

Statistics

Renewables information: Overview



International
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2017

The following analysis is an overview from the publication *Renewables Information 2017*.

Please note that we strongly advise users to read definitions, detailed methodology and country specific notes which can be found online under *References* at www.iea.org/statistics/topics/renewables/

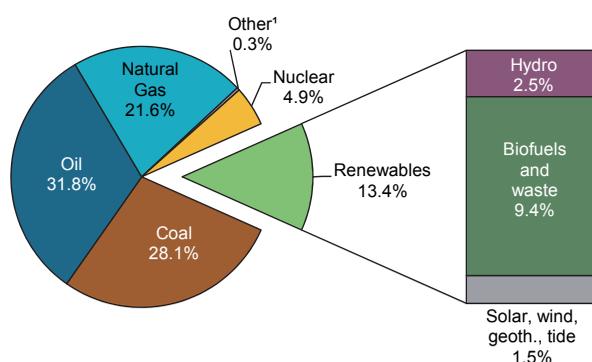
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OVERVIEW OF RENEWABLES AND WASTE IN THE WORLD

In 2015, world Total Primary Energy Supply (TPES) was 13,647 Mtoe, of which 13.4%, or 1,823 Mtoe (up from 1,784 Mtoe in 2014), was from renewable energy sources (Figure 1).

Figure 1: 2015 fuel shares in world total primary energy supply



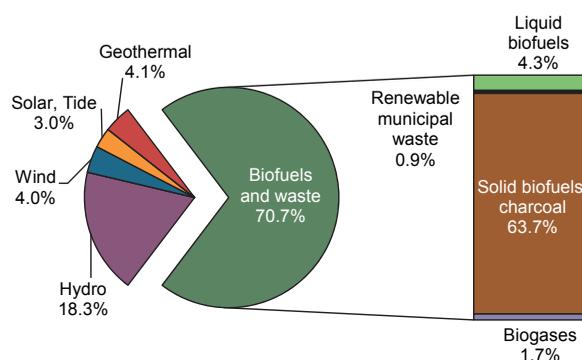
1. Other includes non-renewable wastes and other sources not included elsewhere such as fuel cells.

Note: Totals in graphs might not add up due to rounding.

Due to its widespread non-commercial use in developing countries (i.e. residential heating and cooking), solid biofuels/charcoal remains the largest renewable energy source, representing 63.7% of global renewables supply (Figure 2). The second largest source is hydro power, which provides 2.5% of world TPES or 18.3% of renewable energy supply. Geothermal, liquid biofuels, biogases, solar, wind, and tide each hold a smaller share making up the rest of the renewables energy supply.

Since 1990, renewable energy sources have grown at an average annual rate of 2.0%, which is slightly higher than the growth rate of world TPES, 1.8% (Figure 3).

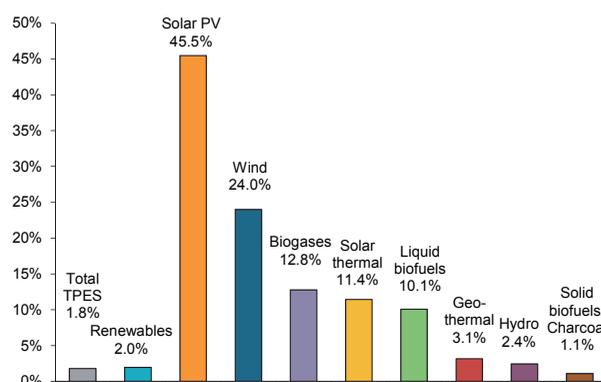
Figure 2: 2015 product shares in world renewable energy supply



Note: Totals in graphs might not add up due to rounding.

Growth has been especially high for solar photovoltaic and wind power, which grew at average annual rates of 45.5% and 24.0% respectively, both from very low bases in 1990. Biogases had the third highest growth rate at 12.8%, followed by solar thermal (11.4%) and liquid biofuels (10.1%).

Figure 3: Average annual growth rates of world renewables supply from 1990 to 2015

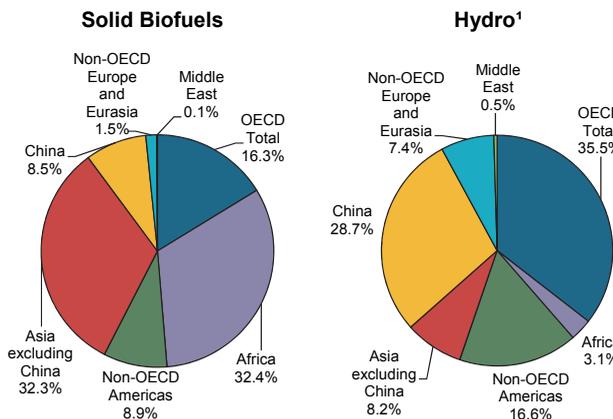


The average annual growth rate of hydroelectric power in non-OECD countries between 1990 and 2015, was 3.9%, much larger than the 0.6% growth in OECD countries. Growth in non-OECD was mainly driven by China accounting for 63.8% of hydro power increase in non-OECD countries. China showed 9.1% of growth rate between 1990 and 2015. Viet Nam and Mozambique are the other main contributors to the high growth rate, with average annual growth rates of 9.8% and 17.8% respectively.

