RENEWABLE ENERGY

Medium-Term Market Report 2013

EXECUTIVE SUMMARY

Market Trends and Projections to 2018

International Energy Agency

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Medium-Term Market Report 2013

Renewable electricity generation increased strongly worldwide in 2012, and deployment is occurring in a greater number of markets. However, the story of renewable energy development is becoming more complex. Short-term indicators in some regions of the globe have pointed to increased challenges. Despite remaining high, global new investment in renewable energy fell in 2012. Policy uncertainties, economic challenges, incentive reductions and competition from other energy sources clouded the investment outlook for some markets. Some countries and regions have faced difficulties in integrating variable renewables in their power grids. The renewable manufacturing industry, particularly solar and wind, entered a deeper period of restructuring and consolidation.

Nevertheless, despite economic, policy and industry turbulence, the underlying fundamentals for renewable deployment remain robust. Even with challenges in some countries, more positive developments elsewhere continue to drive global growth. Competitive opportunities for renewables are emerging across traditional and new markets. While OECD countries remain a driver of renewable power development, non-OECD countries are increasingly accounting for overall growth. The roles of biofuels for transport and renewable heat are also increasing, though at somewhat slower rates than renewable electricity.

The *Medium-Term Renewable Energy Market Report 2013* assesses market trends for the renewable electricity, biofuels for transport and renewable heat sectors, identifying drivers and challenges to deployment, and making projections through 2018. The analysis features in-depth renewable electricity market analysis and forecasts for a slate of countries in the OECD and non-OECD. The report also presents an outlook for renewable electricity technologies, global biofuels supply, final energy use of renewables for heat and prospects for renewable investment.

Market Trends and Projections to 2018

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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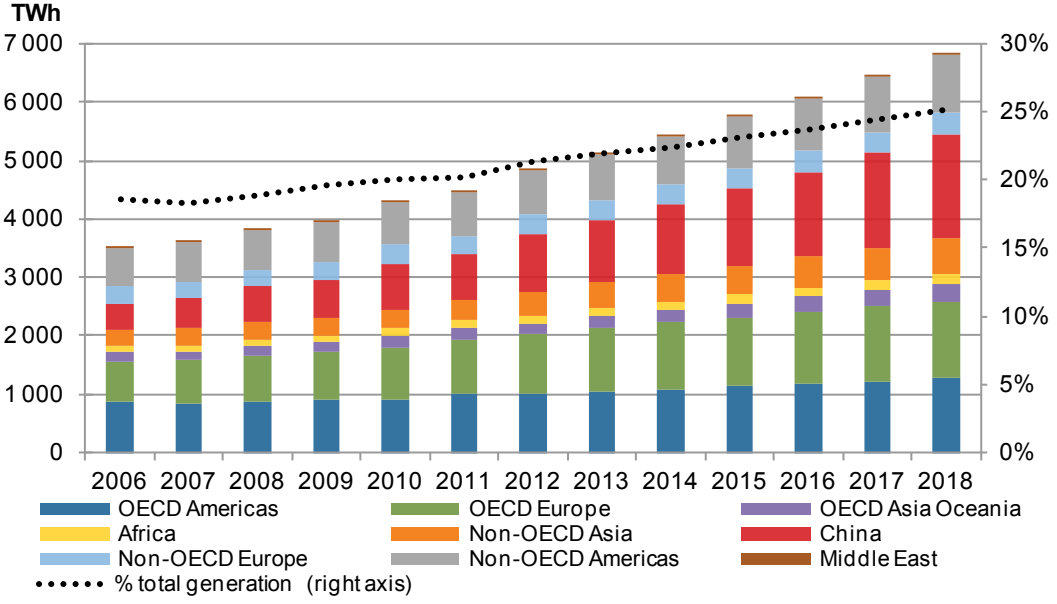
A growing role for renewables in the energy mix

The role of renewable sources in the global power mix continues to increase. On a percentage basis, renewables continue to be the fastest-growing power source. As global renewable electricity generation expands in absolute terms, it is expected to surpass that from natural gas and double that from nuclear power by 2016, becoming the second most important global electricity source, after coal. Globally, renewable generation is estimated to rise to 25% of gross power generation in 2018, up from 20% in 2011 and 19% in 2006. Driven by fast-growing generation from wind and solar photovoltaics (PV), the share of non-hydro renewable power is seen doubling, to 8% of gross generation in 2018, up from 4% in 2011 and 2% in 2006. In the Organisation for Economic Co-operation and Development (OECD), non-hydro renewable power rises to 11% of OECD gross generation in 2018, up from 7% in 2012 and 3% in 2006.

