

Renewables information: Overview

The following analysis is an overview from the publication *Renewables Information 2019* which can be purchased from the IEA [webstore](#). The data can be purchased at <http://data.iea.org>.

Please note that we strongly advise users to read definitions, detailed methodology and country specific notes which can be found at http://wds.iea.org/wds/pdf/ren_documentation.pdf

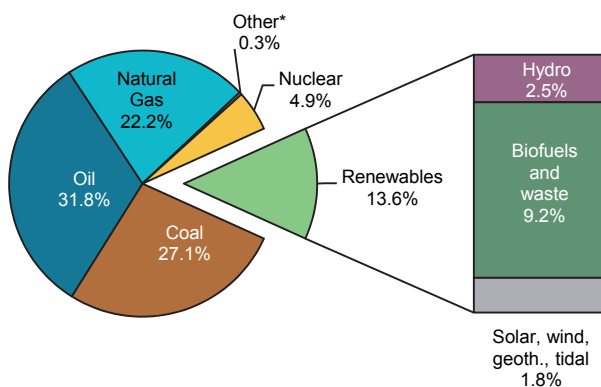
Please address your inquiries to renewaq@iea.org.

Please note that all IEA data are subject to the following Terms and Conditions found on the IEA's website: https://www.iea.org/t_c/

OVERVIEW OF RENEWABLES AND WASTE IN THE WORLD

In 2017, world Total Primary Energy Supply (TPES) was 13 972 Mtoe, of which 13.5%, or 1 894 Mtoe (from 1 845 Mtoe in 2016), was produced from renewable energy sources (Figure 1).

Figure 1: 2017 fuel shares in world total primary energy supply

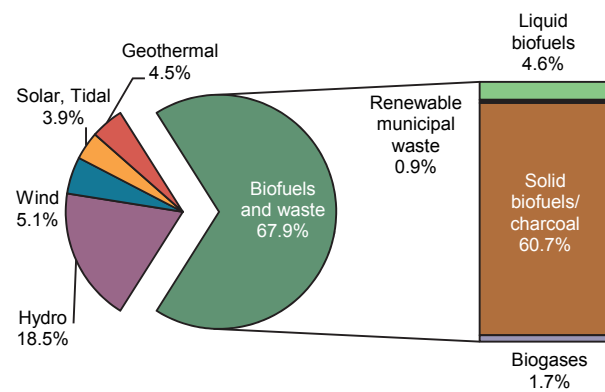


* Other includes non-renewable wastes and other sources not included elsewhere such as fuel cells.

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

Due to its widespread use in developing countries (i.e. residential heating and cooking), solid biofuels/charcoal is by far the largest renewable energy source, representing 60.7% of global renewables supply (Figure 2). The second largest source is hydro¹ power, which provides 2.5% of world TPES and 18.5% of

Figure 2: 2017 product shares in world renewable energy supply



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

renewables. Liquid biofuels, wind, geothermal, solar, biogases, renewable municipal waste and tidal each hold a smaller share making up the rest of the renewables energy supply.

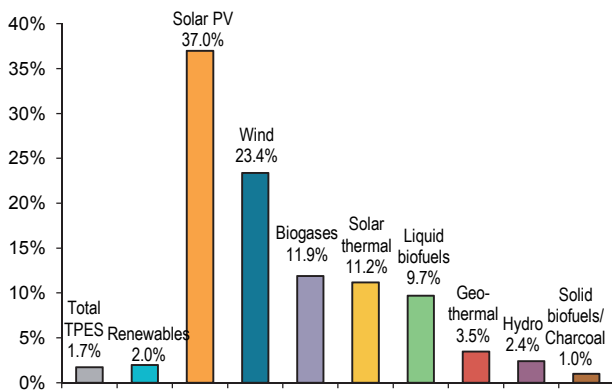
Since 1990, renewable energy sources have grown at an average annual rate of 2.0%, which is slightly higher than the growth rate of world TPES, 1.7% (Figure 3). Growth has been especially high for solar photovoltaic and wind power, which grew at average annual rates of 37.0% and 23.4%, respectively, from very low bases in 1990. Biogases had the third highest growth rate at 11.9%, followed by solar thermal (11.2%) and liquid biofuels (9.7%).

Between 1990 and 2017, the average annual growth rate of hydroelectric power in non-OECD countries was 3.9%, larger than in OECD countries, at 0.6%. Growth in the world in this period was driven by China, which accounted for 53.1% of the hydro

1. Any references to hydro production in this Overview exclude pumped hydro, unless otherwise specified. In the case of hydro generating capacities, hydro is the sum of pure hydro, mixed hydro and pure pumped storage.

power increase, with an average annual growth rate of 8.5%. Brazil, Canada and Viet Nam made the next three biggest contributions to the world increases, with 8.5%, 4.9% and 4.3% of the hydro power increase. The highest average annual growth rates were seen in Mozambique (15.5%), Belarus (11.8%) and Viet Nam (11.0%).

