



# GLOBAL BIOENERGY STATISTICS 2020

World Bioenergy Association

## **DISCLAIMER**

WBA publishes the Global Bioenergy Statistics reports annually to increase awareness of the role of bioenergy in the global energy mix. The reports are prepared with the expert guidance of bioenergy experts from all over the world. Even though every effort is made to ensure the highest quality in data presented in the report, WBA cannot be held liable for the accuracy of the information presented.

## SUMMARY

Fossil fuels dominate the global energy supply. 81% of the total primary energy supply which includes production, imports, exports, and bunkers is supplied by coal, crude oil and natural gas. Renewable energy technologies of solar, wind, hydro, biomass, geothermal etc. had a share of 13.8% in the primary energy supply in 2018.

Coal is a significant contributor to the global electricity mix. In 2018, 38% of electricity produced globally was from coal-based sources with a total of more than 10 000 TWh. In recent years, natural gas is emerging as a major electricity producing energy source. In 2018, 26 730 TWh of electricity was generated globally with renewables having a share of 25.8%, mainly driven by the increasing use of solar and wind as well as significant contribution from hydropower and biomass. In 2018, 6 890 TWh of renewable electricity was produced globally. Hydropower was the largest renewable electricity generating source with a share of 62% followed by wind at 19%. Bioenergy was the third largest renewable electricity generating source with 637 TWh of production.

In 2018, 15 EJ of heat was produced globally via heat only and combined heat and power plants. The heat production has been increasing at an annual growth rate of just over 1%. Coal and natural gas have a combined share of more than 85% in the global heat production. Renewable energy technologies including biomass, geothermal and solar thermal have doubled their share in the global heat production over the past 18 years. 96% of all renewable heat produced was from biomass with minor contribution from geothermal and solar thermal technologies.

Direct heat includes the use of fuel directly for both heating and cooking purposes in residential, commercial, agriculture, fishing sectors etc. In energy terms, use of fuel for direct heat is more than twice the fuel used for electricity production. However, it is concerning to note that during 2000 – 2018, share of renewables in direct heat reduced from 24% to 20% globally. Direct heat production around the world was 35 times higher than derived heat produced in power plants. As is the case with derived heat, bioenergy is the single largest renewable heat source globally with a share of more than 95% followed by solar thermal at 3% and geothermal at 2%.

Transport sector accounts for about 27% of all energy consumed globally. Crude oil and oil products contribute 92% of the energy needs for the transport sector. Liquid biofuels and biogas are the most sustainable and ideal option for the sector right now. Biofuels have a share of more than 3% and have experienced a growth of 13% – almost 6 times as much as the overall energy needs in the transport sector.

Gross final energy consumption includes the total final consumption of all energy sources including the electricity and heat consumption at all end use sectors. In 2018, gross final energy consumption of all energy sources was 471 EJ. The share of renewables has remained constant at 17% since the start of the century.

In 2018, domestic supply of biomass was 55.6 EJ globally. 85% of the domestic supply was from solid biomass sources including wood chips, wood pellets and traditional biomass sources. Liquid biofuels accounted for 7%, municipal and industrial waste sectors accounted for 5% followed by biogas at 3%. In 2019, 1.9 billion m<sup>3</sup> of wood fuel was produced globally. Africa and Americas had the highest share of wood fuel production with a contribution of 36% and 37% respectively. Wood pellets are one of the fastest growing bioenergy sectors worldwide. In 2019, 38.9 million tonnes of pellets were estimated to be produced globally. Wood charcoal is another key bioenergy sector with significant volumes being produced globally. In 2019, 53.1 million tonnes of wood charcoal were produced globally with Africa accounting for 65% of the global production. Agriculture is a key sector for increased potential for bioenergy utilization in the future. In terms of yields of major crops, there is significant potential to increase the yields in various regions to the global average. This will enable increased production of both food and fuel with the agriculture sector playing a key enabler for increased bioenergy use around the world. Energy generation from municipal and industrial waste represents the 3rd feedstock sector after forestry and agriculture. In 2018, domestic supply of energy from municipal and industrial waste was 2.59 EJ with 56% from municipal waste and remaining from industrial waste.

In 2018, 637 TWh of electricity was generated from biomass globally. 66% of all biopower generated was from solid biomass sources followed by 19% from municipal and industrial waste. Biogas share was 14%. Asia accounted for 38% of all biopower generated globally with 243 TWh of production in 2018 followed by Europe at 35%. Electricity only plants are designed to produce electricity only. In 2018, 474 TWh of biopower was produced in electricity only plants, accounting for approx. 75% of all biopower produced globally. CHP or Combined Heat and Power plants refer to those plants that are designed to produce both heat and electricity. In 2018, 226 TWh of biopower was generated globally from biomass-based sources in CHP facilities accounting for a quarter of all biopower produced.

In 2018, 1.12 EJ of heat was produced from biomass-based sources – 53% from solid biomass sources and 26% from municipal solid waste. Europe is the world leader in producing heat from biomass in power plants with a share of 87% globally followed by Asia at 8%. In 2018, 0.21 EJ of bioheat was produced in heat only plants while 0.81 EJ of bioheat was produced globally in CHP facilities which accounts for more than 75% of all bioheat produced globally

In 2018, 160 billion litres of biofuels were produced globally. Bioethanol is the largest biofuel globally with a share of 62% followed by FAME biodiesel at 26%. Rest of the biofuels including HVO (Hydrogenated vegetable oil), renewable diesel, cellulosic ethanol etc. had a share of 12%. Americas dominate the biofuel production globally. North and South America together produce 75% of all biofuels globally with Europe having a share of 14%. In 2018, 59.3 billion m<sup>3</sup> of biogas was produced globally with an equivalent energy content of 1.36 EJ. During 2000 – 2018, the sector experienced an annual growth rate of 9%.

Renewable energy technologies create millions of jobs along the entire value chain. In 2019, an estimated 11.5 million people were employed in the renewable energy sector with bioenergy being the 2nd largest employer with an estimated 3.58 million people.



## WBA MEMBERS

We would like to express our gratitude to the following members for their continued support over the years for the mission to promote sustainable bioenergy development around the world.



\* Only full and associated members are listed.

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## INTRODUCTION

The WBA Global Bioenergy Statistics report is the flagship publications of World Bioenergy Association. First published in 2014, the annually published report is one of the only reports focussing solely on the developments in the bioenergy sector. The 2020 report is the 6th in the series.

Bioenergy is a complex energy system. A multitude of feedstock, technology pathways and end products encompass the biomass to energy conversion. Currently, bioenergy is the largest renewable energy source globally and accounts for more than 2/3rd of the renewable energy mix. In the overall energy scenario, bioenergy accounts for 13 – 14% of the total energy consumption.

Considering the prominence of bioenergy in the overall energy mix, the sector has not received due attention lack of awareness about the potential benefits of bioenergy. Secondly, it is important to note that there is a lack of reliable and updated data on bioenergy globally and locally. Due to the informal and local nature of most of the feedstock and technology used for bioenergy production, it is very challenging to gather, analyse and report accurate and updated information on bioenergy developments.

As readers go through the report, it is important to understand certain key terminologies and definitions used regularly in the report:

**Total primary energy supply or TPES** is a combination of: Indigenous production + Imports – Exports – International bunkers +/- Stock changes. The indigenous production of a particular fuel is the energy content of the fuel, for e.g. the lower heating value of charcoal. However, for fuels like solar and wind, the electricity generated is considered as the primary energy supply.

**Gross final energy consumption or GFEC** is a combination of: Total Final Consumption (TFC) – Non-energy use of fuels + Electricity consumption + Derived Heat consumption. TFC is the consumption of energy commodities in end use sectors, for e.g. residential, commercial, agriculture etc. and is calculated using the energy content of the fuel. The non-energy use of fossil fuels (e.g. in chemical industry) is eliminated. The electricity and heat consumption are derived from 'generation' data after eliminating their use within the industry and losses occurring during transmission and distribution.

**Bioenergy** refers to the use of biological commodity (or biomass) used specifically for energy purposes. The energy use implies the use of biomass for electricity and heat generation and the conversion of biomass to secondary products such as biofuels to be used in the transportation sector. For bioenergy, the energy content of the fuel is considered as primary energy.

**Derived and direct heat.** The end use of biomass for heating is divided into derived and direct heat. If the heat is generated in power plants (combined heat and power and heat only plants), then the heat is termed as derived heat. This is then transported via district heating grids for consumption in end sectors. However, the large part of the use of biomass is for direct heating where biomass (for e.g. charcoal and wood fuel) is burned in end use sectors (e.g. residential, commercial, agriculture etc.) for heating and cooking purposes. This is termed as direct heat.

**Units:** Throughout the report, an effort is made to ensure consistent units for reporting. For all energy related values, Exa Joule ( $10^{18}$  Joule) is considered the standard unit. For electricity, TWh is used as reporting unit while for energy commodities, various units like million tonnes, million m<sup>3</sup> and billion litres are used. For standard conversion factors, please refer to the Appendix.

**Geography:** The data in the report is classified into a 2-tier system – global and continental. The continental classification is available in the Appendix.

**Data sources:** Most of the data is obtained from the IEA Key World Energy Statistics and their online publication. Biomass supply data is obtained from FAOSTAT. Other data sources used in the report include publications from IRENA (e.g. Jobs), World Bank (e.g. country information) and WBA member network.

**Base year:** An attempt is made to obtain the most recent available data for each section. Most of the information available is from 2018 and some from the year 2019 as well.

We hope that the information is useful for you. We are confident that such reports will be a useful tool for politicians, investors, companies, researchers and journalists in better understanding this complex energy sector.

For getting in touch with WBA, please send an email to [info@worldbioenergy.org](mailto:info@worldbioenergy.org).



# CHAPTER 1. GLOBAL ENERGY

## ENERGY SUPPLY

Fossil fuels dominate the global energy supply. 81% of the total primary energy supply which includes production, imports, exports, and bunkers is supplied by coal, crude oil and natural gas.

Renewable energy technologies of solar, wind, hydro, biomass, geothermal etc. had a share of 13.8% in the primary energy supply in 2018. Even with an impressive annual growth rate of 2.4% since 2000, the share of renewables has remained constant throughout the past 2 decades. This is largely because of a comparable growth of the total energy supply at 2.0%. To meet the international energy and climate goals, it is important for renewable energy technologies to grow at a much faster rate, but at the same time, efforts have to be taken to ensure an exit strategy for fossil fuels around the world.

Table 1 Total primary energy supply globally

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewables (%)
2000	420	97.0	154	86.7	28.3	54.4	13.0%
2005	481	125	168	98.8	30.2	59.1	12.3%
2010	538	153	173	115	30.1	67.5	12.5%
2015	569	161	181	123	28.1	75.8	13.3%
2016	573	156	183	126	28.5	78.3	13.7%
2017	584	159	187	130	28.8	80.3	13.8%
2018	598	161	188	137	29.6	82.7	13.8%

All values in EJ

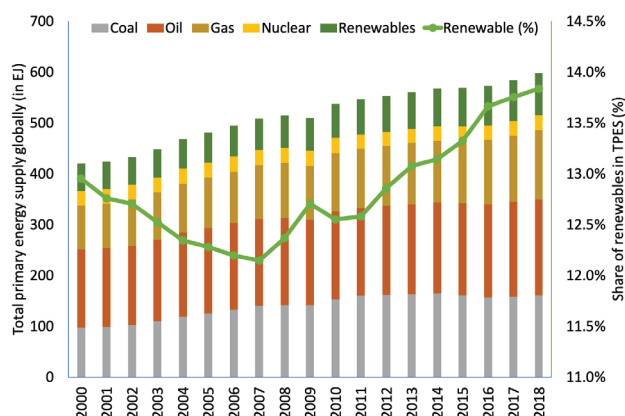


Figure 1 Total primary energy supply globally

In 2018, among continents, total primary energy supply of fossil, nuclear and renewables is highest in Asia. The continent is heavily dependent on coal as a major energy source with 42% of the total energy supply coming from coal. Americas including North, Central and South America are more dependent on crude oil and oil products which have a share of 37% in their energy mix. Among renewable energy sources, African continent has the highest share due to hydropower and traditional biomass for heating and cooking.

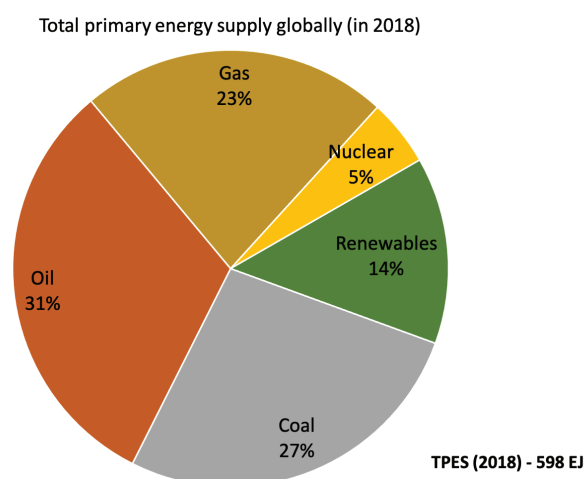


Figure 2 Total primary energy supply globally in 2018

Table 2 Total primary energy supply in continents in 2018

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewables (%)
Africa	35.0	4.75	7.93	5.58	0.13	16.6	47.4%
Americas	140	15.9	52.0	42.6	10.7	19.0	13.5%
Asia	283	120	76.8	46.9	6.29	33.2	11.7%
Europe	115	18.0	31.8	40.0	12.5	13.2	11.4%
Oceania	6.22	1.85	2.10	1.52	0.00	0.75	12.0%
EU - 28	67.1	9.40	21.9	16.4	9.02	10.2	15.3%

All values in EJ

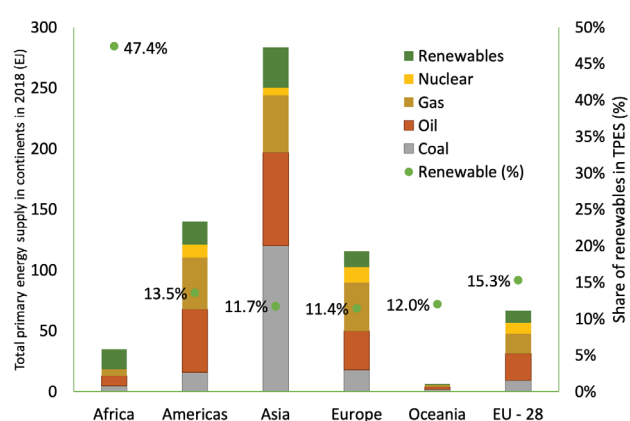


Figure 3 Total primary energy supply in continents in 2018

## ELECTRICITY

Coal is a significant contributor to the global electricity mix. In 2018, 38% of electricity produced globally was from coal-based sources with a total of more than 10 000 TWh. In recent years, natural gas is emerging as a major electricity producing energy source. In the year 2000, electricity from natural gas was equal to the electricity produced from Nuclear power and had a share of 18% in the overall electricity mix. During 2000 – 2018, the share of natural gas in electricity mix increased from 18% to 23% with an annual growth rate of 4.5% - 1.5 percentage points more than coal during the same period.

In 2018, 26 730 TWh of electricity was generated globally with renewables having a share of 25.8%, mainly driven by the increasing use of solar and wind as well as significant contribution from hydropower and biomass. The sector has shown impressive growth with an annual growth rate of more than 4.8% during 2000 – 2018 which was higher than any other energy source including coal and gas. The growth rate was higher than the total growth rate of the electricity sector at 3.1%.

Table 3 Electricity generation globally

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
2000	15 510	5 994	1 184	2 775	2 591	2 944	19.0%
2005	18 368	7 317	1 129	3 706	2 768	3 415	18.6%
2010	21 611	8 662	970	4 842	2 756	4 347	20.1%
2015	24 368	9 534	1 028	5 526	2 570	5 675	23.3%
2016	25 076	9 576	950	5 799	2 608	6 107	24.4%
2017	25 727	9 860	846	5 889	2 636	6 459	25.1%
2018	26 730	10 160	784	6 150	2 710	6 891	25.8%

All values in TWh

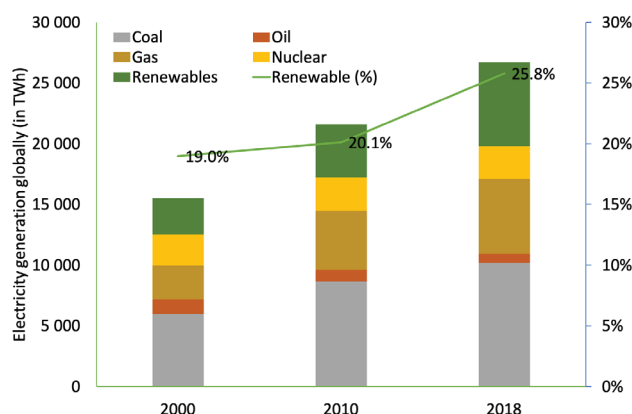


Figure 4 Electricity generation globally

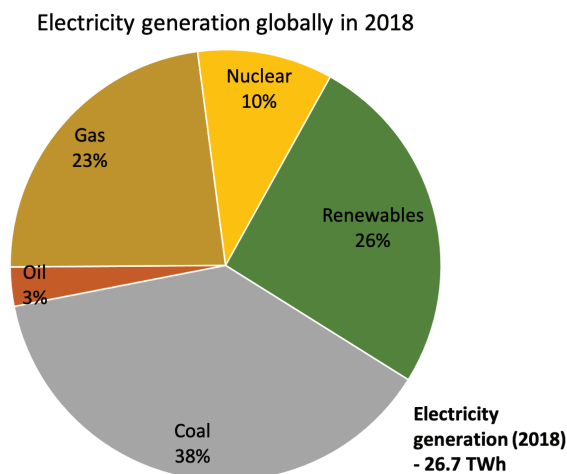


Figure 5 Electricity generation globally in 2018

Among continents, Asia is heavily dependent on electricity from coal. 72% of all electricity produced from coal is produced in Asia – mainly India, China, Indonesia accounting for the large share. 7 307 TWh of electricity was produced from coal in Asia.