Figure 1 Global renewable electricity production by region



Notes: TWh = terawatt hours. Unless otherwise indicated, all materials in figures and tables in this chapter derive from International Energy Agency (IEA) data and analysis.

Renewable electricity growth is expected to accelerate over the medium term. From 2012-18 renewable electricity generation should rise by 40% (1 990 TWh or 6% per year [/yr]), from 4 860 TWh to 6 850 TWh. This growth in generation is 50% higher than the 1 330 TWh increment registered over the 2006-12 period. Generation in 2017 is seen 90 TWh higher than that projected in the *Medium-Term Renewable Energy Market Report 2012* (*MTRMR 2012*). Total renewable capacity is expected to grow from 1 580 gigawatts (GW) in 2012 to 2 350 GW in 2018. While hydropower remains the largest renewable source, a portfolio of non-hydro renewable sources – bioenergy, wind, solar PV, solar thermal electricity from concentrating solar power (CSP) plants, geothermal and ocean power – grows more rapidly.

The roles of biofuels for transport and renewable heat are also increasing, though at slower rates than renewable electricity. Global biofuels production is expected to rise by over 25% from 2012 to 2018, reaching 2.4 million barrels per day (mb/d) in 2018. Biofuels output, adjusted for energy

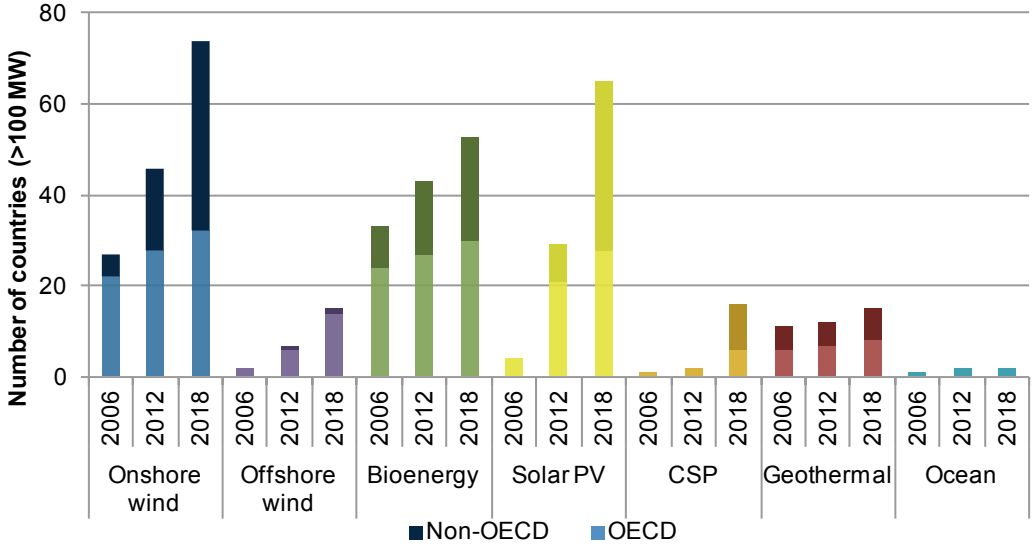
content, should account for 3.9% of global oil demand for road transport in 2018, up from an estimated 3.4% in 2012 and 1.5% in 2006. Still, biofuels face short-term production challenges, including the slow development of advanced biofuels, sluggish oil demand growth in some areas and policy uncertainty regarding the sustainability of feedstock supply chains. Global final energy use of renewable sources for heat, excluding traditional biomass, is expected to grow by 24% over 2012-18 to reach 18 exajoules (EJ). As a portion of final energy consumption for heat, renewable sources should rise to almost 10% in 2018, from over 8% in 2012 and under 8% in 2006.

Complex deployment dynamics and market transitions

Renewable energy development is becoming more complex as renewables increase their share in the global power mix. Challenges have emerged in some regions since the *MTRMR 2012*. Despite remaining high, global new investment in renewable energy fell in 2012. Policy uncertainties continued to cloud the investment outlook for some key markets. In some countries, investment moderated in the face of macroeconomic uncertainties and incentive reductions, particularly in countries with strong deployment of solar PV. In some areas, integration challenges from higher penetrations of variable renewables emerged. Meanwhile, renewables faced strong competition from other energy sources in some markets (*e.g.* natural gas in the United States). In addition, manufacturing industries for renewables, particularly solar PV and wind, entered a more intense period of restructuring and consolidation.