In 2015, non-OECD countries accounted for 64.5% of total hydro power and any further increase is likely to be from these countries, as most of the remaining hydro potential resides in these countries.

Non-OECD countries also account for most of the production of solid biofuels. In 2015, 83.7% was produced and consumed in non-OECD countries, where developing countries, situated mainly in Asia and Africa, use non-commercial biomass for residential cooking and heating (Figure 4). Africa, which accounted for only 5.8% of the world's total TPES in 2015, accounted for 32.4% of the world's solid biofuels supply.

Figure 4: 2015 regional shares in renewables supply



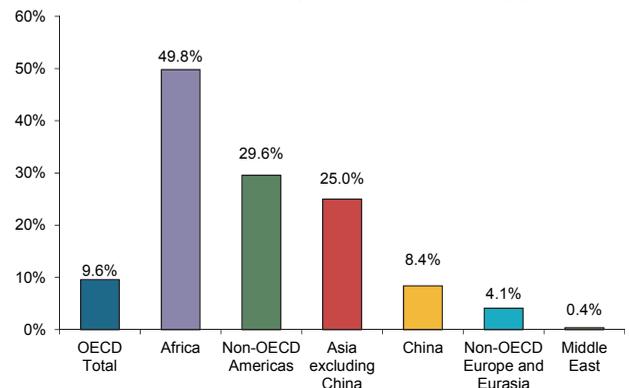
1. Excludes pump storage generation.

Note: Totals in graphs might not add up due to rounding.

Largely because of their use of non-commercial solid biofuels, non-OECD countries are the principal renewable energy users, accounting for 72.3% of world total renewables supply. On the other hand, while OECD countries supply 27.7% of world renewables, they constitute 38.5% of the world TPES. In OECD countries the share of renewables in total energy supply is 9.6% compared to 49.8% in Africa, 29.6% in Non-OECD Americas, 25.0% in Asia excluding China (Figure 5). However, the OECD countries play a

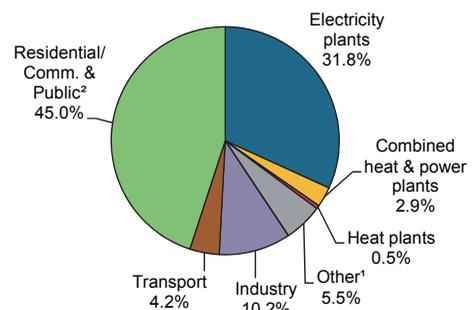
major role when looking at “new” renewables, a loosely defined term used to delineate between traditional and more recent technologies used to produce renewable energy. In 2015, the OECD countries accounted for 64.0% of world energy from solar, wind, tide, renewable municipal waste, biogases and liquid biofuels, whilst Africa represented 0.4%, 9.4% for Non-OECD Americas, 5.0% for Asia excluding China, and 20.1% for China.

Figure 5: 2015 shares of renewables of regional total primary energy supply



About half of the renewable primary energy supply in OECD countries is used in the transformation sector to generate electricity and sold heat. However, on a global level a majority of renewables is consumed in the residential, commercial and public services sectors. Again, this is a consequence of widespread solid biofuels use in the residential sector of developing countries. In fact, globally 35.1% of renewables are used for electricity production and heat production worldwide, while 45.0% are used in the residential, commercial and public sectors (Figure 6).

Figure 6: 2015 world sectoral consumption of renewables



1. Other transformation, energy industry own use, losses.

2. Includes the Agriculture/ forestry, fishing and non-specified industries.

Note: Totals in graphs might not add up due to rounding.

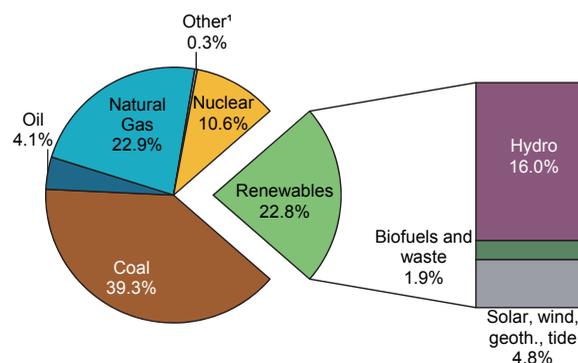
Renewables were the third largest contributor to global electricity production in 2015. They accounted for 22.8% of world electricity generation, after coal (39.3%) and gas (22.9%) and ahead of nuclear (10.6%) and oil (4.1%). However, the relative position of renewables and gas can be influenced by various factors among which the weather conditions play prime role.