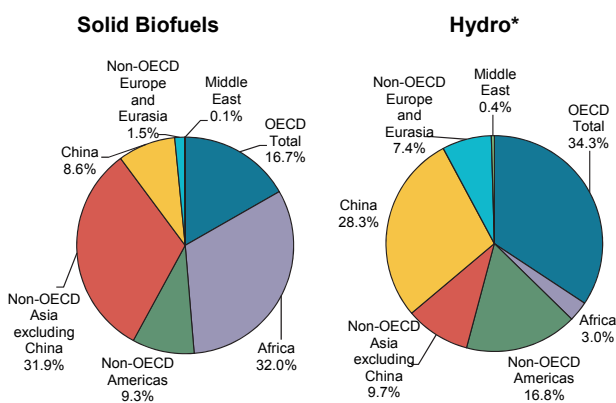
Figure 3: Average annual growth rates of world renewables supply from 1990 to 2017



In 2017, non-OECD countries accounted for 65.7% 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 (Figure 4).

Non-OECD countries account for most of the production of solid biofuels and its importance in these regions has not seen major fluctuations since 1990. Thus, the average annual growth rate for these countries, 0.9%, is slower compared to the OECD, 1.3%, since 1990.

Figure 4: 2017 regional shares in renewables supply



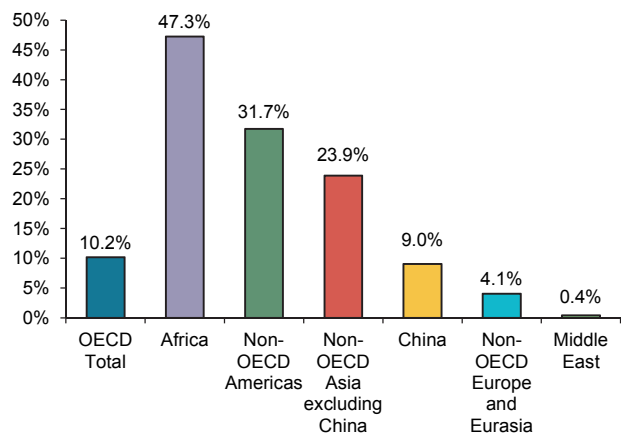
* Excludes pump storage generation.

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

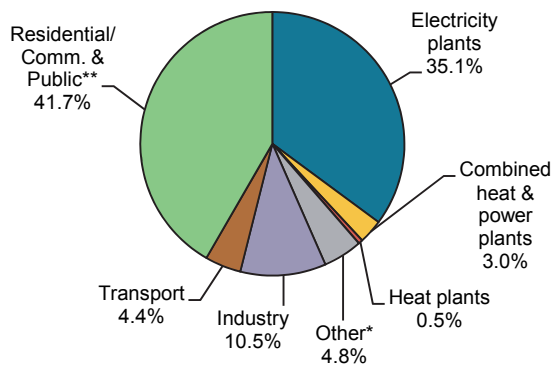
In 2017, 83.4% of solid biofuels were produced in non-OECD countries, where developing countries, situated mainly in Asia and Africa, use biomass for residential cooking and heating. Africa, which accounted for only 5.8% of the world’s total TPES in 2017, accounted for 32.0% of the world’s solid biofuels supply. This was almost equal to the share in non-OECD Asia excluding China, 31.9%.

Non-OECD countries supply 71.5% of the world’s renewable energy which accounts for 9.7% of world TPES. While OECD countries supply 28.5% of world renewables, these renewables constitute only 3.9% of world TPES. Consequently, in OECD countries, the share of renewables in total energy supply is 10.2% compared to 47.3% in Africa, 31.7% in non-OECD Americas, 23.9% in Asia, and 9.0% in China (Figure 5). However, OECD countries play a major role in “new” renewables, a loosely defined term comprising solar, wind, tidal, renewable municipal waste, biogases and liquid biofuels. In 2017, OECD countries accounted for 61.9% of “new” renewables.

Figure 5: 2017 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 heat. However, on a global level, the majority of renewables are consumed in the residential, commercial and public services sectors. This is a consequence of widespread use of solid biofuels in the residential sector of developing countries. 38.6% of renewables are used for electricity and heat production worldwide, while 41.7% are used in the residential, commercial and public sectors (Figure 6).

Figure 6: 2017 world sectoral consumption of renewables

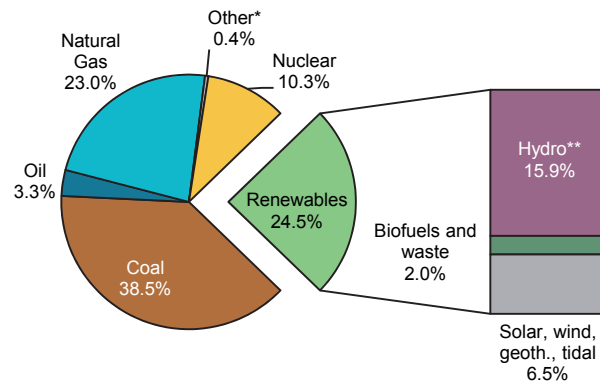
* Other transformation, energy industry own use, losses.

