REN21 Renewable Energy Policy Network for the 21st Century

ADVANCING THE GLOBAL RENEWABLE ENERGY TRANSITION

Highlights of the REN21 Renewables 2017 Global Status Report in perspective

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, non-governmental 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.

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:

Global Status Report: yearly publication since 2005

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

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REN21 PRODUCTS

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 800 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 infographics from the reports as well as offering detailed, exportable data packs.

GLOBAL FUTURES 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.

INTERNATIONAL RENEWABLE ENERGY CONFERENCES (IREC)

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.

Regional Reports


www.ren21.net/map

Global Futures Reports

REN21 Renewables Academy

REN21 Renewables Academy


International Renewable Energy Conferences

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
- Renewables Interactive Map revamp
- SAIREC, South Africa International Renewable Energy Conference

2016
- EAC Renewable Energy and Energy Efficiency Status Report
- First GSR Microsite

2017
- Renewables 100% Global Futures Report
- UNECE Renewable Energy Status Report
- Renewable Energy Tenders and Community [em]Power[ment]
- MEXIREC, Mexico International Renewable Energy Conference, 11-13 September 2017

REN21 MEMBERS

INDUSTRY ASSOCIATIONS

Alliance for Rural Electrification (ARE)

American Council on Renewable Energy (ACORE)

Association for Renewable Energy of Lusophone Countries (ALER)

Chinese Renewable Energy Industries Association (CREIA)

Clean Energy Council (CEC)

European Renewable Energies Federation (EREF)

Global Off-Grid Lighting Association (GOGLA)

Global Solar Council (GSC)

Global Wind Energy Council (GWEC)

Indian Renewable Energy Federation (IREF)

International Geothermal Association (IGA)

International Hydropower Association (IHA)

Portuguese Renewable Energy Association (APREN)

Renewable Energy Solutions for the Mediterranean (RES4MED)

World Bioenergy Association (WBA)

World Wind Energy Association (WWEA)

INTERNATIONAL ORGANISATIONS

Asian Development Bank (ADB)

Asia Pacific Energy Research Centre (APERC)

ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)

European Commission (EC)

Global Environment Facility (GEF)

International Energy Agency (IEA)

International Renewable Energy Agency (IRENA)

Regional Center for Renewable Energy and Energy Efficiency (RCREEE)

United Nations Development Programme (UNDP)

UN Environment (UNEP)

United Nations Industrial Development Organization (UNIDO)

World Bank (WB)

NGOS

Climate Action Network (CAN)

Council on Energy, Environment and Water (CEEW)

Fundación Energías Renovables (FER)

Global Alliance for Clean Cookstoves (GACC)

Global Forum on Sustainable Energy (GFSE)

Greenpeace International

ICLEI – Local Governments for Sustainability, South Asia

Institute for Sustainable Energy Policies (ISEP)

Mali Folkecenter (MFC)

Partnership for Sustainable Low Carbon Transport (SLoCaT)

Renewable Energy Institute (REI)

World Council for Renewable Energy (WCRE)

World Future Council (WFC)

World Resources Institute (WRI)

World Wildlife Fund (WWF)

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Denmark
Germany
India
Norway
South Africa
Spain
United Arab Emirates
United Kingdom
United States of America

SCIENCE AND ACADEMIA

Fundación Bariloche (FB)

International Institute for Applied Systems Analysis (IIASA)

International Solar Energy Society (ISES)

National Renewable Energy Laboratory (NREL)

South African National Energy Development Institute (SANEDI)

The Energy and Resources Institute (TERI)

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REN21

REN21 COMMUNITY

REN21 is a multi-stakeholder network that spans the private and public sectors. Collectively this network of renewable energy, energy access and energy efficiency experts shares its insight and knowledge, helping the REN21 Secretariat produce its annual *Renewables Global Status Report* as well as regional reports. Today the network has over 800 active contributors and reviewers.

These experts engage in the GSR process, giving their time, contributing data and providing comment in the peer review process. The result of this collaboration is an annual publication that has established itself as the world's most frequently referenced report on the global renewable energy market, industry and policy landscape

→ Tracking **155** countries

→ Covering **96%** of global GDP

→ Representing **96%** of global population

REN21 Renewable Energy Policy Network for the 21st Century

A GLOBAL ENERGY TRANSITION IS WELL UNDER WAY

Advancing the Global Renewable Energy Transition: Highlights of the REN21 Renewables 2017 Global Status Report in Perspective

The 2017 edition of the *REN21 Renewables Global Status Report* (GSR) reveals a global energy transition well under way, with record new additions of installed renewable energy capacity, rapidly falling costs, particularly for solar PV and wind power, and the decoupling of economic growth and energy-related carbon dioxide (CO_2) emissions for the third year running. Innovative and more sustainable ways of meeting our energy needs – through better-integrated sectoral planning, the adoption of exciting new business models and the more creative use of enabling technologies – are accelerating the paradigm shift away from a world run on fossil fuels.

HIGHLIGHTS 2017

■ **Newly installed renewable power capacity set new records in 2016**, with 161 gigawatts (GW) added, increasing the global total by almost 9% relative to 2015. Solar PV was the star performer in 2016, accounting for around 47% of the total additions, followed by wind power at 34% and hydropower at 15.5%. For the fifth consecutive year, investment in new renewable power capacity (including all hydropower) was roughly double the investment in fossil fuel generating capacity, reaching USD 249.8 billion. The world now adds more renewable power capacity annually than it adds in net new capacity from all fossil fuels combined.

■ **Cost for electricity from solar PV and wind is rapidly falling**. Record-breaking tenders for solar PV occurred in Argentina, Chile, India, Jordan, Saudi Arabia and the United Arab Emirates, with bids in some markets below USD 0.03 per kilowatt-hour (kWh). Parallel developments in the wind power sector saw record low bids in several countries, including Chile, India, Mexico and Morocco. Record lows in offshore wind power tenders in Denmark and the Netherlands brought Europe's industry closer to its goal to produce offshore wind power more cheaply than coal by 2025.

■ **2016 was the third year in a row where global energy-related CO_2 emissions from fossil fuels and industry remained stable despite a 3% growth in the global economy and an increased demand for energy**. This can be attributed primarily to the decline in coal consumption, but also to the growth in renewable energy capacity and to improvements in energy efficiency. The decoupling of economic growth and CO_2 emissions is an important first step towards achieving the steep decline in emissions necessary for holding global temperature rise well below 2 degrees Celsius (°C).

■ **The myth that fossil and nuclear power are needed to provide "baseload" electricity supply when the sun isn't shining or the wind isn't blowing has been shown to be false**. In 2016, Denmark and Germany successfully managed peaks of 140% and 86.3%, respectively, of electricity generation from renewable sources, and in several countries (Portugal, Ireland and Cyprus, for example), achieving annual shares of 20-30% electricity from variable renewables without additional storage is becoming feasible. The key lesson for integrating large shares of variable renewable generation is to ensure maximum flexibility in the power system.

■ **There has been an upsurge in cities, states, countries and major corporations committing to 100% renewable energy targets** because it makes economic and business sense, quite apart from climate, environment and public health benefits. In 2016, 34 additional businesses joined RE100, a global initiative of businesses committed to sourcing their operations with 100% renewable electricity. Throughout 2016, the number of cities across the globe committed to transitioning to 100% renewable energy – in total energy use or in the electricity sector – continued to grow, and some cities and communities already have succeeded in this goal (for example, in more than 100 communities in Japan). Under the Covenant of Mayors for Climate & Energy, more than 7,200 communities with a combined population of 225 million people are committed to reducing emissions 40% by 2030, by increasing energy efficiency and renewable energy deployment. And it is not only corporations and sub-national actors that are looking to go 100% renewable. At the climate conference in Marrakesh, Morocco in November 2016, the leaders of 48 developing nations committed to work towards achieving 100% renewable energy supply in their respective nations.

■ **A paradigm shift is under way in the developing world**, where billions of people still live without access to electricity (around 1.2 billion) and/or clean cooking facilities (around 2.7 billion). The cumbersome process of providing electricity access through grid extension alone is becoming obsolete as new business models and technologies enable the development of off-grid markets. Markets for both mini-grids and stand-alone systems are evolving rapidly. Bangladesh, with 4 million units installed, has the largest solar home system market using mainly microcredit schemes. Pay-As-You-Go (PAYG) business models, supported by mobile technology (for example, the use of mobile phones for bill paying), are exploding. In 2012, investments in PAYG solar companies amounted to only USD 3 million; by 2016 that figure had risen to USD 223 million (up from USD 158 million just one year before). This trend started in East Africa and is quickly spreading to West Africa, as well as to South Asia. The mini-grid market now exceeds USD 200 billion annually. In 2016, more than 23 MW of solar PV and wind power based mini-grid projects were announced.

■ **The notion that renewable energy is something that only rich countries can afford is not valid**. Most new renewable energy capacity is being installed in developing countries, mainly in China, which has been the single largest developer of new renewable power and heat for the past eight years. With a solar revolution taking off in India, and with 48 developing countries now committed to 100% renewable energy goals, the developing country share of total global renewable energy capacity is likely to increase further. Moreover, in 2015 developing and emerging economies overtook industrialised countries in renewable energy investment for the first time (although industrialised countries retook the lead in 2016, despite the fact that China remained the single largest investor). The myth that renewable energy is too expensive, or that only a handful of rich countries continue to lead the way, has been discredited. In many cases, renewable power is now the least-cost option.

■ **Even in the transport sector, which arguably faces the greatest challenges in transitioning to a renewable energy future, major changes are under way**. Although policy support for renewable energy use in the transport sector continues to focus primarily on biofuel blends, policies to encourage the purchase of electric vehicles (EVs) are emerging. This is starting to pay off: global deployment of EVs for road transport, and particularly passenger vehicles, has grown rapidly in recent years. In 2016, global passenger EV sales reached an estimated 775,000 vehicles, and more than 2 million of the vehicles were on the world's roads by year's end.

Direct links between renewable energy and EVs, however, remain limited; many, if not most, EVs are still powered by nuclear and fossil fuel-generated electricity, with the exception of Norway where EVs run on hydropower. There are promising signs nonetheless. Car sharing companies in the United Kingdom and the Netherlands, for example, have begun offering provisions to charge vehicles with renewable electricity. And as the share of renewables in grid power increases, so will the share of renewables in electrified transport, illustrating that systemic planning and policy design is needed to link the power and transport sectors.

With regard to rail transport, which accounts for about 2% of the total energy used in the transport sector, renewables also are starting to enter the game. A number of railways implemented new projects in 2016 to generate their own electricity from renewables (e.g., wind turbines on railway land and solar panels on railway stations), notably in India and Morocco.

■ **Despite slow progress in the heating and cooling sector, there have been some positive developments**. The use of solar process heat continued to increase in the food and beverage industry as well as in the mining industries, and has expanded into other industries as well. Solar thermal is being incorporated into district heating systems at significant scales, with several large projects in some European countries, with Denmark currently in the lead. Several European Union (EU) countries also have expanded use of geothermal district heating plants, and interest is growing in the use of district heating to provide flexibility to power systems, by converting renewable electricity into heat.

■ **Finally, enabling technologies are facilitating and advancing the deployment of renewable energy** (and are discussed in the GSR for the first time in 2017 given their increasingly important role). ICT (information and communication technology), storage systems, EVs and heat pumps – to name a few – are facilitating and advancing the deployment of renewable energy. Even though these technologies were not developed for this purpose originally, they are showing tremendous capacity to facilitate greater system integration and more effective demand response.

Storage, in particular, is starting to receive a lot of attention, given its potential for providing additional flexibility to the power system. It is taking off in a limited number of markets, but it is still small in scale. In 2016, approximately 0.8 GW of new non-pumped energy storage capacity became operational – mostly consisting of battery (electrochemical) storage but also some CSP thermal storage capacity – bringing the year-end total to an estimated 6.4 GW. This amount complements an estimated 150 GW of pumped storage capacity in operation worldwide. Most of the growth took place in battery (electro-chemical) storage, with innovations being driven largely by the EV industry. Storage systems increasingly are being integrated into large-scale utility projects, and are being used by homeowners to store electricity generated by rooftop solar PV systems.

DRIVERS FOR RENEWABLE ENERGY DEPLOYMENT

Mitigation of climate change has been the primary rationale behind calls for a 100% renewable energy future. But the CO_2 reduction benefit of renewables is by no means the only driver for their deployment.

In many countries, **reducing local air pollution** – and the health problems that it causes – is a key driver. China, for example, announced in early 2017 that it would invest CNY 2.5 trillion (USD 360 billion) in renewables by 2020, due largely to the massive air pollution problems in major Chinese cities caused by coal-fired power plants.

Energy security is another important driver. Senior officials in the US military, for example, have called for increased use of renewable power and fuels as a matter of national security, and for the security of the military's own operations. Energy security also is being considered more widely in the context of increasing energy system resilience in the face of anticipated climate change impacts.

Costs of some renewable technologies are coming down quickly, particularly in the power sector. Innovations in solar PV manufacturing and installation, improvements in wind turbine materials and designs, and advances in thermal energy storage for CSP – to name a few – have contributed to overall cost reductions. In many countries, renewables are now cost-competitive with new fossil fuel and nuclear sources, and even more so if distorting subsidies are taken into account (renewables receive only one-quarter of the subsidies given to fossil fuels).

Finally deployment of renewables creates **local value and jobs**. With economies around the world facing low growth, the renewable energy sector offers a way to increase income, improve trade balances, contribute to industrial development and create jobs. Analysis shows that countries with stable renewable energy policy frameworks benefit most from the local value that this sector generates.

"In 2016 investors were able to acquire more renewable energy capacity for less money."

BUT THE TRANSITION IS NOT HAPPENING FAST ENOUGH

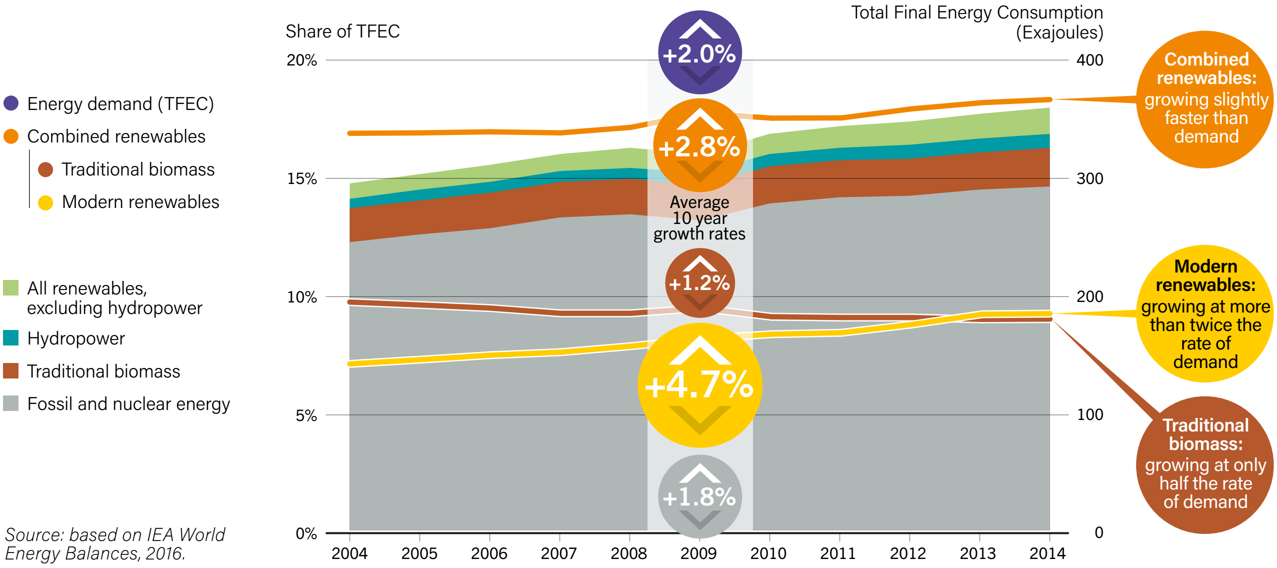
Despite these positive trends, the pace of the transition is not on track to achieve the goals established in the ground-breaking Paris Agreement adopted in December 2015. The Paris Agreement commits governments collectively to keep global temperature rise well below 2°C compared with pre-industrial levels, with the aim of holding it to a safer limit of 1.5°C. To this end, during 2016, 117 countries adopted Nationally Determined Contributions (NDCs), 55 of which featured renewable energy targets and 107 of which featured energy efficiency targets. Yet the sum total of national pledges would take us well over the 2°C threshold, with best estimates ranging between 2.3°C and 3.5°C.

With the right policies in place, the power sector could be emissions-free by mid-century. But the distinction between "electricity" and "energy" often is confused in the public discourse; the energy market actually comprises three major segments: electricity, transport, and heating and cooling. And progress in the transport and heating and cooling sectors lags well behind the tremendous growth of renewables in the power sector.

The Sustainable Energy for All (SEforALL) initiative aims at providing sustainable energy access for all people, doubling the share of renewables (from 18% in 2010 to 36% by 2030) and doubling the global rate of improvement in energy efficiency by 2030 (over 2010 levels). Put simply, a renewable energy future will not be achievable in the absence of dramatic improvements in energy efficiency. Fortunately, energy efficiency measures implemented over the last 25 years have saved an amount of energy equivalent to the total current demand of China, India and Europe combined. From 1990 to 2014, global primary energy intensity declined at an average annual rate of 1.5%, and by 2015 energy intensity was more than 30% lower than it was in 1990.

In 2015 – the latest year for which data were available at the time of GSR publication – global primary energy intensity improved 2.6% over the previous year, bringing the average annual rate of improvement between 2010 and 2015 to 2.1%. This was an important achievement, but energy intensity will need to be improved by 2.6% annually (on average) starting in 2017 if the SEforALL energy efficiency goal is to be met. For every year we lag behind this average rate, we will need to compensate with even higher rates of improvement in future years.

Share of Renewable Energy in Total Final Energy Consumption (TFEC), 2004-2014



Source: based on IEA World Energy Balances, 2016.

RENEWABLE ENERGY INDICATORS 2016

		2015	2016
INVESTMENT			
New investment (annual) in renewable power and fuels[1]	billion USD	312.2	**241.6**
POWER			
Renewable power capacity (total, not including hydro)	GW	785	**921**
Renewable power capacity (total, including hydro)	GW	1,856	**2,017**
Hydropower capacity[2]	GW	1,071	**1,096**
Bio-power capacity	GW	106	**112**
Bio-power generation (annual)	TWh	464	**504**
Geothermal power capacity	GW	13	**13.5**
Solar PV capacity	GW	228	**303**
Concentrating solar thermal power capacity	GW	4.7	**4.8**
Wind power capacity	GW	433	**487**
HEAT			
Solar hot water capacity[3]	GW_{th}	435	**456**
TRANSPORT			
Ethanol production (annual)	billion litres	98.3	**98.6**
Biodiesel production (annual)	billion litres	30.1	**30.8**
POLICIES			
Countries with policy targets	#	173	**176**
States/provinces/countries with feed-in policies	#	110	**110**
States/provinces/countries with RPS/quota policies	#	100	**100**
Countries with tendering/public competitive bidding[4]	#	16	**34**
Countries with heat obligation/mandate	#	21	**21**
States/provinces/countries with biofuel mandates[5]	#	66	**68**

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

[2] The GSR 2016 reported a global total of 1,064 GW of hydropower capacity at end-2015. The value of 1,071 GW shown here reflects the difference between end-2016 capacity (1,096 GW) and new installations in 2016 (25 GW). Differences are explained in part by uncertainty regarding capacity retirements and plant repowering each year. Note also that the GSR strives to exclude pure pumped storage capacity from hydropower capacity data.

