GLOBAL BIOENERGY STATISTICS 2019

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 and cannot be held liable for the accuracy of the information presented.

SUMMARY

Fossil fuels dominate our energy mix and the dependence continued in recent years. During 2016 – 2017, the primary energy supply of fossil fuels has increased more than the supply of renewable energy sources. The 1.5% increase in total primary energy supply during 2016 – 17 has been matched by coal, oil and natural gas while renewables are lagging behind (0.7%). This trend appears to continue to 2018 and 2019 as well.

In 2017, the gross final energy consumption was 370 EJ – an increase of 2% over the past year. 40% of the energy consumed globally comes in the form of oil and oil products while coal and gas have an equal share of 20% each. Combined, fossil fuels accounted for 80% of the energy consumption globally in 2017. The share of renewable energy in the gross final energy consumption globally was 17.7% in 2017 – a drop of 0.2% over the previous year.

Among renewable energy sources, bioenergy (energy from bio-based sources) is the largest. In 2017, bioenergy accounted for 70% of the renewable energy consumption. The contribution of bioenergy share has been decreasing by a few percentage points (approx. 0.5% - 1%) annually partly due to decreasing use of traditional biomass sources.

Renewable energy technologies have made considerable progress in decarbonizing the electricity sector. In 2017, renewable electricity covered about 25% of the electricity generated globally. In 2017, electricity from biomass-based sources was the 3rd largest renewable electricity source after hydropower and wind. 596 TWh of biopower was generated.

Almost half of all energy consumption is in the form of heat – space heating for residential and commercial establishments and heating demand for industrial processes. One of the most widely used renewable energy source for derived heating is biomass which has a 96% share in the renewable heat market globally.

In the transport sector, biomass-based fuels (bioethanol, biodiesel etc.) are one of the best options for replacing fossil oil. The share of biofuels in the transport sector in 2017 was about 3% with a total contribution of 3.5 EJ.

Biomass dominates the end use sector of direct heating. In 2017, 40 EJ of biomass was consumed in end use sectors of residential, commercial, agriculture etc. for heating and cooking purposes which accounts for about 95% of renewable energy use in these sectors.

In 2017, 55.6 EJ of biomass was utilized for energy purposes – 86% of the use was in the form of primary solid biofuels including wood chips, wood pellets, fuelwood for cooking and heating etc. 7% of the biomass was used as liquid biofuels. Biogas, municipal waste, industrial waste had almost equal share at 2 – 3%.

One of the most promising sectors for growth in bioenergy production is in the form of residues from agriculture sector. Currently, the sector contributes less than 3% to the total bioenergy production. Data shows that utilizing the residues from all major crops for energy can generate approx. 4.3 billion tonnes (low estimate) to 9.4 billion tonnes (high estimate) annually around the world. Utilizing standard energy conversion factors, the theoretical energy potential from residues can be in the range of 17.8 EJ to 82.3 EJ. The major contribution would be from cereals – mainly maize, rice and wheat. Energy generation from agricultural residues could meet about 3 – 14% of the total energy supply globally.

The forestry sector is the largest contributor to the bioenergy mix globally. Forestry products including charcoal, fuelwood, pellets and wood chips account for more than 85% of all the biomass used for energy purposes. One of the primary products from forests that are used for bioenergy production is woodfuel. Most of the woodfuel is used for traditional cooking and heating in developing countries in Asia and Africa. Globally, 1.9 billion m^3 of woodfuel was used for energy purposes.

The third and final category for bioenergy supply is municipal and industrial waste utilized for energy predominantly in urban areas. In 2017, domestic supply of waste to bioenergy was 2.51 EJ – 58% was in the form of municipal waste while the remaining was industrial waste to energy.

Biopower or electricity generation from biomass is one of the sustainable and renewable option for reducing fossil fuel demand in the electricity sector. In 2017, 596 TWh of biopower was produced globally which is an increase of 25TWh (+ 4%) over the previous year. Bioheat is heat from biomass or bio-based feedstock. In 2017, 1.08 EJ of bioheat was generated globally which is an increase of about 0.03 EJ over the previous year. Liquid biofuels for transport are part of important strategies to improve fuel security, mitigate climate change and support rural development. In 2017, 138 billion litres of biofuels were produced including bioethanol, biodiesel, HVO (Hydrogenated Vegetable Oil) etc.

Special sectors deals with data on biogas, pellets and charcoal. In 2018, 35.4 million tonnes of wood pellets were produced – 55% of the production occurred in Europe while Americas (mainly USA) accounted for 31%. In 2017, 1.33 EJ of biogas was produced globally while Europe accounted for more than half of the annual production. With regard to charcoal, 51.6 million tonnes of charcoal were produced globally with Africa as the main producer and consumer of charcoal accounting for 65% of the production and using predominantly for cooking.

Renewable energy technologies create jobs. Globally, 11 million people were employed in the renewable energy industry by the end of 2018. Bioenergy is the 2nd largest employer globally with approx. 3.2 million people working in the bioenergy supply chain.

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 one of 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. This 2019 edition is the 5th 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 due to misinformation and 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. This report aims to address the initial challenge of lack of attention while at the same time attempting to address the second challenge of improved data.

As readers go through the report, it is important to understand certain key terminologies and definitions used repeatedly 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 biofuels, the energy content of the biofuels is considered as primary energy. Similar is the case with pellets, biogas and charcoal etc.

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 residential sectors 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^3 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), REN21 Global Status Report (e.g. biofuels), World Bank (e.g. country information) and WBA member network. All data sources are specified in the appendix.

Base year: An attempt is made to obtain the most recent available data for each section. Most of the information available is from 2017 and some from the year 2018 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.

World Bioenergy Association

1. GLOBAL ENERGY SYSTEM

1.1 SUPPLY

Fossil fuels dominate the global energy supply and have been doing so since the dawn of the industrial revolution. Coal, oil and gas are the primary energy drivers globally. Since 2000, primary energy supply of coal has increased by 65%, oil by 22% and natural gas by 50% while at the same time renewables have increased by 48%. In the recent past, the trend has been the same. During 2016 – 2017, the supply of fossil fuels has increased more than the supply of renewable energy. The 1.5% increase in total primary energy supply during 2016 – 17 has been matched by coal (1.5%), oil (1.4%) and natural gas (2.4%) while renewables are lagging behind (0.7%). This trend appears to continue to 2018 and 2019 as well.

Table 1 Total primary energy supply globally

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
2000	420	97.0	153	86.8	28.3	54.7	13.0%
2005	481	125	168	98.8	30.2	59.4	12.3%
2010	539	153	173	115	30.1	68.2	12.6%
2015	572	161	182	123	28.1	77.8	13.6%
2016	576	156	184	127	28.5	80.6	14.0%
2017	585	158	186	130	28.8	81.1	13.9%

Unit: In EJ. (IEA, 2019)

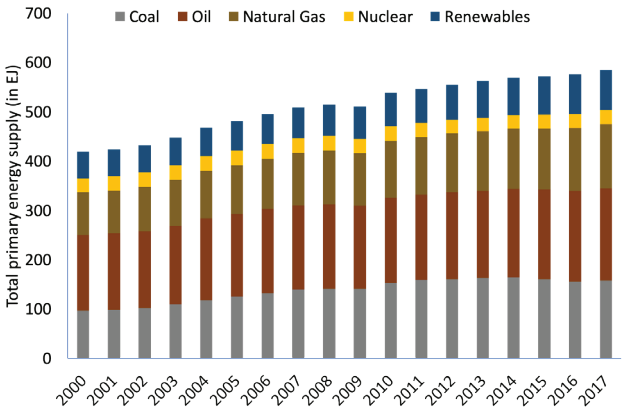

Figure 1 Total primary energy supply globally

The share of renewable supply has been constant over the past 17 years. During 2015 - 2016, the primary energy supply of renewables increased by almost 3 EJ. However, their growth decreased in 2017 with less than 0.5 EJ added to the energy supply while at the same time, fossil fuels added 7 EJ thereby matching the increasing demand for energy globally.

In 2017, primary energy supply of fossil fuels in Asia (284 EJ) was the highest among all continents contributing to 50% of the global supply. Europe, North and South America accounted for 47% while African continent had an extremely low share at 6%. Among renewable energy supply, due to the excessive use of biomass for cooking and heating, 47% of the energy supply in African continent comes from non-fossil sources.

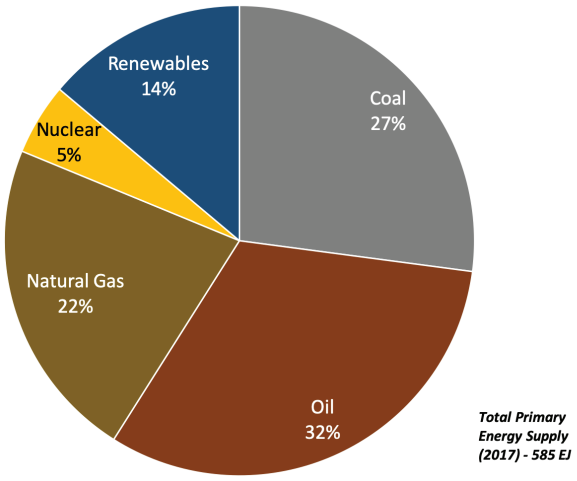

Figure 2 Total primary energy supply globally in 2017

Table 2 Total primary energy supply of energy sources in 2017 in continents

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
Africa	34.6	4.59	8.57	5.13	0.15	16.1	46.5%
Americas	140	16.4	55.2	39.8	10.6	18.3	13.1%
Asia	284	118	82.9	44.6	5.54	33.3	11.7%
Europe	120	17.9	37.5	39.1	12.5	12.7	10.6%
Oceania	6.46	1.89	2.35	1.49	0.00	0.73	11.3%
World	585	158	186	130	28.8	81.1	13.9%

Unit: In EJ. (IEA, 2019)

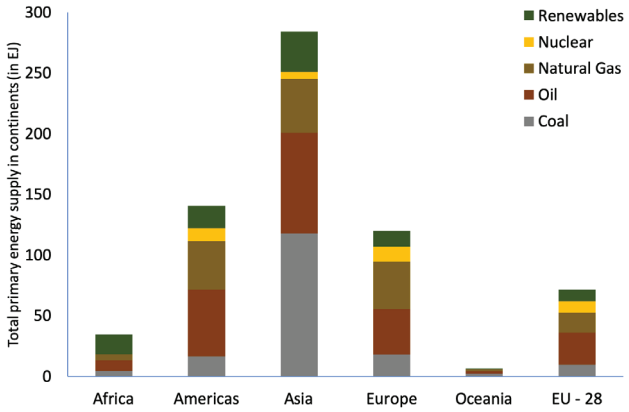

Figure 3 Total primary energy supply of energy sources in 2017 in continents

1.2 CONSUMPTION

In 2017, the gross final energy consumption of energy sources was 370 EJ – an increase of 2% over the past year. 40% of the energy consumed globally comes in the form of oil and oil products while coal and gas have an equal share of 20% each. Combined, fossil fuels accounted for 80% of the energy consumption globally in 2017.

Considering the fact that the share of fossil fuel consumption was 80% in 2000, it shows the limited progress globally in renewables replacing fossil fuels in end use sectors of electricity, heating and transportation.

Even though renewables have shown remarkable growth during 2000 – 2017, the increasing demand for energy around the world ensures that fossil fuels play their part in meeting the demand. The share of renewable energy in the gross final energy consumption globally was 17.7% in 2017 – a drop of 0.2% over the previous year.

Table 3 Gross final energy consumption globally

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
2000	269	43.1	115	55.7	7.64	47.4	17.6%
2005	304	58.9	125	61.2	8.22	50.6	16.6%
2010	338	72.6	129	70.0	8.25	57.0	16.9%
2015	359	76.6	138	73.7	7.72	63.3	17.6%
2016	364	74.8	140	75.7	7.83	65.1	17.9%
2017	370	75.2	143	77.9	7.93	65.7	17.7%

Unit: In EJ. (IEA, 2019)

Renewable energy sources have shown promise in meeting the energy demand globally and the exponential growth of some of the technologies are promising. Solar power has increased 11 times while wind energy has increased by 35 times since 2000 – however, both started off from a very low share initially. To make a significant contribution in reducing fossil fuel use, it is crucial to continue the rapid expansion of renewable energy technologies and at the same time focussing on reducing our global energy demand through energy efficiency measures.

