



WBA GLOBAL BIOENERGY STATISTICS 2018

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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.

EXECUTIVE SUMMARY

The global energy system depends on fossil fuels. In 2016, Coal, Oil and Natural Gas constituted 81% of the total primary energy supply of the world. Renewables accounted for only 14% and have seen an increase of 1% share since 2000.

The Total Primary Energy Supply of energy sources is the highest in Asia due to the large energy supply and use in China, India and other rapidly developing emerging economies in the region. However, in terms of the share of renewables, African continent has the highest share in their energy supply. Almost 50% of the energy supply in Africa comes from renewables - predominantly from biomass-based sources. In comparison, 10.5% of the energy supply in Europe is renewables.

The key indicator for the progress of renewables globally is the share of renewable energy sources in the gross final energy consumption. In 2016, renewables accounted for 17.9% of the global energy consumption. Since 2000, renewable energy share has increased only by 0.3% even though almost 20 EJ of renewable energy consumption was added to the global energy mix.

Bioenergy is the largest renewable energy source globally. In 2016, Total Primary Energy Supply of biomass resources was 56.5 EJ - constituting 70% of the share among all renewable energy sources. Hydropower share was at 18% globally. In continents, the role of biomass is very prominent. In Africa, more than 90% of the total primary energy supply of renewable energy sources is from biomass. In every other continent, biomass is the largest renewable energy source in terms of supply and accounting from between 40% (Oceania) to almost 96% in Africa.

Electricity from hydropower is the largest renewable electricity source globally. In 2016, 6 119 TWh of electricity was produced globally from hydropower - constituting 68% of the overall renewable share. Biopower or electricity from biomass is the 3rd largest renewable electricity generation source. In 2016, 571 TWh of electricity was produced from biomass sources. The electricity sector has numerous renewable energy options for renewable electricity.

The derived heat sector (Heat produced in power plants) is limited in terms of its capacities to decarbonize from fossil fuels. In the limited options available, biomass is the most prominent choice. 1.05 EJ of bioheat was produced in 2016 followed by 0.04 EJ of geothermal heat and 0.01 EJ of solar thermal. In 2016, 96% of the derived renewable heat was from biomass and waste sources.

The other end use of heating sector is direct heat, i.e. direct consumption of energy sources in the end use sectors of agriculture, residential (also includes cooking), commercial etc. and excluding the transport sector. Renewables consumption in direct heating is dominated again by biomass as was the case with derived heating. The use of biomass for direct heating amounted to 42.4 EJ in 2016. To compare, the total energy supply of biomass in 2016 was 56 EJ.

The direct use of biomass for heating and cooking etc. is the largest part of the bioenergy end use. In effect, more than 80% of the biomass supply is used for direct heating and cooking - predominantly in Asia and African continents.

Electrification in the transport sector is making considerable progress. Apart from electrification using renewable electricity, biofuels are the only sustainable alternative to decarbonizing the transportation sector. In 2016, 3.43 EJ of biofuels was used in the transport sector accounting for 3% of the share in the total energy use in transport sector. The use of electricity in transport was 1%. During 2000 - 2016, the consumption of biofuels in transport increased from 1% to 3% while electricity use in transport has remained at 1%.

Biomass supply comes from a variety of feedstock – wood fuel, forestry residues, charcoal, pellets, agriculture crops and residues, municipal and industrial waste, biogas, biofuels etc. Broadly, the supply can be classified into three main sectors – forestry, agriculture and waste. In 2016, the total primary energy supply of biomass was 56.5 EJ. 87% of the supply was in the form of solid biomass - wood chips, wood pellets, fuel wood etc. 5% of the supply is from waste sources - both municipal and industrial waste. Biofuels and biogas shares are at 6% and 2%.

Electricity from biomass (Biopower) is the 3rd largest renewable electricity source globally after hydropower and wind. In 2016, 571 TWh of biopower was generated globally - 65% from solid biomass sources like wood chips and wood pellets, 19% from municipal and industrial waste followed by 15% from biogas - mainly in Europe.

Heat generation from biomass is obtained either via derived heat or direct heat. Derived heat is heat generated in heat only and combined heat and power plants. In 2016, 1.05 EJ of derived heat was generated from

biomass-based sources - predominantly solid biomass.

Liquid Biofuels are the leading renewable solution for the transport sector. They have experienced sustained growth over the past 16 years. Since 2000 - 2017, biofuel production has increased 10 times from 16 billion litres to 143 billion litres. Bioethanol is the largest biofuel and hence, the largest renewable fuel in the global transport sector. Biodiesel is also quite significant in production while advanced/other biofuels are gaining prominence recently. USA and Brazil are the largest biofuel and bioethanol producers globally with a production share of 87% whereas biodiesel production share is evenly distributed between Asia, Americas and Europe.

Biogas is gaseous fuel produced from biomass using the process of anaerobic digestion of organic matter. The gas basically consists of methane and carbon dioxide. 61 billion m³ of biogas was produced globally in 2016. Europe produces more than half of the biogas produced globally while Asia share is 30%.

Pellets are a solid biomass fuel, mainly produced from wood residues but also from agricultural by-products such as straw. 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. 31.2 million tonnes of pellets were produced globally in 2017. Europe is the world leader in pellet production at 57% followed mainly by Americas (e.g. USA) at 31%.

Charcoal is produced via the partial burning of biomass. The residue consists mainly of carbon and other residues. Charcoal sector is a highly underestimated sector due to its largely informal trade of the product. Unlike pellets and liquid biofuels, charcoal is produced and consumed locally. Moreover, the process of conversion is highly inefficient process. In 2017, 44 million tonnes of charcoal were produced - mainly in Africa.

Renewable energy creates jobs. In 2017, 10.4 million people were employed in the renewable energy industry globally. Vast majority of them are in the solar energy industry and bioenergy industry. Bioenergy is the 2nd largest job creator among renewables with more than 3.07 million people working in the sector. The largest job creator in the bioenergy sector is the sugarcane industry in Brazil for production of bioethanol and biopower which employs close to 1 million people.



WORLD BIOENERGY ASSOCIATION - THE GLOBAL VOICE OF BIOENERGY

Mission:

To promote the use of sustainable bioenergy globally & support the business environment for bioenergy

Together with our members:

- We work for an increased use of biomass in the global energy system in the markets for heat, electricity and mobility
- We follow the principles of sustainable, efficient and economic biomass development
- We influence and inform the public opinion in favor of sustainable biomass solutions worldwide and individual countries
- We promote bioenergy as an important player in the global climate mitigation policy
- We cooperate with global institutions such as UNEP, UNFCCC, IPCC, IEA, IEA Bioenergy, IRENA, REN Alliance, FAO, REN21 etc. towards the target of 100% renewables

How we work

- **Office** in Stockholm, Sweden
- **Our board:** 19 members from 17 countries
- **Our members:** 200 members from 50 countries
- **Main areas:** Biomass potential, sustainability of biomass, pellets, small scale heat with biomass, combined heat and power, conventional and advanced biofuels, biogas, carbon neutrality of biomass, bioenergy statistics, biomass trade, bioenergy policy, traditional biomass etc.
- **Main activities:** Factsheets, statistics, position papers, policy reports, workshops, equipment directory, press releases, networking, presentations in conferences and exhibitions etc.

What kind of membership is possible

Full members

Associations on regional, national or international level (fee between 300 and 5000 euros annually depending on situation and size)

Associated members

Companies, energy agencies, research institutes, consultants working in the field of bioenergy (fee between 300 and 5000 euros annually depending on situation and size)

Individual members

Individuals interested in global development of bioenergy as a sustainable and renewable energy source (fee 50 euros annually)

Benefits of WBA membership

- Strengthening of the voice in favour of biomass on a global scale
- Exchange of information and experience between the bioenergy sector worldwide
- Possible cooperation in working groups and projects
- Access to the new global studies and information about bioenergy

We invite you to join WBA!

Contact us at info@worldbioenergy.org or call us at +46 (0)8 441 70 84

FOREWORD

The WBA Global Bioenergy Statistics reports are the only report focussing solely on the developments in the bioenergy sector. The current report is the 5th in this series.

Bioenergy is a complex energy system and is an important energy source and will play a crucial role in the future energy mix. The energy source accounts for 10% of the energy supply or 14% of the energy consumption globally. These reports are an attempt to put fact-based information about bioenergy.

Data is crucial for informed decision making. As they say 'one can't manage what one can't measure'. In the recently released UN report on 'Progress towards Sustainable Development Goals', it is emphasized that the amount of data and statistics needed to track the Sustainable Development Goals poses a major challenge to national and international statistical systems. It calls upon global statistical community to modernize and strengthen statistical system. These statistical reports form an important basis for understanding the progress of bioenergy and renewables in general towards meeting these goals.

For the readers, it is important to understand certain key terminology 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 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) are 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 m³ and billion litres are used. For convenience: 1 EJ = 0.28 PWh or 24 Mtoe or 950 Million MBtu

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 taken from FAOSTAT. Other data sources used in the report include publications from IRENA (e.g. Jobs), REN21 Global Status Report (e.g. biofuels) 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 2016 and some even from 2017.

This is a combined effort and special mention goes to the new collaborative partners who joined as contributors from this year onwards.

We hope that the information is useful for you. We are confident that such reports will be useful tool for politicians, investors, companies, researchers and journalists in better understanding this complex energy sector. We are a small team and we made considerable effort to verify and report accurate data.

For getting in touch with us, please send an email to info@worldbioenergy.org and we look forward to communicating with you.

World Bioenergy Association (info@worldbioenergy.org)

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CHAPTER 1: GLOBAL OVERVIEW

ENERGY SUPPLY

Total Primary Energy Supply (TPES) or energy supply is defined as production of energy sources including import and export of the source as well as storage in bunkers. It is represented in terms of energy content of the fuel.

The global energy system depends on fossil fuels. In 2016, Coal, oil and natural gas constitute 81% of the total primary energy supply of the world. Renewables account for only 14% and have seen an increase of 1% share since 2000. Even though the supply of renewables has been increasing over time, the global primary energy supply is increasing at almost the same pace.