[3] Solar hot water capacity data include water collectors only. The number for 2016 is a preliminary estimate.

[4] Data for tendering/public competitive bidding reflect all countries that have held tenders at any time up through the year of focus.

[5] Biofuel policies include policies listed both under the biofuels obligation/mandate column in Table 3 (Renewable Energy Support Policies) and in Reference Table R25 (National and State/Provincial Biofuel Blend Mandates).

Note: All values are rounded to whole numbers except for numbers <15, biofuels and investment, which are rounded to one decimal point.

AND NOT AS FAST AS IS POSSIBLE

Investments Were Down

Although global investment in new renewable power and fuel capacity was roughly double that in fossil fuels, investments in new renewable energy installations (not including hydropower larger than 50 MW) were down 23% compared to 2015. Among developing and emerging countries, renewable energy investment fell 30%, to USD 116.6 billion, while that of developed countries fell 14% to USD 125 billion. The overall lower level of investment in 2016 was due largely to the slowdowns in the Chinese and Japanese markets and in other emerging economies, notably India and South Africa (the latter due mainly to a delay in renewable energy auctions).

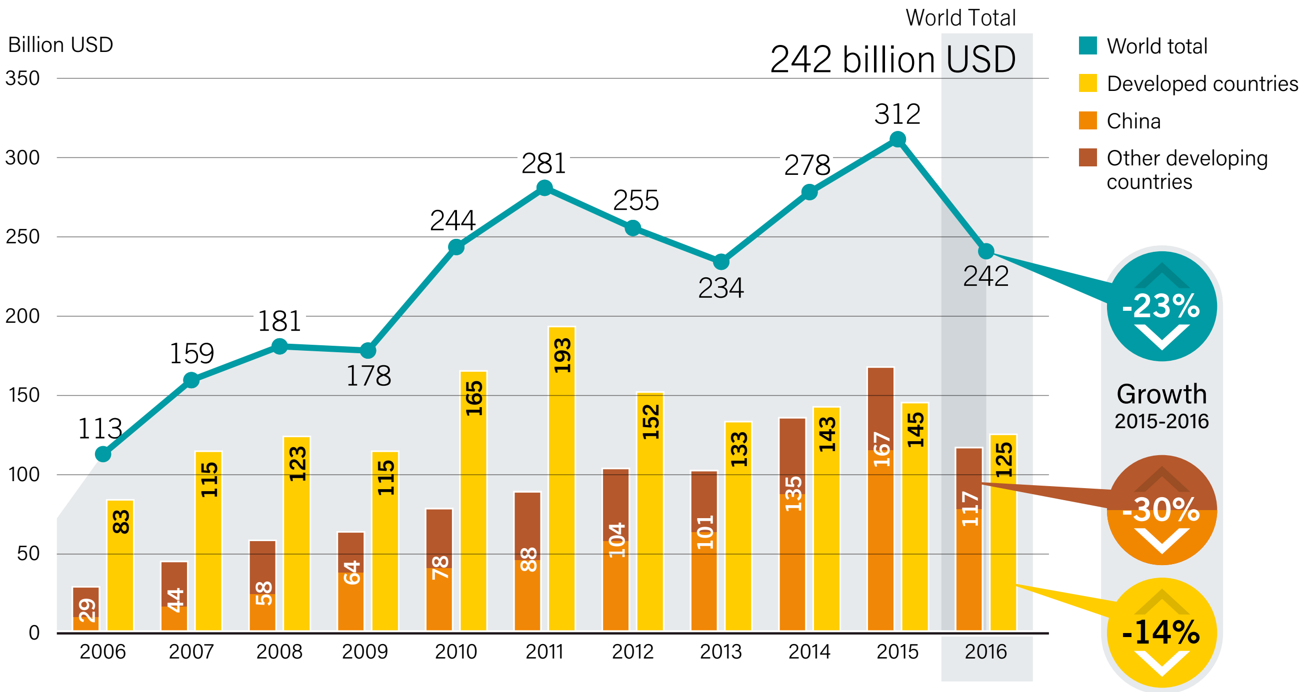
China is still responsible for the largest level of investment (32% of all financing of renewable energy worldwide, excluding hydropower projects larger than 50 MW). But following a record level of investment in 2015, investments in 2016 were diverted in part to grid improvements and to reforms in the power market in order to better utilise existing renewable energy resources. In January 2017 the Chinese government announced that it would spend USD 360 billion through 2020, reinforcing its position as the world leader in renewable energy investments.

In Japan, there was a push to develop renewable power in the wake of the 2011 Fukushima nuclear disaster. In practice, however, utilities showed resistance to this transition, and in the case of wind power, procedural delays were put into place which prevented the market from developing. A shift in policy from a generous feed-in tariff to tendering led to a nearly 70% decline in investment in small-scale, renewable power capacity in 2016.

Slow Progress in Heating and Cooling

As noted earlier, the heating and cooling sector lags far behind the power sector in the renewable energy transition. Energy used for heat (water and space heating, cooking and industrial processes) accounted for more than one-half of total world final energy consumption in 2016, of which renewables comprised around 25%. But more than two-thirds of the renewable share consists of traditional biomass (used predominantly in the developing world for cooking and heating), which often is harvested unsustainably and is highly polluting and damaging to health when burned inefficiently. More than 4 million people die prematurely from illness attributable to household air pollution from cooking with solid fuels. Heat supplied by modern renewable energy sources is used largely for industrial purposes (56%).

Global New Investment in Renewable Power and Fuels, Developed, Emerging and Developing Countries, 2006-2016



Note: Figure does not include investment in hydropower projects larger than 50 MW. Investment totals have been rounded to nearest billion.

Source: BNEF

Space cooling, most of which is supplied by electrical appliances, accounts for only about 2% of total world final energy consumption. The demand for thermal renewable energy-based cooling technologies generally has not kept pace with the rising demand for cooling.

The deployment of renewable technologies in the heating and cooling sector remains a challenge in light of the unique and distributed nature of this market. High up-front investment costs and competition with low-cost (subsidised) fossil fuels continue to impede the deployment of renewable heat. Lack of effective policies and political will contribute to slow renewable energy uptake.

Progress also is constrained by additional factors which could be overcome with effective policy support and political will, including limited awareness of the technologies, and fossil fuel subsidies which keep fossil fuel prices artificially low. In developing countries in particular, despite significant potential for the use of renewables in heating, the lack of installation know-how remains an important barrier, particularly for industrial-scale heat.

Transport – Especially Aviation and Shipping – Lags Behind in the Renewable Energy Transition

The scaling-up of renewables in the transport sector is slow. Despite some progress – in particular rapid development of the EV market – oil products still account for around 93% of final energy consumption in transport. The international community focused increased attention on decarbonisation of the transport sector following the adoption of the Paris Agreement, but only 22 of the NDCs refer specifically to renewable energy in the transport sector, and only 2 of these (Niue and New Zealand) reference the need for EVs to be powered by renewable energy.

Efficiency, optimisation and switching modes of transport – i.e., from individual cars to mass transit – are key levers for decarbonising the transport sector. Renewables-based decarbonisation of the transport sector, however, is not yet being seriously considered, or seen as a priority.

Barriers to electrification in the road transport sector continue to include relatively high EV vehicle costs, perceived limits to range and battery life, and a lack of charging infrastructure. In the developing world, additional barriers relate to the lack of a robust electricity supply. Moreover, the focus in developing countries often is to establish basic transport infrastructure. While this is clearly a genuine need, renewable energy-based solutions should be integrated in planning processes (which often is not the case currently).

With regard to rail transport, the renewable electricity share in the total energy mix of the world's railways increased from 3.4% in 1990 to around 9% in 2013, with some countries reaching much higher penetrations. While urban rail infrastructure and service are already largely electrified, the electrification of long-distance rail requires major infrastructure change and related financing.

Biofuels will be needed increasingly not only for road transport, but also for shipping and aviation, as these sectors are difficult to electrify. Fuels need to be adapted for each of these applications and for different types of engines. Despite continued strong interest in the development of aviation biofuels, the quantities produced in 2016 remained relatively small and mostly for demonstration use. Likewise, biofuel production for maritime use is in its infancy.

At the international level, the International Civil Aviation Organization agreed in 2016 to establish a global market-based measure to reduce CO_2 emissions from aviation, including specifications for advances in the production and use of sustainable aviation fuel; however, progress in decarbonising the aviation sector is moving very slowly. The shipping sector also has yet to address its emissions. Even with lower carbon intensity of individual ships, global emissions will keep increasing with growing global trade and transport services.

Nonetheless, a number of significant developments emerged in 2016. Some governments, mostly in Europe, began looking at medium- to long-term strategies to decarbonise the transport sector, often involving long-term structural changes; many also considered or developed strategies to more closely link the transport and electricity sectors. Germany's climate action plan, developed in 2016, aims to reduce emissions in transport 40-42% by 2030, with a longer-term objective of fully decarbonising the sector.

Fossil Fuel Subsidies Continue to Impede Progress Overall

Finally, a major barrier to the rapid uptake of renewables more generally is the continued subsidising of fossil fuels (and nuclear power), despite many international commitments to phase them out. By the end of 2016 more than 50 countries had committed to phasing out fossil fuel subsidies, and some reforms have occurred, but not enough. In 2014 the ratio of fossil fuel subsidies to renewable energy subsidies was 4:1. In other words, for every USD 1 spent on renewables, governments spent USD 4 perpetuating our dependence on fossil fuels. This is distorting the market in very unproductive ways.

TOP FIVE COUNTRIES

Annual Investment / Net Capacity Additions / Production in 2016

	1	2	3	4	5
Investment in renewable power and fuels (not including hydro > 50 MW)	**China**	United States	United Kingdom	Japan	Germany
Investment in renewable power and fuels per unit GDP[1]	**Bolivia**	Senegal	Jordan	Honduras	Iceland
Geothermal power capacity	**Indonesia**	Turkey	Kenya	Mexico	Japan
Hydropower capacity	**China**	Brazil	Ecuador	Ethopia	Vietnam
Solar PV capacity	**China**	United States	Japan	India	United Kingdom
Concentrating solar thermal power (CSP) capacity[2]	**South Africa**	China	–	–	–
Wind power capacity	**China**	United States	Germany	India	Brazil
Solar water heating capacity	**China**	Turkey	Brazil	India	United States
Biodiesel production	**United States**	Brazil	Argentina/Germany/Indonesia		
Fuel ethanol production	**United States**	Brazil	China	Canada	Thailand

Total Capacity or Generation as of End-2016

	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	Japan	India
Renewable power capacity *per capita* (not including hydro[3])	**Iceland**	Denmark	Sweden/Germany		Spain/Finland
Bio-power generation	**United States**	China	Germany	Brazil	Japan
Geothermal power capacity	**United States**	Philippines	Indonesia	New Zealand	Mexico
Hydropower capacity[4]	**China**	Brazil	United States	Canada	Russian Federat.
Hydropower generation[4]	**China**	Brazil	Canada	United States	Russian Federat.
CSP capacity	**Spain**	United States	India	South Africa	Morocco
Solar PV capacity	**China**	Japan	Germany	United States	Italy
Solar PV capacity *per capita*	**Germany**	Japan	Italy	Belgium	Australia/Greece
Wind power capacity	**China**	United States	Germany	India	Spain
Wind power capacity *per capita*	**Denmark**	Sweden	Germany	Ireland	Portugal
HEAT					
Solar water heating collector capacity[5]	**China**	United States	Turkey	Germany	Brazil
Solar water heating collector capacity *per capita*[5]	**Barbados**	Austria	Cyprus	Israel	Greece
Geothermal heat capacity[6]	**China**	Turkey	Japan	Iceland	India
Geothermal heat capacity *per capita*[6]	**Iceland**	New Zealand	Hungary	Turkey	Japan

[1] Countries considered include only those covered by Bloomberg New Energy Finance (BNEF); GDP (at purchasers' prices) data for 2015 from World Bank. BNEF data include the following: all biomass, geothermal and wind power 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 (small-scale capacity) estimated separately; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more. Small-scale capacity data used to help calculate investment per unit of GDP cover only those countries investing USD 200 million or more.

[2] Only two countries brought CSP plants online in 2016, which is why no countries are listed in places 3, 4 and 5.

[3] Per capita renewable power capacity (not including hydropower) ranking based on data gathered from various sources for more than 70 countries and on 2015 population data from World Bank.

[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] Solar water heating collector rankings for total capacity and per capita are for year-end 2015 and are based on capacity of water (glazed and unglazed) collectors only. Data from International Energy Agency Solar Heating and Cooling Programme. Total capacity rankings are estimated to remain unchanged for year-end 2016.

[6] 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 basis of per capita, national GDP or other, the rankings would be different for many categories (as seen with per capita rankings for renewable power not including hydropower, solar PV, wind power, solar water collector and geothermal heat capacity).

HOW TO SPEED THE TRANSITION

1) Fossil fuels must be left in the ground if the world is serious about meeting its climate commitments.

China announced in January 2017 that it was cancelling more than 100 coal-fired power plants currently in development, and then announced in May that it was suspending the construction of new coal plants in 29 out of 32 provinces. These measures demonstrate how quickly change can happen when there is the political will to do so. Phasing out coal in favour of renewables (combined with increasing energy efficiency) would be the single most cost-effective way to reduce CO_2 emissions, with added benefits for health.

As governments get serious about addressing climate change, the risk that coal and other fossil fuel investments could become stranded assets is increasing.

2) Rather than investing in fossil or nuclear "baseload" power, efforts should focus on developing dispatchable renewable energy and mobilising flexibility options to manage higher shares of variable renewables.

How to do this varies depending on local circumstances: whether demand for power is stable and the grid is well-developed (and inter-connected); whether demand is increasing and supply is being augmented with greater shares of wind and solar power; whether there is already a surplus of supply so that on cloudy or windless days the system can continue to operate normally; whether demand is increasing rapidly (as in many developing countries) but the basic system is not yet well developed; and so forth.

In developing countries, with effective planning, a package of complementary measures can be designed for maximum flexibility at the outset. For existing systems, flexibility measures can include: managing shorter trading times; matching demand more carefully with supply; establishing grid interconnections; investing in storage solutions; utilising automation technologies; and planning for sectoral integration (for example, by charging EVs during the day to take advantage of power produced from solar PV and wind power plants that exceeds electricity demand).

In general, policies should be developed that support and integrate coupling among the power, transport, and heating and cooling sectors. This requires that planning be conducted across sectors and across government departments and ministries. Policy design should be done in close dialogue with the public and private sectors, and policies at different levels of government should be complementary and mutually reinforcing.

3) As efforts intensify to provide modern energy services to the billions of people who lack access, it is crucial that renewable energy and enabling technologies aimed at maximum system flexibility are prioritised, and that the most energy-efficient technologies are utilised.

There should be increased support for distributed renewable energy technologies as well as more attention to developing national policies that serve to strengthen local capacity, particularly in the heating and cooling sector given its large reliance on local resources. In 2015, financing for energy access and distributed renewable energy programmes accounted for less than 16% of all energy investments (USD 3.1 billion out of USD 17.4 billion of total investment). Given the urgency of achieving energy access for all, investment in these areas should be increased dramatically.

Moreover, governments should create an enabling environment that allows businesses to seize opportunities, particularly in serving people who otherwise might not gain access. It is essential that governments eliminate a range of barriers that hinder further development, including (among other things): policy and energy planning uncertainty; lack of access to finance for both companies and consumers; subsidies for kerosene and diesel, which disadvantage renewable alternatives; fiscal and import barriers, which serve to increase prices (for example, import tariffs and value-added tax); scarcity of information and assurance for investors; and the lack of product standards to ensure the quality and reliability of products.

KEY PLAYERS DRIVING THE RENEWABLE ENERGY TRANSITION

While many renewable energy pioneers – including the United States and several countries in Europe – continue to play an important role in the renewable energy transition, new key players have emerged:

Emerging economies: China is the world's renewable energy heavyweight champion, having been the single largest developer of renewable power and heat for the past eight years. In 2016, an ever-growing number of developing countries continued to expand their renewable energy capacities, and some are rapidly becoming important markets. Emerging economies are quickly transforming their energy industries by benefiting from lower-cost, more efficient renewable technologies and more reliable resource forecasting, making countries such as Argentina, Chile, China, India and Mexico attractive markets for investment.

Corporations: A growing number of corporations is committing to powering their operations with 100% renewable electricity. The significance of the commitment of companies such as Google and Facebook, which use massive quantities of electricity to power their data centres, should not be underestimated. By negotiating advance purchase agreements and direct investments, their renewable energy commitments have spurred billions of dollars in investments in new renewable power projects.

Cities: Cities are playing an increasingly important role in driving the renewable energy transition, whether they are doing it to meet climate change mitigation goals or to reduce local sources of air pollution or to create jobs. In 2014, cities accounted for 65% of global energy demand, and each city is faced with its own unique challenges and opportunities. Some cities consume much of their energy in the buildings and transport sectors, while in others, large industrial sectors account for the majority of energy use. Municipal policy makers can use purchasing and regulatory authority to, for example, transition public transportation fleets to renewable fuel or renewably powered EVs, install solar panels on municipal buildings, set local building codes, mandate the use of solar water heaters and enact energy efficiency standards.

MARKET AND INDUSTRY DEVELOPMENTS

Biomass energy

Global production of biodiesel recovered after a decline in 2015. There was continuing growth in bio-power production, notably in the EU and in Asia, particularly in the Republic of Korea. Use of hydrotreated vegetable oil (HVO) and biomethane in transport grew over the course of 2016. Both global bio-power capacity and generation increased by an estimated 6% in 2016, while growth in the use of modern bioenergy for heating has slowed in recent years, to around 1% per year.

Geothermal

Globally, geothermal power produced an estimated 78 terawatt-hours over the course of 2016. However, the industry continues to be burdened by the inherent high risk of exploration and project development as well as the associated lack of risk mitigation. The year ended with Indonesia and Turkey adding the bulk of new geothermal power capacity, and several countries in Europe completed new or expanded geothermal district heat systems.

Hydropower

Improved hydrological conditions in the Americas and Asia improved hydropower production. New capacity was added in a number of countries, including China, Brazil, Ecuador, Ethiopia, and Vietnam. Although China's domestic market continued to contract, it added far more capacity in 2016 than did any other country. Climate risk continues to remain a pressing concern.

Ocean energy

While more companies around the world advanced ocean energy technologies and deployed new and improved devices, the industry continues to face perennial challenges. Chief among these is financing due to relatively high risk and high upfront costs and the need for improved planning, consenting and licensing procedures.

Solar photovoltaics (PV)

Solar PV was the world's leading source of net additions to power generating capacity in 2016, with the equivalent of more than 31,000 solar panels installed hourly. At least 17 countries had enough solar PV capacity by year's end to meet 2% or more of their electricity demand, and several countries saw far higher shares. The year also saw unprecedented price reductions, particularly for modules.

Concentrating solar thermal power (CSP)

All three new CSP facilities that came online in 2016 incorporated thermal energy storage (TES), which allows them to provide dispatchable power, meaning that they can provide power at periods of peak demand. While CSP saw the lowest annual growth rate in total global capacity in 10 years, the sector is on a strong growth trajectory with as much as 900 MW expected to enter operation in 2017. CSP also is receiving increased policy support in countries with limited oil and gas reserves, constrained power networks, a need for energy storage, or strong industrialisation and job creation agendas.