Americas and Europe show an impressive share of renewables in their electricity mix at 31%. However, Asian continent accounts for 41% of all renewable electricity produced globally followed by Americas at 31% and Europe at 24%.

Table 4 Electricity generation in continents in 2018

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
<b>Africa</b>	<b>839</b>	<b>260</b>	<b>66.7</b>	<b>334</b>	<b>11.6</b>	<b>165</b>	<b>19.6%</b>
<b>Americas</b>	<b>6 747</b>	<b>1 419</b>	<b>182</b>	<b>2 031</b>	<b>978</b>	<b>2 131</b>	<b>31.6%</b>
<b>Asia</b>	<b>13 649</b>	<b>7 307</b>	<b>463</b>	<b>2 389</b>	<b>577</b>	<b>2 890</b>	<b>21.2%</b>
<b>Europe</b>	<b>5 189</b>	<b>1 014</b>	<b>66</b>	<b>1 336</b>	<b>1 144</b>	<b>1 624</b>	<b>31.3%</b>
<b>Oceania</b>	<b>305</b>	<b>159</b>	<b>4.85</b>	<b>59.5</b>	<b>0.0</b>	<b>81.6</b>	<b>26.7%</b>
<b>EU - 28</b>	<b>3 279</b>	<b>660</b>	<b>56</b>	<b>623</b>	<b>827</b>	<b>1 109</b>	<b>33.8%</b>

All values in TWh

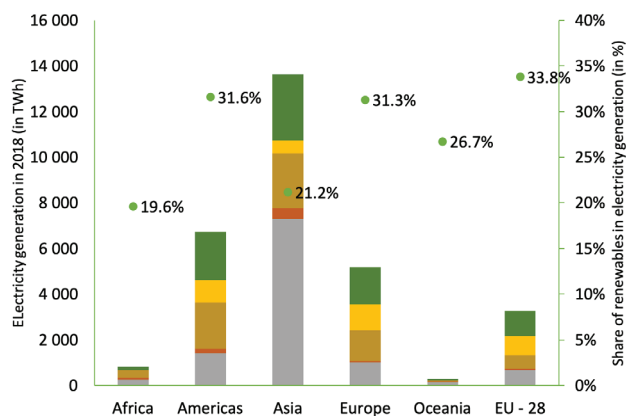


Figure 6 Electricity generation in continents in 2018



## HEAT

In 2018, 15 EJ of heat was produced globally via heat only and combined heat and power plants. The heat production has been increasing at an annual growth rate of just over 1%. Coal and natural gas have a combined share of more than 85% in the global heat production which has remained the same since the start of the century.

It is important to note that the heat production only includes the heat generated in power plants and supplied to customers via district heating networks. The heat production directly in commercial, residential, agriculture etc. sectors is not accounted in the section on Direct Heat.

Renewable energy technologies including biomass, geothermal and solar thermal have doubled their share in the global heat production over the past 18 years. During 2000 – 2018, the annual growth rate of renewables was at 5.7% - almost twice as much as coal and 5 times the total heat production growth rate during the same period. However, share of renewables in heat production is only at 7.7% compared to 26% in electricity.

Table 5 Heat production globally

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
2000	12.2	4.33	1.16	6.24	0.02	0.43	3.53%
2005	13.4	4.79	0.97	6.61	0.02	0.56	4.18%
2010	14.2	5.36	0.84	6.78	0.03	0.81	5.71%
2015	13.7	5.76	0.60	5.89	0.03	1.00	7.25%
2016	14.4	5.99	0.59	6.23	0.03	1.09	7.54%
2017	14.4	6.03	0.53	6.17	0.03	1.13	7.82%
2018	15.0	6.43	0.55	6.28	0.03	1.17	7.76%

All values in EJ

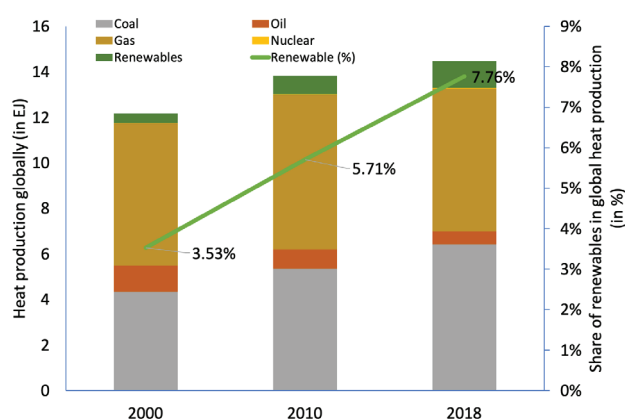


Figure 7 Heat production globally

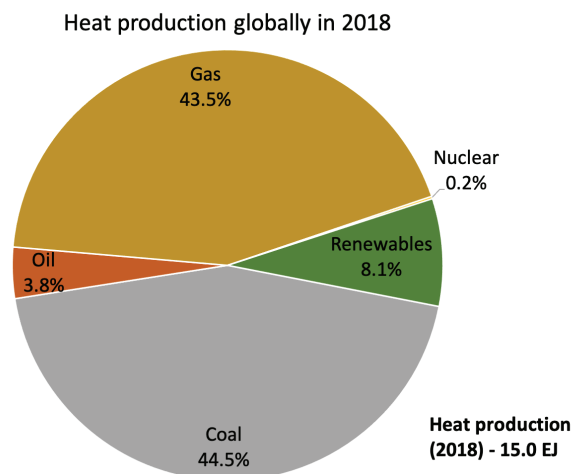


Figure 8 Heat production globally in 2018

In 2018, commercial heat production globally was concentrated in Asia and Europe with both accounting for a share of 90% in the global heat production. Coal accounts for 80% of the heat production in Asia while Natural Gas accounts for 75% and 56% of the heat production in Americas and Europe respectively. Among heat production from natural gas, Europe accounted for 82% in the year 2018.

The share of renewables in global heat production was 7.76% and Europe is the leader in commercial production of renewable heat, mainly due to the increased use of biomass in power plants. Europe accounts for 87% of all renewable heat produced with EU – 28 countries accounting for 65%. Renewable heat accounts for 31% of all heat produced within the EU – 28.

Table 6 Heat production in continents in 2018

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
<b>Africa</b>	<b>0.01</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00%</b>
<b>Americas</b>	<b>0.50</b>	<b>0.03</b>	<b>0.03</b>	<b>0.38</b>	<b>0.00</b>	<b>0.06</b>	<b>11.7%</b>
<b>Asia</b>	<b>5.25</b>	<b>4.18</b>	<b>0.21</b>	<b>0.75</b>	<b>0.00</b>	<b>0.09</b>	<b>1.71%</b>
<b>Europe</b>	<b>9.26</b>	<b>2.22</b>	<b>0.31</b>	<b>5.16</b>	<b>0.03</b>	<b>1.02</b>	<b>11.0%</b>
<b>Oceania</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00%</b>
<b>EU - 28</b>	<b>2.43</b>	<b>0.60</b>	<b>0.08</b>	<b>0.89</b>	<b>0.00</b>	<b>0.76</b>	<b>31.4%</b>

All values in EJ

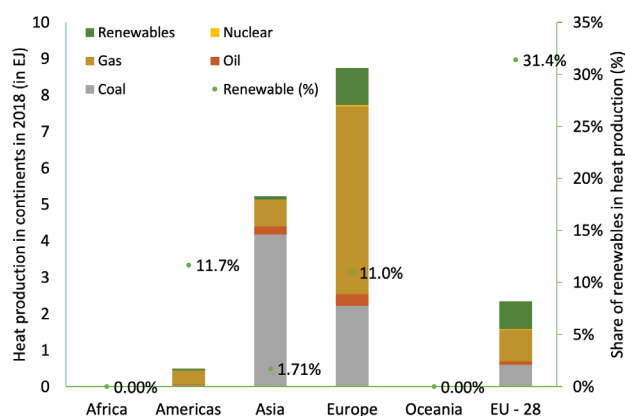


Figure 9 Heat production in continents in 2018

## DIRECT HEAT

Direct heat includes the use of fuel directly for both heating and cooking purposes in residential, commercial, agriculture, fishing sectors etc. It excludes the generation of heat in commercial power plants and distributed to end consumers. The direct heat is calculated by excluding transport sector from total final consumption of fuel.

The use of fuel for heat is a significant consumer of energy sources globally. In energy terms, use of fuel for direct heat is more than twice the fuel used for electricity production. However, it is concerning to note that during 2000 – 2018, share of renewables in direct heat reduced from 24% to 20% globally. The annual growth of renewables (0.4%) was not comparable to the annual growth of total direct heat (1.5%) which was more than compensated by the growth rate of coal (3.4%).

Table 7 Direct heat production globally

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
2000	157	22.7	52.1	44.4	0.00	37.7	24.1%
2005	177	34.5	56.2	46.9	0.00	39.1	22.1%
2010	193	44.3	56.0	52.6	0.00	40.5	20.9%
2015	198	45.9	56.0	55.5	0.00	40.7	20.5%
2016	198	44.1	56.5	56.7	0.00	40.6	20.5%
2017	201	42.6	58.2	59.0	0.00	40.8	20.4%
2018	203	41.6	58.6	62.6	0.00	40.7	20.0%

All values in EJ

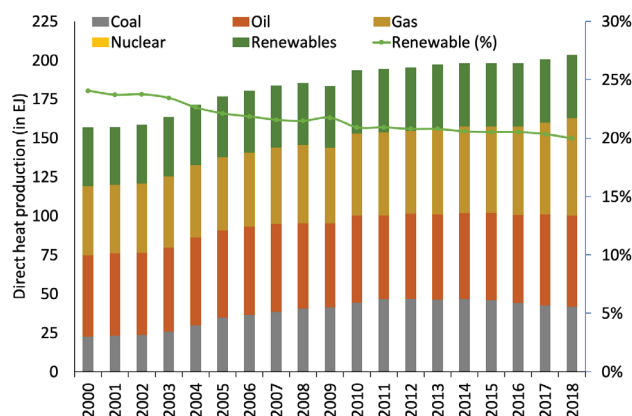


Figure 10 Direct heat globally in 2018

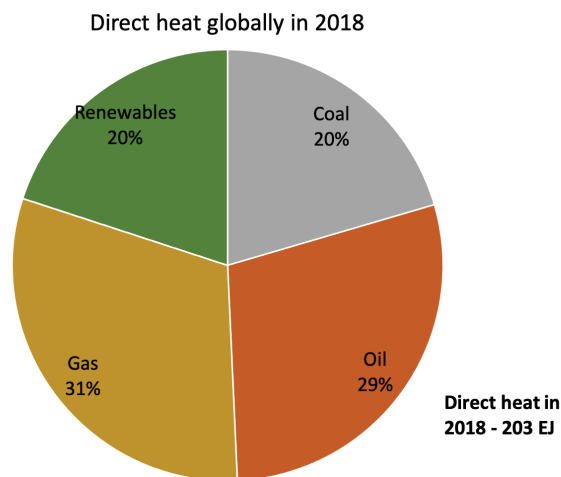


Figure 11 Direct heat globally in 2018

The use of coal for direct heat was the highest for Asian continent with more than 35 EJ being used for direct heating and cooking in end use sectors. Coal use for direct heat in Asia accounted for 85% of all coal use for direct heat globally and had a share of 34% among all energy sources in the region. The highest share of renewables was in the African continent due to its high use of traditional biomass sources such as cow dung, agricultural residues, firewood etc.

Table 8 Direct heat production in continents in 2018

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
<b>Africa</b>	<b>18.0</b>	<b>1.03</b>	<b>2.08</b>	<b>1.92</b>	<b>0.00</b>	<b>13.0</b>	<b>72.1%</b>
<b>Americas</b>	<b>40.8</b>	<b>1.47</b>	<b>13.4</b>	<b>19.9</b>	<b>0.00</b>	<b>6.14</b>	<b>15.0%</b>
<b>Asia</b>	<b>105</b>	<b>35.5</b>	<b>31.5</b>	<b>20.7</b>	<b>0.00</b>	<b>17.4</b>	<b>16.5%</b>
<b>Europe</b>	<b>37.9</b>	<b>3.48</b>	<b>11.1</b>	<b>19.4</b>	<b>0.00</b>	<b>3.91</b>	<b>10.3%</b>
<b>Oceania</b>	<b>1.56</b>	<b>0.15</b>	<b>0.55</b>	<b>0.62</b>	<b>0.00</b>	<b>0.24</b>	<b>15.1%</b>
<b>EU - 28</b>	<b>22.6</b>	<b>1.42</b>	<b>7.23</b>	<b>10.6</b>	<b>0.00</b>	<b>3.35</b>	<b>14.9%</b>

All values in EJ

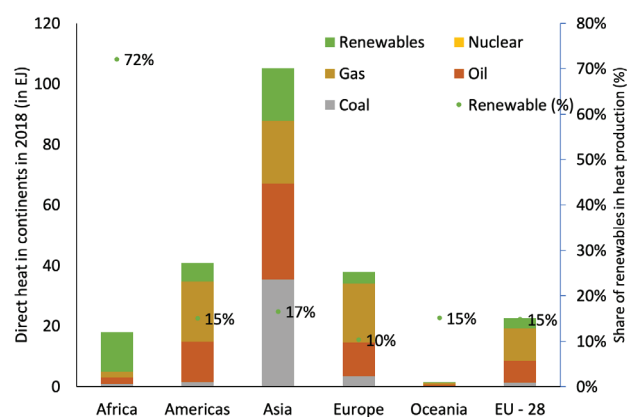


Figure 12 Direct heat in continents in 2018

## TRANSPORT

Transport sector accounts for about 27% of all energy consumed globally. Crude oil and oil products contribute 92% of the energy needs for the transport sector. The energy consumption in transport is more than the energy use for electricity globally and the sector is experiencing significant growth with an annual growth rate of 2.2% during 2000 – 2018. The oil sector has kept pace during the same time period with a growth rate of 1.9%.

Electrification is an important option for decarbonizing the transport sector and even though the contribution to the overall share in transport is less than 1%, the sector is growing faster than the total energy needs in the sector with a growth rate of 3.3%. It is important to note that the share of renewables in the electricity is only about 27% and hence, the overall share of renewable electricity is much lower.

However, liquid biofuels and biogas are the most sustainable and ideal option for the sector right now. Biofuels have a share of more than 3% and have experienced a growth of 13% - almost 6 times as much as the overall energy needs in the transport sector.

Table 9 Energy use in transport globally

	Total	Coal	Oil	Gas	Electricity	Biofuels	Renewable (%)
2000	82.2	0.03	78.5	2.42	0.79	0.42	0.7%
2005	92.9	0.01	88.0	3.10	0.94	0.81	1.1%
2010	102	0.01	94.6	3.73	1.06	2.37	2.5%
2015	113	0.00	104	4.09	1.21	3.27	3.2%
2016	115	0.00	106	4.28	1.27	3.41	3.2%
2017	118	0.01	109	4.40	1.33	3.51	3.3%
2018	121	0.00	111	4.91	1.40	3.75	3.4%

All values in EJ

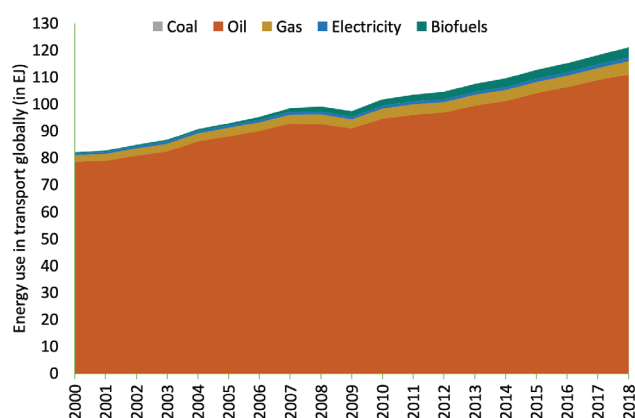


Figure 13 Energy use in transport

Energy use in transport globally in 2018

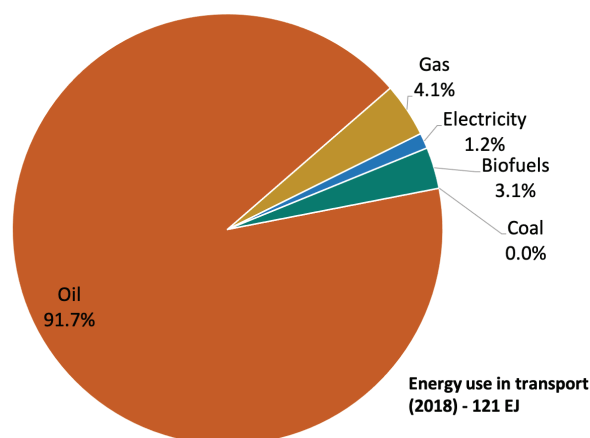


Figure 14 Energy use in transport in 2018

Crude oil and oil products are the dominant source of energy for the transport sector across all continents with its contribution ranging from 84% in Europe to 99% in Africa. The contribution of natural gas varies from 1% to 9% while biofuels have a decent share of 7% in Americas. The dominance of Americas (USA and Brazil) in the renewable fuels sector is quite evident as more than 69% of all biofuels consumed in transport sector occurs in that region while in Europe, the share is lower at 20%.