Table 1 Total primary energy supply of energy sources globally

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
2000	420	96.8	153	86.7	28.3	54.8	13.0%
2005	481	125	168	98.8	30.2	59.4	12.3%
2010	539	153	173	115	30.1	67.8	12.6%
2015	571	161	181	123	28.1	77.8	13.6%
2016	576	156	184	127	28.5	80.6	14.0%

All values in EJ. Source: IEA Key World Energy Statistics

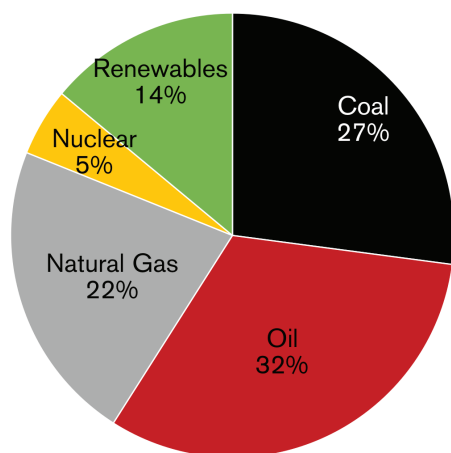


Figure 1 Total energy supply globally in 2016

The global energy supply is also divided into continents - Africa, Americas (North America and South America), Asia, Europe and Oceania (New Zealand and Australia). The Total Primary Energy Supply of energy sources is the highest in Asia due to the large energy supply and use in China, India and other rapidly developing emerging economies in the region. However, in terms of the share of renewables, African continent has the highest share in their energy supply. Almost 50% of the energy supply in Africa comes from renewables - predominantly from biomass based sources. In comparison, 10.5% of the energy supply in Europe is renewables.

Table 2 Total primary energy supply of energy sources in continents in 2016

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
Africa	34.8	4.53	8.29	4.83	0.16	17.0	48.8%
Americas	141	16.9	55.2	40.0	10.6	17.8	12.7%
Asia	276	114	80.8	42.7	5.18	32.6	11.8%
Europe	119	18.5	37.4	37.9	12.5	12.5	10.5%
Oceania	6.26	1.88	2.04	1.62	0.00	0.72	11.5%
World	576	156	184	127	28.5	80.6	13.6%

All values in EJ. Source: IEA Key World Energy Statistics

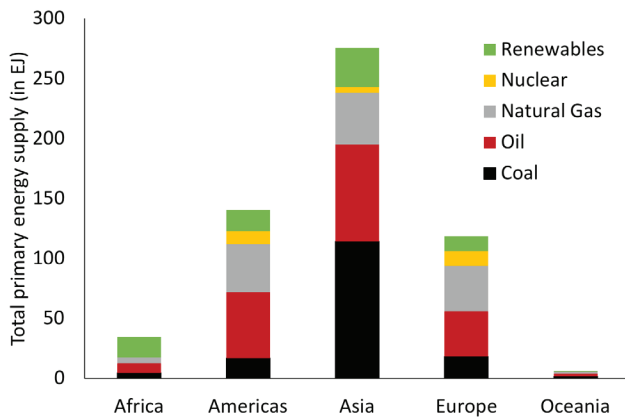


Figure 2 Total primary energy supply in continents in 2016

ENERGY TRADE

Energy trade constitutes import and export of energy sources - mainly coal, oil and gas along with biomass. Crude oil and oil products are the most traded energy commodity in the world. In 2016, 72.1 EJ of crude oil was imported into Asia along with 24.4 EJ of coal.

In exports, Asia again is a leading player with Middle East (classified into Asia) being the dominant exporter of crude oil to the rest of the world.

Renewables usually do not constitute a major part of trade of energy sources. Electricity generation from wind, solar, hydro etc. are largely consumed within the country. The only significant trade of renewable energy occurs in the bioenergy sector in the form of pellets and liquid biofuels - mainly between Europe and North America.

Table 3 Total imports of energy in 2016

	Total	Coal	Oil	Natural Gas	Renewables	Electricity
Africa	7.92	0.32	6.50	0.96	0.00	0.15
Americas	40.5	1.67	32.0	6.14	0.70	0.49
Asia	105	24.4	72.1	14.0	0.37	0.31
Europe	68.8	6.86	42.6	17.0	2.38	1.65
Oceania	2.40	0.02	2.17	0.21	0.00	0.00

All values in EJ. Source: IEA Key World Energy Statistics

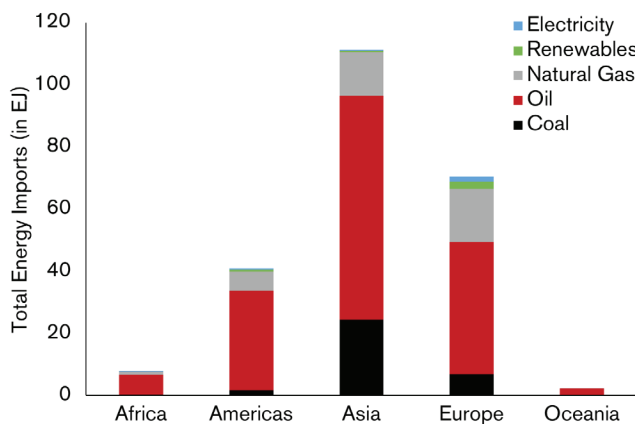


Figure 3 Energy imports in 2016 globally

Table 4 Total exports of energy in 2016

	Total	Coal	Oil	Natural Gas	Renewables	Electricity
Africa	19.6	2.23	14.0	3.22	0.15	0.13
Americas	43.2	4.62	31.4	6.43	0.78	0.50
Asia	90.7	10.7	70.4	9.36	0.29	0.25
Europe	68.6	6.71	41.4	18.2	2.21	0.35
Oceania	13.0	10.6	0.64	1.80	0.00	0.00

All values in EJ. Source: IEA Key World Energy Statistics

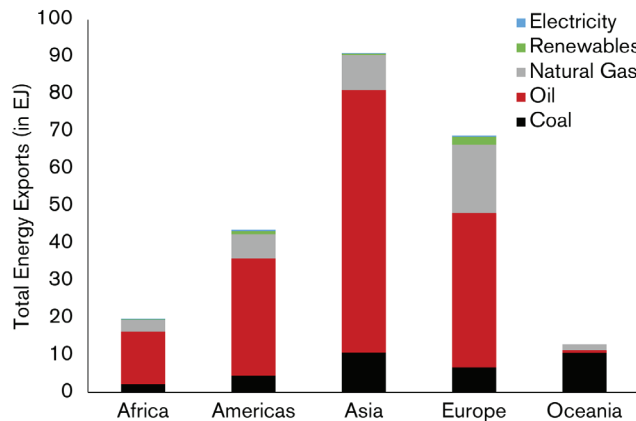


Figure 4 Energy exports in 2016 globally

ENERGY CONSUMPTION

Gross final energy consumption is defined as energy commodities delivered to end use sectors (industrial, commercial, residential, transport etc.) for the use as energy including electricity and heat. Non-energy use of commodities is excluded.

The key indicator for the progress of renewables globally is the share of renewable energy sources in the gross final energy consumption. The data below includes all uses of energy and not just electricity. Since 2000, renewable energy share has increased only by 0.3% even though almost 20 EJ of renewable energy consumption was added to the global energy mix.

Table 5 Gross final energy consumption of energy sources

	Total	Coal	Oil	Gas	Nuclear	Renewables	Renewables (%)
2000	269	43.3	115	55.7	7.63	47.4	17.6%
2005	302	57.3	125	61.1	8.20	50.6	16.7%
2010	335	70.6	129	69.8	8.23	56.7	16.9%
2015	358	74.6	138	73.3	7.68	63.4	17.7%
2016	367	76.1	140	76.4	8.18	65.9	17.9%

All values in EJ. Source: IEA Key World Energy Statistics

Among renewable energy sources, biomass is the largest renewable energy source at 13% share in the global energy mix followed by hydropower at 3% and rest of the renewables (solar, wind, geothermal and tidal etc.) at 2%.

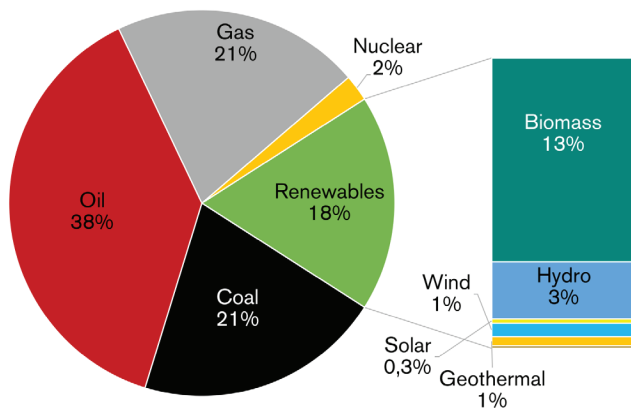


Figure 5 Gross final energy consumption globally in 2016

Asia is a major consumer of energy sources among continents. In 2016, almost 50% of the energy consumption globally was in Asia at 170 EJ. Coal still plays a major role in energy mix of Asia. In comparison, Africa consumes more renewables than any other energy source - mainly due to the high use of traditional biomass resources in the continent.

