitrag/swiss-pv-grows-but-fit-cuts-push-market-towards-self-consumption_100017270.

47 The United Kingdom added 2,402 MW for a total of 5,230 MW, from Orlandi, op. cit. note 25. UK capacity was up 2,448 MW to a total of 5,228 MW, per UK Department of Energy and Climate Change (DECC), "Energy Trends section 6: Renewables," updated 14 May 2015, p. 50, https://www.gov.uk/government/statistics/energy-trends-section-6-renewables.

48 Number of households from UK DECC, cited in "DECC Statistics Reflect Healthy Demand for Residential Solar Installations in the UK," Renewable Energy Focus, 23 January 2015, http://www.renewableenergyfocus.com/view/41217/decc-statistics-reflect-healthy-demand-for-residential-solar-installations-in-the-uk/. Only remaining market for ground-mounted from Nico Tyabji, BNEF, personal communication with REN21, 16 April 2015.

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50 Tariff reduction from BMWi, *Marktanalyse Photovoltaik-Dachlagen*, op. cit. note 44; low FIT payments and surcharge (under the EEG) on self-consumption from Masson, op. cit. note 42.

51 BMWi, *Marktanalyse Photovoltaik-Dachlagen*, op. cit. note 44.

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58 Mike Munsell, "Chile Installs Record-Breaking 150MW of PV in Q1, 380MW Under Construction," Greentech Media, 7 April 2014, http://www.greentechmedia.com/articles/read/chile-installs-record-breaking-150-mw-of-pv-in-q1-380-mw-under-construction. Chile is home to two of the world's largest merchant plants (the 50 MW Maria Elena project, and 70 MW Salvador Project), which rely on the merchant spot market for revenue and thus are cost-competitive without public incentives, from James, op. cit. note 56.

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62 South Africa added about 800 MW for a total of 922 MW, from IEA-PVPS, op. cit. note 2.

63 Kenya off-grid and large projects from Sherelle Jacobs, "Electrifying Kenya: How One African Country Is Approaching Renewable Energy Development," Renewable Energy World, 8 October 2014, http://www.renewableenergyworld.com/rea/news/article/2014/10/electrifying-keyna-how-one-african-country-is-approaching-renewable-energy-development. A 1 MW project at Changoi Tea Farm in Kenya was considered East Africa's largest project as of October 2014, from idem. Larger plants were under development by the end of 2014, and Rwanda all from Maina Waruru, "East African Countries Move to Adopt Renewable Energy Technologies," Renewable Energy World, 17 December 2014, http://www.renewableenergyworld.com/rea/news/article/2014/12/east-african-countries-move-to-adopt-renewable-energy-technologies.

64 The programme includes 300 MW for small rooftop systems and 2 GW for utility-scale projects. In November 2014, 82 applicants qualified for the utility-scale projects, from Egyptian Electricity Regulatory Agency, http://egyptera.org/ar/renewable_energy_companies.aspx (in Arabic), information provided by Maged Mahmoud, Regional Center for Renewable Energy and Energy Efficiency (RCREEE), personal communication with REN21, 12 April 2015.

65 Countries with solar PV targets include Egypt, Iraq, Jordan, Kuwait, the Palestinian Territories, Qatar, Syria, and Yemen. For more information, see Policy Landscape section and Reference Table R15. Also see, for example, Heba Hashem, "What's in Store for the MENA's PV Market?" PV Insider, 4 February 2014, http://news.pv-insider.com/photovoltaics/what%E2%80%99s-store-mena%E2%80%99s-pv-market.

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68 'Middle East-Africa Solar PV Demand Will Increase 625% This Year," Clean Technica, 22 March 2013, http://cleantechnica.com/2013/03/22/middle-east-africa-solar-pv-demand-will-reach-1-gigawatt-this-year-solarbuzz/; "PV in Saudi Arabia," Sunshine Middle East, Riyadh and Madrid, http://www.sunshinemiddleeast.com/solar-pv-in-ksa/, viewed 13 May 2015, Ahmed Nada, "MENA Solar Dispatch: The Middle East's Solar Energy Sunrise," First Solar, 30 October 2013, http://www.firstsolar.com/en/about-us/press-center/blog/2014/november/mena-solar-dispatch.

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since its completion in 2012, a 25 MW solar power plant is helping to provide electricity services and irrigated and treated water in the Modesto Irrigation District in California, per "25 MW Solar Power Plant for US Irrigation District Complete," Renewable Energy Technology, 31 October 2012, http://www.renewable-energy-technology.net/solar-energy-news/25mw-solar-power-plant-us-irrigation-district-complete; in Australia, solar-powered surface and bore pumps are used widely on farms and outback stations to provide water to livestock and for farming, per Energy Matters, "Solar Bore and Surface Water Pumping," http://www.energymatters.com.au/solar-water-pumps/, viewed 14 February 2015; in 2014, the Indian government announced the installation of 26 million solar water pumps for irrigation, per Katherine Tweed, "India Plans to Install 26 Million Solar-powered Water Pumps," IEEE Spectrum, 20 February 2014, http://spectrum.ieee.org/energywise/green-tech/solar/india-plans-for-26-million-solar-water-pumps; 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The Nexus Network Annual Conference" (London: 2014), p. 1, http://thenexusnetwork.org/wp-content/uploads/2014/09/Nexus_Network_Conference_Poster-session-abstracts.pdf.

69 At least 70 projects and 14 countries based on the following sources: Denis Lenardic, "Large-scale Photovoltaic Power Plants Ranking 1-50," pvresources, http://www.pvresources.com/PVPowerPlants/Top50.aspx, updated 22 February 2014, 15 March 2014, 22 February 2015, and 1 March 2015; Denis Lenardic, pvresources, personal communication with REN21, 29 March 2015.

70 Top 10 from ibid. Topaz Solar, in California, achieved full commercial operation with completion of the final 40 MW phase and was finished ahead of schedule in late 2014; it is made up of 9 million solar panels, from Eric Weshoff, "Topaz, the Largest Solar Plant in the World, Is Now Fully Operational," Greentech Media, 24 November 2014, http://www.greentechmedia.com/articles/read/550-megawatts-AC-to-be-exact. Desert Sunlight from Herman K. Trabish, "Desert Sunlight 550 MW Solar PV Project Goes Online," Utility Dive, 15 January 2015, http://www.utilitydive.com/news/desert-sunlight-550-mw-solar-pv-project-goes-online/353325/, and Victoria Cavaliere, "Solar Farm Capable of Powering 160,000 Homes Opens in California," *Reuters*, 11 February 2015, http://planetark.org/wen/72803. Other very large-scale projects in the United States include the Ague Caliente solar project (290 MW) that came on line in Arizona in early 2014, from Peter W. Davidson, "Agua Caliente, World's Largest Solar Photovoltaic Plant, Helps Advance America's Solar Leadership," U.S. Department of Energy (DOE), 29 April 2014, http://energy.gov/articles/agua-caliente-worlds-largest-solar-photovoltaic-plant-helps-advance-americas-solar; the Antelope Valley project (242 MW), from DOE, Loan Programs Office, "Power New Markets: Utility-Scale Photovoltaic Solar" (Washington, DC: February 2015), p. 3, http://www.energy.gov/sites/prod/files/2015/02/f19/DOE_LPO_Utility-Scale_PV_Solar_Markets_February2015.pdf; and the Mount Signal Project (206 MW) in California, from "Abengoa Completes 206MW Mount Signal Project in California, IPOs YieldCo," *PV News*, July 2014, pp. 7–8.

71 Approaching 7.1 GW based on Lenardic, "Large-scale Photovoltaic Power Plants Ranking 1-50," op. cit. note 69, updated 1 March 2015. Note that the 50 plants were all 60 MW and above in size, and located in 12 countries, of which three are in the Americas, four in Asia, four in Europe, and one in Africa.

72 Based on Ibid. Chile and South Africa also from the following: Chile inaugurated a 100 MW plant, said to be the largest in Latin America and built as part of an agreement with the CAP Group, Chile's largest steel mining company, from Lucy Woods, "SunEdison Inaugurates 100MW Chile Solar Plant," PV-Tech, 9 June 2014, http://www.pv-tech.org/news/sunedison_inaugurates_100mw_chile_solar_plant. South Africa also saw completion of two ground-mounted projects totalling 33 MW, from "REIPPP Sees Project Completions in South Africa," *PV News*, July 2014, p. 7; and

a 40 MW plant was also completed in 2014, from "Scatec Solar Completes 40MW Project in South Africa," *PV News*, August 2014, p. 7.

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38 Lack of stable and effective schemes and dearth of installers from Welling, op. cit. note 35, p. 3, and from ESTIF, op. cit. note 34, p. 4. The UK market was slow due greatly to a large number of rules and little promotion of solar thermal by the government, per Chris Laughton, "Great Britain: Performance of the Two UK Renewable Heat Incentive Schemes," Solar Thermal World, 3 November 2014, http://solarthermalworld.org/content/great-britain-performance-two-uk-renewable-heat-incentive-schemes. Competition with other "green" options from Stryi-Hipp, op. cit. note 37, and from Bärbel Epp, "France: Mixed Feelings About 2015 Industry Development," Solar Thermal World, 3 February 2015, http://www.solarthermalworld.org/content/france-mixed-feelings-about-2015-industry-development. The most significant negative factor in the UK market is the feed-in tariff for solar electricity, from Epp, op. cit. note 18.

39 Largest installer based on data from Mauthner, op. cit. note 1; two-millionth system from Verband für Energieeffizienz und Erneuerbare Energien (BDH) and Bundesverband Solarwirtschaft e.V. (BSW-Solar), "2 Millionen Solarheizungen in Betrieb," press release (Berlin/Köln: 5 February 2015), http://www.solarwirtschaft.de/fileadmin/media/pdf/PM_2-2014_BDH_BSW_Solarheizungen.pdf (using Google Translate); down 12% based on 2013 market data from Mauthner, op. cit. note 1.

40 Germany added 630 MW_{th} (0.9 million m^2) in 2014, for a total

of 12.9 GW_{th} (18.4 million m^2), from BSW-Solar, “Statistische Zahlen der deutschen, Solarwärmebranche (Solarthermie),” March 2015, http://www.solarwirtschaft.de/index.php?id=15. Germany had a total of 13.1 GW_{th} and more than 18 million m^2 accounting for retirement of old plants, from Bundesministerium für Wirtschaft und Energie (BMWi), *Entwicklung der erneuerbaren Energien in Deutschland im Jahr 2014* (Berlin: February 2015), pp. 25, 26, http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/entwicklung_der_erneuerbaren_energien_in_deutschland_im_jahr_2014.pdf.

41 BSW-Solar, op. cit. note 40.

42 The United States added just over 1 million m^2 in 2013 (of which 771,400 m^2 were unglazed) for a year-end total of nearly 24 million m^2 (of which 21 million m^2 were unglazed), from Mauthner and Weiss, op. cit. note 1, and from Mauthner, op. cit. note 1. Note that U.S. data are uncertain because the U.S. Energy Information Administration no longer tracks solar thermal and the U.S. Solar Energy Industry Association (SEIA) has not finalised a planned survey, from Bärbel Epp, “USA: GoSolar at SEIA’s Birthday,” Solar Thermal World, 27 January 2014, http://solarthermalworld.org/content/usa-gosolar-seias-birthday.

43 About 58% based on an estimated 20.9 million m^2 of unglazed water collectors in operation in the United States in 2013, and 35.7 million m^2 worldwide, from Mauthner and Weiss, op. cit. note 1, and from Mauthner, op. cit. note 1.

44 Based on data from Mauthner and Weiss, op. cit. note 1.

45 Ibid.

46 Australia added an estimated 585.7 MW_{th} in 2014, retired 230 MW_{th}, and ended 2014 with more than 5.97 GW_{th}. All figures are estimates based on 2013 data (5,616.6 GW_{th} total, of which 3,346 MW_{th} was unglazed) and assuming market stability for 2014, from Sustainability Victoria market survey (unpublished), provided by David Ferrari, Sustainability Victoria, and forwarded by Ken Guthrie, IEA-SHC, Sustainable Energy Transformation Pty Ltd, personal communication with REN21, 1 March 2015.

47 Data from Clean Energy Council of Australia, provided by A. Webb, Clean Energy Council of Australia, personal communication with REN21, 16 April 2015.

48 Mauthner and Weiss, op. cit. note 12. Egypt and Morocco from Emanuela Menichetti, Observatoire Méditerranéen de l'Energie (OME), personal communication with REN21, April 2015. Egypt has a small market but has seen a rapid increase, particularly in the hotel sector, as solar thermal is a readily available option for reducing costly diesel consumption, from Bärbel Epp, “Egypt: Green Star Hotels ‘Download’ the Sun,” Solar Thermal World, 9 January 2013, http://solarthermalworld.org/content/egypt-green-star-hotels-download-sun; in response to rising energy prices in Egypt, solar energy is becoming increasingly attractive for many applications, from Bärbel Epp, “Egypt: Aiming at High-Quality Supply Chain,” Solar Thermal World, 29 September 2014, http://solarthermalworld.org/content/egypt-aiming-high-quality-supply-chain. Kenya has mandated solar thermal in large buildings, which is helping to drive the market there, from IEA-ETSAP and IRENA, op. cit. note 5, p. 18. In Tunisia, thanks to a support scheme introduced in 2009, capacity reached 14,000 m^2 by the end of 2012, mostly in hotels, public baths, and hospitals, and 30 hotels had installed systems by late 2013, from Bärbel Epp, “Tunisia Funds Solar Process Heat,” Solar Thermal World, 7 October 2013, http://solarthermalworld.org/content/tunisia-funds-solar-process-heat; however, Tunisia’s market saw an estimated significant decline in 2014 to 53,000 m^2 (below level of 2007) due to a delay in grant dispersal, and saturation of the market in well-off parts of society. The country’s market peaked in 2009 after rapid growth from 2005, due to a government grant programme, from Tunisia National Agency for Energy Conservation (ANME), cited in Bärbel Epp, “Tunisia: Ups and Downs of Prosol Subsidy Scheme,” Solar Thermal World, 15 December 2014, http://solarthermalworld.org/content/tunisia-ups-and-downs-prosol-subsidy-scheme. South Africa has seen success driven greatly by rising electricity prices, fear of electricity shortages, and a national rebate programme from utility Eskom, per Frank Stier, “South Africa: High Demand from Tourism Sector,” Solar Thermal World, 1 July 2013, http://solarthermalworld.org/content/south-africa-high-demand-tourism-sector.

49 Mauthner, op. cit. note 1.

50 Anton Schwarzlmüller, Domestic Solar Heating, Zimbabwe, cited in “Zimbabwe: Installing 100 Locally Produced Storage Tanks in 2013 Would Be a Big Success,” Solar Thermal World, 1 May 2013, http://solarthermalworld.org/content/zimbabwe-installing-100-locally-produced-storage-tanks-2013-would-be-big-success; Frank Stier, “South Africa: High Demand from Tourism Sector,” Solar Thermal World, 1 July 2013, http://solarthermalworld.org/content/south-africa-high-demand-tourism-sector; Yaping Zhang, “Thailand: Prefabricated Container Solution Improves Quality in Tannery,” Solar Thermal World, 9 April 2013, http://solarthermalworld.org/content/thailand-prefabricated-container-solution-improves-quality-tannery; Alejandro Diego Rosell, “Uruguay: Growing at Its Own Pace,” Solar Thermal World, 15 July 2013, http://solarthermalworld.org/content/uruguay-growing-its-own-pace; Pedro Dias, ESTIF, personal communication with REN21, 27 April 2015. The issue of lack of quality assurance measures goes beyond standards, and ISO standards are available but their existence alone does not address the problem, from idem.

51 Menichetti, op. cit. note 48. Lebanon experienced market growth averaging over 17% during 2008–2012, from Wilson Rickerson et al., *Solar Water Heating Techscope Market Readiness Assessment* (Paris: United Nations Environment Programme (UNEP), 2014), prepared for UNEP, Division of Technology, Industry and Economics, Global Solar Water Heating Initiative, p. 67, http://www.al.undp.org/content/dam/india/docs/EnE/solar-water-heating-techscope-market-readiness-assessment.pdf.

52 Figure of 85% of Israeli households from OME, *Solar Thermal in the Mediterranean Region: Market Assessment Report* (Nanterre, France: September 2012), p. 37, http://www.b2match.eu/system/stworkshop2013/files/Market_Assessment_Report_II.pdf?1357834276; Palestinian Territories from Menichetti, op. cit. note 48.

53 Angelika Cerny, Millennium Energy Industries, Jordan, interviewed by Bärbel Epp, “Jordan: ‘The Solar Bylaw Is Not Going to Have a Strong Impact on the Market’,” Solar Thermal World, 6 January 2015, http://solarthermalworld.org/content/jordan-solar-bylaw-not-going-have-strong-impact-market.

54 Mauthner and Weiss, op. cit. note 1.

55 Yiorgos Lakkotrypis, Cyprian Minister of Energy, Commerce, Industry and Tourism, cited in Frank Stier, “Cyprus: Solar Thermal Industry Off to New Frontiers,” Solar Thermal World, 14 June 2014, http://solarthermalworld.org/content/cyprus-solar-thermal-industry-new-frontiers.

56 Mauthner and Weiss, op. cit. note 1.

57 Ibid.

58 European Commission, op. cit. note 33.

59 Mauthner and Weiss, op. cit. note 1.

60 European Commission, op. cit. note 33.

61 Mauthner and Weiss, op. cit. note 1; Mauthner, op. cit. note 1.

62 Mauthner and Weiss, op. cit. note 12. As of 2014, approximately two out of five systems in Germany were combi-systems, from Bundesindustrieverband Deutschland Haus-, Energie- und Umwelttechnik e.V. (BDH) and Bundesverband Solarwirtschaft (BSW), “Solarkollektorabsatz 2013 rückläufig – Solar- und Heizungsbranche fordern: Wärmewende jetzt einläuten,” press release (Berlin and Cologne: 17 February 2014), http://www.solarwirtschaft.de/fileadmin/media/pdf/pm_kollektorabsatz2013.pdf. Larger share of the market based on fact that combi-systems average three times larger than systems for domestic hot water only, and thus account for the majority of total installed collector area in some countries, per Dias, op. cit. note 50. Poland also from Marcin Czekanski, “Poland: Market in Transition,” Solar Thermal World, 30 May 2013, http://solarthermalworld.org/content/poland-market-transition; France and Switzerland also have a growing share of combi-systems, from European Commission, European Technology Platform on Renewable Heating and Cooling, *Strategic Research and Innovation Agenda for Renewable Heating & Cooling* (Brussels: European Union, 2013), p. 14, http://www.rhc-platform.org/fileadmin/user_upload/members/Downloads/RHC_SRA_epo_final_lowres.pdf; and markets are growing in Russia, particularly in areas with cold climates, per interviews with manufacturers in Russia, New Polus, Inten, and Kassol, cited in Vladislava Adamenkova, “Russia: 2014 – Year of Change and Growth,” Solar Thermal World, 22 January 2014, http://solarthermalworld.org/content/russia-2014-year-change-and-growth.

63 European Commission, op. cit. note 33. The trend towards hybrid systems including heat pumps is seen particularly in Austria, Germany, and Switzerland, where policies and high electricity prices create favourable conditions, per “Solar + Heat Pump Systems,” *Solar Update* (IEA-SHC), January 2013, p. 14, http://www.iea-shc.org/data/sites/1/publications/2013-01-SolarUpdate.pdf.

64 See, for example, SolarWall, "SolarWall® Solar Air Heating and Ventilation Systems," http://solarwall.com/en/products/solarwall-air-heating.php, viewed 19 March 2015; and "Solar Air Heat," https://en.wikipedia.org/wiki/Solar_air_heat, viewed 3 May 2015.

65 Solar Air Heating World Industries Association (SAHWIA), "Building-Integrated Solar Air Heating Systems Hit Milestone," press release (Washington, DC: 18 April 2014), http://sahwia.org/building-integrated-solar-air-heating-systems-hit-milestone/. Note that these systems typically reduce 20–30% of conventional energy required for heating buildings, from Mauthner and Weiss, op. cit. note 12, p. 40.

66 Globally, 76.7 MW_{th} (109,571 m^2) of air collector capacity was added in 2013, and there was an estimated 1,187 MW_{th} (1,695,560 m^2) of unglazed air collectors and 481 MW_{th} (686,516 m^2) of glazed air collectors, for a total of 1,668 MW_{th} (2,382,076 m^2) at end-2013, or 0.4% of total solar thermal collector area, from Mauthner and Weiss, op. cit. note 1, and from Mauthner, op. cit. note 1.

67 Mauthner and Weiss, op. cit. note 1.

68 Largest markets from Mauthner, op. cit. note 1; production flat from Bärbel Epp and Stephanie Banse, "Extreme Weather," *Sun & Wind Energy*, October 2014, pp. 26–41. Solar space heating with air collectors is not common in Europe, per Mauthner and Weiss, op. cit. note 12, p. 40.

69 Mauthner, op. cit. note 12.

70 Franz Mauthner, AEE-INTEC, personal communications with REN21, March–May 2014. Cooling systems include one-stage absorption chillers, adsorption chillers, and desiccant cooling systems (DEC) systems for thermal cooling.

71 With such systems, pressurised water, steam, or thermo-oil can be used as a heat transfer medium, from ibid.

72 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: revised July 2012), http://www.solar-district-heating.eu/Portals/0/SDH-WP2-D2-3-Market-Aug2012.pdf; Diarmaid Williams, "Solar-district Heating Plant Opens in Denmark," COSPP, 6 February 2015, http://www.cospp.com/articles/2015/02/solar-district-heating-plant-opens-in-denmark.html; Eva Augsten, "Denmark: Combined CSP and Flat Plate Collector System Supplies Solar District Heating," Solar Thermal World, 30 January 2015, http://solarthermalworld.org/content/denmark-combined-csp-and-flat-plate-collector-system-supplies-solar-district-heating; "The First Solar District Heating Plant in France is in Operation," and "International Workshop on Solar District Heating in Italy," *SDH Newsletter* (Solar District Heating), December 2014, http://www.solar-district-heating.eu/NewsEvents/Newsletters/No13December2014.aspx. Plants with seasonal storage from, for example, Bärbel Epp, "Denmark: 37 MW Field with 203,000 m^3 Storage Underway," Solar Thermal World, 30 August 2014, http://solarthermalworld.org/content/denmark-37-mw-field-203000-m3-storage-underway; Mauthner and Weiss, op. cit. note 12, p. 36; Eva Augsten, "Denmark: 23 MW_{th} Cover 55% of Heat Demand of 1,500 Households," Solar Thermal World, 28 July 2014, http://solarthermalworld.org/content/denmark-23-mwth-cover-55-heat-demand-1500-households; "South Korean R&D Project Focuses on the First Solar District Heating System with Seasonal Heat Storage," *SDH Newsletter* (Solar District Heating), December 2014, http://www.solar-district-heating.eu/NewsEvents/Newsletters/No13December2014.aspx.