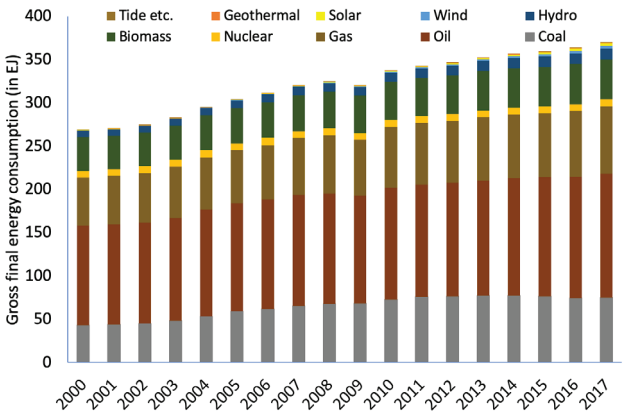

Figure 4 Gross final energy consumption globally

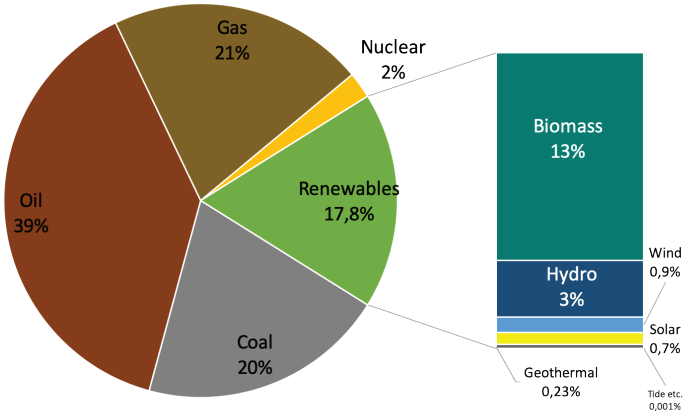

Figure 5 Gross final energy consumption in 2017

Among renewable energy sources, bioenergy (energy from bio-based sources) is the largest renewable energy. In 2017, bioenergy accounted for 70% of the renewable energy consumption. The contribution of bioenergy has been decreasing by a few percentage points (approx. 0.5% - 1%) annually probably because of decreasing use of traditional biomass sources.

Table 4 Gross final energy consumption in continents in 2017

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
Africa	24.5	1.58	7.44	2.08	0.04	13.4	54.5%
Americas	92.1	5.96	44.7	23.7	2.95	14.7	16.0%
Asia	170	58.4	58.7	24.3	1.53	27.1	15.9%
Europe	77.0	8.04	29.4	26.4	3.35	9.81	12.7%
Oceania	3.91	0.63	1.90	0.91	0.00	0.46	11.9%
World	370	75.2	143	77.9	7.93	65.7	17.7%

Unit: In EJ. (IEA, 2019)

Among continents, Asia is one of the largest consumers of fossil fuels. The region consumes close to 80% of all the coal produced globally. The region is also the largest consumer of oil and oil products accounting for 40% of the global consumption followed by North and South Americas at 30% and Europe at 21%. Natural gas consumption is distributed equally among Europe, Americas and Asia whereby each consumes about 1/3rd of the global consumption. Even among renewable energy sources, Asia leads the world. The continent is the largest consumer of renewable sources among all continents for all renewable energy technologies including biomass, hydropower, wind, solar, geothermal and tide etc.

Coal only accounts for 34% of the total energy consumption in Asia while in the rest of the world, the share is far less - e.g. 6% in Africa and Americas. The major fossil fuel in the energy mix for all regions is oil and oil products ranging from a high of 50% in Americas and Oceania to a low of 30% in Africa. Renewable energy sources form a minor part in the energy consumption of the regions. Only bioenergy has a significant share in the energy mix – e.g. 50% of the energy needs of Africa are met by bioenergy while solar, wind, hydro and other renewable energy sources contribute less than 5% in each respective continent.

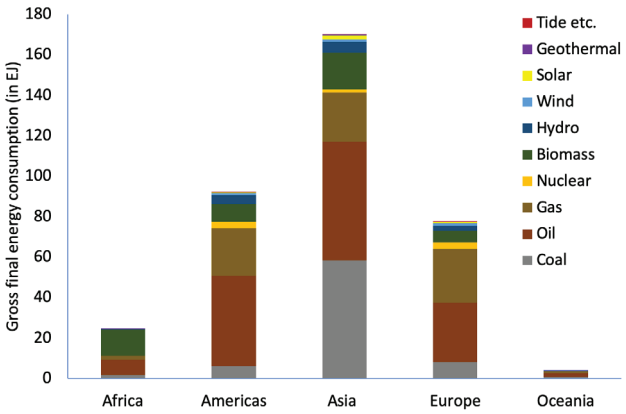

Figure 6 Gross final energy consumption in continents in 2017

1.3 RENEWABLE ENERGY

1.3.1. RENEWABLE SUPPLY

Bioenergy is the largest renewable energy source globally. In 2017, the total primary energy supply of biomass was 55.6 EJ – a drop of 0.9 EJ over the previous year and almost matching the level in 2015. This was the first time since 2010 that biomass supply reduced. Even with the reduction in supply, biomass still has a major share in renewables supply accounting for 70% of the total renewable supply. Compared to 2000, the contribution of biomass has been reducing significantly. However, it is important to note that most of the contribution of biomass supply globally is from traditional use of biomass for cooking and heating in developing regions. With the increasing use of modern biomass solutions like wood pellets, biogas and liquid biofuels, contribution of modern bioenergy sources will be a major part in the future renewable energy mix.

Table 5 Total primary energy supply of renewables

	Total	Biomass	Hydro	Solar	Wind	Geothermal	Tide etc.
2000	54.7	42.8	9.43	0.21	0.11	2.19	0.002
2005	59.4	45.9	10.6	0.31	0.37	2.25	0.002
2010	68.2	51.2	12.4	0.77	1.23	2.61	0.002
2015	77.7	55.1	14.1	2.27	3.02	3.24	0.004
2016	80.5	56.5	14.6	2.60	3.45	3.37	0.004
2017	81.1	55.6	14.7	3.07	4.06	3.59	0.004

Unit: In EJ. (IEA, 2019)

Hydropower comes second at 18% which is relatively stable over the past 17 years. However, the most significant growth among renewables has been for wind and solar energy technologies. Both solar and wind technologies had minor contribution to the energy supply in 2000 but have now increased their share to 4% and 5% in 2017 which is similar in contribution from geothermal energy.

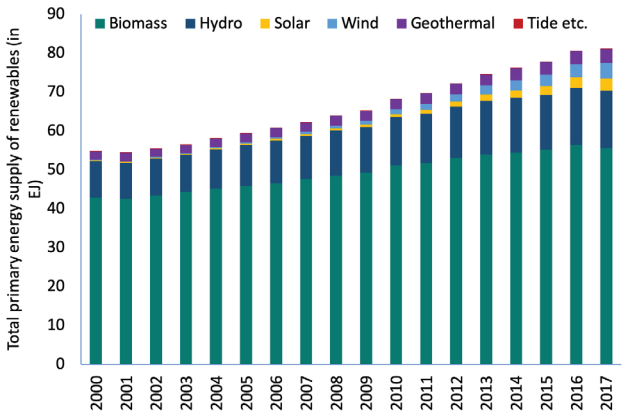

Figure 7 Total primary energy supply of renewables

The role of bioenergy in some region's energy mix is quite evident considering the fact that 96% of all renewable energy supply in Africa is contributed by biomass. It has significantly higher shares in Americas (59%), Asia (65%) and Europe (59%) as well. The availability of a variety of feedstock (forestry, agriculture) to produce useful end products (pellets, wood chips, bioethanol, biogas and biodiesel) for use in electricity, heat and transportation benefits bioenergy development around the world.

Table 6 Total primary energy supply of renewables in continents in 2017

	Total	Biomass	Hydro	Solar	Wind	Geothermal	Tide etc.
Africa	16.1	15.4	0.44	0.03	0.04	0.17	0.000
Americas	18.3	10.8	5.17	0.44	1.27	0.65	0.000
Asia	33.2	21.6	6.17	1.91	1.37	2.12	0.002
Europe	12.7	7.52	2.77	0.62	1.32	0.44	0.002
Oceania	0.73	0.28	0.15	0.05	0.05	0.20	0.000
World	81.0	55.6	14.7	3.05	4.05	3.59	0.004

Unit: In EJ. (IEA, 2019)

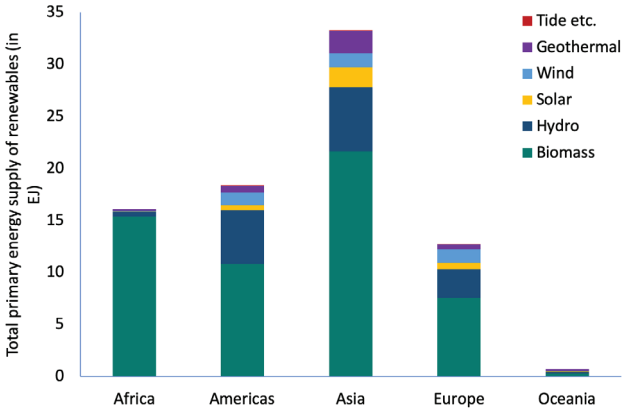

Figure 8 Total primary energy supply of renewables in continents in 2017

1.3.2. RENEWABLE ELECTRICITY

Renewable energy technologies have made considerable progress in decarbonizing the electricity sector. From the start of 2000, renewable electricity share has increased by 6 percentage points, from 19% to 25% in 2017 – all at the same time as overall electricity generation has increased by more than 10 000 TWh.

The biggest increase in electricity generation during the same time period was due to hydropower (1 500 TWh) and wind (1 096 TWh) with significant contributions from biopower (430 TWh) and solar power (450 TWh). However, the rapid rise in power generation from solar and wind is quite obvious from the fact that in 17 years, power generation increased by a factor of 300 and 36 from solar and wind respectively while biopower increased by a factor of 4.

In 2017, electricity from biomass-based sources was the 3rd largest renewable electricity source after hydropower and wind. 596 TWh of biopower was generated.

Table 7 Electricity generation from renewables

	Total Electricity	Renewable Electricity	Biomass	Hydro	Solar	Wind	Geo-thermal	Tide etc.	Renewable (%)
2000	15 522	2 950	164	2 700	1.52	31.4	52.0	0.55	19%
2005	18 381	3 412	226	3 019	4.50	104	58.3	0.52	19%
2010	21 571	4 337	360	3 532	33.8	341	68.1	0.51	20%
2015	24 372	5 689	517	3 993	260	839	80.5	1.01	23%
2016	25 082	6 119	571	4 170	339	958	81.7	1.03	24%
2017	25 717	6 461	596	4 197	454	1 127	85.3	1.04	25%

Unit: In TWh. (IEA, 2019)

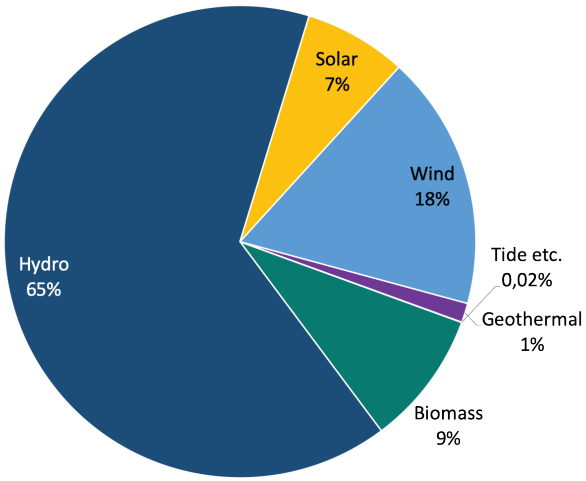

Figure 9 Electricity production from renewables in 2017

In 2017, Americas and Europe have more than 30% of their electricity mix from renewable energy sources while Asia has 20% of its electricity from renewable sources. Asia generates the most amount of renewable electricity at 2 622 TWh followed by Americas at 2 081 TWh – mainly due to extensive availability of hydropower (e.g. China and Brazil). Apart from hydropower, renewable electricity from solar, wind and biomass have similar contributions among all continents.

Table 8 Electricity generation from renewables in continents in 2017

	Total Electricity	Renewable Electricity	Biomass	Hydro	Solar	Wind	Geothermal	Tide etc.
Africa	805	141	1.94	120	4.21	10.3	4.20	0.00
Americas	6 560	2 081	159	1 458	83	352	28.6	0.02
Asia	12 879	2 622	213	1 762	235	381	31.7	0.49
Europe	5 158	1 529	218	809	123	367	12.3	0.53
Oceania	302	76	4.09	41.5	8.15	15	7.91	0.00
World	25 704	6 449	596	4 190	453	1 125	84.7	1.03

Unit: In TWh. (IEA, 2019)

1.3.3. RENEWABLE HEAT

Almost half of all energy consumption is in the form of heat – space heating for residential and commercial establishments, heating demand for industrial processes, heat for cooking etc. One of the most widely used renewable energy source for renewable heating is biomass in the form of woodfuel, charcoal, agriculture residues etc. Apart from biomass which has a 96% share in the renewable heat market globally, minimal contributions are from solar thermal (e.g. Concentrated Solar Power) and geothermal sources.