Table 10 Energy use in transport in continents in 2018

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
<b>Africa</b>	<b>5.18</b>	<b>0.000</b>	<b>5.10</b>	<b>0.05</b>	<b>0.02</b>	<b>0.00</b>	<b>0.0%</b>
<b>Americas</b>	<b>39.0</b>	<b>0.000</b>	<b>34.9</b>	<b>1.38</b>	<b>0.09</b>	<b>2.58</b>	<b>1.9%</b>
<b>Asia</b>	<b>37.3</b>	<b>0.001</b>	<b>34.6</b>	<b>1.64</b>	<b>0.67</b>	<b>0.42</b>	<b>0.2%</b>
<b>Europe</b>	<b>20.2</b>	<b>0.001</b>	<b>17.0</b>	<b>1.82</b>	<b>0.59</b>	<b>0.73</b>	<b>0.8%</b>
<b>Oceania</b>	<b>1.65</b>	<b>0.000</b>	<b>1.60</b>	<b>0.02</b>	<b>0.02</b>	<b>0.01</b>	<b>0.2%</b>
<b>EU - 28</b>	<b>13.7</b>	<b>0.001</b>	<b>12.7</b>	<b>0.15</b>	<b>0.23</b>	<b>0.70</b>	<b>1.2%</b>

All values in EJ

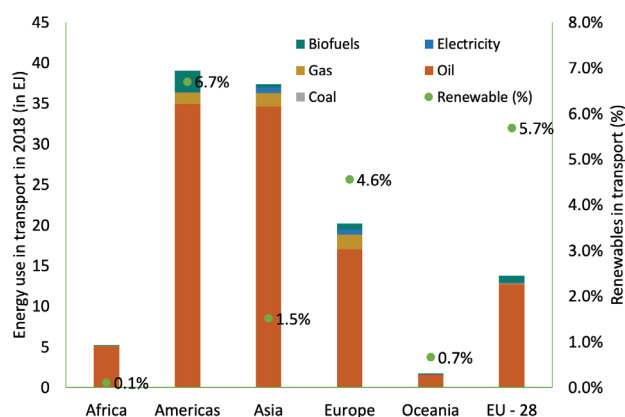


Figure 15 Energy use in transport in continents in 2018

## ENERGY CONSUMPTION

Gross final energy consumption includes the total final consumption of all energy sources including the electricity and heat consumption at all end use sectors. In 2018, gross final energy consumption of all energy sources was 471 EJ. The annual growth rate of energy consumption was about 2.1% since the year 2000.

Coal, Oil and Natural Gas together account for more than 80% of the total energy consumption while the share of renewables has remained constant at 17% since the start of the century. Coal and natural gas have experienced strong annual growth rates of 3.2% and 2.2% - more than the annual consumption growth rate of 1.9%. Growth rate of renewables was at 1.9% as well.

Table 11 Gross final energy consumption globally

	Total	Coal	Oil	Gas	Electricity	Biofuels	Renewable (%)
2000	269	43.1	115	56.0	7.64	47.2	17.6%
2005	304	58.9	125	61.3	8.22	50.5	16.6%
2010	338	73.1	130	70.4	8.26	56.5	16.7%
2015	359	77.1	138	74.3	7.73	61.8	17.2%
2016	363	75.4	140	76.4	7.86	63.3	17.4%
2017	369	75.1	143	78.6	7.95	64.7	17.5%
2018	377	75.5	144	83.1	8.19	66.2	17.5%

All values in EJ

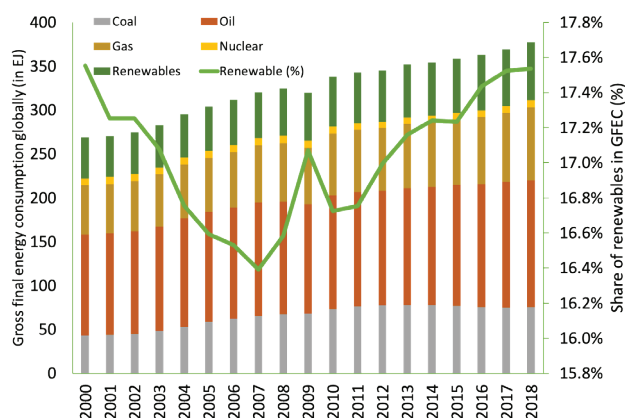


Figure 16 Gross final energy consumption globally

Gross final energy consumption globally in 2018 (in EJ)

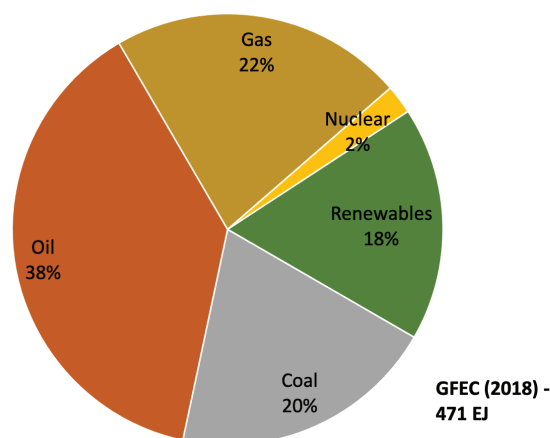


Figure 17 Gross final energy consumption in 2018

In 2018, coal remained the dominant energy source for the Asian continent. 80% of all coal consumption globally is in Asia where coal accounts for 35% of the energy consumption. Asia also consumes more than 40% of all crude oil globally with Americas consuming 33%.

Among renewable energy sources, African continent has the highest share at 55% due to its high share of hydropower and bioenergy in the energy mix. Rest of the regions including Europe had a share less than the global average of 17%.

Table 12 Gross final energy consumption in continents in 2018

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewable (%)
<b>Africa</b>	<b>24.6</b>	<b>1.72</b>	<b>6.99</b>	<b>2.36</b>	<b>0.03</b>	<b>13.5</b>	<b>54.8%</b>
<b>Americas</b>	<b>92.0</b>	<b>5.82</b>	<b>41.8</b>	<b>26.1</b>	<b>3.00</b>	<b>15.3</b>	<b>16.6%</b>
<b>Asia</b>	<b>167</b>	<b>59.4</b>	<b>52.5</b>	<b>27.1</b>	<b>1.75</b>	<b>26.7</b>	<b>15.9%</b>
<b>Europe</b>	<b>71.9</b>	<b>8.17</b>	<b>23.3</b>	<b>26.8</b>	<b>3.37</b>	<b>10.2</b>	<b>14.2%</b>
<b>Oceania</b>	<b>3.81</b>	<b>0.63</b>	<b>1.98</b>	<b>0.72</b>	<b>0.00</b>	<b>0.48</b>	<b>12.7%</b>
<b>EU - 28</b>	<b>56.1</b>	<b>3.87</b>	<b>16.7</b>	<b>12.7</b>	<b>2.54</b>	<b>8.09</b>	<b>14.4%</b>

All values in EJ

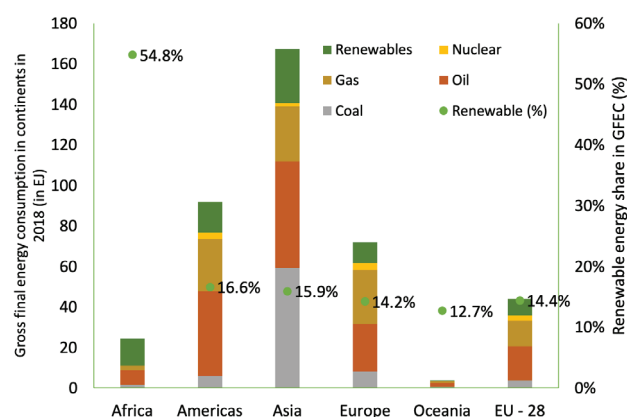


Figure 18 Gross final energy consumption in continents in 2018



## ENERGY MATRIX

The energy matrix provides an overview of the consumption of various fuels among all end use sectors. Globally, 439 EJ of energy was consumed in 2018. 20% of the consumption was in the form of electricity, 28% as fuels for transport sector while the remaining 50% was in the form of heat.

Among the sectors, renewables had the highest share of 26% in the electricity sector – mainly due to the extensive deployment of solar and wind combined with established technologies such as hydropower.

In the heat sector, the share of renewables is 8.1% in derived heat via power plants and 21% as direct heat in end use sectors. Bioenergy is the largest renewable energy source in the heating sector with a share of more than 90% among all renewable sources with minor contribution from geothermal and solar heat.

Transport sector has the lowest share of renewables at only 3.4% out of which bioenergy has a contribution of 3.1%.

Table 13 Energy use in various end use sectors globally in 2018

	Total	Electricity	Heat	Direct heat	Transport	Total	Share (%)
<b>Fossil Fuels</b>	<b>Coal</b>	<b>36.6</b>	<b>6.43</b>	<b>41.6</b>	<b>0.54</b>	<b>85.2</b>	<b>19.4%</b>
	<b>Oil</b>	<b>2.82</b>	<b>0.55</b>	<b>58.6</b>	<b>111</b>	<b>173</b>	<b>39.4%</b>
	<b>Gas</b>	<b>22.1</b>	<b>6.28</b>	<b>62.6</b>	<b>5.23</b>	<b>96.2</b>	<b>21.9%</b>
<b>Nuclear</b>		<b>9.76</b>	<b>0.03</b>	<b>0.00</b>	<b>0.14</b>	<b>9.93</b>	<b>2.26%</b>
<b>Renewables</b>	<b>Bioenergy</b>	<b>2.29</b>	<b>1.12</b>	<b>42.4</b>	<b>3.79</b>	<b>49.6</b>	<b>11.3%</b>
	<b>Hydro</b>	<b>15.6</b>	<b>0.00</b>	<b>0.00</b>	<b>0.23</b>	<b>15.8</b>	<b>3.60%</b>
	<b>Solar</b>	<b>2.04</b>	<b>0.00</b>	<b>1.38</b>	<b>0.03</b>	<b>3.44</b>	<b>0.78%</b>
	<b>Wind</b>	<b>4.58</b>	<b>0.00</b>	<b>0.00</b>	<b>0.07</b>	<b>4.65</b>	<b>1.06%</b>
	<b>Geothermal</b>	<b>0.32</b>	<b>0.04</b>	<b>0.65</b>	<b>0.005</b>	<b>1.02</b>	<b>0.23%</b>
<b>Total</b>		<b>96.1</b>	<b>14.5</b>	<b>207</b>	<b>121</b>	<b>439</b>	<b>100%</b>
<b>Renewables (%)</b>		<b>26%</b>	<b>8.1%</b>	<b>21%</b>	<b>3.4%</b>	<b>17.0%</b>	
<b>Bioenergy (%)</b>		<b>2.4%</b>	<b>7.7%</b>	<b>20%</b>	<b>3.1%</b>	<b>11.3%</b>	

All values in EJ

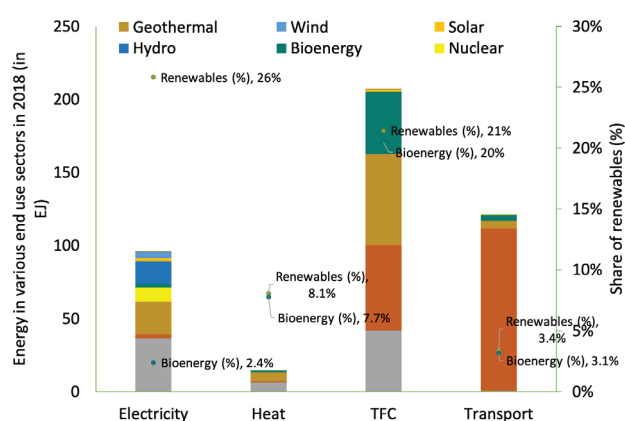


Figure 19 Energy use in various end use sectors in 2018



## CHAPTER 2. RENEWABLE ENERGY

### TPES RENEWABLES

In 2018, total primary energy supply of renewable energy sources was 82.7 EJ. TPES of bio-mass-based sources including municipal waste, industrial waste, solid biomass, liquid biofuels and biogas was 55.6 EJ – an increase of 1.2% over the previous year.

The renewable energy sources have experienced significant growth in this century. During 2000 – 2018, renewable energy technologies had a growth rate of 2.36% with solar and wind having the highest annual growth rate of 16.7% and 22.8% during the same time period.

Table 14 Total primary energy supply of renewables globally

	Total	Solar	Wind	Hydro	Bioenergy	Geothermal
2000	54.4	0.22	0.11	9.41	42.5	2.19
2005	59.1	0.32	0.38	10.6	45.6	2.24
2010	67.5	0.78	1.23	12.4	50.5	2.60
2015	75.8	2.31	3.00	14.0	53.2	3.23
2016	78.1	2.60	3.47	14.6	54.3	3.23
2017	80.3	3.11	4.08	14.7	54.9	3.60
2018	82.7	3.55	4.58	15.2	55.6	3.86

All values in EJ

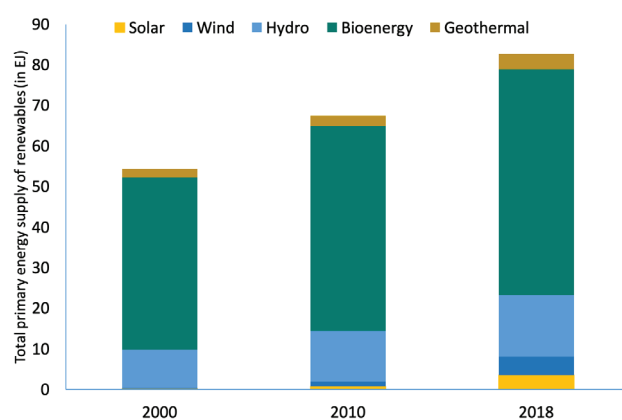


Figure 20 Total primary energy supply of renewables globally

Total primary energy supply of renewables globally in 2018

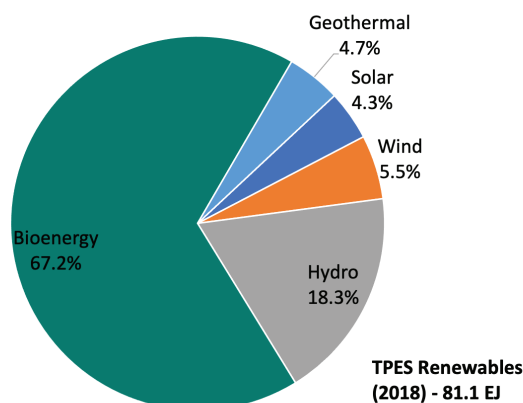


Figure 21 Total primary energy supply globally in 2018

In 2018, TPES of renewable sources was highest in Asia followed by Americas and Africa with a share of 40%. The region had the highest share among all renewable sources including solar power (62%), wind (37%), hydropower (42%), bioenergy (37%) and geothermal (60%). Bioenergy had a significant share among all continents ranging from 36% of all renewables in Oceania to 95% of all renewables in Africa.

Table 15 Total primary energy supply of renewables in continents in 2018

	Total	Solar	Wind	Hydro	Bioenergy	Geothermal
<b>Africa</b>	<b>16.6</b>	<b>0.06</b>	<b>0.05</b>	<b>0.47</b>	<b>15.9</b>	<b>0.19</b>
<b>Americas</b>	<b>19.0</b>	<b>0.56</b>	<b>1.40</b>	<b>5.14</b>	<b>11.2</b>	<b>0.68</b>
<b>Asia</b>	<b>33.2</b>	<b>2.21</b>	<b>1.69</b>	<b>6.41</b>	<b>20.6</b>	<b>2.31</b>
<b>Europe</b>	<b>13.2</b>	<b>0.66</b>	<b>1.38</b>	<b>3.00</b>	<b>7.66</b>	<b>0.47</b>
<b>Oceania</b>	<b>0.75</b>	<b>0.06</b>	<b>0.06</b>	<b>0.15</b>	<b>0.27</b>	<b>0.21</b>
<b>EU - 28</b>	<b>10.3</b>	<b>0.64</b>	<b>1.36</b>	<b>1.26</b>	<b>6.71</b>	<b>0.29</b>

All values in EJ

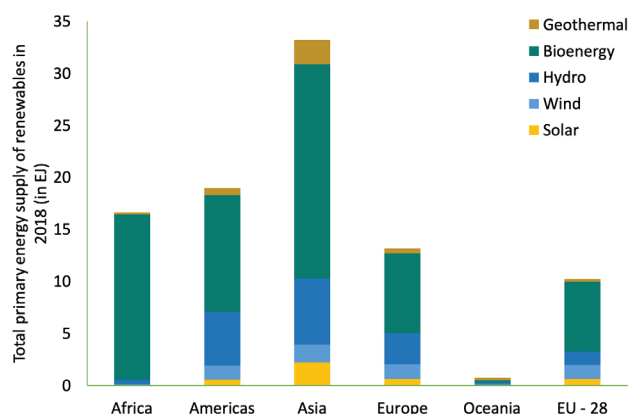


Figure 22 Total primary energy supply of renewables in continents in 2018

## RENEWABLE ELECTRICITY

In 2018, 6 890 TWh of renewable electricity was produced globally. Hydropower was the largest renewable electricity generating source with a share of 62% followed by wind at 19%. Bioenergy was the third largest renewable electricity generating source with 637 TWh of production.