73 Northern Europe from Solar District Heating (SDH), Intelligent Energy Europe Programme of the European Union, "Solar District Heating," http://www.solar-district-heating.eu/SDH.aspx, viewed 6 March 2014; and based on data from Jan-Olof Dalenbäck, Solar Energy Association of Sweden and Chalmers University of Technology, personal communications with REN21, March–May 2015. Movement south from "The First Solar District Heating Plant in France Is in Operation," and "International Workshop on Solar District Heating in Italy," op. cit. note 72 (the first solar district heating plant in France (near Toulouse) began operation in 2014, in combination with a biomass boiler); and from "First Italian Solar District Heating Plant on Its Way," *SDH Newsletter*, October 2014, http://www.solar-district-heating.eu/NewsEvents/Newsletters/No12October2014.aspx.

74 Other regions from the following: Natural Resources Canada, "Canadian Solar Community Sets New World Record for Energy Efficiency and Innovation," press release (Okotoks, Alberta: 5 October 2012), http://www.nrcan.gc.ca/media-room/news-release/2012/2143; Canada also from "Solar Community Tops World Record," *Solar Update* (IEA-SHC), January 2013, p. 16, https://www.iea-shc.org/data/sites/1/publications/2013-01-SolarUpdate.pdf, and from Government of Canada, "Drake Landing Solar Community," brochure, www.dlsc.ca/DLSC_Brochure_e.pdf, viewed 29 April 2014; 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," Solar Thermal World, 10 April 2012, http://solarthermalworld.org/content/china-utopia-garden-sets-new-standard-architectural-integration; the University of Pretoria's 672 m^2 solar thermal system provides warm water for apartments for 550 students, per Stephanie Banse, "South Africa: University of Pretoria's 672 m^2 Solar Thermal System," Solar Thermal World, 12 April 2012, http://solarthermalworld.org/content/china-utopia-garden-sets-new-standard-architectural-integration. Plans also are under way for South Korea's first district heating system with seasonal storage, from "South Korean R&D Project Focuses on the First Solar District Heating System with Seasonal Heat Storage," *SDH Newsletter* (Solar District Heating), December 2014, http://www.solar-district-heating.eu/NewsEvents/Newsletters/No13December2014.aspx.

75 Dalenbäck, op. cit. note 73.

76 Jan-Olof Dalenbäck, "An Emerging Option: Solar District Heating and Cooling," *Euro Heat & Power*, vol. 10, no. (2013), pp. 26–29; Dalenbäck, op. cit. note 73.

77 Plants in Denmark from Dalenbäck, op. cit. note 73. Drivers from Mauthner and Weiss, op. cit. note 12, p. 37. Cost-competitive in Denmark only, from Bärbel Epp, solrico, personal communication with REN21, 29 April 2014; large-scale solar thermal systems are cost-competitive relative to natural gas-drive combined heat and power systems in many cases in Denmark, from Mauthner and Weiss, op. cit. note 12, p. 37. Costs have come down considerably in the past five years, and, in Denmark, the heat price from solar thermal is as low as USD 42.7/MWh (EUR 31/MWh), below that of gas-fired district heating, due to the large size of fields and low interest rates over the expected lifetime of at least 20 years, per Søren Elisiussen, Arcon, cited in Bärbel Epp, "Denmark: 'We Have Improved the Cost/Performance Ratio by Around 50 % over the Last 5 Years'," Solar Thermal World, 4 March 2014, http://solarthermalworld.org/content/denmark-we-have-improved-costperformance-ratio-around-50-over-last-5-years. See also Bärbel Epp, "Germany/Denmark: Solar District Heating Prices Between 37 and 88 EUR/MWh," Solar Thermal World, 24 March 2014, http://solarthermalworld.org/content/germanydenmark-solar-district-heating-prices-between-37-and-88-eurmwh.

78 Dalenbäck, op. cit. note 73. This was up from 50 plants with 389,000 m^2 or 272 MW_{th} at end 2013, from idem.

79 Ibid.

80 Enlargement of Vojens and total capacity from Ibid. The Vojens plant was originally constructed in 2012 with 17,500 m^2 and was extended to a total of 70,000 m^2 (49 MW_{th}) in 2014/early 2015, with seasonal water storage totalling 200,000 m^3, from idem. Other enlarged systems include: the Marstal (Denmark) solar district heat network and storage system, from Eva Augsten, "Denmark: 23 MW_{th} Cover 55% of Heat Demand of 1,500 Households," Solar Thermal World, 28 July 2014, http://solarthermalworld.org/content/denmark-23-mwth-cover-55-heat-demand-1500-households; and Austria's largest solar thermal plant, in Graz, which was first commissioned in 2008 and extended in 2014, from Robert Soell, S.O.L.I.D., Austria, "SDH in Graz: Status Quo and Future Potential," SDH International Workshop IT 2014, 25 November 2014, Milan, Italy (Session 2), and from S.O.L.I.D. cited in "Austria's Largest Solar Thermal Plant Is Extended – 4 Different Large Collectors Will Be Compared on a Test Field," *SDH Newsletter*, October 2014, http://www.solar-district-heating.eu/NewsEvents/Newsletters/No12October2014.aspx.

81 Uli Jakob, Green Chiller Verband für Sorptionskälte e.V., personal communication with REN21, 22 April 2015; Uli Jakob, "Solar Air-Conditioning in Europe," presentation for Chinese Solar Cooling Conference, Shanghai Jiao Tong University, China, 27 March 2015, slides 16, 21. These were mostly commercial-scale demonstration systems, from Mike Dennis, "Reducing Air Conditioner Impacts: The State of Solar Cooling," *ReNew*, Issue 130, Sustainable Cooling Issue, January–March 2015, pp. 46–50. Note that roughly 600 solar cooling systems were installed worldwide in 2010, per Hans-Martin 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, http://solarthermalworld.org/sites/gstec/files/

EuroSun2010_Keynote-Henning.pdf.

82 Figure of 75% estimated based on Jakob, "Solar Air-Conditioning in Europe," op. cit. note 81, slide 16. District systems in Europe from IEA-ETSAP and IRENA, op. cit. note 5, p. 13, http://www.irena.org/DocumentDownloads/Publications/IRENA_ETSAP_Tech_Brief_R12_Solar_Thermal_Residential_2015.pdf. For example, a new large-scale system (180 m² collector field) at a Swedish coffee producer facility in Karlstad, per Bärbel Epp, "Sweden: Novel Solar Cooling Installation Boasts Average Electrical COP of 10.6," Solar Thermal World, 28 October 2014, http://solarthermalworld.org/content/sweden-novel-solar-cooling-installation-boasts-average-electrical-cop-106. Australia, Mediterranean islands, and Middle East from IEA, *Technology Roadmap, Solar Heating and Cooling* (Paris: OECD/IEA, 2012), p. 11, http://www.iea.org/publications/freepublications/publication/Solar_Heating_Cooling_Roadmap_2012_WEB.pdf. The Australian market has grown 30% annually over the past eight years, from Uli Jakob, Green Chiller and Solem Consulting, cited in Eva Augsten, "Australia: Country to Publish First Solar Air Conditioning Standard," Solar Thermal World, 17 June 2013, http://solarthermalworld.org/content/australia-country-publish-first-solar-air-conditioning-standard. Australia also from EnergyAE, "The Urban Solar Thermal Power Station," 26 August 2014, http://www.energyae.com/updates; in India, for example, solar thermal is used for cooling at a hospital and at Muni Seva Ashram in Gujarat state, where 100 parabolic dishes (Scheffler type) supply a 100-tonne air conditioning system, from Eva Augsten, "India: Quarterly Sun Focus Magazine Presents Concentrating Solar Heat," Solar Thermal World, 19 September 2013, http://solarthermalworld.org/content/india-quarterly-sun-focus-magazine-presents-concentrating-solar-heat.

83 Daniel Rowe, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, personal communication with REN21, 29 April 2013.

84 IEA, op. cit. note 82.

85 Moritz, Schubert, Sabine Putz , *Contracting Models for Solar Thermally Driven Cooling and Heating Systems*, prepared for IEA-SHC, Task 48, September 2014, p. 6. Note that the solar collectors generally are used for other applications (e.g., water and space heating) as well.

86 The South Africa project is a concentrating solar thermal collector that powers an absorption chiller in the office of Mobile Telephone Networks, from "South Africa Installs Its First Solar Thermal Cooling Project," *Renewable Energy World*, September/October 2014, p. 14. It was not, however, the first in South Africa, per Uli Jakob, Green Chiller Verband für Sorptionskälte e.V., personal communication with REN21, 22 April 2015. See also Bärbel Epp, "South Africa: Fresnel Collectors Keep It Cool in MTN's Server Rooms," Solar Thermal World, 28 August 2014, http://solarthermalworld.org/content/south-africa-fresnel-collectors-keep-it-cool-mtns-server-rooms. Arizona from Bärbel Epp, "USA: S.O.L.I.D. Operates 3.4 MW_{th} Cooling System as ESCO in Arizona," Solar Thermal World, 29 August 2014, http://solarthermalworld.org/content/usa-solid-operates-34-mwth-cooling-system-esco-arizona.

87 The high school project near Phoenix has a collector area of 4,865 m². Financing challenges (inability to find a backer to pre-finance the project) led S.O.L.I.D. to develop a new fundraising model, providing private investors with fixed interest on loans, and also receiving performance-based incentives from Arizona Public Service for relief that the solar cooling provides to the grid, especially during peak load hours, per Epp, "USA: S.O.L.I.D. Operates…," op. cit. note 86. The high school is the Desert Mountain School in Scottsdale, Arizona. Another source says that the system is 1,750 kW, per "Solar Cooling for Desert Mountain Highschool, USA," *SDH Newsletter*, October 2014, http://www.solar-district-heating.eu/NewsEvents/Newsletters/No12October2014.aspx. Note that several U.S. businesses, including breweries, hotels, universities, dairies, and others, rely on solar thermal for heating and cooling, from SEIA, "New Cost Saving Report Highlights Value of Solar Heating & Cooling," press release (Washington, DC: 8 October 2014), http://www.seia.org/news/new-cost-saving-report-highlights-value-solar-heating-cooling, and from SEIA, *Saving Money & Energy: How Solar Heating & Cooling is Paying Big Dividends for US Businesses* (Washington, DC: 2014), http://www.seia.org/news/new-cost-saving-report-highlights-value-solar-heating-cooling.

88 Mauthner and Weiss, op. cit. note 1. See also, for example, Uli Jacob, Green Chiller, "Status and Perspective of Solar Cooling in Europe," Australian Solar Cooling 2013 Conference, Sydney, Australia, April 2013. Uptake limited from IEA, *Medium-Term Renewable Energy Market Report 2014* (Paris: OECD/IEA, 2014), p. 225.

89 Eva Augsten, "The World of Solar Process Heat," *Sun & Wind Energy*, March 2014, pp. 36–45.

90 Collector area and equivalent capacity from Christoph Brunner and Wolfgang Glatzl, AEE-INTEC, "Solare Prozesswärme weltweit im Aufwärtstrend," undated, http://www.aee.at/aee/index.php?option=com_content&view=article&id=837&Itemid=113 (in German), provided by Bärbel Epp, personal communication with REN21, February 2015; probably miss several plants from Ruud Kempener, IRENA, interview by Bärbel Epp, "'Very Few Countries Have Policies Explicitly Supporting Renewable Deployment in the Industry Sector'," Solar Thermal World, 2 March 2015, http://www.solarthermalworld.org/content/very-few-countries-have-policies-explicitly-supporting-renewable-deployment-industry-sector; from Bärbel Epp, solrico, personal communication with REN21, February 2015; and from IEA-ETSAP and IRENA, *Solar Heat for Industrial Processes*, Technology Brief E21 (Bonn: January 2015), p. 16, http://www.irena.org/DocumentDownloads/Publications/IRENA_ETSAP_Tech_Brief_E21_Solar_Heat_Industrial_2015.pdf. China is seeing growing interest in medium- and high-temperature systems, with 50% market growth for building integration and industrial process heat systems in 2012–2013, up from 35% in 2011, per Sun's Vision, cited in Goess, op. cit. note 18. At least 19 new solar process heat installations have been added in India over the past two years, from Jaideep Malaviya, "India: UNDP Supports 53 New Concentrating Solar Thermal Projects," Solar Thermal World, 23 February 2015, http://www.solarthermalworld.org/content/india-undp-supports-53-new-concentrating-solar-thermal-projects. Note that there is no agreed-upon standard conversion factor for solar concentrators, and an expert group of the IEA-SHC Task 49 is currently dealing with this topic. However, for now conversion using 0.7 kW_{th}/m^2 is considered acceptable, per Mauthner, AEE-INTEC, personal communication with REN21, March–May 2014.

91 Salvador Steffani, Captasol, Guanajuato, Mexico, cited in (and other information from) Alejandro Diego Rosell, "Mexico: Captasol to Enter Industrial Solar Drying Market," Solar Thermal World, 17 November 2014, http://solarthermalworld.org/content/mexico-captasol-enter-industrial-solar-drying-market. For more on India see, for example, Jaideep Malaviya, "India: Solar Drying System with Vacuum Tubes Pays Off Within the First Year," Solar Thermal World, 28 August 2013, http://solarthermalworld.org/content/india-solar-drying-system-vacuum-tubes-pays-within-first-year.

92 Database for Applications of Solar Heat Integration in Industrial Processes (SHIP), http://ship-plants.info/reports/areas/years, viewed 25 February 2015. In addition, a demonstration project began operation in Mongolia in February 2014 to develop collectors that can withstand harsh climates, from Frank Stier, "Mongolia: Cost-Effective Solar Process Heat Collector for Harsh Climates," Solar Thermal World, 12 September 2014, http://solarthermalworld.org/content/mongolia-cost-effective-solar-process-heat-collector-harsh-climates.

93 Jaideep Malaviya, "India: Pilgrim Sites Use Solar Energy," Solar Thermal World, 31 May 2013, http://solarthermalworld.org/content/india-pilgrim-sites-use-solar-energy. At least a dozen large religious sites in India use concentrating solar thermal for community cooking; the largest (Saibaba Ashram in Shirdi, Maharashtra State) uses solar thermal concentrators (parabolic dishes) to cook for 50,000 people per day, saving 100,000 kilograms of liquefied petroleum gas (LPG) annually, from idem. By late 2013, at least 23 additional systems were under development in India, primarily to replace conventional boilers and to generate steam for cooking, per Eva Augsten, "India: Quarterly Sun Focus Magazine Presents Concentrating Solar Heat," Solar Thermal World, 19 September 2013, http://solarthermalworld.org/content/india-quarterly-sun-focus-magazine-presents-concentrating-solar-heat. Note that, as of late 2013 or early 2014, India had 7,967 m² of solar concentrator systems for solar cooling, and a total of 27,972 m² of solar concentrator-based systems for industrial applications, from Shirish Garud, The Energy and Resources Institute, personal communication with REN21, 16 April 2014.

94 Study commissioned by International Finance Corporation, cited in Bärbel Epp, "Egypt, Pakistan and Morocco: Three Countries and Their Solar Process Heat Potential," Solar Thermal World, 27 February 2015, http://www.solarthermalworld.org/content/egypt-pakistan-and-morocco-three-countries-and-their-solar-process-heat-potential. Note that solar thermal for industrial purposes is very specific to the on-site situation, including the amount and temperature of heat needed, integration into processes, specific

local conditions such as availability of other heat options and costs, from Stryi-Hipp, op. cit. note 37.

95 Interest growing from, for example, Vladislava Adamenkova, "Russia: 2014 – Year of Change and Growth," Solar Thermal World, 22 January 2014, http://solarthermalworld.org/content/russia-2014-year-change-and-growth; OME, op. cit. note 52, pp. 40–41, 74–75; Bärbel Epp, "Tunisia Funds Solar Process Heat," Solar Thermal World, 7 October 2013, http://solarthermalworld.org/content/tunisia-funds-solar-process-heat; Emily Hois, "US Ranchers Roundup the Power of the Sun," Renewable Energy World, 16 July 2013, http://www.renewableenergyworld.com/rea/blog/post/2013/07/ranchers-roundup-the-power-of-the-sun; 1% from Mauthner and Weiss, op. cit. note 12, p. 6.

96 European Commission, op. cit. note 33; see also IEA-ETSAP and IRENA, op. cit. note 90, p. 8. Note that the Hyatt Regency in Aruba uses solar thermal to provide its guests with pure drinking water, from S.O.L.I.D., "S.O.L.I.D. Installed a Large Solar Plant at the Hyatt Regency in Aruba," press release (Graz, Austria: 2013), http://www.solid.at/en/news-archive/2013/169-s-o-l-i-d-installed-a-large-solar-plant-at-the-hyatt-regency-in-aruba; and solar thermal is being used in Oman, where it is cheaper than natural gas for powering oil recovery projects, from Wael Mahdi, "Solar Beats Natural Gas to Unlock Middle East's Heavy Oil, Says GlassPoint Solar," *Bloomberg*, 20 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/solar-beats-natural-gas-to-unlock-middle-easts-heavy-oil-says-glassdoor-solar; a pilot "tri-generation" project in Jordan, operational since 2011, uses a parabolic trough system for electricity generation, industrial steam generation, and water desalination and chilling, per Rayer Ltd., "State of the Art Tri-Generation Project," http://www.rayer.co.uk/tri-generation-project, viewed 3 May 2014.

97 Epp and Banse, op. cit. note 68.

98 Ibid.

99 Ibid.; several manufacturers in Western Europe's heating industry have gone through insolvency proceedings or stopped activities in the sector, from Bärbel Epp, "Worldwide: Largest Flat Plate Collector Manufacturers in 2013," Solar Thermal World, 5 November 2014, http://solarthermalworld.org/content/worldwide-largest-flat-plate-collector-manufacturers-2013. In Spain, companies are surviving through export, which accounted for more than 50% of total collector production in 2013, per Pascual Polo, Spanish Solar Thermal Industry Association (ASIT), cited in Alejandro Diego Rosell, "Spain: 'Most of These Companies Will Survive Thanks to Internationalisation'," Solar Thermal World, 16 December 2013, http://solarthermalworld.org/content/spain-most-these-companies-will-survive-thanks-internationalisation. Manufacturers in Spain had 1.3 million m^2 of production capacity but manufactured only 241,000 m^2 in 2013, and more than 50% of total production was exported, from Alejandro Diego Rosell, "Spain: Market Rebounds After Years-Long Struggle," Solar Thermal World, 16 July 2014, http://solarthermalworld.org/content/spain-market-rebounds-after-years-long-struggle. In Cyprus, the industry is focused increasingly on replacements of older systems and exports, per Andreas Ioannides, Johnsun Heaters in Nicosia, cited in Frank Stier, "Cyprus: Solar Thermal Industry Off to New Frontiers," Solar Thermal World, 14 June 2014, http://solarthermalworld.org/content/cyprus-solar-thermal-industry-new-frontiers.

100 Epp and Banse, op. cit. note 68.

101 Epp, personal communication, op. cit. note 90; Epp and Banse, op. cit. note 68.

102 Epp, personal communication, op. cit. note 90; Bärbel Epp, "Turkey: Three Vacuum Tube Manufacturers Eying Export Market," Solar Thermal World, 2 October 2014, http://www.solarthermalworld.org/content/turkey-three-vacuum-tube-manufacturers-eying-export-market. Companies include Lara Solar, Assolar, and Solarsan, from idem. The share of vacuum tube collectors in Turkey increased from 4% in 2007 to 44% in 2013, according to industry estimates, from Hakan Alas, Ezinç, interview by Bärbel Epp, "Turkey: Vacuum Tubes on the Rise," Solar Thermal World, 23 April 2012, http://www.solarthermalworld.org/content/turkey-vacuum-tubes-rise; and from Kutay Ülke, Ezinç, 20 January 2015, email to Bärbel Epp and provided via personal communication with REN21, February 2015.

103 Ranking according to manufacturers' information in market survey by solrico, September/October 2014, cited in Epp and Banse, op. cit. note 68; and Bärbel Epp, "Worldwide: Largest Flat Plate Collector Manufacturers in 2013," Solar Thermal World, 5 November 2014, http://www.solarthermalworld.org/content/worldwide-largest-flat-plate-collector-manufacturers-2013.

104 Linuo Group is an original equipment manufacturer for evacuated tubes and has one customer, Linuo Paradigma (a daughter company in the same group); Himin and South East Corporation are brand companies for solar tubes and complete systems, all from Bärbel Epp, solrico, personal communication with REN21, 22 March 2015.

105 Epp and Banse, op. cit. note 68.

106 Juichen Wang, China Association of Rural Energy Industry, cited in Epp, op. cit. note 16.

107 Epp, op. cit. note 16.

108 Large players include Linuo Paradigma, Sangle, Sunrain, Jingpu Solar, from Sun's Vision, cited in Goess, op. cit. note 18.

109 Hongzhi Cheng, Sun's Vision, cited in Epp, op. cit. note 16.

110 For example: Sopogy (USA), which supplied solar thermal technology to produce solar stem and thermal heat for absorption chillers or industrial process heat (and power), closed operations and liquidated assets, from Eric Wesoff, "Sopogy Liquidates, Another Casualty in Solar Trough CSP Technology," Greentech Media, 23 April 2014, https://www.greentechmedia.com/articles/read/Sopogy-Liquidates-Another-Casualty-in-Solar-Trough-CSP-Technology; Eva Augsten, "Hawaii/California: Sopogy Goes into Liquidation After More Than a Decade in Business," Solar Thermal World, 7 July 2014, http://www.solarthermalworld.org/content/hawaiicalifornia-sopogy-goes-liquidation-after-more-decade-business. Isofoton was under liquidation procedures in late 2014, and its automated production line for flat plate collectors was purchased by Navasol in Malaga, southern Spain, per Alejandro Diego Rosell, "Spain: Andalusia Incentives Continue Until June 2015," Solar Thermal World, 18 January 2015, http://solarthermalworld.org/content/spain-andalusia-incentives-continue-until-june-2015. In 2014, a few smaller manufacturers stopped production of flat plate collectors and left the solar business, including GMP and Tecnosolar (Italy), ZAE Ergom and Solar Polska (both Poland), ZEN Renewables (Belgium), and Richworld Renewables (Portugal), per Epp and Banse, op. cit. note 68, pp. 26–41.