Hydroelectricity supplies the vast majority of renewable electricity, generating 16.0% of world electricity, which is 70.3% of total renewable electricity, whilst biofuels and waste, including solid biofuels, play a minor role in electricity generation, supplying 1.9% of world electricity. Although growing rapidly, geothermal, solar, wind and tide energies accounted for only 4.8% of world electricity production, 21.2% of total renewable electricity in 2015.

Since 1990, renewable electricity generation worldwide grew on average by 3.6% per annum, which is slightly faster than the total electricity generation growth rate (2.9%). So whilst 19.4% of global electricity in 1990 was produced from renewable sources, this share has increased to 22.8% in 2015.

Over this period, hydroelectric power saw its share of total world electricity production fall from 18.1% in 1990 to 16.0% in 2015. Taking out hydroelectricity from renewables, the share of the remaining renewable sources used to produce electricity grew from 1.3% in 1990 to 6.8% in 2015.

Figure 7: Fuel shares in world electricity production in 2015



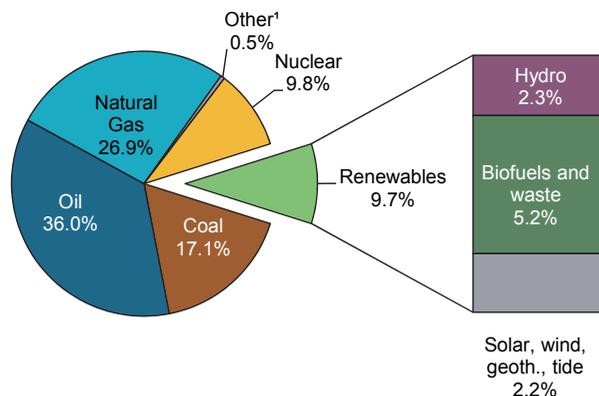
1. Other includes electricity from non-renewable wastes and other sources not included elsewhere such as fuel cells and chemical heat, etc.

Note: Totals in graphs might not add up due to rounding.

OVERVIEW OF RENEWABLES AND WASTE IN OECD COUNTRIES

In 2016, the share of renewables in total OECD primary energy supply reached 9.7%, the highest share since the IEA time series began in 1990 (Figure 8). This represents a slowdown in the growth of the share of renewables in TPES with the share increasing from 9.6% in 2015 and 9.4% in 2014, but well above the 6% level of 1990. OECD Europe experienced an increase in renewable TPES from 14.0% in 2015 to 14.2% in 2016. OECD Americas showed an increase in renewable TPES from 8.2% to 8.5% in the same period. On the other hand, OECD Asia experienced a decrease in renewables share in TPES from 5.0% to 4.8%.

Figure 8: 2016 fuel shares in OECD total primary energy supply



1. Other includes non-renewable wastes and other sources not included elsewhere such as fuel cells.

Note: Totals in graphs might not add up due to rounding.

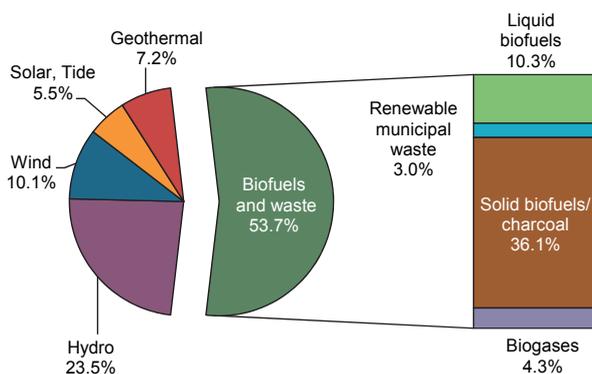
Primary energy supply

In OECD countries, total primary energy supply (TPES) from renewable sources increased from 272 Mtoe to 512 Mtoe between 1990 and 2016, an average annual growth rate of 2.5%. By comparison, the growth of

TPES for non-renewable energy sources (including coal, oil, gas and nuclear) was 0.4%.

The largest portion of renewable primary energy supply in the OECD comes from biofuels and waste, which accounted for 53.7% of the renewable supply (Figure 9). Of the biofuels, solid biofuels, including wood, wood wastes, other solid wastes and charcoal, constitutes the largest share, 36.1% of the renewable supply. The second largest renewable energy source is hydroelectric power, providing 23.5% of renewable primary energy. Solid biofuels and hydro accounted for 59.6% of the total OECD primary renewable energy in 2016.