The sector has seen rapid growth over the years. During 2000 – 2018, renewable electricity sector had an annual growth rate of 5% which is higher than the growth rate of overall electricity sector at 3%. The growth has largely been driven by solar and wind technologies which had an annual growth rate of 40% and 23% respectively while hydropower had a lower growth rate (3%) and bioenergy was able to exceed the growth rate (8%).

Table 16 Electricity generation from renewables globally

	Total	Solar	Wind	Hydro	Bioenergy	Geothermal
2000	2 944	1.33	31.3	2 696	163	52.2
2005	3 414	4.33	104	3 020	228	58.3
2010	4 346	33.7	342	3 535	367	68.1
2015	5 674	260	834	3 982	517	80.6
2016	6 106	340	963	4 151	569	82.2
2017	6 458	455	1 133	4 186	598	85.3
2018	6 890	566	1 273	4 325	637	89.0

All values in TWh

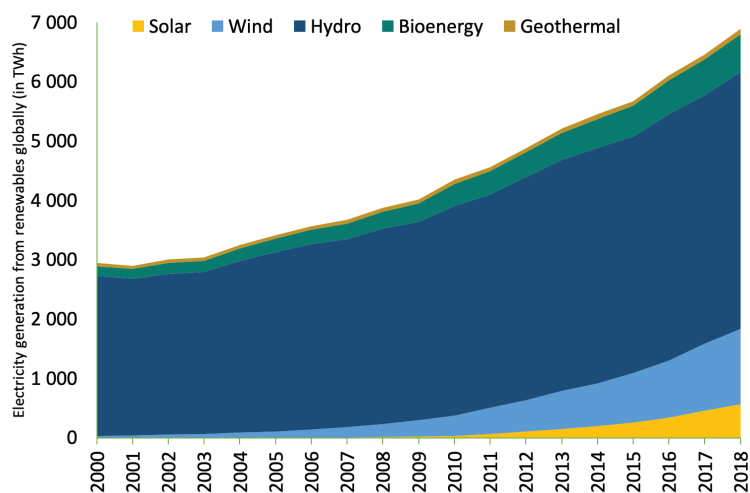


Figure 23 Renewable electricity generation globally

Electricity generation from renewables globally in 2018

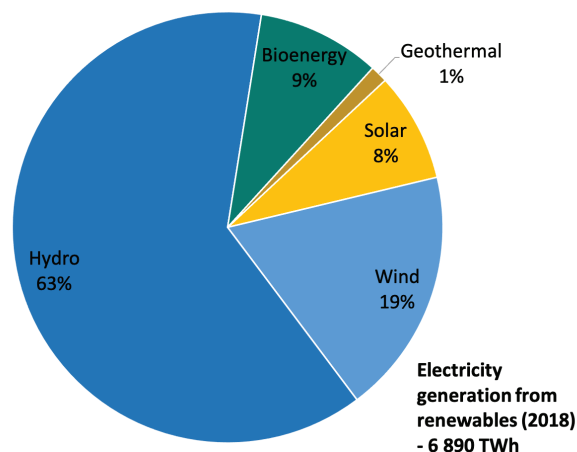


Figure 24 Renewable electricity generation globally in 2018

Asia leads in terms of electricity generation globally. In 2018, 42% of all renewable electricity generated was in Asia followed by Americas (31%) and Europe (24%). Africa had a share of 2% - mainly due to hydropower which had a share of 83% in the Africa renewable electricity mix.

Hydropower remains the largest renewable electricity source among all continents with shares varying from 52% in Oceania to 83% in Africa. Asia is also the largest producer of biopower with an estimated generation of 243 TWh, accounting for 42% of all bioelectricity generation globally.

Table 17 Electricity generation from renewables in continents in 2018

	Total	Solar	Wind	Hydro	Bioenergy	Geothermal
<b>Africa</b>	<b>165</b>	<b>7.26</b>	<b>14.2</b>	<b>136</b>	<b>2.07</b>	<b>5.19</b>
<b>Americas</b>	<b>2 131</b>	<b>103</b>	<b>388</b>	<b>1 449</b>	<b>163</b>	<b>28.2</b>
<b>Asia</b>	<b>2 890</b>	<b>313</b>	<b>470</b>	<b>1 829</b>	<b>243</b>	<b>34.5</b>
<b>Europe</b>	<b>1 623</b>	<b>132</b>	<b>384</b>	<b>869</b>	<b>225</b>	<b>13.1</b>
<b>Oceania</b>	<b>81.6</b>	<b>10.0</b>	<b>17.2</b>	<b>42.3</b>	<b>4.11</b>	<b>7.96</b>
<b>EU - 28</b>	<b>1 108</b>	<b>128</b>	<b>377</b>	<b>379</b>	<b>218</b>	<b>6.66</b>

All values in TWh

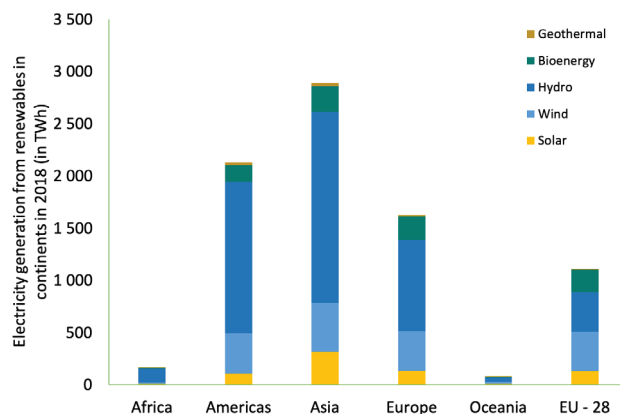


Figure 25 Renewable electricity generation in continents in 2018

## RENEWABLE HEAT

In 2018, 1.17 EJ of renewable heat was produced in both heat only plants as well as combined heat and power plants. 96% of all renewable heat produced was from biomass with minor contribution from geothermal and solar thermal technologies. The sector has seen an annual growth of 6% since 2000 and both bioenergy and geothermal have been able to match the growth rate.

Table 18 Heat production from renewables globally

	Total	Solar	Bioenergy	Geothermal
2000	0.43	0.000	0.41	0.02
2005	0.56	0.000	0.54	0.02
2010	0.81	0.000	0.79	0.03
2015	1.00	0.001	0.96	0.03
2016	1.09	0.001	1.05	0.04
2017	1.13	0.002	1.09	0.04
2018	1.17	0.002	1.12	0.04

All values in EJ

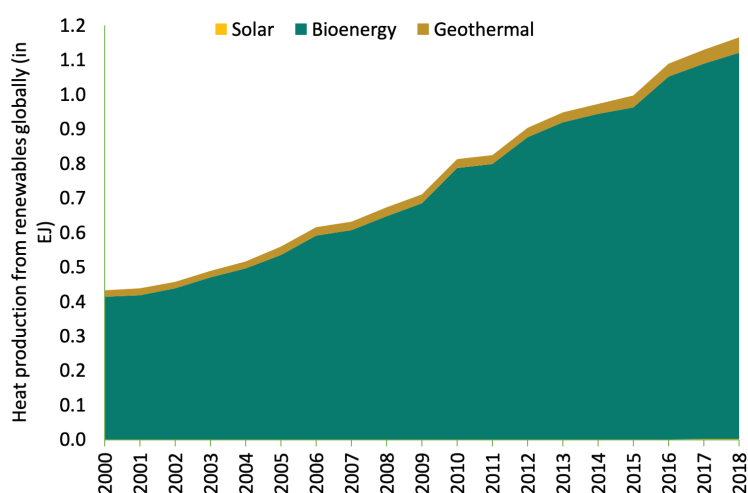


Figure 26 Renewable heat production globally

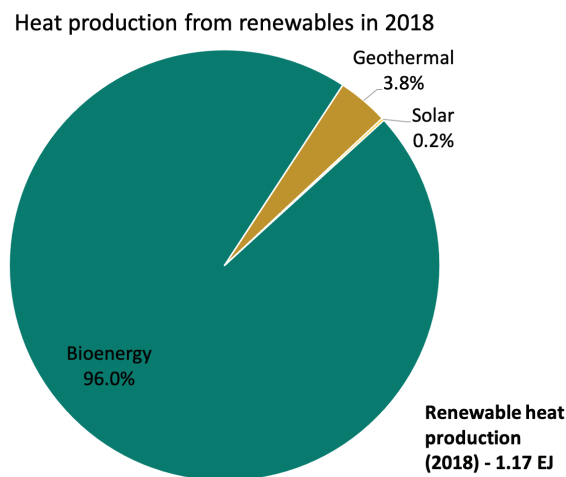


Figure 27 Renewable heat production globally in 2018

In 2018, almost all the heat production from solar thermal and geothermal facilities occurred in Europe – mainly EU 28 countries. Europe also leads the way in terms of use of biomass for heat as close to 60% of bioheat produced globally occurred in Europe. EU – 28 countries accounted for about half of the total European bioheat production.

Table 19 Heat production from renewables in 2018

	Total	Solar	Bioenergy	Geothermal
<b>Africa</b>	<b>0.21</b>	<b>0.000</b>	<b>0.21</b>	<b>0.00</b>
<b>Americas</b>	<b>0.25</b>	<b>0.000</b>	<b>0.25</b>	<b>0.00</b>
<b>Asia</b>	<b>0.31</b>	<b>0.000</b>	<b>0.31</b>	<b>0.00</b>
<b>Europe</b>	<b>0.70</b>	<b>0.002</b>	<b>0.66</b>	<b>0.04</b>
<b>Oceania</b>	<b>0.28</b>	<b>0.000</b>	<b>0.28</b>	<b>0.00</b>
<b>EU - 28</b>	<b>0.56</b>	<b>0.002</b>	<b>0.54</b>	<b>0.01</b>

All values in EJ

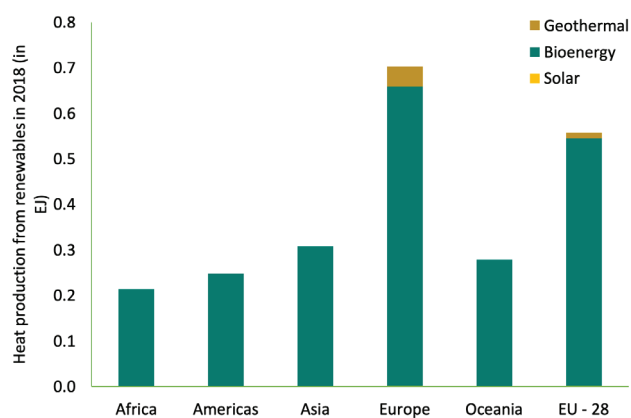


Figure 28 Renewable heat production in continents in 2018



## RENEWABLE DIRECT HEAT

Renewable direct heat includes the use of renewable fuel sources directly for both heating and cooking purposes in residential, commercial, agriculture, fishing sectors etc. It excludes the generation of heat in commercial power plants and distributed to end consumers. The direct heat is calculated by excluding transport sector from total final consumption of fuel.

Direct heat production around the world was 35 times higher than derived heat produced in power plants. As is the case with derived heat, bioenergy is the single largest renewable heat source globally with a share of more than 95% followed by solar thermal at 3% and geothermal at 2%.

Table 20 Direct heat from renewables globally

	Total	Solar	Bioenergy	Geothermal
2000	37.7	0.21	37.4	0.15
2005	39.1	0.30	38.6	0.21
2010	40.5	0.64	39.6	0.26
2015	40.7	1.25	39.0	0.48
2016	40.6	1.29	38.8	0.53
2017	40.8	1.33	38.9	0.57
2018	40.7	1.38	38.6	0.65

All values in EJ

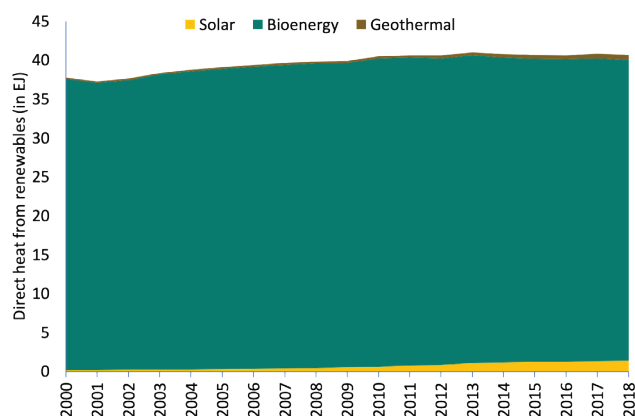


Figure 29 Renewable direct heat globally

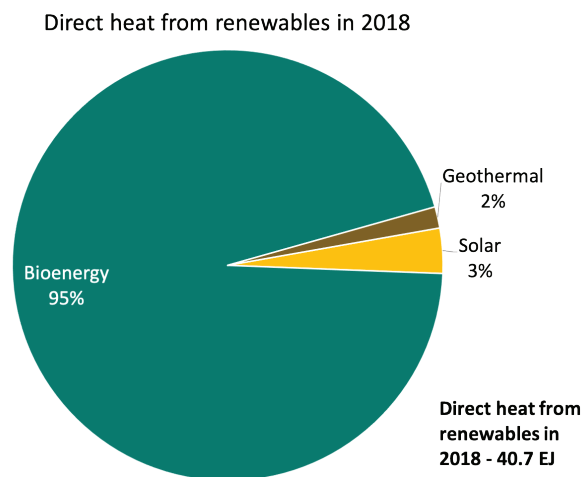


Figure 30 Renewable direct heat in 2018

80% of all renewable direct heat globally produced was in Asia. Asia was also leading in terms of heat production from geothermal and solar thermal with a global share of 87% and 79% respectively.

Bioenergy had a significant share in terms of direct heat generated in continents with a share varying from 89% in Oceania to 100% in Africa.

Table 21 Direct heat from renewables in continents in 2018

	Total	Solar	Bioenergy	Geothermal
<b>Africa</b>	<b>13.0</b>	<b>0.01</b>	<b>13.0</b>	<b>0.00</b>
<b>Americas</b>	<b>6.14</b>	<b>0.16</b>	<b>5.93</b>	<b>0.04</b>
<b>Asia</b>	<b>17.4</b>	<b>1.09</b>	<b>15.7</b>	<b>0.57</b>
<b>Europe</b>	<b>3.91</b>	<b>0.10</b>	<b>3.77</b>	<b>0.03</b>
<b>Oceania</b>	<b>0.24</b>	<b>0.02</b>	<b>0.21</b>	<b>0.01</b>
<b>EU - 28</b>	<b>3.35</b>	<b>0.10</b>	<b>3.23</b>	<b>0.02</b>

All values in EJ

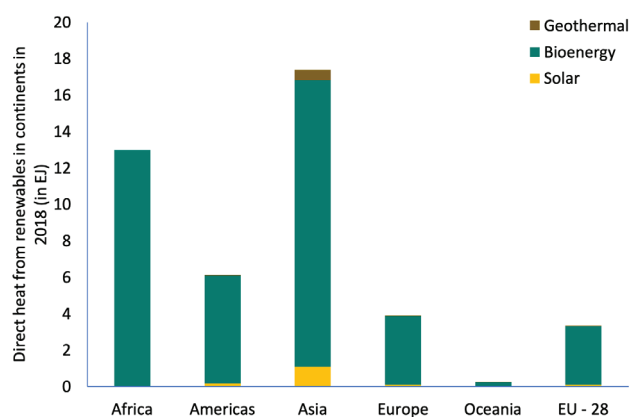


Figure 31 Renewable direct heat in continents in 2018

## RENEWABLE TRANSPORT

In 2018, 4.12 EJ of renewable energy was used in the transport sector globally and liquid and gaseous biofuels accounted for 91% of all renewable energy used in the sector. Share of renewable electricity (calculated based on the share of renewables in overall electricity sector) had a share of 9% only.

During 2000 – 2018, the renewable energy use in transport sector had a growth rate of 12% matched only by biofuels at 13%. Growth rate of electricity use in transport was 3% during the same period.

Table 22 Renewable energy use in transport globally

	Total	Bioenergy	Electricity	Renewable Electricity
2000	0.56	0.42	0.79	0.15
2005	0.98	0.81	0.94	0.17
2010	2.58	2.37	1.06	0.21
2015	3.55	3.27	1.21	0.28
2016	3.72	3.41	1.27	0.31
2017	3.84	3.51	1.33	0.33
2018	4.12	3.75	1.40	0.36

All values in EJ

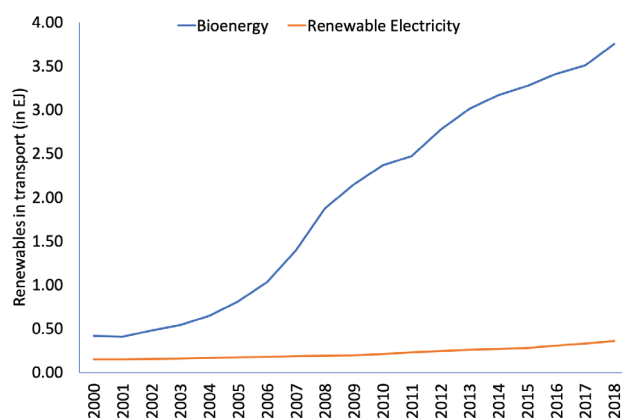


Figure 32 Renewable use in transport

Renewables in transport sector globally in 2018

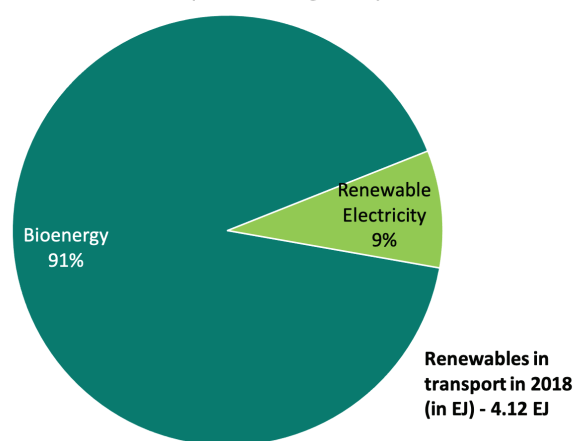


Figure 33 Renewable use in transport in 2018

Biofuels offer the most sustainable and renewable option for decarbonizing the transport sector in all continents. In 2018, Americas had the highest use of biofuels accounting for 69% of all consumption followed by Europe at 20%. Biofuel use in Africa was negligible compared to the global volumes.