Table 6 Gross final energy consumption in continents in 2016

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
Africa	24.9	1.51	7.43	2.03	0.05	13.8	55.6%
Americas	92.4	6.16	44.6	24.0	3.05	14.5	15.7%
Asia	170	59.9	57.9	23.9	1.48	27.1	15.9%
Europe	75.5	7.86	28.0	25.7	3.59	9.95	13.2%
Oceania	4.04	0.64	2.15	0.76	0.00	0.48	12.0%
World	367	76.1	140	76.4	8.18	65.9	17.9%

All values in EJ. Source: IEA Key World Energy Statistics

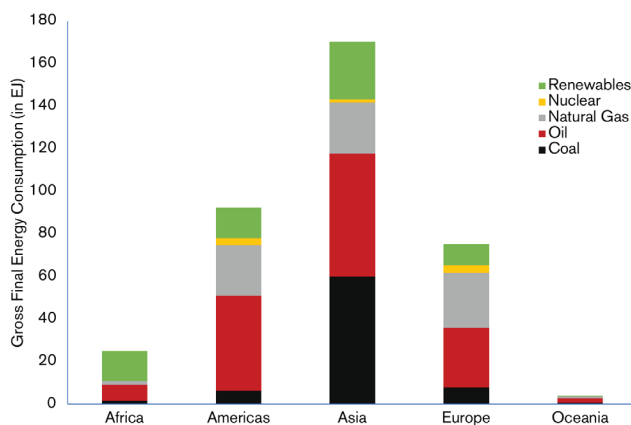


Figure 6 Gross final energy consumption of energy sources in 2016

RENEWABLE ENERGY SUPPLY

Bioenergy is the largest renewable energy source globally. In 2016, Total Primary Energy Supply of biomass resources was 56.5 EJ - constituting 70% of the share among all renewable energy sources. Hydropower share was at 18% globally.

Table 7 Total primary energy supply of renewables globally

	Total	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Ocean etc.
2000	54.8	42.8	9.43	2.19	0.00	0.22	0.11	0.002
2005	59.4	45.9	10.6	2.25	0.01	0.30	0.37	0.002
2010	67.8	50.8	12.4	2.62	0.12	0.66	1.23	0.002
2015	77.8	55.4	14.0	3.10	0.89	1.37	3.02	0.004
2016	80.5	56.5	14.6	3.37	1.18	1.41	3.45	0.004

All values in EJ. Source: IEA Key World Energy Statistics

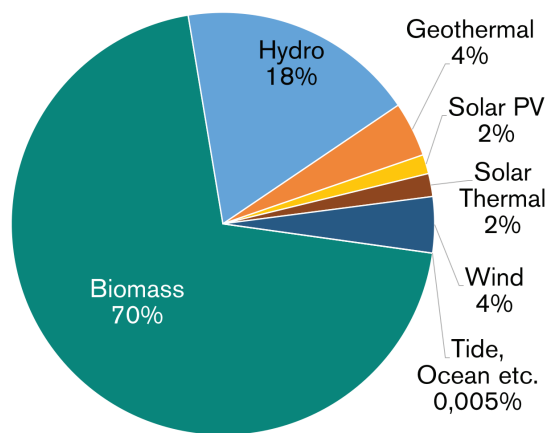


Figure 7 Total primary energy supply of all renewables in 2016

In continents, the role of biomass is very prominent. In Africa, more than 90% of the total primary energy supply of renewable energy sources is from biomass. In every other continent, biomass is the largest renewable energy source in terms of supply and accounting from between 40% (Oceania) to almost 96% in Africa.

Table 8 Total primary energy supply of renewables in continents in 2016

	Total	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Ocean etc.
Africa	17.0	16.3	0.42	0.15	0.01	0.01	0.04	0.000
Americas	17.8	10.7	4.99	0.66	0.20	0.16	1.14	0.000
Asia	32.5	21.8	6.09	1.92	0.56	1.04	1.12	0.002
Europe	12.5	7.38	2.98	0.44	0.39	0.18	1.10	0.002
Oceania	0.72	0.28	0.15	0.20	0.02	0.02	0.05	0.000
World	80.5	56.5	14.6	3.37	1.18	1.41	3.45	0.004

All values in EJ. Source: IEA Key World Energy Statistics

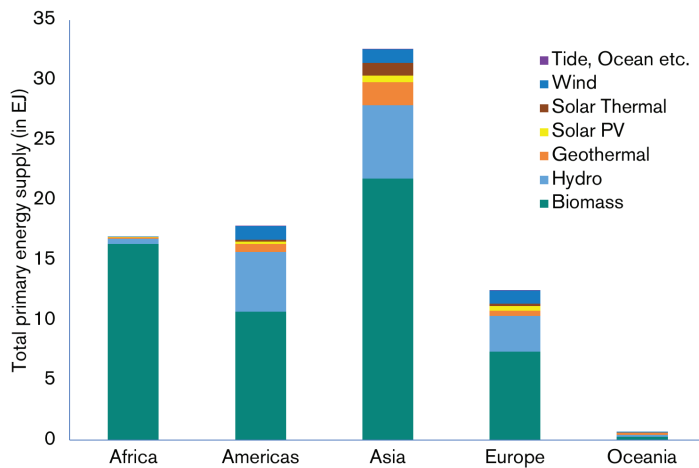


Figure 8 Total primary energy supply of renewables in 2016 (in EJ)

RENEWABLE ELECTRICITY

Electricity from hydropower is the largest renewable electricity source globally. In 2016, 6 119 TWh of electricity was produced globally from hydropower - constituting 68% of the overall renewable share. Bio-power or electricity from biomass is the 3rd largest renewable electricity generation source. In 2016, 571 TWh of electricity was produced from biomass sources.

The situation in 2000 was different when biomass was the 2nd largest after hydro. However, rapid development of solar and wind energy technologies took place over the past decade. Wind electricity increased by 30 times while solar PV and solar thermal electricity generation increased by 300 and 10 times respectively. In the future, solar and wind technologies will play the most prominent role followed by significant contributions from hydro, geothermal and biomass sources.

Table 9 Electricity generation from renewables

	Total	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Ocean etc.
2000	2 950	164	2 700	52.0	0.98	0.53	31.3	0.55
2005	3 413	227	3 019	58.3	3.97	0.60	104	0.52
2010	4 347	372	3 531	68.1	32.4	1.65	341	0.51
2015	5 682	528	3 978	80.4	247	9.42	838	1.01
2016	6 119	571	4 170	81.7	328	10.5	958	1.03

All values in TWh. Source: IEA Key World Energy Statistics

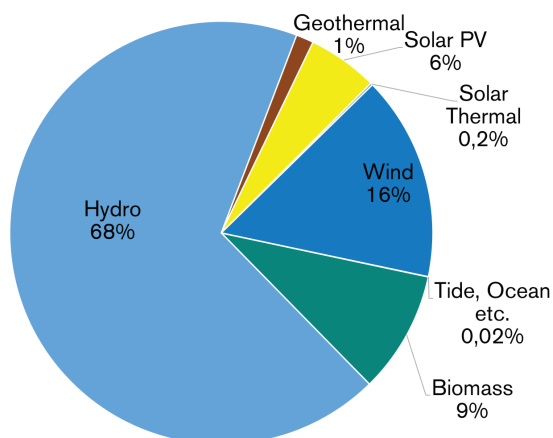


Figure 9 Electricity generation from renewables globally in 2016

Asia is the largest producer of renewable electricity globally. In 2016, the continent produced 2 351 TWh of renewable electricity - predominantly from hydropower. Europe was the largest producer of biopower at 208 TWh.

Table 10 Electricity generation from renewables in 2016 in continents

	Total	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Ocean etc.
Africa	137	1.91	116	4.20	3.31	0.90	10.3	0.00
Americas	1 951	162	1 386	28.7	54.8	3.70	316	0.02
Asia	2 351	152	1 697	29.2	160	0.29	311	1.00
Europe	1 468	208	827	12.2	108	5.58	307	0.50
Oceania	66.9	4.23	37.9	7.43	2.38	0.00	15.0	0.00
World	5 973	528	4 064	81.7	328	10.5	959	1.52

All values in TWh. Source: IEA Key World Energy Statistics

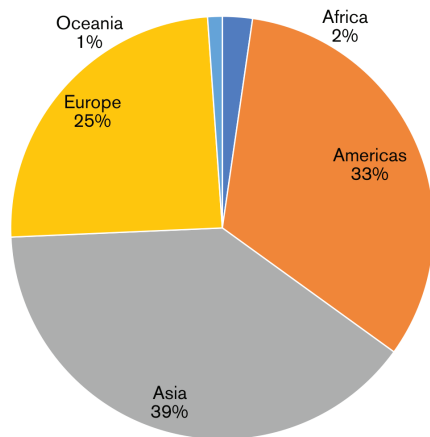


Figure 10 Electricity generation from renewables in 2016

RENEWABLE DERIVED HEAT

Heat is supplied as direct heat or as derived heat. In the case of derived heat, the primary energy carrier goes to a conversion plant (CHP plant, heat alone plant) and then the heat goes via a hot water distribution grid (e.g. district heating system) to the final consumer.

The electricity sector has numerous renewable energy options for renewable electricity. However, the derived heat sector is limited in terms of its capacities to decarbonize from fossil fuels. In the limited options available, biomass is the most prominent choice. 1.05 EJ of bioheat was produced in 2016 followed by 0.04 EJ of geothermal heat and 0.01 EJ of solar thermal. In 2016, 96% of the derived renewable heat was from biomass and waste sources.

The production of derived bioheat occurs in large and small scale combined heat and power plants along with stand alone heat plants - thereby reducing the fossil dependency in the sector.

Table 11 Derived heat generation from renewables globally

	Total	Biomass	Geothermal	Solar Thermal
2000	432 419	414 081	18 314	24.0
2005	554 103	530 237	23 811	55.0
2010	807 324	781 020	26 112	192
2015	975 672	940 492	34 251	929
2016	1 099 129	1 053 861	43 704	1 564

All values in TJ. Source: IEA Key World Energy Statistics

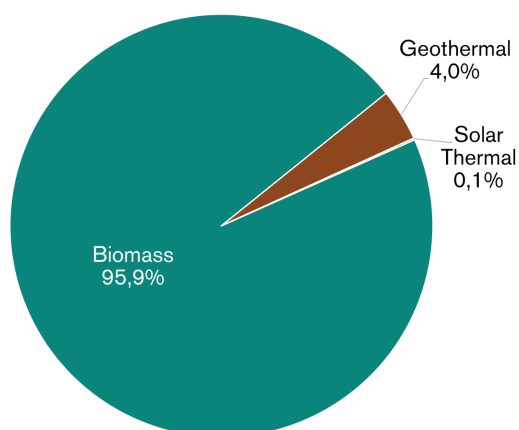


Figure 11 Derived heat generation from renewables in 2016

Europe is the world's largest producer of derived heat from renewable energy sources. 88% of all the derived heat from renewables is produced in Europe and EU - 28 in particular due to the high use of biomass.