Solar thermal heating and cooling

Deployment of solar thermal heating and cooling technologies continued its global expansion in 2016, with sales picking up in several new emerging markets, including Argentina, the Middle East, and parts of Eastern and Central Africa. For larger, established markets, however, 2016 was challenging for several reasons, most notably low oil and gas prices. China kept its lead, accounting for approximately 75% of global additions.

Wind power

Top turbine manufacturers had a good year in 2016, and technology innovation continued in the face of competition from low-cost natural gas and, increasingly, from solar PV. New markets continued to open around the world. By year's end, more than 90 countries were active in developing wind power projects. Offshore wind saw the first commercial projects come online in the Republic of Korea and the United States, and substantial new capacity was added in Germany, the Netherlands and China. At least 24 countries met 5% or more of their annual electricity demand with wind power in 2016, and at least 13 met more than 10%.

4) Policy matters: A system approach is needed across all sectors.

Policy support for renewables in 2016, as in past years, focused mostly on power generation, whereas policies for the heating and cooling and transport sectors has remained virtually stagnant. This has to change: strong policy support for all three pillars of the sustainable energy transition is needed if we are to achieve the goals set out in the Paris Agreement. Policy support can take many forms, at both the national and sub-national levels: targets; feed-in policies; auctions (also called competitive bidding or tenders); regulatory mandates; changes in building codes; fuel efficiency standards; and grants, loans and subsidies. Regardless of the chosen policy framework, transparency and stability are essential.

Several specific policy recommendations should be emphasised:

■ **A systemic approach:** First and foremost, as the share of renewable energy grows to significant levels in a country or region, a systemic approach will be needed. Conversations about how to integrate high shares of variable renewable energy into the power system clearly benefit from looking beyond the narrow confines of a single grid, a single country, a single city or a single sector – as many have begun to do. In a systemic approach, what constitutes a renewables-based energy system moves beyond the traditional, narrow construct of renewable energy sources (wind, solar, hydropower, etc.) to a broader definition which includes supporting infrastructure such as transmission and distribution networks; supply and demand balancing measures, including through efficiency measures and sector coupling (for example the integration of power and transport networks); and a wide range of enabling technologies. The systemic approach should become the norm in energy and infrastructure planning, financing and policy development.

■ **Power:** Many countries are shifting away from feed-in policies and replacing them with auctions aimed at deploying large-scale renewable energy projects. This approach has greatly reduced prices of renewable power, although in some cases, due to scheduling delays, it has had negative consequences, such as reducing market continuity and increasing market insecurity. The continuously delayed energy auctions in South Africa, for example, caused serious problems for the national renewables industry. It is crucial to link energy planning, policy design/formulation and industry development if such consequences are to be avoided. By taking a more strategic approach to energy planning, and ensuring the long-term predictability of auction schedules, continuous market opportunities can be created. This will help in developing a strong renewable power industry around which skills can be built and local value can be created. It also is important to support the deployment of distributed and locally owned renewable energy projects.

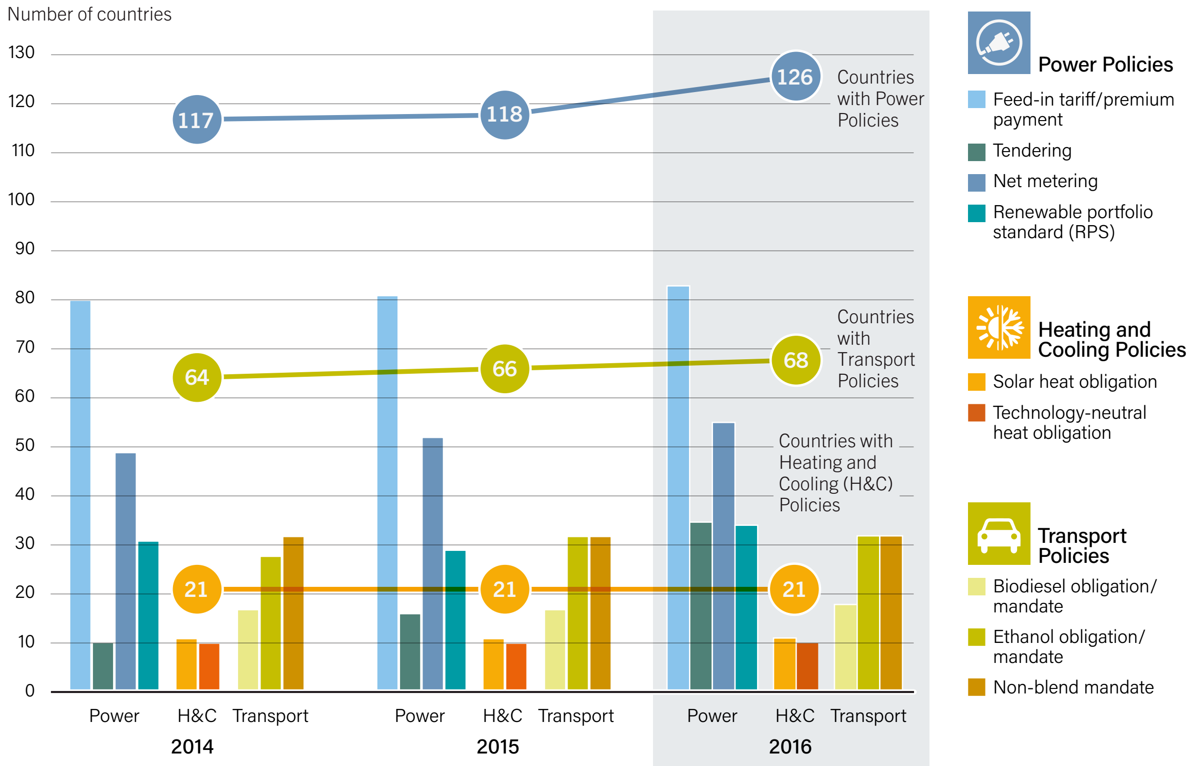
■ **Transport:** Policy support for improving the sustainability of transport traditionally has focused on increasing energy efficiency and expanding the use of biofuels (including advanced biofuels for aviation and maritime transport). Governments should set clear policies to: facilitate research and market opportunities for advancing the development of sustainable biofuels; ensure that the rapid expansion of the EV fleet is powered by renewable sources of electricity (including by integrating EVs into the suite of flexible options for incorporating higher shares of variable renewable energy into the grid); expand mandates and financial support for sustainable biofuels; and incorporate the use of advanced biofuels for aviation, rail and maritime transport in broader strategies to advance the use of bioenergy in the transport sector.

Heating and cooling: In 2016, policy makers continued to focus on financial incentives in the form of grants, loans or tax incentives as well as mandates and building codes to increase deployment of renewable heating and cooling technologies. Some countries enacted policies designed to advance technological development. In addition, some governments have used FITs and tendering mechanisms, mainly focused on the buildings sector and in many cases including links to energy efficiency. Despite positive developments in a number of countries, the renewable heating and cooling sector faced a great deal of policy uncertainty. The single most important thing that governments can do for this sector is to establish long-term policy certainty to facilitate increased investment.

Energy access: As in the power sector, an integrated process that links energy planning, policy formulation and industrial development is essential for ensuring that a range of needs can be met in the most efficient and sustainable way. Developments around distributed renewable energy show that the old paradigm of energy access through grid extension alone is becoming obsolete. To accelerate energy access, it is important that policy makers look to the future so that a stable, off-grid, decentralised market can form and the industry can develop.

A variety of policies can be used to accelerate the paradigm shift: establishing specific distributed renewable energy targets alongside electrification and renewable energy targets to be implemented within a certain time frame; integrating stand-alone solutions, in particular mini-grids, into national electrification plans; establishing a clear policy framework for accessing finance that reflects this newer approach; and measures for upholding quality standards.

Number of Renewable Energy Regulatory Incentives and Mandates, by Type, 2014-2016



Note: Figure does not show all policy types in use. In many cases countries have enacted additional fiscal incentives or public finance mechanisms to support renewable energy. Heating and cooling policies do not include renewable heat FITs (i.e., in the United Kingdom). Countries are considered to have policies when at least one national or state/provincial-level policy is in place. A country is counted a single time if it has one or more national and/or state/provincial-level policies. Some transport policies include both biodiesel and ethanol; in this case, the policy is counted once in each category (biodiesel and ethanol). Tendering policies are presented in a given year if a jurisdiction has held at least one tender during that year.

Source: REN21 Policy Database

POLICY DEVELOPMENT IN 2016

Nearly all countries adopted or had existing policies in 2016 to support the development and deployment of renewable energy technology. These included energy efficiency and renewable energy targets, direct (financial) support policies, and policies to facilitate the integration of variable renewable generation into national energy systems.

Power: Renewable energy auctions were held in 34 countries in 2016 – more than double the year before – with Malawi and Zambia holding their first auctions. Auctions are the most rapidly expanding form of support for renewable energy project deployment and are becoming the preferred policy tool for supporting deployment of large-scale projects.

Transport: As of the end of 2016, biofuel blend mandates existed in 68 countries at the national/sub-national level, with Argentina, India, Malaysia, Panama and Zimbabwe having added or revised mandates, and Denmark adopting an advanced biofuels mandate.

Heating and cooling: Several countries enacted new financial support mechanisms for renewable heating and cooling or revised existing ones, including Bulgaria, Chile, Hungary, Italy, the Netherlands, Portugal, Romania, the Slovak Republic and the United States.

Energy efficiency: By the end of 2016, at least 137 countries had enacted some kind of energy efficiency policy, including 48 countries that adopted new or revised policies during the year. New or revised energy efficiency targets also have been adopted in all regions of the globe: 149 countries have one or more energy efficiency targets in place; 56 of these countries adopted new targets since 2015.

Jobs: In some major markets, job losses followed policy changes, a decrease in investment and rising automation. Even so, global employment numbers rose due to record deployment of renewables (particularly solar PV) in 2016. The global total number of jobs in renewable energy – including large-scale hydropower – has now reached 9.8 million. Jobs in renewables excluding large-scale hydropower increased by 2.8% in 2016.

PERSISTENT CHALLENGES

Policy remains focused primarily on the power sector. At the national/sub-national level, regulatory policies in the power sector exist in nearly twice as many countries as in the transport sector, and in six times as many countries as in the heating and cooling sector.

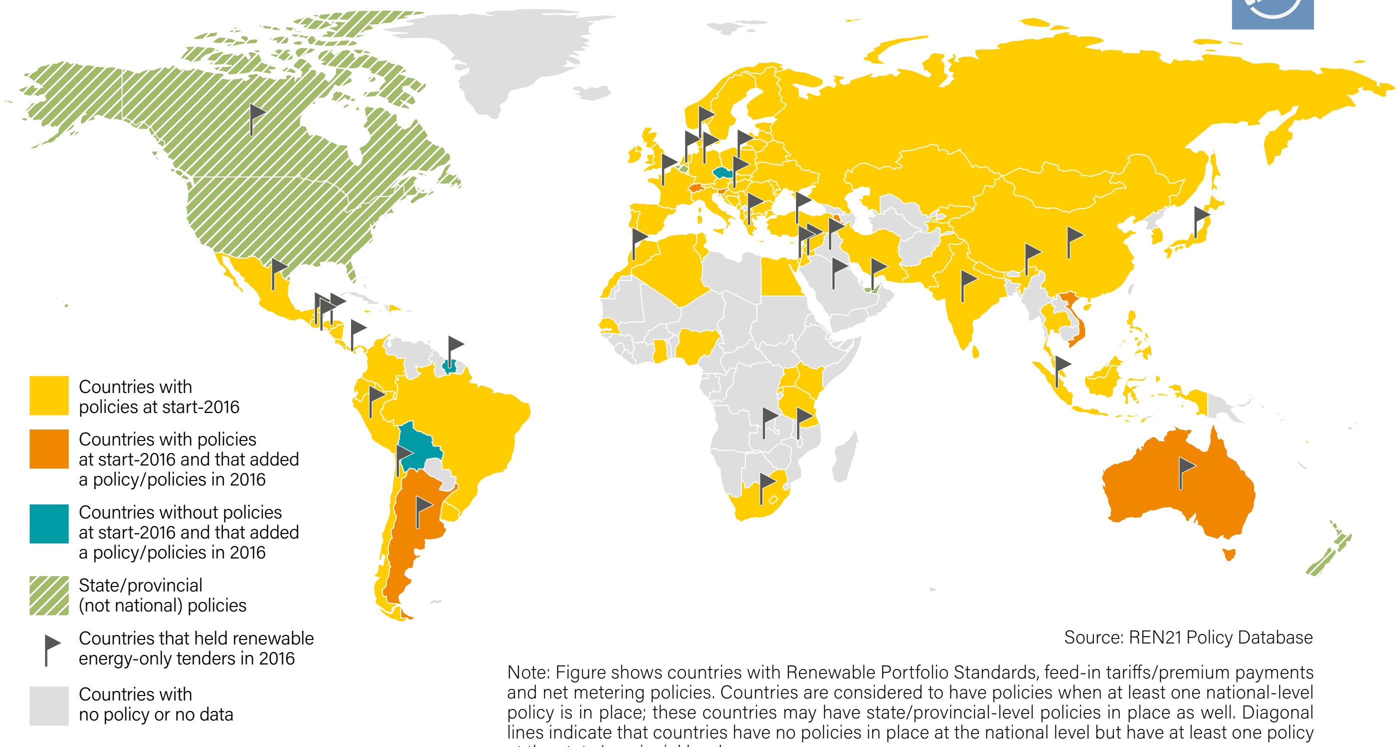
Transport: The number of countries with biofuel blending mandates has remained basically flat, with the total number of countries implementing this policy having increased by only two since 2015. Additionally, comprehensive transport policies linking renewables and EVs are not progressing rapidly.

Heating and cooling: The number of countries with renewable heating obligations remains at 21, making 2016 the third year in a row that not a single new country adopted this policy.

Energy efficiency: Although many countries have adopted energy efficiency targets, several still lack policies to achieve them, particularly in developing countries. Furthermore, policies that support energy efficiency and renewables are not sufficiently integrated globally.

POLICY LANDSCAPE 2016

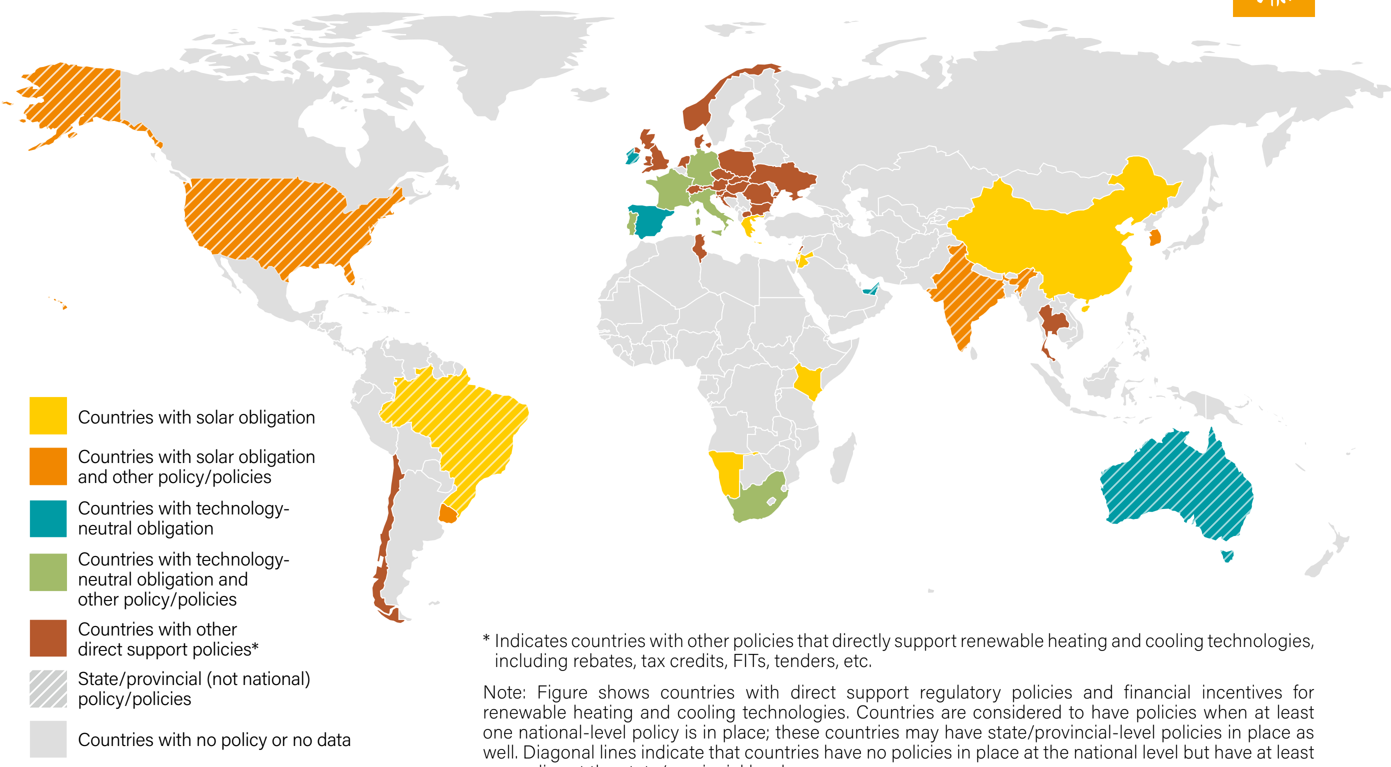
Countries with Renewable Energy Power Policies, by Type, 2016



Source: REN21 Policy Database

Note: Figure shows countries with Renewable Portfolio Standards, feed-in tariffs/premium payments and net metering policies. Countries are considered to have policies when at least one national-level policy is in place; these countries may have state/provincial-level policies in place as well. Diagonal lines indicate that countries have no policies in place at the national level but have at least one policy at the state/provincial level.

Countries with Renewable Energy Heating and Cooling Policies, 2016

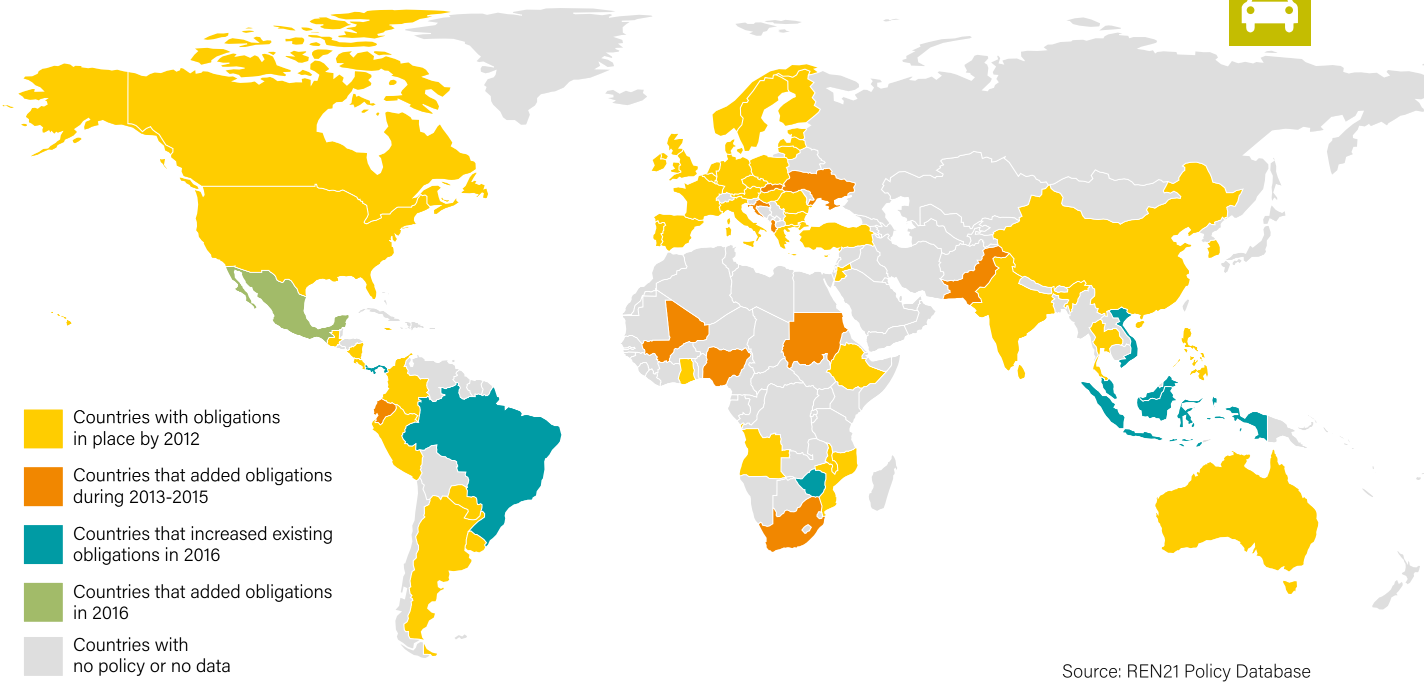


* Indicates countries with other policies that directly support renewable heating and cooling technologies, including rebates, tax credits, FITs, tenders, etc.