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

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

Renewables are the second largest contributor to global electricity production (Figure 7). They accounted for 24.5% of world generation in 2017, after coal (38.5%) and ahead of gas (23.0%), nuclear (10.3%) and oil (3.3%). After surpassing natural gas in 2016, renewables further increased their share by 0.7 percentage points in 2017. Historically, the relative positions of renewables and natural gas have been influenced by various factors, amongst which weather conditions have played a key role. Policies which favour renewables over fossil fuels have also contributed to the increasing importance of renewables in world electricity production.

Hydroelectricity supplies the vast majority of renewable electricity, generating 15.9% of world electricity, and 65.1% of total renewable electricity. Although growing rapidly, geothermal, solar, wind and tidal

Figure 7: Fuel shares in world electricity production in 2017

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

** Excludes pump storage generation.

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

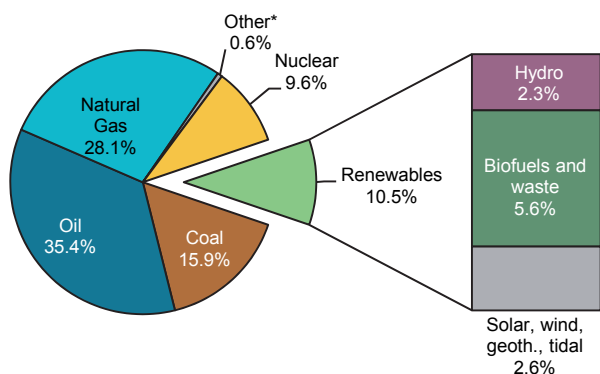
energies accounted for 6.5% of world electricity production, which is 26.6% of total renewable electricity in 2017. Biofuels and waste, including solid biofuels, play a minor role in electricity generation, supplying 2.0% of world electricity.

Since 1990, renewable electricity generation worldwide grew on average by 3.8% per annum, which is greater than the average growth rate of total electricity generation (2.9%). Whilst 19.4% of global electricity in 1990 was produced from renewable sources, this share increased to 24.5% by 2017. Over this period, hydroelectric power saw its share of total world electricity production falling from 18.1% in 1990 to 15.9% in 2017. The share of the remaining renewable sources used to produce electricity grew from 1.3% in 1990 to 8.5% in 2017.

OVERVIEW OF RENEWABLES AND WASTE IN OECD COUNTRIES

In 2018, the share of renewables in total OECD primary energy supply reached a new high of 10.5% (Figure 8). Each OECD region also showed increases in the share of renewables with 15.2% in OECD Europe, 9.1% in OECD Americas and 5.5% in OECD Asia/Oceania in 2018.

Figure 8: 2018 fuel shares in OECD total primary energy supply



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

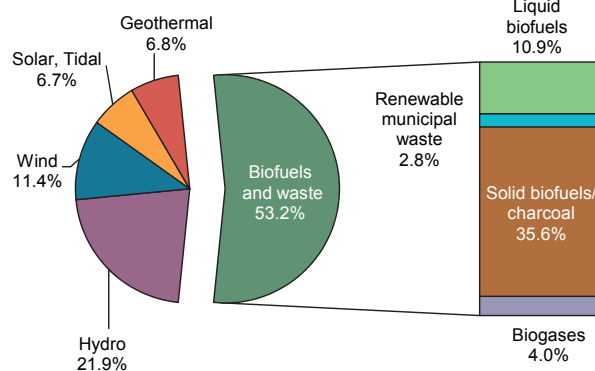
Note: Totals in graphs might not add up due to rounding.

Primary energy supply

In OECD countries, total primary energy supply from renewable sources increased from 272 Mtoe to 562 Mtoe between 1990 and 2018, an average annual growth of 2.6%. By comparison, the growth of TPES for non-renewable energy sources (including oil, gas, coal, and nuclear) is 0.4%. Over this time period, renewables contribution to total OECD primary energy supply grew from 6.0% to 10.5%.

The largest proportion of renewable primary energy supply in the OECD comes from biofuels and waste, which accounts for 53.2% of the renewable supply (Figure 9). Of this category, solid biofuels, including wood, wood wastes, other solid wastes and charcoal, constitutes the largest share, 35.6%, of the supply. The second largest renewable energy source is hydroelectric power, providing 21.9% of renewable primary energy supply. These two renewable energy sources constituted 57.5% of the total OECD primary renewable energy supply in 2018.