Table 12 Derived heat generation from renewables in 2016

	Total	Biomass	Geothermal	Solar Thermal
Africa	0.00	0.00	0.00	0.00
Americas	63 419	63 419	0.00	0.00
Asia	77 747	77 747	0.00	0.00
Europe	957 963	912 695	43 704	1 564
Oceania	0.00	0.00	0.00	0.00
World	1 099 129	1 053 861	43 704	1 564

All values inTJ. Source: IEA Key World Energy Statistics

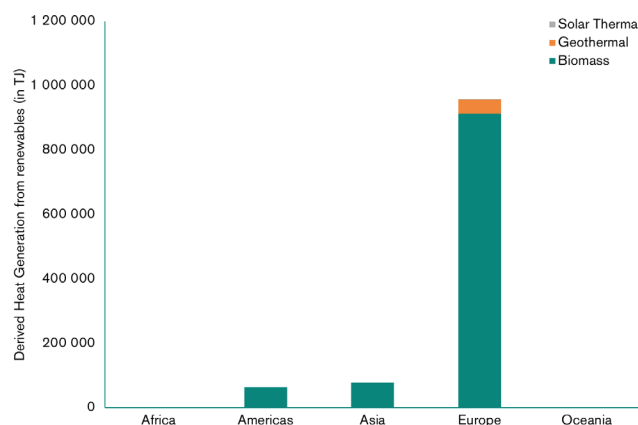


Figure 12 Derived heat from generation renewables in 2016

RENEWABLE DIRECT HEAT

The other end use of heating sector is direct heat, i.e. direct consumption of energy sources in the end use sectors of agriculture, residential, commercial etc. and excluding the transport sector. Renewables consumption in direct heating is dominated again by biomass as was the case with derived heating.

Table 13 Direct heat generation from renewables globally

	Total	Biomass	Geothermal	Solar Thermal
2000	38.0	37.6	0.16	0.21
2005	39.2	38.7	0.22	0.30
2010	40.7	39.8	0.27	0.64
2015	42.4	40.8	0.36	1.25
2016	42.4	40.6	0.54	1.28

All values in EJ. Source: IEA Key World Energy Statistics

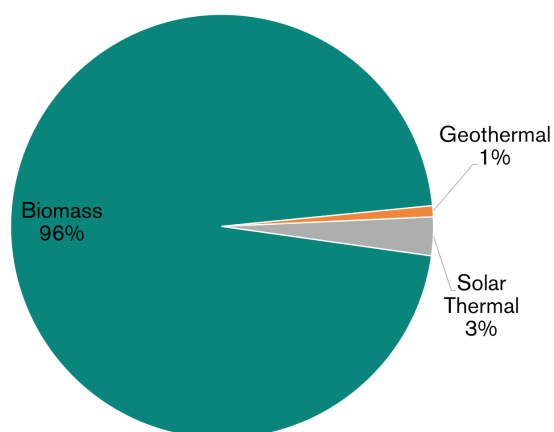


Figure 13 Direct heat generation from renewables in 2016

The use of biomass for direct heating amounted to 42.4 EJ in 2016. To compare, the total energy supply of biomass in 2016 was 56 EJ. The direct use of biomass for heating and cooking etc. is the largest part of the bioenergy end use. In effect, more than 80% of the biomass supply is used for direct heating and cookign - predominantly in Asia and African continents.

Table 14 Direct heat generation from renewables in continents in 2016

	Total	Biomass	Geothermal	Solar Thermal
Africa	13.4	13.4	0.00	0.01
Americas	5.79	5.65	0.01	0.13
Asia	19.1	17.6	0.48	1.04
Europe	3.82	3.69	0.04	0.09
Oceania	0.25	0.22	0.01	0.02
World	42.4	40.6	0.54	1.28

All values in EJ. Source: IEA Key World Energy Statistics

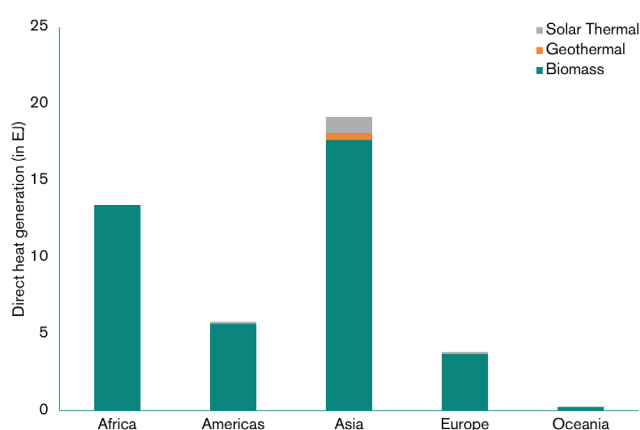


Figure 14 Direct heat generation from renewables in continents

RENEWABLE TRANSPORT

Electrification in the transport sector is making considerable progress. Apart from electrification using renewable electricity, biofuels are the only sustainable alternative to decarbonizing the transportation sector. In 2016, 3.43 EJ of biofuels was used in the transport sector accounting for 3% of the share in the total energy use in transport sector. The use of electricity in transport was 1%. However, during 2000 - 2016, the consumption of biofuels in transport increased from 1% to 3% while electricity use in transport has remained at 1%.

Table 15: Consumption of fuels in transport sector

	Total	Oil	Gas	Biofuels	Electricity
2000	82.0	78.3	2.41	0.42	0.78
2005	92.5	87.7	3.09	0.81	0.91
2010	101	94.2	3.71	2.35	1.05
2015	112	104	4.08	3.29	1.22
2016	115	106	4.27	3.43	1.29

All values in EJ. Source: IEA Key World Energy Statistics

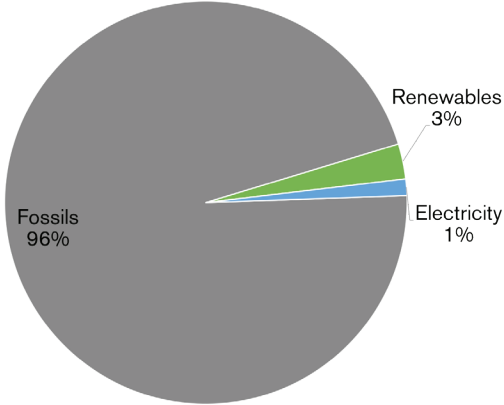


Figure 15 Use of renewable fuels in transport sector in 2016

CHAPTER 2: BIOENERGY SUPPLY

PRIMARY ENERGY SUPPLY OF BIOMASS

Biomass supply comes from a variety of feedstock – woodfuel, forestry residues, charcoal, pellets, agriculture crops and residues, municipal and industrial waste, biogas, biofuels etc. Broadly, the supply can be classified into three main sectors – forestry, agriculture and waste.

In 2016, the total primary energy supply of biomass was 56.5 EJ. 87% of the supply was in the form of solid biomass - wood chips, wood pelles, fuel wood etc. 5% of the supply is from waste sources - both municipal and industrial waste. Biofuels and biogas share is at 6% and 2%.

Table 16 Total primary energy supply of biomass

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	42.8	0.74	0.47	40.9	0.28	0.42
2005	45.9	0.94	0.40	43.2	0.50	0.85
2010	50.8	1.15	0.68	45.7	0.84	2.45
2015	55.4	1.37	0.80	48.7	1.30	3.26
2016	56.5	1.43	1.03	49.1	1.31	3.59

All values in EJ. Source: IEA Key World Energy Statistics

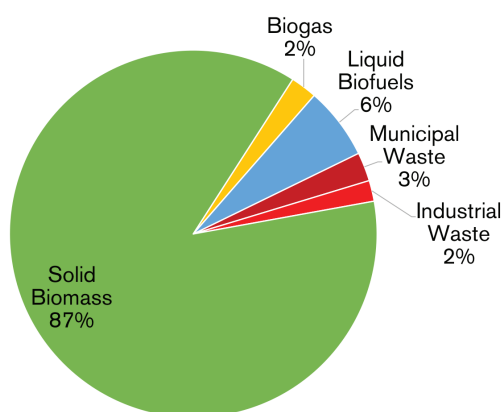


Figure 16 Total primary energy supply of biomass in 2016

The Total Primary Energy Supply of biomass is highest in Asia at 21.8 EJ followed by Africa at 16.3 EJ due to the high use of traditional biomass sources like agricultural residues, firewood, charcoal etc.

Table 17 Total primary energy supply of biomass in continents in 2016

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
Africa	16.3	0.00	0.00	16.3	0.00	0.00
Americas	10.7	0.31	0.05	7.62	0.19	2.53
Asia	21.8	0.19	0.55	20.3	0.40	0.38
Europe	7.38	0.93	0.42	4.66	0.70	0.66
Oceania	0.28	0.00	0.00	0.25	0.02	0.01
World	56.5	1.43	1.03	49.2	1.31	3.57

All values in EJ. Source: IEA Key World Energy Statistics

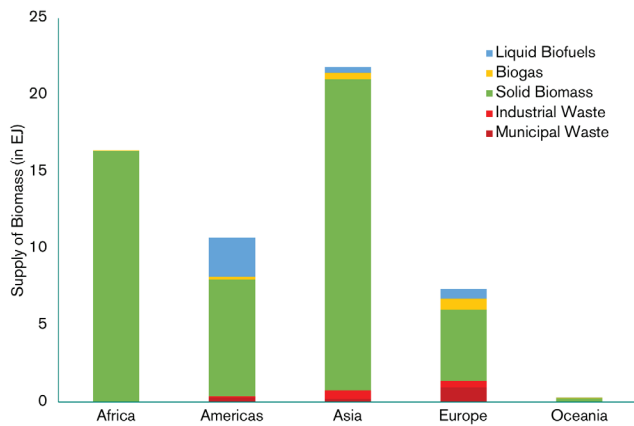


Figure 17 Total primary energy supply of biomass in continents in 2016

LAND

Land is an important part of the global bioenergy supply. The section below presents an overview of all land availability globally and not specific to bioenergy purposes.