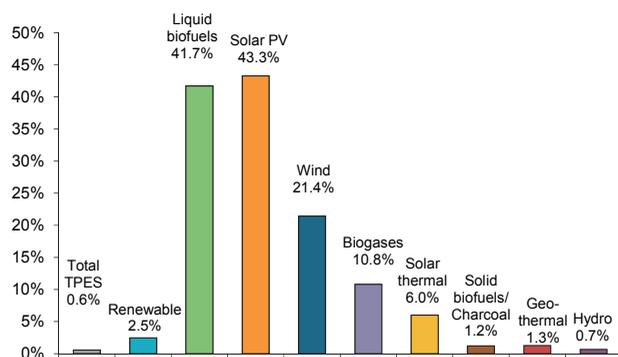
Figure 9: 2016 product shares in OECD renewable energy supply



Note: Totals in graphs might not add up due to rounding.

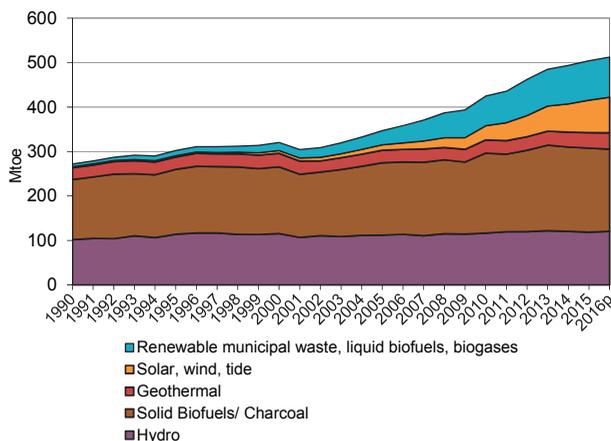
The average annual growth rate of solid biofuels between 1990 and 2016 was 1.2% and 0.7% for hydro (Figure 10), lower than the average annual growth rate of all renewable energies, 2.5%. This is mainly because hydroelectric capacity is mature in most OECD member states, and increasingly difficult to locate suitable sites to expand this energy form.

Figure 10: Annual growth rates of renewable supply from 1990 to 2016 in OECD total



Solid biofuels and hydro influenced much of the growth of total renewables between 1990 and 2001 (Figure 11). However, since 2001, the majority of renewables growth can be attributed to “new” renewables which have all seen growth rate above the average for all renewables. For example, solar photovoltaic experienced the highest growth among the renewables, averaging 43.3% between 1990 and 2016. Also experiencing high growth rates are liquid biofuels, 41.7%, and wind, 21.4% per annum since 1990. Biogases have grown much more rapidly than solid biofuels, with an average annual growth rate of 10.8%.

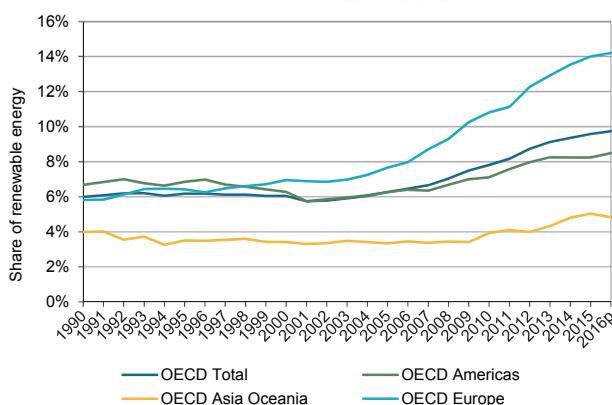
Figure 11: OECD renewable primary energy supply by product



However, despite these significant growth rates, the contribution of such “new” renewables to the total energy supply is still relatively small. Renewable municipal waste, biogases, liquid biofuels, wind, solar, and tide combined still represent only 3.2% of total primary energy supply. Nevertheless, their growing contribution to the renewable energy supply should be noted as their share of total renewables in OECD countries increased from 3.1% in 1990 to 33.2% in 2016.

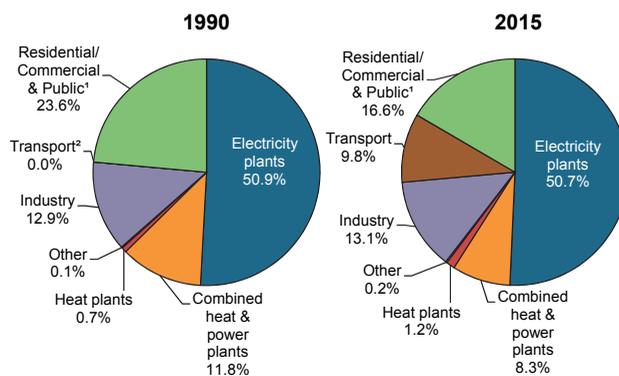
Among the different OECD regions, OECD Europe has the highest share of primary energy supply from renewable sources, with 14.2% in 2016 (Figure 12) and the largest increase in its renewable share since 1990 (up from 5.8%). The increase of the renewable share in OECD Europe is the result of the implementation of strong policies supporting renewable energy in the late 1990s and early 2000s, in particular the European Union’s directive to increase the share of renewable energy in TFC to 20% by 2020, which includes targets for individual countries. The renewable share of TPES in OECD Americas reached 8.5% in 2016, the highest level since the IEA time series began. In OECD Asia Oceania the share of renewable primary energy supply remained more constant between 1990 and 2016 (from 4.0% to 4.8%).