Note: Figure shows countries with direct support regulatory policies and financial incentives for renewable heating and cooling technologies. Countries are considered to have policies when at least one national-level policy is in place; these countries may have state/provincial-level policies in place as well. Diagonal lines indicate that countries have no policies in place at the national level but have at least one policy at the state/provincial level.

Source: REN21 Policy Database

Countries with Biofuels Obligations for Transport, 2016

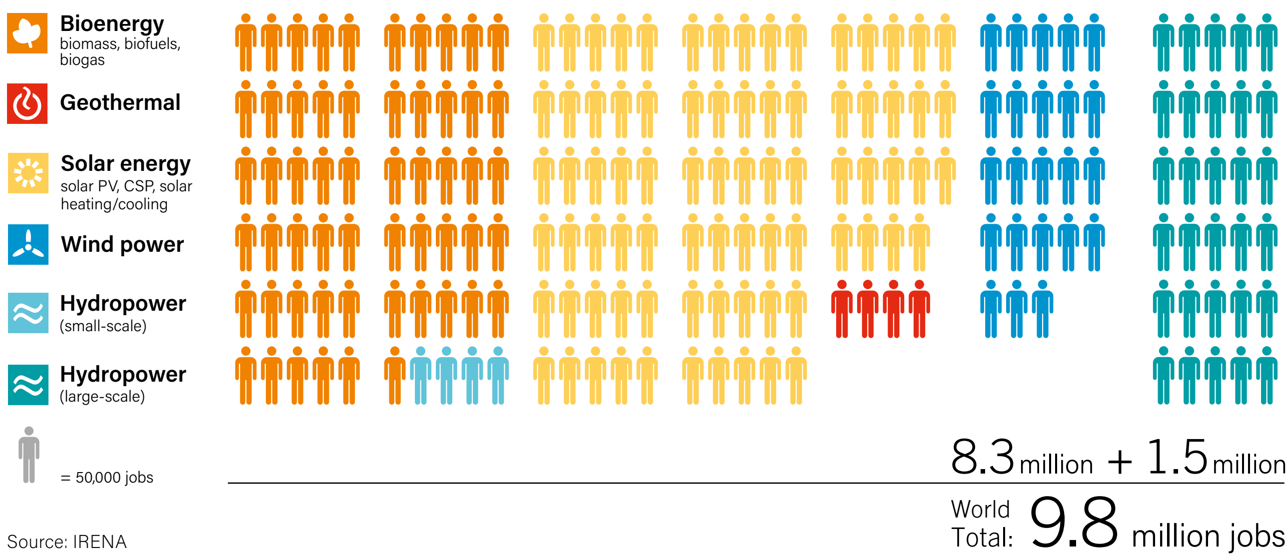


Source: REN21 Policy Database

Note: Figure shows countries with biofuels obligations in the transport sector. Countries are considered to have policies when at least one national-level policy is in place; these countries may have state/provincial-level policies in place as well. Bolivia, the Dominican Republic, the State of Palestine and Zambia added obligations during 2010-2012 but removed them during 2013-2015.

JOBS 2016

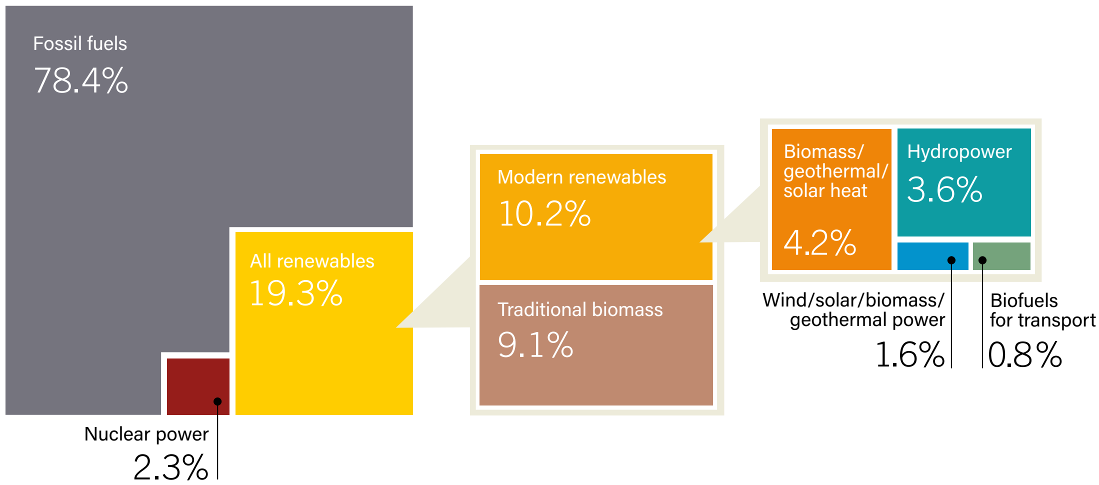
Jobs in Renewable Energy



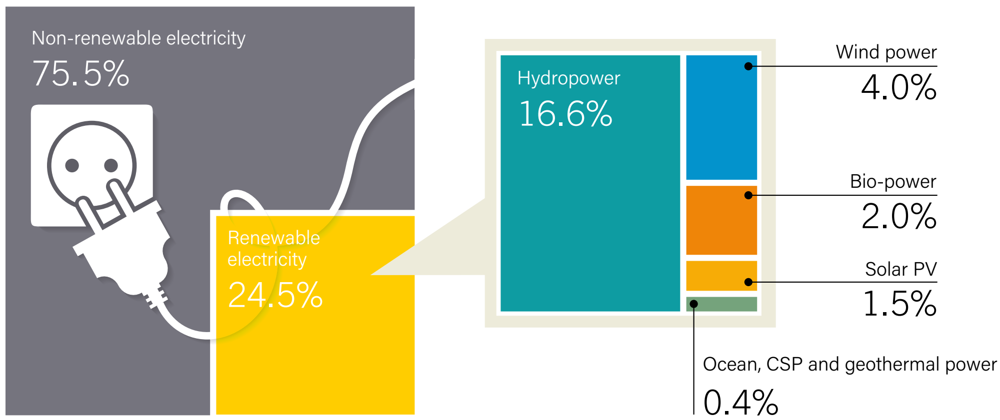
Source: IRENA

GSR 2017 KEY FIGURES

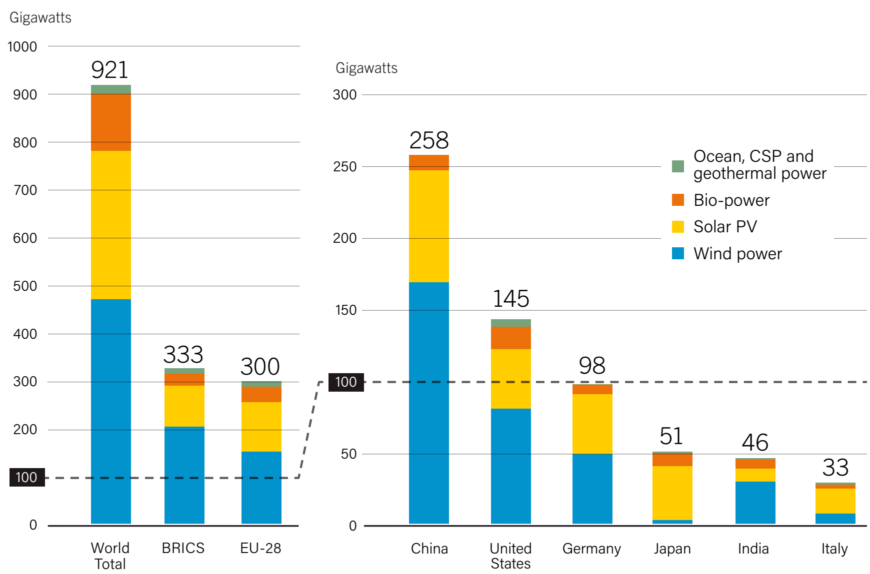
Estimated Renewable Energy Share of Total Final Energy Consumption, 2015



Estimated Renewable Energy Share of Global Electricity Production, End-2016



Renewable Power Capacities* in World, BRICS, EU-28 and Top 6 Countries, 2016

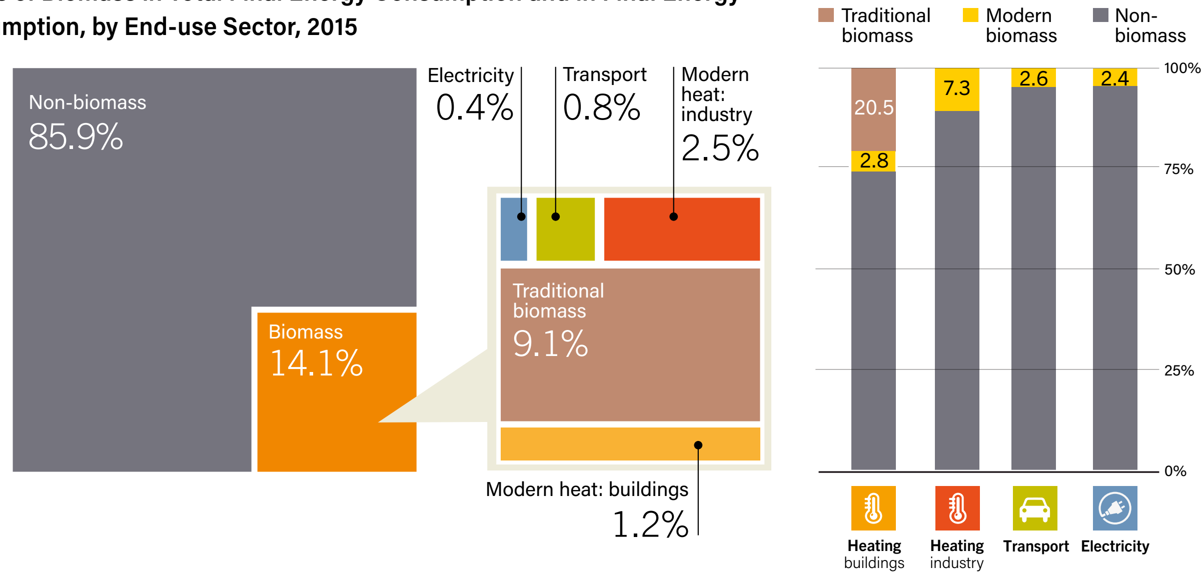


* Not including hydropower. Distinction is made because hydropower remains the largest single component by far of renewable power capacity, and thus can mask developments in other renewable energy technologies if included.

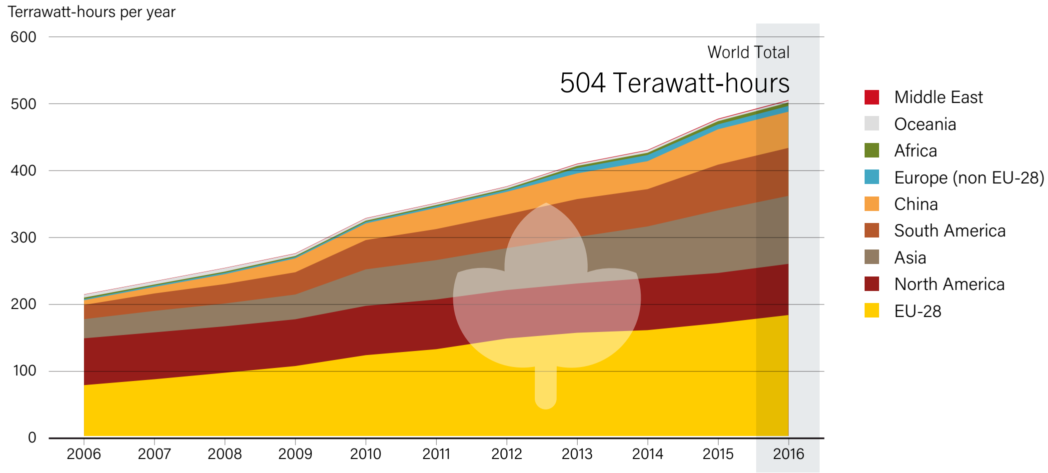
The five BRICS countries are Brazil, the Russian Federation, India, China and South Africa.

BIOMASS ENERGY

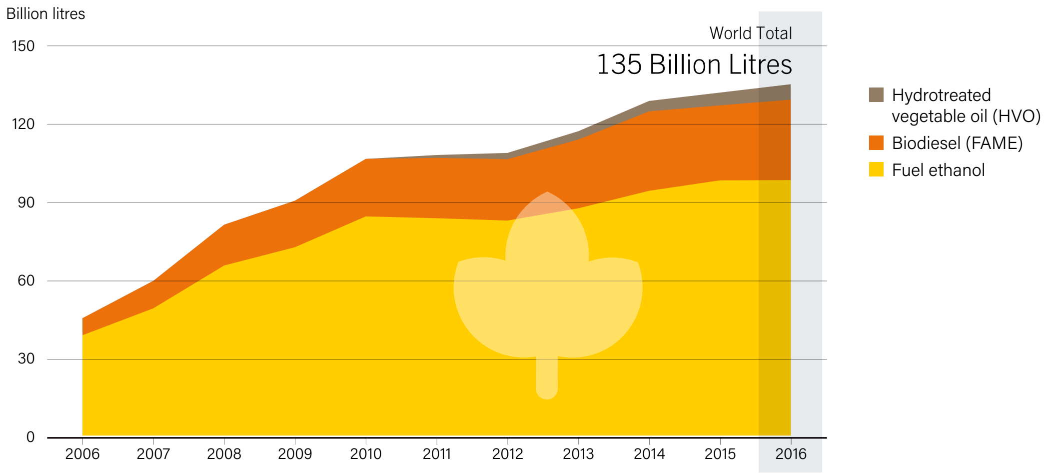
Shares of Biomass in Total Final Energy Consumption and in Final Energy Consumption, by End-use Sector, 2015



Global Bio-Power Generation, by Region, 2006-2016

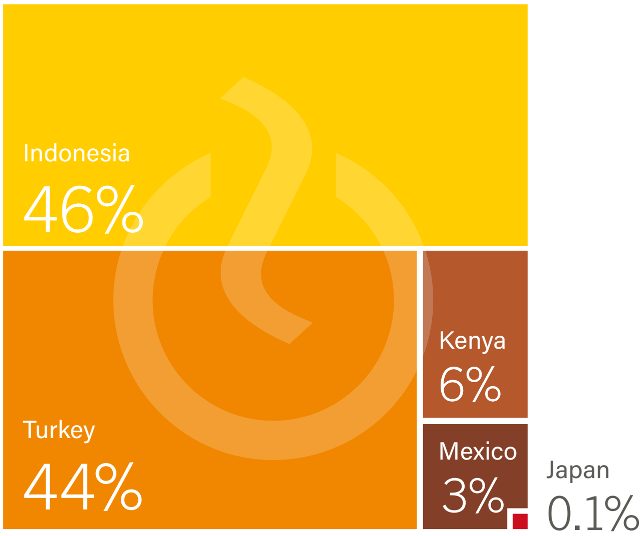


Global Trends in Ethanol, Biodiesel and HVO Production, 2006-2016

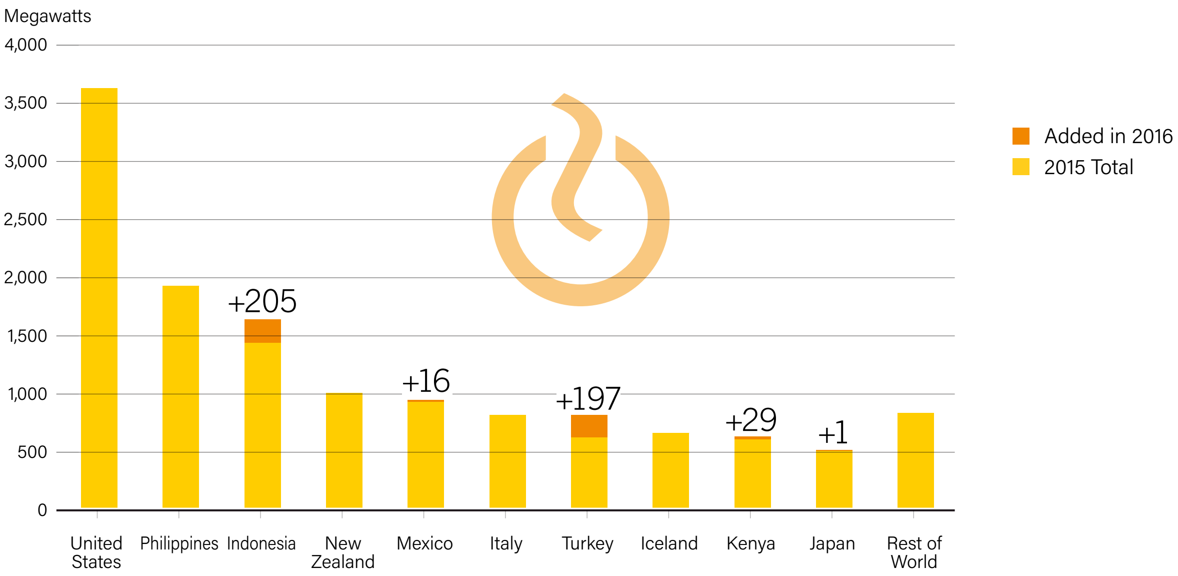


GEOTHERMAL POWER

Geothermal Power Capacity Additions, Share by Country, 2016



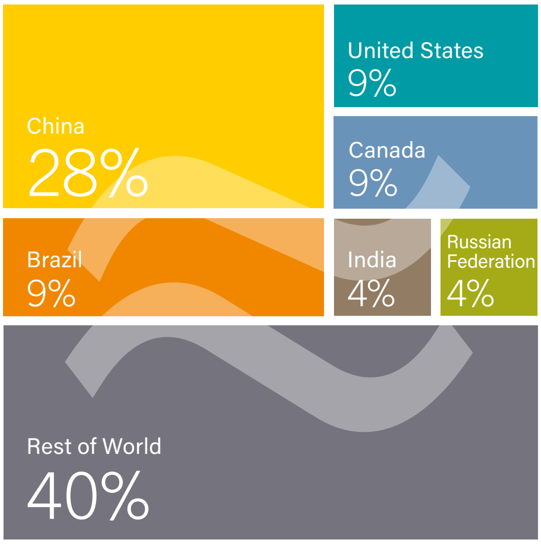
Geothermal Power Capacity and Additions, Top 10 Countries, 2016

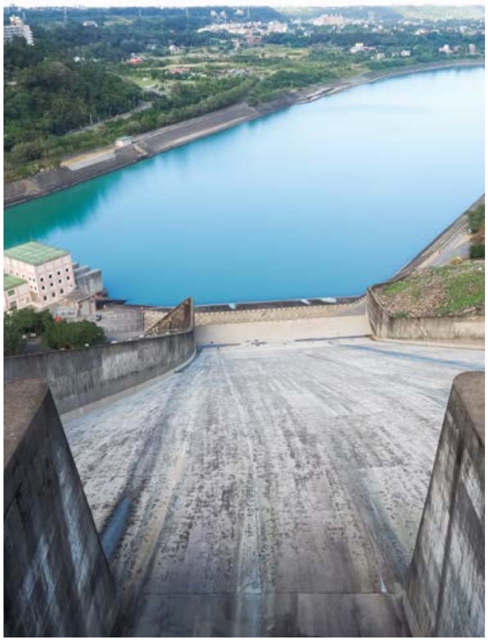


INDONESIA and TURKEY led the way for NEW GEOTHERMAL POWER installations, and EUROPE remained an active market for GEOTHERMAL HEAT.