Table 9 Heat production from renewables

	Total	Biomass	Solar Thermal	Geothermal
2000	0.43	0.41	0.000	0.02
2005	0.55	0.53	0.000	0.02
2010	0.82	0.80	0.000	0.03
2015	1.00	0.96	0.001	0.03
2016	1.10	1.05	0.002	0.04
2017	1.12	1.08	0.002	0.04

Unit: In EJ. (IEA, 2019)

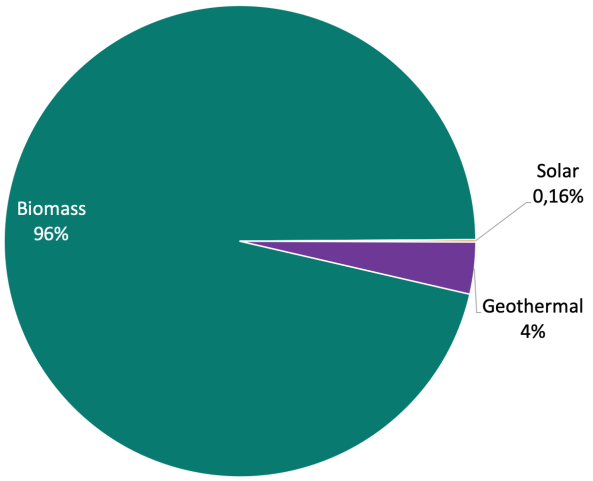

Figure 10 Heat production from renewables in 2017

One of the primary benefits of bioenergy is its availability in all regions. Biomass in the form of forest products and agriculture crops along with residues is available in almost every country around the world while municipal waste is available in every city. The use of local available resources for heating requirements (space heating, hot water etc.) provides much needed alternatives to imported fossil fuels. Among regions, most of the biomass used for heating in power plants, is in Europe. Europe accounts for 87% of all biomass used for renewable heating due to prevalence of district heating networks and policy focus on shifting towards renewable heating. Americas and Asia also have a minor share of renewable heating form biomass-based sources. Among other renewable heating sources, both geothermal and solar energy are concentrated in Europe.

Table 10 Heat production from renewables in continents in 2017

	Total	Biomass	Solar Thermal	Geothermal
Africa	0.00	0.00	0.000	0.00
Ameri-cas	0.06	0.06	0.000	0.00
Asia	0.08	0.08	0.000	0.00
Europe	0.98	0.94	0.002	0.04
Oceania	0.00	0.00	0.000	0.00
World	1.12	1.08	0.002	0.04

Unit: In EJ. (IEA, 2019)

1.3.4. DIRECT HEAT

Direct heating accounts for the use of renewables in end use sectors which are neither electricity, derived heat from power plants nor transport sector. These include direct use of renewable energy sources in residential and commercial sector – e.g. pellet stoves and boilers, rooftop solar thermal and local geothermal installations. Most of the direct use of renewables is for heating and cooking. Similar to the data on derived heat from power plants, biomass dominates the end use sector of direct heating.

In 2017, 40 EJ of biomass was consumed in end use sectors of residential, commercial, agriculture etc. for heating and cooking purposes which accounts for about 95% of renewable energy use in these sectors.

Table 11 Direct heating from renewable sources globally

	Total	Biomass	Solar Thermal	Geothermal
2000	37.9	37.6	0.21	0.16
2005	39.2	38.7	0.29	0.22
2010	41.0	40.1	0.64	0.27
2015	42.1	40.4	1.24	0.50
2016	42.4	40.6	1.28	0.54
2017	41.8	39.9	1.33	0.57

Unit: In EJ. (IEA, 2019)

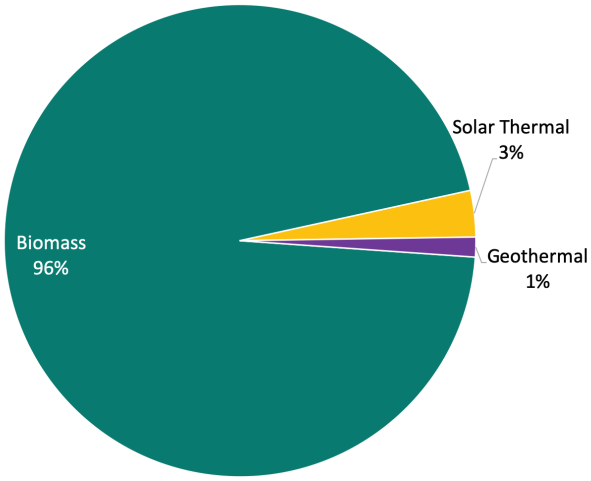

Figure 11 Direct heating from renewable sources in 2017

Among continents, role of non-biomass renewables including solar thermal and geothermal is dominated predominantly in Asia while biomass accounts for more htan 90% of the heating and cooking demand in end use sectors in all regions – highest being almost 100% in Africa.

Table 12 Direct heating from renewable sources in continents in 2017

	Total	Biomass	Solar Thermal	Geothermal
Africa	13.0	12.9	0.01	0.00
Americas	5.92	5.78	0.13	0.01
Asia	18.8	17.2	1.08	0.52
Europe	3.86	3.74	0.10	0.03
Oceania	0.23	0.21	0.02	0.01
World	41.7	39.8	1.33	0.57

Unit: In EJ. (IEA, 2019)

1.3.5. RENEWABLE TRANSPORT

Biomass-based fuels (bioethanol, biodiesel etc.) are a sustainable and renewable option for replacing fossil oil in the transport sector. The share of biofuels in the transport sector in 2017 was about 3% with a total contribution of 3.5 EJ. Rest of the renewable transport option was from electricity which contributed about 1.1% globally. Considering the fact that less than 1/3rd of the electricity sector is renewable, the contribution of renewable electricity is much less ± 0.3%.

Table 13 Energy use in transport sector (non fossil oil) globally

	Total Renewable	Biofuels	Renewable Electricity	Fossil Electricity
2000	1.19	0.42	0.15	0.63
2005	1.72	0.81	0.17	0.74
2010	3.40	2.35	0.21	0.84
2015	4.51	3.29	0.28	0.93
2016	4.72	3.43	0.31	0.97
2017	4.81	3.50	0.33	0.98

Unit: In EJ. (IEA, 2019)

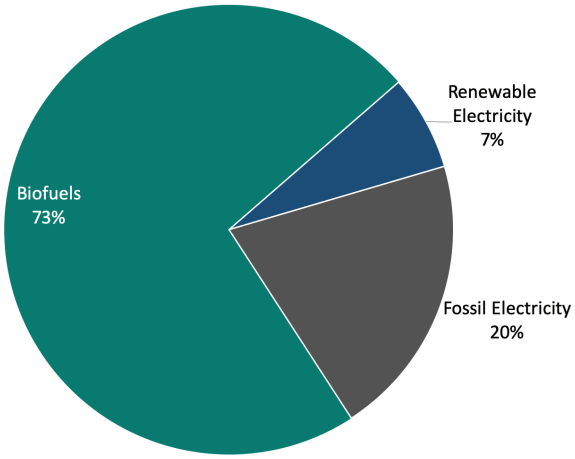

Figure 12 Energy use in transport sector (non fossil oil) globally

Most of the biofuels produced for renewable transport is in Americas due to the high production of bioethanol from corn (USA) and sugarcane (Brazil). The transport sector in Europe has also achieved decent levels of renewable share in transportation due to biofuel consumption.

Table 14 Energy use in transport sector (non fossil oil) in continents in 2017

	Total Renewable	Biofuels	Renewable Electricity	Fossil Electricity
Africa	0.02	0.00	0.00	0.02
Americas	2.55	2.48	0.02	0.05
Asia	0.94	0.34	0.12	0.47
Europe	1.25	0.67	0.17	0.41
Oceania	0.03	0.00	0.01	0.02
World	4.81	3.50	0.33	0.98

Unit: In EJ. (IEA, 2019)

2. SUPPLY

2.1 BIOMASS SUPPLY

Bioenergy is the largest renewable energy source and accounts for more than 2/3rd of the renewable energy supply. Typical classification of biomass sources includes municipal and industrial waste, primary solid biofuels, biogas and liquid biofuels.

In 2017, 55.6 EJ of biomass was utilized for energy purposes – 86% of the use was in the form of primary solid biofuels including wood chips, wood pellets, fuelwood for cooking and heating etc. 7% of the biomass was used as liquid biofuels. Biogas, municipal waste, industrial waste had almost equal share at 2 – 3%.

Compared to the previous year, the primary supply of biomass reduced by about 1 EJ – representing about 1.5% reduction since 2016. The year 2017 marked the first time the supply of biomass reduced over the previous year. The reduction in supply was primarily driven due to reduction in supply of primary solid biofuels while rest of the categories including waste, biogas and liquid biofuels increased.

Table 15 Domestic supply of biomass globally

	Biomass	Municipal Waste	Industrial Waste	Primary Solid Biofuels	Biogases	Liquid Biofuels
2000	42.8	0.74	0.49	40.4	0.28	0.86
2005	45.9	0.94	0.45	42.5	0.50	1.47
2010	51.2	1.16	0.77	45.1	0.84	3.32
2015	55.1	1.38	0.89	46.9	1.30	4.72
2016	56.5	1.43	1.03	49.2	1.31	3.56
2017	55.6	1.45	1.07	48.2	1.33	3.65

Unit: In EJ. (IEA, 2019)

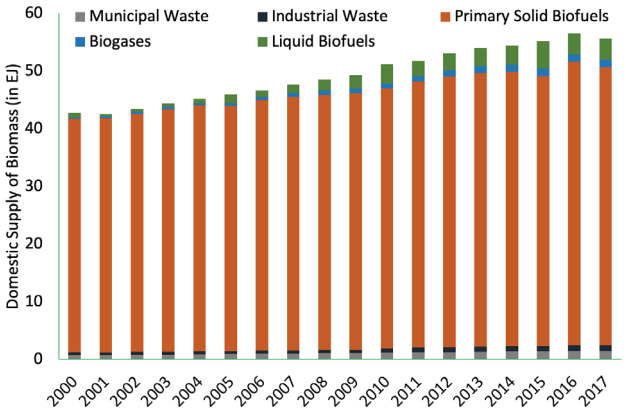

Figure 13 Domestic supply of biomass globally

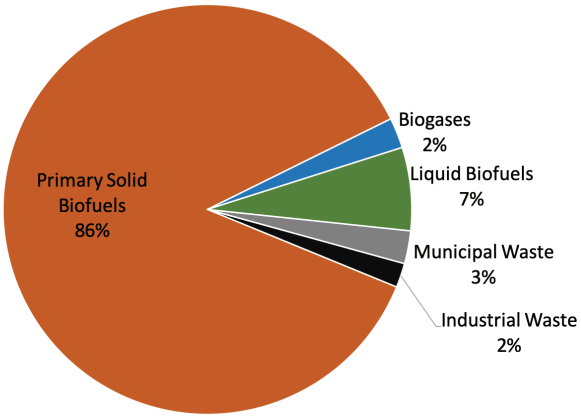

Figure 14 Domestic supply of biomass in 2017

Among continents, domestic supply of biomass is highest in Asia followed by Africa and Americas. Both Asia and Africa account for high share of biomass due to the extensive use of fuelwood and charcoal for heating and cooking purposes. For liquid biofuels, Americas (USA and Brazil) had the highest share due to high production of bioethanol from corn and sugarcane respectively. Together, the region accounts for more than 70% of the global biofuels supply. Europe leads the way in biogas supply as it accounts for more than 50% of the global supply. Due to extensive use of waste to energy technologies including incineration, gasification etc., Europe also leads the world in supply of municipal waste for bioenergy accounting for 2/3rd of the global supply.

Table 16 Domestic supply of biomass in continents in 2017

	Biomass	Municipal Waste	Industrial Waste	Primary Solid Biofuels	Biogases	Liquid Biofuels
Africa	15.4	0.00	0.00	15.4	0.00	0.00
Americas	10.8	0.30	0.05	7.70	0.19	2.57
Asia	21.6	0.20	0.61	20.1	0.41	0.35
Europe	7.52	0.95	0.40	4.73	0.71	0.73
Oceania	0.28	0.00	0.00	0.25	0.02	0.00
World	55.6	1.45	1.07	48.2	1.33	3.65

Unit: In EJ. (IEA, 2019)

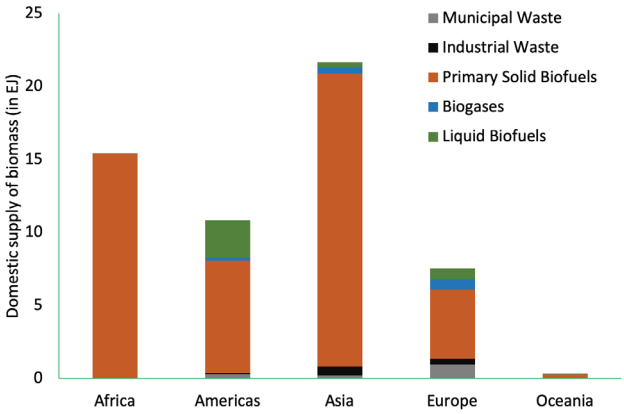

Figure 15 Domestic supply of biomass in continents in 2017

2.2 LAND

Land is one of the primary needs for biomass development for energy.

For agriculture land, the primary demand for bioenergy comes from the use of residues for biogas, dedicated biofuel crops (e.g. sugarcane, corn, soybean) for biofuel production and to a minimal extent, the growing of short rotation crops like poplar and willow for energy generation. The use of forest land and products includes the use of forestry industry residues from pulp and paper mills or sawmills to produce biomass based secondary products, e.g. wood chips and pellets for energy generation.