The total land area available globally is 14 billion ha and almost evenly distributed between agricultural area, forestry area and other land.

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

Table 18 Land area globally

	Land Area	Agricultural Area	Forest Area	Other Land	Inland Water
2000	13 012	4 955	4 056	4 016	435
2005	13 012	4 940	4 033	4 053	435
2010	13 010	4 869	4 016	4 139	457
2015	13 009	4 869	3 999	4 156	458

All values in million ha. Source: FAOSTAT

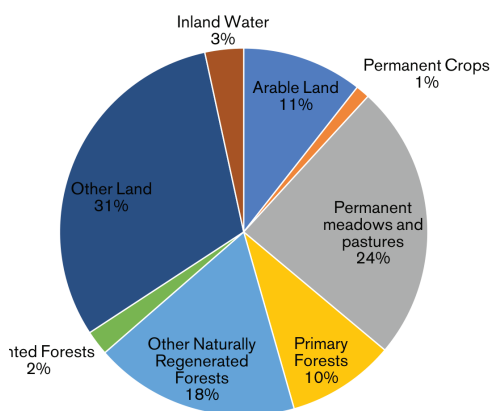


Figure 18 Land area globally in 2015

AGRICULTURE

Agriculture sector is a significant contributor to the biomass supply globally. 10% of all biomass supply (Feedstock) comes from agriculture sector in the form of energy crops for biofuels, biogas etc. It is important to note that the reference to agriculture area in this section deals with all area and not just specifically for bioenergy. The purpose is to educate and inform about the current agriculture area use globally and promote sustainable utilisation.

In 2015, 4.9 billion ha of agriculture area was available globally - mostly in the form of permanent pastures and meadows. 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). The arable land has increased by 26 million ha over the past 15 years.

Table 19 Agriculture area globally

	Agricultural Area	Arable Land	Permanent Crops	Permanent meadows and pastures
2000	4 955	1 400	138	3 417
2005	4 940	1 406	148	3 386
2010	4 869	1 388	159	3 322
2015	4 869	1 426	165	3 275

All values in million ha. Source: FAOSTAT

Table 20 Agriculture area in continents in 2015

	Agricultural Area	Arable Land	Permanent Crops	Permanent meadows and pastures
Africa	1 133	235	33.9	861
Americas	1 225	371	27.8	826
Asia	1 664	496	86.5	1 082
Europe	467	276	15.1	176
Oceania	379	47.3	1.53	331
World	4 869	1 426	165	3 275

All values in million ha. Source: FAOSTAT

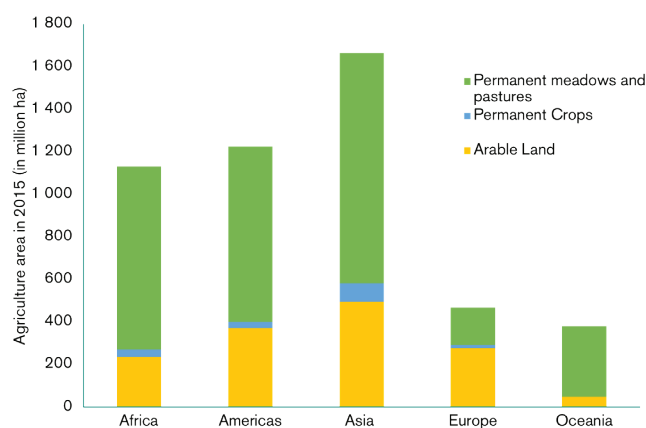


Figure 19 Agriculture area in continents in 2015

CROPS

Agriculture crops have varying uses in supply of biomass for energy purposes. Maize, Sugarcane and oil seed crops are converted to produce liquid bioethanol and biodiesel. Other cereals and sugar crops can be used for producing advanced biofuels via the use of residues like straw, husk and stalk etc. The data shown showcases the area harvested, yield and production quantities of major crops - not specifically focussed for biofuels and bioenergy production.

Table 21 Area harvested

	World		Africa		Americas		Asia		Europe		Oceania	
	2000	2016	2000	2016	2000	2016	2000	2016	2000	2016	2000	2016
Barley	54.4	46.9	4.11	3.55	7.66	5.08	11.5	9.78	27.6	24.3	3.51	4.16
Cassava	17.0	23.5	11.0	17.0	2.51	2.27	3.40	4.18	13.4	17.7	0.02	0.03
Maize	137	188	24.2	36.6	57.3	70.1	41.8	63.5	1.77	0.58	0.10	0.08
Millet	37.1	31.7	19.6	20.0	0.18	0.17	15.5	10.9	8.13	5.79	0.04	0.04
Oats	12.7	9.43	0.12	0.14	2.91	2.19	0.85	0.49	4.68	5.06	0.66	0.83
Olives	8.35	10.7	2.27	3.50	0.07	0.13	1.33	1.92	4.61	8.12	0.00	0.03
Rapeseed	25.9	33.7	0.06	0.11	5.53	8.92	14.2	14.2	0.61	0.67	1.46	2.36
Rice, paddy	154	160	7.56	12.5	7.64	6.12	138	140	8.58	3.58	0.14	0.03
Rye	9.8	4.40	0.02	0.05	0.33	0.34	0.9	0.37	0.23	0.40	0.04	0.05
Sorghum	41.1	44.8	21.2	30.5	7.09	6.01	12.0	7.29	1.08	5.04	0.62	0.52
Soybeans	74.3	122	0.90	1.98	54.6	94.6	17.7	19.9	4.18	3.07	0.06	0.03
Sugar beet	6.01	4.56	0.11	0.32	0.62	0.48	1.09	0.70	0.00	0.00	0.49	0.49
Sugar cane	19.4	26.8	1.29	1.57	8.71	13.9	8.89	10.8	11.3	18.1	0.16	0.02
Sunflower seed	21.2	26.2	0.86	2.23	4.94	2.34	3.93	3.54	55.2	62.5	12.2	11.3
Wheat	215	220	8.14	8.87	41.4	36.9	98.0	100	3.51	4.16	0.00	0.00

All values in million ha. Source: FAOSTAT

In terms of yield, all the crops have higher yields (tons/ha) in 2016 compared with 2000. In other words, more agriculture commodities are produced on a particular area of land than 16 years ago. On the other hand, Africa has some of the lowest crop yields in comparison to world average.

Table 22 Yields of major crops

	World		Africa		Americas		Asia		Europe		Oceania	
	2000	2016	2000	2016	2000	2016	2000	2016	2000	2016	2000	2016
Barley	2.45	3.01	0.52	1.30	2.93	3.69	1.52	2.04	3.04	3.64	2.01	2.25
Cassava	10.4	11.8	8.66	9.25	12.3	13.4	14.5	21.3	4.70	6.62	11.3	9.8
Maize	4.32	5.64	1.81	1.93	5.85	7.81	3.56	5.11	0.90	1.64	5.75	8.17
Millet	0.75	0.89	0.65	0.68	1.18	1.70	0.84	1.23	2.05	2.43	1.46	1.02
Oats	2.06	2.44	0.83	1.31	2.32	2.89	1.81	2.14	2.25	2.33	1.65	1.62
Olives	1.87	1.81	0.71	1.06	3.45	4.25	2.45	1.65	2.55	2.75	1.83	2.29
Rapeseed	1.53	2.04	1.11	1.61	1.49	2.28	1.25	1.63	5.25	6.34	1.22	1.25
Rice, paddy	3.89	4.64	2.31	2.60	4.15	5.88	3.95	4.75	2.11	3.08	7.99	9.37
Rye	2.05	2.94	1.49	1.88	1.84	2.36	1.56	2.55	3.35	3.11	0.57	0.60
Sorghum	1.36	1.43	0.87	0.98	3.28	3.84	0.94	1.09	1.78	2.08	3.40	3.44
Soybeans	2.17	2.76	1.05	1.07	2.47	3.10	1.31	1.45	40.7	60.4	1.87	2.14
Sugar beet	41.6	60.7	51.9	55.4	58.6	73.8	34.5	55.7	98.5	82.6	86.2	73.7
Sugar cane	64.6	70.6	66.7	58.6	65.6	74.7	62.1	67.0	1.18	1.91	1.05	1.09
Sunflower seed	1.25	1.81	1.07	1.00	1.65	1.95	1.03	1.72	3.32	4.00	1.84	2.01
Wheat	2.72	3.41	1.75	2.60	2.67	3.43	2.60	3.25	2.01	2.25	0.00	0.00
Sugarcane	64.7	69.5	66.3	64.4	65.5	71.1	62.6	67.8	98.5	81.0	86.2	76.4