HYDROPOWER

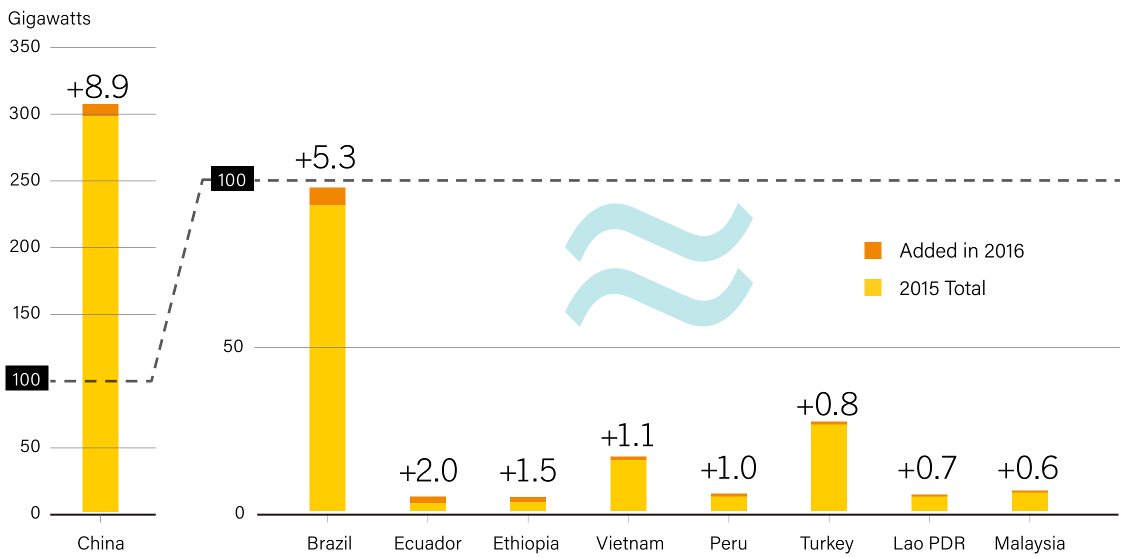
Hydropower Global Capacity,
Shares of Top 6 Countries and Rest of World, 2016





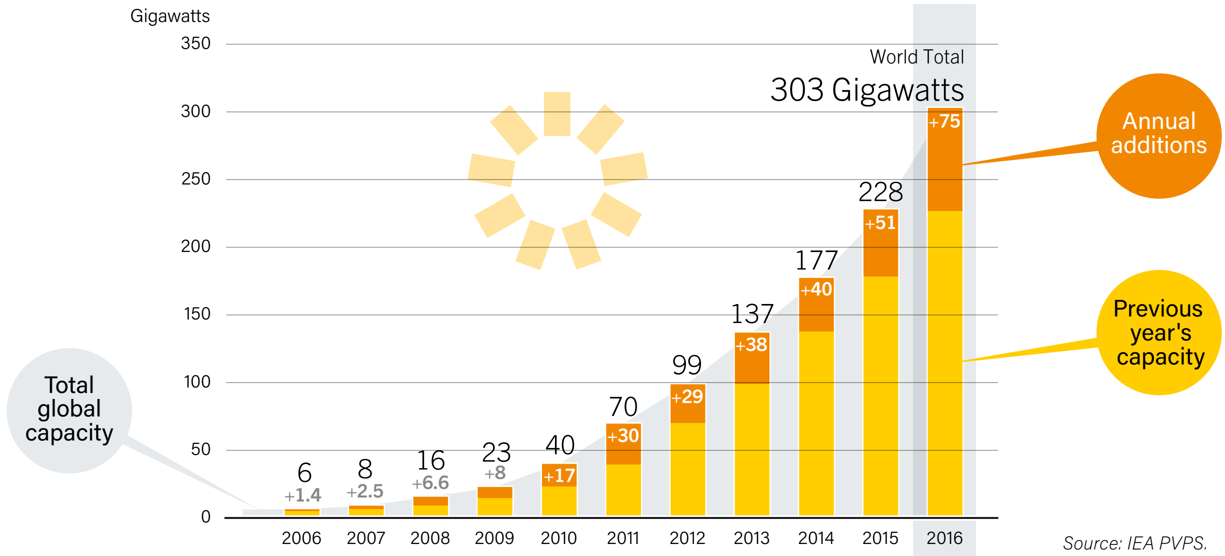
At least 25 GW of HYDROPOWER CAPACITY was commissioned, and PUMPED STORAGE grew by more than 6 GW.

Hydropower Capacity and Additions, Top 9 Countries for Capacity Added, 2016



SOLAR PV

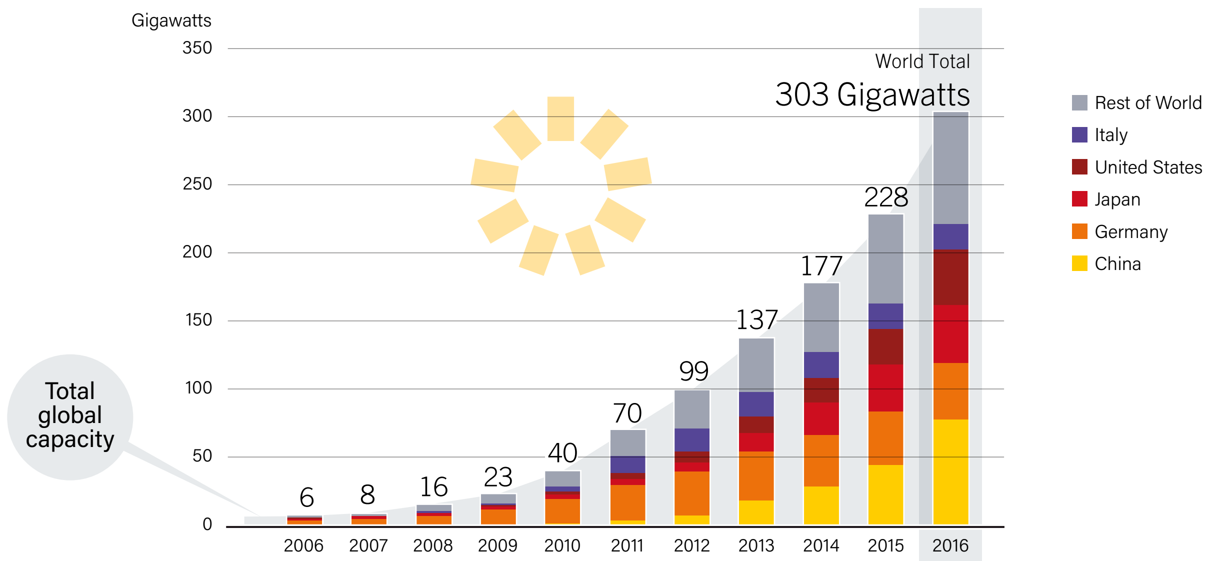
Solar PV Global Capacity and Annual Additions, 2006-2016



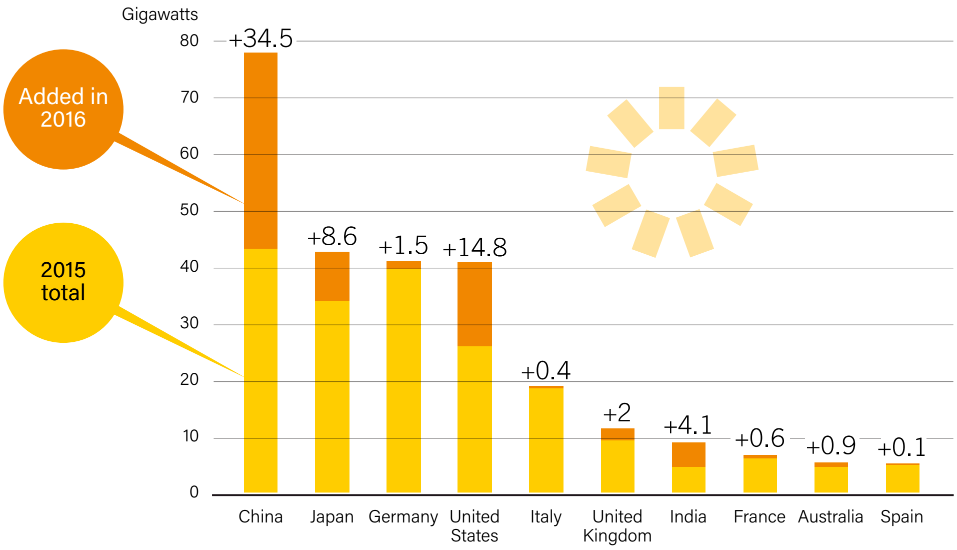
Source: IEA PVPS.

During 2016, at least **75 GW** of solar PV capacity was added worldwide – equivalent to the installation of more than **31,000 SOLAR PANELS EVERY HOUR.**

Solar PV Global Capacity, by Country and Region, 2006-2016

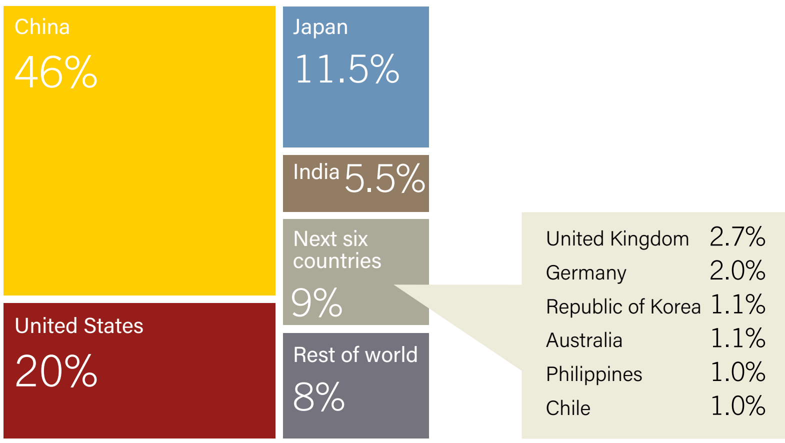


Solar PV Capacity and Additions, Top 10 Countries, 2016

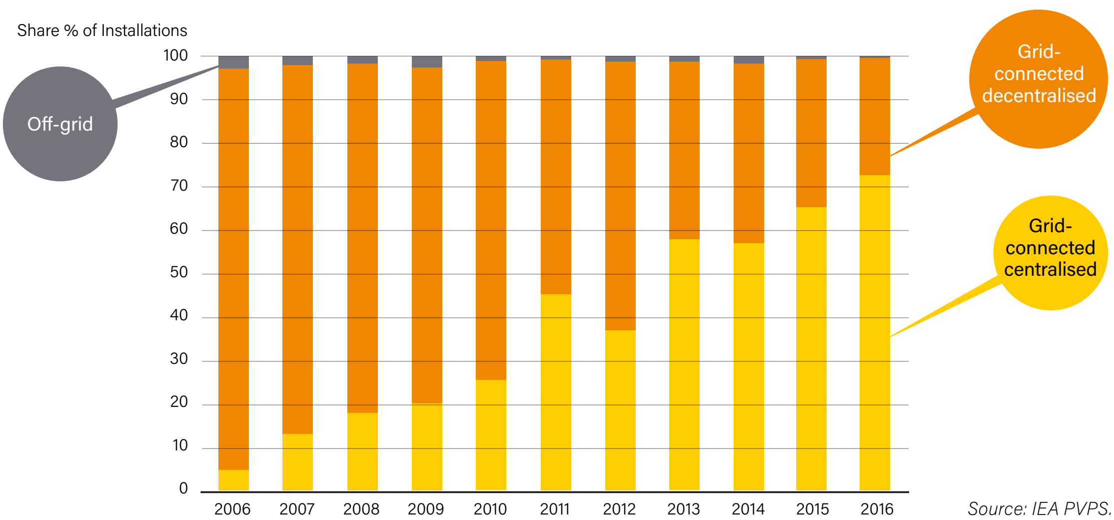


China accounted for **46%** of new capacity.

Solar PV Global Capacity Additions, Shares of Top 10 Countries and Rest of World, 2016



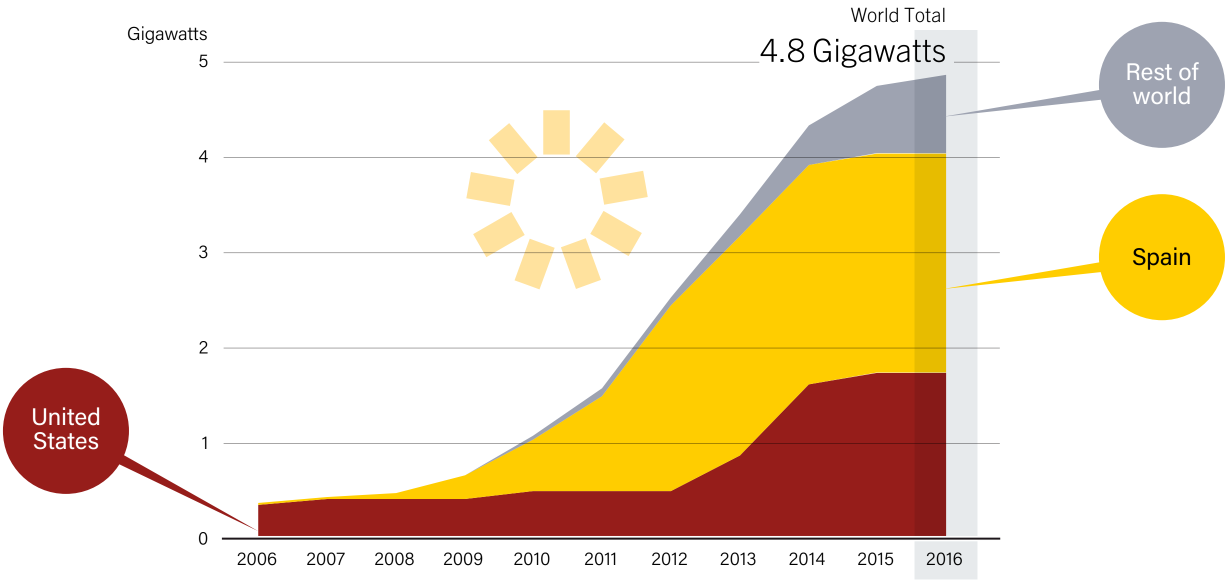
Solar PV Global Additions, Shares of Grid-Connected and Off-Grid Installations, 2006-2016



Source: IEA PVPS.

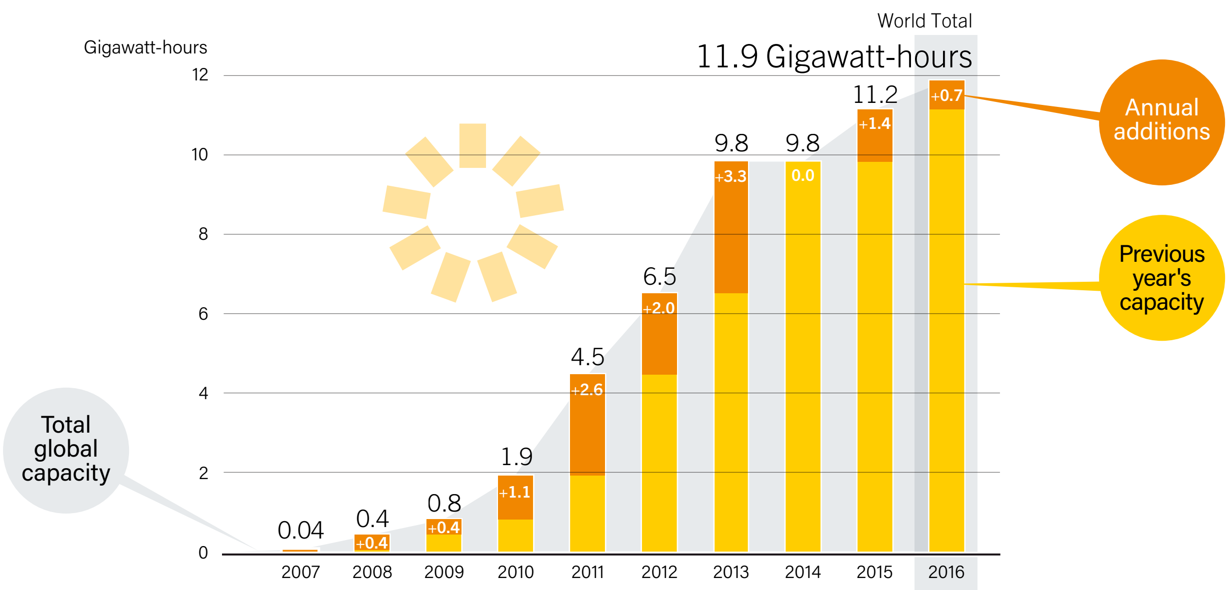
CONCENTRATING SOLAR POWER (CSP)

Concentrating Solar Thermal Power Global Capacity, by Country and Region, 2006-2016