The total land area available globally is about 13 billion ha out of which agriculture land accounts for 37% (4.8 billion ha), forest land accounts for 31% (3.9 billion ha) and other land covers about 32% (4.2 billion ha). Agriculture land includes arable land (10%), land under permanent crops (1%) and land under permanent pastures and meadows (24%) while forest land comprises primary forests (10%), planted forests (2%) and other naturally regenerated forests (18%).

The use of land for biomass and bioenergy is a very small part compared to the use of land for food and feed purposes.

Table 17 Use of land area globally

	Land area	Arable land	Permanent crops	Permanent meadows and pastures	Primary Forest	Other naturally regenerated forest	Planted Forest	Other land
2000	12 998	1 359	134	3 423	1 299	2 533	224	4 041
2005	12 998	1 357	146	3 353	1 284	2 495	254	4 089
2010	12 996	1 348	158	3 293	1 288	2 450	277	4 174
2015	12 995	1 382	165	3 247	1 277	2 429	293	4 192
2016	13 003	1 386	167	3 239	1 277	2 429	293	4 192
2017	13 003	1 391	168	3 266	1 277	2 429	293	4 166

Unit: In million ha (FAOSTAT, 2019)

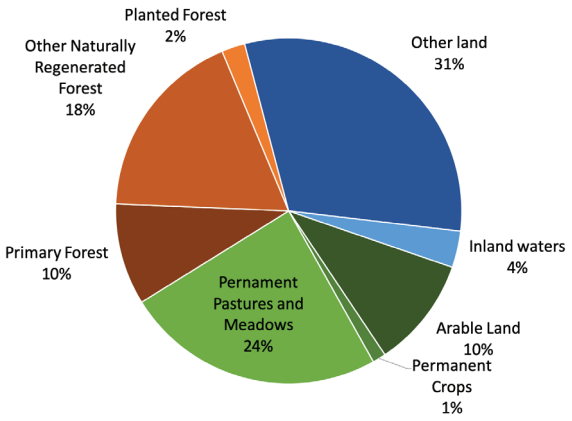

Figure 16 Use of land area globally in 2017

2.3 AGRICULTURE

2.3.1. AGRICULTURE LAND

Agriculture land is usually classified as arable land, land used for permanent crops and land used for permanent pastures and meadows. In 2017, 4.9 billion ha of land was used for agriculture purposes which accounts for slightly more than 1/3rd of the total land area available. Most of the agriculture land use is in the form of land under permanent pastures and meadows which accounts for almost 70% and the use is mainly for cattle. The land under arable land is about 30% while land under permanent crops is less than 4% globally. The trend has been the same over the past 17 years.

Table 18 Agriculture land area globally

	Agriculture Land	Arable Land	Permanent Crops	Permanent pastures and meadows
2000	4 915	1 359	134	3 423
2005	4 856	1 357	146	3 353
2010	4 799	1 348	158	3 293
2015	4 798	1 382	165	3 247
2016	4 795	1 386	167	3 239
2017	4 828	1 391	168	3 266

Unit: In million ha. (FAOSTAT, 2019)

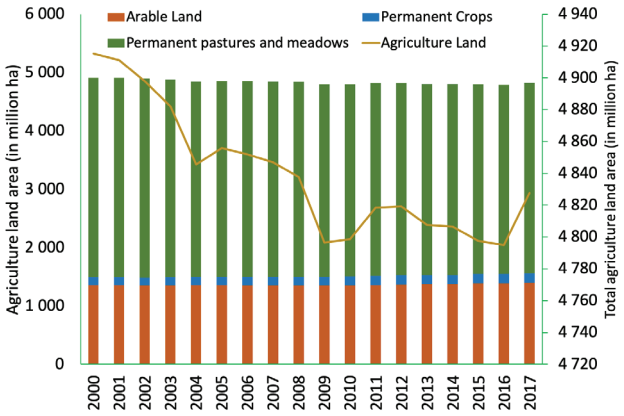

Figure 17 Agriculture land area globally

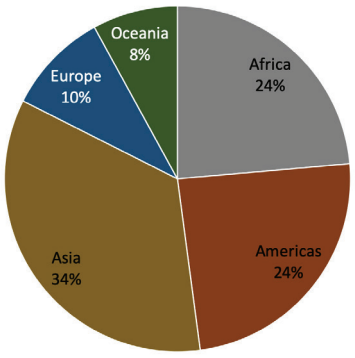

Figure 18 Agriculture land area globally in 2017

Most of the arable land (36%), land under permanent crops (54%) and land under permanent meadows and pastures (33%) is available in Asia. Arable land is typically land in use for temporary crops, temporary meadows or pasture, fallow land etc. Abandoned land is not considered in this category. The most noticeable change compared to 2000 has been the increase in land for use as permanent crops (+ 28 million ha) and a reduction in land use for permanent pastures and meadows (- 37 million ha) in Asia. Rest of the regions have shown negligible change in each category.

Table 19 Agriculture area use in continents in 2000 and 2017

	Agriculture Area		Arable Land		Permanent Crops		Permanent pastures and meadows	
	2000	2017	2000	2017	2000	2017	2000	2017
Africa	1 123	1 140	202	241	28.0	35.3	893	861
Americas	1 157	1 173	345	347	24.7	25.3	788	801
Asia	1 677	1 668	498	498	62.9	90.6	1 116	1 079
Europe	485	463	288	273	16.7	15.2	180	174
Oceania	473	385	25.4	31.9	1.37	1.53	446	351
World	4 915	4 828	1 359	1 391	134	168	3 423	3 266

Unit: In million ha. (FAOSTAT, 2019)

2.3.2 CROPS

The agriculture sector accounted for less than 10% of the overall supply of biomass for bioenergy globally. The main source for energy from agriculture land is in the form of crops for biofuels and residues for biogas as well as use in the form of heating and cooking. A comparison of the area harvested for some of the major crops shows remarkable change in the crop patterns. In terms of area harvested, cereal food crops such as maize, rice and wheat together account for more than 580 million ha of land use and together account for more than 80% of the area harvested for major crops. Crops which show a tremendous growth in area harvested include maize (45%), soybean (66%) and cassava (55%). It is important to note that the use of crops for biofuels is a very small share of the overall use of crops for food production.

A major indication of the significant development in agriculture practices is visible in the increasing yield of crops around the world. Most of the major crops including cereals, oil crops and sugar crops have shown double digit growth in yield globally while at the same time, the area harvested for these crops has not shown similar growth. Some crops such as sugarbeet, barley, sorghum etc. have reduced area harvested while at the same time increasing yields. Globally, more food is produced efficiently from the same area of land than before.

In terms of actual production, major crops such as maize, rice and wheat dominate the crop production globally due to their increasing use in Americas (maize) and Asia (rice and wheat). Although a minor share of maize is used for biofuel production, the potential for energy from crops such as rice and wheat lie in their efficient use of residues such as husk and straw which are currently unutilized and sometimes cause environmental concerns. Among oil crops, both soybean and rapeseed production has almost doubled globally – mainly due to the extensive production of soybean in South America (Americas account for 90% of the soybean production globally) and of rapeseed in Americas, Asia and Europe.

Table 20 Area harvested globally of major crops in 2017

	World	Africa	Americas	Asia	Europe	Oceania
Maize	197	40.6	71.6	67.4	17.5	0.09
Rice	167	15.0	6.02	146	0.64	0.09
Wheat	219	10.4	33.6	100	62.0	12.2
Barley	47.0	4.96	4.70	9.48	23.0	4.88
Millet	31.2	19.5	0.17	11.2	0.34	0.04
Oats	10.2	0.19	2.34	0.72	5.91	1.03
Rye	4.48	0.05	0.27	0.54	3.58	0.04
Sorghum	40.7	27.1	5.40	7.51	0.30	0.37
Olives	10.8	3.52	0.13	1.90	5.20	0.05
Rapeseed	34.7	0.13	9.51	13.6	8.85	2.68
Soybeans	124	2.27	96.2	19.3	5.69	0.03
Sunflower	26.5	2.12	2.64	3.58	18.2	0.03
Cassava	26.3	20.2	2.18	3.91	0.02	0.00
Sugar Beet	4.89	0.30	0.48	0.78	3.34	0.00
Sugarcane	26.0	1.59	13.9	10.0	-	0.50

Unit: In million ha. (FAOSTAT, 2019)

Table 21 Crop yields globally in 2017

	World	Africa	Americas	Asia	Europe	Oceania
Maize	5.75	2.07	8.07	5.37	6.30	7.03
Rice	4.60	2.44	5.92	4.76	6.30	9.38
Wheat	3.53	2.60	3.18	3.34	4.36	2.63
Barley	3.14	1.33	3.57	2.23	3.87	2.83
Millet	0.91	0.66	2.02	1.32	1.49	1.01
Oats	2.55	1.12	2.88	2.58	2.51	2.23
Rye	3.06	1.88	2.36	3.27	3.13	0.75
Sorghum	1.42	1.00	3.72	1.11	3.19	2.71
Olives	1.93	1.06	4.35	1.86	2.48	2.35
Rapeseed	2.19	1.32	2.44	1.64	2.97	1.61
Soybeans	2.85	1.38	3.24	1.37	1.88	2.15
Sunflower	1.80	1.12	1.85	1.73	1.89	1.33
Cassava	11.1	8.79	12.9	21.9	-	11.9
Sugar Beet	61.5	53.8	72.0	55.2	62.2	-
Sugarcane	70.9	58.0	73.9	68.4	74.3	77.1

Unit: In tons/ha (FAOSTAT, 2019)

Table 22 Production quantity of crops globally in 2017

	World	Africa	Americas	Asia	Europe	Oceania
Maize	1135	84.2	578	362	110	0.64
Rice	770	36.6	35.6	693	4.05	0.82
Wheat	772	27.2	107	335	270	32.2
Barley	147	6.61	16.8	21.2	89.1	13.8
Millet	28.5	12.9	0.34	14.7	0.51	0.04
Oats	25.9	0.21	6.74	1.86	14.8	2.30
Rye	13.7	0.10	0.64	1.76	11.2	0.03
Sorghum	57.6	27.2	20.1	8.37	0.94	1.00
Olives	20.9	3.74	0.58	3.53	12.9	0.12
Rapeseed	76.2	0.17	23.2	22.2	26.3	4.32
Soybeans	353	3.13	312	26.5	10.7	0.06
Sunflower	47.9	2.38	4.87	6.20	34.4	0.04
Oil Palm	-	-	-	-	-	-
Cassava	292	178	28.0	85.8	-	0.24
Sugar Beet	301	15.9	34.4	42.8	208	-
Sugarcane	1842	92.1	1025	686	0.01	38.2

Unit: In million tonnes. (FAOSTAT, 2019)

2.3.3 RESIDUES POTENTIAL

One of the most promising sectors for growth in bioenergy production is in the form of residues from agriculture sector. Currently, the sector contributes less than 3% to the total bioenergy production. However, due to the increasing demand for replacing fossil fuels in power plants for heat and electricity with sustainable, renewable and dispatchable energy sources, agriculture residues such as straw and husk can form a major share of the bioenergy generation. Apart from replacing fossil fuels and reducing emissions, agriculture residues also solve the environmental challenge which occurs due to the annual burning of harvest residues in major countries such as India and China.

Considering the fact that 50% of the residues have to be left on the field for soil quality purposes, the theoretical potential for utilizing agricultural residues is enormous. Data shows that utilizing the residues from all major crops for energy can generate approx. 4.3 billion tonnes (low estimate) to 9.4 billion tonnes (high estimate) annually around the world. Utilizing standard energy conversion factors for residues by conservative moisture content and energy content of the fuels, the theoretical energy potential from residues can be in the range of 17.8 EJ to 82.3 EJ. The major contribution would be from cereals – mainly maize, rice and wheat.

In comparison, the domestic supply of biomass for energy in 2017 was about 55.6 EJ. The total energy supply of all energy sources including fossil fuels was about 585 EJ. In other words, energy generation from agricultural residues could meet about 3 – 14% of the total energy supply globally. It is important to note that the sustainable potential including economic, social and environmental factors would be considerably less than theoretical potential. Even considering all sustainable factors, agriculture residues have great potential to be a part of the future energy mix.