Nevertheless, the global deployment drivers of a portfolio of renewable sources have remained robust, despite economic, policy and industry turbulence. Over the longer term, the expected persistence of supportive policy frameworks will be crucial to maintaining deployment momentum. In the near term, despite challenges in some countries, the global picture is more than compensated for by renewable deployment elsewhere.

Figure 2 Number of countries with non-hydro renewable capacity above 100 megawatts (MW)



Total renewable electricity generation grew strongly in 2012, increasing by 8.2% from 2011. In absolute terms, global renewable generation in 2012 exceeded the electricity consumption of China. Part of the strength in 2012 growth stemmed from stronger-than-anticipated hydropower production, particularly in China. Yet it also reflected a continued rapid build-out of non-hydro sources, whose generation rose

by 16% year-on-year. Among the OECD regions, non-hydro renewable generation was the second-largest source of power generation growth in 2012, expanding by 90 TWh. By comparison, gas-fired generation rose by over 150 TWh, while both coal and nuclear declined. Globally, the most dynamic sectors – solar PV and onshore wind – grew faster than expected in the *MTRMR 2012*, spurred by falling generation costs. Still, the expansion of other technologies – offshore wind, CSP, geothermal – remained more moderate, owing to relatively higher costs and more challenging financing situations.

Renewable power deployment is expected to continue expanding geographically. Non-hydro renewable electricity development is becoming increasingly widespread, with growth shifting beyond traditional support markets in Europe. In 2018, the number of countries with cumulative renewable electricity capacities above 100 MW is expected to increase significantly for many non-hydro technologies. Onshore wind, already widespread in 2012, is expected to be deployed in almost 75 countries by 2018. Deployment of solar PV at the 100 MW level should be reached in 65 countries by 2018, up from 30 in 2012, and of bioenergy at that level in over 50 countries by 2018, up from 40 in 2012. The spread of offshore wind, CSP, geothermal and ocean deployment should remain relatively slower, however.

Competitiveness is improving, but market and policy frameworks are keys for investment

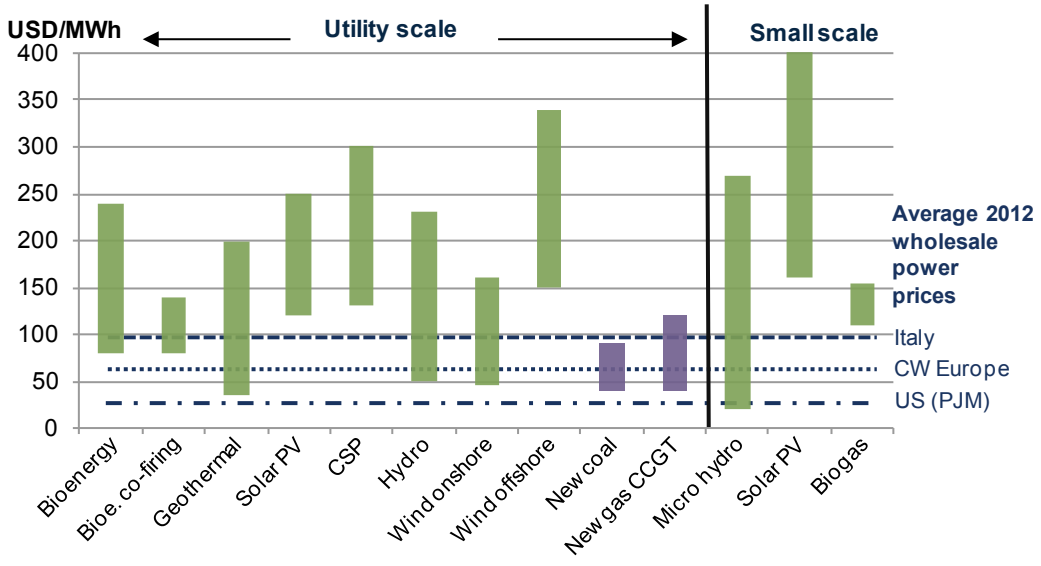
Renewable power sources are becoming more competitive in an increasing number of countries and circumstances. Hydropower and geothermal in areas with good resources are already generally competitive versus new fossil-fuel power plants. Large-scale bioenergy plants are also competitive depending on feedstock prices and availability, while co-firing with biomass in coal and gas power plants has increased. Levelised costs for other renewables generally remain higher than new fossil-fuel generation; as such, these sources often require policy support to remain economically attractive. Yet the most dynamic technologies – onshore wind and solar PV – have reached, or are approaching, competitiveness in a number of markets without generation-based incentives.