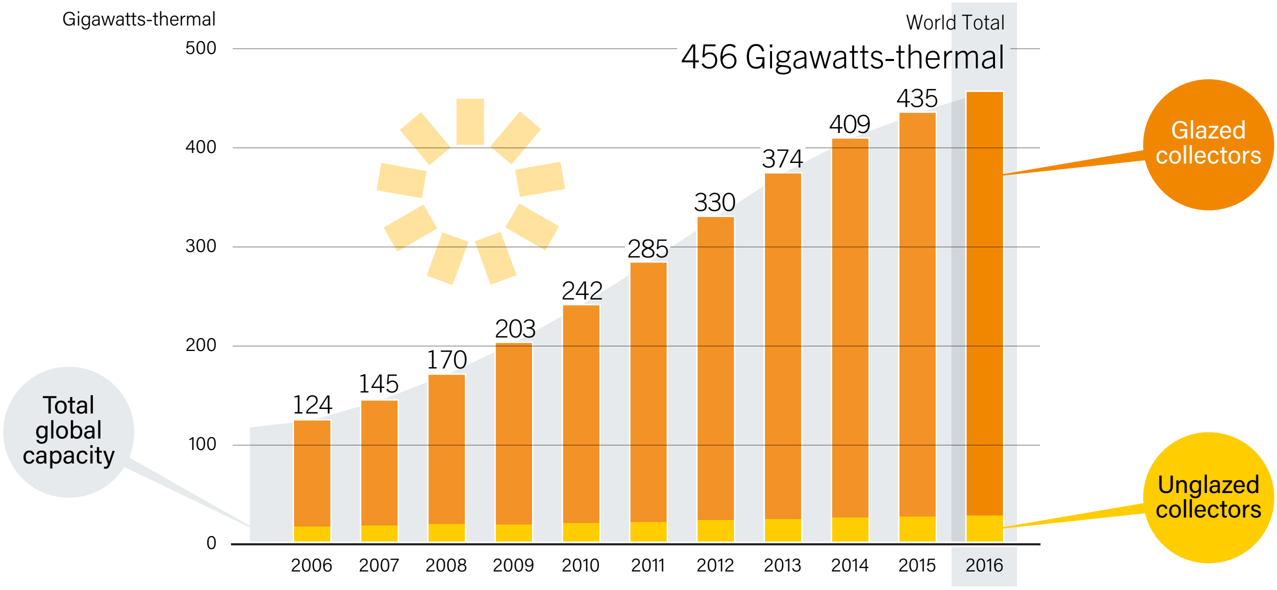
All new facilities that came online incorporated thermal **ENERGY STORAGE.**

CSP Thermal Energy Storage Global Capacity and Annual Additions, 2007-2016



SOLAR THERMAL HEATING AND COOLING

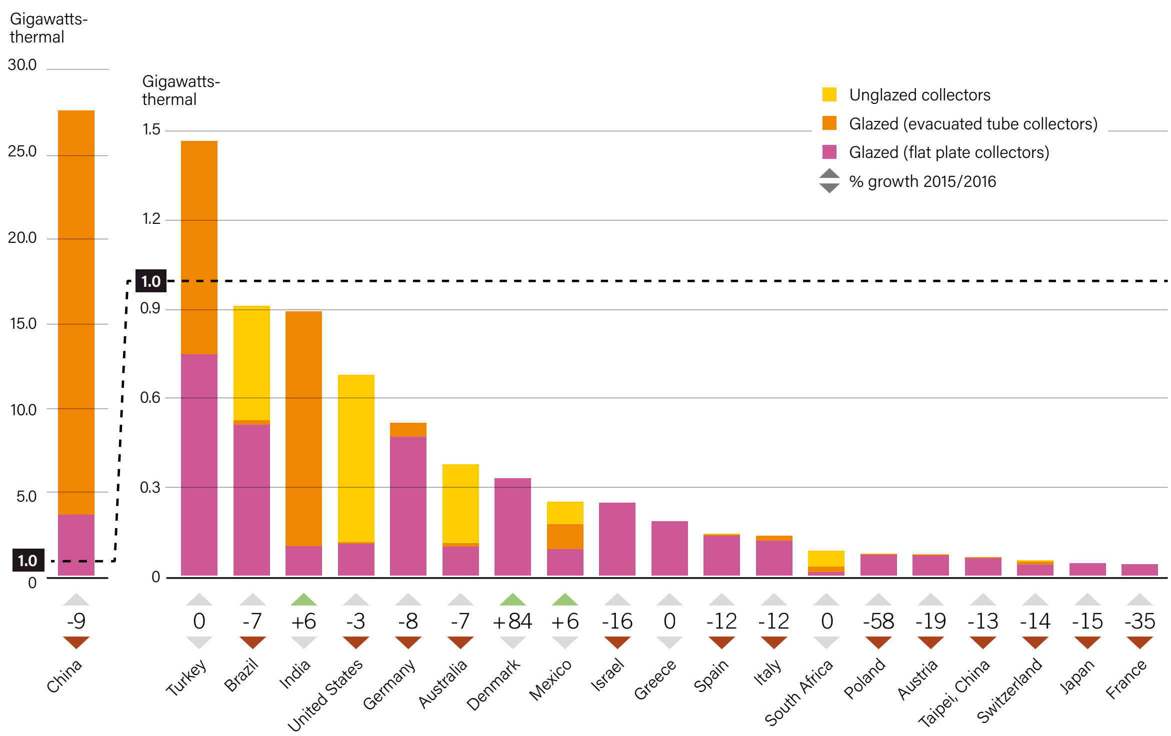
Solar Water Heating Collectors Global Capacity, 2006-2016



Source: IEA SHC.

Solar district heating capacity **DOUBLED** in Denmark (in 2016).

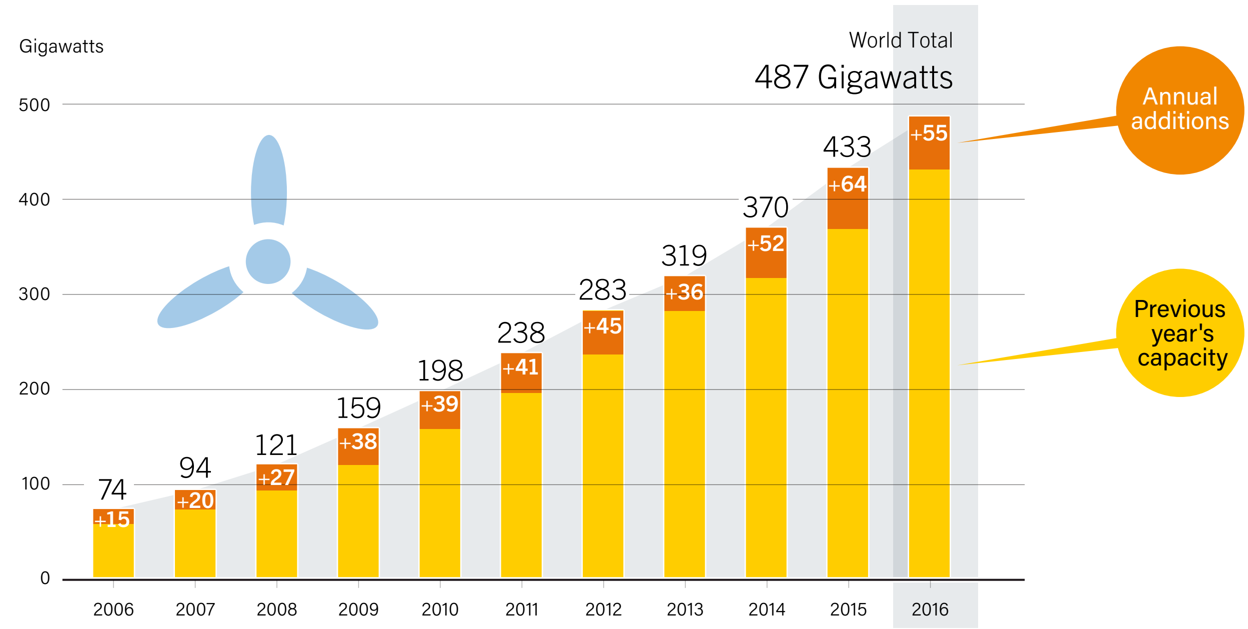
Solar Water Heating Collector Additions, Top 20 Countries for Capacity Added, 2016



Note: Additions represent gross capacity added.

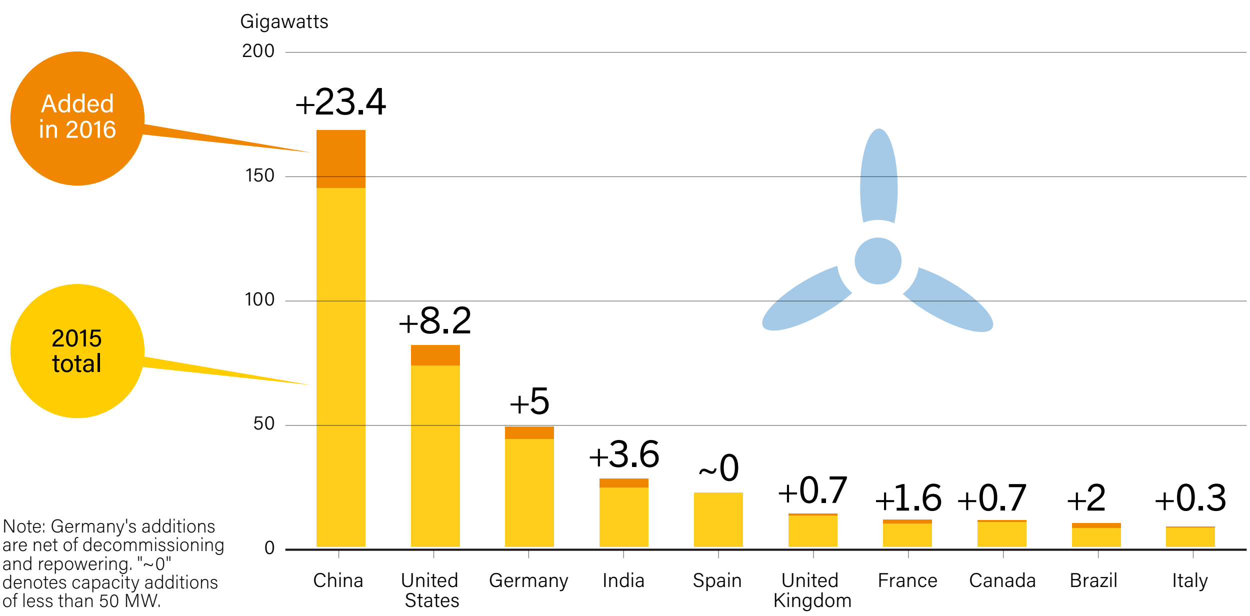
WIND POWER

Wind Power Global Capacity and Annual Additions, 2006-2016



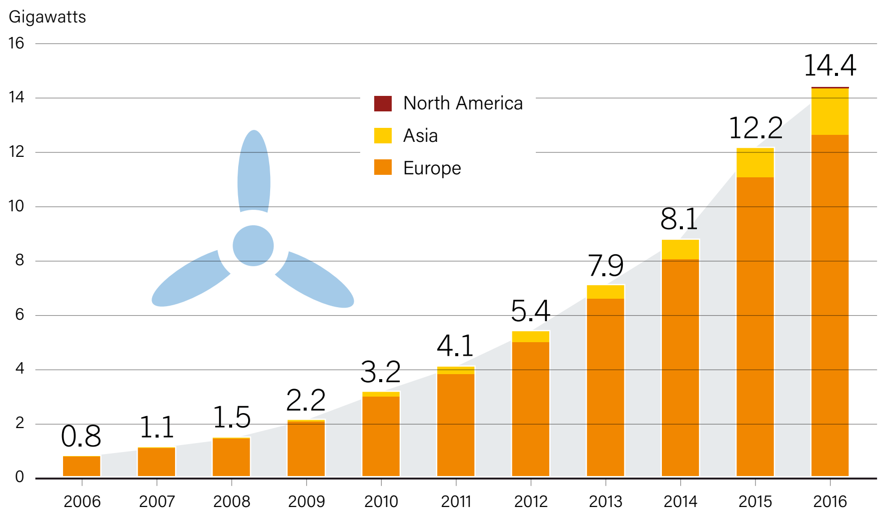
By the end of 2016, **OVER 90 COUNTRIES** had seen commercial wind activity, and **29 COUNTRIES** had more than 1 GW in operation.

Wind Power Capacity and Additions, Top 10 Countries, 2016

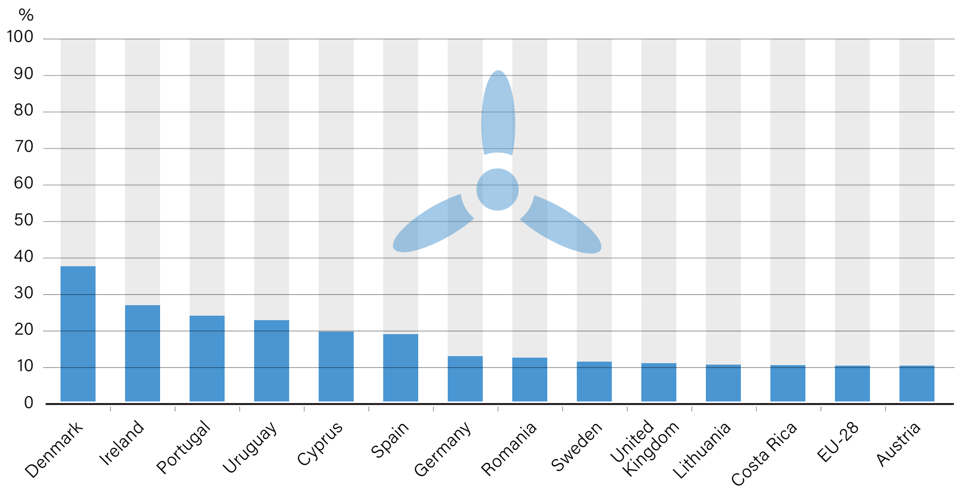


Note: Germany's additions are net of decommissioning and repowering. "~0" denotes capacity additions of less than 50 MW.

Wind Power Offshore Global Capacity, by Region, 2006-2016

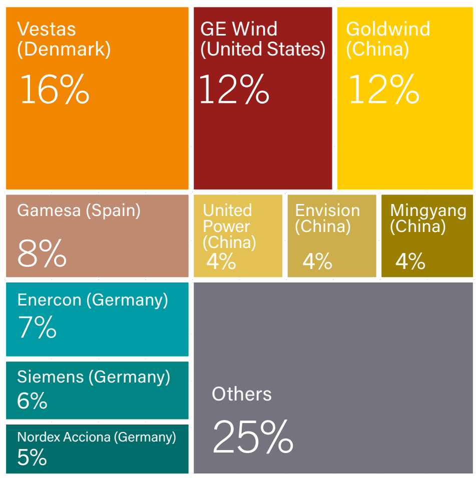


Share of Electricity Demand Met by Wind Power, Selected Countries Over 10% and EU28, 2016



WIND has become the **LEAST-COST** option for new power generating capacity in an increasing number of markets.

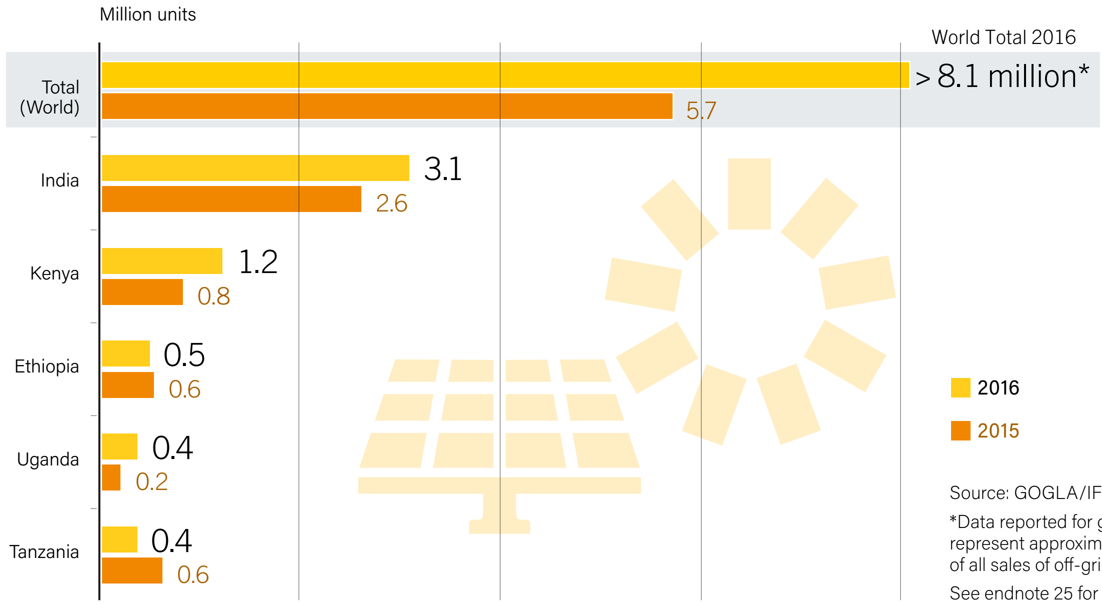
Market Shares of Top 10 Wind Turbine Manufacturers, 2016



Source: FTI Consulting.

DISTRIBUTED RENEWABLE ENERGY

Sales of Off-Grid Solar Systems in Top 5 Countries, 2015-2016



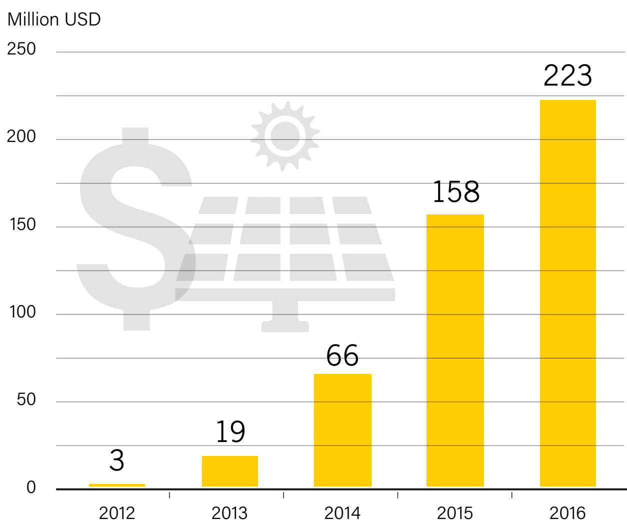
Source: GOGLA/IFC.
*Data reported for global sales represent approximately 50% of all sales of off-grid products.
See endnote 25 for this chapter.

The renewable energy **MINI-GRIDS** market accelerated in 2016 and exceeded

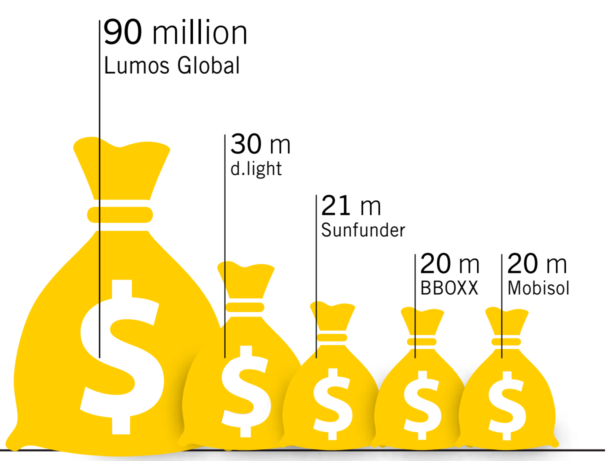
USD 200 BILLION

annually by year's end.

