WBA GLOBAL BIOENERGY STATISTICS 2017

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DISCLAIMER

MESSAGE FROM THE PRESIDENT

Dear readers,

Welcome to the 4th edition of our flagship publication - WBA Global Bioenergy Statistics 2017.

As a global organization, we are dedicated to supporting and representing the wide range of actors in the bioenergy sector. We see that it is necessary to track development of bioenergy worldwide to understand and notice the various trends - positive and negative - globally. This allows us to disseminate the best examples and success stories and also to improve the technology and knowledge transfer.

The process of the global climate change and the Paris Agreement requests us to speed up the advancement of all the renewable energy technologies, and especially bioenergy, as it is the largest renewable energy source globally, having ability to serve as perfect energy carrier for all needs – for production of heat, electricity and transport fuels.

We have certainly made considerable progress in the electricity sector. Bioenergy is the 3rd largest renewable electricity source. In the heating sector, biomass is the leader in providing a clean and renewable heating source. Finally, although electrification is increasing in transport, liquid and gaseous biofuels are the leading renewable solution for the sector. We also see a lot of progress in other biofuel sectors of biogas and pellets.

Finally, to get credible and updated data on bioenergy is a challenge which WBA is working well to address with this report. I invite all relevant stakeholders to join us in improving this report.

Now is the time to show strong leadership in bioenergy deployment, therefore we urge governments all over the world, international and national bioenergy associations, research institutions and companies to put even more efforts towards clean and fossil-free future!

Remigijus Lapinskas

President

World Bioenergy Association

WORLD BIOENERGY ASSOCIATION - THE GLOBAL VOICE OF BIOENERGY

Mission:

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

Together wih 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 bio mass, bioenergy statistics, bioimass 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

EXECUTIVE SUMMARY

Renewable supply globally increased to 18.6% in 2014 - a 0.3% increase over the previous year. The growth is prominent in Asian and African continents which together accounted for half of the renewable energy supply while Europe accounted for 10%. Among the top 10 countries in energy supply, India (25.4%), Brazil (39%) and Indonesia (34.4%) have the highest share of renewables supply.

In consumption, renewables share increased to 18.6% - a 0.2% increase over the previous year. Asia consumes almost half of the renewable energy consumption globally. Again, among the top 10, India, Brazil and Indonesia have the highest share of renewables due to a large presence of biomass and hydropower in their energy system.

Among the end consumption sectors of electricity, heat and transportation, the share of renewables is highest in the electricity sector. The global renewable electricity generation increased to 5 469 TWh accounting for 23% of the global electricity generation. Biomass is the 3rd largest renewable electricity generating source with generation of 493 TWh. However, solar and wind electricity are the fastest growing sectors with annual growth rates of 45.1% and 25.1%.

Derived heat (heat produced in power plants) and Direct Heat (heat directly consumed in end sectors) are dominated by biomass. The renewables share is 7.1% in derived heat and 27.7% in direct heat. In both sectors, biomass contribution is more than 95%. The contribution of renewables - solar thermal and geothermal - is minimal. Heat sector is the single most important future development sector for biomass.

The share of renewables in transport sector is quite low. Only 2.8% - of the transport sector is renewable. This is largely due to the use of biofuels and they are growing at a faster rate than electrification.

The total supply of biomass in 2014 was 59.2 EJ accounting for 10.3% of the global energy supply. The growth is at 2.3% annually. The forestry sector is key for biomass development. Fuelwood accounts for 67% of the biomass feedstock share followed by 7% from charcoal, 6% from recovered wood and 5% from wood industry residues. The forestry sector as a whole accounts for 87% of the supply of biomass.

Agriculture sector contributes 10% to biomass supply - via the use of animal byproducts, agricultural byproducts and energy crops.

The third sector of waste to energy accounts for the remaining 3% with energy generated from Municipal Solid Waste (MSW) and landfill gas.

Bioenergy development requires land. The total land area is 13 billion ha - 37.6% in agriculture sector and 30% in the forestry sector. Since 2000, the arable land for temporary crops has increased by 0.09% while the area set aside for permanent crops and meadows increased to 1.28%. More than half of the global agricultural area is in Europe.

Primary forestry area decreased while planted forests (mainly in China) has seen an annual growth of 1.9% to reach 290 million ha.

In agricultural sector, comparing yields of major crops across all continents, Africa has the lowest average yields. Agricultural residues have significant potential to increase bioenergy supply from the agriculture sector. Theoretical estimate show a high potential of 123 EJ.

In forestry sector, one third of all the forest area is available in two countries - Russia and Brazil. In terms of forestry products, 1.9 billion m^3 of woodfuel is generated globally with India still maintaining the lead in woodfuel production.

Waste sector is a highly disorganized sector with data lacking globally. The energy recovery from waste is increasing at an annual rate of 4% since 2000. 55% of all the waste to energy conversion happens in Europe.

Bioelectricity is still a significant portion of the electricity mix for countries globally. However, Europe leads the way in bioelectricity production with generation of 196 TWh. The production efficiencies vary across regions as electricity only plants are increasing in Asia while Europe predominantly uses combined heat and power plants for electricity generation.

Bioheat is the most important use of biomass globally. More than 90% of the biomass use is in heating - derived and direct heating. The use varies globally with EU - 28 nations generating 66% of all derived heat from biomass globally while Asia and Africa cover 79% of all direct heating from biomass globally.

In transport sector, liquid biofuels production has reached 126 billion litres globally. 95.1 billion litres is produced in USA and Brazil. The biofuels sector is a rapid growth sector with annual growth rates of 15%

EXECUTIVE SUMMARY (CONTINUED..)

since 2000. In comparison, the annual growth of biomass supply is 2.3%.

Land is a factor for liquid biofuel production. An estimate of the total land used for agricultural purposes shows that biofuel production covered about 2.9% of the total agricultural land. Moreover, the production of liquid biofuels also produced protein - an important feed for livestock globally. The total production of DDGS (Dried Distillers Grain Solubles) and oil cake was 75.3 million tonnes.

Some special biofuel sectors with rapid growth or volumes are biogas, pellets and charcoal. Biogas production reached 58.7 billion Nm^3 with an average growth rate of 11.2%. Almost half of the biogas production occurs in Europe.

Pellets are one of the fastest growing bioenergy carriers. Globally, 28 million tonnes were produced annually, with 59% of the production in Europe and 34% in Americas. Asian countries (South Korea and Japan) are the largest pellet importers outside the EU - 28 nations.

Globally, 52 million tonnes of charcoal was produced annually - almost twice the amount of pellets. 62% of the global charcoal production is in Africa.

Renewable energy created 9.8 million jobs globally - largely in the solar energy sector in Asia. Bioenergy sector employed 2.8 million people. Most of the bioenergy jobs are in the biofuels sector in USA and Brazil. The actual number of jobs created in the bioenergy sector will be a lot higher as traditional biomass sector is not considered in jobs creation.

Finally, WBA made an attempt to gather updated renewable and bioenergy sector data from countries. 10 countries were opted and data is presented. The section shows various challenges in data collection, analysis and reporting.

WBA MEMBERS

FULL AND ASSOCIATED MEMBERS

* Individuals members are not listed

TABLE OF CONTENTS

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 4th in this series.

Bioenergy is a complex energy system. Many years of experience in the sector doesn't yet come close to understanding the immense complexity in feedstock, conversion technologies, end uses, policies etc. which encompass this sector. One thing for sure is that bioenergy is an important energy source and will play a crucial role in the future energy mix. It is surprising that not everyone is aware of the fact that bioenergy 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 on a global level.

In the age of sensationalizing news, it is sometimes a hard task to capture headlines. Although some sectors of bioenergy are increasing at an impressive growth rate, for e.g. pellets and liquid biofuels, others have shown decent growth. This is also progress and has to be appreciated. At the same time, it is clear the rate of progress is quite slow and bioenergy still faces immense challenges in development. These challenges include technology, costs, and most importantly the unstable regulatory framework.

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 Sustainabel 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 woodfuel) 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 3 tier system – global, continental and regional. The continental classification is available in the Appendix. For regional data, the top 10 countries in that particular category are reported. In the top 10, European countries are not included and EU – 28 is reported in a separate row. The bioenergy data for EU – 28 is already well reported.

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. As most of the

data is from IEA, the base year for the report for energy gures is 2014. Supply data includes 2015 data while special sectors like biofuels and jobs have data for 2016.

This is a combined effort and special mention goes to the new collaborative partners who joined as contributors from this year onwards. In the past year, we reported country data for 5 countries. This increased to 10 largely due to the excellent work by our contributors.

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. Mistakes can happen and we appreciate your feedback as always to improve.

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

Bharadwaj Kummamuru

Project Officer and Lead Author, WBA GBS

World Bioenergy Association

1. GLOBAL OVERVIEW

KEY FINDINGS

Energy Supply

- Renewables share in energy supply grew by 0.3% to 14.1% in 2014
- Renewables supply in African continent covers 50% of its energy supply.

Energy trade

- Renewables play a minor role in trade of energy with import and export of bioenergy products (e.g. pellets and liquid biofuels) dominating
- EU – 28 nations import 9 times as much energy (mostly fossil fuels) in comparison to whole African continent

Energy consumption

- The share of renewables in consumption has increased to 18.6% - a 0.2% increase in the consumption
- Asia consumes the highest amount of renewable energy – 30.4 EJ – almost half of the global consumption of renewables
- Out of the top 10 nations in energy consumption, developing countries like Brazil (41.4%), India (36.6%) and Indonesia (38.1%) have the highest share of renewables.

Energy supply to consumption

- Energy consumption in the electricity sector is dominated by the use of coal (29 EJ), natural gas (15.4 EJ) and Hydropower (11.9 EJ) while bioenergy has a minor share (1.47 EJ).
- In derived heat sector, coal and gas are still the major energy sources while in direct heat, biomass competes on a comparable level to fossil fuels.
- The only significant inroads for renewables in the transportation sector is via the use of biofuels whose share has increased to 2.8% (0.3% increase over previous year)

Renewable supply

- Since 2000, supply of solar PV and wind energy has grown at an annual average growth rate of 45.1% and 25.1%. Total renewables growth was 2.8%
- Bioenergy had a growth rate of 2.3%
- Bioenergy is the largest renewable energy source globally – accounting for 73% of all renewable energy supply.

Renewable electricity, heat and transport

- Renewable electricity production increased to 5 469 TWh accounting for 23% of the total electricigy generation.
- Renewables share in heating sector is 7.1% in derived heat (heat generated in power plants) and 27.7% in direct heat (heat directly consumed in end sectors).
- Only 2.8% of the transportation sector is renewable - mostly due to use of liquid biofuels

1.1 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 is dependent on fossil fuels. In 2014, 81% of the global energy supply is via the supply of coal, oil and natural gas. During 2000 – 2014, the global energy supply increased at an annual increment of 2.2%. Coal (3.8%) and natural gas (2.4%) had higher growth rates. At the same time, renewables supply is also growing.

Renewable energy share in the supply of energy increased by 1 percent point – from 13.1% to 14.1% in the past 14 years (Table 1). During the time, the annual average growth of renewables was 2.8% which exceeded the growth of total energy supply. Renewables supply increased by 0.3% during 2013 - 2014. Nuclear energy is the only energy source with a decreasing supply globally.

Table 1 Total primary energy supply of energy sources globally

	Total	Coal	Oil	Natural gas	Nuclear	Renewables	Renewables (%)
2000	420	97.0	153	86.7	28.3	55.0	13.1%
2005	483	125	168	98.8	30.2	60.9	12.6%
2010	542	153	173	115	30.1	71.2	13.1%
2014	573	164	179	121	27.7	80.8	14.1%
Growth (%)	2.2%	3.8%	1.1%	2.4%	-0.2%	2.8%	

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

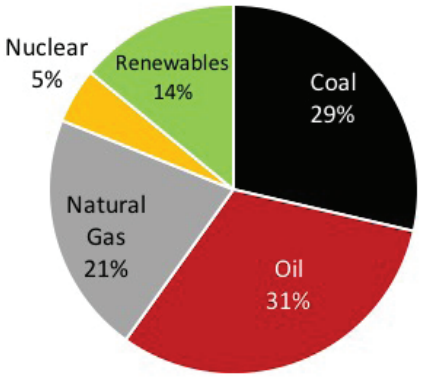

Figure 1 Total energy supply globally in 2014

Asian continent has the highest total energy supply globally along with the highest renewable energy supply (Table 2). However, in terms of share of renewables, African continent due to its large use of biomass and hydropower leads the way. Almost half of all the energy supply in Africa is via renewable energy sources. In comparison, Europe has only 10.3% share of renewables in its energy supply.

Table 2 Total primary energy supply of energy sources in continents in 2014

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
Africa	32.3	4.69	6.89	4.54	0.15	16.0	49.6%
Americas	141	20.8	53.4	38.3	10.6	17.4	12.4%
Asia	267	117	70.2	40.4	4.11	35.0	13.1%
Europe	112	19.4	31.6	36.6	12.9	11.6	10.3%
Oceania	6.10	1.80	2.10	1.51	0.00	0.69	11.3%
World	573	164	179	121	27.7	80.8	14.1%

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

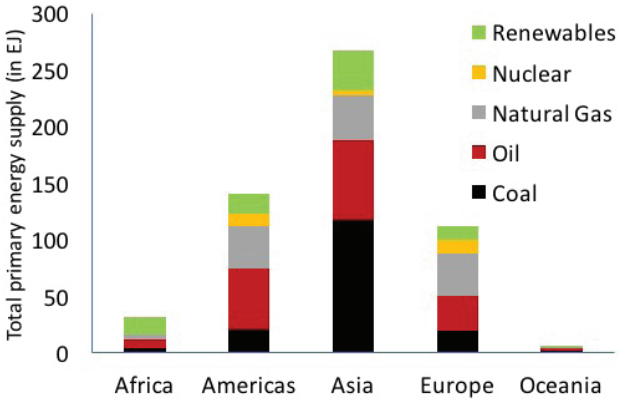

Figure 2 Total primary energy supply in continents in 2014

Among the top 10 countries (excluding the EU – 28), Brazil, Indonesia and India have more than 25% of their energy supply via renewables (Table 3).