In some markets with good resources, the levelised cost of electricity (LCOE) for onshore wind is competitive or close to competitiveness versus new coal- and natural gas-fired power plants. In Brazil, onshore wind competes well with new gas-fired plants and other historically less expensive renewable sources, such as hydropower and bioenergy. In Australia, wind is competitive versus the generation costs of new coal- and gas-fired plants with carbon pricing, and the best wind sites can compete without carbon pricing. In Turkey and New Zealand, onshore wind has been competing well in the wholesale electricity market for several years. With long-term power purchase agreements (PPAs), onshore wind costs are approaching that of new coal-fired plants in South Africa. In Chile and Mexico, onshore wind competes – or is close to competing – with new gas-fired plants. In the United States, although onshore wind remains more expensive than new gas-fired generation, long-term PPAs for wind power can provide cost-effective hedges against rising fuel prices over the long term, even without federal tax incentives.

Falling system costs support the emergence of competitive market segments for solar. Utility-scale solar – solar PV during the day, CSP in the evening – can be competitive in sunny countries when demand peaks are met by oil products (though oil subsidies may distort this picture). In oil-exporting countries, solar PV generation is cheaper when the opportunity cost of not selling oil on the international market is considered (*e.g.* Saudi Arabia). Other emerging competitive segments are linked to the concept of grid or "socket" parity – when the LCOE of decentralised solar PV systems becomes lower than retail electricity prices that system owners would otherwise pay. Such markets are appearing in Spain, Italy, southern Germany, southern California, Australia and Denmark, and

across residential and commercial segments. While this parity still requires support for the power system integration of solar PV, it is nonetheless a driver for increased investment in the sector.

Figure 3 Global levelised costs of power generation ranges, first quarter of 2013



Notes: costs are indicative and ranges reflect differences in resources, local conditions and the choice of sub-technology. CCGT = combined-cycle gas turbine. Central-Western (CW) Europe = Austria, France, Germany, Switzerland. United States (US). PJM = regional transmission organisation covering 13 states and the District of Columbia (DC).

Source: IEA analysis with power price data from Bloomberg LP, 2013.

Still, the competitiveness of renewables depends on the market and policy framework within which they operate. Policy, market and technology risks can undermine project viability even when resources are good and technology costs are favourable. Policy uncertainty is chief among these risks, but non-economic barriers, integration challenges, counterparty risk, and macroeconomic and currency risks can all increase financing costs and weigh upon investments. In markets based on short-term marginal pricing, remuneration flows can be uncertain and capital-intensive technologies, such as renewables, can often require financial incentives. By contrast, renewable power capacity is being deployed with little financial support in some areas with rising energy needs, good resources and predictable long-term policies. Market design based on competition over long-term contracts (as in Brazil and some other Latin American countries) is one way that is sustaining investment.

Non-OECD countries increasingly drive renewable power deployment

In 2018, non-OECD countries are expected to comprise 58% of total renewable generation, up from 54% in 2012 and 51% in 2006. Deployment in most countries still hinges on cheap and abundant hydropower, but other technologies continue to scale up in countries with good resources and emerging support measures. Non-OECD regions account for two-thirds of global renewable generation growth over 2012-18 and over 50% of the non-hydro portion of new generation.

China is expected to account for 40%, or 310 GW, of the growth in global renewable power capacity over 2012-18. This deployment is supported by rising power demand, diversification needs and a favourable policy framework. While China is developing a portfolio of renewable sources, led

by hydropower and onshore wind, a more positive outlook for solar PV is the largest change since the *MTRMR 2012*. A stronger policy push, improved financial incentives and grid access for small-scale projects amid continued falling system prices should make China the largest deployment market for solar PV over 2013-18. Nevertheless, the scale of existing and planned deployment of variable renewables (wind and solar PV) will continue to pose grid and system integration challenges.