All values in tons/ ha. Source: FAOSTAT

Table 23 Production quantities of crops

	World		Africa		Americas		Asia		Europe		Oceania	
	2000	2016	2000	2016	2000	2016	2000	2016	2000	2016	2000	2016
Barley	133	141	2.12	4.61	22.4	18.8	17.5	20.0	84.0	88.6	7.05	9.36
Cassava	176	277	95.4	157	30.8	30.3	49.5	89.3	0	0	0.18	0.25
Maize	592	1 060	43.8	70.6	335	547	149	324	63.1	117	0.60	0.63
Millet	27.7	28.4	12.7	13.6	0.21	0.29	13.1	13.4	1.59	0.96	0.06	0.04
Oats	26.1	23.0	0.10	0.18	6.74	6.32	1.54	1.06	16.7	14.1	1.09	1.35
Oil, palm	22.2	0.00	1.85	0.00	1.32	0.00	18.7	0	0.00	0	0.37	0
Olives	15.7	19.3	1.61	3.70	0.24	0.54	3.27	3.17	10.5	11.8	0.00	0.08
Rapeseed	39.6	68.9	0.07	0.18	8.23	20.3	17.7	23.1	11.7	22.3	1.78	2.95
Rice, paddy	599	741	17.5	32.5	31.7	36.0	545	668	3.18	4.22	1.12	0.28
Rye	20.1	12.9	0.03	0.10	0.61	0.81	1.35	0.94	18.1	11.1	0.02	0.03
Sorghum	55.8	63.9	18.4	29.8	23.3	23.1	11.3	7.96	0.76	1.25	2.12	1.80
Soybeans	161	335	0.95	2.12	135	293	23.2	28.8	1.92	10.5	0.10	0.06
Sugar beet	250	277	5.79	17.6	36.5	35.7	37.7	38.9	170	185	0.00	0
Sugar cane	1 253	1 891	86.1	91.7	572	1 041	552	722	0.11	0.01	42.1	36.2
Sunflower seed	26.5	47.3	0.93	2.23	8.13	4.56	4.06	6.09	13.3	34.4	0.17	0.03
Wheat	585	749	14.3	23.1	110	127	255	327	183	250	22.4	22.7

All values in million tonnes. Source: FAOSTAT

FORESTRY AREA

Forestry sector is the largest contributor to biomass supply globally and important factors include the area of forest land and production of forest products including wood fuel, charcoal. Following data is for the global forestry area including primary forests, other naturally regenerated forests and planted forests.

The total forestry area has been reducing over the past few years. In 2015, approx. 4 billion ha of forestry area was available globally - most of it as naturally regenerative forests.

Table 24 Forestry area globally

	Forest Area	Primary Forests	Other Naturally Regenerated Forests	Planted Forests
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

All values in million ha. Source: FAOSTAT

Most of the primary forests exist in Americas - Canada and Brazil. However, Asia has more planted forests than any other continent.

Table 25 Forest area in 2015

	Primary Forests	Other Naturally Regenerated Forests	Planted Forests
Africa	135	473	16.3
Americas	720	814	58.3
Asia	117	347	129
Europe	278	652	85.5
Oceania	26.9	142	4.4
World	1 277	2 429	293

All values in million ha. Source: FAOSTAT

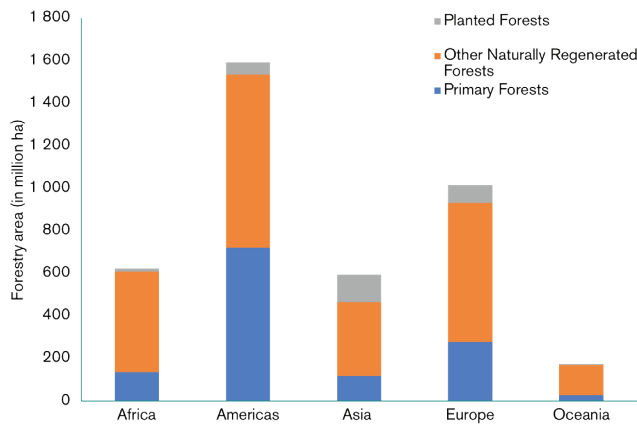


Figure 20 Forest land area in 2015

WOOD FUEL

Woodfuel is 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.

In 2017, 1.9 billion m³ of woodfuel was produced globally - predominantly in Asia (38%) and in Africa (36%).

Table 26 Wood fuel production globally

	World	Africa	Americas	Asia	Europe	Oceania
2000	1 772	542	314	808	94.8	12.7
2005	1 799	589	300	792	107	11.5
2010	1 824	631	290	764	127	10.7
2015	1 872	666	307	732	157	10.0
2016	1 889	673	323	727	157	9.93
2017	1 892	673	325	727	158	10.0

All values in million m³. Source: FAOSTAT

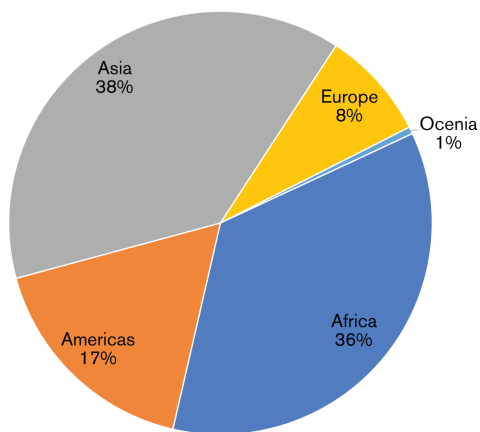


Figure 21 Wood fuel production globally

WASTE

Municipal and Industrial Waste are two important sources for bioenergy production. Together, they contribute about 3% to the total biomass supply. Use of waste to produce energy solves both energy and environmental problems. In 2015, 2.17 EJ of energy was produced from waste sector globally.

Table 27 Energy recovery from waste globally

	Total	Energy from MSW	Energy from Industrial Waste
2000	1.20	0.74	0.47
2005	1.34	0.94	0.40
2010	1.83	1.15	0.68
2015	2.17	1.37	0.80

All values in EJ. Source: IEA Key World Energy Statistics

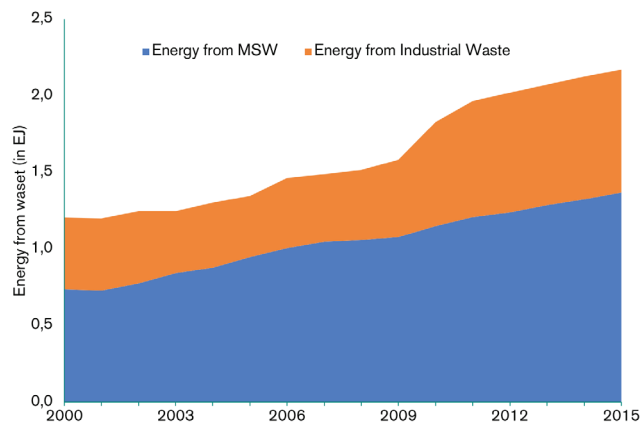


Figure 22 Energy recovery from waste globally

Most of the waste to energy conversion plants are located in Europe and EU 28 countries - e.g. Sweden and UK.

Table 28 Energy recovery from waste in continents in 2015

	Total	Energy from MSW	Energy from Industrial Waste
World	2.17	1.37	0.80
Africa	0.00	0.00	0.00
Americas	0.36	0.30	0.06
Asia	0.56	0.20	0.36
Europe	1.24	0.87	0.37
Oceania	0.00	0.00	0.00

All values in EJ. Source: IEA Key World Energy Statistics

CHAPTER 3: BIOMASS TO ELECTRICITY

ELECTRICITY GENERATION FROM BIOMASS

Electricity from biomass (Biopower) is the 3rd largest renewable electricity source globally after hydropower and wind. In 2016, 571 TWh of biopower was generated globally - 65% from solid biomass sources like wood chips and wood pellets, 19% from municipal and industrial waste followed by 15% from biogas - mainly in Europe.

Table 29 Electricity generation from biomass

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	164	34.3	15.3	102	13.1	0.00
2005	227	46.2	11.8	146	21.0	1.98
2010	372	60.6	20.7	239	46.2	5.07
2015	528	71.4	22.8	344	82.5	7.62
2016	571	71.9	36.5	369	84.7	8.1

All values in TWh. Source: IEA Key World Energy Statistics

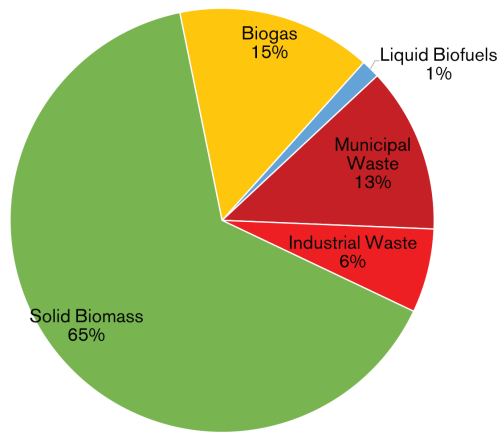


Figure 23 Electricity generation from biomass in 2015

Europe and mainly EU - 28 nations are leaders in biopower production globally with 208 TWh of production. In terms of feedstock, Europe also leads the production of electricity from biogas, liquid biofuels and municipal waste. Asia utilises a lot of industrial waste for electricity production while North and South America produce the most biopower from solid biomass - e.g. wood chips and pellets.

Table 30 Electricity generation from biomass in continents in 2015

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
Africa	1.94	0.00	0.00	1.91	0.04	0.00
Americas	163	17.0	2.01	128	15.6	0.21
Asia	189	10.4	26.7	145	4.33	2.57
Europe	213	44.5	7.83	91.9	63.2	5.30
Oceania	4.30	0.00	0.00	2.78	1.52	0.00
World	571	71.9	36.5	369	84.7	8.07

All values in TWh. Source: IEA Key World Energy Statistics

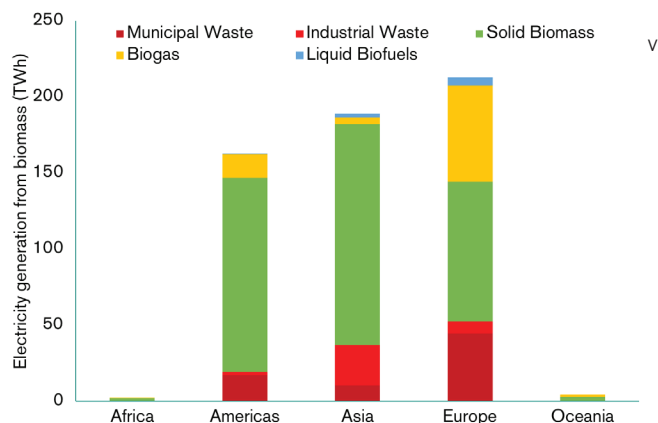


Figure 24 Electricity generation from biomass in continents in 2016

ELECTRICITY ONLY PLANTS

Electricity only plants refer to plants designed to generate electricity only while the heat is not utilized. In 2016, 6.5 EJ of biomass was utilized globally for electricity generation in electricity only plants.