Table 3 Total primary energy supply of energy sources in top 10 countries in 2014

	Country	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables %
1	China	128	84.2	21.1	6.43	1.45	14.6	11.4%
2	USA	92.6	18.1	32.8	26.1	9.06	6.58	7.11%
3	India	34.5	15.8	7.74	1.81	0.39	8.75	25.4%
4	Russia	29.8	4.35	6.96	15.6	1.99	0.93	3.13%
5	Japan	18.5	4.96	8.04	4.51	0.00	0.98	5.32%
6	Brazil	12.6	0.73	5.29	1.48	0.17	4.90	39.0%
7	Canada	11.9	0.81	4.07	3.72	1.17	2.11	17.7%
8	Korea	11.2	3.42	4.03	1.81	1.71	0.27	2.39%
9	Iran	9.90	0.04	3.68	6.11	0.05	0.07	0.73%
10	Indonesia	9.44	1.51	3.15	1.53	0.00	3.25	34.4%
Total (Top 10)		358	134	96.8	69.1	16.0	42.4	11.8%
EU - 28		65.4	11.2	21.3	14.4	9.56	8.96	13.7%
World		573	164	179	121	27.7	80.8	14.1%

All values in EJ. Top 10 excludes EU – 28 countries. Source: IEA Key World Energy Statistics

1.2 ENERGY TRADE

Renewables 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. The 28 member countries in the European Union (EU – 28) imported 59 EJ of energy – more than 9 times as much as the whole African continent combined (Table 4). This is largely due to the over dependence of the EU – 28 nations on crude oil and oil products.

Table 4 Total imports of energy in 2014

	Total	Coal	Oil	Natural Gas	Renewables	Electricity
Africa	6.38	0.31	5.63	0.30	0.00	0.14
Americas	37.7	1.73	29.7	5.65	0.14	0.47
Asia	104	25.2	65.0	13.5	0.03	0.28
Europe	66.2	8.00	40.2	15.6	0.68	1.70
Oceania	2.40	0.02	2.14	0.25	0.00	0.00
EU - 28	59.4	6.69	37.2	13.4	0.67	1.39

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

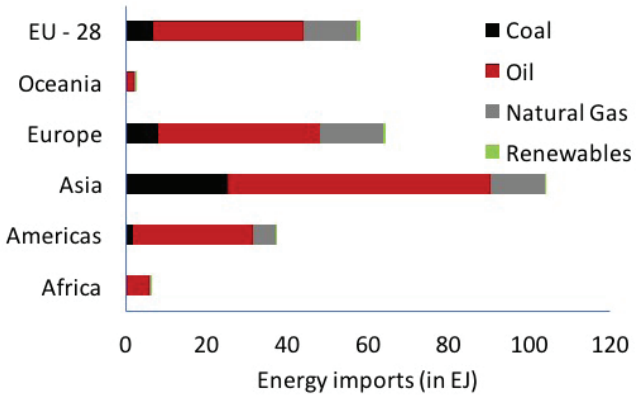

Figure 3 Energy imports in 2014 globally

Renewable exports play a small share dominated by the export of pellets and liquid biofuels (Table 5). In contrast with imports, EU – 28 nations export as much energy as the whole African continent combined. Asia is the largest exporter of energy predominantly due to the export of crude oil from the Middle East.

Table 5 Total exports of energy in 2014

	Total	Coal	Oil	Natural Gas	Renewables	Electricity
Africa	20.5	2.08	15.1	3.18	0.02	0.11
Americas	40.6	5.59	28.5	5.77	0.24	0.43
Asia	80.3	11.6	59.4	9.01	0.07	0.17
Europe	64.6	6.60	38.7	17.0	0.46	1.77
Oceania	12.1	10.2	0.69	1.14	0.00	0.00
EU - 28	22.3	1.57	15.3	3.73	0.42	1.34

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

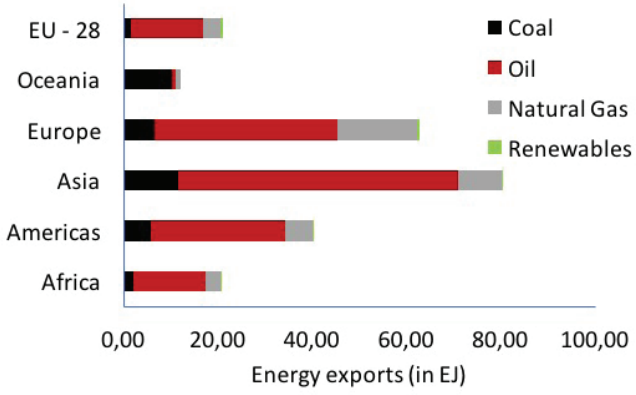

Figure 4 Energy exports in 2014 globally

1.3 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.

In 2014, 360 EJ of energy was consumed globally in the end use sectors of electricity, heating and transportation. During 2000 - 2014, the energy consumption increased by 2.1% annually. The largest part of energy consumption is in the form of crude oil and oil products in the transport sector. 38% of the energy consumption is in the form of oil and oil products.

The share of renewables has increased to 18.6% - a 0.2% increase in the consumption in comparison to the previous year. Even though the consumption of renewables has been growing by 2.5% annually since 2000, the total energy consumption is also growing at approximately the same rate.

Table 6 Gross final energy consumption of energy sources

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
2000	269	43.3	115	55.7	7.65	47.6	17.7%
2005	305	57.6	125	61.6	8.22	52.1	17.1%
2010	338	70.7	129	69.8	8.25	60.1	17.8%
2014	360	76.3	136	73.2	7.59	66.9	18.6%
Growth (%)	2.1%	4.1%	1.2%	2.0%	-0.1%	2.5%	

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

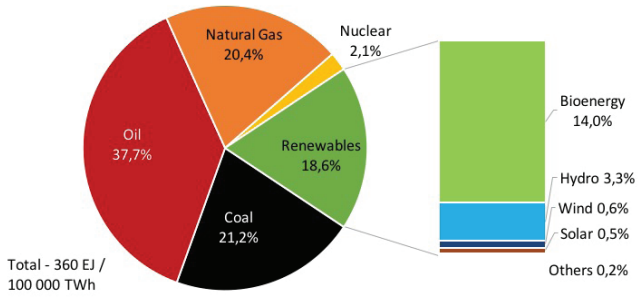

Figure 5 Gross final energy consumption globally in 2014

Among the continents, Africa has 57% renewables in the consumption – the highest among all continents. Oceania (11.5%) along with Europe (12%) have the lowest share. In energy terms, Asia consumes the highest amount of renewable energy – 30.4 EJ which is almost half of the global consumption of renewables.

Table 7 Gross final energy consumption in continents in 2014

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
Africa	23.1	1.55	6.49	1.83	0.04	13.2	57.1%
Americas	93.7	7.36	45.4	24.1	2.95	13.8	14.8%
Asia	168	59.4	54.3	22.4	1.17	30.4	18.1%
Europe	71.6	8.14	27.3	24.1	3.43	8.57	12.0%
Oceania	3.94	0.60	2.10	0.79	0.00	0.45	11.5%
World	360	76.3	136	73.2	7.59	66.9	18.6%

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

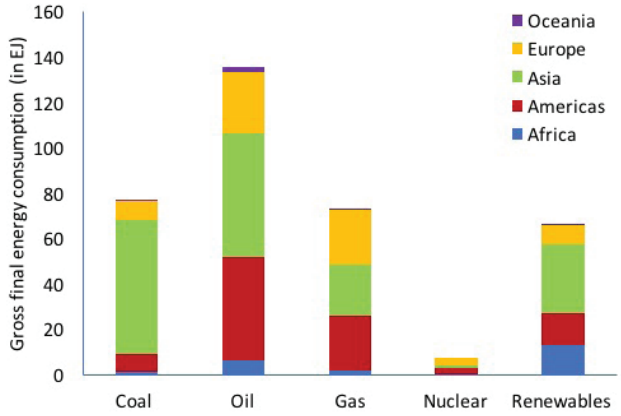

Figure 6 Gross final energy consumption of energy sources in 2014

Considering the consumption of energy in the top 10 countries globally; China, USA and India top the table (Table 8). 7 of the top 10 countries are from the Asian continent while not even a single country from Africa makes it to the top 10. Out of the top 10 nations, developing countries like Brazil (41.4%), India (36.6%) and Indonesia (38.1%) have the highest share of renewables. It is important to note that this includes total renewable energy use not only in electricity sector, but also heating and transportation.

EU - 28 nations have a total share of 16.7% in the final energy consumption which is slightly lower than the global average of 18.6%.

Table 8 Gross final energy consumption in top 10 countries in 2014

	Country	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
1	**China**	76.6	43.4	15.1	4.43	0.40	13.2	17.2%
2	**USA**	59.2	6.26	26.9	18.0	2.57	5.39	9.11%
3	**India**	21.5	7.30	5.68	0.58	0.10	7.87	36.6%
4	**Russia**	15.6	1.64	4.00	8.84	0.47	0.65	4.20%
5	**Japan**	10.7	2.11	5.42	2.62	0.00	0.54	5.04%
6	**Brazil**	8.95	0.40	4.07	0.73	0.04	3.70	41.4%
7	**Canada**	7.68	0.30	3.03	2.19	0.32	1.83	23.8%
8	**Iran**	6.68	0.01	2.49	4.10	0.01	0.06	0.95%
9	**Indonesia**	6.60	0.65	2.71	0.73	0.00	2.51	38.1%
10	**Korea**	5.22	1.24	1.80	1.42	0.50	0.26	4.92%
	Total (Top 10)	219	63.3	71.2	43.8	4.38	36.1	16.5%
	EU - 28	41.6	4.59	16.0	11.4	2.67	6.96	16.7%
	World	360	76.3	136	73.2	7.59	66.9	18.6%

All values in EJ. Top 10 excludes EU – 28 countries. Source: IEA Key World Energy Statistics

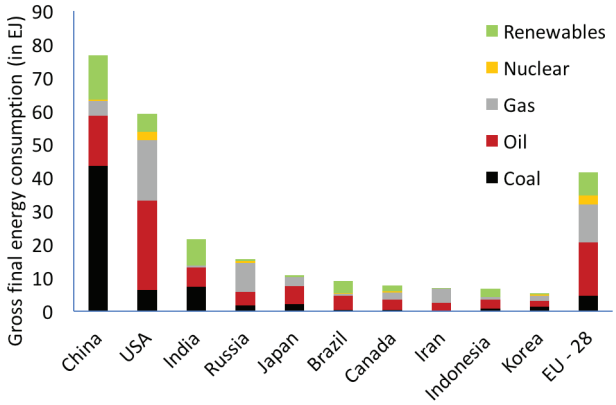

Figure 7 Gross final energy consumption of top 10 countries in 2014

1.4 ENERGY SUPPLY TO CONSUMPTION

Energy resources like fossil fuels, nuclear and renewables have various end uses. The end uses can be classified into electricity, heat (derived and direct) and transportation. In 2014, the total primary energy supply was 573 EJ out of which the final energy consumption was 360 EJ. The rest of the energy is lost in transmission and distribution, energy industry own uses and losses. Majority of the losses occur in the fossil fuel sector.

Energy resource consumption in the electricity sector is dominated by the use of coal (29 EJ), natural gas (15.4 EJ) and Hydropower (11.9 EJ) (Table 9). Among renewables, bioenergy is the 3rd largest renewable electricity generating source.

In the heating sector, derived heat is heat generated in power plants, for e.g. heat only plants and combined heat and power plants. The generated heat is supplied to various end use sectors like industries, residential, commercial etc. In the case of direct heat, energy resources are directly consumed in the end use sectors without undergoing any transformation. In derived heat sector, coal and gas are still the major energy sources while in direct heat, biomass competes on a comparable level to fossil fuels. This shows the significance of the use of biomass in the heating sector.

The final end use of energy sources is in the transportation sector. Crude oil and oil products cover 93.6% of all energy consumption in that sector. The only significant inroads for renewables in the sector is via the use of biofuels whose share has increased to 2.8% - slightly lower than natural gas consumption.

Table 9 Total primary energy supply to gross final energy consumption in 2014

Fuels	Primary energy	Final energy				
		Total	Electricity	Derived heat	Direct heat	Transport
Coal	164	76.3	29.0	4.74	42.4	0.12
Oil	179	136	3.05	0.54	30.4	102
Gas	121	73.2	15.4	5.07	48.6	4.10
Nuclear	27.7	7.59	7.57	0.02	0.00	0.00
Bioenergy	59.2	50.5	1.47	0.77	45.1	3.09
Hydro	14.0	11.9	11.9	0.00	0.00	0.00
Wind	2.14	2.14	2.14	0.00	0.00	0.00
Solar PV	0.57	0.57	0.57	0.00	0.00	0.00
Solar Thermal	1.31	1.22	0.03	0.001	1.20	0.00
Geothermal	2.99	0.59	0.23	0.03	0.33	0.00
Tidal, Wave etc.	0.003	0.003	0.003	0.00	0.00	0.00
Total	573	360	71.3	11.2	168	109

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

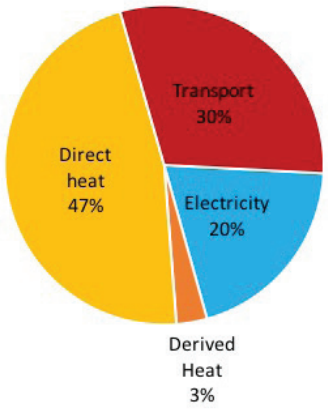

Figure 8 Consumption of energy in end use sectors in 2014

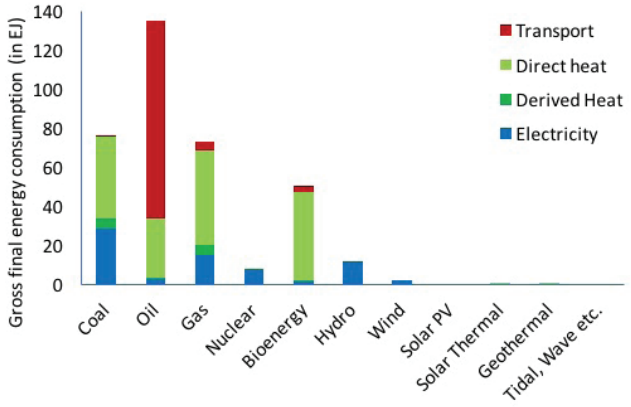

Figure 9 Gross final energy consumption of all energy sources in end use sectors in 2014

1.5 RENEWABLE ENERGY

PRIMARY ENERGY SUPPLY

Renewable energy technologies are rapidly evolving with innovations and finance leading to increased use of these technologies. Solar and wind have seen tremendous growth over the past decade. Since 2000, supply of solar PV and wind energy resources have grown at an annual average growth rate of 45.1% and 25.1% in comparison to the total renewables growth of 2.78% (Table 10).