111 Bärbel Epp, "Germany: Asset Deal Finalised—Wagner Brand Lives On," Solar Thermal World, 30 September 2014, http://www.solarthermalworld.org/content/germany-asset-deal-finalised-wagner-brand-lives; Bärbel Epp, "Germany: Insolvency of Long-Standing Collector Manufacturer," Solar Thermal World, 5 May 2014, http://solarthermalworld.org/content/germany-insolvency-long-standing-collector-manufacturer.

112 Bärbel Epp, "Denmark: New Arcon-Sunmark Focuses on Large-Scale Turnkey Installations," Solar Thermal World, 12 February 2015, http://www.solarthermalworld.org/content/denmark-new-arcon-sunmark-focuses-large-scale-turnkey-installations; Bärbel Epp, "Denmark: From Sunmark to Sunmark Solutions," Solar Thermal World, 1 April 2014, http://solarthermalworld.org/content/denmark-sunmark-sunmark-solutions.

113 Dalenbäck, op. cit. note 73.

114 IEA-ETSAP and IRENA, op. cit. note 90, p. 1; Swiss Federal Office of Energy, cited in Eva Augsten, "Switzerland: Solar Thermal Systems Cost Almost Twice as Much as in Austria," Solar Thermal World, 20 December 2014, http://solarthermalworld.org/content/switzerland-solar-thermal-systems-cost-almost-twice-much-austria. For example, a system for a single-family home in Switzerland costs about 30% more than one in southern Germany and averages double the cost of a similar system in Austria due to high labour costs in Switzerland as well as quality standards, more expensive storage tanks, and other factors.

115 Stryi-Hipp, op. cit. note 37.

116 IEA, op. cit. note 88, p. 222.

117 IEA-ETSAP and IRENA, op. cit. note 5, p. 10.

118 In China, obligations are driving some key manufacturers (e.g., Linuo Paradigma, Sangle, Himin, Sunrain) to develop new technologies for building integrated systems, from Goess, op. cit. note 18.

119 Liners and floating covers from Bärbel Epp, "Germany/Denmark: Geosynthetic Lining for Large-Scale Underground Heat Storage Tank," Solar Thermal World, 27 October 2014, http://solarthermalworld.org/content/germanydenmark-geosynthetic-lining-large-scale-underground-heat-storage-tank; proven with minimal risk from Søren Elisiussen, CEO at Arcon Solar, interviewed for Stephanie Banse, "Denmark: Dronninglund Inaugurates 26 MW_{th} Solar District Heating Plant," Solar Thermal World, 1 June 2014, http://solarthermalworld.org/content/denmark-dronninglund-inaugurates-26-mwth-solar-district-heating-plant.

120 Jens-Peter Meyer, "More Than Temperature Difference," *Sun & Wind Energy*, February 2015, pp. 32–41.

121 Irina Mitina, "Technology Survey: Pros and Cons of Different PVT Collectors," Fachhochschule Düsseldorf, Arbeitsgruppe E2-Erneuerbare Energien und Energieeffizienz, presentation for SMEThermal 2014, Berlin, 18 February 2014.

122 Epp and Banse, op. cit. note 68; solrico, "World Map of Solar Thermal Industry 2014," http://www.solrico.com/en/solar-market-research/world-map-2014.html, viewed 7 May 2015; Epp, personal communication, op. cit. note 90.

123 Companies that pulled out of the market in 2013–2014 included XNE Group and Arise New Energy (both China), Catch Solar (Norway), Kioto Clear Energy (Mexico), Bipin Engineers (India); joining were Energe (small systems for drying grain) and Enersol (glazed collectors for domestic heating) (both Argentina), Brassolar (Brazil), Sunex (Poland), Anitcam (Turkey), Elsol (Serbia), Solar Infra Systems (Canada), Sammler (Greece), and D&K Solar (Germany), from Epp and Banse, op. cit. note 68.

124 Jakob, "Solar Air-Conditioning in Europe," op. cit. note 80, slide 18.

125 Jakob, personal communication, op. cit. note 80.

126 Jakob, "Solar Air-Conditioning in Europe," op. cit. note 81.

127 Eva Augsten, "Germany: Additional Support for Small Solar Cooling Systems," Solar Thermal World, 3 February 2014, http://solarthermalworld.org/content/germany-additional-support-small-solar-cooling-systems.

128 Daniel Mugnier, TECSOL SA, personal communication with REN21, 11 April 2014. See, for example, Helioclim website, http://en.helioclim.fr/.

129 U. Jakob, "Technologies and Perspectives of Solar Cooling Systems," AHK Conference Sydney, Australia, 24 March 2014, http://www.docstoc.com/docs/169908741/DrJakob_Green_Chiller_Assoc.pdf, cited in IEA-ETSAP and IRENA, op. cit. note 90, p. 12.

130 Moritz, Schubert, and Putz, op. cit. note 85, pp. 6–7, 33; Jakob, op. cit. note 81.

131 The first World Map of the Solar Process Heat Collector Industry includes 36 companies from 10 countries including 18 parabolic trough collector manufacturers, 4 Fresnel collector manufacturers, 1 evacuated flat plate collector manufacturer, 8 scheffler/paraboloid dish collector manufacturers, and 4 receiver (tube) manufacturers, per Augsten, op. cit. note 88. Only a small portion (perhaps one-third) of manufacturers is also active in the CSP field, per Bärbel Epp, solrico, personal communication with REN21, 26 March 2014.

132 Solar parabolic dish leaders include Taylormade Solar Solutions Pvt. Ltd., Sharada Inventions Pvt. Ltd, Megawatt Solutions Pvt. Ltd., and Clique Developments Ltd. (all India); Trivelli Energia Sri (Italy), Solitem (Germany) and NEP Solar AG (Switzerland) are leaders for parabolic trough collectors; and Industrial Solar GmbH (Germany) and Chromasun (USA) are leaders for Linear Fresnels, from Augsten, op. cit. note 89, pp. 36–45.

133 Niche markets based on survey with manufacturers of process heat systems, from Augsten, op. cit. note 89, pp. 36–45; improving economics from IEA-ETSAP and IRENA, op. cit. note 90, p. 4.

134 Based on survey with manufacturers of process heat systems, from Augsten, op. cit. note 89, pp. 36–45, and from Mauthner, op. cit. note 1.

135 IEA-SHC, "Solar Rating & Certification," http://task43.iea-shc.org/, viewed 14 March 2015.

136 Regions from Bärbel Epp, solrico, personal communication with REN21, February 2015. See also, Alejandro Diego Rosell, "COPANT: One Common Standard—Better than 31 Different Ones?" Solar Thermal World, 6 November 2013, http://www.solarthermalworld.org/content/copant-one-common-standard-better-31-different-ones; Bärbel Epp, "Arab Countries/Germany: Kick-off Meeting for ARSOL Certification Programme," Solar Thermal World, 4 August 2012, http://www.solarthermalworld.org/content/arab-countries-germany-kick-meeting-arsol-certification-programme; Bärbel Epp, "Albania: UNDP/UNEP Regional Workshop Illustrates Showcases in the Region," Solar Thermal World, 3 April 2013, http://www.solarthermalworld.org/content/albania-undpunep-regional-workshop-illustrates-showcases-region. Brazil from Vanessa Kriele, "Brazil: Mandatory Certification Postponed to September 2015," Solar Thermal World, 18 February 2015, http://www.solarthermalworld.org/content/brazil-mandatory-certification-postponed-september-2015. Test centres in India included the School of Energy Studies at Savitribai Phule Pune University, located in Maharashtra state, which set up India's first vacuum tube testing centre in December 2014, per Jaideep Malaviya, "India: First Vacuum Tube Testing Centre Established," Solar Thermal World, 2 December 2014, http://www.solarthermalworld.org/content/india-first-vacuum-tube-testing-centre-established; and the first test centre for concentrating solar process heat technologies, which opened in July 2014, per Jaideep Malaviya, "India: Portable Kit Allows Testing Bulky Concentrating Collectors Onsite," Solar Thermal World, 20 August 2014, http://www.solarthermalworld.org/content/india-portable-kit-allows-testing-bulky-concentrating-collectors-onsite.

137 Epp, personal communication, op. cit. note 90; Vanessa Kriele, "Brazil: Mandatory Certification Postponed to September 2015," Solar Thermal World, 18 February 2015, http://www.solarthermalworld.org/content/brazil-mandatory-certification-postponed-september-2015; Bärbel Epp, "Brazil: Solar Thermal Market Diversifies in 2013," Solar Thermal World, 25 July 2014, http://www.solarthermalworld.org/content/brazil-solar-thermal-market-diversifies-2013; Serkan Güngör, "Turkey: State Activities in Solar Thermal Market Difficult to Research," Solar Thermal World, 2 January 2015, http://www.solarthermalworld.org/content/turkey-state-activities-solar-thermal-market-difficult-research. Brazil is working on a regional certification scheme to support trade and meet its ambitions to export its locally produced solar thermal systems throughout the region, from IEA-ETSAP and IRENA, op. cit. note 5, p. 18.

138 Standards Australia Limited, "Solar Heating and Cooling Systems—Calculation of Energy Consumption," Sydney, 2013, http://infostore.saiglobal.com/store/details.aspx?ProductID=1636574; Ken Guthrie, IEA-SHC and Sustainable Energy Transformation Pty Ltd, Australia, personal communication with REN21, 1 March 2015. See also IEA-SHC, "2013 Highlights SHC Task 48 Quality Assurance and Support Measures for Solar Cooling," February 2014, http://task48.iea-shc.org/data/sites/1/publications/Task48-Highlights-2013.pdf.

1 A total of 51,473 MW was added during the year, bringing cumulative global capacity to 369,597 MW, from Global Wind Energy Council (GWEC), *Global Wind Report 2014: Annual Market Update* (Brussels: April 2015), p. 7, http://www.gwec.net/wp-content/uploads/2015/03/GWEC_Global_Wind_2014_Report_LR.pdf; 52,251 MW added for total of 370,893 MW, from World Wind Energy Association (WWEA), *World Wind Energy Report 2014* (Bonn: forthcoming 2015); 51,716 MW added for a total of 369,678 MW at year's end, from Feng Zhao et al., *Global Wind Market Update—Demand & Supply 2014* (London: FTI Consulting LLP, March 2015), p. xi; 52,129 MW added for a total of more than 371,191 MW (including capacity not grid-connected by year's end), from EurObserv'ER, *Wind Energy Barometer* (Paris: February 2015), p. 3, http://www.energies-renouvelables.org/observ-er/stat_baro/observ/barojde16_WindEnergy_EN.pdf. **Figure 22** based on historical data from GWEC, op. cit. this note, and from WWEA, op. cit. this note, and data for 2014 from sources in this note.

2 Figure of 84% based on data from Zhao et al., op. cit. note 1, and from GWEC, op. cit. note 1, p. 7.

3 Shruti Shukla, GWEC, personal communication with REN21, 6 April 2015, and from GWEC, "Global Wind Statistics 2013" (Brussels: 5 February 2014), p. 6. Note that 52 countries saw commercial wind activity in 2014 alone, and at least 77 had more than 10 MW and 24 had more than 1 GW by the end of 2014, from WWEA, op. cit. note 1.

4 GWEC, *Global Wind 2006 Report* (Brussels: 2006), pp. 8–9, http://gwec.net/wp-content/uploads/2012/06/gwec-2006_final_01.pdf.

5 Seventh consecutive year from GWEC, op. cit. note 1, p. 8; shares based on idem., p. 7; Zhao et al., op. cit. note 1, pp. 29–32. North America includes the United States and Canada. Note that Asia accounted for 50.2% of newly installed capacity in 2014, Europe for 25.8%, and North America for 13.9%, from EurObserv'ER, op. cit. note 1, p. 3.

6 Steve Sawyer, GWEC, personal communication with REN21, 13 April 2015.

7 GWEC, op. cit. note 1, p. 7.

8 GWEC, op. cit. note 1, p. 7; Zhao et al., op. cit. note 1, pp. 29–32. **Figure 23** based on country-specific data and sources provided throughout this section.

9 WWEA, "New Record in Worldwide Wind Installations: More than 50 GW Additional Wind Power Capacity, Wind Power Worldwide Close to 370 GW," press release (Bonn: 5 February 2015); FTI Consulting, "Record Year for the Global Top 10 Turbine OEMs," press release (London: 23 February 2015), http://www.fticonsulting.com/global2/press-releases/united-states/record-year-global-top-10-turbine-oems.aspx. The large market in 2014 was due primarily to China as well as to the rush to install before policy changes, from Zhao et al., op. cit. note 1, p. 29.

10 Least-cost from Foreword in GWEC and Greenpeace International, *Global Wind Energy Outlook 2014* (Brussels and Amsterdam: October 2014), p. 3; also, see references for industry text below. New markets from GWEC, op. cit. note 1; Zhao et al., op. cit. note 1; and WWEA, op. cit. note 1.

11 Steve Sawyer, GWEC, personal communication with REN21, 9 March 2015.

12 The top five in 2014 were Denmark (876.8 W per person), Sweden (557.9 W), Germany (499.6 W), Spain (481.5 W), and Ireland (470.1 W), followed by Portugal (454.4 W), Canada (278.3 W), Austria (254.8 W), Estonia (240.6 W), and the United States (206.2 W), from WWEA, op. cit. note 1. The top five in 2013 were Denmark (863 W per person), Sweden (487.6 W), Spain (420.5 W), Portugal (412 W), and Ireland (381 W), followed by Germany (372.1 W per capita), Canada (209.7 W), Estonia (191.2 W), Austria (182.2 W), and the United States (167.7 W), from WWEA, *World Wind Energy Report 2013* (Bonn: 2014).

13 Steve Sawyer, GWEC, personal communication with REN21, 28 October 2014; FTI Consulting, op. cit. note 9; Shi Pengfei, Chinese Wind Energy Association (CWEA), personal communication with REN21, 1 April 2015. See also GWEC, op. cit. note 1, p. 38.

14 Additions of 23,196 MW and total of 114,609 GW from CWEA, provided by Shi, op. cit. note 13, and from GWEC, op. cit. note 1, p. 7; added 23,196 MW from Zhao et al., op. cit. note 1, p. 30. Total also from National Energy Board, cited by China National Energy Administration (CNEA), "Wind Power Industry Monitoring," 12 February 2015, http://www.nea.gov.cn/2015-02/12/c_133989991.htm (using Google Translate). China added 23,350 MW for a total of 114,763 MW from WWEA, op. cit. note 1; added 26,150 MW for a total of 112,890 MW, from China Renewable Energy Engineering Institute (CREEI), *Wind Power Statistical Evaluation Report of China* (in Chinese), 14 April 2015, provided by Shi Pengfei, CWEA, personal communication with REN21, 15 April 2015. Note that the differences in statistics likely result from differences in what is counted and when; higher additions noted by CREEI probably include some capacity that other sources counted for 2013.

15 Figures of 20,720 MW for a total of 95,810 MW, from China Electricity Council, provided by Shi, op. cit. note 13; China added 19.81 GW and 96.37 GW from National Energy Board, cited by CNEA, op. cit. note 14; and China added 20,160 MW for a total of 97,316 MW certified and grid-connected capacity that was receiving the FIT premium by year's end, from CREEI, op. cit. note 14. As above, differences in statistics likely result at least in part from differences in what is counted and when. Note that most of the capacity added in 2014 was feeding the grid by year's end. The difference in statistics among Chinese organisations and agencies is explained by the fact that they count different things: installed capacity refers to capacity that is constructed and has wires carrying electricity from the turbines to a substation; certified wind power capacity has undergone up to several months of test feeding into the grid; capacity qualifies as grid-connected (included in China Electricity Council statistics) once certification is granted and operators begin receiving the FIT premium payment, which can take weeks or even months. It is no longer the case that thousands of turbines stand idle awaiting connection in China because projects must be permitted to start construction; however, there is still a 2–10 month lag from when turbines are wire-connected to the substation until the process of certification and payment of FIT premium is complete. Steve Sawyer, GWEC, personal communication with REN21, 20 April 2015.

16 Wind generation from China Electricity Council, available in Chinese at http://www.cec.org.cn/guihuayutongji/gongxufenxi/dianliyunxingjiankuang/2015-02-02/133565.html, provided by Liming Qiao, GWEC, personal communication with REN21, 16 April 2015; share of output from CREEI, op. cit. note 14; share in 2013 from China Electricity Council, provided by Shi Pengfei, CWEA, personal communication with REN21, 14 March 2014.

17 Top provinces and shares, from CREEI, op. cit. note 14. Inner Mongolia led with 22,312.31 MW, followed by Gansu Province (10,725.95 MW), Hebei Province (9,872.4 MW), and Xinjiang (9,668.06 MW), from GWEC, op. cit. note 1, p. 40. Benefitting from transmission and management, from idem., p. 40.

18 GWEC, op. cit. note 1, pp. 38–41. New high-voltage lines under construction helping to address the curtailment problem also from Steve Sawyer, GWEC, personal communication with REN21, 11 February 2015; incentives for development in less-windy areas from J. Matthew Roney, "Wind Power Beats Nuclear Again in China," Earth Policy Release (Washington, DC: 5 March 2015), www.earth-policy.org/data_highlights/2015/highlights50.

19 National Energy Board, cited by CNEA, op. cit. note 14. 14.9 TWh from Shi Pengfei, CWEA, personal communication with REN21, 16 April 2015. It should be taken into account that 2014 was a low wind speed year compared to average, from Shi, op. cit. note 13.

20 Yang Jianxiang, "Curtailment Solutions Boost Confidence in China," *Wind Power Monthly*, 30 September 2014, http://www.windpowermonthly.com/article/1314288/curtailment-solutions-boost-confidence-china; Sawyer, op. cit. note 6. Note that "measures are being taken on a trial basis to allow wind to power heating facilities in winter and fine-tune the administration of rationed grid feed-in on different power sources. Successful trials show these measures help solve the curtailment problem, too," from Jianxiang, op. cit. this note. For more on use of wind for heating purposes, as well as hydrogen production, see CNEA, "National Energy Board on Doing: 2015 Annual Wind Power Consumptive Notification Related Work," *States to New Energy*, 23 March 2015, http://zfxxgk.nea.gov.cn/auto87/201504/t20150407_1900.htm (using Google Translate).

21 Sawyer, op. cit. note 18.

22 Freddie G. Lazaro, "2014 Was Year of Wind Energy," *Manila Bulletin*, 29 December 2014, http://www.mb.com.ph/2014-was-year-of-wind-energy/; Iris Gonzales, "SEA's Biggest Wind Farm Powers Luzon," *Philippine Star*, 9 November 2014, https://ph.news.yahoo.com/sea-biggest-wind-farm-powers-000000102.html. The Philippines added 317 MW, from Zhao et al., op. cit. note 1, p. 30; added 150 MW for a total of 216 MW, from GWEC, op. cit. note 1, p. 7; and added 183 MW for a total of 216 MW from WWEA, op. cit. note 1.

23 Pakistan and Japan from GWEC, "Global Wind Statistics

2014," 10 February 2015, http://www.gwec.net/wp-content/uploads/2015/02/GWEC_GlobalWindStats2014_FINAL_10.2.2015.pdf; Pakistan added 150 MW for a total of 256 MW, and Japan added 130 MW for a total of 2,788 MW from WWEA, op. cit. note 1. Cumbersome procedures from GWEC, op. cit. note 1, p. 62. More than 6 GW of projects were at different states in the environment impact assessment process as of early 2015, from Zhao et al., op. cit. note 1, p. 36.

24 India installed 2,315 MW for a total of 22,465 MW, from GWEC, op. cit. note 1, p. 7, and from WWEA, op. cit. note 1; increase over 2013 based on 2014 additions and figure of 1,729 MW added in 2013 for a year-end total of 20,150 MW, from Zhao et al., op. cit. note 1, p. 30.

25 Yielded to Asia based on data from European Wind Energy Association (EWEA), *Wind in Power: 2013 European Statistics* (Brussels: February 2014), p. 3, http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA_Annual_Statistics_2013.pdf; from GWEC, *Global Wind Report: Annual Market Update 2013* (Brussels: April 2014), p. 17, http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf; from WWEA, *World Wind Energy Report 2013* (Bonn: 2014); from GWEC, op. cit. note 1; from WWEA, op. cit. note 1; from Zhao et al., op. cit. note 1; and from EWEA, *Wind in Power: 2014 European Statistics* (Brussels, February 2015), http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA-Annual-Statistics-2014.pdf. Market up 4% from EWEA, idem.

26 EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25.

27 Ibid.

28 The EU-28 added 11,829 MW for a year-end total of 128,790 MW (and Europe—not including Turkey—added 12,054 MW for a total of 130,244 MW), from GWEC, op. cit. note 1, pp. 7 and 44, and from EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25.

29 Shruti Shukla, GWEC, personal communication with REN21, 13 April 2015.

30 EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25, p. 10; markets in southern and eastern Europe continued to struggle during 2014 due to "erratic and harsh changes in the policy arena," from EWEA, "Wind Energy Installations Outperform Gas and Coal in 2014," press release (Brussels, 10 February 2015), http://www.ewea.org/news/detail/2015/02/10/wind-energy-installations-outperform-gas-and-coal-in-2014/; Giorgio Corbetta, EWEA, personal communication with REN21, 20 March 2015.

31 EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25; 2013 data from EWEA, *Wind in Power: 2013 European Statistics*, op. cit. note 25, p. 3.

32 Germany added 4,750 MW of capacity onshore and 529 MW of grid-connected offshore capacity, for a total of 5,279 MW new capacity installed, from GWEC, op. cit. note 1, pp. 48–50; added a total of 5,274 MW from Zhao et al., op. cit. note 1, p. 33. Germany added 4,745 MW onshore and 1,437 MW offshore (including offshore capacity not connected to the grid by year's end) for a total of 6,182 MW, from C. Ender, "Wind Energy Use in Germany – Status 31.12.2014," *DEWI Magazin*, February 2015, pp. 26–37, http://www.dewi.de/dewi_res/fileadmin/pdf/publications/Magazin_46/05.pdf.