Table 31 Use of biomass in electricity only plants globally

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	1.08	0.38	0.06	0.52	0.12	0.00
2005	2.10	0.51	0.03	0.97	0.19	0.41
2010	3.43	0.60	0.18	1.80	0.29	0.55
2015	5.50	0.66	0.22	2.82	0.45	1.35
2016	6.51	0.67	0.34	3.54	0.45	1.50

All values in EJ. Liquid Biofuels in Mt. Source: IEA Key World Energy Statistics.

CHP PLANTS

Combined heat and power (CHP) plants is the simultaneous production and utilization of heat and electricity. The use of cogeneration leads to higher overall efficiencies as the heat is also utilized – predominantly for district heating networks.

In 2016, 3.04 EJ of biomass was used for electricity generation in CHP plants.

Table 32 Use of biomass for electricity in combined heat and power plants

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	1.05	0.19	0.14	0.69	0.03	0.00
2005	1.56	0.29	0.12	0.91	0.05	0.19
2010	2.45	0.37	0.13	1.09	0.15	0.70
2015	3.01	0.49	0.14	1.48	0.32	0.58
2016	3.04	0.52	0.15	1.52	0.33	0.52

All values in EJ. Liquid Biofuels in Mt. Source: IEA Key World Energy Statistics.

CHAPTER 4: BIOMASS TO DERIVED HEAT

Bioheat is heat generated from bio based resources or biomass. Biomass is the largest renewable energy source for heating sector globally. The heat is used in various sectors including residential, industrial, commercial, agriculture etc.

Heat generation from biomass is obtained either via derived heat or direct heat. Derived heat is heat generated in heat only and combined heat and power plants.

In 2016, 1.05 EJ of derived heat was generated from biomass based sources - predominantly solid biomass.

Table 33 Derived heat generation from biomass globally

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	414 081	125 141	74 975	208 995	4 931	39.0
2005	530 237	152 549	82 630	284 745	6 615	3 698
2010	781 020	206 212	126 337	426 477	12 296	9 698
2015	940 492	265 300	138 958	498 795	32 948	4 491
2016	1 053 861	294 983	166 924	549 507	37 475	4 972

All values in TJ. Source: IEA Key World Energy Statistics

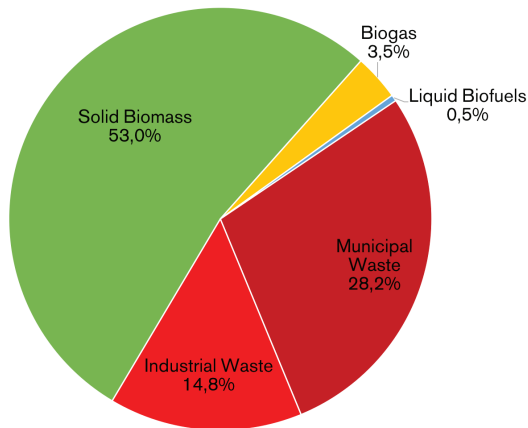


Figure 25 Derived heat generation from biomass in 2016

Most of the derived heat is generated in Europe and EU 29 countries.

Table 34 Derived heat generation from biomass in continents in 2016

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
Africa	0	0	0	0	0	0
Americas	63 419	17 243	6 815	34 314	5 047	0
Asia	77 747	9 983	50 231	15 086	2 447	0
Europe	912 695	267 757	109 878	500 107	29 981	4 972
Oceania	0	0	0	0	0	0
World	1 053 861	294 983	166 924	549 507	37 475	4 972

All values in EJ. Source: IEA Key World Energy Statistics

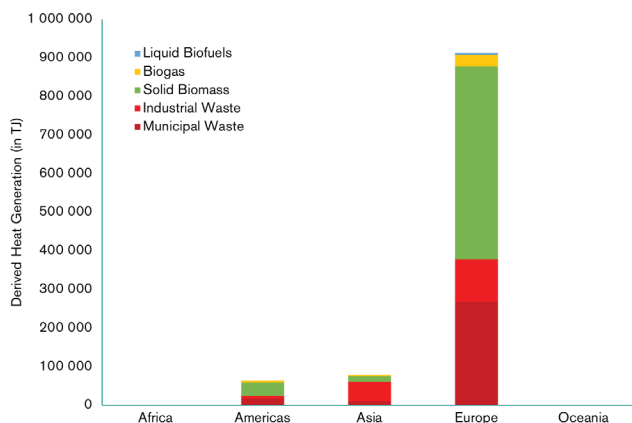


Figure 26 Derived heat generation from biomass in 2016

HEAT ONLY PLANTS

Heat only plants are power plants designed only to produce heat and sell it to a third party. In 2016, 0.62 EJ of biomass was used to generate heat in heat only plants.

Table 35 Use of biomass in heat only plants

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	0.24	0.05	0.04	0.15	0.00	0.00
2005	0.39	0.07	0.05	0.19	0.00	0.08
2010	0.68	0.10	0.10	0.24	0.01	0.24
2015	0.54	0.08	0.12	0.26	0.01	0.07
2016	0.62	0.10	0.13	0.30	0.01	0.08

All values in EJ. Liquid Biofuels in Mt. Source: IEA Key World Energy Statistics.

CHP PLANTS

Heat from biomass can also be generated in combined heat and power plants. Such cogeneration ensures higher efficiency of conversion of biomass where electricity produced is transferred to the grid and the heat can be utilized in district heating networks. In 2016, 3.04 EJ of biomass was used in CHP plants.

Table 36 Use of biomass in CHP plants

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	1.05	0.19	0.14	0.69	0.03	0.00
2005	1.56	0.29	0.12	0.91	0.05	0.19
2010	2.45	0.37	0.13	1.09	0.15	0.70
2015	3.01	0.49	0.14	1.48	0.32	0.58
2016	3.04	0.52	0.15	1.52	0.33	0.52

All values in EJ. Source: IEA Key World Energy Statistics. Average conversion of 30%

CHAPTER 5: BIOMASS TO LIQUID BIOFUELS

BIOFUELS PRODUCTION

Liquid Biofuels are the leading renewable solution for the transport sector. They have experienced sustained growth over the past 16 years. Since 2000 - 2017, biofuel production has increased 10 times from 16 billion litres to 143 billion litres.

Table 37 Liquid biofuels production globally

	Total	Bioethanol	Biodiesel	Other Biofuels
2000	15.9	12.2	0.78	2.97
2005	34.1	24.5	3.42	6.16
2010	94.4	60.5	18.9	15.0
2015	125	82.0	28.9	14.6
2016	132	85.6	32.6	13.6
2017	143	-	-	-

All values in billion litres. Source: IEA Key World Energy Statistics and REN21 GSR 2018

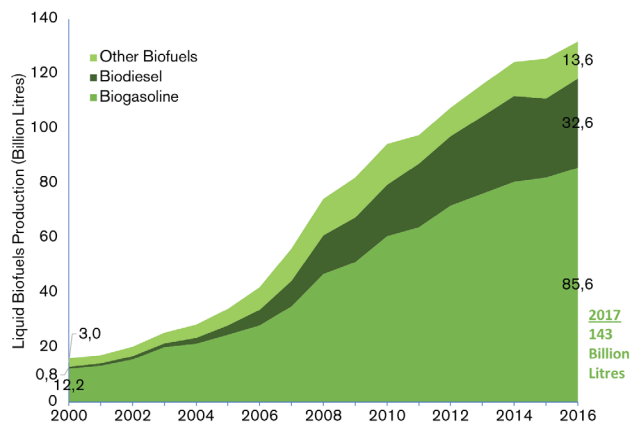


Figure 27 Liquid biofuels production globally

Bioethanol is the largest biofuel and hence, the largest renewable fuel in the global transport sector. Biodiesel is also quite significant in production while advanced/other biofuels are gaining prominence recently. USA and Brazil are the largest biofuel and bioethanol producers globally with a production share of 87% whereas biodiesel production share is evenly distributed between Asia, Americas and Europe.

Table 38 Liquid biofuels production in continents in 2016

	Total	Biogasoline	Biodiesel	Other Biofuels
Africa	0.07	0.07	0.00	0.00
Americas	101	72.1	12.5	16.0
Asia	13.9	5.95	7.48	0.47
Europe	19.3	4.42	13.7	1.13
Oceania	0.29	0.2	0.06	0.00

All values in billion litres. Source: IEA Key World Energy Statistics

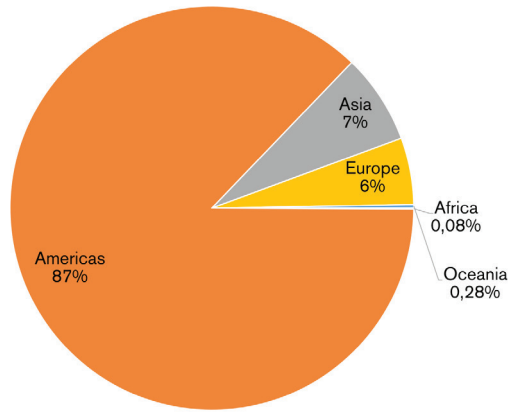


Figure 28 Liquid bioethanol production in 2016

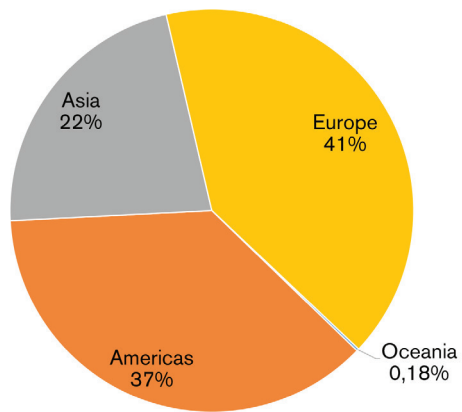


Figure 29 Liquid biodiesel production in 2016

CHAPTER 6: SPECIAL SECTORS

BIOGAS

Biogas is gaseous fuel produced from biomass using the process of anaerobic digestion of organic matter. The gas basically consists of methane and carbon dioxide. Typical feedstock includes manure and sewage, agricultural residues and organic part of household waste. The biogas can be either used directly in the transportation sector (after upgrading to biomethane) or burned to generate heat and electricity.