Table 10 Total primary energy supply of renewables globally

	Total	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, wave and ocean
2000	55.0	43.0	9.43	2.19	0.00	0.21	0.11	0.002
2005	60.9	47.4	10.6	2.25	0.01	0.30	0.37	0.002
2010	71.2	54.2	12.4	2.62	0.12	0.66	1.23	0.002
2014	80.7	59.2	14.0	2.99	0.68	1.31	2.58	0.004
Growth (%)	2.78%	2.30%	2.87%	2.26%	45.1%	13.8%	25.1%	4.41%

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

Bioenergy had a growth rate of 2.3% .

However, in absolute terms, bioenergy is still the largest renewable energy source globally – accounting for 73% of all renewable energy supply. Also, there was good growth in solar thermal and geothermal technologies, but negligible impact by ocean technologies.

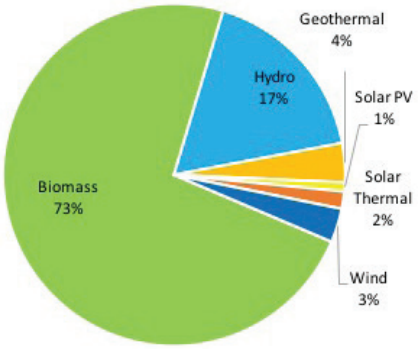

Figure 10 Total primary energy supply of all renewables in 2014

Asia has the highest total of renewable energy supply globally in 2014 – 32.6 EJ. This accounts for 40% of global renewable energy share and is expected to increase further. Africa and Asia together have 60% of the total renewable supply globally. The role of bioenergy dominates the renewable energy mix for each continent.

Table 11 Total primary energy supply of renewables in continents in 2014

	Total	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, wave and ocean
Africa	16.0	15.4	0.44	0.15	0.01	0.01	0.02	0.000
Americas	17.3	10.7	4.98	0.51	0.09	0.13	0.83	0.000
Asia	32.6	26.0	5.45	0.14	0.23	0.03	0.76	0.002
Europe	12.1	6.71	2.99	1.09	0.34	0.03	0.92	0.002
Oceania	1.51	0.26	0.15	0.20	0.02	0.83	0.04	0.000
World	80.7	59.2	14.0	2.99	0.68	1.31	2.58	0.004

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

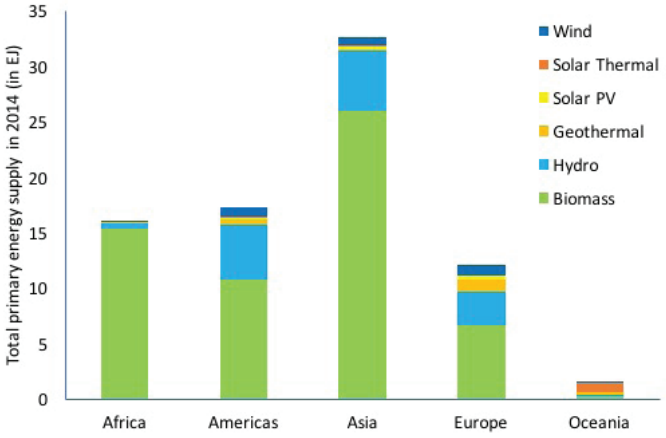

Figure 11 Total primary energy supply of renewables in 2014 (in EJ)

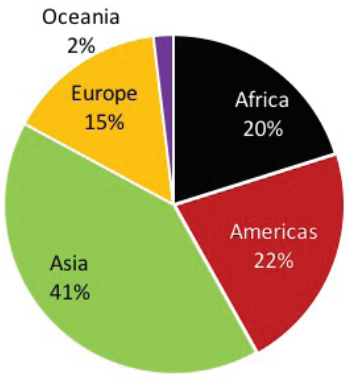

Figure 12 Total Primary Energy Supply of renewables in continents in 2014

Due to the high supply of biomass resources, Asia and African continents make up 7 out of the top 10 countries in renewable energy supply (Table 12). Only USA, Brazil and Canada are exceptions. To note, EU – 28 countries are not included in the lists are mentioned separately.

For individual nations, biomass supply is more than 50% for all the top 10, excluding Canada which has a high share of hydropower. For some African countries like Nigeria, Ethiopia and Congo DR in the list – biomass is almost their only source of renewable energy.

Table 12 Total primary energy supply of renewables in top 10 countries in 2014

	Country	Total	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Wave etc.
1	China	17.5	9.10	3.78	0.20	3.01	0.83	0.56	0.00
2	India	8.82	8.10	0.47	0.00	0.08	0.02	0.13	0.00
3	USA	6.92	4.41	0.94	0.38	0.42	0.12	0.66	0.00
4	Brazil	4.99	3.48	1.34	0.00	0.09	0.03	0.04	0.00
5	Nigeria	4.57	4.55	0.02	0.00	0.00	0.00	0.00	0.00
6	Indonesia	3.25	2.47	0.05	0.72	0.00	0.00	0.00	0.00
7	Canada	2.11	0.64	1.38	0.00	0.01	0.00	0.08	0.00
8	Ethiopia	1.91	1.87	0.03	0.00	0.00	0.00	0.00	0.00
9	Pakistan	1.46	1.34	0.11	0.00	0.00	0.00	0.00	0.00
10	Congo DR	1.13	1.10	0.03	0.00	0.00	0.00	0.00	0.00
Total (Top 10)		47.4	36.0	7.82	1.31	0.13	1.23	0.90	0.00
EU-28		8.74	5.87	1.33	0.85	0.29	0.25	0.15	0.00
World		78.1	57.7	13.6	2.29	0.50	2.77	1.19	0.00

All values in EJ. Top 10 excludes EU – 28 countries. Source: IEA Key World Energy Statistics

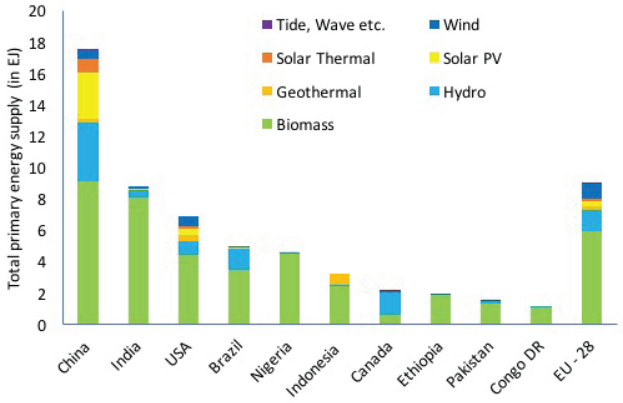

Figure 13 Total primary energy supply of renewables in top 10 countries and EU - 28 in 2014

ELECTRICITY GENERATION FROM RENEWABLES

Hydropower dominates the renewable electricity sector. In the year 2014, 3 983 TWh of electricity generation was from large and small scale hydropower (Table 13) which is almost three quarters of all renewable electricity generation. However, its share in the generation has dropped from 92% in 2000 to 73% currently in 2014. Part of the reason is the tremendous growth of solar and wind energy technologies in renewable electricity generation. Favourable policies, falling costs and innovation are driving growth in these sectors.

During 2000 – 2014, the renewable electricity sector grew at an average annual growth rate of 4.5% which was largely driven to the very high growth rates of 45% for solar PV and 25% for wind. In 2011, wind eclipsed bioenergy as the 2nd largest renewable electricity generation source. Bioenergy had a modest growth of 8.2% achieving a total electricity generation of 493 TWh in 2014. This is still 2.6 times as much electricity generation as from solar PV.

Table 13 Electricity generation from renewables in 2014 in continents

	Renewables	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Wave etc.
2000	2 950	164	2 700	52.0	1.03	0.53	31.3	0.55
2005	3 409	223	3 019	58.3	4.04	0.60	104	0.52
2010	4 342	367	3 531	68.1	32.4	1.65	341	0.51
2014	5 469	493	3 983	77.4	190	8.49	717	1.00

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

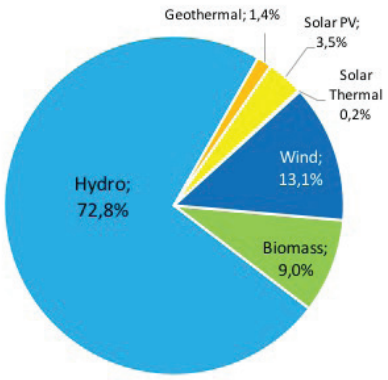

Figure 14 Electricity generation from renewables globally in 2014

Asia leads the world in generating electricity from renewable energy sources with a share of 36% closely followed by Americas (North, Central and South America) at 34% (Table 14). In terms of biopower or electricity generation from biomass, the highest share was in Europe due to the presence of a large number of combined heat and power plants.

Table 14 Electricity generation from renewables in 2014 in continents

	Renewables	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Wave etc.
Africa	139	1.83	126	4.08	1.46	0.00	5.35	0.00
Americas	1 845	153	1 404	28.7	24.9	2.75	231	0.02
Asia	1 980	138	1 540	25.4	64.7	0.28	211	0.50
Europe	1 434	196	869	11.9	93.8	5.46	257	0.48
Oceania	71.5	4.15	42.8	7.26	4.87	0.00	12.5	0.00
World	5 469	493	3 983	77.4	190	8.49	717	1.00

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

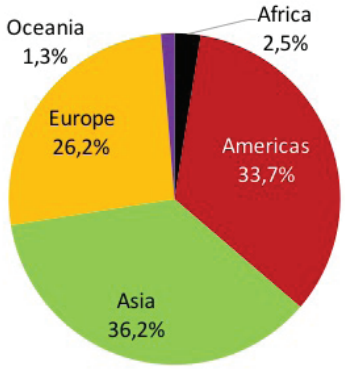

Figure 15 Electricity generation from renewables in 2014

China – the top renewable electricity generating nation –generated 1 307 TWh out of which more than 80% of renewable electricity comes from Hydropower. In comparison, EU – 28 countries combined generated 954 TWh of renewable electricity with a more diversified electricity mix with a combination of biomass (20%), hydropower (43%), wind (27%) and other renewable electricity sources.

Table 15 Renewable electricity generation in top 10 countries in 2014

	Country	Renewables	Biomass	Hydro	Geothermal	Solar PV	Solar Thermal	Wind	Tide, Wave etc.
1	China	1 307	57.4	1 064	0.13	29.2	0.03	156	0.01
2	USA	591	81.8	282	18.7	21.9	2.69	184	0.00
3	Brazil	432	46.0	373	0.00	0.00	0.00	12.2	0.00
4	Canada	412	5.36	383	0.00	1.76	0.00	22.5	0.02
5	India	199	25.4	132	0.00	4.91	0.00	37.2	0.00
6	Russia	181	3.10	177	0.46	0.16	0.00	0.10	0.00
7	Japan	155	35.5	86.9	2.58	24.5	0.00	5.04	0.00
8	Norway	139	0.39	137	0.00	0.00	0.00	2.22	0.00
9	Venezuela	87.2	0.00	87.2	0.00	0.00	0.00	0.00	0.00
10	Vietnam	59.0	0.06	58.5	0.00	0.00	0.00	0.09	0.00
	Total (Top 10)	3 561	255	2 780	21.9	82.4	2.72	419	0.02
	EU - 28	954	189	406	6.22	92.3	5.46	253	0.48
	World	5 469	493	3 983	77.4	190	8.49	717	1.00

All values in TWh. Top 10 excludes EU – 28 countries. Source: IEA Key World Energy Statistics

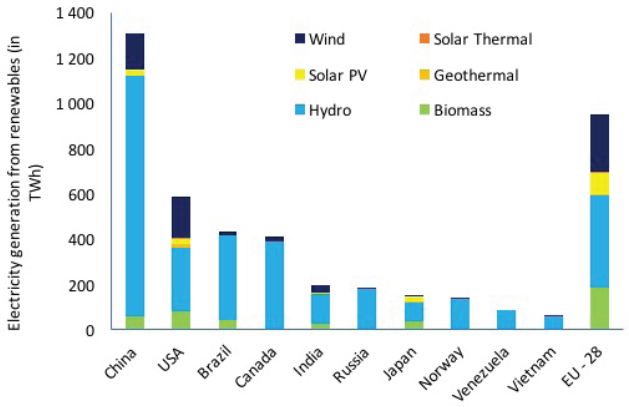

Figure 16 Electricity generation from renewables in top 10 countries and EU – 28 in 2014

DERIVED HEAT FROM RENEWABLES

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.

In contrast with the electricity sector, the derived heat sector does not have many options for renewable heat apart from biomass, geothermal and solar thermal technologies. Among the available technologies, clearly, biomass is the leading source for derived heat. 97% of all renewable derived heat is obtained from biomass technologies.