Table 23 Theoretical potential of agricultural residues globally

	Residues (Million tonnes)		Residues (EJ)	
Crops	Low	High	Low	High
Maize	1 532	4 540	5.67	35.7
Rice	770	2 041	3.29	15.2
Wheat	618	1 235	2.98	8.92
Barley	118	192	0.57	1.09
Millet	31.3	56.9	0.16	0.3
Oats	23.4	36.3	0.12	0.19
Rye	12.4	22	0.07	0.12
Sorghum	51.8	426	0.27	2.24
Olives	4.7	4.7	0.03	0.03
Rapeseed	107	152	0.78	1.11
Soybeans	353	1 389	1.86	7.31
Sunflower	105	153	0.71	1.03
Oil palm	110	140	0.15	0.67
Cassava	46.7	292	0.35	2.17
Sugarbeet	60.2	120	0.12	0.25
Sugarcane	368	1 216	0.65	6.01
Total	3 942	10 801	17.1	76.3

(FAOSTAT, 2019) (WBA 2019)

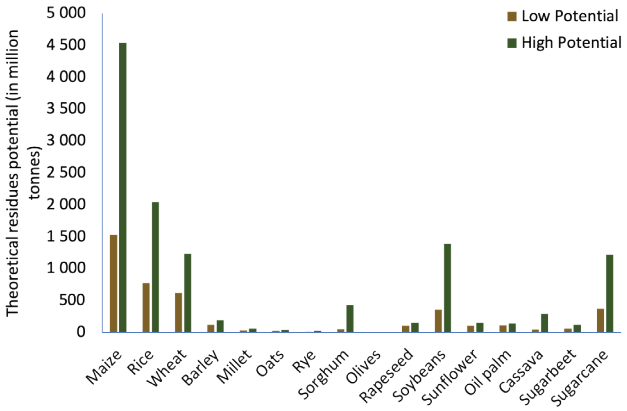

Figure 19 Theoretical potential of agricultural residues globally

2.4 FOREST

The forestry sector is the largest contributor to the bioenergy mix globally. Forestry products including charcoal, fuelwood, pellets and wood chips account for more than 85% of all the biomass used for energy purposes. Most of the use of forestry products is in the form of residues from pulp, paper and sawmill industries while a significant portion is also the use of fuelwood for cooking in heating purposes in Africa and Asia – so called traditional biomass.

2.4.1. FOREST LAND

Globally, 3.99 billion ha of land is classified as forest land. Most of the forest land is in the form of other naturally regenerated forest (61%) while primary forest accounted for 1/3rd of all forest land. Recently planted forests have been increasing leading to an increasing forest land globally although they account for a minor share (7%).

Globally, forest land has been decreasing since 2000. The decrease in forest area is noticeable in Africa (- 7.7%) followed by Americas (- 3.1%) while the decrease has been compensated noticeably due to increasing forest land in Asia (+5.1%) and Europe (+ 1.4%).

Table 24 Forest land area globally

	Forest land	Primary Forest	Other Naturally Regenerated Forest	Planted Forest
2000	4 056	1 299	2 533	224
2005	4 033	1 284	2 495	254
2010	4 016	1 288	2 450	277
2015	3 999	1 277	2 429	293
2016	3 996	-	-	-
2017	3 993	-	-	-

Unit: In million ha. (FAOSTAT, 2019)

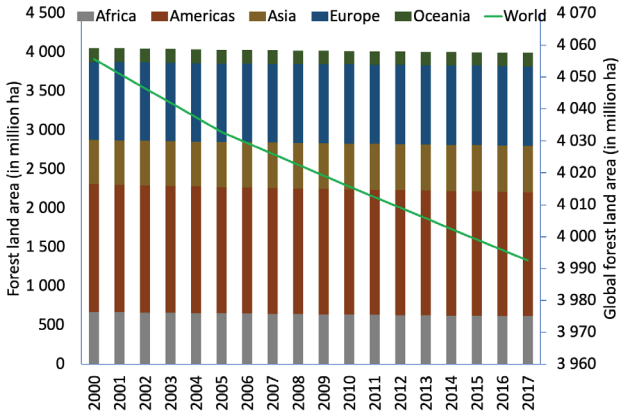

Figure 20 Forest land area globally

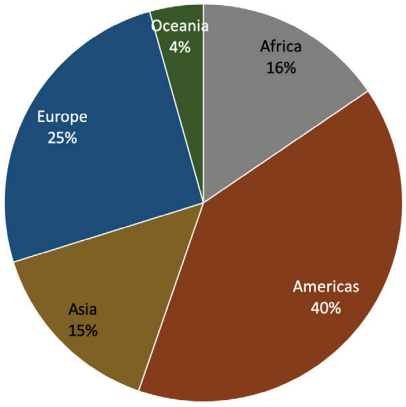

Figure 21 Forest land area in continents in 2017

Among continents, majority of the forest land occurs in Americas (40%) followed by Europe (25%) and equal share in Africa (15%) and Asia (15%). This is due to the enormous area of primary forest in the Amazon in South America which accounts for almost half of all primary forests globally. These primary forests are naturally regenerated forests of native species with no visible indications of human intervention.

Due to significant afforestation efforts in major economies like India and China, the global planted forest area has increased by more than 30% during 2000 – 2017 even though planted forests account for a minor share of the overall forest land. Asian continent accounts for 45% of all the planted forests globally. Planted forests include those forests where the trees are predominantly of introduced species and mainly due to human intervention.

Americas also account for the highest share of other naturally regenerated forests (34%) globally which are tree species that are predominantly non-native and do not require human intervention to reproduce/maintain population over time.

Table 25 Primary forest, other naturally regenerated forest and planted forest

	Forest Land		Primary Forest		Other Naturally regenerated forest		Planted forest	
	2000	2017	2000	2017	2000	2017	2000	2017
Africa	670	618	145	135	513	473	12.8	16.3
Americas	1 639	1 589	736	720	860	814	43.0	58.3
Asia	566	595	120	117	354	347	91.7	129
Europe	1 002	1 016	263	278	666	652	73.3	85.5
Oceania	178	174	35.3	26.9	139	142	3.48	4.38
World	4 056	3 993	1 299	1 277	2 533	2 429	224	293

Unit: In million ha. (FAOSTAT, 2019)

2.4.2. FOREST PRODUCTS – WOODFUEL

One of the primary products from forests that are used for bioenergy production is woodfuel. Most of the woodfuel is used for traditional cooking and heating in developing countries in Asia and Africa. Globally, 1.9 billion m^3 of woodfuel was used for energy purposes – e.g. fuelwood and charcoal production. The volumes include wood removed from felling of forests or from trees killed or damaged by natural causes. It is important to note that woodfuel does not include the use of wood residues from industrial processing of roundwood which forms a major share of bioenergy in Europe.

Among continents, both Asia and Africa together account for 3/4th of all woodfuel production globally. The share has remained constant since the past 17 years.

Table 26 Woodfuel production

	World	Africa	Americas	Asia	Europe	Oceania
2000	1 789	551	314	808	103	12.7
2005	1 813	600	300	792	111	11.5
2010	1 845	643	290	764	136	10.7
2015	1 889	679	307	735	157	10.0
2016	1 903	686	321	730	156	9.93
2017	1 920	693	322	725	170	10.0
2018	1 929	693	329	725	173	10.0

Unit: In million m^3. (FAOSTAT, 2019)

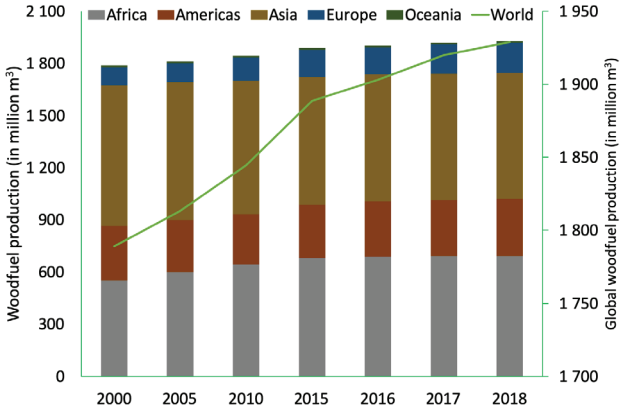

Figure 22 Woodfuel production globally

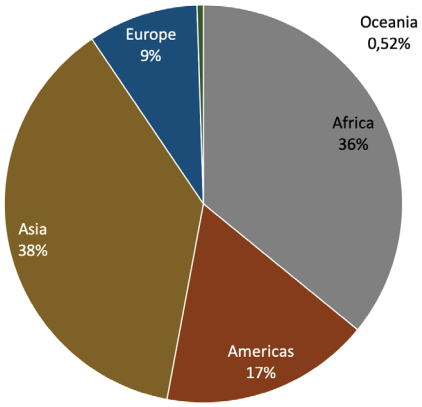

Figure 23 Woodfuel production in continents in 2018

2.5 WASTE

The third and final category for bioenergy supply is municipal and industrial waste utilized for energy predominantly in urban areas. The technologies in use include gasification and combustion of biogenic fraction of the waste to produce steam to generate turbines and produce electricity and heat for domestic and commercial purposes.

Municipal waste basically comprises of products combusted directly from households, industries etc. in power plants for generating heat and/or power while industrial waste is typically of non-renewable origin and consists of solid and liquid products (e.g. rubber tyres) that are combusted in specialized plants for heat and/or power. It is a challenge to identify and categorize the renewable and biogenic part of both municipal and industrial waste and hence, all waste used for energy is presented here.

Table 27 Domestic supply of municipal and industrial waste

	Total	Municipal Waste	Industrial Waste
2000	1.23	0.74	0.49
2005	1.39	0.94	0.45
2010	1.94	1.16	0.77
2015	2.27	1.38	0.89
2016	2.46	1.43	1.03
2017	2.51	1.45	1.07

Unit: In EJ. (IEA, 2019)

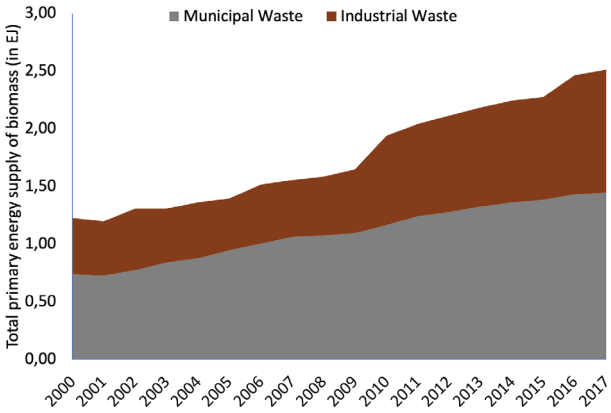

Figure 24 Domestic supply of municipal and industrial waste globally

In 2017, domestic supply of waste to bioenergy was 2.51 EJ – 58% was in in the form of municipal waste while the remaining was industrial waste to energy. Due to the availability of commercial technology, Europe leads the way in the utilization of waste to energy. In 2017, more than half of the domestic supply of waste is in Europe while 30% is in Asia.

Table 28 Domestic supply of municipal and industrial waste in continents in 2017

	Total	Municipal Waste	Industrial Waste
Africa	0.00	0.00	0.00
Americas	0.35	0.30	0.05
Asia	0.80	0.20	0.61
Europe	1.35	0.95	0.40
Oceania	0.00	0.00	0.00
World	2.51	1.45	1.07

Unit: In EJ. (IEA, 2019)

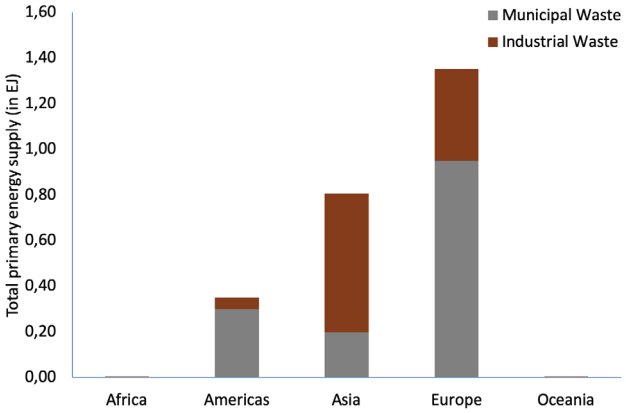

Figure 25 Domestic supply of waste in continents in 2017

3. BIOMASS TO ELECTRICITY

Biopower or electricity generation from biomass is a sustainable and renewable option for reducing fossil fuel demand in the electricity sector. Unlike other renewable sources, biomass offers the added benefit of being dispatchable and ease of storage in the form of pellets and chips etc.

In 2017, 596 TWh of biopower was produced globally which is an increase of 25 TWh (+ 4%) over the previous year. During 2000 – 2017, the production of biopower increased by 3.6 times. 65% of the biopower generation was from primary solid biofuels including wood chips, wood pellets etc. in large scale electricity only and combined heat/power plants. Municipal and industrial waste accounted for 19% while biogas had a share of 14%. Liquid biofuels form a minor part of biopower generation and are well suited to meet the transport sector needs instead.

Table 29 Biopower generation globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
2000	164	34.3	15.3	102	13.1	0.00
2005	226	46.2	11.7	145	21.0	1.98
2010	360	62.4	20.4	226	46.4	5.07
2015	517	72.8	30.2	324	82.7	7.62
2016	571	71.9	36.5	369	84.7	8.07
2017	596	74.1	40.0	389	86.3	6.68

Unit: In TWh. (IEA, 2019)

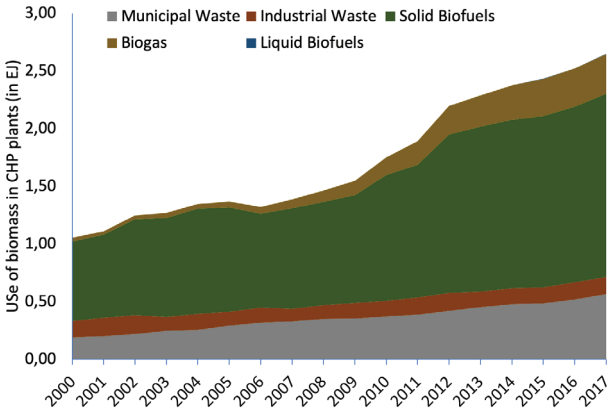

Figure 26 Biopower generation globally

Both Asia and Europe are the largest producers of biomass power in the world. 212 TWh and 218 TWh of biopower was generated in Asia and Europe respectively. Most of the biopower generation was in the form of solid biofuels like pellets, woodchips etc. Among waste to bio-power, Europe produces the most biopower from municipal waste (63%) and almost 3/4th of the world's biopower production from liquid biofuels and biogas occurs in Europe.