The remainder of the non-OECD countries are expected to account for 23%, or 175 GW, of renewable electricity capacity growth over the medium term. India's deployment should be led by onshore wind, hydropower and solar PV. With acute rural electrification needs, distributed solar PV and bioenergy installations should also continue to grow. In Brazil, deployment should be led by hydropower, onshore wind and bioenergy. Thailand is expected to deploy a portfolio of renewable sources, including bioenergy, solar PV and onshore wind. In both Morocco and South Africa, tendering schemes drive growth in onshore wind, solar PV and CSP. Meanwhile, rapidly declining system costs should prompt increased solar PV deployment towards the end of the forecast period, particularly in Asia, the Middle East and the non-OECD Americas. Still, a number of challenges may weigh upon non-OECD development in some areas, including grid integration, non-economic barriers, and the relatively high cost and low availability of financing.

OECD countries grow robustly, but face distinct drivers and challenges

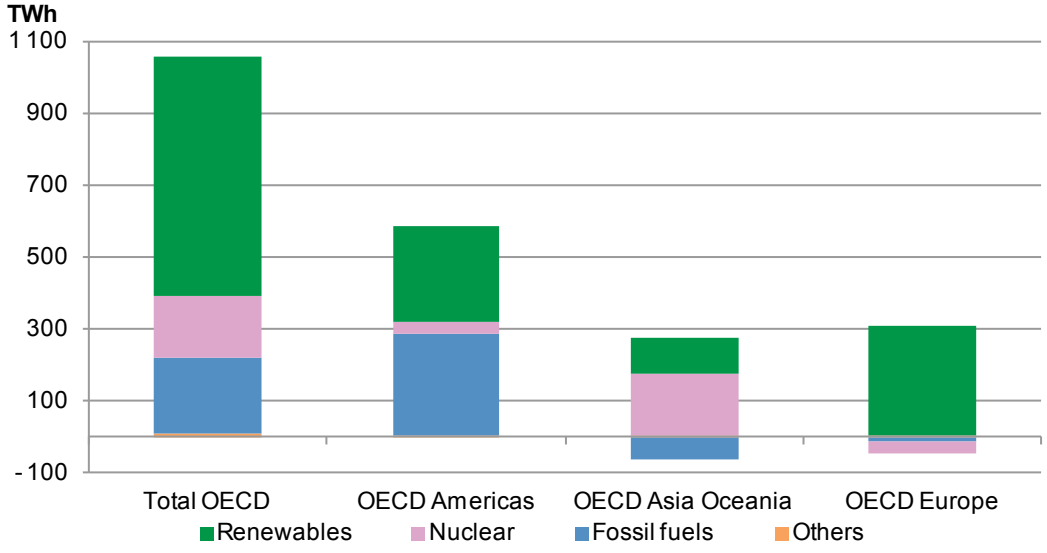
Renewable electricity is expected to account for 60% of the increase in OECD gross power generation over 2012-18. In OECD Europe, new renewable generation is triple that of natural gas. In the OECD Americas, new renewable generation is expected to be second to fossil fuels (largely gas), but still accounts for over 40% of the increase in gross generation. In OECD Asia Oceania, renewable sources account for around 40% of the increase in gross generation, second to nuclear, assuming a partial return of nuclear power plants in Japan. In the OECD, renewable generation is seen growing to 24% of gross power generation in 2018, up from over 20% in 2012 and 16% in 2006.

OECD countries are expected to remain a robust source of global growth, accounting for 37%, or almost 290 GW, of new renewable electricity capacity over 2012-18. The drivers and challenges for OECD countries vary significantly. More mature markets – such as Germany, Italy and the United Kingdom – typically face low or negative growth in power demand, a need to integrate higher penetrations of variable renewables, and challenges in providing predictable policy frameworks that adapt to technology cost changes. Less mature markets – such as Chile, Mexico and Turkey – enjoy robust demand growth and excellent resource availability, but may face hurdles in scaling up deployment due to non-economic barriers, market design or the cost/availability of financing. Overall, onshore wind and solar PV should drive capacity additions in the OECD, with still-significant expansions expected in hydropower and bioenergy. Relatively higher cost offshore wind should grow more modestly, though OECD countries account for two-thirds of the expected global expansion. OECD countries are also expected to drive most developments in ocean power, which is currently at an early stage of maturity.