Table 16 Derived heat generation from renewables globally

	Renewables	Biomass	Geothermal	Solar Thermal
2000	0.43	0.41	0.02	0.00002
2005	0.55	0.53	0.02	0.00006
2010	0.81	0.78	0.03	0.00019
2014	0.95	0.92	0.03	0.00074

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

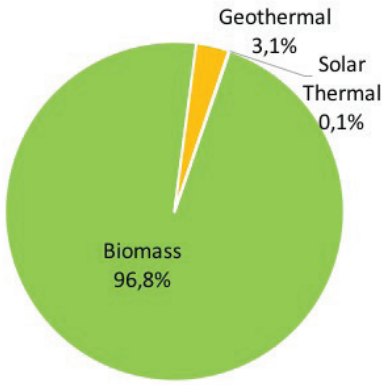

Figure 17 Derived heat generation from renewables in 2014

African continent has negligible derived heat generation from renewables which is the same case with Oceania countries – Australia and New Zealand (Table 17). Europe is the leading continent with a high share of renewable derived heat generation – predominantly due to the high use of biomass for district heating networks. There is hardly any heat generation from geothermal and solar thermal among other continents.

Table 17 Derived heat generation from renewables in 2014

	Total - Ren	Biomass	Geothermal	Solar Thermal
Africa	0.00	0.00	0.00	0.000
Americas	0.05	0.05	0.00	0.000
Asia	0.09	0.09	0.00	0.000
Europe	0.82	0.78	0.03	0.001
Oceania	0.00	0.00	0.00	0.000
World	0.95	0.92	0.03	0.001

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

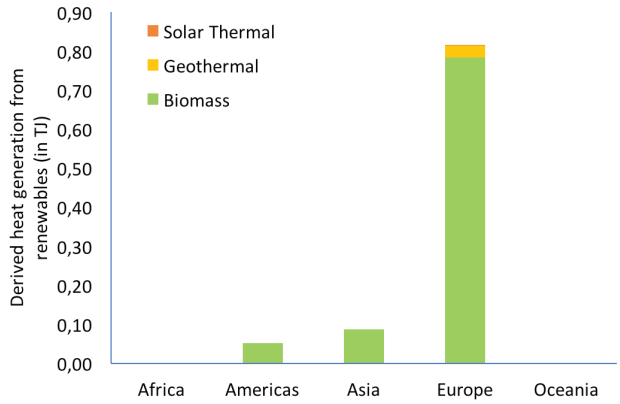

Figure 18 Derived heat from generation renewables in 2014

Most of the derived heat generation occurs in Europe and predominantly in the EU – 28 countries and Russia. Russia, China and UK have the largest generation of derived heat from renewables, although it is important to note that EU – 28 countries individually have a higher heat generation. For example, Sweden is the largest renewable derived heat generating nation due to high use of biomass in combined heat and power generation plants.

Table 18 Derived heat generation from renewables in top 10 countries in 2014

	Country	Renewables	Biomass	Geothermal	Solar Thermal
1	Russia	0.11	0.11	0.000	0.000
2	China	0.05	0.05	0.000	0.000
3	USA	0.05	0.05	0.000	0.000
4	Korea	0.03	0.03	0.000	0.000
5	Iceland	0.02	0.00	0.022	0.000
6	Belarus	0.02	0.02	0.000	0.000
7	Norway	0.02	0.02	0.000	0.000
8	Switzerland	0.01	0.01	0.000	0.000
9	Ukraine	0.01	0.01	0.000	0.000
10	Canada	0.01	0.01	0.000	0.000
	Total (Top 10)	0.33	0.31	0.023	0.000
	EU - 28	0.25	0.25	0.000	0.000
	World	0.95	0.92	0.030	0.001

All values in EJ. Top 10 excludes EU – 28 countries. Source: IEA Key World Energy Statistics

DIRECT HEAT FROM RENEWABLES

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. Out of a total of 46.7 EJ of direct heat from renewables, biomass share was 97% while the contribution from geothermal and solar thermal is low.

Table 19 Direct heat generation from renewables globally

	Renewables	Biomass	Geothermal	Solar Thermal
2000	38.2	37.8	0.16	0.21
2005	40.7	40.2	0.22	0.30
2010	44.1	43.2	0.27	0.64
2014	46.7	45.1	0.33	1.20

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

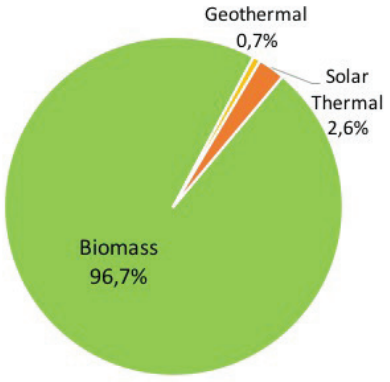

Figure 19 Direct heat generation from renewables in 2014

In the direct heat sector, Asia consumes the highest amount of renewables. More than half of the renewables used in the direct heating sector is in the Asian continent while 27% is in Africa. This is in sharp contrast to derived heat, where Europe was the sole leader.

Table 20 Direct heat generation from renewables in continents in 2014

	Total - Ren	Biomass	Geothermal	Solar Thermal
Africa	12.8	12.8	0.00	0.01
Americas	6.05	5.91	0.01	0.13
Asia	24.1	22.9	0.27	0.97
Europe	3.41	3.28	0.04	0.08
Oceania	0.24	0.21	0.01	0.01
World	46.7	45.1	0.33	1.20

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

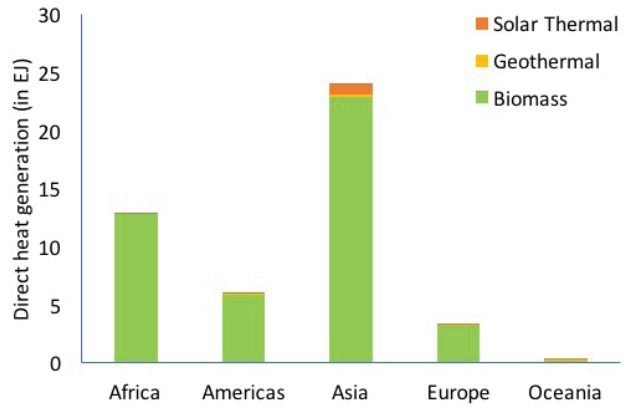

Figure 20 Direct heat generation from renewables in continents

The dominance of Asia and Africa is reflected in the top 10 countries with renewable direct heat, where only 2 countries (USA and Brazil) are not from that region. Biomass is the key resource to providing renewable heating to majority of the countries in Africa and Asia.

Table 21 Direct heat generation from renewables in top 10 countries in 2014

	Country	Renewables	Biomass	Geothermal	Solar Thermal
1	**China**	9.17	8.14	0.20	0.83
2	**India**	7.33	7.31	0.00	0.02
3	**Nigeria**	4.19	4.19	0.00	0.00
4	**Indonesia**	2.38	2.38	0.00	0.00
5	**USA**	2.10	1.99	0.01	0.09
6	**Brazil**	1.84	1.81	0.00	0.03
7	**Ethiopia**	1.51	1.51	0.00	0.00
8	**Pakistan**	1.32	1.32	0.00	0.00
9	**Congo DR**	0.81	0.81	0.00	0.00
10	**Tanzania**	0.77	0.77	0.00	0.00
	Total (Top 10)	31.4	30.2	0.21	0.98
	EU - 28	2.95	2.85	0.02	0.08
	World	46.7	45.1	0.33	1.20

All values in EJ. Top 10 excluding EU – 28. Source: IEA Key World Energy Statistics

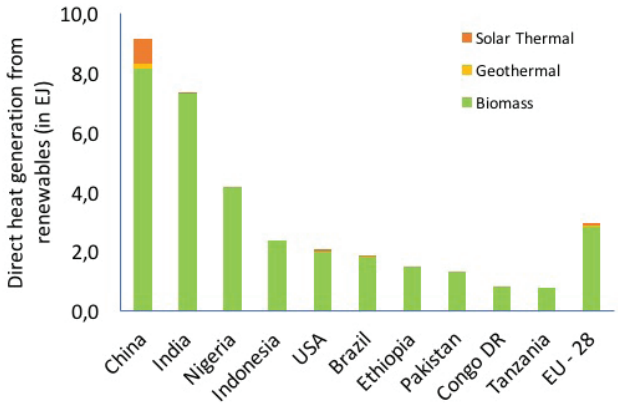

Figure 21 Direct heat generation from renewables in 2014 in top 10 countries

RENEWABLES IN 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. The current share of renewables in transportation is about 2.8% due to use of biofuels – bioethanol, biodiesel, advanced biofuels, biogas etc. More details available in Biofuels section.

2. BIOENERGY SUPPLY

KEY FINDINGS

Biomass supply

- The total supply of biomass in 2014 was 59.2 EJ – 10.3% of all energy supply globally
- Biomass supply grew at annual growth rate of 2.3%
- Biomass is the largest renewable energy source and most of it is from the forestry sector

Feedstock

- Forestry industry generates more than 87% of all the biomass feedstock for bioenergy
- Agriculture sector contributes 10% with animal and agricultural by-products.
- Municipal solid waste and landfill gas cover remaining 3% of the biomass feedstock source

Land

- Total land area globally is 13 billion ha – 37.6% in use in agriculture, 30% in forests and the remaining by other land: built up and related land, barren land etc.
- Since 2000, the arable land for temporary crops has increased slightly by 0.09% while area for permanent crops increased at a rate of 1.28%.
- Planted forests have seen a growth at an annual rate of 1.9% since 2000 to reach 290 million ha
- Primary forests and other naturally regenerative forests have declined

Agriculture

- More than half of the agricultural area in Europe is arable land while the share is less than 12% for Oceania region
- Permanent pastures and meadows cover more than 50% of the agricultural area for the rest of the regions excluding Europe
- Globally, the largest crops in terms of area harvested include wheat (220 million ha), maize (185 million ha) and rice (163 million ha)
- African continent has the lowest yields among all major crops

Forestry

- Close to 40% of the global forest area is in Americas – North, South and Central America
- One third of all the forest area occurs in two countries – Russia and Brazil
- Globally, 1.9 billion m^3 of wood fuel is produced – mostly in Asia and Africa.

Waste

- 2.12 EJ of waste was converted to energy globally – large part of it was from municipal waste from households and industries
- The waste to energy sector has increased at an annual rate of 4% during 2000 – 2014.
- 55% of all waste to energy conversion occurs in Europe while the rest is in Asia and Americas

OVERVIEW

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 2014, the total primary energy supply of biomass was 59.2 EJ which is 10.3% of all the supply of energy globally of 573 EJ (Table 22). Since 2000, the biomass supply grew at an average annual growth rate of 2.3%. Biogas and liquid biofuels had the highest increase at 11.2% and 15.6% respectively.

Table 22 Total primary energy supply of biomass

	Total	Municipal Waste	Industrial Waste	Solid biomass	Biogas	Liquid Biofuels
2000	43.0	0.74	0.47	41.1	0.28	0.42
2005	47.4	0.94	0.40	44.7	0.50	0.85
2010	54.2	1.15	0.68	49.1	0.84	2.44
2014	59.2	1.32	0.80	52.6	1.27	3.21

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

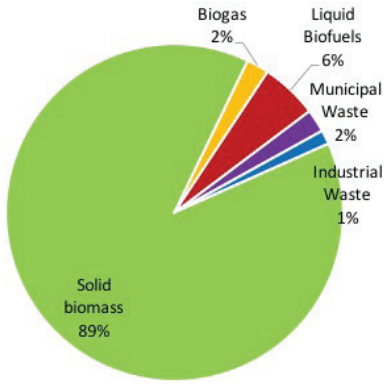

Figure 22 Total primary energy supply of biomass in 2014

The supply of biomass varies among continents. Most of the bioenergy produced from municipal solid waste is in Europe. Americas is a world leader in producing bioenergy from liquid biofuels. For biogas as a source, Europe again leads. However, half of the biomass source globlally is via solid biomass use in Asia.

Table 23 Total primary energy supply of biomass in continents in 2014

	Total	Municipal Waste	Industrial Waste	Solid biomass	Biogas	Liquid Biofuels
Africa	15.4	0.00	0.00	15.4	0.00	0.00
Americas	10.7	0.30	0.06	7.86	0.21	2.30
Asia	26.0	0.19	0.38	24.8	0.40	0.26
Europe	6.71	0.82	0.35	4.26	0.63	0.65
Oceania	0.26	0.00	0.00	0.23	0.02	0.01
World	59.2	1.32	0.80	52.6	1.27	3.21

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

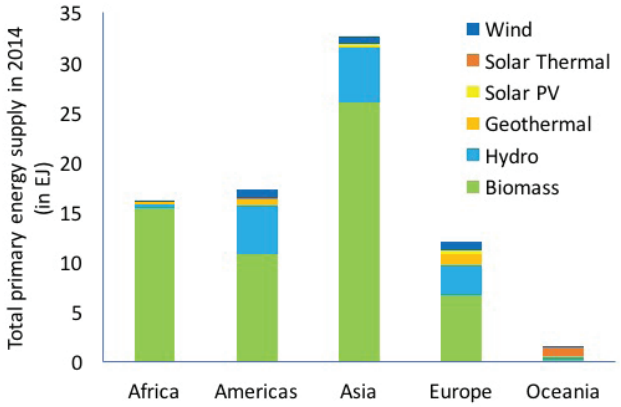

Figure 23 Total primary energy supply of biomass in continents in 2014

The top 10 countries in the biomass supply are dominated by countries from Asia and Africa due to their high dependence on solid biomass (Table 24). These top 10 countries supplied more than 60% of the global biomass supply.