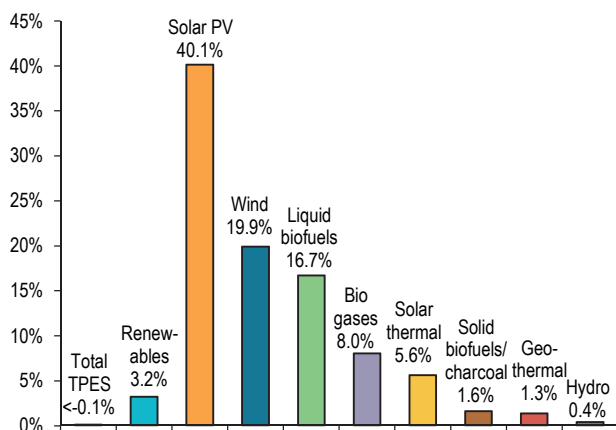
Figure 9: 2018 product shares in OECD renewable energy supply



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

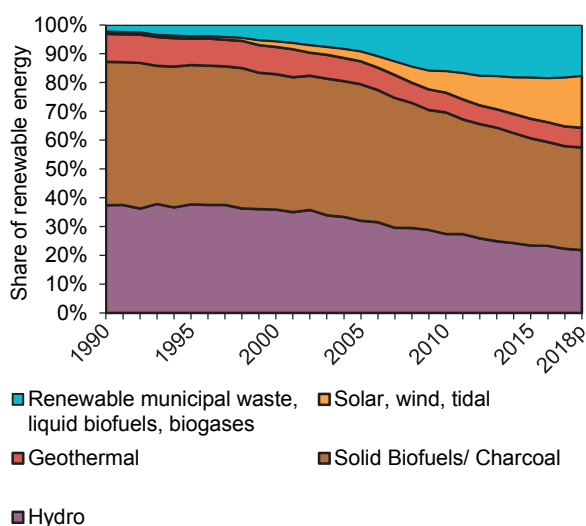
Renewables showed a larger increase in the average annual growth rate in the time period from 2000 to 2018 than in the period from 1990 to 2000, with rates of 3.2% and 1.7%, respectively (Figure 10). Higher growth rates are seen in “new” renewables, such as solar PV (40.1%), wind (19.9%), liquid biofuels (16.7%), biogases (8.0%) and solar thermal (5.6%). Lower growth rates are seen in solid biofuels/charcoal (1.6%), geothermal (1.3%) and hydro (0.4%).

Figure 10: Average annual growth rates of renewable supply from 2000 to 2018 in OECD total



Contrary to the 2000 – 2018 period where “new” renewables dominated the growth trends, solid biofuels and hydro influenced much of the growth of total renewables between 1990 and 2000. Despite this, the contribution of such “new” renewables to the total energy supply is still minor. Liquid biofuels, wind, solar, biogases, renewable municipal waste, and tidal combined still represent only 3.7% 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 35.7% in 2018 (Figure 11).

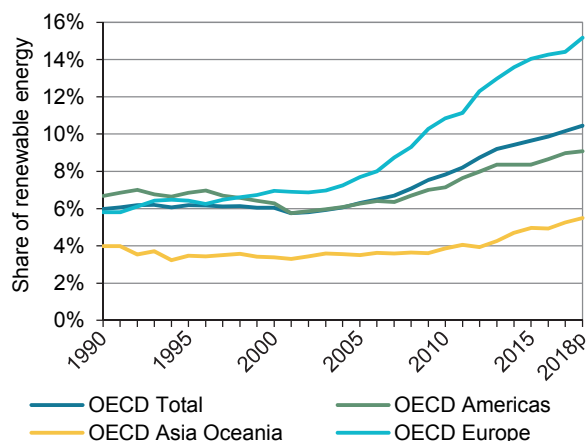
Figure 11: Shares of OECD Renewable Energy Supply by Product



Among the different OECD regions, OECD Europe has the highest share of primary energy supply from renewable sources, with 15.2% in 2018 (Figure 12). It is also the OECD area that has experienced the largest increase (from 5.8%) in its renewable share since 1990.

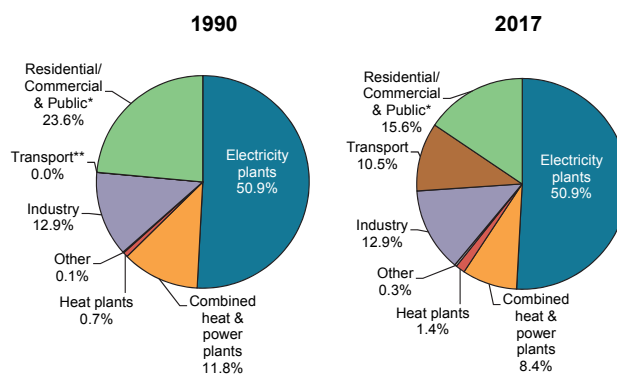
The increase of the renewable share in OECD Europe has certainly been the consequence of the implementation of supporting policies introduced in the late 1990s and 2000s. The renewable share of TPES in OECD Americas reached a new high of 9.1% in 2018 from 6.7% in 1990. In OECD Asia Oceania the share of renewable primary energy supply increased from 4.0% in 1990 to reach 5.5% in 2018.