Figure 12: OECD regional shares in renewable energy supply



As a result of diversification in the use of renewables, sectoral renewables consumption has changed compared to 1990 (Figure 13). The most significant trend is the step growth of biofuels used for transport. In 2015, liquid biofuels and biogases used for transport constituted 9.8% of the consumption of renewables.

Figure 13: OECD sectoral consumption of renewables



1. Includes the Agriculture/ forestry, fishing and non-specified industries.
2. Represents less than 0.05%.

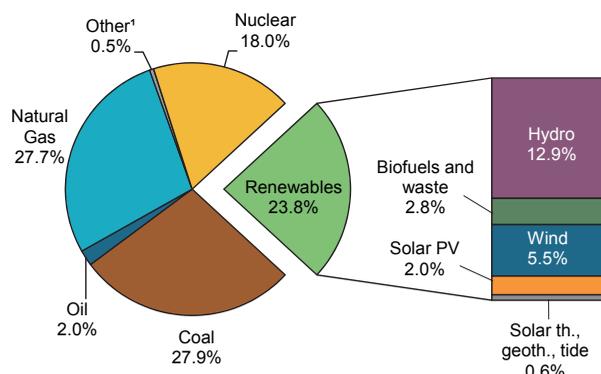
Note: Totals in graphs might not add up due to rounding.

Electricity production

OECD gross electricity production from renewable products (excluding generation from pumped storage plants) reached 2 588.3 TWh in 2016, a 3.8% increase from the 2015 level of 2 494.1 TWh. This represents 23.8% of total OECD electricity production in 2016 (Figure 14), which is the largest share of renewables in gross electricity production for any year in the renewables time series beginning from 1990.

The increase in electricity production from renewables was mainly caused by wind and solar PV. For wind, electricity production increased by 43.1 TWh which is mostly coming from the US (36.3 TWh), followed by Turkey (3.8 TWh) and Italy (2.8 TWh). Solar PV increased by 35.0 TWh, again mainly driven by the US, which had increased electricity production from solar PV by 18.0 TWh, followed by Japan (8.0 TWh), UK (2.7 TWh) and Chile (1.3 TWh).

Figure 14: Renewable shares in OECD electricity production in 2016



1. Other includes electricity from non-renewable wastes and other sources not included elsewhere such as fuel cells and chemical heat, etc. Note: Totals in graphs might not add up due to rounding.

Since 1990, electricity generation from renewable energy sources in OECD has been growing at an average rate of 2.6% per year, almost double the rate for total electricity generation (1.4%), mainly through the strong growth in “new” renewable products, such as solar PV, wind, renewable municipal waste and biogases.

Among renewables sources, hydroelectric power production has experienced the lowest average growth rate of any renewables electricity source from 1990 to 2016, 0.7% (Figure 15). This is because hydroelectric power has reached its capacity limit in most OECD

countries. Hydroelectricity generated 15.4% of total OECD electricity in 1990 but this share has decreased to 12.9% in 2016. With growth in other types of renewables, the hydroelectricity share of electricity from renewable energy sources declined from 89.4% in 1990 to 54.2% in 2016.

The share of non-hydro renewable electricity in total OECD electricity production increased from 1.8% in 1990 to 10.9% in 2016. In 1990, the majority of non-hydroelectricity was generated by solid biofuels and geothermal energy accounting for 7.2% and 2.2% of renewable electricity respectively, whilst solar photovoltaic, wind, biogases and liquid biofuels combined represented less than 0.6%. However, between 1990 and 2016, these technologies grew much faster than any other power source (Figure 15). Most notable is wind, which grew from 0.3% in 1990 to 23.2% of renewable electricity in 2016, a 21.4% average annual growth rate, making it now the second largest renewable source for electricity. The share of solar PV in OECD renewable electricity production increased from 0.0% to 8.4% in the same time period, and biogases increased from 0.3% to 3.1%, average growth from 1990 of 43.3% and 12.7% respectively. All of these sources experienced higher average growth rates than older technologies such as hydro power (0.7%), solid biofuels (2.6%) and geothermal (2.3%). As a result, non-hydro renewable electricity production experienced an 8.5% of average annual growth rate between 1990 and 2016 (Figure 15).