Table 24 Total primary energy supply of biomass in top 10 countries in 2014

	Countries	Total	Municipal Waste	Industrial Waste	Solid biomass	Biogas	Liquid Biofuels
1	China	9.10	0.00	0.23	8.47	0.32	0.07
2	India	8.10	0.03	0.00	8.04	0.02	0.01
3	Nigeria	4.55	0.00	0.00	4.55	0.00	0.00
4	USA	4.41	0.30	0.06	2.37	0.18	1.50
5	Brazil	3.48	0.00	0.00	2.84	0.01	0.64
6	Indonesia	2.47	0.00	0.00	2.43	0.00	0.04
7	Ethiopia	1.87	0.00	0.00	1.87	0.00	0.00
8	Pakistan	1.34	0.00	0.00	1.35	0.00	0.00
9	Congo DR	1.10	0.00	0.00	1.10	0.00	0.00
10	Thailand	1.08	0.01	0.00	0.98	0.03	0.06
	Total (Top 10)	37.5	0.33	0.29	34.0	0.56	2.33
	EU - 28	5.93	0.75	0.16	3.75	0.07	1.20
	World	59.2	1.32	0.80	52.6	1.27	3.21

All values in EJ. Top 10 excluding the EU – 28. Source: IEA Key World Energy Statistics

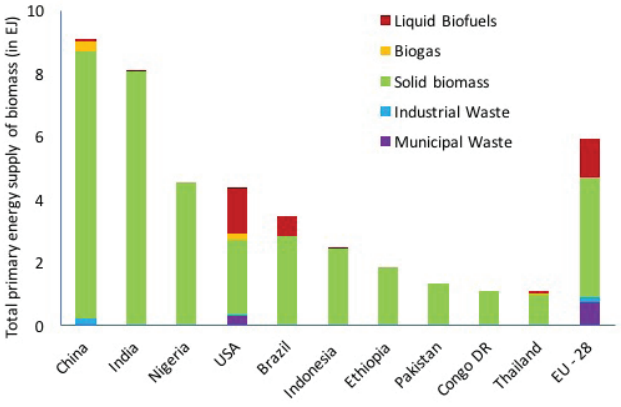

Figure 24 Total primary energy supply of biomass in top 10 countries in 2014

FEEDSTOCK

Forestry is the mainstay of the bioenergy sector. The forestry industry generates more than 87% of all the biomass feedstock for bioenergy in the form of fuelwood, charcoal, forestry and wood industry residues, recovered wood and black liquor. The agriculture sector contributes 10% with animal and agricultural by-products. Energy crops producing bioethanol and biodiesel are included in the agricultural sector. Finally, municipal solid waste and landfill gas cover the remaining 3% of the biomass feedstock sources.

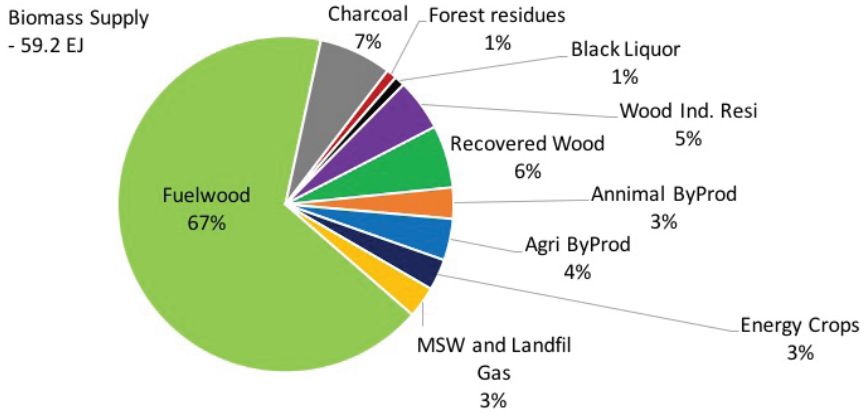

Figure 25 Biomass feedstock sources

2.1 LAND

Land use is a critical factor for bioenergy development. Unlike other renewable energy sources, biomass requires significant land for growing forests, agriculture crops etc. to supply the bioenergy demand globally.

In 2014, the total land area globally was 13 billion ha out of which agriculture area covered 37.6% of the area while forestry covered 30.7% of the land.

In the agriculture sector, arable land is the land under temporary agricultural crops and meadows/pastures etc., permanent crops land is area for crops planted for many years (e.g. cocoa, coffee etc.) while permanent meadows and pastures are land permanently used for growing herbaceous crops – either cultivated or growing wild. Since 2000, the arable land for temporary crops has increased slightly by 0.09% and area for permanent crops increased at a rate of 1.28%.

In the forestry sector, primary forests are naturally regenerative forests with no clear indication of human intervention while other naturally regenerated forests show visible indication of human activities. Planted forests are predominantly composed of trees established through planting and/or deliberate seeding. In the past 14 years, planted forests have seen a tremendous growth at an annual rate of 1.9% to reach 290 million ha in 2014 while primary forests and other naturally regenerative forests have declined in forest area in the same duration.

It is important to note that not all the land is used/available for bioenergy production.

Table 25 Land area globally

	Total Land Area	Agriculture area			Forest Area			Other Land
		Arable Land	Permanent Crops	Permanent Pastures and Meadows	Primary Forests	Other Naturally Regenerated Forests	Planted Forests	
2000	13 026	1 400	138	3 417	1 299	2 533	224	4 016
2005	13 026	1 406	148	3 386	1 284	2 495	254	4 053
2010	13 024	1 388	159	3 322	1 288	2 450	277	4 139
2014	13 021	1 417	165	3 316	1 279	2 433	290	4 121

All values in million ha. Source: FAOSTAT

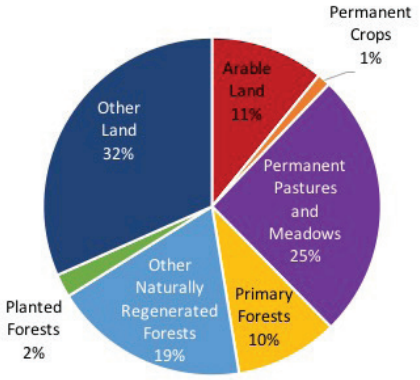

Figure 26 Land area globally in 2014

2.2. AGRICULTURE

Agriculture sector is a significant contributor to the biomass supply in terms of energy crops for biofuels production and heat and electricity along with the use of residues. It is crucial to understand the sector in terms of area, crops production and yields, residues potential etc.

AREA

More than half of the agricultural area in Europe is under arable land while the share is less than 12% for Oceania region (Table 26). Permanent pastures and meadows cover more than 50% of the agricultural area for the rest of the regions excluding Europe. For example, in Oceania, 88% of all agricultural area is permanent pastures and meadows. In Asia, most of the agricultural area (66%) is in the form of pastures and meadows.

Table 26 Agriculture area in continents in 2014

	Agriculture Area	Arable Land	Permanent Crops	Permanent Pastures and Meadows
Africa	1 132	234	34.0	861
Americas	1 230	376	27.6	826
Asia	1 650	482	86.2	1 082
Europe	468	277	15.3	176
Oceania	420	48.1	1.55	370
World	4 897	1 417	165	3 316

All values in million ha. Source: FAOSTAT

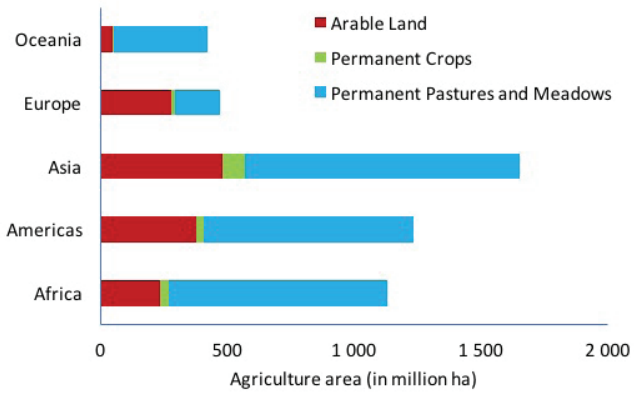

Figure 27 Agriculture area in continents in 2014

Excluding the EU – 28 nations, the top countries with agricultural area are China, USA and Australia (Table 27). Saudi Arabia has the 8th largest agricultural area globally – largely due to large area of permanent pastures and meadows. Except India with a large share of arable land (87%), rest of the countries have a higher share of permanent pastures and meadows in their countries.

Table 27 Agriculture area in top 10 countries globally

	Countries	Agriculture area	Arable land	Permanent crops	Permanent pastures and meadows
1	China	515	106	16.2	393
2	USA	408	155	2.60	251
3	Australia	406	47.0	0.35	359
4	Brazil	283	80.0	6.57	196
5	Russia	218	123	1.60	93.0
6	Kazakhstan	217	29.4	0.13	187
7	India	180	156	13.0	10.2
8	Saudi Arabia	174	3.50	0.15	170
9	Argentina	149	39.2	1.00	109
10	Mongolia	113	0.57	0.01	112
	Total (Top 10)	2 662	740	41.6	1 880
	EU - 28	186	108	12.0	65.3
	World	4 897	1 417	165	3 316

All values in million ha. Top 10 excluding EU – 28. Source: FAOSTAT

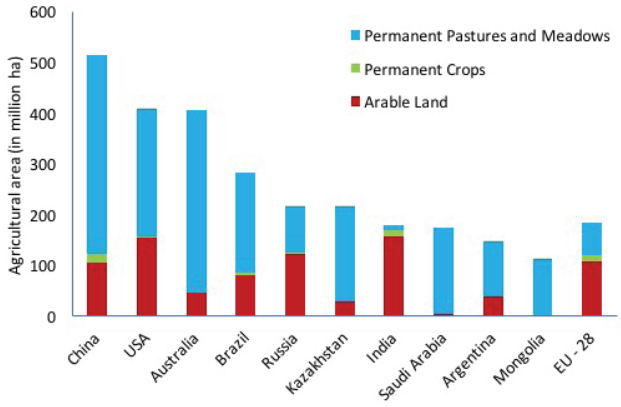

Figure 28 Agriculture area in top 10 countries in 2014

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. Globally, the largest crops in terms of area harvested include wheat (220 million ha), maize (185 million ha) and rice (163 million ha) which are predominantly produced in Asia, Americas and Asia respectively (Table 28). It is imprtant to note that not all the area is available for biofuel production and only a fraction is used.

Table 28 Area harvested

	World		Africa		Americas		Asia		Europe		Oceania	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Maize	137	185	24.3	37.1	57.1	68.3	41.8	60.7	13.7	18.7	0.10	0.08
Rice	154	163	7.56	11.9	7.61	6.63	138	143	0.61	0.64	0.14	0.08
Wheat	215	220	8.15	9.9	41.3	36.9	98.2	102	55.3	58.7	12.2	12.7
Barley	54.4	49.4	4.11	4.39	7.66	4.79	11.5	11.0	27.6	25.4	3.51	3.87
Millet	37.1	31.4	19.6	19.7	0.18	0.18	15.5	10.9	1.77	0.57	0.04	0.04
Oats	12.7	9.59	0.12	0.16	2.92	2.02	0.85	0.52	8.13	6.17	0.66	0.72
Rye	9.82	5.31	0.02	0.05	0.33	0.24	0.86	0.41	8.57	4.55	0.04	0.05
Sorghum	41.2	45.0	21.3	29.4	7.08	7.22	12.0	7.46	0.23	0.39	0.62	0.53
Olives	8.35	10.3	2.27	3.29	0.07	0.13	1.32	1.78	4.68	5.05	0.00	0.03
Rapeseed	25.8	36.1	0.04	0.14	5.53	8.93	14.2	15.2	4.62	9.11	1.46	2.72
Soybeans	74.4	118	0.90	1.88	54.6	91.6	17.7	19.6	1.11	4.50	0.06	0.04
Sunflower	21.2	25.2	0.87	2.84	4.94	2.22	3.91	3.71	11.3	16.4	0.16	0.03
Oil palm	10.0	18.7	4.11	4.46	0.46	1.16	5.38	12.9	0.00	0.00	0.08	0.17
Cassava	17.0	23.9	11.0	17.3	2.52	2.43	3.40	4.10	0.00	0.00	0.02	0.02
Sugar beet	6.01	4.47	0.11	0.27	0.62	0.49	1.09	0.62	4.19	3.09	0.00	0.00
Sugarcane	19.4	27.1	1.30	1.48	8.76	14.2	8.85	11.0	0.00	0.00	0.49	0.43

All values in million ha. Source: FAOSTAT

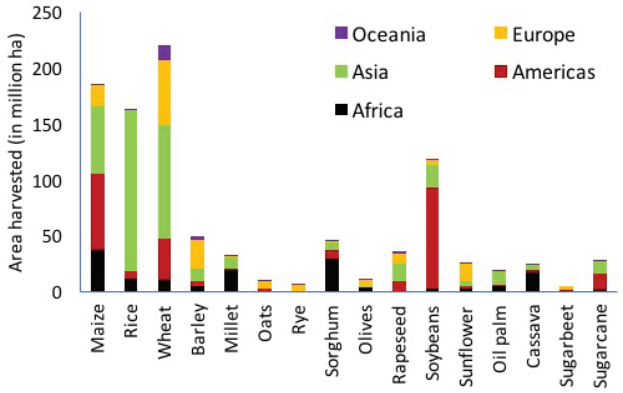

Figure 29 Area harvested globally (in million ha)

Yields are a crucial part of the food and fuel debate in the biofuels sector. There is significant potential to producing more crops for food, feed and fuel by increasing the crop yields in various regions. Comparing yields of major crops across all continents, Africa has the lower yields than the world average (Table 29) in all major crops.