Table 23 Renewable energy use in transport in continents in 2018

	Total	Bioenergy	Electricity	Renewable Electricity
<b>Africa</b>	<b>0.01</b>	<b>0.00</b>	<b>0.02</b>	<b>0.00</b>
<b>Americas</b>	<b>2.61</b>	<b>2.58</b>	<b>0.09</b>	<b>0.03</b>
<b>Asia</b>	<b>0.57</b>	<b>0.42</b>	<b>0.67</b>	<b>0.14</b>
<b>Europe</b>	<b>0.92</b>	<b>0.73</b>	<b>0.59</b>	<b>0.19</b>
<b>Oceania</b>	<b>0.01</b>	<b>0.01</b>	<b>0.02</b>	<b>0.01</b>
<b>EU - 28</b>	<b>0.78</b>	<b>0.70</b>	<b>0.23</b>	<b>0.08</b>

All values in EJ

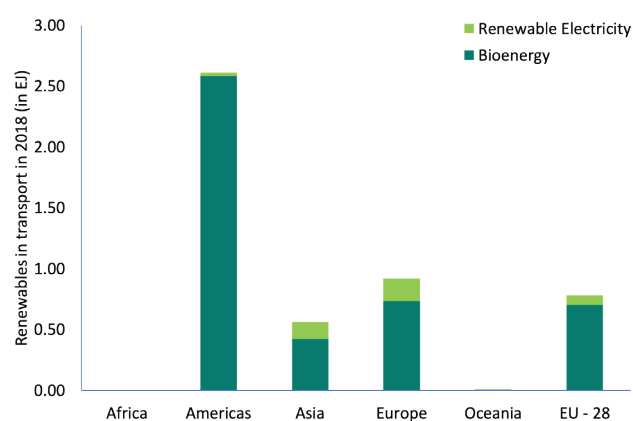


Figure 34 Renewable use in transport in continents in 2018

## CHAPTER 3. BIOMASS SUPPLY

### SUPPLY

In 2018, domestic supply of biomass was 55.6 EJ globally. 85% of the domestic supply was from solid biomass sources including wood chips, wood pellets and traditional biomass sources. Liquid biofuels accounted for 7%, municipal and industrial waste sectors accounted for 5% followed by biogas at 3%.

The average annual growth rate of the bioenergy sector during 2000 – 2018 was 2%. Among all feedstock types, liquid biofuels were the fastest growing sector at a growth rate of 13% followed by biogas at 9%.

Table 24 Domestic supply of biomass globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
2000	42.5	0.74	0.49	40.5	0.29	0.43
2005	45.6	0.96	0.45	42.8	0.51	0.87
2010	50.5	1.18	0.77	45.1	0.85	2.53
2015	53.2	1.38	0.90	46.2	1.29	3.45
2016	54.3	1.42	1.04	46.9	1.30	3.58
2017	54.9	1.44	1.07	47.3	1.33	3.72
2018	55.6	1.45	1.13	47.6	1.36	3.98

All values in EJ

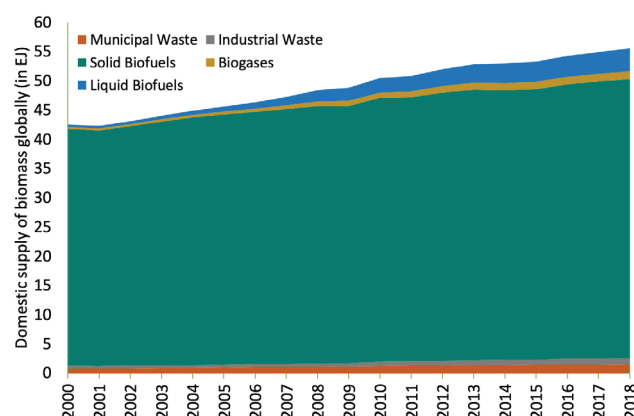


Figure 35 Domestic supply of biomass globally

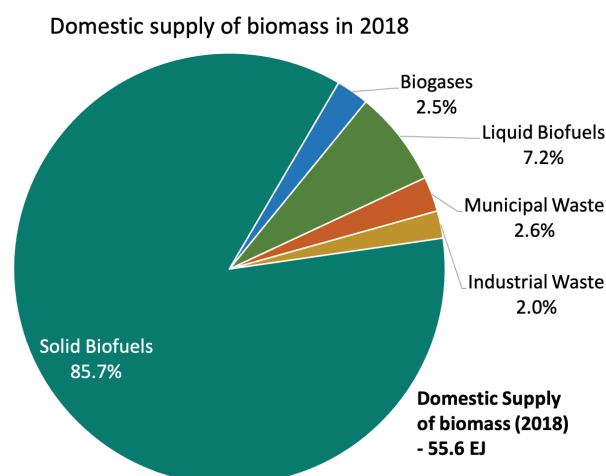


Figure 36 Domestic supply of biomass in 2018

In 2018, solid biomass products including wood chips, pellets, charcoal etc. predominantly from the forestry sector made up the majority of biomass supply in all continents. In terms of municipal waste, Europe accounted for 65% of all energy from municipal waste. Europe was also the leader in biogas supply accounting for more than half of the global biogas supply. Americas (mainly USA and Brazil) had significant supply of liquid biofuels accounting for 69% of the global supply.

Table 25 Domestic supply of biomass in continents in 2018

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
<b>Africa</b>	<b>15.9</b>	<b>0.00</b>	<b>0.00</b>	<b>15.9</b>	<b>0.00</b>	<b>0.00</b>
<b>Americas</b>	<b>8.30</b>	<b>0.30</b>	<b>0.05</b>	<b>7.95</b>	<b>0.19</b>	<b>2.72</b>
<b>Asia</b>	<b>19.7</b>	<b>0.21</b>	<b>0.63</b>	<b>18.8</b>	<b>0.44</b>	<b>0.45</b>
<b>Europe</b>	<b>6.14</b>	<b>0.94</b>	<b>0.45</b>	<b>4.74</b>	<b>0.71</b>	<b>0.81</b>
<b>Oceania</b>	<b>0.25</b>	<b>0.00</b>	<b>0.00</b>	<b>0.24</b>	<b>0.02</b>	<b>0.01</b>
<b>EU - 28</b>	<b>5.23</b>	<b>0.87</b>	<b>0.19</b>	<b>4.16</b>	<b>0.70</b>	<b>0.78</b>

All values in EJ

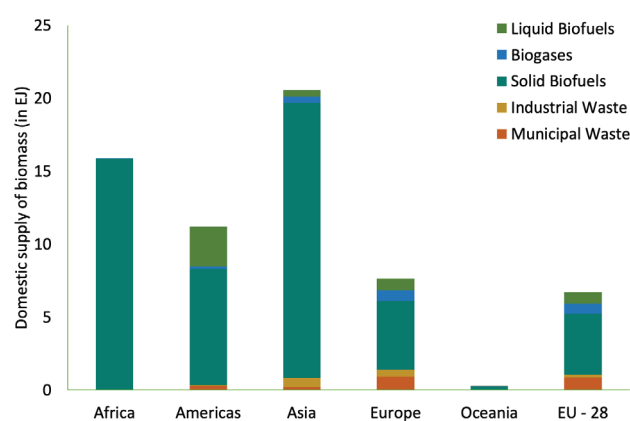


Figure 37 Domestic supply of biomass in continents in 2018

## WOOD FUEL

Roundwood that will be used for fuel purpose such as cooking, heating or power production is classified as wood fuel. In 2019, 1.9 billion m<sup>3</sup> of wood fuel was produced globally. Africa and Americas had the highest share of wood fuel production with a contribution of 36% and 37% respectively.

The sector has seen a slow growth over the past few years. During 2000 – 2018, the annual growth rate of wood fuel production was about 0.4% with both Asia and Oceania reducing their wood fuel production while Europe has increased its share. However, Europe still accounted for only 9% of the global wood fuel production in 2019.

Table 26 Wood fuel production globally

	World	Africa	Americas	Asia	Europe	Oceania	EU - 28
2000	1 795	551	314	808	109	12.7	85.2
2005	1 825	600	300	792	123	11.5	91.9
2010	1 863	644	290	764	154	10.7	116
2015	1 902	679	307	735	170	10.0	122
2016	1 929	686	331	730	170	9.93	121
2017	1 931	693	331	725	172	10.0	121
2018	1 948	700	340	719	180	10.0	125
2019	1 944	700	340	719	176	10.0	126

All values in million m<sup>3</sup>

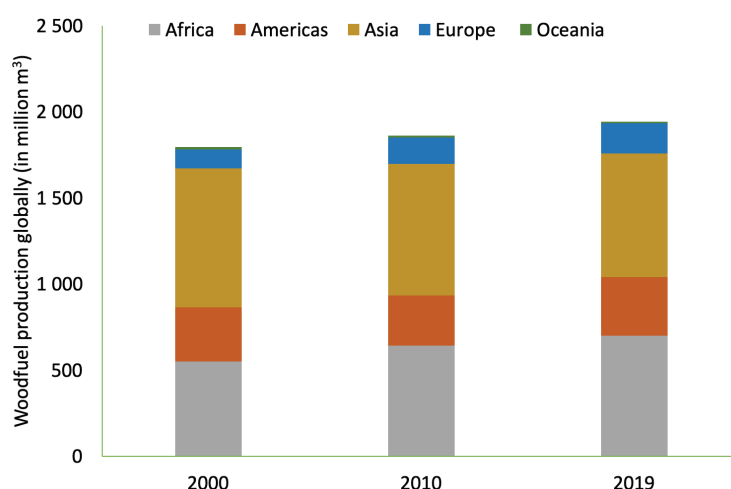


Figure 38 Woodfuel production globally

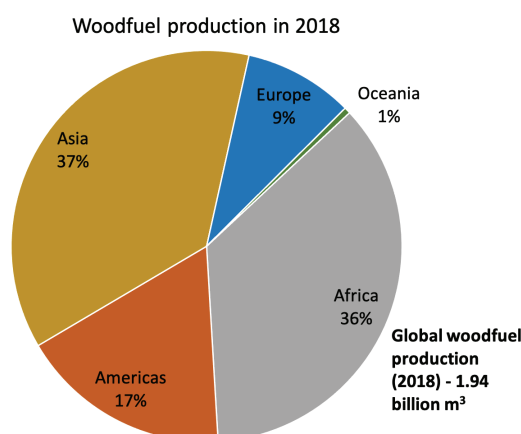


Figure 39 Woodfuel production in 2018

## WOOD PELLETS

Wood pellets are one of the fastest growing bioenergy sectors worldwide. In 2019, 38.9 million tonnes of pellets were estimated to be produced globally. During the past 7 years since data is available, the sector has seen an annual growth rate of 11.6%. Asia had the highest growth rate of 49% followed by Oceania at 30%. However, Europe still accounts for the majority of wood pellets production with a share of 55% globally followed by Americas at 32%.

Table 27 Wood pellets production globally

	World	Africa	Americas	Asia	Europe	Oceania	EU - 28
2012	18.1	0.00	5.10	0.30	12.5	0.03	11.0
2013	21.2	0.00	6.65	0.62	13.9	0.03	12.3
2014	25.1	0.04	7.96	1.72	15.2	0.14	13.3
2015	27.4	0.03	8.76	2.04	16.4	0.15	14.1
2016	29.3	0.04	9.49	2.59	17.0	0.16	14.3
2017	33.4	0.06	10.4	3.52	19.2	0.25	15.9
2018	36.6	0.07	11.2	5.01	20.1	0.21	16.9
2019	38.9	0.07	12.3	5.01	21.3	0.21	17.8

All values in million tonnes

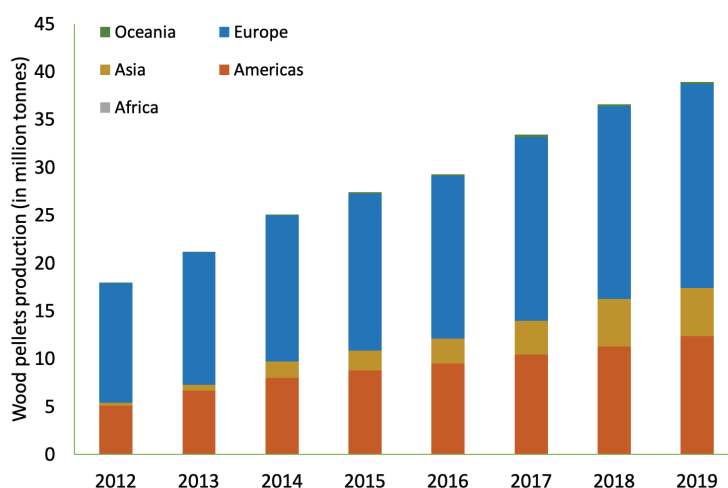
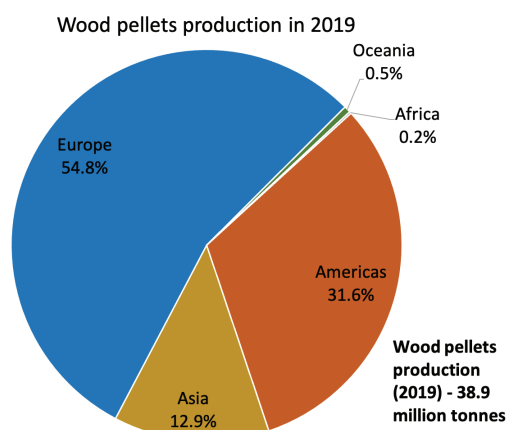


Figure 40 Wood pellets production globally





## WOOD CHARCOAL

Wood charcoal is another key bioenergy sector with significant volumes being produced globally. In 2019, 53.1 million tonnes of wood charcoal were produced globally with Africa accounting for 65% of the global production. The sector has shown a growth rate of 2% over the past 19 years with Africa and Europe accounting for a major share of the growth at 2.8% and 4.2%.

Table 28 Wood charcoal production globally

	World	Africa	Americas	Asia	Europe	Oceania	EU - 28
2000	36.7	20.2	9.67	6.54	0.30	0.04	0.22
2005	43.9	24.4	10.9	8.01	0.51	0.03	0.31
2010	46.5	28.5	8.86	8.54	0.57	0.04	0.25
2015	51.2	32.1	9.38	9.05	0.58	0.04	0.25
2016	50.7	32.8	8.29	9.04	0.61	0.04	0.30
2017	51.6	33.5	8.32	9.04	0.70	0.04	0.32
2018	53.1	34.2	9.15	9.03	0.65	0.04	0.27
2019	53.1	34.2	9.15	9.03	0.63	0.04	0.28

All values in million tonnes

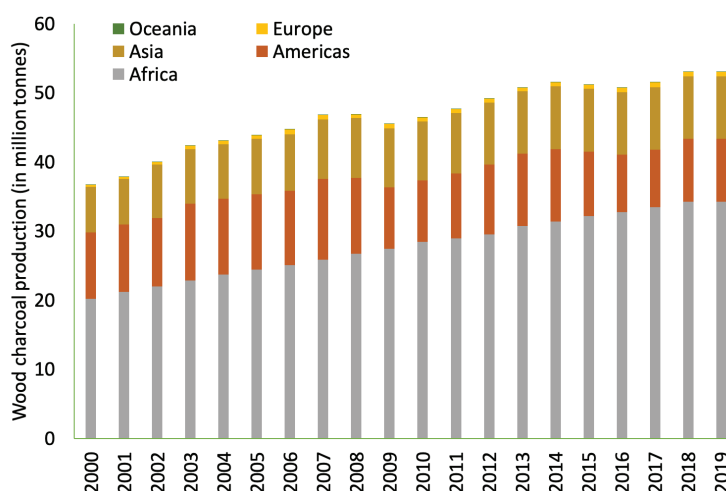


Figure 42 Wood charcoal production globally

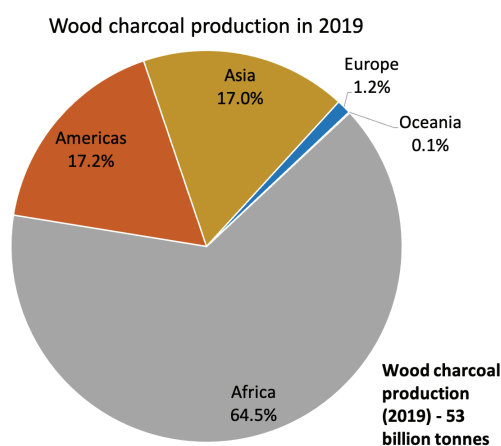


Figure 43 Wood charcoal production in 2019

## CROPS

Agriculture is a key sector for increased potential for bioenergy utilization in the future. Although the sector accounts for about 10% of the global biomass supply, there is significant potential for increasing its contribution. The feedstock from agriculture sector comes in the form of residues such as rice husk and wheat straw as well as biofuel crops such as sugarcane, rapeseed, oil palm etc.