Figure 15: Annual growth rates of electricity production between 1990 and 2016 in OECD countries

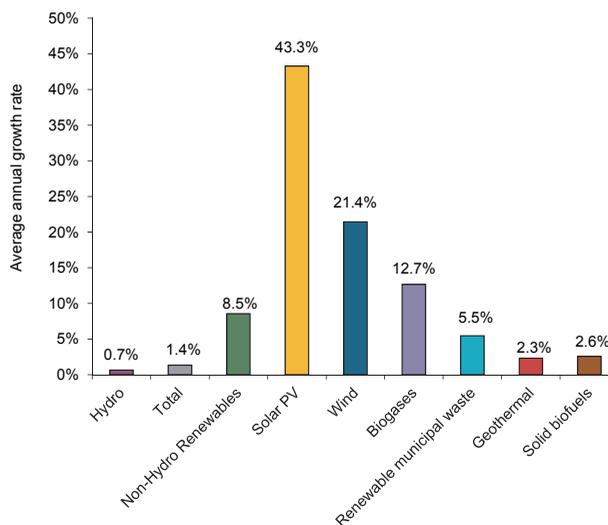
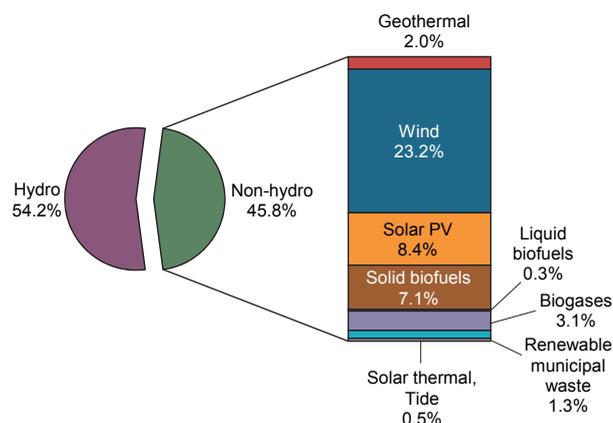


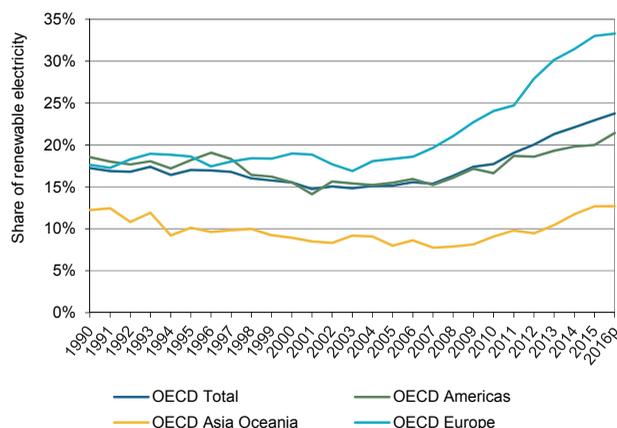
Figure 16: Shares in OECD renewable electricity production in 2016



Note: Totals in graphs might not add up due to rounding.

Renewable electricity production in OECD Europe grew 3.6% per annum since 1990. This growth rate is higher than other OECD regions, 1.9% for OECD Americas and 2.1% for OECD Asia Oceania. OECD Europe supplied 46.0% of total OECD renewable electricity production in 2016, up from 35.5% in 1990, slightly higher than the level of OECD Americas of 44.3%. The shares of electricity from renewables increased from 18.5% in 1990 to 21.4% in 2016 in OECD Americas, from 17.6% to 33.3% in OECD Europe, and from 12.3% in 1990 to 12.7% in OECD Asia Oceania (Figure 17). As a result of these increases, the OECD region as a whole saw its share of electricity from renewable sources grow to 23.8% in 2016 from 17.3% in 1990.

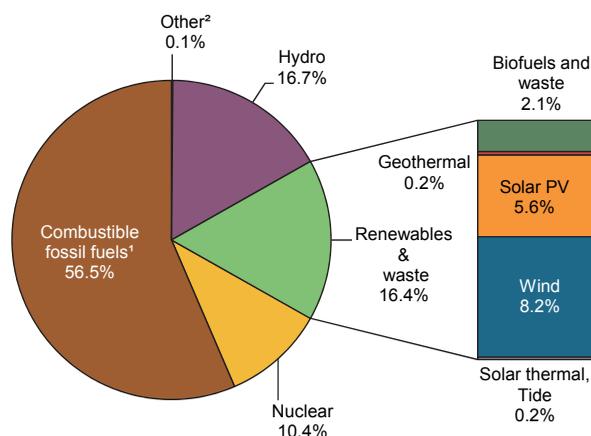
Figure 17: OECD regional shares in renewable electricity production from 1990 to 2016



Installed generating capacity

In 2015, 957.3 GW, 33.1% of total OECD generating capacity, was renewable energy and waste sources (Figure 18). Compared to 2014, total electricity generation capacity increased by 31.5 GW with the biggest growth seen in solar PV (28.6 GW) and wind (24.6 GW), offsetting the decreases experienced in nuclear (-2.5 GW) and combustible fuels (-27.6 GW). The largest increase in solar PV occurred in Japan which added 10.8 GW, followed by the US (6.8 GW) and the UK (3.8 GW). The sum of these three countries account for 74.6% of total increase. Regarding wind capacity, the largest growth was in the US, 8.3 GW, followed by Germany with 5.5 GW increment.