Table 29 Yields of major crops

	World		Africa		Americas		Asia		Europe		Oceania	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Maize	4.32	5.62	1.82	2.10	5.87	7.72	3.56	5.00	4.63	6.89	5.75	8.14
Rice	3.89	4.56	2.31	2.59	4.15	5.75	3.95	4.65	5.25	7.33	7.99	10.2
Wheat	2.72	3.31	1.75	2.63	2.67	2.92	2.59	3.13	3.32	4.25	1.84	2.03
Barley	2.45	2.92	0.51	1.37	2.93	3.28	1.52	1.78	3.05	3.69	2.01	2.47
Millet	0.75	0.90	0.65	0.63	1.17	1.75	0.84	1.36	0.90	1.40	1.46	0.99
Oats	2.06	2.37	0.83	1.09	2.30	2.79	1.81	1.90	2.05	2.37	1.65	1.79
Rye	2.05	2.87	1.70	1.86	1.84	2.00	1.56	2.31	2.11	3.01	0.57	0.59
Sorghum	1.36	1.53	0.87	0.99	3.28	3.79	0.94	1.30	3.34	3.53	3.40	2.41
Olives	1.87	1.50	0.71	0.97	3.44	4.34	2.38	1.52	2.27	1.76	1.84	2.22
Rapeseed	1.53	2.04	1.13	1.42	1.49	1.92	1.25	1.57	2.54	3.16	1.22	1.41
Soybeans	2.17	2.61	1.06	1.26	2.47	2.95	1.31	1.31	1.74	1.95	1.87	2.16
Sunflower	1.25	1.64	1.07	1.07	1.65	1.59	1.02	1.57	1.17	1.77	1.05	1.41
Oil palm	12.0	14.7	3.63	4.19	14.8	14.9	18.1	18.3	0.00	0.00	17.2	14.0
Cassava	10.4	11.2	8.66	8.42	12.3	13.3	14.5	21.9	0.00	0.00	11.3	10.2
Sugar beet	41.6	60.3	51.9	53.8	58.6	62.3	34.5	53.1	40.7	62.0	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

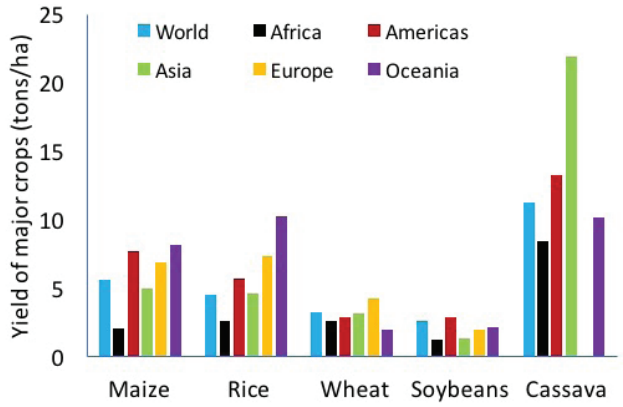

Figure 30 Yield of major crops in continents

Among biofuel crops, sugarcane is the largest produced crop globally . 1 884 million tonnes of sugarcane is produced annually - largely in Americas (Brazil) and Asia (India). Maize is the 2nd largest crop with a production volume of 1 038 million tonnes. More than half of it is produced in Americas (USA). It is important to note that not all the production is used for biofuel production and only a minor fraction is used for biofuels - e.g. Sugarcane in Brazil, Maize in USA and Rapeseed in EU etc.

Table 30 Production quantities of crops

	World		Africa		Americas		Asia		Europe		Oceania	
	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014	2000	2014
Maize	592	1 038	44.3	78.0	335	527	149	304	63.5	129	0.60	0.65
Rice	599	741	17.5	30.8	31.6	38.1	546	667	3.18	4.72	1.12	0.83
Wheat	585	729	14.3	26.1	110	108	255	320	184	249	22.4	25.7
Barley	133	144	2.09	6.00	22.4	15.7	17.6	19.6	84.0	93.7	7.05	9.58
Millet	27.7	28.4	12.7	12.4	0.21	0.31	13.1	14.8	1.60	0.80	0.06	0.04
Oats	26.1	22.7	0.10	0.17	6.70	5.64	1.54	0.99	16.7	14.6	1.09	1.29
Rye	20.1	15.2	0.03	0.09	0.61	0.48	1.35	0.96	18.1	13.7	0.02	0.03
Sorghum	55.9	68.9	18.4	29.2	23.2	27.4	11.3	9.68	0.76	1.38	2.12	1.29
Olives	15.6	15.4	1.61	3.19	0.24	0.54	3.15	2.71	10.6	8.90	0.00	0.07
Rapeseed	39.5	73.8	0.05	0.20	8.23	17.1	17.7	23.9	11.7	28.8	1.78	3.84
Soybeans	161	307	0.95	2.38	135	270	23.2	25.6	1.92	8.77	0.10	0.08
Sunflower	26.5	41.4	0.94	3.05	8.13	3.53	4.00	5.83	13.3	29.0	0.17	0.04
Oil palm	120	275	14.9	18.7	6.85	17.2	97.2	236	0.00	0.00	1.40	2.40
Cassava	176	268	95.4	146	31.1	32.4	49.5	89.8	0.00	0.00	0.19	0.25
Sugar beet	250	270	5.79	14.3	36.5	30.7	37.7	32.9	170	192	0.00	0.00
Sugarcane	1 256	1 884	86.1	95.5	574	1 008	554	748	0.11	0.01	42.1	32.6

All values in million tonnes. Source: FAOSTAT

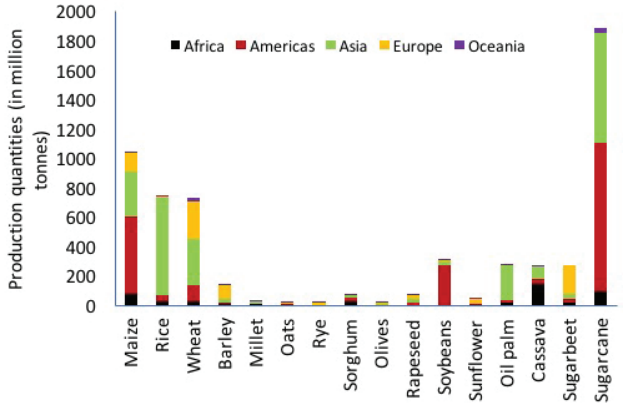

Figure 31 Production quantity of major crops

AGRICULTURAL RESIDUES

The agricultural sector contributes 10% of the global biomass supply. However, it has significant potential to increase the supply of biomass. Unused land can be used for agricultural purposes to produce both energy and food. Crop yields could be increased to produce more tonnes per ha of land. The use of agricultural residues can be a major source of energy generation.

A theoretical estimate of agricultural residues production shows that about 3.6 – 17.2 billion tonnes can be produced globally (Table 31). These include straw, husk, cobs, kernels, leaves and tops etc. which are generated during harvest and processing of agricultural crops. The crops considered include cereals, oil seeds and sugar crops. The estimated theoretical potential of agricultural resides is in the range of 14.6 EJ to 123 EJ (Figure 32). The high variation of residue potential is due to various parameters: variation in moisture content, Residue to Product ratio and Lower Heating Value (LHV) of the residues.

Table 31 Theoretical energy potential of agricultural residues in 2014

	Residues (million tonnes)		Residues (EJ)	
Crops	**Low**	**High**	**Low**	**High**
Maize	1 453	7 399	5.05	60.9
Rice	460	3 196	2.05	23.5
Wheat	510	1 312	2.46	9.47
Barley	86.7	260	0.42	1.48
Millet	31.2	56.8	0.16	0.30
Oats	25.0	45.4	0.13	0.24
Rye	16.8	30.5	0.09	0.16
Sorghum	62.0	510	0.33	2.68
Olives	3.47	3.47	0.02	0.02
Rapeseed	125	273	0.91	1.98
Soybeans	307	1 208	1.61	6.35
Sunflower	82.8	170	0.56	1.14
Oil palm	106	140	0.13	0.67
Cassava	16.6	268	0.12	2.00
Sugarbeet	108	108	0.21	0.22
Sugarcane	188	2 186	0.29	11.9
Total	3 582	17 166	14.6	123

Source: FAOSTAT and WBA calculations

The high potential of 123 EJ covers almost 20% of all energy supply globally. It is important to estimate the sustainable potential of agricultural residues after considering socio, economic and environmental factors.

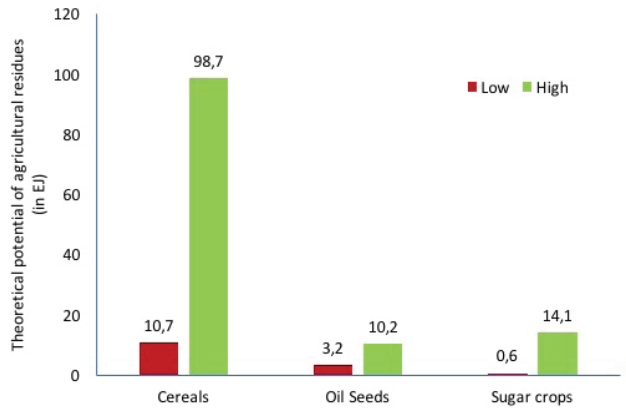

Figure 32 Theoretical potential of agricultural residues (in 2014)

2.3. FORESTRY

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.

AREA

American continent including North, Central and South America holds the largest amount of forest land globally. Close to 40% of the forest area is in that region (Table 32). Europe follows second at 25% largely due to the high concentration of forests in Russia. Asian continent has the highest share of planted forests.

Table 32 Forest area in 2014

	Forest Area	Primary Forests	Other Naturally Regenerated Forests	Planted forest
Africa	627	136	475	16.1
Americas	1 595	721	816	57.5
Asia	593	118	348	127
Europe	1 015	278	652	85.2
Oceania	173	27.4	141	4.35
World	4 002	1 279	2 433	290

All values in million ha. Source: FAOSTAT

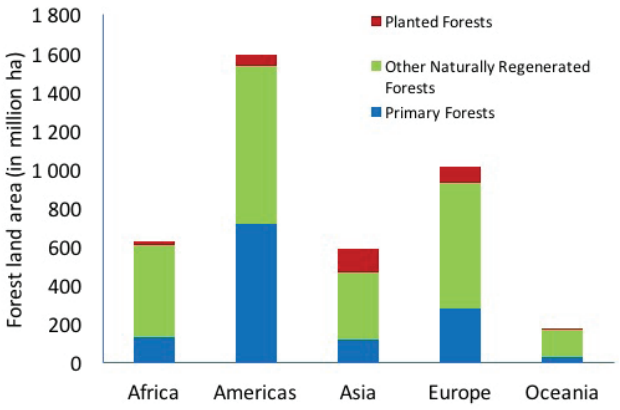

Figure 33 Forest land area in 2014

The top 10 countries with highest forest land area (excluding EU - 28) are led by Russia, Brazil and Canada (Table 33). One third of all the forest area is in two countries – Russia and Brazil. Primary forests are those with no visible human activities. These are the highest in Russia, Brazil and Canada. Among planted forests, China has planted 77.8 million ha of forests – the highest among all top 10 countries.

Table 33 Forest area - Top 10 countries in 2014

	Countries	Forest area	Primary forests	Other naturally regenerative forests	Planted forests
1	Russia	815	273	522	19.8
2	Brazil	495	203	284	7.58
3	Canada	347	206	126	15.4
4	USA	310	75.3	208	26.2
5	China	207	11.6	117	77.8
6	DR Congo	153	103	50.0	0.06
7	Australia	124	5.04	117	1.99
8	Indonesia	91.7	46.3	40.5	4.92
9	Peru	74.1	65.9	7.08	1.12
10	India	70.5	15.7	43.0	11.9
Total (Top 10)		2 687	1 004	1 516	167
EU - 28		161	4.05	101	55.5
World		4 002	1 279	2 433	290

All values in million ha. Top 10 excluding EU – 28. Source: FAOSTAT

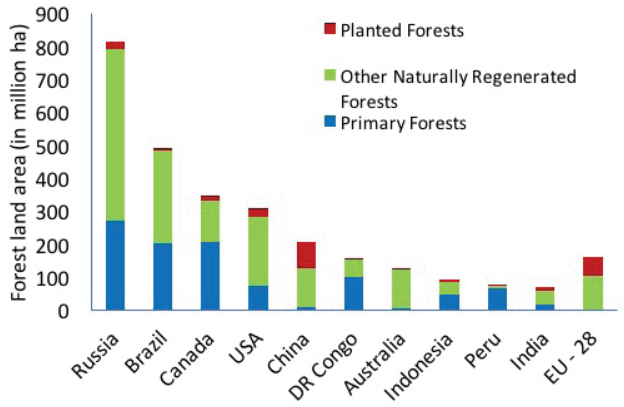

Figure 34 Forest land area in top 10 countries in 2014

WOOD FUEL

Woodfuel is wood used for fuel purposes – cooking, heating or power production. It includes wood harvested from main stems, branches and other parts of trees. The exact definitions may vary.

It is the major contributor to biomass supply globally. Globally, 1.87 billion m^3 of wood fuel is produced – mostly in Asia and Africa. Considering the average growth since 2000, Europe wood fuel production increased by 3% annually while Asia reduced its production growth rate by 0.7%.

Table 34 Wood fuel production globally

	World	Africa	Americas	Asia	Europe	Oceania
2000	1 771	542	314	808	93.6	12.7
2005	1 799	589	300	792	107	11.5
2010	1 823	631	290	764	127	10.7
2015	1 866	666	314	730	147	10.6

All values in million m^3. Source: FAOSTAT

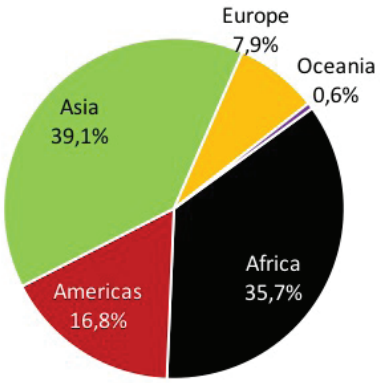

Figure 35 Wood fuel production in continents in 2015

India is the largest producer of woodfuel globally – 307 million tonnes in 2015. The country has seen a 11% increase in production in 15 years while in contrast, China decreased its production by 24%. All African countries have increased their production. Brazil, Indonesia and USA have reduced their production of woodfuel.