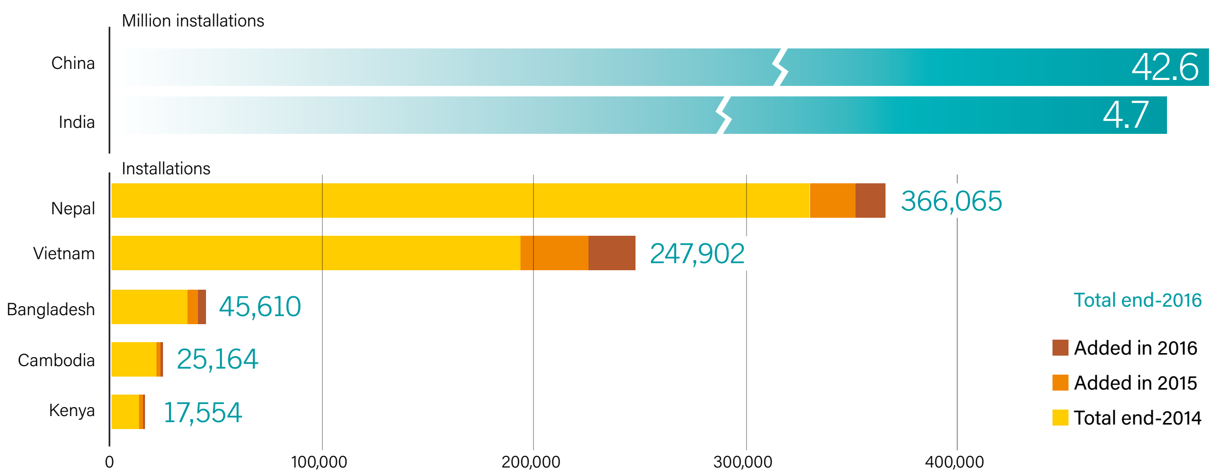
Investment in Pay-As-You-Go Solar Companies, 2012-2016



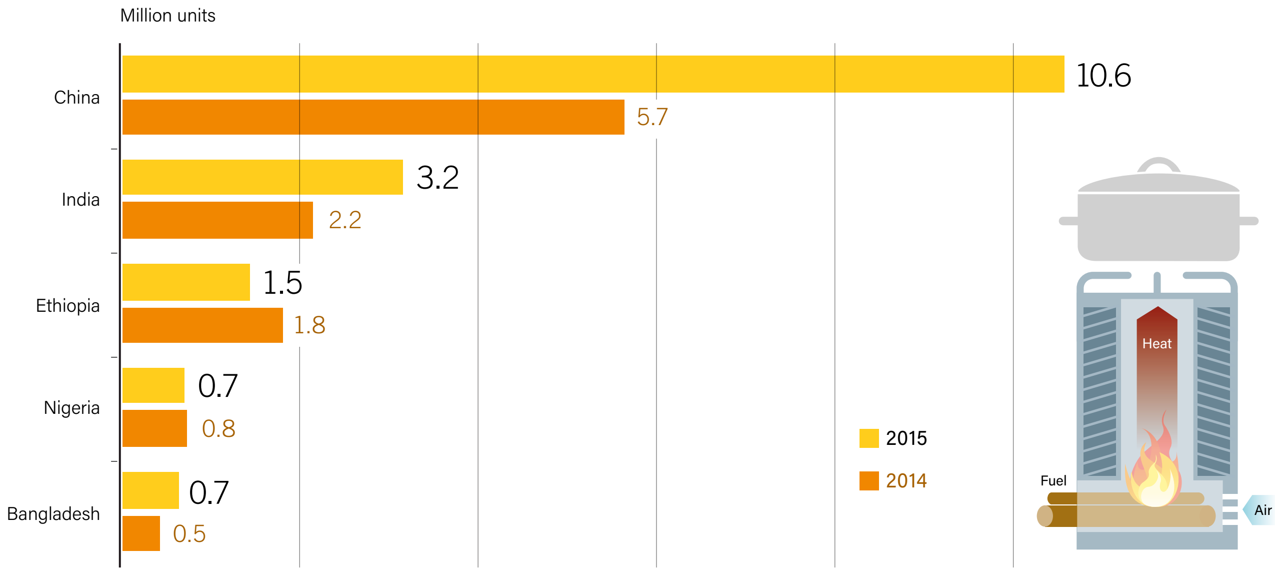
Top 5 PAYG solar companies (for investment) in 2016:



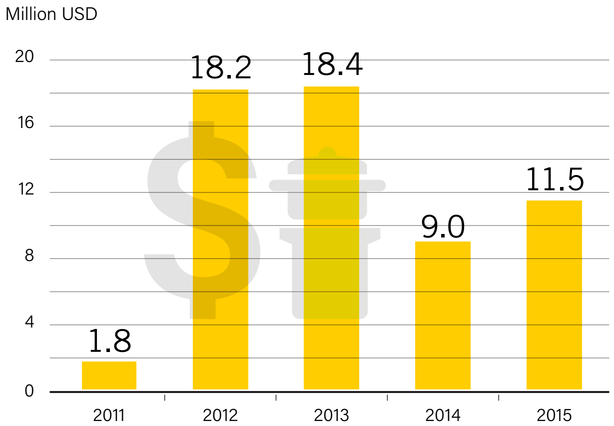
Number of Domestic Biogas Plants Installed in Top 5 Countries, Total and Annual Additions, 2014-2016



Number of Clean Cook Stoves Added in Top 5 Countries, 2014 and 2015

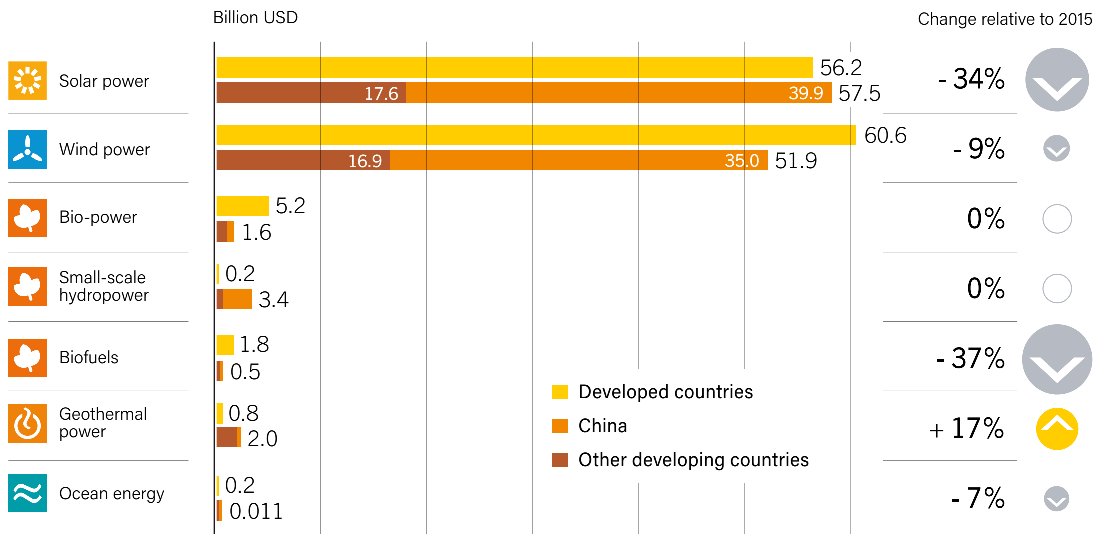


Investment in Clean Cook Stoves, 2011-2015



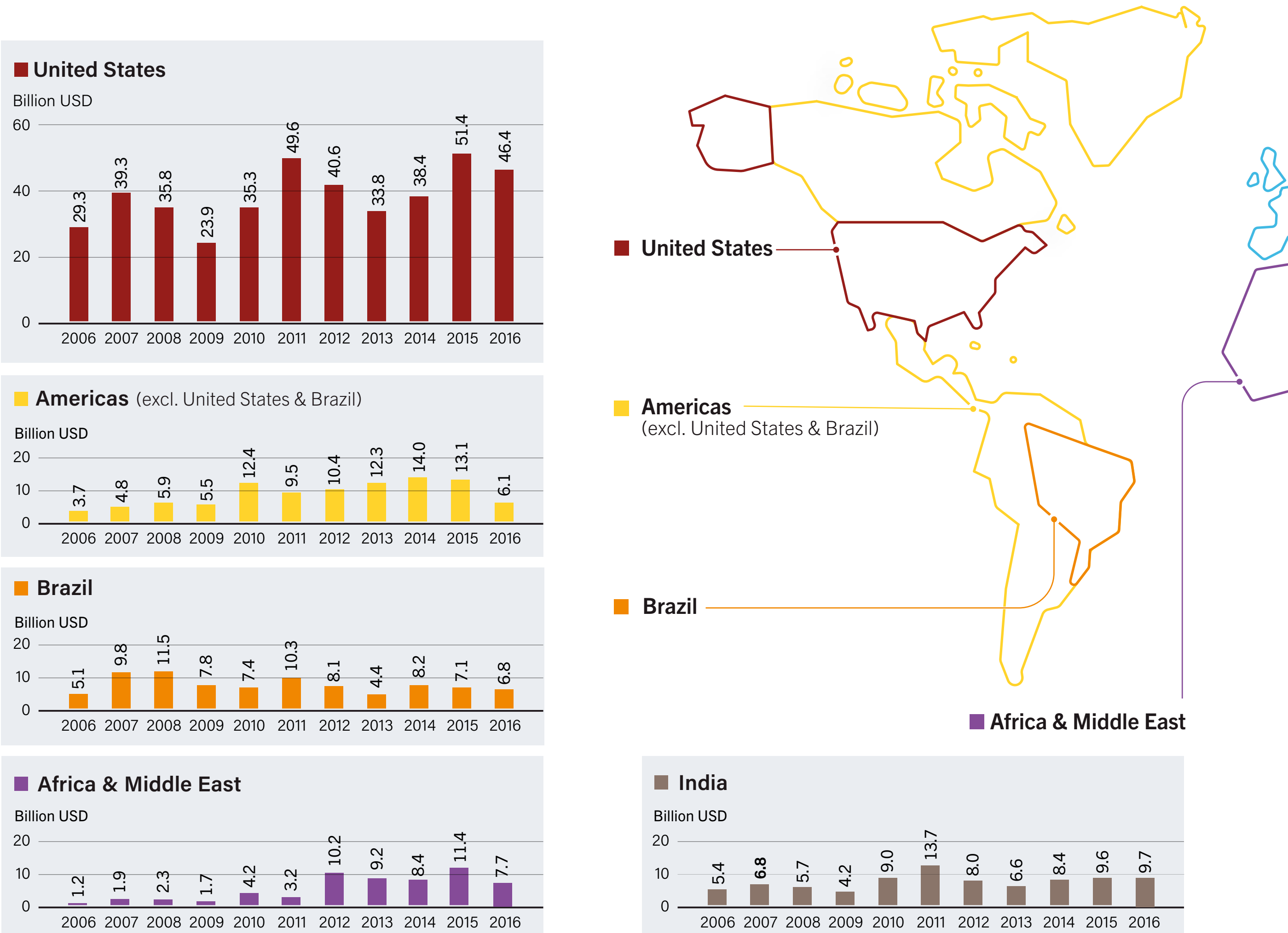
GLOBAL INVESTMENT 2016

Global New Investment in Renewable Energy by Technology, Developed and Developing Countries, 2016

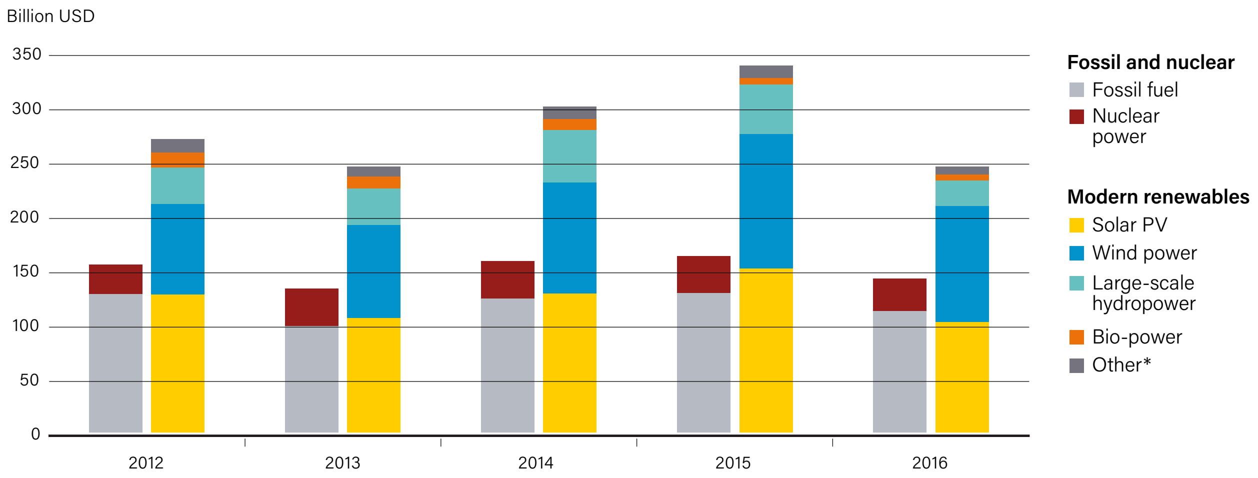


Source: BNEF

Global New Investment in Renewable Power and Fuels, by Country and Region, 2006-2016

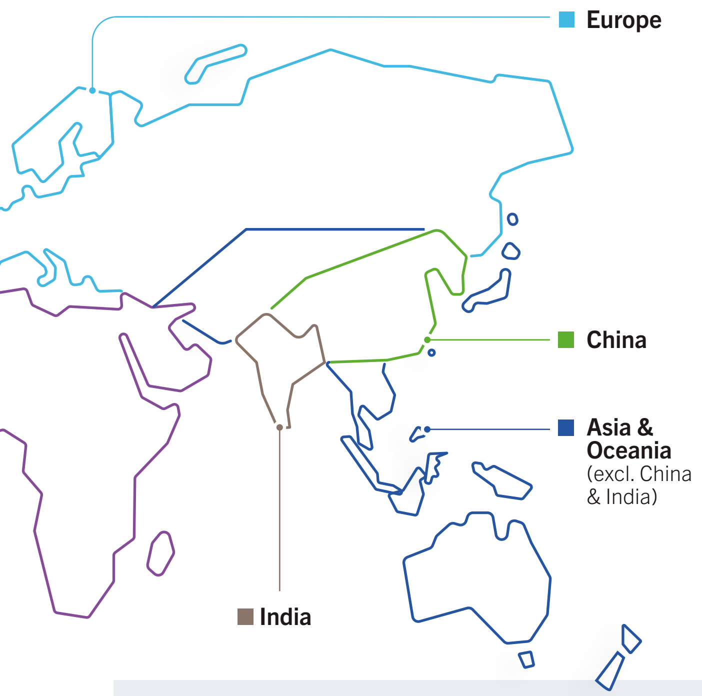


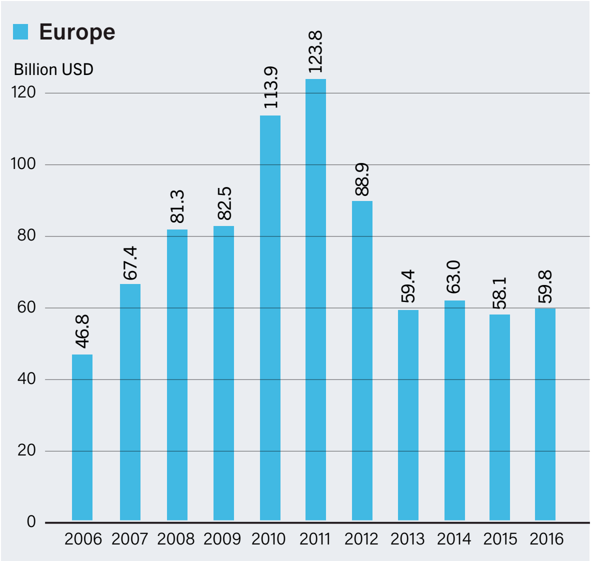
Global Investment in Power Capacity, by Type (Renewable, Fossil Fuel and Nuclear Power), 2012-2016



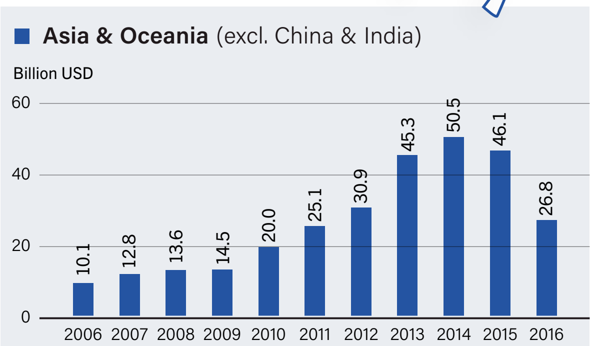
* CSP, geothermal, small-scale hydropower and ocean energy

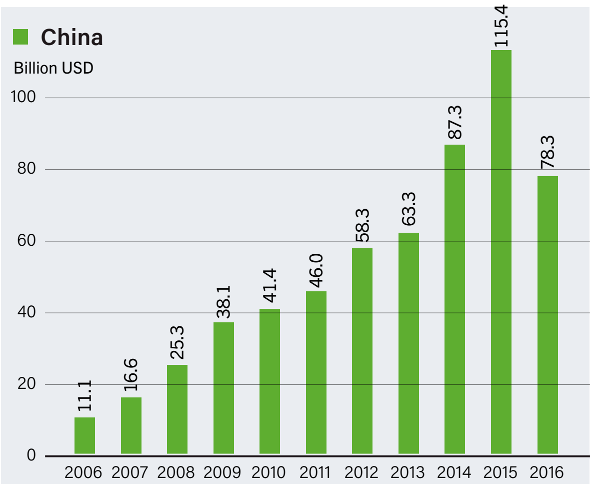
Source: BNEF.





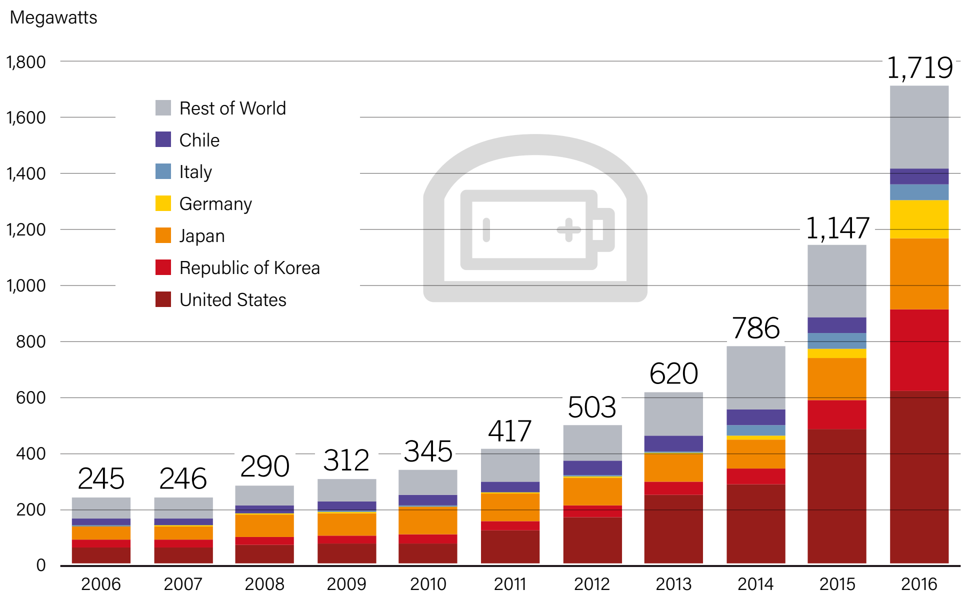
Source: BNEF.
Note: Data include government and corporate R&D.