Figure 12: OECD regional shares of renewable energy supply



Over the course of the last three decades there has been a diversification in the use of renewables, resulting in changes in the sectoral composition of renewables consumption since 1990 (Figure 13). The most significant trend is the steep growth of biofuels used for transport. In 2017², liquid biofuels and biogases used for transport constituted 10.5% of the consumption of renewables.

Figure 13: OECD sectoral consumption of renewables



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

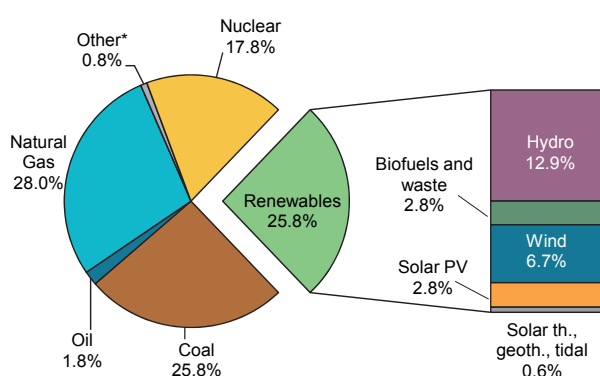
Note: Totals in graphs might not add up due to rounding.

2. At the time of publication, sectoral consumption data were only available through the end of 2017.

Electricity production

OECD gross electricity production from renewable products³ reached 2 862.1 TWh in 2018, 4.9% higher than the 2017 level of 2 727.5 TWh. This represents one quarter (25.8%) of total OECD electricity production in 2018 (Figure 14), which is the largest share of renewables in gross electricity production and is now the same as coal.

Figure 14: Renewable shares in OECD electricity production in 2018



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

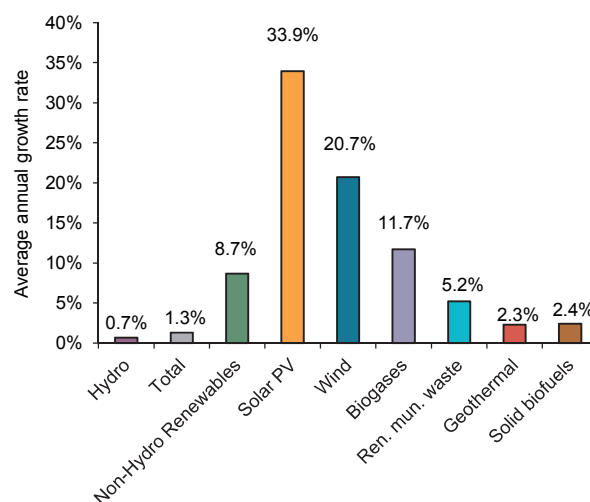
Note: Totals in graphs might not add up due to rounding.

Since 1990, OECD electricity generation from renewable energy sources has been growing at an average rate of 2.8% per year, more than double the rate for total electricity generation (1.3%), reflecting the strong growth in “new” renewable products, such as solar PV, wind, renewable municipal waste and bio-gases for electricity production in recent years.

Among renewable sources, hydroelectric power production constitutes the biggest share at 50.0% (1 429.6 TWh) but it has experienced the lowest average growth rate of any renewable electricity source from 1990 to 2018, 0.7% (Figure 15). Wind has grown from 0.3% (3.8 TWh) in 1990 to 26.0% (745.3 TWh) of renewable electricity in 2018, a 20.7% average annual growth rate, making it the second largest renewable source for electricity. The share of solar PV in OECD renewable electricity production increased from 0.0% to 11.0% (315.5 TWh, a 33.9% average

annual growth rate) in the same time period, and bio-gases increased 0.3% to 2.8% (81.4 TWh), 11.7% average annual growth from 1990. All of these sources experienced higher than average growth rates than older technologies such as the aforementioned hydro power (0.7%), solid biofuels (2.4%) and geothermal (2.3%). As a result, non-hydro renewable electricity experienced a combined 8.7% annual growth rate between 1990 and 2018.