33 Decommissioned capacity amounted to 364 MW, for a net increase of 4,915 MW, and Germany had a total of 39,165 MW at end-2014, from GWEC, op. cit. note 1, p. 48; year-end total was 39,115 MW from Zhao et al, op. cit. note 1, p. 33; dismantled capacity was 386 MW, and year-end capacity totalled 40,457 MW installed with 39,154 MW connected to the grid, from Ender, op. cit. note 32, pp. 26–37; Germany's year-end capacity was 40.5 GW (including capacity not yet grid-connected), per German Federal Ministry for Economic Affairs and Energy (BMWi), *Development of Renewable Energy Sources in Germany 2014*, based on data from the Working Group on Renewable Energy-Statistics (AGEE-Stat), as of February 2015, p. 15, http://www.bmwi.de/English/Redaktion/Pdf/development-of-renewable-energy-sources-in-germany,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf.

34 Zhao et al., op. cit. note 1, p. 33; Ender, op. cit. note 32, pp. 26–37.

35 Capacity totalling 1,147.88 MW was identified as being for repowering, amounting to at least 24.4% of gross additions in 2014, from Deutsche WindGuard, *Status of Land-Based Wind Energy Development in Germany*, January 2015, https://www.wind-energie.de/en/press/press-releases/2015/onshore-wind-energy-2014-record-4750-megawatt-rise-installations-germany; and 1,148 MW was for repowering from GWEC, op. cit. note 1, p. 50. An estimated 1,729 MW of capacity added onshore was for repowering, accounting for 36% of newly installed onshore capacity, per Ender, op. cit. note 32, pp. 26–37.

36 Provisional data as of February 2015, from Working Group on Renewable Energy-Statistics (AGEE-Stat), "Development of Renewable Energy Sources in Germany 2014," February 2015, p. 15, http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/development-of-renewable-energy-sources-in-germany-2014.pdf. Generated 55.964 TWh in 2014, up from 51.7 TWh in 2013, from EurObserv'ER, op. cit. note 1, p. 9, and generated 51.4 TWh in 2014, from Fraunhofer Institute for Solar Energy Systems, *Annual Report 2014* (Freiburg, Germany: 5 January 2015), https://www.energy-charts.de/index_de.htm, viewed 7 March 2015.

37 EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25. The country added 1,736 MW for a total of 12,267 MW in 2014, from Zhao et al., op. cit. note 1, p. 33; the United Kingdom added 1,736 MW (1,301 MW offshore) for a total of 12,440 MW (4,494 MW offshore), from GWEC, op. cit. note 1, pp. 7, 53, 74. Additions were down from 1,883 MW in 2013, from Zhao et al., op. cit. note 1, p. 30. Share offshore based on data in GWEC, op. cit. note 1, pp. 7, 53.

38 Generation from EurObserv'ER, op. cit. note 1, pp. 3, 9; figure of 9% (up from 7.8% in 2013) from GWEC, op. cit. note 1, p. 74.

39 Sweden added an estimated 1,050 MW for a total of 5,425 MW, and France added an estimated 1,042 MW for a total of 9,285 MW, from EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25. In 2013, Sweden added 689 MW for a total of 4,382 MW, and France added 630 MW for a total of 8,243 MW, from idem.

40 Denmark added 67 MW (down from 694.5 MW) for a total of 4,845 MW, Italy added 107.5 MW (437.7 MW) for a total of 8,662.9 MW, and Spain added 27.5 MW (175.1 MW) for a total of 22,986.5 MW from EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25; Denmark added 105 MW for a total of 4,883 MW, Italy added 108 MW for a total of 8,663 MW, and Spain added 28 MW for a total of 22,987 MW, from GWEC, op. cit. note 1, p. 7; Denmark added 105 MW (down from 657 MW in 2013), Italy added 107 MW (down from 444 MW), and Spain added 27 MW (down from 175 MW), from Zhao et al., op. cit. note 1, pp. 30–31.

41 Rankings based on data in this section; the United States added 4,854 MW for a total of 65,879 MW from American Wind Energy Association (AWEA), "American Wind Power Rebounded in 2014, Adding Over Four Times as Much as Year Before," press release (Washington, DC: 28 January 2015), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=7181. The United States generated 181.791 TWh of electricity with wind, from U.S. Energy Information Administration (EIA), *Electric Power Monthly with Data for December 2014* (Washington, DC: U.S. Department of Energy (DOE), February 2015), Table 1.17.B. Net Generation from Wind by State, by Sector, Year-to-Date through December 2014 and 2013, p. 44, http://www.eia.gov/electricity/monthly/.

42 AWEA, "Wind Was Largest Source of New Electricity in 2014, Congress Still Must Provide Long-Term Policy Certainty," press release (Washington, DC: 5 March 2015), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=7294.

43 AWEA, op. cit. note 41.

44 Ibid.

45 Canada added an estimated 1,871 MW in 2014 for a total of 9,694 MW; Ontario added 999 MW, Quebec added 460 MW, and Alberta added 351 MW, from GWEC, op. cit. note 1, p. 34.

46 Figure of 4.3 GW based on data for Latin America and the Caribbean (3,749 MW) not including Mexico, plus 522 MW added in Mexico, for total additions of 4,271 MW, from GWEC, "Global Wind Statistics 2014," op. cit. note 23. The region added 4,291 MW for a total capacity of 10,838 MW, from Zhao et al., op. cit. note 1, p. 29. Data for Mexico (633.7 MW added for a total of 2,551 MW), Chile (506 MW; 836 MW), Uruguay (405 MW; 464 MW), and Peru (146 MW; 148 MW) from GWEC, op. cit. note 1; Mexico added 559 MW for a total of 2,551 MW, Chile (502 MW: 836 MW); Uruguay (470 MW; 529.4 MW); and Peru (147.3 MW; 148 MW), from WWEA, op. cit. note 1. Uruguay added 421.9 MW for a total of 481.3 MW, from Uruguay Secretary of Energy, Ministry of Industry, Energy and Mining (MIEM), provided by Stephanie Grunvald, MIEM, personal communication with REN21, 17 April 2015. Other countries in the region where global wind turbine suppliers are competing for orders are Honduras, Guatemala, and Nicaragua, from Zhao et al., op. cit. note 1, p. 37.

47 Fourth globally and Brazil added 2,472 MW in 2014 for a total of 5,939 MW, from GWEC, op. cit. note 1, p. 32. Brazil added 2,472

MW new capacity for total of 5,928 MW, from Zhao et al., op. cit. note 1, p. 37; and Brazil added 2,495.5 MW for a total of 5,961.6 MW, from WWEA, op. cit. note 1.

48 Steve Sawyer, GWEC, personal communication with REN21, 3 September 2014. However, as of April 2015, the auction process for grid access had not yet begun, from Sawyer, op. cit. note 15.

49 Camila Ramos, Clean Energy Latin America (CELA), personal communication with REN21, 3 April 2015.

50 At year's end, Brazil's cumulative wind capacity was 5,939 MW, of which 5,005 MW was fully operational and grid-connected, and a further 600 MW was grid-connected under "test operation phase", with 334 MW waiting to be connected, from GWEC, op. cit. note 1, p. 32. Note that Associação Brasileira de Energia Eólica (ABEEólica) deems capacity to be installed and grid-connected once it has achieved the status "Able to Operate", meaning that the wind farm operator receives monthly payment for power sales, according to the accounting system of the Chamber of Electric Energy Commercialisation (CCEE), which considers the energy to be delivered under the contract at the contracted price. This status was created due to delays in completion of some transmission lines.

51 Australia added 567 MW for a total of 3,806 MW, from GWEC, "Global Wind Statistics 2014," op. cit. note 23; and added 757 MW for a total of 3,806 MW, from WWEA, op. cit. note 1.

52 Zhao et al., op. cit. note 1, p. 117.

53 More than 40 wind projects have been on hold since the national government said it would cut support for wind power, and investors and operators (including Australian-based companies like Pacific Hydro and Infigen, which has said it will focus on the U.S. market) have threatened to downscale or leave the country if these changes are made, from Byron Kaye, "RPT-Australian Wind Farms Face $13 bln Wipeout from Political Impasse," *Reuters*, 8 February 2015, http://uk.reuters.com/article/2015/02/08/australia-windfarms-idUKL4N0VH03820150208.

54 Aby Thomas, "Masdar Delivers Samoa's First Wind Farm," Construction Week Online, 31 August 2014, http://www.constructionweekonline.com/article-29798-masdar-delivers-samoas-first-wind-farm/. Samoa added 0.5 MW for a total of 0.5 MW, from WWEA, op. cit. note 1.

55 Figure of 0.5 GW annually from GWEC, "Turkish Wind Bridging the Continents," personal communication with REN21, 9 March 2015; Turkey added nearly 804 MW in 2014 for a total of 3,762 MW from Turkish Wind Energy Association, *Turkish Wind Energy Statistics Report*, January 2015, pp. 4-5, http://www.tureb.com.tr/en/twea-announcements/434-turkish-wind-energy-statistics-report-january-2015. Note that Turkey added 0.8 GW in 2014 for a total of 3,511 MW at the end of 2014, per Turkish Electricity Transmission Company (TEIAS), information provided by Abdelghani El Gharras and Emanuela Menichetti, Observatoire Méditerranéen de l'Energie, personal communication with REN21, 16 April 2015.

56 GWEC, "Global Wind Statistics 2014," op. cit. note 23. Iran added 4 MW in 2014, from Zhao et al., op. cit. note 1, p. xi.

57 GWEC, op. cit. note 1, p. 68, and Algeria from Maged Mahmoud, Regional Center for Renewable Energy and Energy Efficiency (RCREEE), personal communication with REN21, 14 April 2015. Algeria added no capacity for a total of 10.1 MW; Egypt (66 MW; 610 MW); Morocco (300 MW; 787 MW); South Africa (468 MW; 570 MW), from WWEA, op. cit. note 1. Egypt added 60 MW out of a 200 MW project to be fully operational in 2015, and another two state-owned wind projects of a total 320 MW were contracted end-2014, from Maged Mahmoud, RCREEE, personal communication with REN21, 12 April 2015. "Morocco Wind Farm, Africa's Biggest, Starts Generating Power," Phys.org, 24 April 2014, http://phys.org/news/2014-04-morocco-farm-africa-biggest-power.html. South Africa added 473 MW for a total of 673 MW, from Zhao et al., op. cit. note 1, p. 37. Also, Tunisia added 11 MW, from idem., p. 32.

58 Morocco had 787 MW at the end of 2014, up from 487 MW, and Egypt had 610 MW, up from 550 MW, from GWEC, op. cit. note 1, p. 7; also from Mahmoud, op. cit. note 57; under construction from idem; Morocco leads Africa for total capacity, with 796 MW at end-2014, from Zhao et al., op. cit. note 1, p. 37; and with 787 MW, from GWEC, op. cit. note 1, p. 7.

59 Kenya's Lake Turkana from Stefan Nicola, "Africa's Largest Wind Farm Moves Forward," Renewable Energy World, 16 December 2014, http://www.renewableenergyworld.com/rea/news/article/2014/12/africas-largest-wind-farm-moves-forward; GWEC, op. cit. note 1, p. 26. Ghana, Senegal, and Tanzania from Sawyer, op. cit. note 18 and op. cit. note 11; and from GWEC, op. cit. note 1, pp. 27–28. Note also that Tunisia commissioned two wind farms (Metline and Kchabta) with a total capacity of 190 MW at the end of 2013, from African Energy, "Power Update: Tunisia on Hold Awaiting New Government," 13 February 2014, http://www.africa-energy.com/power-update-tunisia-on-hold-awaiting-new-government.

60 Figure of 1,683 MW added to the grid for a total of 8,540 MW, based on Europe data from EWEA, cited in GWEC, op. cit. note 1, pp. 52–55; on Japan (added no capacity for total of 50 MW), South Korea (0 MW; 5 MW), and the United States (0 MW; 0.02 MW), from GWEC, op. cit. note 1, pp. 52–55; and China from Shi, op. cit. note 19.

61 Europe added 1,483.3 MW to its grids for a total of 8,045.3 MW, from EWEA, *The European Offshore Wind Industry—Key Trends and Statistics 2014* (Brussels: January 2015), p. 3, http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA-European-Offshore-Statistics-2014.pdf; and from GWEC, op. cit. note 1, p. 52. Another 2.9 GW was under construction off European coasts at year's end.

62 The United Kingdom added 813.4 MW to the grid for a total of 4,494.4 MW; Germany added 528.9 MW to the grid for a total of 1,048.9 MW; and Belgium added 141 MW to the grid for a total of 712 MW, all from EWEA, op. cit. note 61, pp. 5, 10. Three countries in Europe added capacity to the grid in 2014: Belgium (141 MW for total of 713 MW), Germany (165 MW for total of 722 MW), and the U.K. (644 MW for total of 4,323 MW), for a European total of 1,181 MW installed and connected to the grid during the year and cumulative capacity of 8,179 MW, from Zhao et al., op. cit. note 1, p. 40. According to Zhao et al., their numbers are lower than EWEA's because their statistics for a Siemens project include only capacity that was installed, connected, and delivered to clients by year's end. Germany built 1,437.4 MW in 2014, and 529 MW started feeding the grid during the year; at year's end, Germany had a total 2,352.3 MW of offshore capacity (including capacity that was not grid-connected), from Ender, op. cit. note 32, pp. 26–37.

63 Leveling off of development from Katharina Garus, "Offshore Wind Installations Stabilise in 2014," offshorewindindustry.com, 30 January 2015, http://www.offshorewindindustry.com/news/offshore-wind-installations-stabilise-2014; UK developers cancelled more than 9.5 GW of potential offshore projects from November to July 2014; challenging conditions made it too expensive to develop, from Alex Morales, "Centrica, Dong, Quit Plans for 4.2 GW of Offshore Wind," *Bloomberg*, 31 July 2014, http://www.bloomberg.com/news/2014-07-31/centrica-dong-quit-plans-for-4-2-gw-of-offshore-wind.html; uncertainty surrounding the UK government's electricity market reforms have undermined investment and several developers shelved major projects from Jessica Shankleman, "Germany to Overtake UK in Offshore Wind Race this Year," BusinessGreen.com, 2 February 2015, http://www.businessgreen.com/bg/news/2393024/germany-to-overtake-uk-in-offshore-wind-race-this-year; companies in Europe have scrapped plans for more than 5.7 GW from November 2013 to July 2014, from Feifei Shen, "China Three Years Late on Installing Offshore Wind Farms," Renewable Energy World, 17 July 2014, http://www.renewableenergyworld.com/rea/news/article/2014/07/china-three-years-late-on-installing-offshore-wind-farms.

64 "The Second Wave is Rolling in," *Offshore Wind Industry*, February 2015, p. 41, http://www.offshorewindindustry.com/sites/default/files/owi_04_2014_teaser.pdf. At year's end, 1,049.2 MW offshore feeding grid, with another 1,302.1 MW installed and awaiting grid connection, from Deutsche WindGuard GmbH, "Status of Offshore Wind Energy Development in Germany: Year 2014" (Varel, Germany: undated), http://www.windguard.de/_Resources/Persistent/9d9c89b0202690467e45c34c5f19ce50b84a6f8a/Factsheet-Status-Offshore-Wind-Energy-Development-Year-2014-eng.pdf, viewed 13 February 2015. Germany added 529 MW of offshore capacity to its grid in 2014 for a total of 1,049 MW, with another 1,218 MW completed and scheduled to come on line in 2015, from GWEC, op. cit. note 1, p. 50; and Germany added 1,437 MW of capacity in 2014, of which 529 MW was grid-connected, for a total of 2,352 MW installed offshore and 1,049 MW grid-connected at year's end, from Ender, op. cit. note 32.

65 Denmark had 1,271 MW operating offshore at end-2014, from EWEA, op. cit. note 61, p. 10. Denmark's 312 MW Borkum Riffgrund 1 offshore project in the North Sea exported its first power in early 2015, and the project is expected to be fully commissioned in first half of 2015, from "Riffgrund 1 Notches First Power," reNEWS, 17 February 2015, http://renews.biz/84214/riffgrund-1-notches-first-power/.

66 Shruti Shukla, Paul Reynolds, and Felicity Jones, *Offshore Wind*

Policy and Market Assessment: A Global Outlook (Delhi: GWEC, December 2014), p. 10, http://www.gwec.net/wp-content/uploads/2015/02/FOWIND_offshore_wind_policy_and_market_assessment_15-02-02_LowRes.pdf.

67 China added 200 MW grid-connected capacity for a total of 440 MW grid-connected from Shi, op. cit. note 19; added 229 MW for a total of 658 MW from CWEA, provided by Shukla, op. cit. note 3; added 230 MW for a total of 659 MW from Zhao et al., op. cit. note 1, p. 40.

68 Zhao et al., op. cit. note 1, p. 45. Zhao et al. note that 6.2 GW was under construction in eight countries: Germany (2,589.7 MW), China (1,951 MW), the United Kingdom (749.4 MW), Belgium (129 MW), the Netherlands (129 MW), South Korea (30 MW), the United States (30 MW), and Japan (14 MW), for a total of 6,168 MW under construction; most of these are expected to come on line in 2015. However, the first US project ("Deepwater Wind", off the coast of Rhode Island) is scheduled to begin construction in mid-2015 and to be operational by end-2016, from Deepwater Wind, "Block Island Wind Farm," http://dwwind.com/block-island/block-island-project-overview, viewed 15 April 2015.

69 See, for example, "Big Business Rethinks Its Energy Habits," *IRENA Quarterly*, October 2014, http://www.irena.org/Quarterly/IRENA%20Quarterly_October2014.pdf, Rona Fried, "Big Corporations to Utilities: Please Make It Easy to Buy Renewable Energy," Sustainable Business, 21 July 2014, http://www.sustainablebusiness.com/index.cfm/go/news.display/id/25818; Ehren Goossens, "IKEA Buys Second U.S. Wind Farm, Plans More in Renewables Push," *Bloomberg*, 18 November 2014, http://www.bloomberg.com/news/2014-11-18/ikea-buys-second-u-s-wind-farm-plans-more-in-renewables-push.html. See also Heather Clancy, "IKEA, Swiss Re, Mars, H&M Go All-in on Renewable Energy," Greenbiz, 22 September 2014, http://www.greenbiz.com/blog/2014/09/22/ikea-swiss-re-mars-hm-make-100-renewable-energy-pledges.

70 For Australia, see, for example, "Australia's First Community-Owned Wind Farm in Daylesford," *Castlemaine Independent*, 18 October 2013, http://www.castlemaineindependent.org/2013/10/australias-community-owned-wind-farm-daylesford/, and The Greens, "Unleashing Community-Owned Energy," http://greens.org.au/community-energy, viewed 11 March 2015; in Canada, for example, the country's first union-owned and -operated wind turbine came on line, in Ontario (Port Elgin), per Ken Lewenza, President of Canadian Auto Workers (CAW), cited in "CAW Owned and Operated Wind Turbine Begins Operation in Port Elgin, Ontario," 25 March 2013, http://www.newswire.ca/en/story/1135425/caw-owned-and-operated-wind-turbine-begins-operation-in-port-elgin-ontario; Japan from Tetsu Iida, Institute for Sustainable Energy Policies, Tokyo, personal communication with REN21, 14 January 2014; United States from A.C. Orrell et al., *2012 Market Report on Wind Technologies in Distributed Applications* (Richland, WA: Pacific Northwest Laboratory, August 2013), p. 59; from Windustry, "Community Wind," http://www.windustry.org/community-wind, viewed 11 March 2015, and from "Municipalities Drive Wind Power Deployment," *IRENA Quarterly*, October 2014, http://www.irena.org/Quarterly/IRENA%20Quarterly_October2014.pdf. Europe from, for example, Energy4All Limited, "Delivering Community-Owned Green Power," http://www.energy4all.co.uk/, viewed 11 March 2015, and from Corbetta, op. cit. note 30. A 2.5 MW community wind farm is to be built in South Lanarkshire, Scotland, with funding acquired in early 2015. Scotland supports community ownership through the Community Energy Empowerment programme, from "Community Wind Farm Lands £8m," reNEWS, 3 February 2015, http://renews.biz/84971/community-wind-farm-lands-8m/. See also "Community Wind Energy," http://en.wikipedia.org/wiki/Community_wind_energy, viewed 11 March 2015. Citizen-owned from Detlef Loy, Loy Energy Consulting, Germany, personal communication with REN21, 13 April 2015.

71 Figure for 2013 from Stefan Gsänger and Jean-Daniel Pitteloud, *2015 Small Wind World Report* (Bonn: WWEA and New Energy Husum, March 2015), Summary, http://small-wind.org/wp-content/uploads/2014/12/Summary_SWWR2015_online.pdf; 2012 increase from Stefan Gsänger and Jean-Daniel Pitteloud, *Small Wind World Report 2014 Update* (Bonn: WWEA, March 2014), Summary, http://small-wind.org/wp-content/uploads/2014/03/2014_SWWR_summary_web.pdf.

72 Gsänger and Pitteloud, *2015 Small Wind World Report*, op. cit. note 71. Note that these numbers are based on available data, and the total excludes data for Italy (for number of units) and India (number of units and capacity), both of which are important markets. WWEA estimates that the actual total is more than 1 million units worldwide.

73 Global annual installations in 2014 were an estimated 254.9 MW, from Navigant Research, "Small and Medium Wind Power," http://www.navigantresearch.com/research/small-and-medium-wind-power, viewed 12 February 2014; and Navigant Research, "Worldwide Small & Medium Wind Power Installations Are Expected to Total More than 3.2 Gigawatts from 2014 through 2023," press release (Boulder, CO: 5 January 2015), https://www.navigantresearch.com/newsroom/worldwide-small-medium-wind-power-installations-are-expected-to-total-more-than-3-2-gigawatts-from-2014-through-2023.

74 WWEA, *Small Wind World Report 2014 Update*, op. cit. note 71, p. 7; Pike Research, "Small Wind Power," www.pikeresearch.com/research/small-wind-power, viewed March 2013; WWEA, *Small World Wind Power Report 2013* (Bonn: March 2013), Summary, http://www.wwindea.org/webimages/SWWR_summary.pdf; RenewableUK, *Small and Medium Wind UK Market Report* (London: October 2013), http://www.renewableuk.com/en/publications/index.cfm/Small-and-Medium-Wind-UK-Market-Report-2013. Displace diesel from Navigant Research, "Small and Medium Wind Power," op. cit. note 73; and Navigant Research, "Worldwide Small & Medium Wind Power Installations Are Expected…," op. cit. note 73. Note that the Navigant report also discusses turbines up to 500 kW. Off-grid and mini-grid applications prevail in developing countries, per Gsänger and Pitteloud, *Small Wind World Report 2014 Update*, op. cit. note 71, p. 7. Note that globally, interest is increasing with growing demand for distributed generation, from Navigant Research, "Small and Medium Wind Power," op. cit. note 73; and Navigant Research, "Worldwide Small & Medium Wind Power Installations Are Expected… ," op. cit. note 73.