Despite slowing growth, OECD Europe should lead deployment within the OECD over 2012-18, with an expansion over 130 GW. Germany, the United Kingdom, Turkey and France are expected to drive growth. Germany is led by solar PV, onshore wind and offshore wind, though solar PV deployment has slowed with incentive adjustments. The United Kingdom should lead European offshore wind deployment. Turkey is buoyed by strong hydropower and onshore wind growth. France's growth is led by onshore wind. With adjustments to incentive schemes and more challenging economic conditions, renewable growth in Italy and Spain should moderate. Renewable capacity growth in the

relatively smaller power sectors of Denmark and Ireland is focused largely on wind (onshore and offshore), while Denmark's coal-to-biomass conversions support a strong bioenergy increase.

Figure 4 Changes in power generation by source and region, OECD, 2012-18



Notes: Other includes non-renewable municipal and industrial waste. In Europe, the expected decline in coal- and oil-fired generation is slightly larger than an expected increase in gas-fired generation, leading to a net negative change in fossil fuel generation.

Renewable power capacity in the OECD Americas rises by over 100 GW over 2012-18. The large US market size combined with state targets and good economic attractiveness in some areas should spur strong deployment of a portfolio of renewables, including onshore wind, solar PV and CSP, and geothermal. Still, the stability of federal incentives remains a key uncertainty, suggesting continued volatility in onshore wind additions there. Canada's capacity growth is led by onshore wind, hydropower, solar PV and bioenergy. Based on excellent resources and diversification needs, Chile's renewable capacity should almost double, led by wind and solar PV, though the cost and availability of financing will remain a constraint. Excellent resources and rising power needs should drive renewable growth in Mexico over 2012-18, led by onshore wind and solar PV. Yet, a relative lack of financial incentives and power sector barriers may limit expansion there.

In OECD Asia Oceania, renewable electricity capacity is expected to rise by 55 GW over 2012-18. Buoyed by generous feed-in tariffs, solar PV is expected to grow strongly in Japan, with onshore wind, hydropower, bioenergy and geothermal all making modest growth contributions in the region. Australia's renewable capacity should be boosted by competitive onshore wind and good economic attractiveness for distributed solar PV. Korea's growth is expected to be led by onshore and offshore wind development, hydropower, and solar PV. Korea is also expected to have the world's largest ocean power capacity in 2018.

Biofuels for transport and renewable heat continue to grow, despite uncertainties

World biofuels production is expected to reach 2.36 mb/d in 2018, up 0.5 mb/d from 2012. Still, the sector faces some uncertainties. Globally, advanced biofuels capacity is expected to expand only slowly, though the first commercial-scale plants in the United States and OECD Europe were recently commissioned. Ethanol output in the United States is currently impacted by last year's severe drought and high corn prices. While the United States should remain the largest producer, technical

and economic challenges related to blending more than 10% ethanol in the gasoline pool raise uncertainty over the outlook. In Brazil, more optimistic sugar cane harvest conditions and new government support measures should drive continued growth, though the ethanol sector there still faces financial difficulties. Meanwhile, high feedstock prices and poor margins continue to challenge biofuel producers in OECD Europe. The medium-term outlook there carries uncertainties associated with a European Commission proposal to limit blending requirements for food-based biofuels to 5% of transport energy demand, versus a current maximum 10%.