In terms of yields of major crops, there is significant potential to increase the yields in various regions to the global average. This will enable increased production of both food and fuel with the agriculture sector playing a key enabler for increased bioenergy use around the world.

Table 29 Crop yields globally

	World	Africa	Americas	Asia	Europe	Oceania	EU - 28
<b>Barley</b>	<b>2.95</b>	<b>1.70</b>	<b>3.66</b>	<b>2.08</b>	<b>3.55</b>	<b>2.30</b>	<b>4.61</b>
<b>Cassava</b>	<b>11.3</b>	<b>9.1</b>	<b>12.8</b>	<b>21.5</b>	<b>0.0</b>	<b>12.3</b>	<b>0.0</b>
<b>Maize</b>	<b>5.92</b>	<b>2.04</b>	<b>8.18</b>	<b>5.37</b>	<b>7.54</b>	<b>7.98</b>	<b>8.39</b>
<b>Oats</b>	<b>2.34</b>	<b>1.57</b>	<b>2.88</b>	<b>2.51</b>	<b>2.27</b>	<b>1.43</b>	<b>2.83</b>
<b>Oil palm fruit</b>	<b>14.4</b>	<b>4.27</b>	<b>14.9</b>	<b>17.9</b>	<b>0.0</b>	<b>13.5</b>	<b>0.0</b>
<b>Olives</b>	<b>2.00</b>	<b>1.26</b>	<b>4.63</b>	<b>1.32</b>	<b>2.67</b>	<b>2.35</b>	<b>2.67</b>
<b>Rapeseed</b>	<b>2.00</b>	<b>1.50</b>	<b>2.22</b>	<b>1.61</b>	<b>2.58</b>	<b>2.35</b>	<b>2.90</b>
<b>Rice, paddy</b>	<b>4.68</b>	<b>2.33</b>	<b>6.33</b>	<b>4.83</b>	<b>6.43</b>	<b>9.85</b>	<b>6.74</b>
<b>Rye</b>	<b>2.74</b>	<b>1.88</b>	<b>2.28</b>	<b>3.21</b>	<b>2.75</b>	<b>0.70</b>	<b>3.21</b>
<b>Sorghum</b>	<b>1.41</b>	<b>1.00</b>	<b>3.63</b>	<b>1.24</b>	<b>4.57</b>	<b>2.72</b>	<b>5.63</b>
<b>Soybean</b>	<b>2.79</b>	<b>1.36</b>	<b>3.17</b>	<b>1.45</b>	<b>2.13</b>	<b>1.70</b>	<b>2.97</b>
<b>Sugar beet</b>	<b>57.2</b>	<b>54.6</b>	<b>69.5</b>	<b>56.2</b>	<b>55.8</b>	<b>0.0</b>	<b>68.5</b>
<b>Sugar cane</b>	<b>72.6</b>	<b>61.3</b>	<b>73.5</b>	<b>73.1</b>	<b>60.4</b>	<b>72.5</b>	<b>60.4</b>
<b>Sunflower</b>	<b>1.95</b>	<b>1.14</b>	<b>2.00</b>	<b>1.86</b>	<b>2.05</b>	<b>1.82</b>	<b>2.48</b>
<b>Wheat</b>	<b>3.43</b>	<b>2.86</b>	<b>3.18</b>	<b>3.39</b>	<b>4.00</b>	<b>1.94</b>	<b>5.41</b>

All values in t/ha

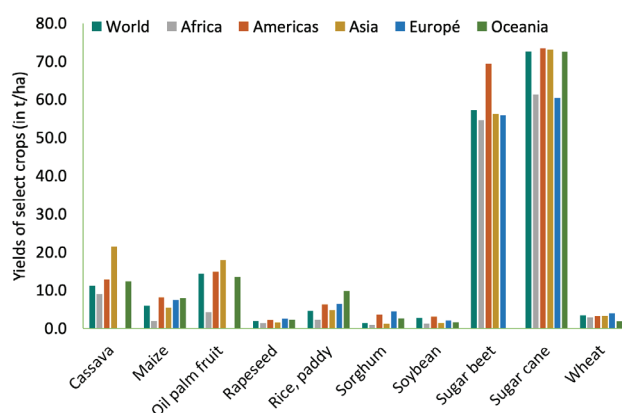


Figure 44 Yields of select crops

## WASTE TO ENERGY

Energy generation from municipal and industrial waste represents the 3rd feedstock sector after forestry and agriculture. In 2018, domestic supply of energy from municipal and industrial waste was 2.59 EJ with 56% from municipal waste and remaining from industrial waste. During 2000 – 2018, the sector has seen impressive annual growth rate of 4% due to the increased production of municipal waste in urban areas and the need for a sustainable and ecological solution.

Table 30 Domestic supply of waste globally

	Total	Municipal Waste	Industrial Waste
2000	1.23	0.74	0.49
2005	1.40	0.96	0.45
2010	1.95	1.18	0.77
2015	2.28	1.38	0.90
2016	2.45	1.42	1.04
2017	2.50	1.44	1.07
2018	2.59	1.45	1.13

All values in EJ

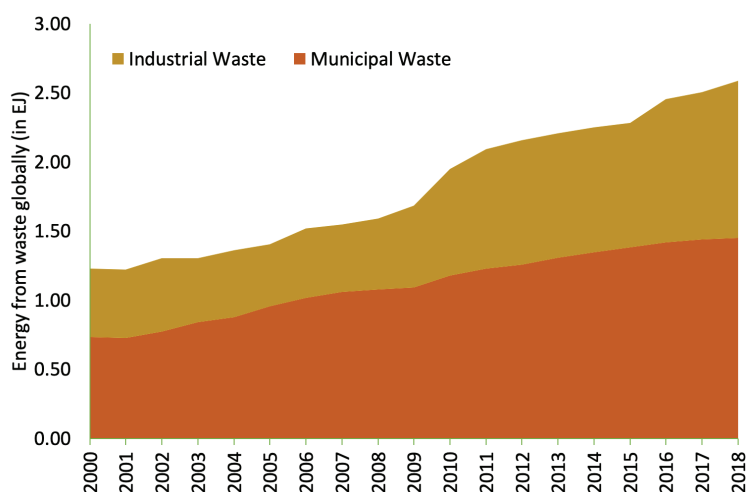


Figure 45 Energy from waste globally

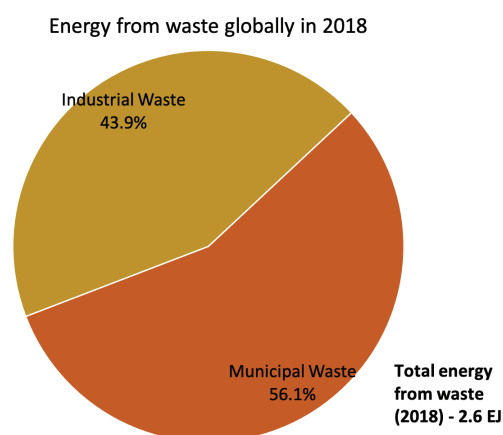


Figure 46 Energy from waste globally in 2018

Europe is the world leader in the production of energy from waste. In 2018, domestic supply of municipal and industrial waste was 1.39 EJ. Europe accounted for 54% of all global domestic supply of energy from waste followed by Americas at 32%.

Table 31 Domestic supply of waste in continents in 2018

	Total	Municipal Waste	Industrial Waste
Africa	0.00	0.00	0.00
Americas	0.36	0.30	0.05
Asia	0.83	0.21	0.63
Europe	1.39	0.94	0.45
Oceania	0.00	0.00	0.00
EU - 28	1.06	0.87	0.19

All values in EJ

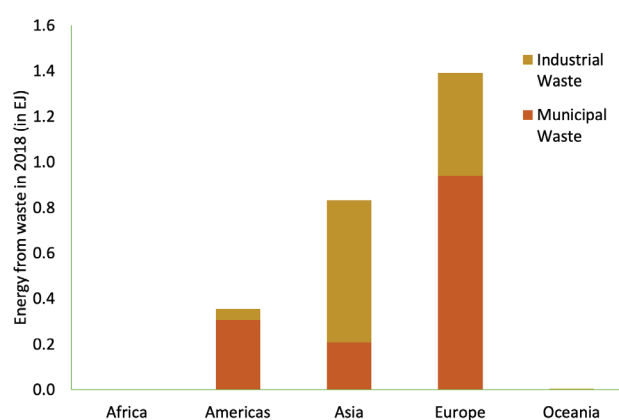


Figure 47 Energy from waste in continents in 2018

## CHAPTER 4. BIOMASS TO ELECTRICITY

### BIOPOWER

In 2018, 637 TWh of electricity was generated from biomass globally. 66% of all biopower generated was from solid biomass sources followed by 19% from municipal and industrial waste. Biogas share was 14%. During 2000 – 2018, the average annual growth rate of biopower generation was 8%, mainly due to the increased use of solid biomass for biopower generation.

Table 32 Electricity generation from biomass globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
2000	163	34.3	15.3	101	13.1	0.00
2005	228	46.5	11.7	146	21.2	1.98
2010	367	62.7	26.6	226	46.8	4.99
2015	517	73.4	28.4	324	83.6	8.26
2016	569	72.5	36.7	366	85.5	8.37
2017	598	74.3	39.1	391	87.2	6.96
2018	637	76.5	42.3	421	89.0	8.35

All values in TWh

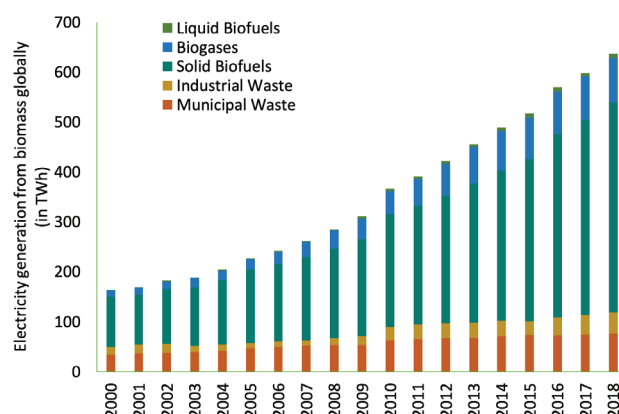


Figure 48 Electricity generation from biomass globally

Electricity generation from biomass globally in 2018

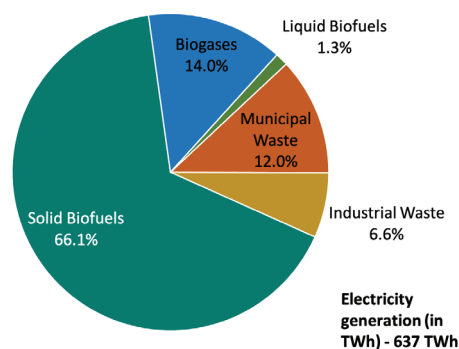


Figure 49 Electricity generation from biomass globally in 2018

Asia accounted for 38% of all biopower generated globally with 243 TWh of production in 2018 followed by Europe at 35%. Europe leads the world in biopower produced from Municipal waste accounting for 63% of the production while Asia leads in using industrial waste for electricity with a global share of 79%. Biopower from biogas is dominant in Europe with a global share of 72%.

Table 33 Electricity generation from biomass in continents in 2018

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
<b>Africa</b>	<b>2.07</b>	<b>0.00</b>	<b>0.00</b>	<b>2.05</b>	<b>0.02</b>	<b>0.00</b>
<b>Americas</b>	<b>163</b>	<b>16.7</b>	<b>2.29</b>	<b>127</b>	<b>15.9</b>	<b>0.74</b>
<b>Asia</b>	<b>243</b>	<b>11.4</b>	<b>33.2</b>	<b>189</b>	<b>7.00</b>	<b>2.69</b>
<b>Europe</b>	<b>225</b>	<b>48.3</b>	<b>6.76</b>	<b>100</b>	<b>64.5</b>	<b>4.92</b>
<b>Oceania</b>	<b>4.11</b>	<b>0.00</b>	<b>0.00</b>	<b>2.57</b>	<b>1.53</b>	<b>0.00</b>
<b>EU - 28</b>	<b>218</b>	<b>45.5</b>	<b>4.10</b>	<b>99.5</b>	<b>63.7</b>	<b>4.92</b>

All values in TWh

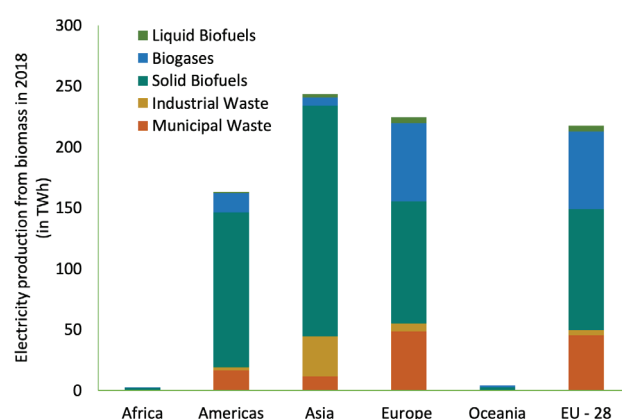


Figure 50 Electricity generation from biomass in continents in 2018

## ELECTRICITY ONLY PLANTS

Electricity only plants are designed to produce electricity only. They do not produce any heat from biomass and have an average conversion efficiency of about 30%. In 2018, 474 TWh of biopower was produced in electricity only plants, accounting for approx. 75% of all biopower produced globally. The sector experienced an annual growth rate of about 10% since 2000 with solid biofuels and industrial waste having similar growth rate.

Table 34 Electricity generation from biomass in electricity only plants globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
<b>2000</b>	<b>89.6</b>	<b>31.5</b>	<b>4.98</b>	<b>42.9</b>	<b>10.2</b>	<b>0.00</b>
<b>2005</b>	<b>136</b>	<b>39.0</b>	<b>2.33</b>	<b>78.0</b>	<b>15.5</b>	<b>1.26</b>
<b>2010</b>	<b>233</b>	<b>48.0</b>	<b>19.5</b>	<b>139</b>	<b>25.8</b>	<b>1.59</b>
<b>2015</b>	<b>338</b>	<b>52.3</b>	<b>22.8</b>	<b>220</b>	<b>37.7</b>	<b>4.52</b>
<b>2016</b>	<b>410</b>	<b>51.8</b>	<b>28.5</b>	<b>288</b>	<b>37.3</b>	<b>4.89</b>
<b>2017</b>	<b>431</b>	<b>50.8</b>	<b>31.5</b>	<b>307</b>	<b>37.4</b>	<b>4.48</b>
<b>2018</b>	<b>474</b>	<b>52.9</b>	<b>33.1</b>	<b>344</b>	<b>38.9</b>	<b>4.85</b>

All values in TWh

In 2018, Asia produces 65% of all biopower produced in electricity only plants. More importantly, 91% of all biopower from industrial waste in electricity only plants is in Asia as well. Europe leads the biopower production from biogas in electricity only plants accounting for about half of all global production.

Table 35 Electricity generation from biomass in electricity only plants in continents in 2018

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
<b>Africa</b>	<b>2.84</b>	<b>0.00</b>	<b>0.00</b>	<b>2.82</b>	<b>0.03</b>	<b>0.00</b>
<b>Americas</b>	<b>79.9</b>	<b>21.0</b>	<b>1.22</b>	<b>44.0</b>	<b>13.0</b>	<b>0.70</b>
<b>Asia</b>	<b>310</b>	<b>8.83</b>	<b>30.2</b>	<b>262</b>	<b>6.57</b>	<b>2.28</b>
<b>Europe</b>	<b>79.4</b>	<b>23.1</b>	<b>1.68</b>	<b>34.6</b>	<b>18.2</b>	<b>1.88</b>
<b>Oceania</b>	<b>1.69</b>	<b>0.00</b>	<b>0.00</b>	<b>0.56</b>	<b>1.13</b>	<b>0.00</b>
<b>EU - 28</b>	<b>79.0</b>	<b>22.8</b>	<b>1.68</b>	<b>34.5</b>	<b>18.1</b>	<b>1.88</b>

All values in TWh

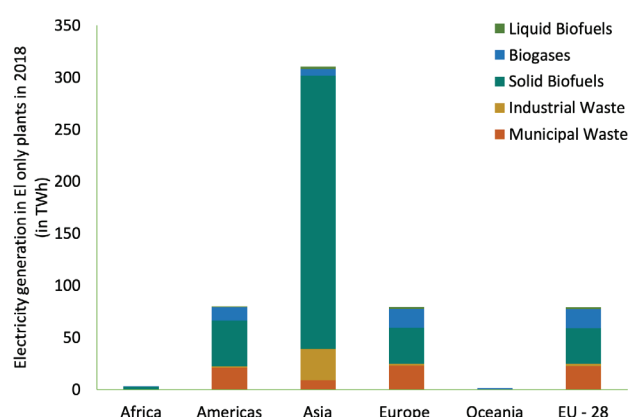


Figure 51 Electricity generation from biomass in electricity only plants in continents in 2018

## CHP PLANTS

CHP or Combined Heat and Power plants refer to those plants that are designed to produce both heat and electricity. These are also referred to as cogeneration facilities. The conversion efficiency varies widely among CHP facilities. For the sake of convenience, an average electricity conversion efficiency of 30%.

In 2018, 226 TWh of biopower was generated globally from biomass-based sources in CHP facilities accounting for a quarter of all biopower produced. Solid biofuels account for 60% of all biopower produced in CHP facilities followed by municipal waste at 21%.