75 Gsänger and Pitteloud, *2015 Small Wind World Report*, op. cit. note 71.

76 Ibid.

77 United States and competition with solar PV from Navigant Research, "Small and Medium Wind Power," op. cit. note 73, and Navigant Research, "Worldwide Small & Medium Wind Power Installations Are Expected…," op. cit. note 73; United Kingdom also from RenewableUK, op. cit. note 74. The U.S. market for new and refurbished small-scale wind turbines declined in 2013 by about 70%, from 18.4 MW in 2012 to 5.6 MW in 2013; the market for new small-scale turbines only fell 44% (from 8.9 MW in 2012 to 5 MW in 2013), from U.S. DOE, Office of Energy Efficiency and Renewable Energy (EERE), *2013 Distributed Wind Market Report* (Richland, WA: August 2014), pp. iii–iv, 6. In terms of number of installations, the U.S. market saw a 27% decrease in 2013 relative to 2012, and the U.K. market for sub-50 kW new turbines fell by nearly 80%, from Gsänger and Pitteloud, *2015 Small Wind World Report*, op. cit. note 71. U.S. momentum building from Navigant Research, "Small and Medium Wind Power," op. cit. note 73; and Navigant Research, "Worldwide Small & Medium Wind Power Installations Are Expected…," op. cit. note 73.

78 Easier to finance from Andrew Kruse, Endurance Wind Power Inc., Surrey, Canada, personal communication with REN21, 21 April 2013. Globally, the average size of small turbines is increasing, from 0.66 kW in 2010 to 0.85 kW in 2013, with average size differing from country to country, per Gsänger and Pitteloud, *2015 Small Wind World Report*, op. cit. note 71. In the United States, for example, the number of small-scale turbines sold dropped 50% in 2012, while the number of mid-size machines (101–1,000 kW) increased more than 250%, from Orrell et al., op. cit. note 70, p. 3.

79 Orrell et al., op. cit. note 70, p. 47; James Montgomery, "VAWT on the Vineyard: Small Wind Revisited," Renewable Energy World, 22 November 2013, http://www.renewableenergyworld.com/rea/blog/post/2013/11/vawt-on-the-vineyard-small-wind-revisited. See also Gsänger and Pitteloud, *2015 Small Wind World Report*, op. cit. note 71.

80 Repowering definition from International Energy Agency (IEA), *Technology Roadmap – Wind Energy, 2013 Edition* (Paris: OECD/IEA, 2013), p. 10. Repowering began in Denmark and Germany, due to a combination of incentives and a large number of ageing turbines. It is driven by technology improvements and the desire to increase output while improving grid compliance and reducing noise and bird mortality, from idem., and from James Lawson, "Repowering Gives New Life to Old Wind Sites," Renewable Energy World, 17 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/repowering-gives-new-life-to-old-wind-sites. Ultimately, repowering, where it happens, is driven by the economics of the project, and relevance of other factors depends on whether the government puts incentives in place in relation to

them, from Sawyer, op. cit. note 6. New business from Zhao et al., op. cit. note 1, p. 102.

81 During 2014, decommissioned capacity included 29 MW in Denmark, 6 MW in Finland, 386 MW in Germany, 3 MW in Italy, 7 MW in Sweden, 11 MW in Japan, 2 MW in Taiwan, from Zhao et al., op. cit. note 1, p. 101.

82 Germany dismantled at least 544 turbines with total capacity of 364 MW from Deutsche WindGuard, op. cit. note 35; and from GWEC, op. cit. note 1, p. 50. Germany dismantled 588 turbines with capacity totalling 386 MW from Ender, op. cit. note 32, pp. 26–37, and from Zhao et al., op. cit. note 1, p. 101. At least 413 turbines (1,148 MW) were installed from Deutsche WindGuard, op. cit. note 35; and from GWEC, op. cit. note 1, p. 50. A total of 619 turbines with capacity of 1,729 MW were installed in repowering projects, from Ender, op. cit. note 32, pp. 26–37; and from B. Neddermann, "Repowering in Germany in 2014: Last Chance to Use the Repowering Bonus," *DEWI Magazin*, February 2015, http://www.dewi.de/dewi_res/fileadmin/pdf/publications/Magazin_46/06.pdf.

83 Key markets include Bulgaria, Poland, Romania, Turkey, Vietnam, and several countries in South America, from Lawson, op. cit. note 80. Markets also elsewhere, such as Italy and Ireland, from "European Wind Repowering Continues to Gather Pace," Renewable Energy World, 11 June 2014, http://www.renewableenergyworld.com/rea/news/article/2014/06/european-wind-repowering-continues-to-gather-pace.

84 Figure of 7.5% based on estimated 247 TWh of generation in 2014, from EurObserv'ER, op. cit. note 1, pp. 3, 9. (This was up from 7.1% in 2013, based on 234 TWh in 2013. Note that winds in 2014 were not as favourable as those in 2013, from idem.) Wind power capacity installed by end-2014 would be enough to produce 284 TWh in a normal wind year, enough to cover 10.2% (of which 1% is offshore wind) of the EU's electricity consumption, from EWEA, *Wind in Power: 2014 European Statistics*, op. cit. note 25. Wind energy penetration levels were calculated by EWEA using average capacity factors onshore and offshore, and Eurostat electricity consumption figures for 2012 (latest available data as of 21 January 2015). Note that wind power provided 10% of the European continent's electricity in 2014, from Zhao et al., op. cit. note 1, p. 117; wind represented 9.3% of the UK's total electricity supply in 2014, up from 7.8% in 2013, from idem, p. 33; and wind power accounted for about 3.5% of France's total electricity supply, from idem, p. 34.

85 Countries meeting 10% or more of power demand with wind include Denmark, Ireland, Portugal, and Spain, from WWEA, "New Record in Worldwide Wind Installations: More than 50 GW Additional Wind Power Capacity, Wind Power Worldwide Close to 370 GW," press release (Bonn: 5 February 2015). Denmark was up from up from 33.2% in 2013, and 18.8% in 2004, from "Denmark Sets World Record in Wind Energy," euractiv.com, 14 January 2015, http://www.euractiv.com/sections/energy/denmark-sets-world-record-wind-energy-311083; Ireland statistic from Kenneth Matthews, Irish Wind Energy Association (IWEA), cited in IWEA, "Irish Wind Energy Investment Tops €350 Million in 2014" (Osberstown, Naas, Ireland: 8 January 2015), http://www.iwea.com/index.cfm?page=viewNews&id=131&cYear=2015&cMonth=1; Portugal from Zhao et al., op. cit. note 1, p. 117; Spain (20.4%) from Red Eléctrica de España, *The Spanish Electricity System Preliminary Report 2014* (Madrid: December 2014), p. 5, http://www.ree.es/sites/default/files/downloadable/preliminary_report_2014.pdf. In the UK, grid-connected and standalone wind turbines met 9.3% of electricity demand in 2014, up from 7.8% in 2013, according to National Grid, cited in James Murray, "UK Wind Power Smashes Annual Output Record," BusinessGreen.com, 5 January 2015, http://www.businessgreen.com/bg/news/2388553/uk-wind-power-smashes-annual-output-record. Wind accounted for an estimated 8.6% (preliminary) of Germany's gross power production in 2014, from BMWi, "Renewable Energy at a Glance," http://www.bmwi.de/EN/Topics/Energy/Renewable-Energy/renewable-energy-at-a-glance.html, viewed 12 February 2015.

86 Mecklenburg-Vorpommern had enough wind to meet 76.3% of its electricity demand, followed by Schleswig-Holstein (70%), Brandenburg (55.7%), and Sachsen-Anhalt (55.5%); the next state was Niedersachsen (28.6%), all from Ender, op. cit. note 32, p. 34. Germany had enough capacity at year-end to supply an estimated 14.5% of electricity demand, from idem. Australia from Clean Energy Council and the Australian Energy Market Operator, http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions, provided by A. Webb, Clean Energy Council, personal communication with REN21, 16 April 2015.

87 U.S. EIA, *Electric Power Monthly with Data for December 2014* (Washington, DC: February 2015), Table 1.6.A., "Net Generation by State, by Sector, Year-to-Date Through December 2014 and 2013 (Thousand Megawatthours)," p. 22, and Table 1.17.B., "Net Generation from Wind by State, By Sector, Year-to-Date Through December 2014 and 2013 (Thousand Megawatthours)," p. 44, http://www.eia.gov/electricity/monthly/current_year/february2015.pdf. Iowa met 28.5% of its demand with the wind in 2014 (up from 27% in 2013), and South Dakota 25.3% (down from 26%). Data from 2013 for Iowa and South Dakota from AWEA, "Wind Energy Generation Records," http://www.awea.org/generationrecords, viewed 6 March 2014, and for 2014 from U.S. EIA, *Electric Power Monthly*, op. cit. this note. Other states in the top nine in 2014 were Kansas (21.7%), Idaho (18.3%), North Dakota (17.6%), Oklahoma (16.9%), Minnesota (15.9%), Colorado (13.6%), and Oregon (12.7%), from U.S. EIA, *Electric Power Monthly*, op. cit. this note. Wind provided 10.6% of Texas' power in 2014, up from 9.9% in 2013, per Electric Reliability Council of Texas (ERCOT), cited in "ERCOT: Texas Wind Provided Nearly 11% of Electricity for 2014," North American Windpower, 23 January 2015, http://www.nawindpower.com/e107_plugins/content/content.php?content.13868, and up from 6.2% in 2009, from ERCOT, cited in Joshua S. Hill, "Texas Wind Energy Provided 10% in 2014," CleanTechnica.com, 24 February 2015, http://cleantechnica.com/2015/02/24/texas-wind-energy-provided-10-2014/. For comparison, wind accounted for 4.1% of U.S. electricity generation in 2013, from AWEA, "American Wind Power Reaches Major Power Generation Milestones in 2013," press release (Washington, DC: 5 March 2014), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=6184, and for 3.5% of U.S. generation in 2012, from U.S. 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.

88 Wind power generated 833.7 TWh and total net generation in 2014 was 4,050.2 TWh, from Dirección de Estudios Económicos y Tarifas (Directorate of Economic Studies and Tariffs), Instituto Nacional de Energía, "Generación Neta Por Tipo De Empresa Sistema Eléctrico Nacional Año 2014 (MWh)," http://www.ine.gob.ni/DGE/estadisticas/2014/GeneracionNeta_2014_actAbr15.pdf, viewed 30 April 2015.

89 Figure of 3.1% based on estimated electricity generation in 2014 of 23,480 TWh (based on 23,127 TWh in 2013 from BP, *Statistical Review of World Energy 2014* (London: 2014), and an estimated 1.52% growth in global electricity generation for 2014), on 370 GW of capacity at end-2014, and on average 22.7% capacity factor based on average capacity factors for on- and offshore from IEA, *Medium-Term Renewable Energy Market Report 2014* (Paris: 2014), p. 24, http://www.iea.org/bookshop/480-Medium-Term_Renewable_Energy_Market_Report_2014. FTI estimates a share of 3.2%, based on capacity installed at end-2014 and 25% capacity factor, and on total global electricity generation of 22,721 TWh in 2012 (from IEA's New Policies Scenario) and assumed compound annual average growth rate of 2.1%, from Zhao et al., op. cit. note 1, p. 118. WWEA puts 370 GW of installed capacity at enough to contribute close to 5% of global electricity demand, from WWEA, "New Record in Worldwide Wind Installations: More than 50 GW Additional Wind Power Capacity, Wind Power Worldwide Close to 370 GW," press release (Bonn: 5 February 2015).

90 Losses from FTI Consulting, "Industry Shake Up as Policy Uncertainty Forces a Quarter of Businesses Out of the Wind Market," press release (London, 12 January 2015), http://www.fticonsulting.com/global2/press-releases/united-states/industry-shake-up-as-policy-uncertainty-forces-a-quarter-of-businesses-out-of-the-wind-market.aspx, and FTI Consulting, *Global Wind Supply Chain Update 2015* (London: January 2015), Executive Summary. More than 120 suppliers (including 88 from Asia), 23 from Europe, 18 from North America) have closed shop or stayed out of the wind industry over the past two years, from Zhao et al., op. cit. note 1, p. 15. Back into the black and order books, from Sawyer, op. cit. note 11. Note that manufacturers overly reliant on the US market, particularly GE, were not as well off with regard to orders, from idem.

91 FTI Consulting, both references, op. cit. note 90.

92 Steve Sawyer, GWEC, personal communication with REN21, 10 April 2014.

93 Australia, Brazil, Chile, Mexico, New Zealand, Turkey, and South Africa from IEA, op. cit. note 80, p. 14. See also Zhao et al., op. cit. note 1, p. 89. New wind is cheaper per kWh than new coal in South Africa, per Sawyer, op. cit. note 11. In the United States, utilities are selecting wind power as the low-cost option, even as projects

have moved into areas with lower wind speeds; average levelised long-term prices from wind power sales agreements that were signed in the United States in 2013 were around USD 25/MWh, from Ryan Wiser et al., *2013 Wind Technologies Market Report* (Washington, DC: U.S. DOE, August 2014), Executive Summary, p. ix, http://www.energy.gov/sites/prod/files/2014/08/f18/2013%20Wind%20Technologies%20Market%20Report_1.pdf; also in the United States, wind power costs declined by more than one-third between 2008 and 2013, and, "in some markets with excellent wind resource and transmission availability, wind power sales prices are competitive with fossil generation," from U.S. DOE, *Wind Vision: A New Era for Wind Power in the United States* (Oak Ridge, TN: March 2015), pp. xxvi–xxviii, http://energy.gov/windvision. In Brazil, wind power is very competitive, although the levelised cost of energy (LCOE) is marginally higher than in the United States, from Sawyer, op. cit. note 48. Mexico and Turkey from Zhao et al., op. cit. note 1, pp. 35, 37. Also, in Australia, unsubsidised renewable energy is now cheaper than electricity from new-build coal- and gas-fired power stations (including cost of emissions under new carbon pricing scheme), per Bloomberg New Energy Finance (BNEF), "Renewable Energy Now Cheaper Than New Fossil Fuels in Australia," 7 February 2013, http://about.bnef.com/2013/02/07/renewable-energy-now-cheaper-than-new-fossil-fuels-in-australia/; the best wind projects in India can generate power and the same costs as coal-fired power plants and cheaper in some locations, per Ravi Kailas, CEO of India's third-largest wind farm developer, cited in Natalie Obiko Pearson, "Wind Installations 'Falling Off a Cliff' in India," *Bloomberg*, 26 November 2012, http://www.renewableenergyworld.com/rea/news/article/2012/11/wind-installations-falling-off-a-cliff-in-india; cheaper in some locations from Greenko Group Plc, cited in Natalie Obiko Pearson, "In Parts of India, Wind Energy Proving Cheaper Than Coal," *Bloomberg*, 18 July 2012, http://www.renewableenergyworld.com/rea/news/article/2012/07/in-parts-of-india-wind-energy-proving-cheaper-than-coal; many EU countries from Stefan Gsänger, WWEA, personal communication with REN21, 16 April 2014.

94 Over the five-year period from Q3 2009 to the second half of 2014, from Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP Centre) and BNEF, *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2015). In the United States, LCOE fell 58% from 2009 to 2014, per Lazard, *Lazard's Levelized Cost of Energy Analysis—Version 8.0*, September 2014, p. 9, http://www.lazard.com/PDF/Levelized%20Cost%20of%20Energy%20-%20Version%208.0.pdf.

95 Sawyer, op. cit. note 6. For example, in early 2015 the winning bid from Vattenfall for the 400 MW project Horns Rev 3 (Denmark) was for USD 125 (EUR 103/MWh) (a function of the unique conditions of the project), from Shukla, op. cit. note 3. In addition, a new Iberdrola project came in at costs much lower than expected, from Sawyer, op. cit. note 6. Offshore wind costs in the UK fell almost 11% from 2011 to 2014, based on completed as well as unbuilt projects, per The Crown Estate, "Offshore Wind Costs Falling Faster Than Expected," 26 February 2015, http://www.thecrownestate.co.uk/news-and-media/news/2015/offshore-wind-costs-falling-faster-than-expected/.

96 IEA, op. cit. note 80, p. 10; Japan from Navigant Research, *World Market Update 2013: International Wind Energy Development. Forecast 2014-2018* (Copenhagen: March 2014), Executive Summary. China was home to 8 of the top 15 manufacturers, from idem; France from Feng Zhao, FTI Consulting, personal communication with REN21, 13 April 2015.

97 IEA, op. cit. note 80, p. 11. See also GWEC, *Global Wind Report—Annual Market Update 2013* (Brussels: April 2014), p. 17, http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf, p. 40. Turbine manufacturers are located in many other countries as well. For example, in 2013 Argentinean firm IMPSA sold 574 MW to the Brazilian market, from Gonzalo Bravo, Fundación Bariloche, personal communication with REN21, 16 April 2014.

98 FTI Consulting, *Global Wind Supply Chain Update 2015* (London: January 2015), Executive Summary.

99 68% based on data from Zhao et al., op. cit. note 1, p. 19. Figure of 70% in 2013 from Navigant Research, op. cit. note 96. Down from 77% in 2012 per Navigant's BTM Consult, *World Market Update 2012* (Copenhagen: March 2013).

100 Zhao et al., op. cit. note 1, pp. xii, 18–19. Vestas was first and Siemens second (up three steps from 2013 rankings) from GlobalData, cited in "Vestas Tops Global Wind Podium," reNEWS, 10 March 2015, http://renews.biz/85417/vestas-tops-global-wind-podium/.

101 Zhao et al., op. cit. note 1, pp. xii, 18–19. Goldwind held onto third, GE was fourth (not on top five list in 2013), and Enercon slipped from second to fifth per GlobalData, cited in "Vestas Tops Global Wind Podium," op. cit. note 100.

102 Zhao et al., op. cit. note 1, pp. xii, 18–19. Ranking of these countries was Suzlon Group (6), United Power (7), Gamesa (8), Mingyang (9), and Envision (10); Suzlon sold Senvion in early 2015, but the two companies are covered as one for 2014; if listed separately Senvion ranks tenth and Suzlon drops out of the top 10, from Zhao et al., op. cit. note 1, p. 19. Note that Suzlon dropped from fifth in 2013 to 10th in 2014, per GlobalData, cited in "Vestas Tops Global Wind Podium," op. cit. note 100. Five Chinese manufacturers (Goldwind, Sanyi, Sinovel, Mingyang, and XEMC) exported products to the international market to 28 countries in 2014, from Shi, op. cit. note 13. **Figure 24** based on data from Zhao et al., op. cit. note 1, pp. xii, 19.

103 FTI Consulting, cited in "Vestas Tops Turbine Table", reNEWS, 23 February 2015, http://renews.biz/84494/vestas-tops-turbine-table/; Feng Zhao, FTI Consulting, cited in Charlotte Malone, "Record Breaking Year for Wind Turbine Manufacturers," blueandgreentomorrow.com, 23 February 2015, http://blueandgreentomorrow.com/2015/02/23/2014-a-record-breaking-year-for-wind-turbine-manufacturers/.

104 In Latin America, for example, wind power projects are being delayed due to lack of grid infrastructure, from Gonzalo Bravo, Fundación Bariloche, personal communication with REN21, 14 January 2014; grid connection remains a major challenge for offshore wind, particularly off Germany's coast, from B. Neddermann, "German Offshore Market Growing Despite Problems with Grid Connection," *DEWI Magazin*, February 2014, p. 55, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/09.pdf, and from Ender, op. cit. note 32; an issue formerly seen in the developing world/emerging markets of Latin America and China, is now seen in the established market of Germany, where electricity is re-routed through Poland and the Czech Republic, from Aris Karcanias, FTI Consulting, personal communication with REN21, 14 April 2014; curtailment and inability to integrate in several countries, including China and India, from Shruti Shukla, GWEC, personal communication with REN21, 19 March 2014, also from Sawyer, op. cit. note 13 and op. cit. note 11.

105 Sawyer, op. cit. note 104, both references.

106 Overcapacity from FTI Consulting, op. cit. note 90, both references. Operating at partial capacity from Navigant Research, "Supply Chain Assessment 2014—Wind Energy," http://www.navigantresearch.com/research/supply-chain-assessment-2014-wind-energy, viewed 11 February 2015. Navigant has estimated that global annual turbine manufacturing capacity in 2014 exceeded 71 GW, from Navigant Research, "Global Wind Turbine Manufacturing Capacity Has Far Surpassed Demand," 8 December 2014, http://www.navigantresearch.com/newsroom/global-wind-turbine-manufacturing-capacity-has-far-surpassed-demand.

107 Navigant Research, "Supply Chain Assessment 2014—Wind Energy," op. cit. note 106.

108 Yang Jianxiang, "Curtailment Solutions Boost Confidence in China," *Wind Power Monthly*, 30 September 2014, http://www.windpowermonthly.com/article/1314288/curtailment-solutions-boost-confidence-china; Judy Chen, "China Clean Energy Defaults Loom Amid Record Debt Loads," Renewable Energy World, 5 September 2014, http://www.renewableenergyworld.com/rea/news/article/2014/09/china-clean-energy-defaults-loom-amid-record-debt-loads; Liu Yuanyuan, "China's Wind Power Industry Shows Overall Recovery," Renewable Energy World, 19 August 2014, http://www.renewableenergyworld.com/rea/news/article/2014/08/chinas-wind-power-industry-shows-overall-recovery; Judy Chen, "China Wind Manufacturer Sinovel Seeks to Avert Default," Renewable Energy World, 23 December 2014, http://www.renewableenergyworld.com/rea/news/article/2014/12/china-wind-manufacturer-sinovel-seeks-to-avert-default.

109 EurObserv'ER, op. cit. note 1, p. 14. In Spain, lack of new investment is directly affecting the wind industry, and companies have been forced to close factories and consider whether to leave, from Asociación Empresarial Eólica (AEE), "The Spanish Wind Power Industry Installed Less Than 0.1 MW in the First Semester Due to the Regulatory Situation," press release (Madrid: 29 July 2014), http://www.aeeolica.org/uploads/140729_NP_The_Spanish_wind_power_industry_installed_less_than_0.1_MW_in_the_first_semester.pdf.