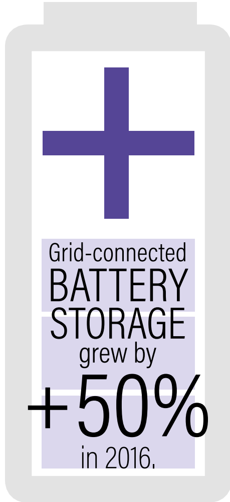




ENABLING TECHNOLOGIES

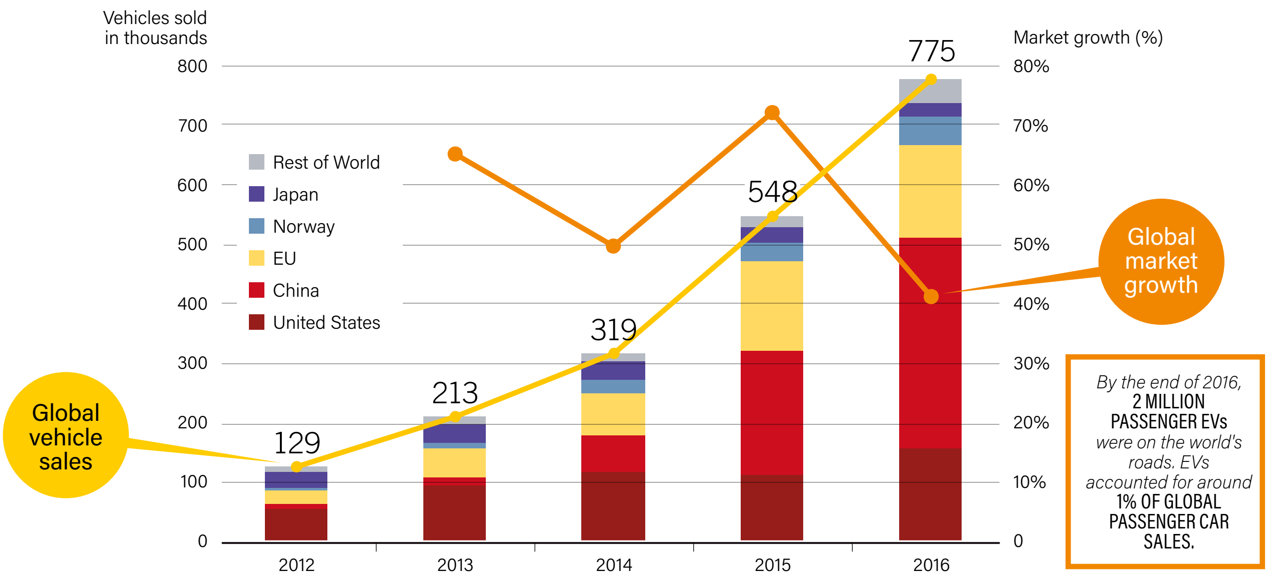
Global Grid-Connected Stationary Battery Storage Capacity, by Country, 2006-2016





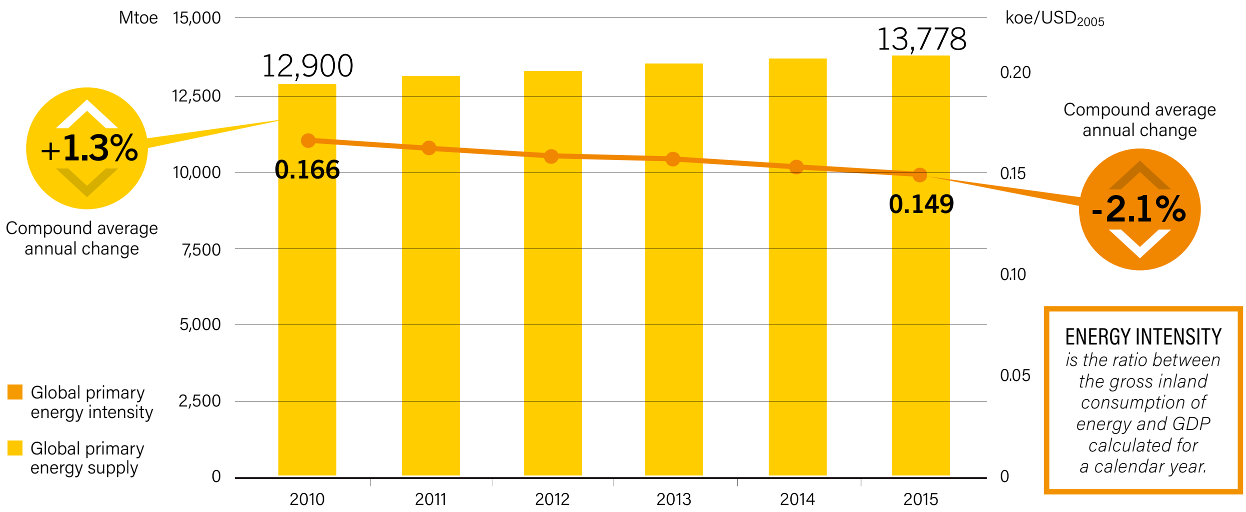
ENABLING TECHNOLOGIES such as information and communication technologies, storage and EVs facilitate **GREATER USE OF RENEWABLES.**

Global Passenger Electric Vehicle Market (Including PHEVs), 2012-2016



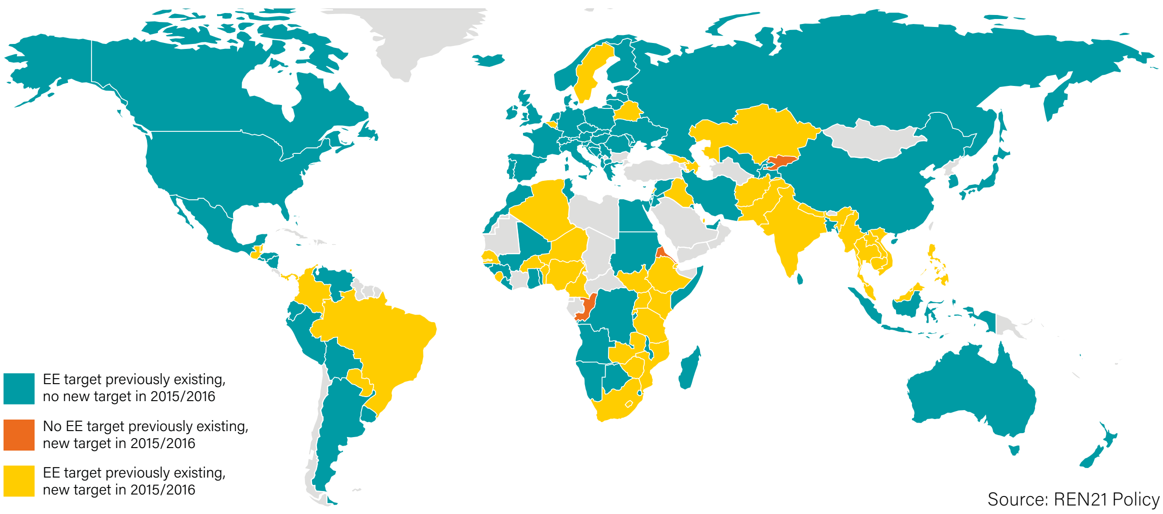
ENERGY EFFICIENCY

Global Primary Energy Intensity and Total Primary Energy Supply, 2010-2015



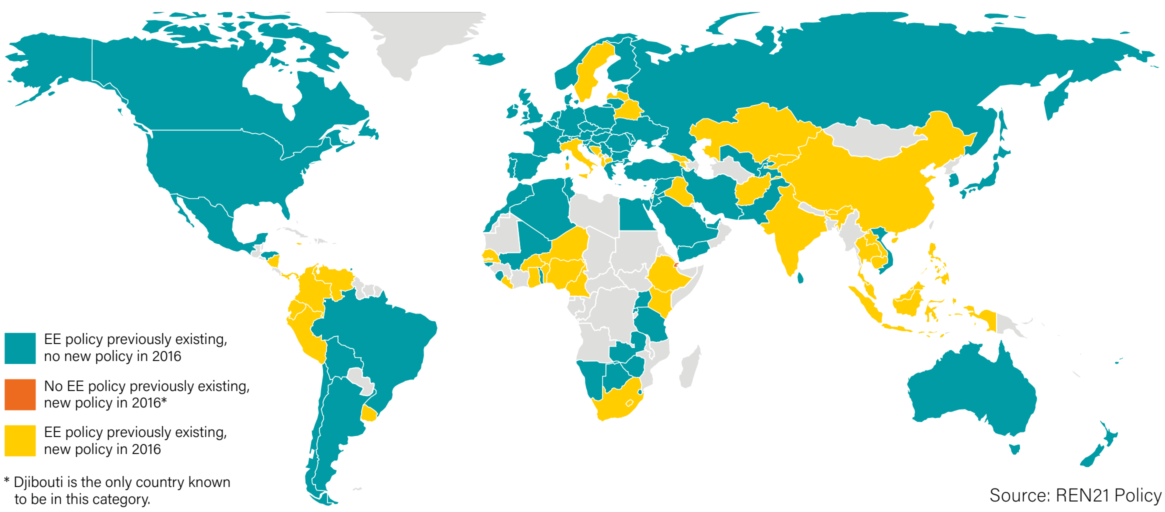
Note: Dollars are at constant purchasing power parities.

Countries with Energy Efficiency Targets, 2016



Source: REN21 Policy Database

Countries with Energy Efficiency Policies, 2016

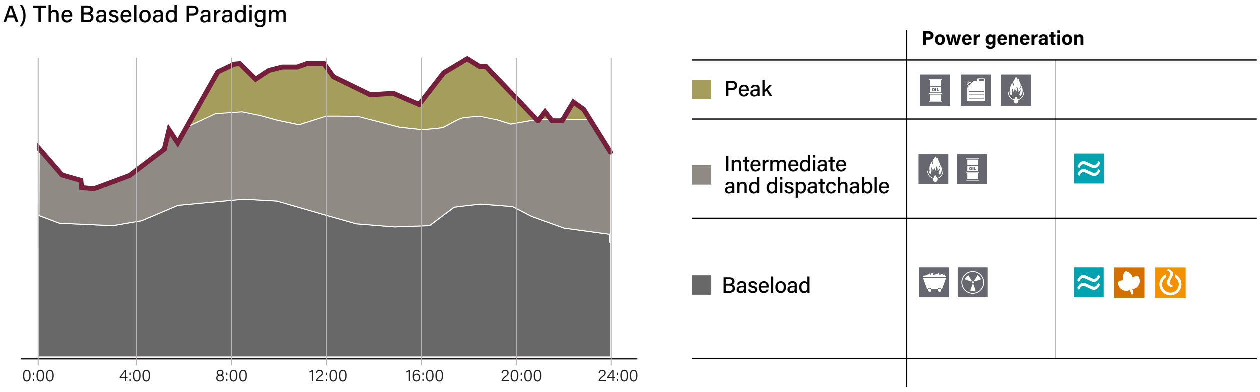


Source: REN21 Policy Database

FEATURE 2017: DECONSTRUCTING BASELOAD

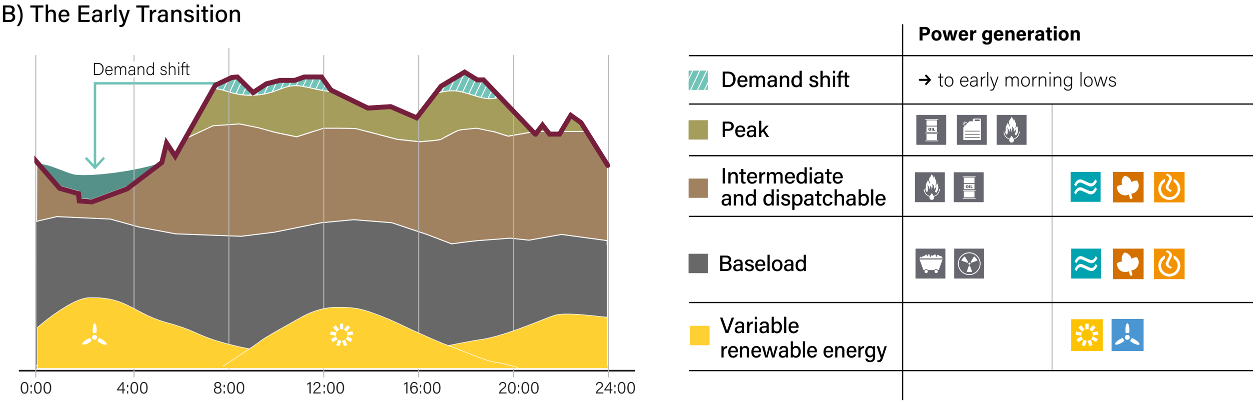
Conceptual Progression from the Baseload Paradigm to a New Paradigm of 100% Renewable Electricity

A) The Baseload Paradigm



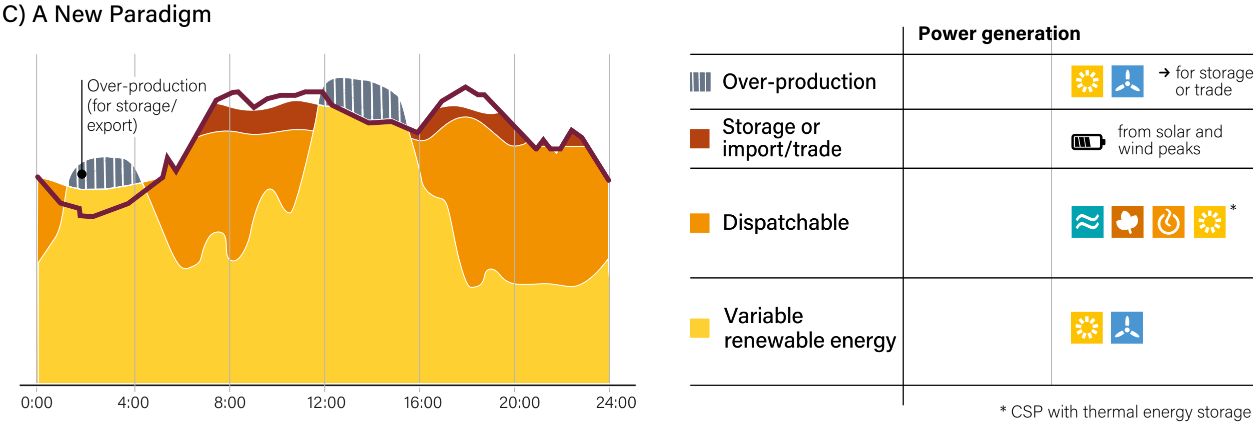
In the early stages of progression to larger shares of variable renewable generation, power systems make some adjustments in their grid operations, develop forecasting systems for renewable energy production, and introduce improved control technology and operating procedures for efficient scheduling and dispatch.

B) The Early Transition



In the late stages of progression towards fully renewable power systems, variable renewable power will be integrated through advanced resource forecasting, grid reinforcements and strengthened interconnections, improved information and control technologies for grid operations, widespread deployment of storage technologies, greater efficiency and scope of demand response, and coupling of electricity, heating and cooling, and transport sectors.

C) A New Paradigm



* CSP with thermal energy storage

Overview of Approximate Impacts and Responses to Rising Shares of Variable Renewable Energy

Impacts	**No noticeable impacts.**	Small increase in supply variability and uncertainty is **noticeable** at the system operations level. Limited impact on operations of individual power plants.	Growing supply variability and uncertainty has **significant impacts** at the system operations level. Noticeable impact on operations of some power plants.	Elevated supply variability and uncertainty has **major impacts** at the system operations level. Noticeable impact on operations of virtually all power plants.	Structural surplus of VRE generation and seasonal energy imbalances.
Response Requirements	No additional measures.	Some adjustments in system operations and grid infrastructure.	Significant changes to system operations. Greater flexibility of supply and demand. Some grid reinforcement for voltage and frequency stability.	Major changes to system operations. Significant additional flexibility of supply and demand. Significant grid reinforcement for voltage and frequency stability.	Additional steps to manage supply and demand imbalances.
RESPONSES – Resource forecasting		■	■ ■	■ ■ ■	■ ■ ■
RESPONSES – Grid operations		■	■ ■	■ ■ ■	■ ■ ■
RESPONSES – Storage			■	■ ■	■ ■ ■
RESPONSES – Demand management			■	■ ■	■ ■ ■
RESPONSES – Grid reinforcement			■	■ ■	■ ■ ■
RESPONSES – Sector coupling				■	■ ■ ■
Examples of Technological and Operational Responses	Gathering information about grid conditions and planning, including technical standards, for future growth in VRE.	Establishing a renewable energy production forecast system. Introducing improved control technology and operating procedures for efficient scheduling and dispatch of system resources.	Managing variability through advanced resource forecasting, improved transmission infrastructure and a significantly more dynamic operation of a growing number of dispatchable system resources. Co-ordination across control areas with the aid of improved information and control technology, and strengthened transmission interconnections.	Improving significantly the efficiency and scope of demand response with better information and control technology. Deploying significant additional advanced storage on the grid and behind the meter for energy balancing and for voltage and frequency support.	Sector coupling – electrification of heating, cooling and transport as a daily, weekly and even seasonal buffer for VRE generation. Converting electricity into chemical forms that can be stored (e.g., hydrogen).
Countries with This Range of VRE Penetration	Indonesia, Mexico, South Africa	Australia, Austria, Belgium, Brazil, Chile, China, India, the Netherlands, New Zealand, Sweden	Germany, Greece, Italy, Portugal, Spain, the United Kingdom, Uruguay	Denmark, Ireland	

Note: This table represents generalisations. Various impacts and priorities for technological and operational responses will vary by system and will not be confined to a single path.

MAKING THE CONNECTIONS

Good decisions require up-to-date information. The ***Renewables Global Status Report*** (GSR) tracks the annual development of renewables, using the most up-to-date information and data available. Its neutral, fact-based approach documents in detail the annual developments in market, industry and policy. The report is a collaborative effort, drawing on an international network of more than 800 authors, contributors, and reviewers from over 155 countries. Now in its twelfth year the GSR is the most frequently referenced report on renewable energy market, industry, and policy trends.

Advancing the Global Renewable Energy Transition: Highlights of the REN21's Renewables 2017 Global Status Report in Perspective is a complementary publication to help decision makers understand the evolution of the renewable energy sector in the context of the overall energy transition. It looks at positive developments that occurred over the past year, notes areas where progress is lagging and offers recommendations for how to speed up the energy transition with renewables.

While the *Renewables Global Status Report* series provides a real-time snapshot of what is happening, REN21's ***Renewables Global Futures Report*** series presents thinking about how a renewable energy future will evolve. This series presents a range of credible possibilities for the future of renewable energy. It does not present just one vision of the future, but rather a full and objective range of visions, based on the collective and contemporary thinking of many.

Collectively these reports illustrate the distance between where we are now and what needs to happen if an energy transition with renewables is to be achieved.

The ***Renewables Global Futures Report: Great debates towards 100% renewable energy*** was released in April 2017. The report documents global views about the feasibility of achieving a 100% renewable energy future by mid-century. While there may be agreement that we need to decarbonise our energy system, there is no one way to achieve this; what works in one country does not necessarily work in another. The report analyses the views of over 110 renowned energy experts from around the world who were interviewed over the course of 2016. It does not predict the future. The report is meant to spur debate about the opportunities and challenges of a 100% renewable energy future and, in turn, to support good decision making.

Access to the reports:

www.ren21.net/GSR and **www.ren21.net/GFR**

The REN21 Secretariat has produced this document to highlight the important trends that have occurred in 2016 and put them in perspective of the global energy transition. It draws on elements from its *Renewables 2017 Global Status Report*.

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HIGHLIGHTS
2017

RENEWABLES 2017
GLOBAL STATUS REPORT

For further details and access to the report and references, visit **www.ren21.net/GSR**

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