Figure 15: Annual growth rates of electricity production between 1990 and 2018 in OECD countries

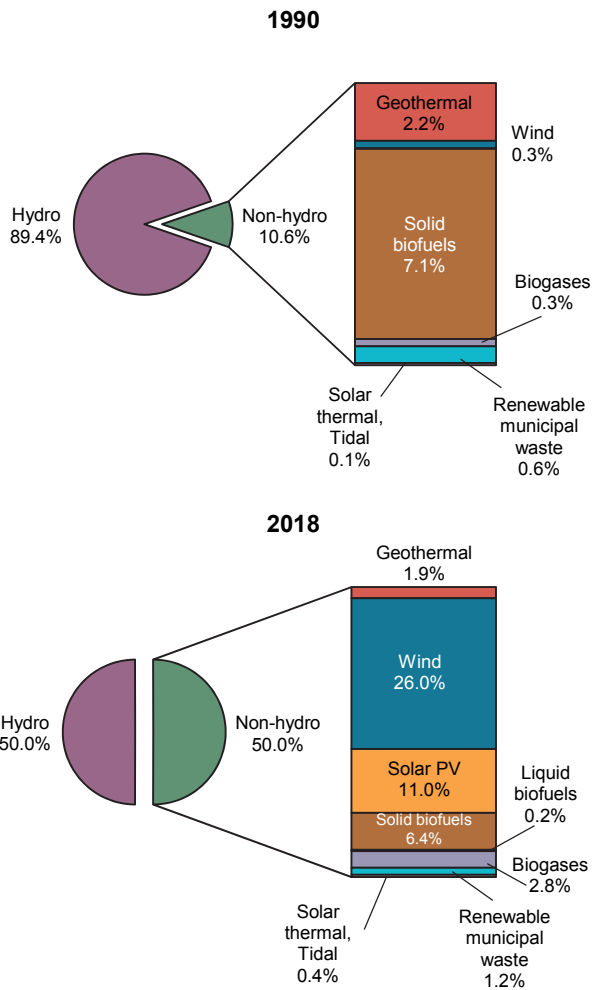


With growth in other types of renewables, the hydro-electricity share of electricity from renewable energy sources declined from 89.4% in 1990 to 50.0% in 2018 (Figure 16). In 1990, the majority of non-hydro-electricity was generated by solid biofuels (67.4%) and geothermal energy (20.4%), whilst solar PV and wind represented 3.8% of non-hydro renewable electricity in 1990. However, between 1990 and 2018, solar PV and wind grew much faster than any other power source, to account for 37.1%.

Renewable electricity production in OECD Europe grew 3.7% on an average annual basis since 1990. This growth rate is higher than other OECD regions, 2.1% for OECD Americas and 2.5% for OECD Asia Oceania. The shares of electricity from renewables increased from 18.5% in 1990 to 23.1% in 2018 in OECD Americas, and from 17.5% to 35.7% in OECD Europe, and from 12.4% in 1990 to 14.6% in 2018 in OECD Asia Oceania (Figure 17). As a result of the increases, the OECD region as a whole produced its highest share of electricity from renewable sources from 1990 (17.2%) to 2018 (25.8%).

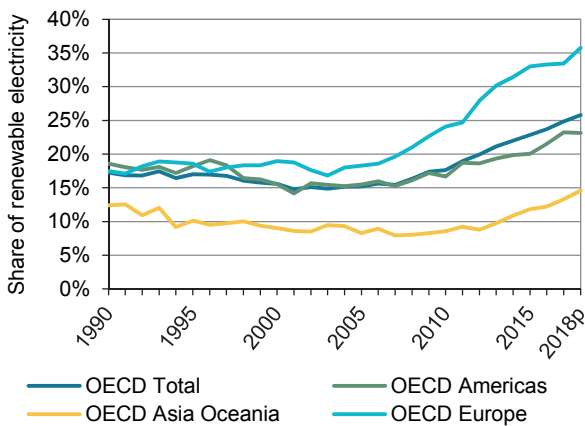
3. Excluding generation from pumped storage plants.

Figure 16: Changing shares of OECD renewable electricity production



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

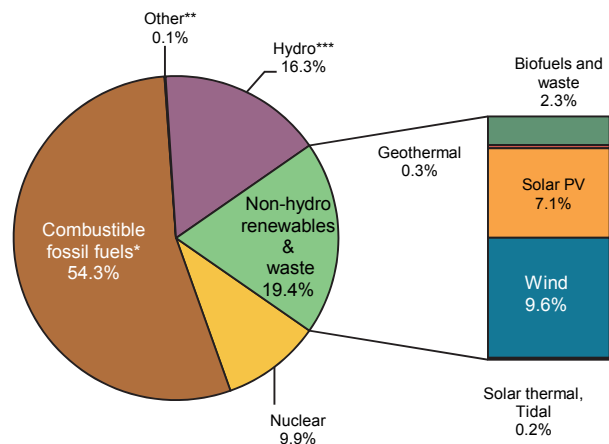
Figure 17: OECD regional shares in renewable electricity production from 1990 to 2018



Installed generating capacity⁴

At the end of 2017, approximately 1 075.6 GW, or 35.7%, of total OECD generating capacity, was renewable energy and waste sources (Figure 18). Compared to 2016, total capacity had increased by 54.8 GW, driven by solar PV and wind, increasing 26.0 GW and 23.7 GW, respectively (nuclear generating capacity decreased 4.0 GW, which is why the sum of the increases in solar PV and wind are greater than the total increases in OECD generating capacity).