110 GE (USA), Siemens (Germany), and Vestas (Denmark) cut

hundreds of jobs and closed operations in several states; there were also US plant closures or job reductions made by Gamesa (Spain), Nordex (Germany), Suzlon (India), Acciona (Spain), from Ros Davidson, "Analysis: US Manufacturing Hit Despite Capacity Increase," *Wind Power Monthly*, 10 November 2014, http://www.windpowermonthly.com/article/1321137/analysis-us-manufacturing-hit-despite-capacity-increase; Jack Bramwell, "GE Shutting Down Wind Manufacturing in Tehachapi," Bakersfieldcalifornian.com, 22 October 2014, http://www.bakersfield.com/news/2014/10/22/ge-shutting-down-wind-manufacturing-in-tehachapi.html. See also Wiser et al., op. cit. note 93, pp. v–vi. The United States has more than 500 manufacturing facilities in 43 states, per AWEA, op. cit. note 41. By early 2015, Vestas was ramping up production with a new blade factory in Colorado that will be hiring 400 new staff, from "Vestas Hiring 400 as US Surges," reNEWS, 13 March 2015, http://renews.biz/85650/vestas-hiring-400-as-us-surges/.

111 Sawyer, op. cit. note 48.

112 Vanessa Dezem, "Suzlon to Build First Wind Plant in Latin America," *Bloomberg*, 17 July 2014, http://www.bloomberg.com/news/2014-07-17/suzlon-to-build-first-wind-plant-in-latin-america.html; James Quilter, "Alstom Opens Third Factory in Brazil," *Wind Power Monthly*, 2 February 2015, http://www.windpowermonthly.com/article/1332029/alstom-opens-third-factoty-brazil; and Elizabeth Trovall, "What's Hampering Brazil's Wind Sector?" bnamericas.com, 3 February 2015, http://www.bnamericas.com/news/electricpower/whats-hampering-brazils-wind-sector. The company, JV Torres Eólicas do Nordeste, will be located in Jacobina, Bahia state, and will produce steel towers for wind turbines, from Trovall, op. cit. this note. There are plans to produce up to 200 towers annually. Alstom's other plants in Brazil are a nacelle factory in Bahia and a tower plant in Rio Grande do Sul, which opened in 2011 and 2013, respectively, from Quilter, op. cit. this note.

113 Feng Zhao, FTI Consulting, Copenhagen, personal communication with REN21, 13 April 2015; Vestas plans to start production in May 2015 of blades for a wind farm in Liverpool Bay, from "Isle of Wight Wind Turbine Firm Vestas Creates 200 Jobs," *BBC News*, 5 February 2015, http://www.bbc.com/news/uk-england-hampshire-31145066.

114 Restructuring from EurObserv'ER, op. cit. note 1, p. 14.

115 Mercom Capital Group, "Wind Sector Acquisition Activity Ramps Up, Project Acquisitions Double to $13 Billion in 2014, Reports Mercom Capital Group," http://mercomcapital.com/wind-sector-acquisition-activity-ramps-up-project-acquisitions-double-to-$13-billion-in-2014-reports-mercom-capital-group, viewed 13 February 2015.

116 Ibid.

117 MHI Vestas Offshore Wind, "MHI Vestas Offshore Wind Receives Breakthrough First Order for the V164-8.0 MW," press release (Aarhus, Denmark: 19 December 2014), http://www.mhivestasoffshore.com/media-and-news/news/2014/19-12-2014; GE and Alstom from FTI Consulting, "Record Year for the Global Top 10 Turbine OEMs," press release (London: 23 February 2015), http://www.fticonsulting.com/global2/press-releases/united-states/record-year-global-top-10-turbine-oems.aspx; Areva, "Areva and Gamesa Signed Binding Agreements for the Creation of a Global Leader in the Offshore Wind Segment," press release (France: 7 July 2014), http://www.areva.com/EN/news-10257/areva-and-gamesa-signed-binding-agreements-for-the-creation-of-a-global-leader-in-the-offshore-wind-segment.html; Areva, "Gamesa and Areva Create the Joint-Venture Adwen," press release (France: 9 March 2015), http://www.areva.com/EN/news-10478/gamesa-and-areva-create-the-jointventure-adwen.html; Areva and Gamesa formed a joint venture in summer of 2014 and a new name was created in 2015 from Zhao, op. cit. note 113; Senvion from James Quilter, "Suzlon Sells Senvion in €1bn Cash Deal," *Wind Power Monthly*, 22 January 2015, http://www.windpowermonthly.com/article/1330456/suzlon-sells-senvion-%e2%82%ac1bn-cash-deal.

118 Zhao et al., op. cit. note 1; Justin Martino, "Advancements in Wind Turbine Technology: Improving Efficiency and Reducing Cost," Power Engineering, 14 March 2014, http://www.power-eng.com/articles/print/volume-118/issue-3/features/advancements-in-wind-turbine-technology-improving-efficiency-and-reducing-cost.html. With the market picking up in China, for example, manufacturers are increasing their focus on better quality turbines with enhanced performance and that are adapted to varied wind and environment conditions, including low speed, typhoon, high altitude, and offshore, from Yang Jianxiang, "Curtailment Solutions Boost Confidence in China," *Wind Power Monthly*, 30 September 2014, http://www.windpowermonthly.com/article/1314288/curtailment-solutions-boost-confidence-china. Advances to reach stronger winds include, for example, concrete-steel hybrid towers with hub heights greater than 140 metres are popular in many European markets; Siemens and Lagerwey have developed alternative bolted steel towers; GE introduced in 2014 a five-legged tower with 139-metre hub height – the lattice type structure is covered by plastic fabric, all from Eize de Vries, "What's New in Wind Technology?" Renewable Energy World, 10 July 2014, http://www.renewableenergyworld.com/rea/news/article/2014/07/whats-new-in-wind-technology?.

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120 Navigant Research, "Global Wind Turbine Manufacturing Capacity Has Far Surpassed Demand," 8 December 2014, http://www.navigantresearch.com/newsroom/global-wind-turbine-manufacturing-capacity-has-far-surpassed-demand; Navigant Research, "Longer Blades and New Materials Are Dramatically Affecting the Global Wind Turbine Manufacturing Industry," press release (Boulder, CO: 27 February 2015), https://www.navigantresearch.com/newsroom/longer-blades-and-new-materials-are-dramatically-affecting-the-global-wind-turbine-manufacturing-industry; 2014 saw further development of hybrid materials, combining properties of carbon and glass fibre for lighter blades, and design and production of long blades in segments to ease transport and installation, from Zhao et al., op. cit. note 1, p. xiii.

121 Navigant Research, "Longer Blades and New Materials…," op. cit. note 120.

122 Martino, op. cit. note 118; Europe and China from Sawyer, op. cit. note 11; and from Corbetta, op. cit. note 30.

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124 In 2014, the average size delivered to market was 1,981 kW, from Zhao et al., op. cit. note 1, p. xiii. Average size delivered to market (based on measured rated capacity) was 1,926 kW in 2013, from Navigant Research, *World Market Update 2013: International Wind Energy Development. Forecast 2014-2018* (Copenhagen: March 2014), Executive Summary.

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126 Figures for 2014 from EWEA, *The European Offshore Wind Industry – Key Trends and Statistics 2014* op. cit. note 25, p. 3. The average size of turbines installed offshore in Europe was about 0.5 MW in 1994, 2.4 MW in 2004, and 2.6 MW in 2009 based on data estimated from Figure 23 in idem. In 2013, the average size was about 4 MW, from EWEA, *The European Offshore Wind Industry – Key Trends and Statistics 2013*, op. cit. note 25, p. 9; and fell from 3,793 kW in 2012 to 3,613 kW in 2013, per Navigant Research, op. cit. note 124.

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128 Corbetta, op. cit. note 30; Steve Sawyer, Foreword in Shukla, Reynolds, and Jones, op. cit. note 66, p. 4.

129 EWEA, *The European Offshore Wind Industry – Key Trends and Statistics 2014*, op. cit. note 25, pp. 3, 18.

130 Ibid., p. 3.

131 Corbetta, op. cit. note 30. See, for example, Darius Snieckus, "Gicon Cleared for Baltic Pilot of SOF Floating Wind Turbine," Recharge News, 10 April 2015, http://www.rechargenews.com/wind/1396770/gicon-cleared-for-baltic-pilot-of-sof-floating-wind-turbine; Richard A. Kessler, "Danish Developer Alpha Wind Energy (AWE) Has Submitted Lease Requests to the US Interior Department (DOI) for Two Proposed 51-Turbine, 408 MW Floating Wind Projects in Federal Waters Off Oahu, Hawaii," Recharge News, 20 March 2015, http://www.rechargenews.com/wind/1395004/danes-propose-816mw-of-wind-floaters-off-hawaii.

132 Offshore wind power costs rose 41% per MWh from the second quarter of 2009 till the first quarter of 2014, as projects moved to deeper water farther from shore, from FS-UNEP Centre and BNEF, op. cit. note 94, p. 37. See also Aris Karcanias and Athanasia Arapogianni, *Innovative Financing of Offshore Wind* (London: FTI Consulting, April 2014). Better, cheaper, safer from Shukla, Reynolds, and Jones, op. cit. note 66, p. 23; Steve Sawyer, Foreword in idem., p. 4.

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134 EurObserv'ER, op. cit. note 1, p. 12.

135 Offshore costs 50% higher from Shukla, Reynolds, and Jones, op. cit. note 66, p. 20; 50–60% from Sawyer, op. cit. note 15. Considering all locations with offshore development under way, costs likely range from 50–150% more for offshore, depending on the resource, regulatory market (e.g., permitting and environmental requirements), distance from shore, depth, etc. Note that Japan's FIT payment for offshore wind is about 1.6 times higher than that for onshore wind, all from Sawyer, op. cit. note 15. The increased costs associated with offshore construction and turbine servicing, associated risks, and other factors increase the rate of return that investors expect (from average onshore of 7-9% in developed markets to about 12%), from Jesse Broehl, "Vestas, Mitsubishi Settle on Offshore Turbine Design," Renewable Energy World, 26 February 2015, http://www.renewableenergyworld.com/rea/blog/post/2015/02/vestas-mitsubishi-settle-on-offshore-turbine-design. Ranges for U.K. and Germany from Shukla, Reynolds, and Jones, op. cit. note 66, p. 20. The low price in Denmark is due in large part to technological developments combined with a successful tendering process, from Jesper Caruso, "Denmark Gets Cheaper Power from Offshore Wind Turbines," Danish Ministry of Climate, Energy and Building, 27 February 2015, http://www.kebmin.dk/en/news/denmark-gets-cheaper-power-from-offshore-wind-turbines; in addition, Denmark has strong winds relatively close to shore and in relatively shallow waters, from Sawyer, op. cit. note 11.

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142 U.S. DOE, EERE, op. cit. note 77, p. v.

143 **Table 2** derived from the sources outlined in this endnote. Note that IRENA data are exclusive of subsidies, based on an assumed 7.5% weighted average cost of capital (WACC) for OECD countries and China, and WACC of 10% for the rest of the world, and derived from actual project data for over 9000 utility-scale projects, with O&M costs sourced from International Renewable Energy Agency (IRENA). Assumptions for the calculations of levelised cost of electricity not derived from project data are defined in IRENA, *2014 Renewable Power generation Costs Report* (Bonn: January 2015), Table 1.1, http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=494. Note that this table was updated to the extent possible. For updated information and statistics, sources are provided below by sector and technology; for all other information, please see Table 2 and the relevant Endnote in GSR 2014.

POWER SECTOR - Bioenergy power: Bioenergy levelised costs of energy for power generation vary widely with costs of biomass feedstock, complexity of technologies, and a variety of other factors (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, etc.) that also apply to other technologies. Updates from IRENA, *Renewable Power Generation Costs in 2014* (Bonn: January 2015), http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf. **Geothermal:** Updates from Bloomberg New Energy Finance (BNEF) and The Business Council for Sustainable Energy, *Sustainable Energy in America 2014 Factbook* (London: February 2014), http://www.bcse.org/factbook/pdfs/2014%20Sustainable%20Energy%20in%20America%20Factbook.pdf. **Hydropower:** Note that hydro facilities that are designed to provide system balancing (rather than baseload) have lower capacity factors and therefore higher generation costs per kWh, on average, but provide additional value. Updates from Michael Taylor, IRENA, personal communication with REN21, January 2015. **Ocean Energy:** Note that this is based on a very small number of pilot and demonstration installations to date. Updates from Ocean Energy – Technology Readiness, Patents, Deployment Status and Outlook, May 2015, http://www.irena.org/DocumentDownloads/Publications/IRENA_Ocean_Energy_report_2014.pdf. **Solar PV:** Note that values outside of these ranges are possible for exceptional sites (higher) or where siting is suboptimal (lower); adding tracking systems can raise capacity factors significantly. Updates from IRENA, *Renewable Power Generation Costs in 2014*, op. cit. this note. **CSP:** Not updated for GSR 2015. See **Table 2** and relevant Endnote in GSR 2014. **Wind power:** Updates from IRENA, Renewable Power Generation Costs in 2014, op. cit. this note, pp. 31, 37; small-scale wind from World Wind Energy Association, *2015 Small Wind World Report* (Bonn: 2015), http://small-wind.org/wp-content/uploads/2014/12/Summary_SWWR2015_online.pdf.

HEATING AND COOLING SECTOR - Biomass heat: Cost variations among heat plants are wide for reasons similar to those listed above. Data not updated for GSR 2015. See **Table 2** and

relevant Endnote in GSR 2014. **Geothermal heat:** Not updated for GSR 2015. See **Table 2** and relevant Endnote in GSR 2014. **Heat Pumps:** Updates from Thomas Nowak, European Heat Pump Association, personal communication with REN21, March-May 2015; **Solar thermal heating:** Updates from: Residential data from IEA Energy Technology Systems Analysis Program (IEA-ETSAP) and IRENA, *Solar Heating and Cooling for Residential Applications* (Bonn: January 2015), http://www.irena.org/DocumentDownloads/Publications/IRENA_ETSAP_Tech_Brief_R12_Solar_Thermal_Residential_2015.pdf.
Industry data from IEA-ETSAP and IRENA, *Solar Heat for Industrial Processes* (Bonn: January 2015), http://www.solarthermalworld.org/sites/gstec/files/news/file/2015-02-27/irena-solar-heat-for-industrial-processes_2015.pdf. **Solar cooling:** Updates from IEA-ETSAP and IRENA, *Solar Heating and Cooling for Residential Applications* and Dr. Uli Jakob, Green Chiller Association for Sorption Cooling e.V. Berlin, Germany.
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 in table exclude value of any co-products. Data were not updated for GSR 2015. See Table 2 and relevant Endnote in GSR 2014.
DISTRIBUTED RENEWABLE ENERGY IN DEVELOPING COUNTRIES Data were not updated for GSR 2015. See Table 2 and relevant Endnote in GSR 2014.

INVESTMENT FLOWS

1 The BNEF estimate for investment in large hydropower (>50 MW) is based on about 17.5 GW (average of estimated range of 15–20 GW) of capacity commissioned during 2014 and a capital cost per MW of USD 1.75 million, bringing the total investment in large hydro to USD 31 billion. The figure USD 1.75 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 2014 was actually invested in prior years; in addition, there was investment during 2014 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 2015* due to different methodologies and data sources. This GSR estimates that about 37 GW of total hydropower capacity was commissioned worldwide during 2014, and a significant portion of this was projects larger than 50 MW (see Hydropower section in this report), whereas BNEF estimates that 18.5–23.5 GW of hydro capacity was commissioned in 2014, including 15–20 GW of large projects (>50 MW). Taking the BNEF estimate that 3.5 GW of small-scale hydropower capacity (from 1 MW to <50 MW) was added, it is likely that BNEF's estimate of larger projects is underestimated.

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3 See Endnote 1 for this section.

4 Note that these dollar amounts for capacity investment are based on BNEF estimates that some 103 GW of new capacity (not including hydropower >50 MW) was added in 2014, up from an estimated 86 GW in 2013. These BNEF estimates are not necessarily consistent with capacity data provided elsewhere in the *GSR*.

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 US Database of State Incentives for Renewables & Efficiency (DSIRE), RenewableEnergyWorld.com, press reports, submissions from REN21 regional- and country-specific contributors, 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** and **Figures 28** and **29** are based on idem and numerous sources cited throughout this section.

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solar PV data from Christopher Werner, Hanergy, personal communication with REN21, 15 October 2013, and from IEA, op. cit. this note; bio-power from idem, workbook with summary tables, table 5, "Bioenergy Capacity"; geothermal from GEA, op. cit. this note; ocean energy from IEA, op. cit. this note, workbook with summary tables, Table 17, "Ocean capacity"; hydropower from System Operator of the Unified Energy System of Russia, Report on the Unified Energy System in 2014 (Moscow: undated), http://www.so-ups.ru/fileadmin/files/company/reports/disclosure/2015/ups_rep2014.pdf. **India**: Wind power from GWEC, op. cit. this note, and from WWEA, op. cit. this note; solar PV from Bridge to India, May 2015, provided by Sinead Orlandi, Becquerel Institute, personal communication with REN21, 11 May 2015; bio-power from Indian Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," as of 31 December 2014, http://mnre.gov.in/mission-and-vision-2/achievements/; geothermal from idem; CSP from "Weekly Intelligence Brief: July 21–28," CSP Today, 28 July 2014, http://social.csptoday.com/markets/weekly-intelligence-brief-july-21-28, from NREL, "Concentrating Solar Power Projects: Megha Solar Plant," updated 21 November 2014, http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=264, and from NREL, "Concentrating Solar Power Projects: Dhursar," updated 21 November 2014, http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=272; hydropower from installed capacity in 2014 (units larger than 25 MW) from Government of India, Ministry of Power, Central Electricity Authority, "Installed Capacity as of 31 December 2014," http://www.cea.nic.in/installed_capacity.html, and from idem, "List of H.E. Stations in the Country with Station Capacity Above 25 MW," http://www.cea.nic.in/reports/hydro/

list_he__stations.pdf; capacity additions in 2014 (>25 MW) of 992.02 MW from Central Electricity Authority, "Executive Summary of the Power Sector (monthly)," http://www.cea.nic.in/exesum_cood.html; installed capacity in 2014 (<25 MW) from MNRE, "Physical Progress (Achievements)," http://www.mnre.gov.in/mission-and-vision-2/achievements/, viewed 18 January 2014 and 21 January 2015. **China**: Wind power from Shi Pengfei, Chinese Wind Energy Association (CWEA), personal communication with REN21, 1 April 2015, from GWEC, op. cit. this note, and from Feng Zhao et al., *Global Wind Market Update—Demand & Supply 2014* (London: FTI Consulting LLP, March 2015); solar PV from China's National Energy Board, cited in National Energy Administration (NEA), "2014 PV Statistics," 9 March 2015, http://www.nea.gov.cn/2015-03/09/c_134049519.htm (using Google Translate); bio-power from Amanda Zhang, Chinese Renewable Energy Industries Association, personal communication with REN21, April 2015; geothermal from GEA, op. cit. this note; CSP from NREL, op. cit. this note, and from "CSP Today Global Tracker," CSP Today, http://social.csptoday.com/tracker/projects, viewed 27 April 2014; hydropower from China Electricity Council, an overview of China's power industry in 2014, 10 March 2015, http://www.cec.org.cn/yaowenkuaidi/2015-03-10/134972.html. **South Africa**: Wind power from GWEC, op. cit. this note; solar PV from IEA-PVPS, op. cit. this note; bio-power from IEA, op. cit. this note, workbook with summary tables, table 5, "Bioenergy Capacity"; geothermal from GEA, op. cit. this note; only small pilots for CSP by the end of 2014; hydropower from Hydro4Africa, "African Hydropower Database—South Africa," http://hydro4africa.net/HP_database/country.php?country=South%20Africa, viewed 6 May 2015. **United States**: Wind power from American Wind Energy Association (AWEA), "American Wind Power Rebounded in 2014, Adding Over Four Times as Much as Year Before," press release (Washington, DC: 28 January 2015), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=7181; solar PV from GTM Research and U.S. Solar Industries Association (SEIA), *U.S. Solar Market Insight Report: 2014 Year in Review* (Washington, DC: 2015), Executive Summary, p. 3, https://www.greentechmedia.com/research/ussmi; bio-power from FERC, Office of Energy Projects Energy Infrastructure Update for December 2013; https://www.ferc.gov/legal/staff-reports/2013/dec-energy-infrastructure.pdf; geothermal from GEA, op. cit. this note; CSP from NREL, "Concentrating Solar Power Projects," op. cit. this note; ocean energy from Ocean Renewable Power Company, "America's First Ocean Energy Delivered to the Grid," press release (Portland, ME: 13 September 2012), from "Tidal Emerges as First US Grid Connected Ocean Energy Source," Tidal Today, 26 February 2013, http://social.tidaltoday.com; no additions in 2013 or 2014; hydropower from U.S. Energy Information Administration (EIA), *Electric Power Monthly*, February 2015 (data for December 2014), Table 6.2.B "Net Summer Capacity of Utility Scale Units Using Primarily Renewable Energy Sources and by State," http://www.eia.gov/electricity/monthly. **Germany**: Wind power from EWEA, op. cit. this note; solar PV from Bundesministerium für Wirtschaft und Energie (BMWi), *Marktanalyse Photovoltaik-Dachlagen* (Berlin: BMWi, 2015), http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/bmwi_de/marktanalysen-photovoltaik-photovoltaik.pdf, and from BMWi, *Entwicklung der Erneuerbaren Energien in Deutschland im Jahr 2014* (Berlin: 2015), data from Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), as of February 2015, http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/entwicklung_der_erneuerbaren_energien_in_deutschland_im_jahr_2014.pdf; bio-power from idem, p. 17; geothermal from German Geothermal Association (Bundesverband Geothermie), list of geothermal projects in Germany, http://www.geothermie.de/fileadmin/useruploads/wissenswelt/Projekte/Projektliste_Tiefe_Geothermie_2015_bundesland.pdf; CSP and ocean energy from BMWi, *Entwicklung der Erneuerbaren Energien in Deutschland im Jahr 2014*, op. cit. this note, p. 19; hydropower from idem, p. 7. **Italy**: Wind power from EWEA, op. cit. this note; solar PV from IEA-PVPS, op. cit. this note; bio-power based on data from Gestore dei Servizi Energetici - GSE S.p.A., provided by Noemi Magnanini, GSE, personal communication with REN21, 16 May 2014, and from IEA, op. cit. this note, workbook with summary tables, table 5, "Bioenergy Capacity"; geothermal from GEA, op. cit. this note; CSP from Luis Crespo, European Solar Thermal Electricity Association (ESTELA), personal communication with REN21, February 2014; no capacity added in 2014; ocean energy from GSE S.p.A., op. cit. this note; no capacity added in 2014; hydropower based on data from idem, from Eurostat, http://ec.europa.eu/eurostat/web/products-datasets/-/nrg_113a; and from IJHD, op. cit. this note, Table "World Hydro Potential and Development," pp. 13–15. **Spain**: Wind power from EWEA, op. cit. this note; solar PV from Masson, op. cit. this note, and from IEA-PVPS, op. cit. this note; bio-power from Comisión Nacional de los Mercados y la Competencia (CNMC) cited in Red Eléctrica de España (REE), "Potencia Instalada Peninsular (MW)," as of 31 December 2014, updated March 2015, www.ree.es; geothermal from GEA, op. cit. this note; CSP from NREL, "Concentrating Solar Power Projects," op. cit. this note, and from Alcauza, op. cit. this note; ocean energy from OES *Annual Report 2011* (Lisbon: 2011), Table 6.1, p. 122, http://www.ocean-energy-systems.org/index.php; no capacity added in intervening years; hydropower based on data from Eurostat, op. cit. this note; from REE, op. cit. this note, updated 15 January 2015; and from Hydropower and Dams, op. cit. this note. **Japan**: Wind power from GWEC, op. cit. this note, and from WWEA, op. cit. this note; solar PV from IEA-PVPS, op. cit. this note; bio-power and hydropower data from Japanese Ministry of Energy, Trade and Industry, "Announcement Regarding the Present Status of Introduction of Facilities Generating Renewable Energy as of December 31, 2014," April 2015, and from Institute for Sustainable Energy Policies (ISEP), *Renewables 2014 Japan Status Report*, provided by Hironao Matsubara, ISEP, Tokyo, personal communication with REN21, 14 May 2015; capacity of RPS certified plants is included; geothermal from GEA, op. cit. this note; no CSP or ocean energy capacity. **Per capita data** based on capacity data provided in Table R2 and on 2013 country population data from World Bank, "World Development Indicators – Population, Total," 2015, http://data.worldbank.org/indicator/SP.POP.TOTL, viewed 15 May 2015.