Table 35 Production of woodfuel - top 10 countries in 2014

	Countries	2015	2000
1	India	307	277
2	China	172	228
3	Brazil	118	132
4	Ethiopia	108	87.5
5	DR Congo	82.5	64.9
6	Nigeria	65.3	59.3
7	Indonesia	48.3	89.0
8	USA	44.3	45.9
9	Ghana	44.0	26.7
10	Uganda	42.4	34.1
	Total (Top 10)	1 032	1 045
	EU - 28	98.6	69.6
	World	1 866	1 771

All values in million m^3. Source: FAOSTAT

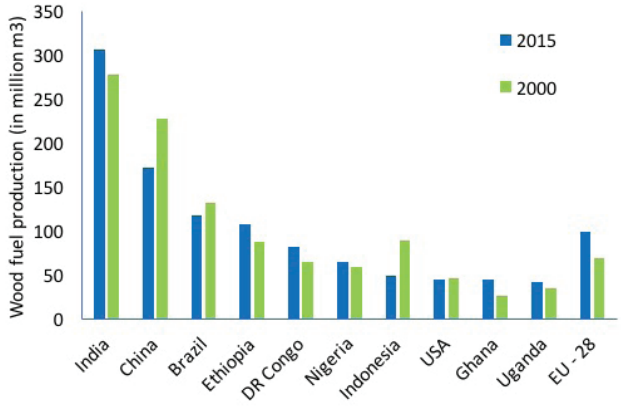

Figure 36 Wood fuel production in top 10 countries in 2015

Forestry residues

Forestry sector is the largest contributor to the biomass supply. Significant forestry residues are utilized globally, especially in European countries. However, there is a potential to utilize more forestry residues.

A theoretical estimate shows that more than 777 million tonnes of forest residues is produced globally (Table 36). These residues are produced during logging, sawmilling, plywood and particle board production along with chemical pulp production. The residues are in the form of solid wood, fine dust or liquids.

A theoretical estimate of the potential suggests that 5.78 EJ – 8.81 EJ of potential is readily available in these residues. The estimate is more than 10 – 15% of the global biomass supply. It is important to note that part of the energy is already in use. Moreover, the sustainable potential of utilizing the residues will be lower and should be investigated.

Table 36 Forest residues potential globally

	Residues (million tonnes)	Energy Potential - Low (EJ)	Energy Potential - High (EJ)
Field Based residues	371	0.89	2.94
Processing Based - Solid Wood	70.2	0.32	1.11
Processing Based - Fines Dust	37.3	0.09	0.29
Processing Based - Liquids	298	4.48	4.48
Total	777	5.78	8.81

Source: FAOSTAT and WBA calculations

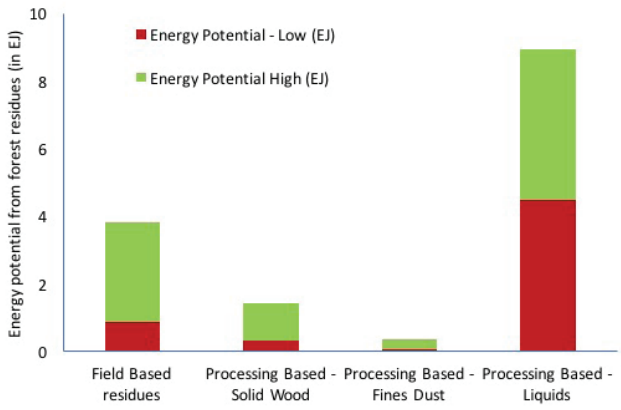

Figure 37 Forest residues energy potential

2.4. WASTE

Waste to energy is an important part of the bioenergy supply. Waste obtained from municipalities and industries contributes to the increasing supply of biomass globally. Currently, the total share of waste sector in biomass supply is only 3%. This sector is classified into municipal waste (Renewable and non-renewable) and industrial waste. Municipal waste consists of products obtained from households, industry, hospitals etc. which are collected by local authorities for incineration. On the other hand, Industrial waste is waste consisting of solid and liquid products (e.g. tyres) combusted directly in specialized plants.

In 2014, 2.12 EJ of waste was converted to energy globally – large part of it was from municipal waste from households and industries (Table 37). The waste sector has increased at an annual rate of 4% during 2000 – 2014.

Table 37 Energy recovery from waste globally

	Total Waste	Municipal Waste - Total	Municipal Waste - Renewable	Industrial Waste
2000	1.20	0.74	0.37	0.47
2005	1.34	0.94	0.49	0.40
2010	1.83	1.15	0.60	0.68
2014	2.12	1.32	0.67	0.80

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

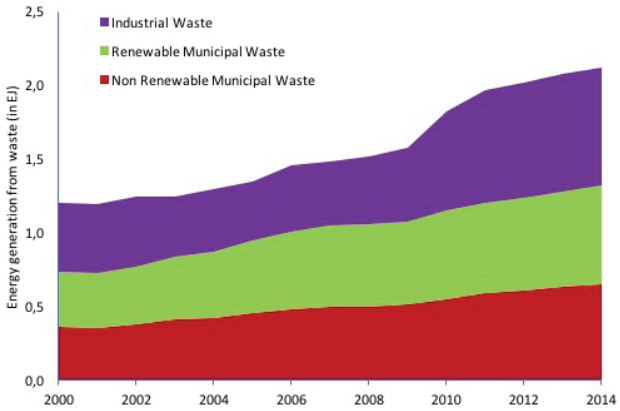

Figure 38 Energy recovery from waste globally

Large part of the waste to energy conversion occurs in Europe. 55% of all waste to energy occurs in Europe while the rest is in Asia and Americas (Table 38). Although there might be waste conversion facilities in Africa and Oceania, they are not in the scale occurring in the rest of the regions.

Table 38 Energy recovery from waste in continents in 2014

	Total Waste	Municipal Waste - Total	Municipal Waste - Renewable	Industrial Waste
Africa	0.00	0.00	0.00	0.00
Americas	0.37	0.30	0.16	0.06
Asia	0.58	0.19	0.10	0.38
Europe	1.17	0.82	0.42	0.35
Oceania	0.00	0.00	0.00	0.00
World	2.12	1.32	0.67	0.80

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

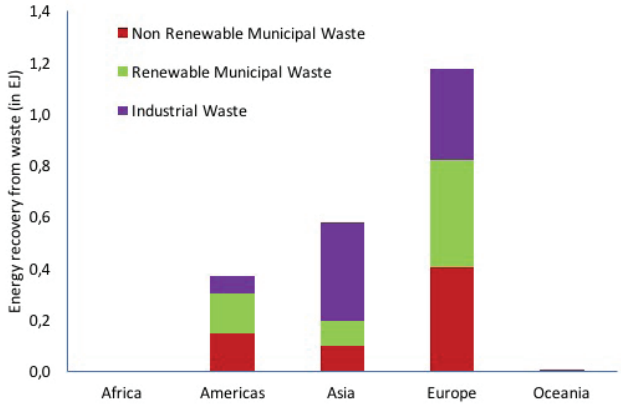

Figure 39 Energy recovery from waste in continents

The top 4 non-EU countries to convert large scale waste to energy are USA, Taiwan, Switzerland and Japan. Om renewable municipal waste generation, these countries cover 79% of all conversion. The rest occurs in EU – 28 nations. However, the data is not completely representative of the global waste to energy generation sector.

Table 39 Energy recovery from renewable municipal waste in 2014 in top 4 countries

	Renewable Municipal Waste
United States	0.15
Taiwan	0.03
Switzerland	0.02
Japan	0.02
Total (Top 4)	0.53
EU - 28	0.38
World	0.67

All values in EJ Top 4 excludes EU - 28 Source: IEA Key World Energy Statistics

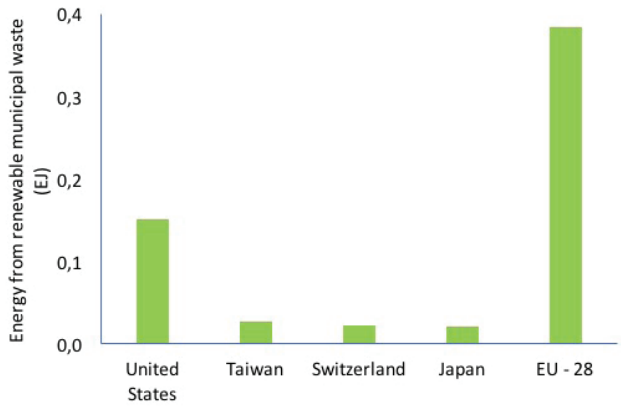

Figure 40 Energy recovery from municipal renewable solid waste in top 4 countries

3. BIOMASS TO ELECTRICITY

KEY FINDINGS

Bioelectricity

- Bioelectricity is the 3rd largest renewable electricity generating source.
- In the year 2014, the bioelectricity generation was 493 TWh – most of it from solid biomass sources.
- 40% of the global bioelectricity generation totalling 196 TWh occurs in Europe.

Electricity only plants

- 3.98 EJ of biomass was utilized globally for electricity generation in electricity only plants.
- Using an average conversion efficiency for electricity only plants of 32%, 354 TWh of electricity was generated in 2014 in electricity only plants

CHP plants

- In 2014, 2.4 EJ of biomass was used for electricity generation in combined heat and power plants
- Utilizing a global average conversion efficiency of 23%, 154 TWh of electricity was generated in CHP plants globally.

OVERVIEW

Renewable electricity can be generated from biomass by thermal conversion of biomass. Bioelectricity is the 3rd largest renewable electricity generating source.

During 2000 – 2014, the bioelectricity generation increased by an annual growth rate of 8.2% (Table 40). In the year 2014, the bioelectricity generation was 493 TWh – most of it from solid biomass sources. These include wood chips, wood pellets, agricultural residues, forest residues etc. Municipal and Industrial waste generated about 93.5 TWh – about 19% of the total bioelectricity generation.

Table 40 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	223	46.2	11.8	143	21.0	1.98
2010	367	60.4	20.1	235	46.5	5.07
2014	493	68.7	24.8	313	80.1	6.31

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

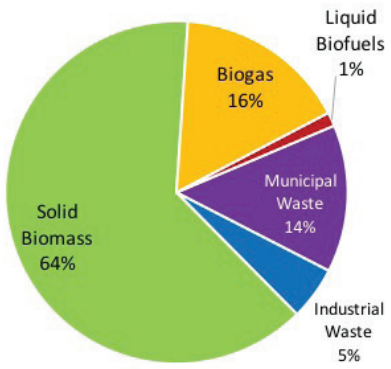

Figure 41 Electricity generation from biomass in 2014

Most of the bioelectricity generation is in Europe (Table 41). 40% of the global bioelectricity generation totalling 196 TWh occurs in Europe. Municipal waste to electricity generation is prominent in Europe while Asia has higher energy generation from industrial waste. Solid biomass generation is highest in Americas – 118 TWh. Europe generates almost two thirds of global bioelectricity generation from biogas and liquid biofuels.

Table 41 Electricity generation from biomass in continents in 2014

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
Africa	1.83	0.00	0.00	1.80	0.03	0.00
Americas	153	16.9	2.90	118	15.4	0.21
Asia	138	11.7	15.2	106	3.51	1.26
Europe	196	40.2	6.74	85.4	59.3	4.85
Oceania	4.15	0.00	0.00	2.27	1.88	0.00
World	493	68.7	24.8	313	80.1	6.31

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

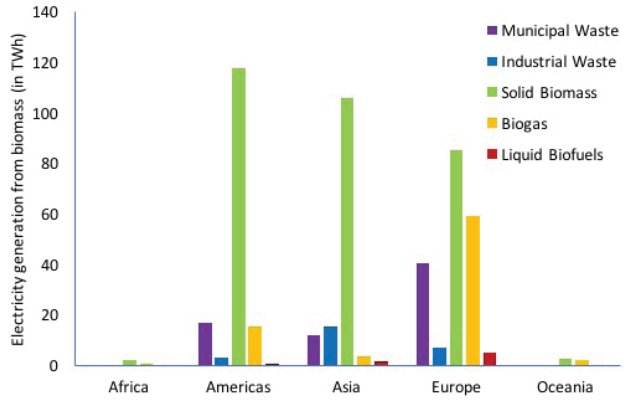

Figure 42 Electricity generation from biomass in continents in 2014

Europe is the world leader in bioelectricity generation and EU – 28 countries generated more than 38% of all bioelectricity (Table 42). The top 10 countries below do not include the EU – 28 nations. USA, China and Brazil are the leading bioelectricity generating countries in 2014.

Table 42 Electricity generation from biomass in top 10 countries globally

	Countries	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
1	**USA**	81.8	16.6	2.82	48.6	13.6	0.21
2	**China**	57.4	0.00	13.0	44.4	0.00	0.00
3	**Brazil**	46.0	0.00	0.00	45.4	0.56	0.00
4	**Japan**	35.5	4.83	1.77	28.9	0.00	0.00
5	**India**	25.4	1.54	0.00	22.9	0.97	0.00
6	**Thailand**	8.54	0.32	0.00	7.67	0.55	0.00
7	**Canada**	5.36	0.27	0.00	4.12	0.97	0.00
8	**Chile**	5.33	0.00	0.00	5.29	0.04	0.00
9	**Taiwan**	3.68	3.27	0.00	0.39	0.02	0.00
10	**Australia**	3.51	0.00	0.00	1.88	1.64	0.00
	Total (Top 10)	273	26.8	17.5	210	18.3	0.21
	EU - 28	189	37.5	3.41	84.8	58.9	4.85
	World	493	68.7	24.8	313	80.1	6.31

All values in TWh. Top 10 excludes the EU – 28. Source: IEA Key World Energy Statistics

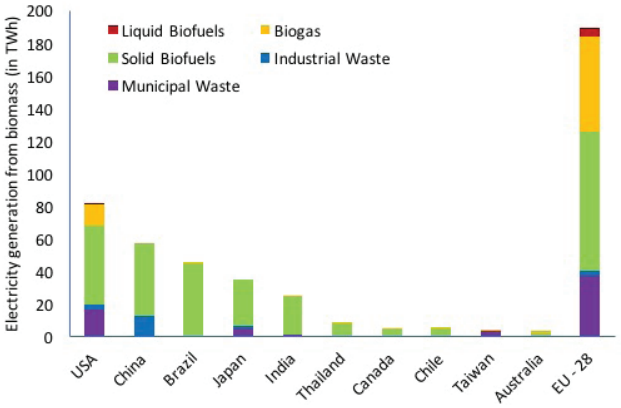

Figure 43 Electricity generation from biomass in top 10 countries in 2014

3.1 ELECTRICITY ONLY PLANTS

Electricity only plants refer to plants designed to generate electricity only while the heat is not utilized. 3.98 EJ of biomass was utilized globally for electricity generation in electricity only plants. Using an average conversion efficiency for electricity only plants of 32%, 354 TWh of electricity was generated in 2014.