Table 30 Biopower generation in continents in 2017

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
Africa	1.80	0.00	0.00	1.78	0.02	0.00
Americas	159	16.3	1.92	125	16.1	0.22
Asia	212	10.6	31.8	164	4.68	1.47
Europe	218	47.0	6.23	95.3	64.1	4.99
Oceania	4.17	0.09	0.00	2.63	1.45	0.00
World	596	74.1	40.0	389	86.3	6.68

Unit: In TWh. (IEA, 2019)

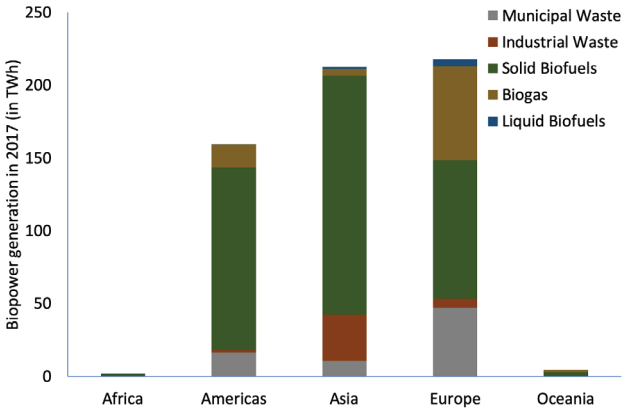

Figure 27 Biopower generation in continents in 2017

3.1 ELECTRICITY ONLY PLANTS

Biopower can be produced either in electricity only plants or from combined heat and power plants which simultaneously produce electricity and heat. In electricity only plants, 5.15 EJ of biomass was used for electricity production which translates to approx. 429 TWh. Exact amount of biopower produced from electricity only plants is challenging to identify due to varying degrees of efficiency of producing electricity.

Table 31 Use of biomass in electricity only plants

	Total electricity generation*	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
2000	90.3	1.08	0.38	0.06	0.52	0.12	0.000
2005	141	1.69	0.51	0.03	0.97	0.19	0.000
2010	235	2.82	0.62	0.18	1.73	0.29	0.001
2015	343	4.11	0.68	0.28	2.70	0.45	0.001
2016	418	5.01	0.67	0.34	3.54	0.45	0.001
2017	429	5.15	0.64	0.38	3.68	0.44	0.001

Unit: In EJ (* in TWh). Approximate electric conversion factor of 30% for electricity only plants. (IEA, 2019)

Asia is the world's leader in producing biopower in electricity only plants. 64% of all biomass used globally for biopower generation in electricity only plants is in Asia while Europe and Americas account for minor share – 18%. However, the efficiency of conversion of biomass in such plants is quite low and it would be worthwhile to invest in combined heat and power plants to generate more energy from a unit of biomass used.

Table 32 Use of biomass in electricity only plants in continents in 2017

	Total electricity generation*	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
Africa	2.27	0.03	0.00	0.00	0.03	0.00	0.000
Americas	76.5	0.92	0.24	0.01	0.50	0.16	0.000
Asia	276	3.31	0.14	0.35	2.76	0.05	0.001
Europe	72.7	0.87	0.25	0.02	0.38	0.22	0.001
Oceania	1.65	0.02	0.00	0.00	0.01	0.01	0.000
World	429	5.15	0.64	0.38	3.68	0.44	0.001

Unit: In EJ (* in TWh). Approximate electric conversion factor of 30% for electricity only plants. (IEA, 2019)

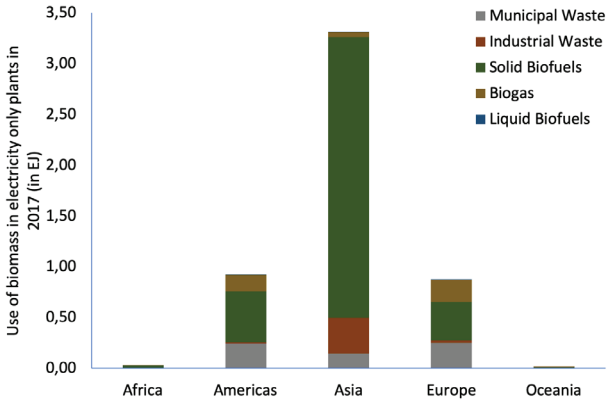

Figure 28 Use of biomass in electricity only plants in continents in 2017

3.2 CHP PLANTS

Another form of producing biopower is in combined heat and power plants. Biomass fed into such plants is combusted to produce heat which converts water to steam to drive a turbine to generate electricity. Using CHP technology is one of the most efficient modes of converting biomass to energy. In 2017, 2.65 EJ of biomass was used in CHP plants to produce heat and steam which in comparison is about half of all biomass used for electricity only plants.

Table 33 Use of biomass in CHP plants

	Total Electricity generation *	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
2000	70.3	1.05	0.19	0.14	0.69	0.03	0.000
2005	91.3	1.37	0.29	0.12	0.91	0.05	0.000
2010	117	1.75	0.37	0.14	1.09	0.15	0.001
2015	162	2.43	0.49	0.14	1.48	0.32	0.001
2016	168	2.52	0.52	0.15	1.52	0.33	0.001
2017	177	2.65	0.57	0.15	1.59	0.35	0.001

Unit: In EJ (*in TWh) Approximate electric conversion factor of 24% CHP plants. (IEA, 2019)

Most of the use of biomass in CHP plants is in the form of solid biofuels and Europe is the world leader in biomass CHP technology. 63% of all biomass used in CHP facilities is in Europe followed by 35% in Americas.

Table 34 Use of biomass in CHP plants in continents

	Total Electricity generation *	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
Africa	0.83	0.01	0.00	0.00	0.01	0.00	0.000
Americas	60.2	0.90	0.03	0.01	0.84	0.02	0.000
Asia	2.20	0.03	0.00	0.01	0.01	0.01	0.000
Europe	111	1.66	0.53	0.12	0.70	0.31	0.000
Oceania	2.35	0.04	0.00	0.00	0.03	0.00	0.000
World	177	2.65	0.57	0.15	1.59	0.35	0.001

Unit: In EJ (* in TWh). Approximate electric conversion factor of 24% CHP plants (IEA, 2019)

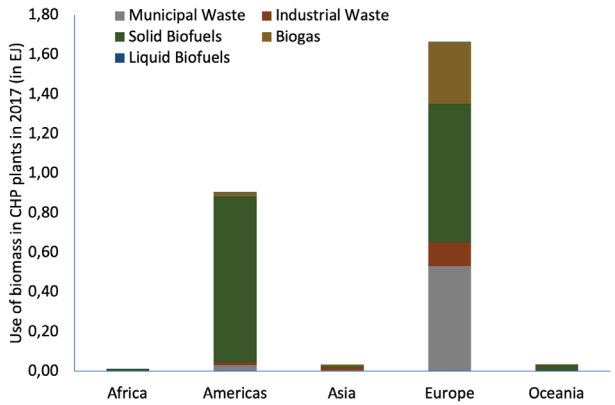

Figure 29 Use of biomass in CHP plants in continents in 2017

4. BIOMASS TO HEAT

Almost half of all the energy use in end sectors is in the form of heating. Heating covers space heating and hot water demands for residential, industrial and commercial establishments around the world. The world has made considerable progress in decarbonizing the electricity sector while the heating sector is lagging way behind – although its performance is slightly better than the transport sector.

The options for heating sector are quite limited. Geothermal and solar thermal are some of the options for reducing fossil fuel use in the heating sector, but biomass heating is one of the most important renewable energy options for heating.

4.1 DERIVED HEAT

Bioheat is heat from biomass or bio-based feedstock. In 2017, 1.08 EJ of bioheat was generated globally which is an increase of about 0.03 EJ over the previous year. Solid biofuels such as wood pellets and wood chips contributed almost half to the bioheat sector followed by waste (including both municipal and industrial) and minor contributions from biogas and liquid biofuels.

Table 35 Bioheat generation globally

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
2000	0.41	0.13	0.07	0.21	0.00	0.000
2005	0.53	0.15	0.08	0.28	0.01	0.004
2010	0.80	0.22	0.13	0.43	0.01	0.010
2015	0.96	0.28	0.14	0.50	0.03	0.004
2016	1.05	0.29	0.17	0.55	0.04	0.005
2017	1.08	0.29	0.16	0.58	0.04	0.004

Unit: In EJ. (IEA, 2019)

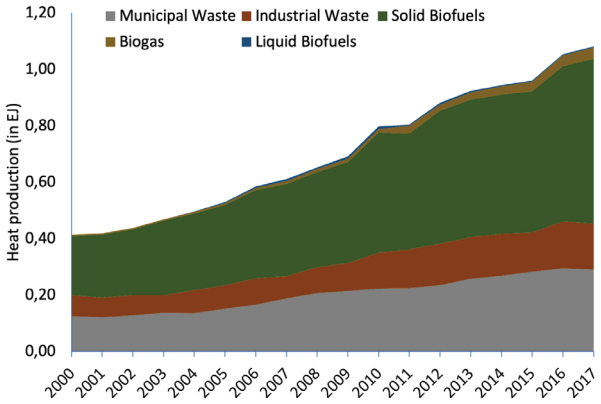

Figure 30 Bioheat generation globally

Among continents, Europe is the world leader in using biomass for heat in industrial power plants – e.g. heat only plants and combined heat and power plants. It is important to note that the data here depicts bioheat generated in power plants. Hence, Europe leads while Asia has minor contribution in this sector even though the latter uses most of the biomass for heating in residential sectors directly as direct heat. 87% of the biomass heat generated globally is in Europe – mainly due to extensive use of all biomass feedstock including municipal waste, solid biofuels and industrial waste.

Table 36 Bioheat generation in continents in 2017

	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
Africa	0.00	0.00	0.00	0.00	0.000	0.000
Americas	0.06	0.02	0.01	0.03	0.005	0.000
Asia	0.08	0.01	0.05	0.02	0.003	0.000
Europe	0.94	0.26	0.11	0.53	0.032	0.004
Oceania	0.00	0.00	0.00	0.00	0.000	0.000
World	1.08	0.29	0.16	0.58	0.04	0.004

Unit: In EJ. (IEA, 2019)

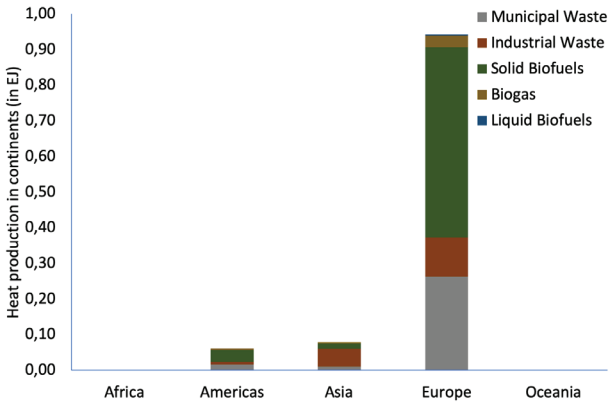

Figure 31 Bioheat generation in continents in 2017

4.2 HEAT ONLY PLANTS

Derived heat from biomass is generated either via heat only plants or via combined heat and power plants. In heat only plants, only bioheat is generated without any additional electricity.

Table 37 Use of biomass in heat only plants

	Total heat production	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
2000	0.15	0.24	0.05	0.04	0.15	0.00	0.000
2005	0.19	0.31	0.07	0.05	0.19	0.00	0.000
2010	0.28	0.46	0.12	0.10	0.24	0.01	0.000
2015	0.30	0.50	0.11	0.12	0.26	0.01	0.000
2016	0.33	0.55	0.10	0.13	0.30	0.01	0.000
2017	0.32	0.53	0.09	0.12	0.32	0.01	0.000

Unit: In EJ. (IEA, 2019) Approximate heat conversion factor of 60% for heat only plants.

In heat only facilities, 0.53 EJ of biomass was used to produce bioheat in 2017. However, for the first time in recent history, the use of biomass for bioheat in heat only plants reduced year on year basis after reaching a high of 0.55 EJ in 2016. In 2017, 0.44 EJ of biomass was used for bioheat in heat plants in Europe – accounting for 84% of all biomass globally.