Figure 18: OECD generating capacity 2015



1. The capacities of plants which co-fire biofuels and waste with fossil fuels (e.g. solid biofuels that are co-fired with coal) are included under the dominant fuel.

2. Other: fuel cells, waste/chemical heat.

Note: Totals in graphs might not add up due to rounding.

The largest share (16.7%) of total generating capacity is hydroelectric plants, 483.4 GW, followed by 238.5 GW from wind (8.2%), 161.7 GW from solar photovoltaic (5.6%), and 62.1 GW from biofuels and waste (2.1%).

Of the biofuels and waste, 31.6 GW was solid biofuel capacity, 12.6 GW was municipal waste, 13.2 GW was biogases and 2.4 GW was liquid biofuels. The remaining generating capacity is accounted for by geothermal (0.2%), solar thermal, tide, wave and ocean power capacity, with less than 0.2%. Hydro pumped storage capacity represented 70.7 GW.

Detailed electricity production by source

This section provides more detailed analyses of individual renewable and waste energy sources in the electricity production. The energy sources are listed in the order of decreasing share in the renewable electricity production of OECD countries.

Hydroelectricity

As mentioned above, hydroelectric power is nearing its potential capacity limit in most OECD countries. Between 1990 and 2016, electricity generated from hydroelectric plants (excluding generation from pumped storage plants) increased from 1,183.8 TWh to 1 401.9 TWh in the OECD, yielding an average annual increase of 0.7%. While 89.4% of electricity produced from renewable sources came from hydroelectric plants in 1990, this share decreased to 54.2% in 2016 due to the rapid growth of electricity generation from other renewable sources. Despite this decrease, hydroelectric power is still the largest electricity producer among renewable technologies. In 2016, the largest hydroelectric power generating countries were Canada, the United States and Norway which represented 27.7%, 19.1% and 10.2%, respectively, of OECD hydroelectric production. Whilst the highest share in total electricity generated was seen in Norway (96.3%) followed by Iceland (72.6%) and Austria (61.2%).

Wind

In 2016, wind turbines produced 23.2% of renewable electricity in the OECD. Between 1990 and 2016, wind power increased from 3.8 TWh to 599.4 TWh, achieving an average annual growth rate of 21.4%. This is the second fastest growth rate of renewable electricity after solar photovoltaic. Among OECD regions, wind electricity production is the highest in OECD Europe, with 51.4% of the total OECD production in 2016. Most of the growth also occurred in OECD Europe, where wind grew by 25.9% per annum. In absolute terms, the United States, Germany and Spain are the largest producers of electricity from wind within the OECD, producing 229.3 TWh, 77.4 TWh and 48.9 TWh respectively.

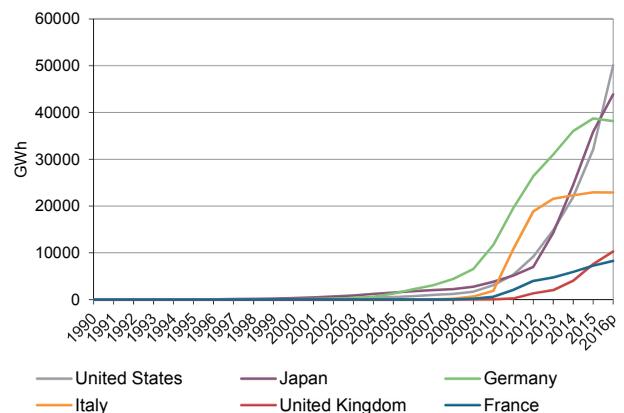
Solar photovoltaic

The OECD as a whole produced 218.3 TWh of PV electricity in 2016, 8.4% of its total renewable electricity production. The five largest producers of solar

photovoltaic (PV) electricity in the OECD were the United States with 50.1 TWh, Japan with 43.8 TWh, Germany with 38.2 TWh, Italy with 22.9 TWh, and the UK with 10.3 TWh. These five countries combined produced 75.7% of the PV electricity in the OECD.

While being small in absolute terms, electricity from solar PV increased from 19 GWh in 1990 to 218 283 GWh in 2016, achieving a 43.3% annual growth rate, the fastest of all renewable electricity technologies. US, the largest producer among OECD countries, increased production from 183 GWh in 2000 to 50 103 GWh in 2016, achieving a 42.0% growth rate over that time (Figure 19). Japan, the second largest producer, increased production from 347 GWh in 2000 to 43 846 GWh in 2016, with a growth rate over those years of 35.3%.