61 billion m³ of biogas was produced globally in 2016. Europe produces more than half of the biogas produced globally while Asia share is 30%.

Table 39 Biogas production globally

	Biogas (Billion m ³)	Biogas (EJ)
2000	13.2	0.28
2005	23.1	0.50
2010	38.7	0.84
2015	60.0	1.30
2016	60.8	1.31

Source: IEA Key World Energy Statistics

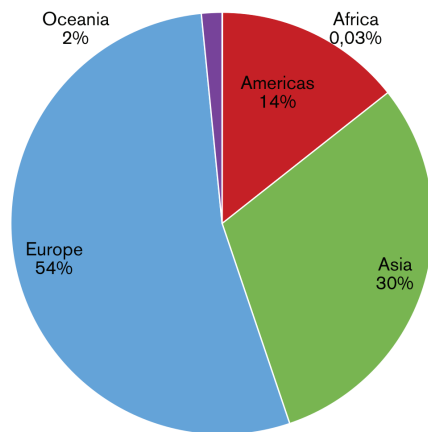


Figure 30 Biogas production in continents in 2016

PELLETS

Pellets are a solid biomass fuel, mainly produced from wood residues but also from agricultural by-products such as straw. 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. 31.2 million tonnes of pellets were produced globally in 2017. Europe is the world leader in pellet production at 57% followed mainly by Americas (USA) at 31%.

Table 40 Pellet 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	13.8	0.03
2014	25.0	0.04	7.96	1.72	15.2	0.14
2015	27.4	0.03	8.76	2.01	16.5	0.15
2016	29.7	0.04	9.49	3.38	16.6	0.16
2017	31.2	0.04	9.81	3.38	17.8	0.16

All values in million tonnes. Source: FAOSTAT

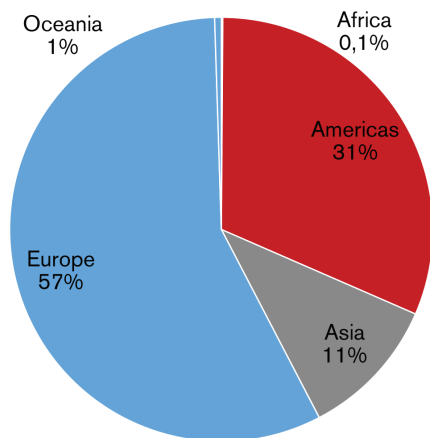


Figure 31 Pellet production globally in 2017

CHARCOAL

Charcoal is produced via the partial burning of biomass. The residue consists mainly of carbon and other residues. Charcoal sector is a highly-underestimated sector due to its largely informal trade of the product. Unlike pellets and liquid biofuels, charcoal is produced and consumed locally. Moreover, the process of conversion is highly inefficient process. In 2017, 44 million tonnes of charcoal was produced - mainly in Africa.

Table 41 Charcoal production globally

	World	Africa	Americas	Asia	Europe	Oceania
2012	37.0	20.4	9.67	6.54	0.30	0.04
2013	38.1	21.4	9.77	6.57	0.30	0.04
2014	40.2	22.2	9.87	7.73	0.38	0.04
2015	42.5	23.0	11.1	7.89	0.46	0.04
2016	43.2	23.8	11.0	7.87	0.50	0.03
2017	44.0	24.5	10.9	8.01	0.51	0.03

All values in million tonnes. Source: FAOSTAT

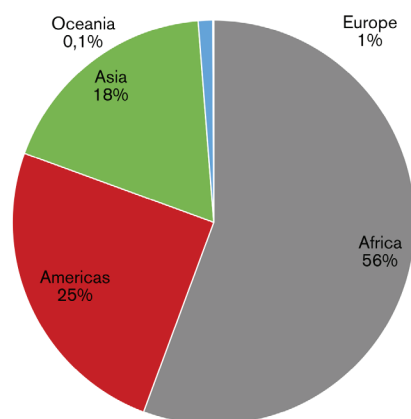


Figure 32 Charcoal production in 2017

CHAPTER 7: RENEWABLE JOBS

Renewable energy technologies create jobs. In 2017, 10.4 million people were employed in the renewable energy industry globally. Vast majority of them are in the solar energy industry and bioenergy industry. Bioenergy is the 2nd largest job creator among renewables with more than 3.07 million people working in the sector.

Table 42 Renewable energy jobs (2012 - 2017)

	Total	Hydro	Solar	Bioenergy	Wind	Others
2012	7.14	1.41	2.25	2.40	0.75	0.33
2013	8.22	1.74	2.77	2.50	0.83	0.38
2014	9.34	1.66	3.26	2.99	1.03	0.40
2015	9.70	1.63	3.71	2.88	1.08	0.40
2016	9.79	1.52	3.92	2.74	1.16	0.45
2017	10.4	1.51	4.18	3.06	1.15	0.45

All values in million jobs. Source: IRENA

The largest job creator in the bioenergy sector is the sugarcane industry in Brazil for production of bioethanol and biopower which employs close to 1 million people. It is important to note that these data does not include traditional biomass which accounts for the major supply of bioenergy globally. Including traditional biomass would further increase the bioenergy jobs globally.

Table 43 Renewable energy jobs in 2017

	World	Americas	Asia	Europe
Total	10 343	1 888	5 216	1 268
Hydro	1 804	231	728	148
Solar	4 206	303	3 351	140
Bioenergy	3 055	1 181	557	660
Wind	1 148	140	576	344
Geothermal	93	35	4	25

All values in million jobs. Source: IRENA

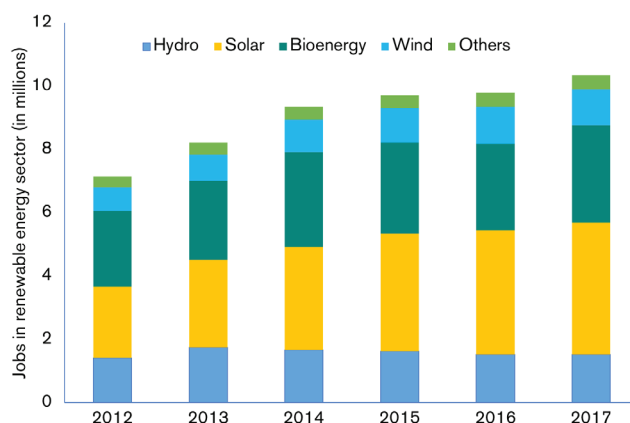


Figure 33 Renewable energy jobs in continents in 2017

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, 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

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).

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

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.

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

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

Derived heat: Derived heat covers the total heat production in heating plants and in combined heat and power plants.

Direct heat: Direct heat from biomass is the heat produced and used from direct combustion of biomass. It excludes the heat production from power plants. It is calculated as:

Biomass for direct heating = Total primary energy supply of Biomass - Biomass use for electricity - Biomass use for biofuels

District heat: District heating is the concept of using surplus heat from power plants for heating residential, public and/or commercial buildings as well as meeting industrial demands for low temperature heat.

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

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

Gross Final Energy Consumption: GFEC (Gross Final Energy Consumption): It is the sum of: Total final energy consumption, Consumption of electricity and heat by the transformation sector, including the energy industry own use, Losses in transmission and distribution of electricity and heat

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

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.

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.

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).

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, vapourized, and the vapours then quenched into the Pyrolysis Oil liquid, also known as bio-oil.

Renewable municipal waste: Municipal waste – renewable consists of the biodegradable part of municipal waste products that are combusted directly to produce heat and/or electricity. It comprises waste produced by the residential, commercial and public services sectors that is collected by local authorities for disposal in a central location, including biodegradable hospital waste.

Roundwood: Roundwood comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period, calendar year or forest year.

Torrefaction or torrefied biomass: Torrefaction is the thermal treatment of various woody and agricultural residue feedstock in which biomass is heated to 250 – 300 °C and at atmospheric pressures.

Total Primary Energy Supply: TPES (Total Primary Energy Supply): It is the energy content of the energy sources and is calculated as production + imports – exports +/- international bunkers +/- stock changes.

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

Vegetable oils: It includes the production and consumption of coconut oil, cottonseed oil, olive oil, palm oil, palm kernel oil, peanut oil, rapeseed oil, soybean oil and sunflower seed oil.

Vegetal waste: Mainly crop residues (cereal straw from maize, wheat, paddy rice, etc.) and food processing wastes (rice hulls, coconut husks, ground nut shells, etc.) used for fuel. Bagasse is excluded.

Wood charcoal: Wood charcoal is wood carbonised 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 metres solid volume underbark (i.e. excluding bark).

GENERAL DATA

USEFUL CONVERSIONS

Table A1 Energy units conversion

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

(Source: IEA)

Table A2 Average density and energy content values for bioenergy

	Density	Unit	Energy content	Unit
Bioethanol	0.79	kg/l	23.4	MJ/l
Biodiesel	0.88	kg/l	35.2	MJ/l
Adv. Biof.	0.84	kg/l	29.3	MJ/l
Biogas			21.6	MJ/Nm ³
Pellets	600	kg/m ³	17.3	MJ/kg
Charcoal			30	GJ/ton

(Source: WBA)

REFERENCES

The information contained in this report is gathered from a range of sources:

1. IEA Key World Energy Statistics
2. FAOSTAT
3. REN21 Global Status Report
4. World Bank Data
5. World Bioenergy Association Factsheets
6. IRENA

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