Table 38 Use of biomass in heat only plants in continents in 2017

	Total heat production	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.000
Americas	0.00	0.01	0.00	0.00	0.00	0.00	0.000
Asia	0.05	0.08	0.01	0.05	0.02	0.00	0.000
Europe	0.27	0.44	0.07	0.07	0.30	0.01	0.000
Oceania	0.00	0.00	0.00	0.00	0.00	0.00	0.000
World	0.32	0.53	0.09	0.12	0.32	0.01	0.000

Unit: In EJ (IEA, 2019) Unit: In EJ. Approximate heat conversion factor of 60% for heat only plants

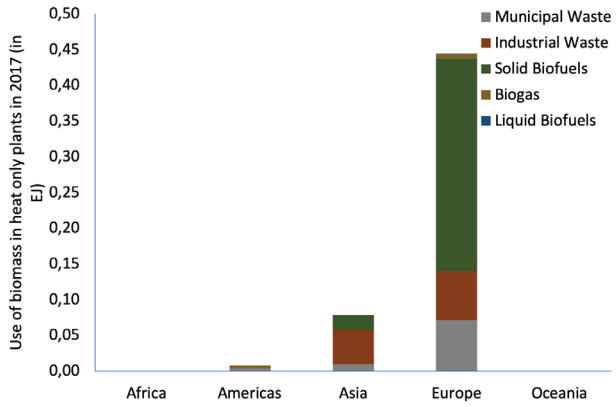

Figure 32 Use of biomass in heat only plants in continents in 2017

4.3 CHP PLANTS

In CHP facilities, the heat from the steam after driving the turbine, is used to heat district heating networks which then supply heating to residential and commercial establishments in the form of space heating and hot water. CHP facilities are one of the most efficient conversion systems with very high efficiencies. In CHP facilities, utilizing an average conversion factor of 40%, approx. 1.06 EJ of biomass heating was generated in CHP plants worldwide in 2017.

Table 39 Use of biomass in CHP plants

	Total heat generation	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
2000	0.42	1.05	0.19	0.14	0.69	0.03	0.000
2005	0.55	1.37	0.29	0.12	0.91	0.05	0.000
2010	0.70	1.75	0.37	0.14	1.09	0.15	0.001
2015	0.97	2.43	0.49	0.14	1.48	0.32	0.001
2016	1.01	2.52	0.52	0.15	1.52	0.33	0.001
2017	1.06	2.65	0.57	0.15	1.59	0.35	0.001

Unit: In EJ. (IEA, 2019). Unit: In EJ. Approximate heat conversion factor of 40% for CHP plants

Most of the heat from combined heat and power plants was produced in Europe – about 0.67 EJ followed by 0.36 EJ in Americas with low amount of bioheat produced in rest of the world.

Table 40 Use of biomass in CHP plants in continents in 2017

	Total heat generation	Total use of biomass	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
Africa	0.00	0.01	0.00	0.00	0.01	0.00	0.000
Americas	0.36	0.90	0.03	0.01	0.84	0.02	0.000
Asia	0.01	0.03	0.00	0.01	0.01	0.01	0.000
Europe	0.67	1.66	0.53	0.12	0.70	0.31	0.000
Oceania	0.01	0.04	0.00	0.00	0.03	0.00	0.000
World	1.06	2.65	0.57	0.15	1.59	0.35	0.001

Unit: In EJ. (IEA, 2019) Approximate heat conversion factor of 40% for CHP plants

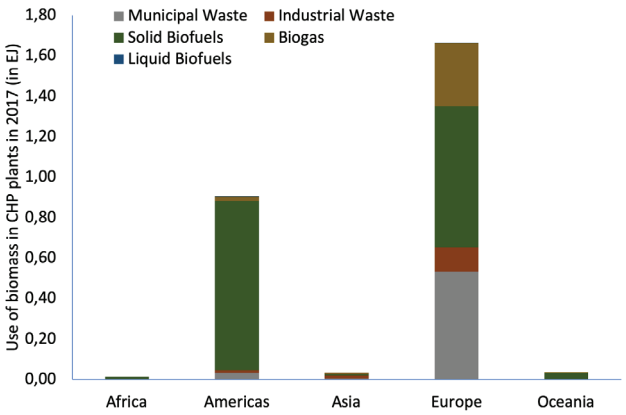

Figure 33 Use of biomass in CHP plants in continents in 2017

5. BIOMASS TO LIQUID BIOFUELS

Liquid biofuels for transport are part of important strategies to improve fuel security, mitigate climate change and support rural development.

Liquid biofuels can be produced from a huge range of organic materials through a variety of technological production pathways, resulting in a number of different fuels, each with different properties. Feedstock include cereals, sugars, oil crops and residues along with municipal waste.

Biofuel production not only delivers ethanol and biodiesel but also protein feed, with the quantities of these both being produced on a similar scale. Other biofuels based on cellulosic feedstocks, various waste streams and algae have a large potential in the future. However, some of these are in early commercial phase in the market at present but most of these new technologies remain in a precommercial phase.

In 2017, 138 billion litres of biofuels were produced including bioethanol, biodiesel, HVO (Hydrogenated Vegetable Oil) etc. Bioethanol produced from sugar crops (sugarcane, corn) accounted for 62% of the global biofuel production. USA and Brazil continue to dominate bioethanol production and the region accounted for 87% of the global production with Europe and Asia accounting for 6 – 7% each.

Table 41 Liquid biofuels production globally

	Total	Bioethanol	Biodiesel	Other Biofuels
2000	18.0	13.2	0.84	3.92
2005	38.4	26.7	3.66	8.09
2010	106	66.5	19.9	19.7
2015	128	79.4	30.0	19.0
2016	134	82.7	33.9	17.3
2017	138	85.1	36.1	16.4

Unit: In Billion litres. (IEA, 2019)

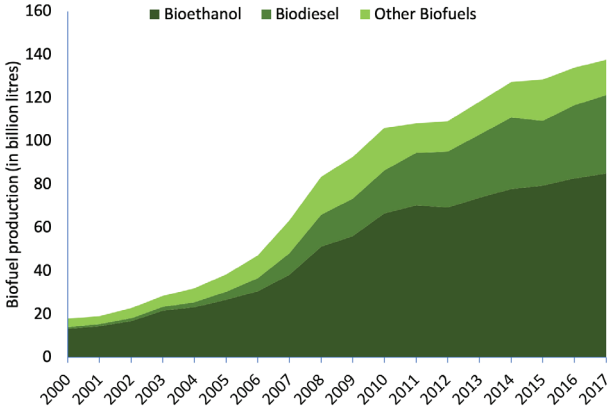

Figure 34 Liquid biofuels production globally

Biodiesel is produced from oil crops (e.g. rapeseed, soybean) by transesterification and can be blended with diesel. South America and Europe have a share in the global production of biodiesel of 37% and 44% respectively.

Finally, other biofuels include those which are not categorized into bioethanol or biodiesel and fuels such as cellulosic ethanol and HVO fall in this category. Americas - mainly North America accounted for the large share of other biofuels which accounted for 94% of the global production.

Table 42 Liquid biofuels production in continents in 2017

	Total	Bioethanol	Biodiesel	Other Biofuels
Africa	0.06	0.06	0.00	0.00
Americas	103	74.3	13.2	15.3
Asia	13.4	5.77	7.18	0.41
Europe	21.2	4.74	15.8	0.66
Oceania	0.20	0.19	0.00	0.00
World	138	85.1	36.1	16.4

Unit: In Billion litres. (IEA, 2019)

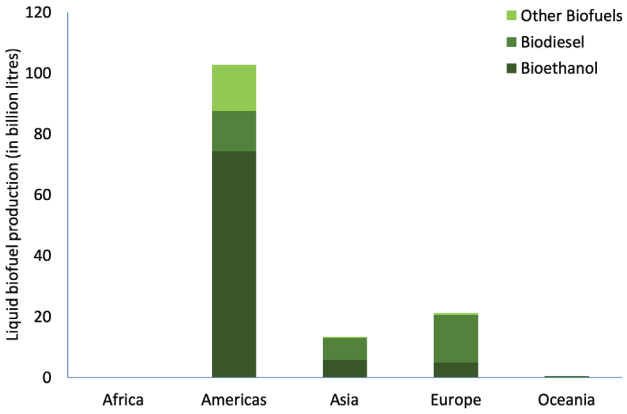

Figure 35 Liquid bioethanol, biodiesel and other biofuels production in continents in 2017

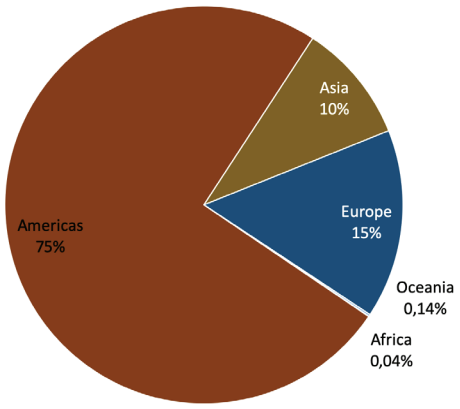

Figure 36 Liquid biofuels production in continents in 2017

6. SPECIAL SECTORS

6.1 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 (CH_4) and carbon dioxide (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.

Europe is a world leader in the production and use of biogas. In 2017, the region accounted for half of the global supply of biogas followed by Asia accounting for 1/3rd of the supply. Globally, domestic supply of biogas was 1.33 EJ or approximately 62 million Nm^3. Overall, the share of biogas supply in the bioenergy sector accounts for only about 2% and has potential to contribute much more.

Table 43 Domestic supply of biogas globally

	Total Biogas production*	World	Africa	Americas	Asia	Europe	Oceania
2000	13.2	0.28	0.0	0.13	0.05	0.10	0.01
2005	23.2	0.50	0.0	0.17	0.15	0.17	0.01
2010	39.1	0.84	0.0	0.13	0.33	0.37	0.02
2015	60.0	1.30	0.0	0.21	0.39	0.67	0.02
2016	60.8	1.31	0.0	0.19	0.40	0.70	0.02
2017	61.7	1.33	0.0	0.19	0.41	0.71	0.02

Unit: In EJ. (*in million Nm^3) Using approximate conversion factor of 21.6 MJ/Nm^3. (IEA, 2019)

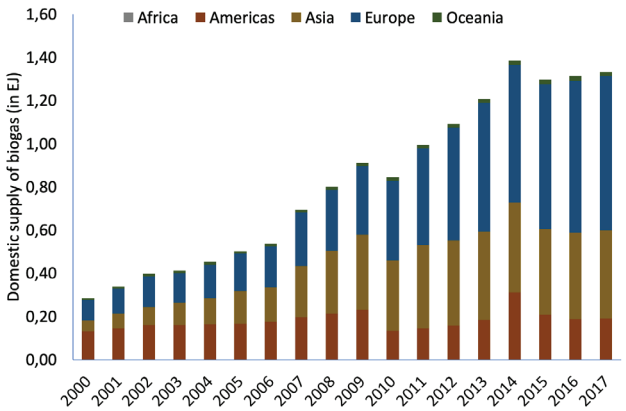

Figure 37 Domestic supply of biogas globally

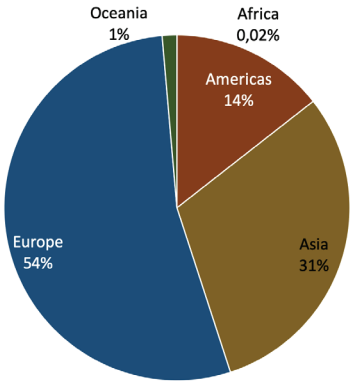

Figure 38 Domestic supply of biogas in continents in 2017

6.2 PELLETS

Pellets are a solid biomass fuel, mainly produced from wood residues but also from agricultural by-products such as straw. Specific advantages of pellets as compared to unprocessed biomass include standardized properties, high energy content, high density and therefore reduced costs for transport, storage and handling. Pellets are used for residential heating in pellet stoves and pellet boilers, for the generation of heat, steam and electricity in the service industry, manufacturing and power generation.

Globally, the wood pellet sector has shown tremendous growth over the past few years to become one of the largest biomass commodities produced and traded globally. In 2018, 35.4 million tonnes of wood pellets were produced – 55% of the production occurred in Europe while Americas (mainly USA) accounted for 32%.

Table 44 Pellets production globally

	World	Africa	Americas	Asia	Europe	Oceania
2012	18.1	0.09	5.10	0.30	12.5	0.03
2013	21.2	0.04	6.65	0.62	13.9	0.03
2014	25.1	0.04	7.96	1.72	15.2	0.14
2015	27.5	0.03	8.76	2.04	16.5	0.15
2016	29.2	0.04	9.49	2.52	17.0	0.16
2017	33.1	0.04	10.5	3.47	18.9	0.25
2018	35.4	0.04	11.2	4.55	19.4	0.25

Unit: Million tonnes. (FAOSTAT, 2019)

Since 2012, the production of wood pellets globally has almost doubled. Even though Europe and USA account for a majority of the production, Asia has seen exponential growth over the past 6 years as production has increased 15 times. The potential for replacing coal in power generation and the availability of forestry and agricultural residues as feedstock globally indicates that pellets will continue to play a prominent role in the global energy transformation.