Figure 19: Solar photovoltaic electricity in six major OECD producing countries from 1990 to 2016



Solid biofuels

Electricity generation from solid biofuels grew from 95.2 TWh to 184.3 TWh between 1990 and 2016, a 2.6% average annual growth. As the fourth largest renewable electricity source, solid biofuels accounted for 7.1% of renewable electricity generation in 2016. The United States (45.3 TWh) accounted for 24.6% of electricity generated from solid biofuels within the OECD, where it makes up 7.1% of the country's renewable electricity production. The second largest producer of electricity from solid biofuels is Japan (29.3 TWh), where it represents 18.1% of the country's renewable electricity supply. Other large producers of electricity from solid biofuels in the OECD in 2016 are the UK, Germany, and Finland, producing 19.6 TWh, 11.0 TWh and 10.8 TWh respectively.

Biogases

Electricity in the OECD from biogases grew from 3.7 TWh in 1990 to 81.3 TWh in 2016. With an average annual growth rate of 12.7% since 1990, biogases are the third fastest growing source of renewable electricity in the OECD.

The driver of this growth is OECD Europe, which accounted for 79.5% of OECD production in 2016. Much of the growth is due to Germany, where production grew by 20.9% per annum since 1990, making it the largest producer in the OECD (42.0%). The third and fourth largest OECD producers were also located in Europe. Italy produced 9.0 TWh or 11.0% of OECD production, and the United Kingdom produced 7.4 TWh (9.2%).

The second largest OECD producer in 2016 is the United States which produced 13.3 TWh, or 16.3% of electricity from biogases in the OECD. However, despite its large share in OECD production, the United States growth rate (6.6% per year since 1990) has been lower than many of the European Union countries that use biogases, e.g. 38.2% in Italy and 20.9% in Germany.

Geothermal

Similar to hydroelectric power, geothermal electricity production has not experienced significant growth between 1990 and 2016. It grew at an average annual rate of 2.3%, from 28.6 TWh to 51.8 TWh.

Geothermal electricity generation remained almost static in OECD Americas over the period 1990 to 2016, although the region remains the largest geothermal electricity producer, with a 48.8% share of OECD production in 2016. The United States is the largest producer with 37.2% of the OECD total in 2016, with a production of 19.2 TWh, slightly above the 16.0 TWh level in 1990. The second largest producer is New Zealand, with 7.9 TWh in 2016, representing 15.2% of total OECD production. Other major producers are Italy (12.0%), Mexico (11.7%), and Iceland (9.8%).

Renewable municipal waste

Renewable municipal waste represented 1.3% of renewable electricity generation in 2016 in OECD countries. Renewable municipal waste has one of the smallest portions of renewable electricity portfolio. The highest share it represented in any one country is the Netherlands at 13.8%, Luxembourg at 9.3% and Hungary at 7.6%.

It should be noted that sometimes data are estimates rather than observations because the energy classification systems of some countries do not separate renewable and non-renewable municipal waste.

In 2016, 32.8 TWh of electricity was produced from renewable waste in the OECD. By far the largest producer of electricity from renewable municipal waste is the United States, generating 8.4 TWh, or 25.6% of OECD production. The second largest producer is Germany, with a production of 6.0 TWh (18.2%). With 2.6 TWh (7.8%), the UK is the third largest producer. Italy experienced the highest growth rate, increasing production from 37.0 GWh to 2,538 GWh (a growth rate of 17.7% per annum).

Liquid biofuels

Liquid biofuels for electricity production is a relatively new technology. The first country to report electricity production of this type was Germany in 2001 with 15 GWh. Since then, an increasing number of countries have produced substantial amounts of electricity from liquid biofuels. In 2016, ten countries reported a total of 6 499 GWh of production. The largest producer currently is Italy with 4,818 GWh.

Solar thermal

Solar thermal power production experienced rapid growth in the 1980's and 90's reaching 887 GWh in 1998, but stagnated in the following years. During the period of 1999 to 2006, average annual growth rates for solar thermal were essentially zero. Due to the recent renewed interest in solar thermal, the US has increased its production from 527 GWh in 1999 to 5 533 GWh in 2016. Prior to 2007, OECD solar thermal production took place mostly in the United States with small demonstration plants in Australia. With the opening of a new solar thermal power plant in 2007, Spain became the third OECD country to report electricity production from solar thermal with 5 506 GWh in 2016. These three countries combined produced all 11 045 GWh of OECD electricity from solar thermal in 2016.

Tide, wave, ocean

In 2016, 1 008 GWh of electricity were generated from tide, wave and ocean motion in three OECD countries. In 2016, France and Korea produced 500 GWh and 495 GWh respectively. The other contributor was Canada producing 13 GWh in 2016.