Figure 18: OECD generating capacity 2017



* 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.

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

*** Includes pumped hydro.

Note: Totals in graphs might not add up due to rounding. Generating capacities include pure hydro, mixed hydro and pure pumped storage.

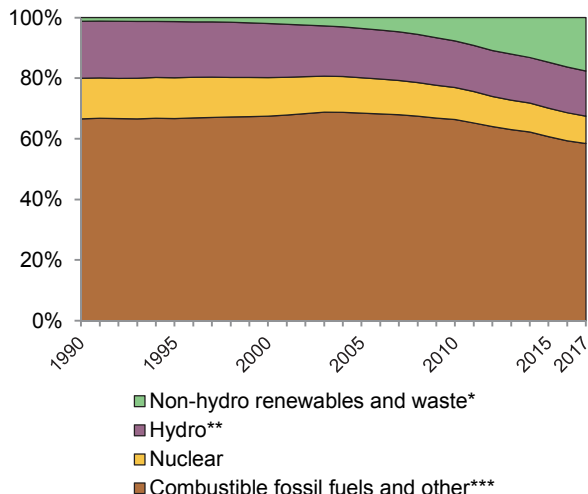
The largest share (16.3%) of total generating capacity is hydroelectric plants, 492.4 GW, followed by 288.0 GW from wind (9.6%), 214.5 GW from solar photovoltaic (7.1%), and 68.6 GW from biofuels and waste (2.3%).

Within biofuels and waste, 35.0 GW was solid biofuel capacity, biogases were 15.3 GW, municipal waste was 13.4 GW, and liquid biofuels was 2.4 GW. The remaining generating capacity was accounted for by geothermal (0.3%) and solar thermal, tide, wave and ocean power capacity, with 0.2%.

4. Capacity data is only available for OECD countries through the end of 2017 at the time of publication.

From 1990 to 2017, the renewable shares of generating capacities for OECD countries have increased (Figure 19). Over this time period, the average annual growth rates of renewables and waste generating capacities (3.7%) have outpaced the average annual growth rates of non-renewable generating capacities (1.4%).

Figure 19: Changing shares of OECD generating capacities 1990 – 2017



* Includes solar PV, solar thermal, wind, biofuels, tidal, industrial and municipal wastes and geothermal.

** Includes pumped hydro.

*** 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. Also includes "other" which is defined as fuel cells and waste/chemical heat.

Detailed electricity production by source

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

Hydroelectricity

Hydroelectric power is nearing its potential capacity limit in most OECD countries. Between 1990 and 2018, electricity generated from hydroelectric plants (excluding generation from pumped storage plants) increased from 1 185.2 TWh to 1 429.6 TWh in the OECD, yielding an average annual increase of 0.7%. In 2018, the largest hydroelectric power generating countries were Canada, the United States and Norway which represented 26.8%, 20.6% and 9.8%, respectively, of OECD hydroelectric production. The

countries with the highest reliance on hydroelectric power are Norway, Iceland and New Zealand, where the share of hydro generation was 95.0%, 69.7% and 59.3%, respectively, in 2018. The output from hydro is dependent on rainfall, and fluctuations in weather patterns can have a strong effect on a country's hydroelectric production.

Wind

In 2018, wind turbines produced 26.0% of renewable electricity in the OECD. Between 1990 and 2018, wind power increased from 3.8 TWh to 745.2 TWh, achieving an average annual growth rate of 20.7%. 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 52.8% of the total OECD production in 2018 and an average growth rate of 24.9% per annum since 1990. In absolute terms, the United States, Germany and the United Kingdom are the largest producers of electricity from wind in 2018 within the OECD, producing 277.9 TWh, 111.6 TWh and 57.1 TWh, respectively.

Offshore wind will be an area of significant growth in OECD countries in the coming years. In 2017⁵, the share of offshore wind in total wind production was 7.4%.

Solar photovoltaic

The OECD produced 315.5 TWh of solar PV electricity in 2018, 11.0% of its total renewable electricity production. The five largest producers of solar PV electricity in the OECD were United States with 87.1 TWh, Japan with 67.6 TWh, Germany with 46.1 TWh, Italy with 22.7 TWh, and the United Kingdom with 12.9 TWh. These five countries combined produced 75.0% of the PV electricity in the OECD.