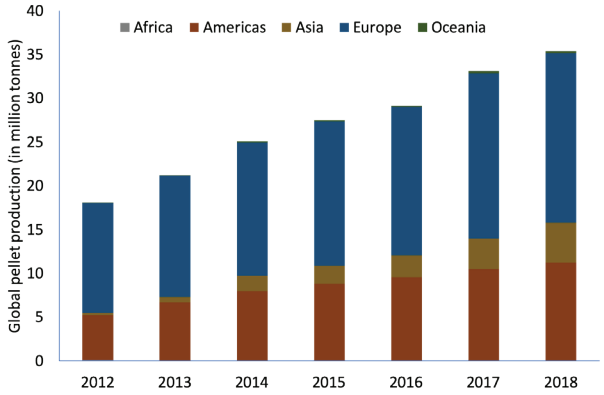

Figure 39 Pellets production globally

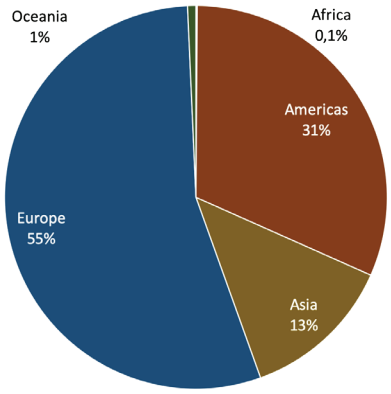

Figure 40 Pellets production in continents in 2018

6.3 CHARCOAL

Charcoal is mainly produced from biomass sources such as woody biomass, but also from agricultural products and biogenic fraction of municipal solid waste. Predominantly produced in developing countries in Asia, Africa and South America, charcoal is the main source of energy for cooking and heating. In some regions, the fuel accounts for more than 90% of the national energy consumption.

Charcoal is a much neglected sector in the bioenergy industry. Even though the global production of charcoal far exceeds wood pellet production (approx. 1.5 times), there is significantly much less attention drawn to the challenges and opportunities for efficient production and use of charcoal. The global production of charcoal in 2000 was 36.7 million tonnes – more than the current wood pellet production. In 2017, 51.6 million tonnes of charcoal were produced globally.

Africa is the main producer and consumer of charcoal accounting for 65% of the production and using predominantly as cooking fuel in semi urban and rural areas. The continent accounted for 90% of the growth in the charcoal production since the turn of the century. However, data suggests that the global production has relatively stabilized over the past few years.

Table 45 Global charcoal production

	World	Africa	Americas	Asia	Europe	Oceania
2000	36.7	20.2	9.67	6.54	0.30	0.04
2005	43.9	24.4	10.9	8.01	0.51	0.03
2010	46.5	28.5	8.86	8.54	0.57	0.04
2015	51.2	32.1	9.38	9.05	0.61	0.04
2016	50.8	32.8	8.29	9.04	0.61	0.04
2017	51.6	33.5	8.31	9.05	0.71	0.04

Unit: Million Tonnes (FAOSTAT, 2019)

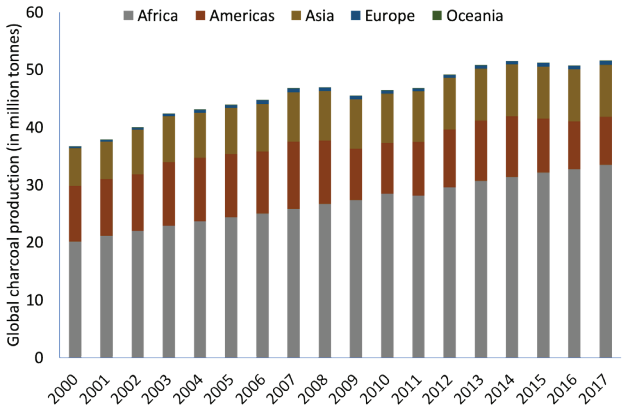

Figure 41 Global charcoal production

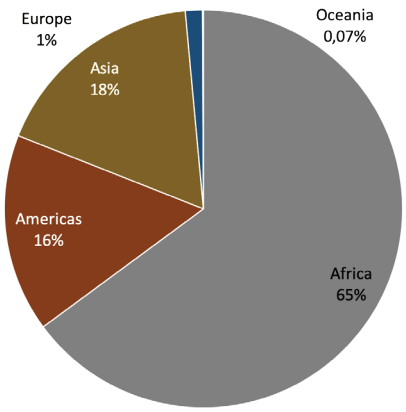

Figure 42 Global charcoal production in 2018

7. JOBS

Renewable energy technologies create jobs. Globally, 11 million people were employed in the renewable energy industry. Bioenergy is the 2nd largest employer among renewable energy technologies after solar power. In 2018, 3.2 million people were working in the bioenergy industry along the complete value chain – production of feedstock, transportation, conversion to biobased products for energy, equipment manufacturing etc. Overall, bioenergy accounted for 1/3rd of the global renewable energy employment.

It is important to note that a major part of the bioenergy industry is not accounted as traditional biomass is not included in the renewable jobs estimates which indicates a much higher employment figure for the sector.

Table 46 Jobs in renewable energy sector

	Total	Bioenergy	Solar	Wind	Hydro	Others
2012	7.28	2.40	2.25	0.75	1.66	0.22
2013	8.54	2.50	2.77	0.83	2.21	0.23
2014	9.51	2.99	3.26	1.03	2.04	0.19
2015	10.0	2.88	3.71	1.08	2.16	0.20
2016	10.1	2.74	3.92	1.16	2.06	0.24
2017	10.5	3.06	4.18	1.15	1.99	0.16
2018	11.0	3.18	4.41	1.16	2.05	0.18

Unit: Millions. (IRENA, 2019)

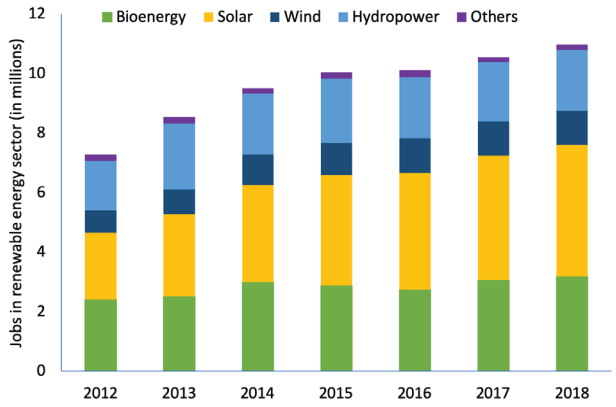

Figure 43 Jobs in renewable energy (in millions)

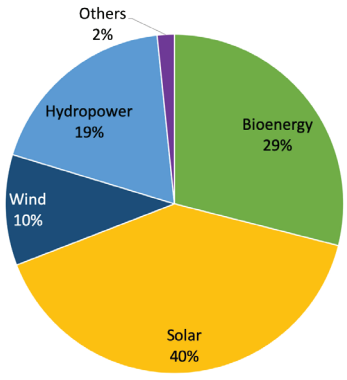

Figure 44 Jobs in renewable energy in 2018

8. APPENDIX

8.1 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, Swaziland, 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

8.2 GLOSSARY

Advanced biofuels: Advanced biofuels or second-generation biofuels are liquid fuels with the conversion technology still in R&D, pilot or demonstration phase. However, in the past few years, commercial plants have started production. They include hydro treated vegetable oil, biofuels from lignocellulose biomass and algae-based biofuels.

Agriculture area: Agricultural area, this category is the sum of areas under a) arable land - land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years).

Arable land: Arable land is the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years).

Bagasse: Bagasse is a plant fiber that is left over after the production of sugarcane, sorghum or agave.

Biodiesel: Biodiesel is a liquid fuel produced predominantly from vegetable oil or animal fats.

Bioelectricity: Energy that is collected from renewable resources such as sunlight, wind, rain, tides, waves, and geothermal heat.

Bioenergy: Bioenergy is energy produced from biomass (including biological origin fraction of municipal waste) and used directly as fuel or processed into liquids or gases.

Bioethanol: Bioethanol is ethanol produced from biomass and/or biodegradable fraction of waste.

Biogas: Biogas is the gas obtained from anaerobic fermentation of biomass in landfills, sewage etc. – comprising primarily of methane and carbon dioxide

Bioheat: Bioheat is heat generated from biomass based sources

Biomass: Biomass is any organic matter derived from plants, animals or algae.

Briquettes: A compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, wood chips, peat, or paper used for fuel and kindling to start a fire.

Combined Heat and Power (CHP): CHP plants are designed to cogenerate heat and electricity from a variety of plants, sizes and technologies.

Crop residues: Often used to make solid biofuels such as briquettes, pellets and charcoal. They are also high in energy content and can be used directly for heating and cooking.

Crop yield: The measure of grains or seeds generated from a unit of land.

Electricity only: Electricity plants refers to plants which are designed to produce electricity only.

Feedstocks: A feedstock refers to any unprocessed material used to supply a manufacturing process. Particularly as it relates to energy, a feedstock refers specifically to a renewable, biological material that can be converted into energy or fuel.

Forest area: Forest area is the land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ.

Heat only: Heat plants, refers to plants (including heat pumps and electric boilers) designed to produce heat only.

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

Inland water: Permanent water bodies inland from the coastal zone and areas whose properties and use are dominated by the permanent, seasonal, or intermittent occurrence of flooded conditions.

Land area: Land area is the total area of the country excluding area under inland water bodies.

Liquid biofuels: Liquid biofuels includes bioethanol, biodiesel and other liquid biofuels.

Lower Heating Values (LHV): The lower heating value (also known as net calorific value) of a fuel is defined as the amount of heat released by combusting a specified quantity (initially at 25°C) and returning the temperature of the combustion products to 150°C, which assumes the latent heat of vaporization of water in the reaction products is not recovered.

Moisture Content Value (MCV): The moisture content of a crop is an indicator of the amount of water present the crop.

Municipal wastes: Municipal waste consists of products that are combusted directly to produce heat and/or power and comprises of wastes from household, industry, hospitals and other sources which are collected by local authorities for incineration.

Other land: Other land is the land not classified as Agricultural land and Forest area. It includes built-up and related land, barren land, other wooded land, etc.

Other naturally occurring regenerated forests: The process by which woodlands are restocked by trees that develop from seeds that fall and germinate in situ

Other solid biofuels: Includes forest and agriculture residues, such as woodchips and wood pellets.

Pellets: Wood pellets are mostly produced from sawdust and wood shavings compressed under high pressure. They are cylindrical in shape and usually 6-10 mm in diameter.

Permanent crops: Permanent crops are sown or planted once, and then occupy the land for some years and need not be replanted after each annual harvest, such as cocoa, coffee and

rubber

Permanent meadows and pastures: Permanent meadows and pastures is the land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

Planted forests: a forest that at maturity is predominantly composed of trees established through planting and/or deliberate seeding.

Primary forests: largely undisturbed by industrial-scale land uses and infrastructure such as logging, mining, and dams and roads.

Pyrolysis oil: Pyrolysis Oil is a dark-brown, free flowing liquid made from plant material by a process called fast pyrolysis, whereby biomass particles are rapidly heated to ~500 °C in the absence of oxygen, vaporized and the vapors then quenched into the Pyrolysis Oil liquid, also known as bio-oil.

Residue to Product Ration (RPR): the ratio of above ground crop production to the total grain production

Solid biofuels: It is defined as any plant matter used directly as fuel. This covers a multitude of woody materials generated by industrial processes or provided directly by forestry and agriculture (firewood, wood chips, bark, sawdust, shavings, chips, sulphite lyes also known as black liquor, animal materials/wastes and other solid biomass).

Traditional biomass: Traditional biomass refers to the use of fuel wood, charcoal, animal dung and agricultural residues in stoves with low efficiencies.

Wood charcoal: Wood charcoal is wood carbonized by partial combustion or the application of heat from external sources.

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 charcoal production (e.g. in pit kilns and portable ovens). It also includes wood chips to be used for fuel that are made directly (i.e. In the forest) from roundwood. It excludes wood charcoal. It is reported in cubic meters solid volume underbark (i.e. excluding bark).

8.3 GENERAL REGIONAL DATA

Table 47: General Regional Data

Country Name	Population (2018)	Energy Use per capita (2014)	GDP per capita (2018)	CO_2 Emissions per capita (2014/18)
Unit	million	kg oil eq.	Current US$	tonnes
Central Europe and the Baltics	103	2 471	15 902	6.21
East Asia & Pacific	2 328	2 135	11 132	6.13
Europe & Central Asia	919	3 159	25 070	6.80
European Union	513	3 079	36 532	6.32
Latin America & Caribbean	641	1 358	9 024	2.98
Middle East & North Africa	449	2 353	8 057	5.78
North America	364	7 055	60 968	15.9
Pacific island small states	2.5	-	4 193	1.01
Sub-Saharan Africa	1 078	688	1 574	0.76
World	7 594	1 922	11 297	4.76

(World Bank, 2019)

8.4 SOME USEFUL CONVERSIONS

Table 48 Useful energy conversion factors

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 49 Useful energy unit conversion factors

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

8.5 REFERENCES

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SILVER SUPPORTERS OF WBA

Lantmännen

AGRANA

SUPPORTERS OF WBA GBS 2019

KLASMANN-DEILMANN BioEnergy

Granulita