Table 36 Electricity generation from biomass in CHP plants globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
2000	87	15.8	11.8	57.3	2.55	0.00
2005	118	27.6	10.1	75.5	4.40	0.42
2010	150	34.4	11.3	90.3	12.6	1.69
2015	208	44.4	11.4	124	26.5	1.58
2016	215	47.7	12.1	126	27.8	1.42
2017	225	49.7	12.4	133	29.0	1.39
2018	226	48.4	12.7	133	30.1	1.69

All values in TWh

Among continents, Europe leads in terms of biopower produced in CHP facilities. Europe produced 139 TWh of biopower in cogeneration facilities accounting for 62% of global production. Except for solid biofuels, Europe has the highest share of biopower produced from all biomass feedstock including municipal waste (87%), industrial waste (82%), biogas (88%) and liquid biofuels (87%).

Table 37 Electricity generation from biomass in CHP plants in continents in 2018

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
Africa	1.21	0.00	0.00	1.21	0.00	0.00
Americas	75.1	2.32	1.14	69.4	2.04	0.21
Asia	7.08	4.13	1.18	0.65	1.12	0.00
Europe	139	41.9	10.4	59.0	26.6	1.47
Oceania	2.86	0.00	0.00	2.52	0.34	0.00
EU - 28	125	37.4	2.13	57.4	26.2	1.47

All values in TWh

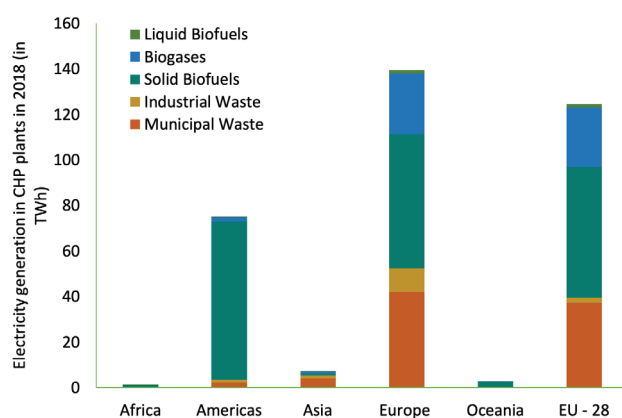


Figure 52 Electricity generation from biomass in CHP plants in continents in 2018



## CHAPTER 5. BIOMASS TO HEAT

### BIOHEAT

In 2018, 1.12 EJ of heat was produced from biomass-based sources – 53% from solid biomass sources and 26% from municipal solid waste. Bioenergy is one of the most promising options for decarbonizing the heat sector including residential, commercial, agriculture, fishing etc. The sector has seen an annual growth rate of 6% since 2000.

Table 38 Heat production from biomass globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
2000	0.41	0.13	0.07	0.21	0.00	0.00
2005	0.54	0.16	0.08	0.29	0.01	0.00
2010	0.79	0.22	0.13	0.42	0.01	0.01
2015	0.96	0.27	0.14	0.51	0.03	0.00
2016	1.05	0.29	0.17	0.56	0.04	0.00
2017	1.09	0.30	0.16	0.58	0.04	0.00
2018	1.12	0.30	0.18	0.59	0.05	0.01

All values in EJ

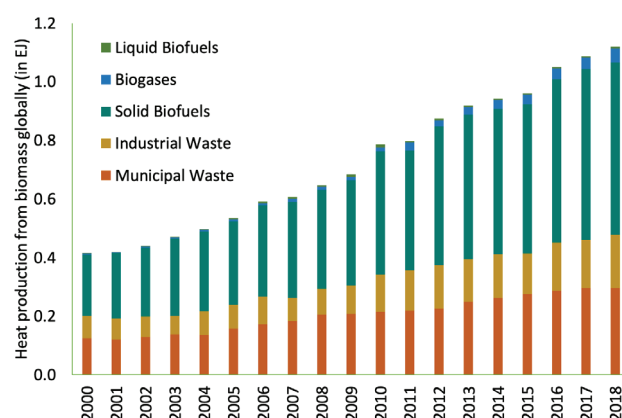


Figure 53 Heat production from biomass globally

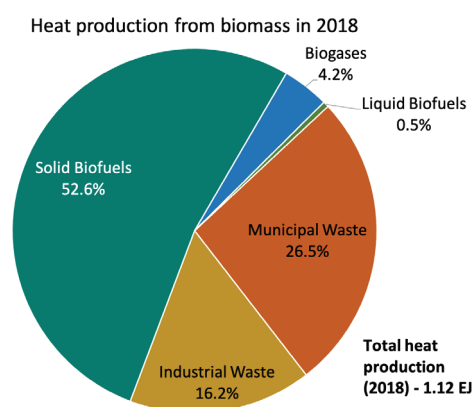


Figure 54 Heat production from biomass globally in 2018

Europe is the world leader in producing heat from biomass in power plants with a share of 87% globally followed by Asia at 8%. It is important to note that the bioheat only includes heat production in heat only and CHP plants which is transmitted and distributed to end consumers predominantly via district heating networks. It does not include the use of biomass for heat in end use sectors.

Table 39 Heat production from biomass in continents in 2018

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
<b>Africa</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>Americas</b>	<b>0.06</b>	<b>0.02</b>	<b>0.01</b>	<b>0.03</b>	<b>0.00</b>	<b>0.00</b>
<b>Asia</b>	<b>0.09</b>	<b>0.02</b>	<b>0.05</b>	<b>0.02</b>	<b>0.00</b>	<b>0.00</b>
<b>Europe</b>	<b>0.97</b>	<b>0.26</b>	<b>0.13</b>	<b>0.54</b>	<b>0.04</b>	<b>0.01</b>
<b>Oceania</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>
<b>EU - 28</b>	<b>0.75</b>	<b>0.24</b>	<b>0.01</b>	<b>0.46</b>	<b>0.04</b>	<b>0.01</b>

All values in EJ

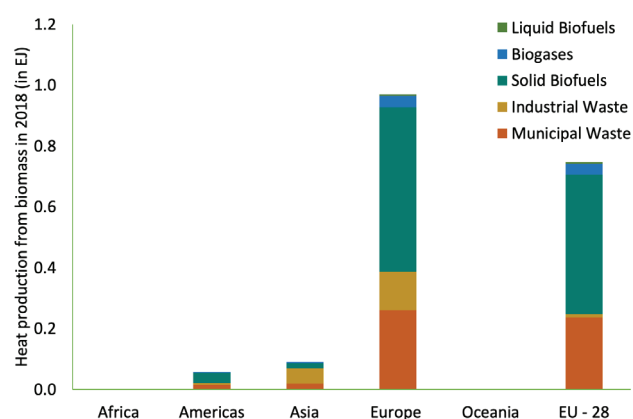


Figure 55 Heat production from biomass in continents in 2018

## HEAT ONLY PLANTS

Bioheat is produced either via heat only plants or CHP plants. Heat only plants are specifically designed to produce heat only and sold to a third party – e.g. residential, commercial or industrial consumers. In 2018, 0.21 EJ of bioheat was produced in heat only plants. 61% of the bioheat was produced from solid biofuels, 22% from industrial waste and 15% from municipal waste.

Table 40 Heat production from biomass in heat only plants globally

	Total	Municipal Waste	Industrial Waste	Solid Bio-fuels	Biogases	Liquid Biofuels
<b>2000</b>	<b>0.10</b>	<b>0.02</b>	<b>0.02</b>	<b>0.06</b>	<b>0.00</b>	<b>0.000</b>
<b>2005</b>	<b>0.13</b>	<b>0.03</b>	<b>0.02</b>	<b>0.08</b>	<b>0.00</b>	<b>0.001</b>
<b>2010</b>	<b>0.18</b>	<b>0.04</b>	<b>0.04</b>	<b>0.09</b>	<b>0.00</b>	<b>0.004</b>
<b>2015</b>	<b>0.19</b>	<b>0.04</b>	<b>0.05</b>	<b>0.11</b>	<b>0.00</b>	<b>0.001</b>
<b>2016</b>	<b>0.21</b>	<b>0.03</b>	<b>0.05</b>	<b>0.12</b>	<b>0.00</b>	<b>0.001</b>
<b>2017</b>	<b>0.21</b>	<b>0.03</b>	<b>0.05</b>	<b>0.13</b>	<b>0.00</b>	<b>0.001</b>
<b>2018</b>	<b>0.21</b>	<b>0.03</b>	<b>0.05</b>	<b>0.13</b>	<b>0.00</b>	<b>0.001</b>

All values in EJ

Europe and especially EU 28 countries dominate the bioheat sector in heat only plants. 84% of all bioheat produced globally in heat only plants are produced in Europe. Asia has a share of 15% while Americas, Africa and Oceania have negligible shares. Americas are dominant in producing heat from biogas in heat only plants with a share of 62%.

Table 41 Heat production from heat only plants in continents in 2018

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
<b>Africa</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.000</b>	<b>0.000</b>
<b>Americas</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.001</b>	<b>0.001</b>
<b>Asia</b>	<b>0.03</b>	<b>0.00</b>	<b>0.02</b>	<b>0.01</b>	<b>0.000</b>	<b>0.000</b>
<b>Europe</b>	<b>0.17</b>	<b>0.03</b>	<b>0.03</b>	<b>0.12</b>	<b>0.001</b>	<b>0.002</b>
<b>Oceania</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0.000</b>	<b>0.000</b>
<b>EU - 28</b>	<b>0.11</b>	<b>0.02</b>	<b>0.00</b>	<b>0.08</b>	<b>0.001</b>	<b>0.002</b>

All values in EJ

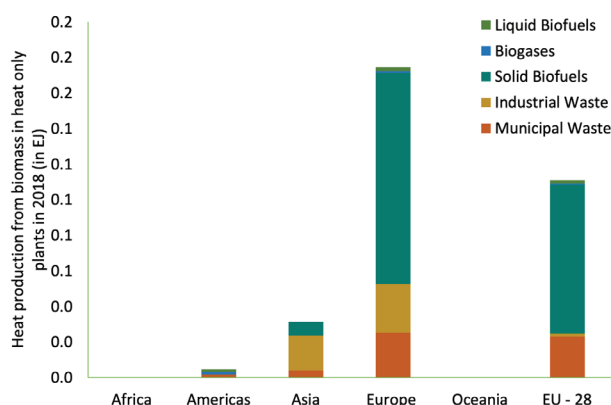


Figure 56 Heat production from biomass in heat only plants in continents in 2018

## CHP PLANTS

CHP (Combined Heat and Power) plants or cogeneration plants are designed to produce both heat and electricity. In 2018, 0.81 EJ of bioheat was produced globally which accounts for more than 75% of all bioheat produced globally. As is the case with heat only plants, solid biofuels are the largest contributor to heat production from biomass globally in CHP plants.

Table 42 Heat production from CHP plants globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
<b>2000</b>	<b>0.31</b>	<b>0.06</b>	<b>0.04</b>	<b>0.21</b>	<b>0.01</b>	<b>0.00</b>
<b>2005</b>	<b>0.43</b>	<b>0.10</b>	<b>0.04</b>	<b>0.27</b>	<b>0.02</b>	<b>0.00</b>
<b>2010</b>	<b>0.54</b>	<b>0.12</b>	<b>0.04</b>	<b>0.32</b>	<b>0.05</b>	<b>0.01</b>
<b>2015</b>	<b>0.75</b>	<b>0.16</b>	<b>0.04</b>	<b>0.45</b>	<b>0.10</b>	<b>0.01</b>
<b>2016</b>	<b>0.78</b>	<b>0.17</b>	<b>0.04</b>	<b>0.45</b>	<b>0.10</b>	<b>0.01</b>
<b>2017</b>	<b>0.81</b>	<b>0.18</b>	<b>0.04</b>	<b>0.48</b>	<b>0.10</b>	<b>0.01</b>
<b>2018</b>	<b>0.81</b>	<b>0.17</b>	<b>0.05</b>	<b>0.48</b>	<b>0.11</b>	<b>0.01</b>

All values in EJ

In 2018, Europe produced 0.67 EJ of bioheat globally via cogeneration facilities – accounting for 82% of the global production. Americas also had significant production of bioheat in CHP plants with a global share of 44% in 2018.

Table 43 Heat production from CHP plants in continents in 2018

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogases	Liquid Biofuels
<b>Africa</b>	<b>0.01</b>	<b>0.00</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>0.00</b>
<b>Americas</b>	<b>0.36</b>	<b>0.01</b>	<b>0.01</b>	<b>0.33</b>	<b>0.01</b>	<b>0.00</b>
<b>Asia</b>	<b>0.03</b>	<b>0.02</b>	<b>0.01</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>
<b>Europe</b>	<b>0.67</b>	<b>0.20</b>	<b>0.05</b>	<b>0.28</b>	<b>0.13</b>	<b>0.01</b>
<b>Oceania</b>	<b>0.01</b>	<b>0.00</b>	<b>0.00</b>	<b>0.01</b>	<b>0.00</b>	<b>0.00</b>
<b>EU - 28</b>	<b>0.60</b>	<b>0.18</b>	<b>0.01</b>	<b>0.28</b>	<b>0.13</b>	<b>0.01</b>

All values in EJ

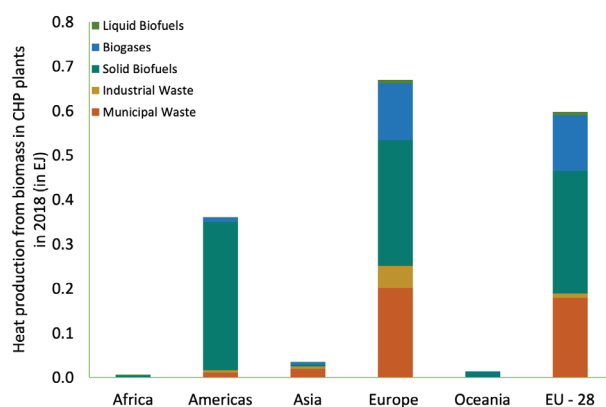


Figure 57 Heat production from biomass in CHP plants in continents in 2018

## CHAPTER 6. BIOFUELS

### LIQUID BIOFUELS

In 2018, 160 billion litres of biofuels were produced globally. Bioethanol is the largest biofuel globally with a share of 62% followed by FAME biodiesel at 26%. Rest of the biofuels including HVO (Hydrogenated vegetable oil), renewable diesel, cellulosic ethanol etc. had a share of 12%. During 2000 – 2018, the liquid biofuels sector grew at an annual rate of 13%.

Table 44 Biofuels production globally

	Biofuels	Bioethanol	Biodiesel	Other Biofuels
<b>2000</b>	<b>17.3</b>	<b>13.5</b>	<b>0.72</b>	<b>3.13</b>
<b>2005</b>	<b>37.1</b>	<b>27.2</b>	<b>3.43</b>	<b>6.51</b>
<b>2010</b>	<b>103</b>	<b>67.6</b>	<b>19.5</b>	<b>15.8</b>
<b>2015</b>	<b>136</b>	<b>90.4</b>	<b>30.6</b>	<b>15.1</b>
<b>2016</b>	<b>142</b>	<b>93.8</b>	<b>34.2</b>	<b>13.8</b>
<b>2017</b>	<b>148</b>	<b>98.9</b>	<b>36.0</b>	<b>13.2</b>
<b>2018</b>	<b>160</b>	<b>98.4</b>	<b>41.8</b>	<b>19.6</b>

All values in billion litres

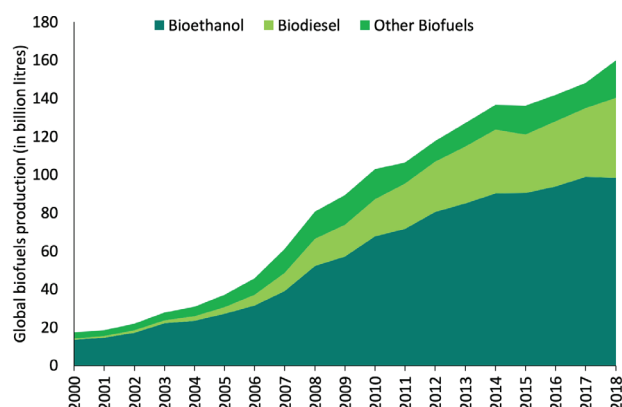


Figure 58 Global liquid biofuels production

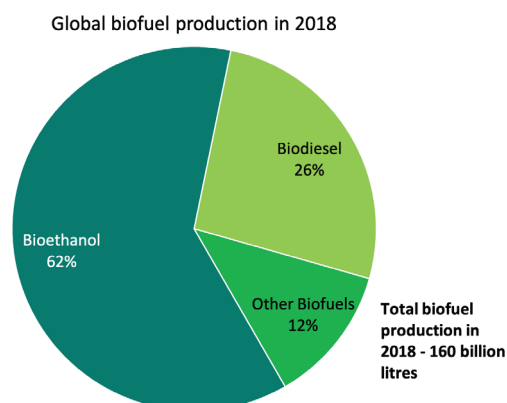


Figure 59 Global biofuel production in 2018

Americas dominate the biofuel production globally. North and South America together produce 75% of all biofuels globally with Europe having a share of 14%. The main biofuel in Americas is bioethanol with a share of 87% global bioethanol production – mainly corn ethanol in USA and sugarcane ethanol in Brazil.