3 **Table R3** derived from the following sources: United States based on U.S. Department of Agriculture, Foreign Agricultural Service, Global Agricultural Trade System, http://apps.fas.usda.gov/gats/default.aspx, viewed February 2015; Canada from Wood Resources International LLC, "Pellet Exports from North America to Europe Has Plateaued in 2014 with Canadian Shipments Declining and Exports from the US South Continuing Upward," 23 October 2014, http://www.pr.com/press-release/597701, and from Wood Resources International LLC, "Wood Pellet Exports from North America Reached a New Record High in the 3Q/14 Thanks to Higher Shipments to Asia," 16 February 2015, http://news.cision.com/wood-resources-international-llc/r/wood-pellet-exports-from-north-america-reached-a-new-record-high-in-the-3q-14-thanks-to-higher-shipm,c9724668; all other data from Eurostat 2015, International Trade Database, http://ec.europa.eu/eurostat/web/international-trade/data/database, viewed February 2015.

4 **Table R4** derived from the following sources: Unless otherwise noted, all data for 2013 and 2014 from F.O. Licht, "Fuel Ethanol: World Production by Country," 2015, and "Biodiesel: World Production, by Country," 2015, with permission from F.O. Licht / Licht Interactive Data; preliminary 2013 data that appeared in GSR 2014 have been updated where possible. Netherlands HVO production assumes that the Neste Oil facility in Rotterdam produced the same amount of HVO as in prior years, with data from F.O. Licht, 2014; China biodiesel production from U.S. Department of Agriculture, Global Agricultural Information Network, *People's Republic of China 2014 Biofuels Annual* (Washington, DC: 4 November 2014), http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Beijing_China%20-%20Peoples%20Republic%20of_11-4-2014.pdf; ethanol data converted from cubic metres to litres using 1,000 litres/cubic metre; biodiesel data converted from units of 1,000 tonnes using a density value for biodiesel to give 1,136 litres per tonne based on NREL, *Biodiesel Handling and Use Guide*, Fourth Edition (Golden, CO: 2009), http://www.biodiesel.org/docs/using-hotline/nrel-handling-and-use.pdf?sfvrsn=4. 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** derived from the following sources: GEA, from Benjamin Matek, GEA, personal communication with REN21, March 2015; Ruggero Bertani, "Geothermal Power Generation in the World: 2010-2014 Update Report," *Proceedings of the World Geothermal Congress 2015* (Melbourne, Australia: 19–25 April 2015). Further information, by country, as follows: **Germany:** The co-generating Sauerlach binary plant (5 MW/4 MW_{th}) was inaugurated in January 2014, delivering heat and electricity on the outskirts of Munich, and about 4 MW of power came on line at the Oberhaching-Laufzorn plant later in the year; see Stadtwerke München, "Geothermie-Heizkraftwerk Sauerlach geht offiziell in Betrieb," press release (Munich: 30 January 2014), http://www.swm.de/

dms/swm/pressemitteilungen/2014/01/versorgung20140130/Pressemitteilung%20vom%2030.01.2.014.pdf; "SWM Geothermie-Kraftwerk in Sauerlach eröffnet," Muenchen.de, 31 January 2014, http://www.muenchen.de/themen/aktuell/swm-geothermie-kraftwerk.html; Erdwärme Grünwald, "Grüner Strom aus Geothermie," undated, http://www.erdwaerme-gruenwald.de/Startseite/Informationen-Medien/Informationen/News-Archiv/Gruener-Strom-aus-Geothermie-E1172.htm. Two more co-generating binary plants in Bavaria, at Taufkirchen/Oberhaching (5 MW/35 MW_{th}) and Traunreut (4 MW/12 MW_{th}), started producing power and heat in 2014; see German Geothermal Association (Bundesverband Geothermie), list of geothermal projects in Germany, http://www.geothermie.de/fileadmin/useruploads/wissenswelt/Projekte/Projektliste_Tiefe_Geothermie_2015_bundesland.pdf; **Indonesia:** Suryantini, Institut Teknologi Bandung, "Indonesia Geothermal Potential; Status in 2014, and Opportunities for Medium-Low-Enthalpy Resources Development," presentation at the Geothermal Resources Council Annual Meeting 2014, Portland, OR, 28 September–1 October 2014; Raras Cahyafitri, "Patuha Plant Under Trial, Sarulla to Start Drilling Operations," *Jakarta Post*, 23 August 2014, http://www.thejakartapost.com/news/2014/08/23/patuha-plant-under-trial-sarulla-start-drilling-operations.html; **Italy:** Enel Green Power, "Enel Green Power Begins Operation of New Bagnore 4 Geothermal Power Plant," press release (Rome: 22 December 2014), http://www.enel.com/en-GB/media/press_releases/enel-green-power-begins-operation-of-new-bagnore-4-geothermal-power-plant/r/1663019; **Kenya:** Ormat Technologies, "Olkaria III Geothermal Complex in Kenya Reaches 110 MW with Commercial Operation of Plant 3," press release (Reno, NV: 4 February, 2014), http://www.ormat.com/news/latest-items/olkaria-iii-geothermal-complex-kenya-reaches-110-mw-commercial-operation-plant-3; "Olkaria III Geothermal Raises Capacity to 110 MW," *Business Daily Africa*, 24 February 2014, http://www.businessdailyafrica.com/Corporate-News/Olkaria-III-geothermal-raises-capacity-to-110MW/-/539550/2219544/-/i88kphz/-/index.html; Kenya Electricity Generating Company (KenGen), "Ongoing Projects," http://www.kengen.co.ke/index.php?page=business&subpage=current; KenGen, "KenGen Finally Connects Olkaria 280 MW to the Grid," press release (Nairobi: 10 December 2014), http://www.kengen.co.ke/index.php?page=press&subpage=releases; **Philippines:** Energy Development Corporation, "EDC Boosts Visayas Grid with New 49.4-MW Geothermal plant in Negros Oriental," http://www.energy.com.ph/uncategorized/edc-boosts-visayas-grid-with-new-49-4-mw-geothermal-plant-in-negros-oriental; **Turkey:** European Geothermal Energy Council, *EGEC Market Report 2013/2014 Update*, Fourth Edition (Brussels: December 2014).

6 **Table R6** derived from the following sources: **China:** China Electricity Council, an overview of China's power industry in 2014, 10 March 2015, http://www.cec.org.cn/yaowenkuaidi/2015-03-10/134972.html; **Brazil:** 3,315 MW (138 MW small hydro and 3,177 MW large hydro) added in 2014, per ANEEL, "Resumo Geral dos Novos Empreendimentos de Geração," updated March 2015, http://www.aneel.gov.br/area.cfm?idArea=37; and "Resumo Geral das Usinas," updated March 2015, http://www.aneel.gov.br/arquivos/zip/Resumo_Geral_das_Usinas_março_2015.zip; large hydro capacity is listed as 84,095 MW at end-2014, small (1–30 MW) hydro at 4,790 MW, and very small (<1 MW) hydro at 308 MW, for a total of 89,193 MW; generation from National Electrical System Operator of Brazil (ONS), "Geração de Energia," http://www.ons.org.br/historico/geracao_energia.aspx; **United States:** capacity from U.S. Energy Information Administration (EIA), *Electric Power Monthly,* Table 6.2.B, http://www.eia.gov/electricity/monthly; generation from idem., Table 1.1; **Canada:** IHA Hydropower Database, from IHA, personal communication with REN21, March 2015; Statistics Canada, "Table 127-0009 Installed Generating Capacity, by Class of Electricity Producer," http://www5.statcan.gc.ca/cansim; generation from idem, "Table 127-0002 Electric Power Generation, by Class of Electricity Producer"; **Russia:** capacity and generation from System Operator of the Unified Energy System of Russia, *Report on the Unified Energy System in 2014* (Moscow: undated), http://www.so-ups.ru/fileadmin/files/company/reports/disclosure/2015/ups_rep2014.pdf; **India:** installed capacity in 2014 (units larger than 25 MW) of 40,867.43 MW from Government of India, Ministry of Power, Central Electricity Authority, "Installed Capacity as of 31 December 2014," http://www.cea.nic.in/installed_capacity.html, and from idem, "List of H.E. Stations in the Country with Station Capacity Above 25 MW," http://www.cea.nic.in/reports/hydro/list_he__stations.pdf; capacity additions in 2014 (>25 MW) of 992.02 MW from idem, "Executive Summary of the Power Sector (monthly)," http://www.cea.nic.in/exesum_cood.html; installed capacity in 2014 (<25 MW) of 3,990.83 MW from Government of India, Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," http://www.mnre.gov.in/mission-and-vision-2/achievements/, viewed 18 January 2014 and 21 January 2015; capacity additions in 2014 (<25 MW) of 228 MW based on difference of year-end 2014 figure (above) and year-end 2013 figure (3,763.15 MW) from MNRE, idem; generation for plants larger than 25 MW from Government of India, Central Electricity Authority, "Executive Summary…," op. cit. this note, and output from hydropower plants smaller than 25 MW estimated, based on capacity from MNRE, op. cit. this note, and on average capacity factor for large hydropower facilities in India; **Turkey:** Enerji Atlasi, "Elektrik Kurulu Gücü 2014'te %8,61 Arttı," 12 January 2015. http://www.enerjiatlasi.com/haber/elektrik-kurulu-gucu-2014-te-8-61-artti; and Enerji Atlas, "Hydrolektrik," http://www.enerjiatlasi.com/hidroelektrik; **World:** Based on input from IHA, op. cit. this note. Additions in 2014 are lower than IHA value of 39 GW published in May 2015 to reflect lower actual capacity additions in Malaysia of 0.8 GW compared to 3.3 GW, with much of the difference installed in prior years.

7 **Table R7** derived from the following sources: **China:** China's National Energy Board, cited in National Energy Administration, "2014 PV Statistics," 9 March 2015, http://www.nea.gov.cn/2015-03/09/c_134049519.htm (using Google Translate); **Japan:** IEA-PVPS, *Snapshot of Global PV Markets 2014* (Brussels: 2015), http://www.iea-pvps.org/index.php?id=trends0; *United States:* GTM Research and U.S. Solar Industries Association, *U.S. Solar Market Insight Report: 2014 Year in Review* (Washington, DC: 2015), Executive Summary, p. 3, https://www.greentechmedia.com/research/ussmi; **United Kingdom:** 2013 from IEA-PVPS, op. cit. this note; 2014 from Gaëtan Masson and Sinead Orlandi, IEA-PVPS and Becquerel Institute, personal communication with REN21, May 2015; and from UK Department of Energy and Climate Change (DECC), "Energy Trends section 6: Renewables," updated 14 May 2015, p. 50, https://www.gov.uk/government/statistics/energy-trends-section-6-renewables; **Germany:** BMWi, *Marktanalyse Photovoltaik-Dachlagen* (Berlin: 2015), http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/bmwi_de/marktanalysen-photovoltaik-photovoltaik.pdf; BMWi, *Entwicklung der Erneuerbaren Energien in Deutschland im Jahr 2014* (Berlin: 2015) data from Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), as of February 2015, http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/entwicklung_der_erneuerbaren_energien_in_deutschland_im_jahr_2014.pdf; Bundesverband Solar Wirtschaft e.V. (BSW-Solar), "Statistische Zahlen der deutschen Solarstrombranche (Photovoltaik)," March 2015, http://www.solarwirtschaft.de/fileadmin/media/pdf/2013_2_BSW_Solar_Faktenblatt_Photovoltaik.pdf; **France, Australia, South Korea, South Africa, Italy, and Spain:** IEA-PVPS, op. cit. this note; **India:** Bridge to India, May 2015, provided by Sinead Orlandi, Becquerel Institute, personal communication with REN21, 11 May 2015; **World:** Masson and Becquerel Institute, op. cit. this note; European Photovoltaic Industry Association, *Global Market Outlook for Photovoltaics 2015-2019* (Brussels: forthcoming 2015).

8 **Table R8** derived from the following sources: REN21, *Renewables 2014 Global Status Report* (Paris: June 2014), http://www.ren21.net/Portals/0/documents/Resources/GSR/2014/GSR2014_full%20report_low%20res.pdf; Elisa Prieto Casaña, Frederick H. Morse, and Francisco Javier Martínez Villar, Abengoa Solar, personal communications with REN21, 28 April 2015; Eduardo Garcia Iglesias, Protermosolar, personal communication with REN21, 29 April 2015; NREL, "Concentrating Solar Power Projects," http://www.nrel.gov/csp/solarpaces/, viewed 24 April 2015; "CSP Today Global Tracker," CSP Today, http://social.csptoday.com/tracker/projects, viewed 27 April 2014.

9 **Table R9** derived from Franz Mauthner and Werner Weiss, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2013*, edition 2015 (Gleisdorf, Austria: IEA-SHC, 2015), and from Franz Mauthner, AEE-INTEC, Gleisdorf, Austria, personal communications with REN21, March–May 2015.

10 **Table R10** derived from the following sources: year-end world and country data for 2013 from GWEC, *Global Wind Report 2014: Annual Market Update* (Brussels: April 2015), p. 7, http://www.gwec.net/wp-content/uploads/2015/03/GWEC_Global_Wind_2014_Report_LR.pdf (unless otherwise noted). Data for 2014 from the following sources: **China**: 2013 from Chinese

Wind Energy Association (CWEA) and China Electricity Council, provided by Shi Pengfei, CWEA, personal communication with REN21, 1 April 2015; 2014 data from GWEC, op. cit. this note, p. 7; added 23,196 MW from Feng Zhao et al., *Global Wind Market Update—Demand & Supply 2014* (London: FTI Consulting LLP, March 2015), p. 30; National Energy Board, provided by China National Energy Administration, "Wind Power Industry Monitoring," 12 February 2015, http://www.nea.gov.cn/2015-02/12/c_133989991.htm (using Google Translate); China Renewable Energy Engineering Institute, "Wind Power Statistical Evaluation Report of China" (in Chinese), 14 April 2015, provided by Shi Pengfei, CWEA, personal communication with REN21, 15 April 2015. **Germany**: Zhao et al., op. cit. this note, p. 33; GWEC, op. cit. this note, p. 48; BMWi, *Development of Renewable Energy Sources in Germany 2014*, based on data from the Working Group on Renewable Energy-Statistics (AGEE-Stat), as of February 2015, p. 15, http://www.bmwi.de/English/Redaktion/Pdf/development-of-renewable-energy-sources-in-germany,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf; C. Ender, "Wind Energy Use in Germany – Status 31.12.2014," *DEWI Magazin*, February 2015, pp. 26–37, http://www.dewi.de/dewi_res/fileadmin/pdf/publications/Magazin_46/05.pdf. **United States**: American Wind Energy Association, "American Wind Power Rebounded in 2014, Adding Over Four Times as Much as Year Before," press release (Washington, DC: 28 January 2015), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=7181. **Brazil**: GWEC, op. cit. this note, pp. 7, 32; Zhao et al., op. cit. this note, p. 37; WWEA, *World Wind Energy Report 2015* (Bonn: 2015). **India**: GWEC, op. cit. this note, p. 7; Zhao et al., op. cit. this note, p. 37; WWEA, op. cit. this note. **Canada**: GWEC, op. cit. this note, p. 34. **United Kingdom**: EWEA, *Wind in Power: 2014 European Statistics* (Brussels, February 2015), http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA-Annual-Statistics-2014.pdf; Zhao et al., op. cit. this note, p. 33; GWEC, op. cit. this note, pp. 7, 53, 74. **Sweden**: EWEA, op. cit. this note. **France**: EWEA, op. cit. this note. **Turkey**: Turkish Wind Energy Association, *Turkish Wind Energy Statistics Report*, January 2015, pp. 4–5, http://www.tureb.com.tr/en/twea-announcements/434-turkish-wind-energy-statistics-report-january-2015. **Spain and Italy**: EWEA, op. cit. this note, p. 7; Zhao et al., op. cit. this note, pp. 30–31; WWEA, op. cit. this note. **World**: GWEC, op. cit. this note, p. 7; Zhao et al., op. cit. this note, p. 29; WWEA, op. cit. this note. See Wind Power text and related endnotes for further world and country statistics and details.

11 **Table R11** from Frankfurt School-UNEP Centre/BNEF, *Global Trends in Renewable Energy Investment 2015* (Frankfurt: 2015), http://www.fs-unep-centre.org

12 **Table R12** derived from the following sources: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER, *The State of Renewable Energies in Europe* (Paris: 2014), http://www.energies-renouvelables.org/observ-er/stat_baro/barobilan/barobilan14_EN.pdf. For online updates, see the "Renewables Interactive Map" at www.ren21.net.

13 **Table R13** derived from the following sources: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER; Targets for the EU-28 were set in each country's National Renewable Energy Action Plan (NREAP), available at http://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans. Certain NREAP targets have been revised subsequently. For online updates, see the "Renewables Interactive Map" at www.ren21.net.

14 **Table R14** from REN21 database compiled from all available policy references plus submissions from report contributors. Targets for the EU-28 and Energy Community countries were set in each country's NREAP. Certain NREAP targets have been revised subsequently. For online updates, see the "Renewables Interactive Map" at www.ren21.net.

15 **Table R15** derived from the following sources: REN21 database compiled from all available policy references plus submissions from report contributors; MNRE, "IREEED: Indian Renewable Energy and Energy Efficiency Policy Database," www.ireeed.gov.in, viewed 3 March 2015; N.C. Clean Energy Technology Center, "Database of State Incentives for Renewables & Efficiency," www.dsireusa.org, viewed 3 March 2015.

16 **Table R16** derived 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. Additional policies added include: **Andorra:** LAWIN, *Global Renewable Energy Guide* (Ankara, Turkey: Cakmak Publishing, 2013), http://www.lawin.com/files/global_renewable_energy_guide_2013.pdf; **Liechtenstein:** Jorn Banasiak, "Feed-in Tariff," RES Legal, updated 24 November 2014, http://www.res-legal.eu/search-by-country/liechtenstein/single/s/res-e/t/promotion/aid/feed-in-tariff-3/lastp/409/; **San Marino:** United Nations Framework Convention on Climate Change, *The Second Communication of the Republic of San Marino to the United Nations Framework Convention on Climate Change*, 28 January 2013, http://unfccc.int/resource/docs/natc/smrnc2.pdf.

17 **Table R17** derived from Ibid.

18 **Table R18** lists only biofuel blend mandates; transport and biofuel targets can be found in Table R15. Source: Table R18 from ibid. and from Jim Lane, "Biofuels Mandates Around the World: 2015," Biofuels Digest, 31 December 2014, http://www.biofuelsdigest.com/bdigest/2014/12/31/biofuels-mandates-around-the-world-2015/.

19 **Table R19** derived from the following sources: For selected targets and policies, see: EU Covenant of Mayors; ICLEI – Local Governments for Sustainability; REN21, *Global Futures Report* (Paris: 2013); and REN21, ISEP, and ICLEI, *2011 Global Status Report on Local Renewable Energy Policies* (Paris: May 2011). For selected examples in urban planning, see: City of Malmö, "Environmental Programme for the City of Malmö 2009-2020" (Malmö: 2009), http://malmo.se/download/18.6301369612700a2db9180006235/Environmental-Programme-for-the-City-of-Malmo-2009-2020.pdf; IRENA, *Renewable Energy Policy in Cities: Selected Case Studies - Malmö, Sweden* (Abu Dhabi: January 2013), https://www.irena.org/Publications/RE_Policy_Cities_CaseStudies/IRENA%20cities%20case%207%20Malmo.pdf; and City of Sydney, *Decentralised Energy Master Plan Renewable Energy* (Sydney: 2013), http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0003/153282/Renewable-Energy-Master-Plan.pdf

20 **Table R20** derived from the following sources: REN21 database; IEA, *World Energy Outlook 2014,* Energy Access Database, http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/; submissions from report contributors; and from World Bank, "Rwanda Electricity Access Scale-up and Sector Wide Approach (SWAp) Development Project (P111567): Implementation Status and Results Report" (Washington, DC: 7 January 2015), http://documents.worldbank.org/curated/en/2015/01/23181044/rwanda-rwanda-electricity-access-scale-up-sector-wide-approach-swap-development-project-p111567-implementation-status-results-report-sequence-10

21 **Table R21** derived from IEA, *World Energy Outlook 2014*, Energy Access Database, http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/, and from submissions from report contributors.