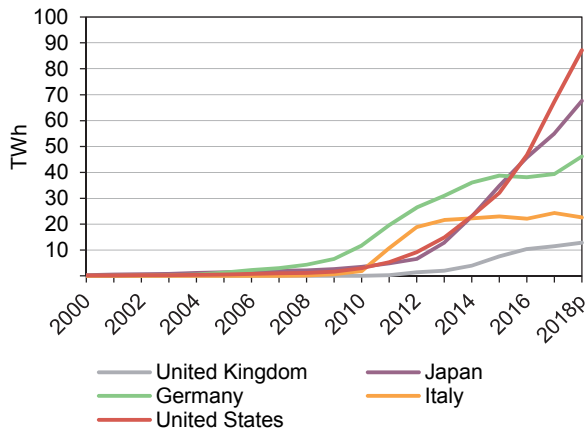
The countries with the highest share of solar PV in their electricity generation in 2018 are Luxembourg (11.9%), Italy (7.8%), Greece (7.2%), Germany (7.2%) and Japan (6.6%). Luxembourg imports most of the electricity consumed in the country, which leads to a higher than average solar PV generation share.

Electricity from solar PV increased from 88.7 GWh in 1990 to 315.5 TWh in 2018, achieving a 33.9% annual

5. At the time of publication, offshore wind data was only available through 2017.

growth rate, the fastest of all renewable electricity technologies. The United States, the largest producer among OECD countries, increased production from 183 GWh in 2000 to 87.2 TWh in 2018, reflecting a 38.9% average annual growth rate over that time (Figure 20).

Figure 20: Solar photovoltaic electricity in five major OECD producing countries from 2000 to 2018



Solid biofuels

Electricity generation from solid biofuels grew from 94.3 TWh to 184.2 TWh between 1990 and 2018, a 2.4% average annual growth. As the fourth largest renewable electricity source after hydropower, wind and solar PV, solid biofuels accounted for 6.4% of renewable electricity generation in 2018. The United States (45.6 TWh) accounted for 24.8% of electricity generated from solid biofuels within the OECD, where it makes up 6.1% of the country's renewable electricity production. The second largest producer of electricity from solid biofuels is the United Kingdom (24.9 TWh), where it represents 22.4% of the country's renewable electricity supply. Other large producers of electricity from biofuels in the OECD in 2018 are Japan, Finland and Germany with 18.9 TWh, 11.6 TWh, and 10.7 TWh, respectively. The countries with the largest share of electricity generation from solid biofuels are Finland (16.6%), Denmark (14.4%), Lithuania (11.9%), Luxembourg (10.2%), and Estonia (9.9%).

Biogases

Electricity in the OECD from biogases grew from 3.7 TWh in 1990 to 81.4 TWh in 2018. Production of electricity from biogases grew by an average annual rate of 11.7% since 1990, making it the fourth 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 2018. Much of the growth is attributable to Germany, where electricity production from biogases grew by an average growth rate of 19.2% per annum since 1990 to 33.9 TWh in 2018, making it the largest producer in the OECD with 41.7% of the total OECD electricity generation from biogases.

The second largest OECD producer in 2018 is the United States which produced 13.1 TWh, or 16.1% of electricity from biogases in the OECD. However, despite its large share in OECD production, the United States average annual growth rate (6.1% since 1990) has been much slower than many of the European Union countries that use biogases, e.g. 34.6% in Italy and 18.9% in Belgium. The third and fourth largest OECD producers were also located in Europe. Italy produced 8.2 TWh or 10.0% of OECD production, and the United Kingdom produced 7.2 TWh (8.8%).

Geothermal

Similar to hydroelectric power, geothermal electricity production has not experienced significant growth between 1990 and 2018. It grew at an average annual rate of 2.3%, from 28.6 TWh to 54.4 TWh.

The United States is the largest producer with 43.0% of the OECD total in 2018, with a production of 19.0 TWh, slightly above the 16.0 TWh level in 1990. The second largest producer is New Zealand, with 7.9 TWh in 2018, representing 14.5% of total OECD production and 21.4% of its total electricity generation. Other major producers are Turkey (12.7% of total OECD in 2018), Italy (11.2%) and Iceland (11.0%).

Renewable municipal waste⁶

Renewable municipal waste represented 1.2% of renewable electricity generation in 2018 in OECD countries, making it one of the smallest portions of the renewable electricity portfolio. The highest share of renewable electricity generation was in the Netherlands at 12.0%, followed by Luxembourg at 7.0% and Belgium at 5.5%. In 2018, 34.3 TWh of electricity was produced from renewable waste in the OECD.

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.

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 only 15 GWh. Since then, an increasing number of countries have produced substantial amounts of electricity from liquid biofuels. In 2018, 14 countries reported a total of 6 298 GWh of production. The largest producer is Italy with 4 299 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. From

2007, solar thermal electricity production grew in Spain, followed by the U.S., with average annual growth rates of 80.2% and 19.2%, respectively. These two countries account for almost 100% of solar thermal electricity production in 2018 with 5.2 TWh in Spain and 4.6 TWh in the United States. The remaining 2.6 GWh were produced in Australia.

Tide, wave, ocean

In 2018, at least one country in each OECD region used tide, wave and ocean motion to produce electricity. The countries were France (680 GWh), Korea (485 GWh), Canada (20 GWh) and the United Kingdom (8.3 GWh).