Figure 5 Global biofuels supply, 2012-18

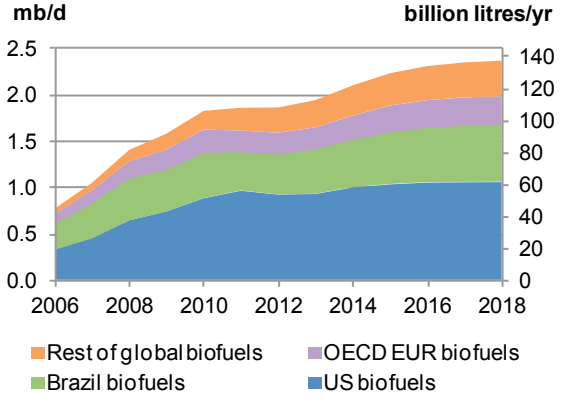
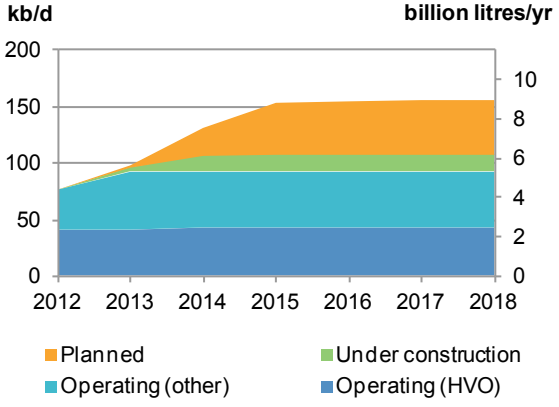
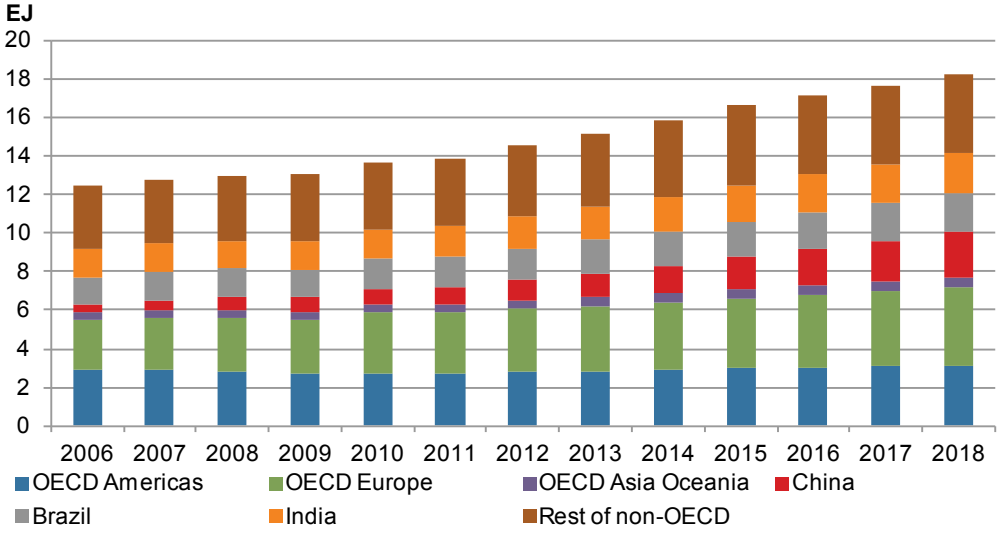


Figure 6 Global advanced biofuel capacity



Note: kb/d = thousand barrels per day; HVO = hydrotreated vegetable oil.

Figure 7 Global final energy use of renewable sources for heat (including commercial heat)



Note: excludes traditional biomass, *i.e.* the use of fuelwood, charcoal, animal dung and agricultural residues in stoves with very low efficiencies.

Renewable sources are playing an increasing role in final energy use for heat. Global final energy consumption of renewable sources for heat, excluding traditional biomass, is seen growing from 13.9 EJ in 2011 to 17.9 EJ in 2018. Renewable heat policy frameworks have evolved slowly, with relatively fewer countries with policies to support development in comparison to renewable electricity. To date, the most extensive policy drivers have emerged in OECD Europe, though comprehensive frameworks are generally still lacking. Over the medium term, OECD Europe should account for over

20% of growth, driven by 2020 targets in the European Union and increasing bioenergy, both for direct use and commercial heat, with solar thermal and geothermal growing from low bases. China should account for over 35% of global growth, driven by government targets and good competiveness of solar thermal heating. As a share of global final energy consumption for heat, renewable sources rise to almost 10% in 2018, from over 8% in 2012 and under 8% in 2006.

Renewable electricity broadly on track in clean energy scenarios

As a portfolio of renewable technologies continues to become more competitive, renewable power is on track to meet global climate change objectives, *i.e.* the interim 2020 targets in the IEA *Energy Technology Perspectives 2012* (*ETP 2012*) 2 °C Scenario (2DS), in absolute generation and investment levels. That scenario assumes over 7 400 TWh of renewable generation in 2020, versus total generation of 27 165 TWh. Biofuels for transport face a more challenging path. Production must more than double from current levels to meet the 2DS target of 240 million litres per year in 2020. Advanced biofuels production, in particular, needs to accelerate to meet 2DS objectives.