Table 45 Biofuels production in continents in 2018

	Biofuels	Bioethanol	Biodiesel	Other Biofuels
<b>Africa</b>	<b>0.09</b>	<b>0.09</b>	<b>0.00</b>	<b>0.00</b>
<b>Americas</b>	<b>121</b>	<b>86.0</b>	<b>16.4</b>	<b>18.2</b>
<b>Asia</b>	<b>17.1</b>	<b>6.87</b>	<b>9.69</b>	<b>0.59</b>
<b>Europe</b>	<b>21.8</b>	<b>5.22</b>	<b>15.7</b>	<b>0.82</b>
<b>Oceania</b>	<b>0.24</b>	<b>0.24</b>	<b>0.00</b>	<b>0.00</b>

All values in billion litres

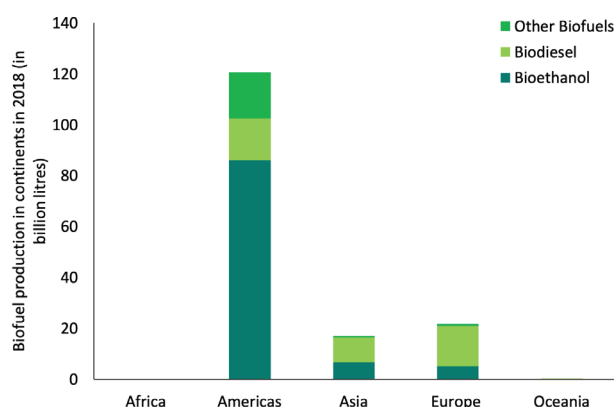


Figure 60 Biofuel production in continents in 2018

## BIOGAS

Biogas is an extremely important sector for the whole bioenergy industry. Biogas is produced by anaerobic fermentation of different forms of organic matter and is composed mainly of methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ). Typical feedstocks for biogas production are manure and sewage, residues of crop production (i.e., straw), the organic fraction of the waste from households and industry, as well as energy crops including maize and grass silage. Biogas is supplied to a variety of uses or markets, including electricity, heat and transportation.

In 2018, 59.3 billion m<sup>3</sup> of biogas was produced globally with an equivalent energy content of 1.36 EJ. During 2000 – 2018, the sector experienced an annual growth rate of 9%.

Table 46 Biogas production globally

	Biogas (billion m3)	Biogas (EJ)
<b>2000</b>	<b>12.4</b>	<b>0.29</b>
<b>2005</b>	<b>22.0</b>	<b>0.51</b>
<b>2010</b>	<b>37.1</b>	<b>0.85</b>
<b>2015</b>	<b>56.0</b>	<b>1.29</b>
<b>2016</b>	<b>56.6</b>	<b>1.30</b>
<b>2017</b>	<b>57.7</b>	<b>1.33</b>
<b>2018</b>	<b>59.3</b>	<b>1.36</b>

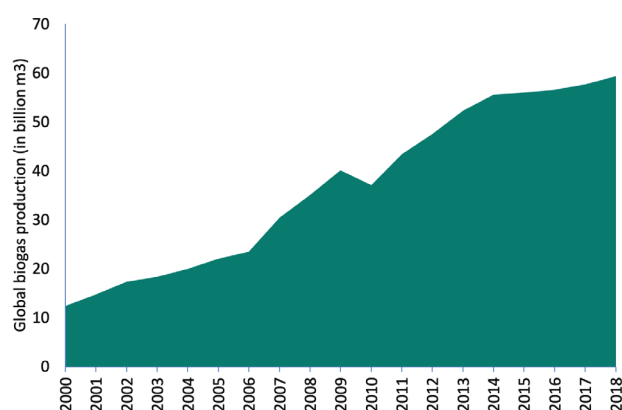


Figure 61 Biogas production globally

Europe is the world leader in biogas production. In 2018, Europe produced 30.9 billion m3 of biogas with an energy equivalent of 0.71 EJ. The production accounted for more than half of the global biogas production with Asia coming 2nd with a share of 32%.

Table 47 Biogas production in continents in 2018

	Biogas (billion m3)	Biogas (EJ)
<b>Africa</b>	<b>0.01</b>	<b>0.00</b>
<b>Americas</b>	<b>8.34</b>	<b>0.19</b>
<b>Asia</b>	<b>19.3</b>	<b>0.44</b>
<b>Europe</b>	<b>30.9</b>	<b>0.71</b>
<b>Oceania</b>	<b>0.84</b>	<b>0.02</b>
<b>EU - 28</b>	<b>30.3</b>	<b>0.70</b>

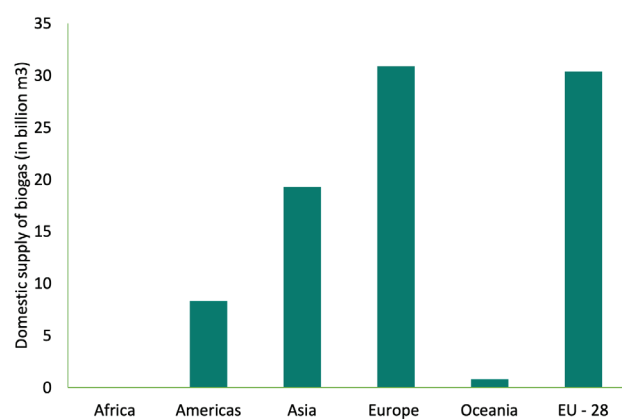


Figure 62 Biogas production in continents in 2018



## CHAPTER 7. RENEWABLE ENERGY JOBS

Renewable energy technologies create millions of jobs along the entire value chain. In 2019, an estimated 11.5 million people were employed in the renewable energy sector with bioenergy being the 2nd largest employer with an estimated 3.58 million people.

Table 48 Renewable energy jobs

	Total	Solar	Wind	Hydropower	Bioenergy	Others
2012	7.28	2.25	0.75	1.66	2.40	0.22
2013	8.55	2.77	0.83	2.21	2.50	0.23
2014	9.50	3.25	1.03	2.04	2.99	0.19
2015	10.0	3.71	1.08	2.16	2.88	0.20
2016	10.1	3.92	1.16	2.06	2.74	0.24
2017	10.5	4.18	1.15	1.99	3.05	0.16
2018	11.0	4.48	1.16	2.05	3.18	0.18
2019	11.5	4.57	1.17	1.96	3.58	0.18

All values in millions

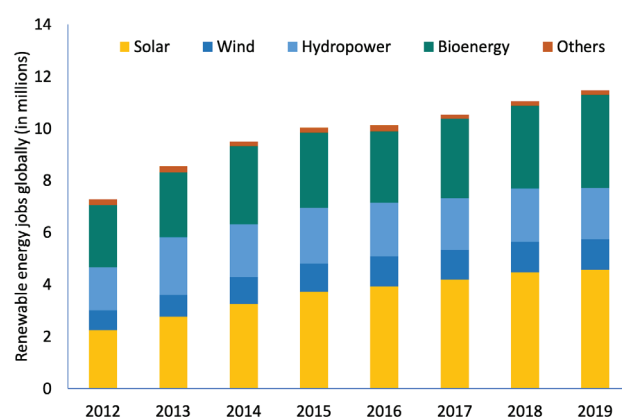


Figure 63 Jobs in renewable energy

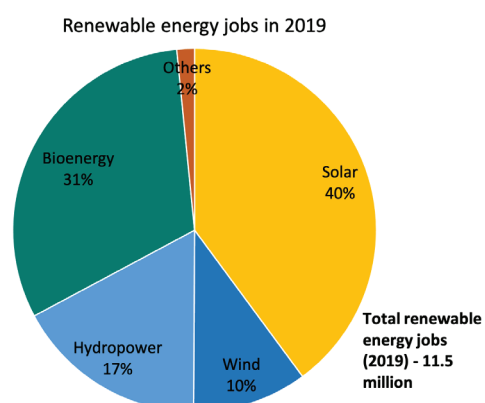


Figure 64 Jobs in renewable energy in 2019



## CHAPTER 8. APPENDIX

### GEOGRAPHICAL INFORMATION

**Africa:** Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Democratic Republic of the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Guinea – Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swazi-land, Togo, Tunisia, Uganda, United Republic of Tanzania, Western Sahara, Zambia, Zimbabwe.

**Americas:** Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, British Virgin Islands, Canada, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Falklands Islands, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Suriname, Turks and Caicos Islands, United States of America, Uruguay, Venezuela.

**Asia:** Afghanistan, Bahrain, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, China, Hong Kong SAR, China, Macao SAR, Democratic People's Republic of Korea, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, Japan, Jordan, Korea Democratic Republic, Kuwait, Lao People's Democratic Republic, Lebanon, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Oman, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, Sri Lanka, Syrian Arab Republic, Thailand, Turkey, United Arab Emirates, Viet Nam, Yemen.

**Europe:** Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Gibraltar, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Former Yugoslav Republic of Macedonia, Ukraine, United Kingdom.

**Oceania:** Australia, New Zealand

### GLOSSARY

**Bioenergy:** Bioenergy is equal to sum of industrial waste, municipal waste, primary solid biofuels, biogas, bioethanol, biodiesel, other liquid biofuels and charcoal etc.

**Geothermal:** Geothermal energy is the energy available as heat emitted from within the earth's crust, usually in the form of hot water or steam. It is exploited at suitable sites:

- for electricity generation using dry steam or high enthalpy brine after flashing
- directly as heat for district heating, agriculture, etc.

**Municipal Waste:** Municipal waste consists of products that are combusted directly to produce heat and/or power and comprises wastes produced by households, industry, hospitals and the tertiary sector that are collected by local authorities for incineration at specific installations. Municipal waste is split into renewable and non-renewable.

**Industrial Waste:** Industrial waste of non-renewable origin consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants, to produce heat and/or power. Renewable industrial waste is not included here, but with solid biofuels, biogases or liquid biofuels.

**Solid Biofuels:** Primary solid biofuels are defined as any plant matter used directly as fuel or converted into other forms before combustion. This covers a multitude of woody materials generated by industrial process or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, sulphite lye also known as black liquor, animal materials/wastes and other solid biofuels).

**Bioethanol:** Biogasoline includes bioethanol (ethanol produced from biomass and/or the biodegradable fraction of waste), biomethanol (methanol produced from biomass and/or the biodegrad-

able fraction of waste), bioETBE (ethyl-tertio-butyl-ether produced on the basis of bioethanol; the percentage by volume of bioETBE that is calculated as biofuel is 47%) and bioMTBE (methyl-tertio-butyl-ether produced on the basis of biomethanol: the percentage by volume of bioMTBE that is calculated as biofuel is 36%). Biogasoline includes the amounts that are blended into the gasoline - it does not include the total volume of gasoline into which the Biogasoline is blended.

**Biodiesels:** Biodiesels includes biodiesel (a methyl-ester produced from vegetable or animal oil, of diesel quality), biodimethylether (dimethyl ether produced from biomass), Fischer Tropsch (Fischer Tropsch produced from biomass), cold pressed bio-oil (oil produced from oil seed through mechanical processing only) and all other liquid biofuels which are added to, blended with or used straight as transport diesel. Biodiesels includes the amounts that are blended into the diesel - it does not include the total volume of diesel into which the biodiesel is blended.

**Other Biofuels.** Other liquid biofuels include liquid biofuels not reported in either bio gasoline or biodiesels.

**Biogases:** Biogases are gases arising from the anaerobic fermentation of biomass and the gasification of solid biomass (including biomass in wastes). The biogases from anaerobic fermentation are composed principally of methane and carbon dioxide and comprise landfill gas, sewage sludge gas and other biogases from anaerobic fermentation.

**Liquid Biofuels:** Liquid biofuels is sum of Biogasoline, biodiesel and other liquid biofuels.

**Land Area:** Country area excluding area under inland waters and coastal waters.

**Arable Land:** The total of areas under temporary crops, temporary meadows and pastures, and land with temporary fallow. Arable land does not include land that is potentially cultivable but is not normally cultivated.

**Permanent Crops:** Land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee), land under trees and shrubs producing flowers (such as roses and jasmine), and nurseries (except those for forest trees, which should be classified under "Forestry"). Permanent meadows and pastures are excluded from land under permanent crops.

**Permanent Pastures and Meadows:** Land used permanently (five years or more) to grow herbaceous forage crops through cultivation or naturally (wild prairie or grazing land). Permanent meadows and pastures on which trees and shrubs are grown should be recorded under this heading only if the growing of forage crops is the most important use of the area. Measures may be taken to keep or increase productivity of the land (i.e., use of fertilizers, mowing or systematic grazing by domestic animals.) This class includes:

- Grazing in wooded areas (agroforestry areas, for example)
- Grazing in shrubby zones (heath, maquis, garigue)
- Grassland in the plain or low mountain areas used for grazing: land crossed during transhumance where the animals spend a part of the year (approximately 100 days) without returning to the holding in the evening: mountain and subalpine meadows and similar; and steppes and dry meadows used for pasture.

**Naturally Regenerative Forests:** Forest predominantly composed of trees established through natural regeneration. Explanatory notes 1. Includes forests for which it is not possible to distinguish whether planted or naturally regenerated. 2. Includes forests with a mix of naturally regenerated native tree species and planted/seeded trees, and where the naturally regenerated trees are expected to constitute a major part of the growing stock at stand maturity. 3. Includes coppice from trees originally established through natural regeneration. 4. Includes naturally regenerated trees of introduced species.

**Planted Forests:** Forest predominantly composed of trees established through planting and/or deliberate seeding. Explanatory notes 1. In this context, predominantly means that the planted/seeded trees are expected to constitute more than 50 percent of the growing stock at maturity. 2. Includes coppice from trees that were originally planted or seeded.

**Wood Fuel:** Roundwood that will be used as fuel for purposes such as cooking, heating or power production. It includes wood harvested from main stems, branches and other parts of trees (where these are harvested for fuel) and wood that will be used for the production of charcoal (e.g. in pit kilns and portable ovens), wood pellets and other agglomerates. The volume of roundwood used in charcoal production is estimated by using a factor of 6.0 to convert from the weight (mt) of charcoal produced to the solid volume (m<sup>3</sup>) of roundwood used in production. It also includes wood chips to be used for fuel that are made directly (i.e. in the forest) from round-

wood. It excludes wood charcoal, pellets and other agglomerates. It is reported in cubic metres solid volume underbark (i.e. excluding bark)

**Wood Pellets:** Agglomerates produced either directly by compression or by the addition of a binder in a proportion not exceeding 3% by weight. Such pellets are cylindrica, with a diameter not exceeding 25 mm and a length not exceeding 100 mm. It is reported in metric tonnes.

**Wood Charcoal:** It covers the solid residue of the destructive distillation and pyrolysis of wood and other vegetal material.

**Electricity Only:** Refers to plants which are designed to produce electricity only. If one or more units of the plant is a CHP unit (and the inputs and outputs cannot be distinguished on a unit basis) then the whole plant is designated as a CHP plant.

**Heat Only:** Refers to plants (including heat pumps and electric boilers) designed to produce heat only and who sell heat to a third party (e.g. residential, commercial or industrial consumers) under the provisions of a contract.

**CHP:** Refers to plants which are designed to produce both heat and electricity (sometimes referred to as co-generation power stations). If possible, fuel inputs and electricity/heat outputs are on a unit basis rather than on a plant basis.

## GENERAL REGIONAL DATA

Table 49 Some general regional data on energy, emissions and population

Country Name	Population	GDP (Current USD)	Emissions (kt)
Central Europe and the Baltics	102 378 579	1 656 928 913 108	656 859
East Asia & Pacific	2 340 628 292	26 979 805 534 123	13 955 922
Europe & Central Asia	921 140 092	22 748 788 538 190	6 269 012
European Union	447 512 041	15 592 795 166 700	2 881 621
Latin America & Caribbean	646 430 841	5 719 252 824 663	1 836 828
Middle East & North Africa	456 707 404	3 701 386 017 856	2 608 737
Pacific island small states	2 493 696	10 456 001 897	3 370
Sub-Saharan Africa	1 106 957 898	1 755 011 419 751	853 107
South Asia	1 835 776 742	3 597 970 348 648	2 736 913
World	7 673 533 972	87 697 518 999 809	35 999

(World Bank, 2019)

## USEFUL CONVERSIONS

Table 50 Average energy content of fuels

Fuel	Value	Unit
Biogas	23.0	MJ/m <sup>3</sup>
Bioethanol	21.1	MJ/l
Biodiesel	34.5	MJ/l
Other Biofuels	27.8	MJ/l

Table 51 Standard energy unit conversions

To:	TJ	Gcal	Mtoe	Mbtu	GWh
From:					
TJ	1	238.8	2.388E-05	947.8	0.2778
Gcal	4.1868E-03	1	1E-06	3.968	1.163E-03
Mtoe	4.1868E+04	1E+08	1	3.97E+07	11 630
Mbtu	1.0551E-03	0.252	2.52E-08	1	2.931E-04
GWh	3.6	860	8.6E-05	3 412	1

Table 52 Standard unit conversions

To:	Exa	Peta	Tera	Giga	Mega	Kilo	Joule
From:	Multiply by						
Exa	1	1E+03	1E+06	1E+09	1E+12	1E+15	1E+18
Peta	1E-03	1	1E+03	1E+06	1E+09	1E+12	1E+15
Tera	1E-06	1E-03	1	1E+03	1E+06	1E+09	1E+12
Giga	1E-09	1E-06	1E-03	1	1E+03	1E+06	1E+09
Mega	1E-12	1E-09	1E-06	1E-03	1	1E+03	1E+06
Kilo	1E-15	1E-12	1E-09	1E-06	1E-03	1	1E+03
Joule	1E-18	1E-15	1E-12	1E-09	1E-06	1E-03	1

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