22 **Table R22** derived from the following sources: All consolidated data at country level were provided by REN21 country contributors and topical (DRE) contributors. Programme and organisational information was provided by Alliance for Rural Electrification (ARE); Asian Development Bank (ADB); Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ); Foundation Rural Energy Services (FRES); Global Off-Grid Lighting Association (GOGLA); Inter-American Development Bank (IDB); Mobisol; Plan International Spain; Renewable Energy and Energy Efficiency Promotion in International Cooperation (REPIC); SNV Netherlands Development Organisation; and Sunna Design. Systems/projects installed by ARE members are based on consolidated 2014 data that ARE collected from its members in April 2015. (Respondents to ARE's survey include: EDP - Energias de Portugal, FRES, Fundacion Accioná Microenergia, Generalia, Iberdrola, Mobisol, Off-Grid Energy Australia, Phaesun, Rahimafrooz, Smart Hydro Power, Socomec, Solarland, and SunEdison). Systems/projects implemented under the EnDev Programme were provided by GIZ and based on EnDev figures as of end-2014. Systems/projects implemented by GOGLA and the World Bank were provided by GOGLA and represent the sales of GOGLA members and of products that have been quality verified by the Lighting Global Quality Assurance Program. MNRE, *Annual Report 2014*, http://mnre.gov.in/file-manager/annual-report/2014-2015/EN/index.htm; ONE (National Electricity Utility in Morocco), Programme d'Electrification Rurale Global, http://www.one.org.ma/FR/pages/interne.asp?esp=2&id1=6&t1=1, viewed 26 April 2015.

METHODOLOGICAL NOTES

This 2015 report is the tenth edition of the *Renewables Global Status Report* (GSR), which has been produced annually since 2005 (with the exception of 2008). Readers are directed to the previous GSR editions for historical details.

Most 2014 data for national and global capacity, output, growth, and investment portrayed in this report are preliminary. Where necessary, information and data that are conflicting, partial, or older are reconciled by using reasoned expert judgment. Endnotes provide additional details, including references, supporting information, and assumptions where relevant. (For information on renewable energy data and related challenges, see Sidebar 4 in this report, and Sidebar 1 in GSR 2014.)

Each edition draws from thousands of published and unpublished references, including: reports from international organisations and industry associations; input from the GSR community via hundreds of questionnaires submitted by country, regional, sectoral, and technology contributors, and feedback from several rounds of formal and informal reviews; additional personal communications with scores of international experts; as well as a variety of electronic newsletters, news media, and other sources.

Much of the data found in the GSR is built from the ground up by the authors with the aid of these resources. This often involves extrapolation of older data, based on recent changes in key countries within a sector, or based on recent growth rates and global trends. Other data, often very specific and narrow in scope, come more-or-less prepared from third parties. The GSR attempts to synthesise these datapoints into a collective whole for the focus year.

The GSR endeavours to cover accurately, on a global level, all data related to renewable energy markets and industries, policy developments, as well as renewable energy-related advances to expand energy access in developing countries. It aims to provide the best data available in each successive edition; as such, data should not be compared with previous versions of this report to ascertain year-by-year changes.

NOTE ON ACCOUNTING AND REPORTING

A number of issues arise when counting renewable energy capacities and energy output. Some of these are discussed below:

1. CAPACITY VERSUS ENERGY DATA

The GSR aims to give accurate estimates of capacity additions and totals, as well as of electricity, heat, and transport fuel production in the past year. These measures are subject to some uncertainty, with the level of uncertainty differing from technology to technology. The section on Market and Industry Trends includes estimates for energy produced where possible, but, due to data constraints, it focuses mainly on electricity or heat capacity data. This is because capacity data generally can be estimated with a greater degree of certainty. Further, actual heat and electricity generation data for most countries are usually available only 12 months or more after the fact, and sometimes not at all.

2. CONSTRUCTED CAPACITY VERSUS CONNECTED CAPACITY AND OPERATIONAL CAPACITY

Over the past few years, the solar PV and wind power markets have seen significant amounts of capacity that was connected to the electricity grid 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 but connected to the grid during the next). This phenomenon has been particularly evident for wind power installations in China (2009–2014), as well as for solar PV in some European countries in recent years.

Starting with the 2012 edition, the GSR has aimed to count only capacity additions that were grid-connected, or that otherwise went into service (e.g., capacity intended for off-grid use), during the previous calendar year. However, there may be exceptions borne out of necessity of data availability (as with China, for example). Known deviations to this approach are outlined in the text and/or endnotes for the technology sections.

The reasoning is that the sources from which the GSR draws have varying methodologies for counting installations, and many official bodies report grid connection statistics. 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, have shifted to tracking and reporting on operational/grid-connected rather than installed capacities (with some exceptions).

3. BIO-POWER DATA

Given existing complexities and constraints (see Figure 6 in this report, and Sidebar 2 in GSR 2012), the GSR strives to provide the best and latest available data regarding biomass energy developments. The reporting of biomass-fired combined heat and power (CHP) systems varies among countries, which adds to the challenges experienced when assessing total heat and electricity capacities and total bioenergy outputs. Wherever possible, the bio-power data presented include capacity and generation from both electricity-only and CHP systems using solid biomass, landfill gas, biogas, and liquid biofuels.

Note that the methodology for calculating shares of different biomass feedstock (solid v. gaseous) in electricity and heat changed in this GSR relative to GSR 2012, the last edition to provide such numbers. Values for GSR 2014 were calculated using a linear regression based on data from the International Energy Agency (IEA), "Statistics: World: Renewables and Waste 2008-2012," http://www.iea.org/statistics/, viewed 1 May 2015. Municipal solid waste (MSW) values were assumed to be only 50% renewable, consistent with IEA assumptions. Industrial waste was excluded from calculations.

4. HYDROPOWER DATA REVISION AND TREATMENT OF PUMPED STORAGE

The GSR 2014 reported a global total of 1,000 GW at the end of 2013. That figure has been revised upwards in this edition by 18 GW, based on the best estimates of new capacity additions of 37 GW and total year-end capacity of 1,055 GW.

Starting with the 2012 edition, the GSR has attempted 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. It involves conversion losses and is potentially fed by all forms of electricity, renewable and non-renewable. However, some conventional hydropower facilities do have pumping capability that is not separate from, or additional to, their normal generating capability. It is the aim of the GSR to distinguish and separate only the pure (or incremental) pumped storage component. (As noted in Sidebar 3 of GSR 2013, pumped storage can play an important role as balancing power in a grid system, particularly where a large share of variable renewable resources appears in the generation mix.)

This method of accounting is accepted practice by the industry. The International Hydropower Association is working to track and report pure pumped storage numbers separately. In addition, several countries report data for pumped storage separately from data for conventional hydropower and other renewables.

5. SOLAR THERMAL HEAT DATA

Starting with the 2014 edition, the GSR includes all solar thermal collectors that use water as the heat-transfer medium (or heat carrier) in global capacity data and ranking of top countries. Previous GSRs focused primarily on glazed water collectors (both flat plate and evacuated tube); this edition also includes unglazed water collectors, which are used predominantly for swimming pool heating.

Note that data for solar air collectors (solar thermal collectors that use air as the heat carrier) are far more uncertain, and these collector types play a minor role in the market overall. Solar thermal air collectors are included where specified.

6. OTHER

Editorial content of this report closed by 17 May 2015 for technology data, and by 1 May for other content.

All exchange rates in this report are as of 31 December 2014 and are calculated using the OANDA currency converter (http://www.oanda.com/currency/converter/).

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 (vapour compression) cooling systems in two ways: 1) the absorption process is thermo-chemical in nature rather than mechanical, and 2) the substance that is circulated as a refrigerant is water rather than chlorofluorocarbons (CFCs) or hydro chlorofluorocarbons (HCFCs), also called Freon. The chillers generally are supplied with district heat, waste heat, or heat from co-generation, and they can operate with heat from geothermal, solar, or biomass resources.

ADSORPTION CHILLERS. Chillers that use heat energy from any source to drive air conditioning or refrigeration systems. They differ from absorption chillers in that the adsorption process is based on the interaction between gases and solids. A solid material in the chiller's adsorption chamber releases refrigerant vapour when heated; subsequently, the vapour is cooled and liquefied, providing a cooling effect at the evaporator by absorbing external heat and turning back into a vapour, which is then readsorbed into the solid.

AUCTION. (*See* Tendering.)

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. (*Also see* Hydrotreated vegetable oil.)

BIOENERGY. Energy derived from any form of biomass (solid, liquid, or gaseous) for heat, power, and transport. (*See* Biofuels.)

BIOFUELS. A fuel derived from biomass that may include liquid fuel ethanol and biodiesel, as well as biogas. Biofuels 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 feedstocks derived from the lignocellulosic fractions of biomass sources or from algae. They are made using non-traditional biochemical and thermochemical conversion processes.

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 micro-organisms 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 also can 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 that is available for conversion to a wide range of convenient energy carriers.

BIOMASS ENERGY, MODERN. Energy derived from combustion of solid, liquid, and gaseous biomass fuels in high-efficiency conversion systems, which range from small domestic appliances to large-scale industrial conversion plants. Modern applications include heat and electricity generation, combined heat and power (CHP), and transport.

BIOMASS ENERGY, TRADITIONAL. Solid biomass including fuel wood, charcoal, agricultural and forest residues, and animal dung, that is typically used in rural areas of developing countries with traditional technologies such as open fires for cooking, kilns, and ovens for small-scale agricultural and industrial processing. Often the use of traditional biomass leads to high pollution levels, forest degradation, and deforestation.

BIOMASS ENERGY PELLETS. Solid biomass fuel produced by compressing pulverised dry biomass, such as waste wood and agricultural residues. Pellets typically are 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. (*Also see* Torrefied wood.)

CAPACITY. The rated capacity of a heat or power generating plant, which 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 co-generation). 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.

COMPETITIVE BIDDING. (*See* Tendering.)

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 locations with high normal direct insolation and low moisture.

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.

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 solar PV module is the ratio between the electricity generated and the total solar energy received by the solar PV module. If 100 kWh of solar radiation is received and 10 kWh electricity is generated, the conversion efficiency is 10%.

CROWDFUNDING. The practice of funding a project or venture by raising money—often relatively small individual amounts—from a relatively large number of people ("crowd"), generally using the Internet and social media. The money raised through crowdfunding does not necessarily buy the lender a share in the venture, and there is no guarantee that money will be repaid if the venture is successful. However, some types of crowdfunding reward backers with an equity stake, structured payments, and/or other products.

DEGRESSION. A mechanism built into policy design establishing automatic downwards rate revisions, which can occur after specific thresholds are crossed (e.g., after a certain amount of capacity is contracted, or a certain amount of time passes).

DISTRIBUTED RENEWABLE ENERGY. Energy systems are considered to be distributed if 1) the systems of production are relatively small and dispersed (such as small-scale solar PV on rooftops), rather than relatively large and centralised; or 2) generation and distribution occur independently from a centralised network. Specifically for the purpose of the section on Distributed Renewable Energy in Developing Countries, "distributed renewable energy" meets both conditions. It includes energy services for electrification, cooking, heating, and cooling that are generated and distributed independent of any centralised system, in urban and rural areas of the developing world.

ENERGIEWENDE. German term that means "transformation of the energy system". It refers to the move away from nuclear and fossil fuels towards an energy system based primarily on energy efficiency improvements and renewable energy.

ENERGY. The ability to do work, which comes in a number of forms including thermal, radiant, kinetic, chemical, potential, and electrical.

ENERGY, FINAL. The part of primary energy, after deduction of losses from conversion, transmission, and distribution, that reaches the consumer and is available to provide heating, hot water, lighting, and other services. Final energy forms include electricity, district heating, mechanical energy, liquid hydrocarbons such as kerosene or fuel oil, and various gaseous fuels such as natural gas, biogas, and hydrogen. Final energy accounts only for the conversion losses that occur upstream of the end-user, such as losses at refineries and power plants.

ENERGY, PRIMARY. The theoretically available energy content of a naturally occurring energy source (such as coal, oil, natural gas, uranium ore, geothermal, and biomass energy, etc.) before it undergoes conversion to useful final energy delivered to the end-user. Conversion of primary energy into other forms of useful final energy (such as electricity and fuels) entails losses. Some primary energy is consumed at the end-user level as final energy without any prior conversion.

ENERGY INTENSITY. Primary energy consumption per unit of economic output. Energy intensity is typically used as a proxy for energy efficiency in macro-level analyses due to the lack of an internationally agreed-upon high-level indicator for measuring energy efficiency.

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, co-operative, NGO, or private company, and typically installs energy systems on or near customer sites. An ESCO also can 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.

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. Ethanol is also used in chemical and beverage industries.

FEED-IN POLICY (FEED-IN TARIFF OR FEED-IN PREMIUM). A policy that typically guarantees renewable generators specified payments per unit (e.g., USD/kWh) over a fixed period. Feed-in tariff policies may also establish regulations by which generators can interconnect and sell power to the grid. Numerous options exist for defining the level of incentive, such as whether the payment is structured as a guaranteed minimum price (e.g., a feed-in tariff), or whether the payment floats on top of the wholesale electricity price (e.g., a feed-in premium).

FISCAL INCENTIVE. An incentive that provides individuals, households, or companies with a reduction in their contribution to the public treasury via income or other taxes.

GENERATION. The process of converting energy into electricity and/or useful heat from a primary energy source such as wind, solar radiation, natural gas, biomass, etc.

GEOTHERMAL ENERGY. Heat energy emitted from within the earth's crust, usually in the form of hot water and steam. It can be used to generate electricity in a thermal power plant or to provide heat directly at various temperatures.

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 (such as renewable energy credits, green tags, and 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.

HEAT PUMP. A device that transfers heat from a heat source to a heat sink using a refrigeration cycle that is driven by external electric or thermal energy. It can use the ground (geothermal), the surrounding air (aerothermal/air-source), or a body of water (hydrothermal/water-source) as a heat source in heating mode, and as a heat sink in cooling mode. A heat pump's final energy output can be several multiples of the energy input, depending on its inherent efficiency and operating conditions. The output of a heat pump is at least partially renewable on a final energy basis. However, the renewable component can be much lower on a primary energy basis, depending on the composition and derivation of the input energy; in the case of electricity, this includes the efficiency of the power generation process. The output of a heat pump can be fully renewable energy if the input energy is also fully renewable.

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 (often defined as more than 10 MW of installed capacity, but the definition varies by country) to small, mini, micro, and pico.

HYDROTREATED VEGETABLE OIL (HVO). A "drop-in" biofuel produced by using hydrogen to remove oxygen from waste cooking oils, fats, and vegetable oils. The result is a hydrocarbon fuel that blends more easily with diesel and jet fuel than does biodiesel produced from triglycerides as fatty acid methyl esters (FAME).

INVERTER (and micro-inverter). Inverters convert the direct current (DC) generated by solar PV modules to alternating current (AC), which can be fed into the electric grid or used by a local, off-grid network. Conventional string and central solar inverters are connected to multiple modules to create an array that effectively is a single large panel. By contrast, micro-inverters convert generation from individual solar PV modules; the output of several micro-inverters is combined and often fed into the electric grid. A primary advantage of micro-inverters is that they isolate and tune the output of individual panels, reducing the effects that shading or failure of any one (or more) module(s) has on the output of an entire array. They eliminate some design issues inherent to larger systems and allow for new modules to be added as needed.

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 fiscal incentive that allows investments in renewable energy to be fully or partially credited against the tax obligations of a project developer, industry, building owner, etc.

JOULE. A Joule (J) is a unit of work or energy equal to the energy expended to produce one Watt of power for one second. The potential chemical energy stored in one barrel of oil and released when combusted is approximately 6 gigajoules (GJ); a tonne of oven dry wood contains around 20 GJ of energy.

LEVELISED COST OF ENERGY (LCOE). The unique cost price of energy outputs (e.g., USD per kWh or USD per 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, a stated amount of capacity, or the required use of a specified renewable technology. 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 specified shares of biofuels (biodiesel or bioethanol) 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.

MERIT ORDER. A way of ranking available sources of energy (particularly electricity generation) in ascending order based on short-run marginal costs of production, such that those with the lowest marginal costs are the first ones brought on line to meet demand, and those with the highest are brought on last. The merit-order effect is a shift of market prices along the merit-order or supply curve due to market entry of power stations with lower variable costs (marginal costs). This displaces power stations with the highest production costs from the market (assuming demand is unchanged), and admits lower-priced electricity into the market.

MICRO-GRIDS. These are similar to mini-grids, but there is no universal definition differentiating the two (see Mini-grids). For distributed renewable energy in developing countries, micro-grids typically refer to independent grid networks operating on a scale of 1–10 kW. In the United States, for example, micro-grids also refer to larger networks (up to several MW) that can operate independently of, or in conjunction with, an area's main power grid. They can be intended as backup power or to bolster main grid power during periods of heavy demand. They often are used to reduce costs, enhance reliability, and/or as a means of incorporating renewable energy.

MINI-GRIDS. Grids that provide small-scale generation (10 kW to 10 MW) and distribution of grid-quality electricity to a relatively small and concentrated group of customers, most commonly in remote areas. They are often managed locally, and can operate with or without interconnection to the wider external transmission grid.

NET METERING / NET BILLING. A regulated arrangement in which utility customers with onsite electricity generators can receive credits for excess generation, which can be applied to offset consumption. Under net metering, customers typically receive credit at the level of the retail electricity price. Under net billing, customers typically receive credit for excess power at a rate that is lower than the retail electricity price. Different jurisdictions may apply these terms in different ways, however.

OCEAN ENERGY. Energy captured from ocean waves, tides, currents, salinity gradients, and ocean temperature differences. Wave energy converters capture the energy of ocean waves to generate electricity; tidal stream generators use kinetic energy of tidal currents to power turbines; and tidal barrages are essentially dams that cross tidal estuaries and capture energy as tides ebb and flow.

POWER. The rate at which energy is converted, expressed in Watts (Joules/second).

PRODUCTION TAX CREDIT. A tax incentive that provides the investor or owner of a qualifying property or facility with a tax credit based on the amount of renewable energy (electricity, heat, or biofuel) generated by that facility.

PUBLIC FINANCING. A type of financial support mechanism whereby governments provide assistance, often in the form of grants or loans, to support the development or deployment of renewable energy technologies.

PUMPED STORAGE HYDROPOWER. Plants that pump water from a lower reservoir to a higher storage basin using surplus electricity, and that 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, and technology/fuel specific 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. Targets may be backed by specific compliance mechanisms or policy support measures. Some targets are legislated while others are set by regulatory agencies, ministries, or public officials.

RENEWABLE PORTFOLIO STANDARD (RPS). An obligation placed by a government on a utility company, group of companies, or consumers to provide or use a predetermined minimum targeted renewable share of installed capacity, or of electricity or heat generated or sold. A penalty may or may not exist for non-compliance. These policies also are known as "renewable electricity standards", "renewable obligations", and "mandated market shares", depending on the jurisdiction.

REVERSE AUCTION. (*See* Tendering.)

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 low power photovoltaic 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) generates electricity and replaces conventional materials in parts of a building envelope, such as the roof or façade. Bifacial PV modules are double-sided panels that generate electricity with sunlight received on both sides (direct and reflected) and are used primarily in the BIPV sector.

SOLAR PHOTOVOLTAIC-THERMAL (PV-T). Solar PV-thermal hybrid system that includes solar thermal collectors mounted beneath PV modules to convert solar radiation into electrical and thermal energy. The solar thermal collector removes waste heat from the PV module, enabling it to operate more efficiently.

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. 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 thermosyphon 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.

TENDERING (also called auction/reverse auction or tender). A procurement mechanism by which renewable energy supply or capacity is competitively solicited from sellers, who offer bids at the lowest price that they would be willing to accept. Bids may be evaluated on both price and non-price factors.

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. 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. A kilowatt-hour is the amount of energy equivalent to steady power of 1 kW operating for one hour.

YIELD COMPANY (YIELDCO). Renewable energy yieldcos are publicly traded financial vehicles created when power companies spin off their renewable power assets into separate, high-yielding entities. They are formed to reduce risk and volatility, and to increase capital and dividends. Shares are backed by completed renewable energy projects with long-term power purchase agreements in place to deliver dividends to investors. They attract new types of investors who prefer low-risk and dividend-like yields, and those who wish to invest in renewable projects specifically. The capital raised is used to pay off debt or to finance new projects at lower rates than those available through tax equity finance.

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 US 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 ethanol = 84,530 Btu / US gallon = 21.2 MJ / l

1 l biodiesel = 127,960 Btu / US gallon = 32.1 MJ / 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.
3) Heat values from U.S. Department of Energy Alternative Fuels Data Center.

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.

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Renewable Energy Policy Network for the 21st Century

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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
BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
CHP	Combined heat and power
CIS	Commonwealth of Independent States
CNG	Compressed natural gas
CO_2	Carbon dioxide
CPV	Concentrating solar photovoltaic
CSP	Concentrating solar (thermal) power
DRE	Distributed renewable energy
DSM	Demand-side management
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EEG	German Renewable Energy Law – “Erneuerbare-Energien-Gesetz“
EJ	Exajoule
EMEC	European Marine Energy Centre
EnMS	Energy management systems
EPA	U.S. Environmental Protection Agency
EPS	Energy performance standards
ESCO	Energy service company
EU	European Union (specifically the EU-28)
EV	Electric vehicle
FAME	Fatty acid methyl ester (biodiesel)
FIP	Feed-in premium
FIT	Feed-in tariff
FPIC	Free, Prior, and Informed Consent
FUNAE	Energy Fund of Mozambique – “Fundo de Energia“
GACC	Global Alliance for Clean Cookstoves
GEF	Global Environment Facility
GFR	Global Futures Report
GHP	Ground-source heat pump
GSR	Renewables Global Status Report
GW / GW_{th}	Gigawatt / Gigawatt-thermal
GWh	Gigawatt-hour
HSAP	Hydropower Sustainability Assessment Protocol
HVO	Hydrotreated vegetable oil
IEA	International Energy Agency
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
kW / kWh	Kilowatt / kilowatt-hour
LCOE	Levelised cost of energy
LED	Light-emitting diode
LPG	Liquefied petroleum gas
m^2	Square metre
m^3	Cubic metre
MENA	Middle East and North Africa
MFI	Microfinance institution
MSW	Municipal solid waste
MW / MWh	Megawatt / megawatt-hour
NGO	Non-governmental organisation
NREAP	National Renewable Energy Action Plan
NZEB	Net zero energy building
nZEB	Nearly zero energy buildings
OECD	Organisation for Economic Co-operation and Development
PPP	Public-private partnership
PTC	Production tax credit
PV	Photovoltaic
RPS	Renewable portfolio standard
SE4ALL	United Nations Sustainable Energy for All initiative
SHS	Solar home system
SPS	Solar pico system (pico PV)
SWH	Solar water heater / solar water heating
toe	Tonne of oil equivalent
TW / TWh	Terawatt / Terawatt-hour
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USD	United States dollar
VAT	Value-added tax
W_p	Watt-peak (nominal power)
WTO	World Trade Organization

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