Figure 8 Global renewable electricity generation, the *MTRMR 2013* projection versus *ETP* 2DS

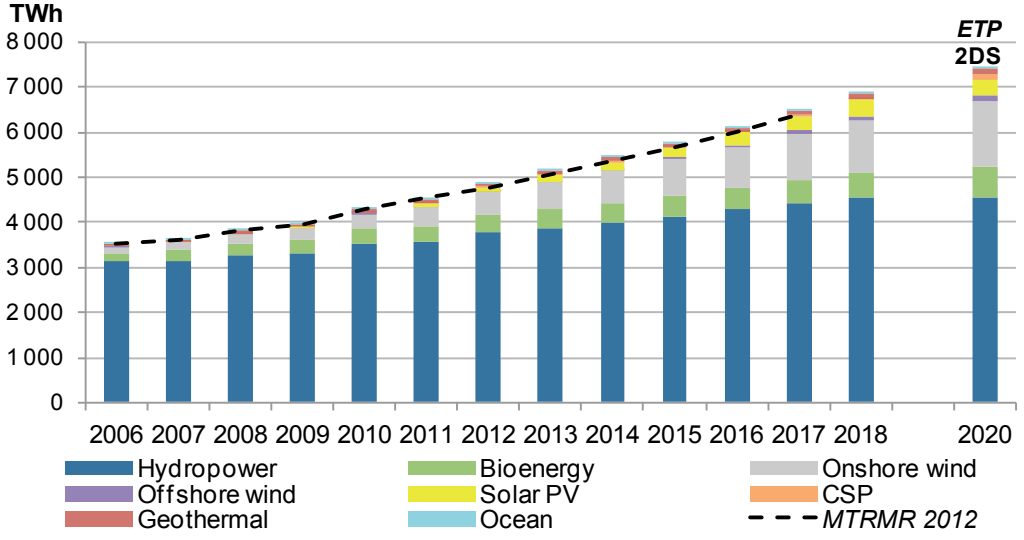


Table 1 World renewable electricity capacity and projection (GW)

	2011	2012	2013	2014	2015	2016	2017	2018
Hydropower	1 071	1 102	1 138	1 173	1 209	1 249	1 291	1 330
Bioenergy	75	82	89	96	105	112	119	125
Wind	236	282	321	368	413	459	508	559
Onshore	232	276	313	357	399	442	486	531
Offshore	4	5	8	11	14	17	22	28
Solar PV	69	98	128	161	194	230	268	308
Solar CSP	2	3	4	6	7	8	10	12
Geothermal	11	11	12	12	13	14	14	15
Ocean	1	1	1	1	1	1	1	1
Total	**1 465**	**1 579**	**1 693**	**1 815**	**1 941**	**2 073**	**2 211**	**2 351**

Notes: capacity data are rounded to the nearest GW and are generally presented as cumulative installed capacity, irrespective of grid-connection status. Grid-connected solar PV capacity (including small-distributed capacity) is counted at the time that the grid connection is made, and off-grid solar PV systems are included at the time of the installation.

Table 2 World renewable electricity generation and projection (TWh)

	2006	% of total gen, 2006	2011	% of total gen, 2011	2012	2013	2014	2015	2016	2017	2018
Hydropower	3 122	16.4%	3 567	16.1%	3 792	3 888	4 010	4 136	4 276	4 423	4 570
Bioenergy	209	1.1%	352	1.6%	373	396	428	463	498	530	560
Wind	133	0.7%	438	2.0%	519	626	725	840	952	1 080	1 220
Onshore	131	0.7%	428	1.9%	505	606	697	803	906	1 020	1 144
Offshore	2	0.0%	10	0.0%	13	20	28	36	46	59	76
Solar PV	6	0.0%	62	0.3%	100	138	178	221	267	316	368
Solar CSP	1	0.0%	3	0.0%	6	9	14	18	22	28	34
Geothermal	60	0.3%	70	0.3%	72	77	80	83	88	93	97
Ocean	1	0.0%	1	0.0%	1	1	1	1	2	2	2
Total	**3 531**	**18.6%**	**4 492**	**20.2%**	**4 862**	**5 136**	**5 436**	**5 762**	**6 104**	**6 471**	**6 851**

Notes: hydropower includes generation from pumped storage, which was reported at 75 TWh for 2011. Data for 2011 and 2012 are estimates; the split for onshore and offshore wind is estimated for historical data.

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