Table 43 Use of biomass in electricity only plants globally

	Total	Total (TWh)	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	1.08	95.8	0.38	0.06	0.52	0.12	0.00
2005	1.68	149	0.51	0.03	0.94	0.19	0.01
2010	2.84	252	0.60	0.18	1.75	0.29	0.02
2014	3.98	354	0.64	0.25	2.60	0.44	0.04

All values in EJ. Source: IEA Key World Energy Statistics. Average conversion efficiency of 32%

3.2 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 2014, 2.4 EJ of biomass was used for electricity generation in CHP plants. Utilizing a slightly lower global average conversion efficiency of 23%, 154 TWh of electricity was generated in CHP plants globally.

Table 44 Use of biomass for electricity in combined heat and power plants

	Total	Total (TWh)	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	1.05	67.3	0.19	0.14	0.69	0.03	0.00
2005	1.37	87.7	0.29	0.12	0.91	0.05	0.00
2010	1.77	113	0.37	0.13	1.09	0.15	0.02
2014	2.40	154	0.48	0.14	1.47	0.30	0.02

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

4. BIOMASS TO HEAT

KEY FINDINGS

Derived Heat

- Derived heat is heat generated in heat only and combined heat and power plants.
- In 2014, 0.92 EJ of derived heat was generated globally
- EU – 28 nations generated 66% of all derived heat from biomass

Heat only plants

- Heat only plants are power plants designed only to produce heat and sell it to a third party.
- In 2014, 0.48 EJ of biomass was used to generate heat in heat only plants

CHP plants

- Heat from biomass can also be generated in combined heat and power plants.
- In 2014, 2.4 EJ of biomass was used in CHP plants

Direct Heat

- Direct heating is the use of biomass directly in residential, industrial, commercial, agriculture etc. sectors
- 98% of all biomass used for heating is in the form of direct heating out of which 92% is via the use of solid biomass
- The use of biomass for direct heating is prominent in Asia and African continents. They alone cover 79% of all use of biomass for direct heating

OVERVIEW

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. Direct heat is direct consumption of biomass in end use sectors. Almost 98% of all bioheat is consumed as direct heat. Less than 2% of bioheat is generated in power plants (Table 45).

Table 45 Total heat generated from biomass

	Total Heat	Derived Heat	Direct Heat
2000	38.2	0.41	37.8
2005	40.7	0.53	40.2
2010	43.9	0.78	43.2
2014	46.0	0.92	45.1

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

4.1 DERIVED HEAT

Derived heat covers the total heat production in heating plants and in combined heat and power plants (Table 46). In 2014, 0.92 EJ of bioheat was generated globally – mostly as solid biomass. Waste to heat generation reached 0.4 EJ globally.

Table 46 Derived heat generation from biomass globally

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	0.41	0.13	0.07	0.21	0.00	0.00
2005	0.53	0.15	0.08	0.28	0.01	0.00
2010	0.78	0.21	0.13	0.43	0.01	0.01
2014	0.92	0.25	0.15	0.49	0.03	0.00

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

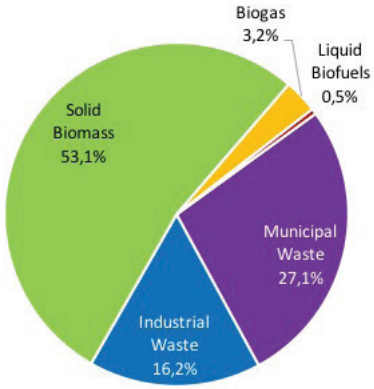

Figure 44 Derived heat generation from biomass in 2014

Large part of the derived heat was generated in Europe (Table 47). There was negligible heat generation in power plants in Africa and Oceania region.

Table 47 Derived heat generation from biomass in continents in 2014

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
Africa	0.00	0.00	0.00	0.00	0.00	0.00
Americas	0.05	0.01	0.00	0.03	0.00	0.00
Asia	0.09	0.02	0.05	0.02	0.00	0.00
Europe	0.78	0.22	0.10	0.44	0.02	0.00
Oceania	0.00	0.00	0.00	0.00	0.00	0.00
World	0.92	0.25	0.15	0.49	0.03	0.00

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

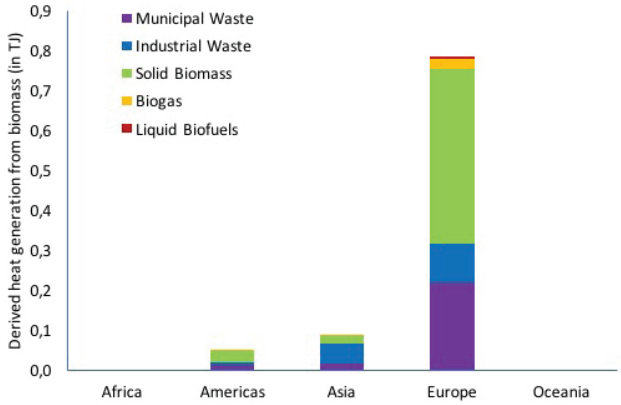

Figure 45 Derived heat generation from biomass in 2014

EU – 28 nations generated 66% of all derived bioheat globally (Table 48). The top 10 nations generated about half of all derived bioheat generated in the EU nations. Among the EU – 28 nations, Sweden was the largest derived bioheat generating source.

Apart from the EU – 28 nations, Russia was the largest bioheat generating nation – 0.11 EJ was generated in 2014. Most of it is via the use of industrial waste to generate heat.

Table 48 Derived heat generation from biomass in top 10 countries in 2014

	Countries	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
1	Russia	0.11	0.00	0.08	0.03	0.00	0.00
2	China	0.05	0.00	0.04	0.01	0.00	0.00
3	USA	0.05	0.01	0.00	0.03	0.00	0.00
4	Korea	0.03	0.02	0.01	0.01	0.00	0.00
5	Belarus	0.02	0.00	0.00	0.02	0.00	0.00
6	Norway	0.02	0.01	0.00	0.00	0.00	0.00
7	Switzerland	0.01	0.01	0.00	0.00	0.00	0.00
8	Ukraine	0.01	0.00	0.00	0.01	0.00	0.00
9	Canada	0.01	0.00	0.00	0.00	0.00	0.00
10	Turkey	0.00	0.00	0.00	0.00	0.00	0.00
	Total (Top 10)	0.31	0.05	0.14	0.11	0.01	0.00
	EU - 28	0.61	0.20	0.01	0.38	0.02	0.00
	World	0.92	0.25	0.15	0.49	0.03	0.00

All values in TJ. Top 10 excludes the EU – 28. Source: IEA Key World Energy Statistics

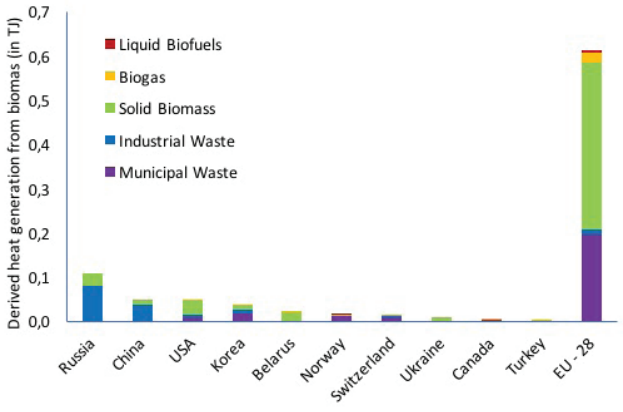

Figure 46 Derived heat from biomass in top 10 countries in 2014

4.2 HEAT ONLY PLANTS

Heat only plants are power plants designed only to produce heat and sell it to a third party. In 2014, 0.48 EJ of biomass was used to generate heat in heat only plants (Table 49). Utilizing an approximate conversion factor of 40% for heat generation in heat only plants, 0.19 EJ of bioheat was generated globally in heat only plants in 2014.

Table 49 Use of biomass in heat only plants

	Total	Total (EJ)	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	0.24	0.10	0.05	0.04	0.15	0.00	0.00
2005	0.31	0.13	0.07	0.05	0.19	0.00	0.00
2010	0.46	0.18	0.10	0.10	0.24	0.01	0.01
2014	0.48	0.19	0.08	0.13	0.25	0.01	0.00

All values in EJ. Source: IEA Key World Energy Statistics. Average conversion rate of 40%

4.3. 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 2014, 2.4 EJ of biomass was used in CHP plants (Table 50). CHP plants usually have a lower conversion rate than heat only plants. Assuming a 30% conversion, 0.72 EJ of bioheat was generated in CHP plants in 2014.

Table 50 Use of biomass in CHP plants

	Total	Total (EJ)	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	0.24	0.10	0.05	0.04	0.15	0.00	0.00
2005	0.31	0.13	0.07	0.05	0.19	0.00	0.00
2010	0.46	0.18	0.10	0.10	0.24	0.01	0.01
2014	0.48	0.19	0.08	0.13	0.25	0.01	0.00

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

4.4. DIRECT HEAT

Direct heating is the use of biomass directly in residential, industrial, commercial, agriculture etc. sectors. The direct heating excludes the use of biomass in energy transformation sector – electricity plants, CHP and heat only plants.

98% of all biomass used for heating is in the form of direct heating out of which 92% is via the use of solid biomass (Table 51).

Table 51 Direct heat from biomass

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
2000	37.8	0.11	0.22	36.1	0.13	1.21
2005	40.2	0.08	0.19	38.2	0.26	1.46
2010	43.2	0.08	0.25	41.0	0.36	1.55
2014	45.1	0.11	0.27	42.5	0.49	1.78

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

The use of biomass for direct heating is prominent in Asia and African continents. They alone cover 79% of all use of biomass for direct heating (Table 52, Table 53). The countries in the continents are highly dependent on traditional biomass for heating (e.g. charcoal, woodfuel, agriculture residues etc.).

Table 52 Direct heat from biomass in 2014

	Total	Municipal Waste	Industrial Waste	Solid Biomass	Biogas	Liquid Biofuels
Africa	12.8	0.00	0.00	11.8	0.00	1.06
Americas	5.91	0.02	0.03	5.53	0.02	0.31
Asia	22.9	0.01	0.11	22.0	0.36	0.38
Europe	3.28	0.07	0.13	2.96	0.10	0.03
Oceania	0.21	0.00	0.00	0.21	0.00	0.00
World	45.1	0.11	0.27	42.5	0.49	1.78

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

Table 53 Direct heat generation from biomass in top 10 countries in 2014

	Countries	Total	Municipal Waste	Industrial Waste	Solid Biofuels	Biogas	Liquid Biofuels
1	China	8.14	0.00	0.00	7.82	0.32	0.00
2	India	7.31	0.00	0.00	7.21	0.00	0.10
3	Nigeria	4.19	0.00	0.00	4.07	0.00	0.12
4	USA	1.99	0.02	0.02	1.88	0.02	0.05
5	Brazil	1.81	0.00	0.00	1.65	0.00	0.16
6	Ethiopia	1.51	0.00	0.00	1.32	0.00	0.19
7	Pakistan	1.32	0.00	0.00	1.31	0.00	0.01
8	Congo DR	0.81	0.00	0.00	0.69	0.00	0.12
9	Tanzania	0.77	0.00	0.00	0.71	0.00	0.06
10	Thailand	0.60	0.00	0.00	0.44	0.02	0.14
	Total (Top 10)	28.4	0.02	0.02	27.1	0.37	0.93
	EU - 28	2.85	0.07	0.10	2.57	0.10	0.02
	World	45.1	0.11	0.27	42.5	0.49	1.78

All values in EJ. Source: IEA Key World Energy Statistics. Top 10 excludes the EU – 28.

5. BIOMASS TO LIQUID BIOFUELS

KEY FINDINGS

Overview

- In 2014, the total biofuels production reached 126 billion litres globally
- 95.1 billion litres of biofuels are produced in Americas – predominantly in USA and Brazil.
- The annual growth rate of biofuels of 15% since 2000 is lot higher than the average growth of all biomass supply at 2.3%.

Land use and protein production

- Biofuel production covers 2.9% of the land area used for production of major biofuel crops
- The global production of biofuels also produced 75.3 million tonnes of protein production - a major source of feed.

OVERVIEW

Liquid biofuels for transport are the leading source of renewable energy in that sector. Biofuels are used predominantly for road transport while options are available for marine and aviation sectors as well. The biofuels industry has seen tremendous growth in the past 14 years despite decreasing oil prices and various debates on sustainability.

In 2014, the total biofuels production reached 126 billion litres globally (Table 54). The annual growth rate of 15% since 2000 is lot higher than the average growth of all biomass supply at 2.3%. Most of the biofuels produced was from bioethanol produced from fermentation of sugar based crops. Rest from biodiesel via transesterification of vegetable oils and animal fats. The third category is advanced biofuels – a definition encompassing all liquid biofuels excluding bioethanol and biodiesel. This would include cellulosic based ethanol, hydro treated vegetable oil, renewable diesel etc.

Table 54 Liquid biofuels production globally

	Biofuels	Bioethanol	Biodiesel	Advanced Biofuels
2000	18.0	13.2	0.84	3.94
2005	38.6	26.9	3.64	8.14
2010	105	65.4	20.2	19.8
2014	126	78.0	32.0	16.4
2015	128			
2016	129			

All values in billion litres. Source: IEA Key World Energy Statistics and REN21 GSR 2017

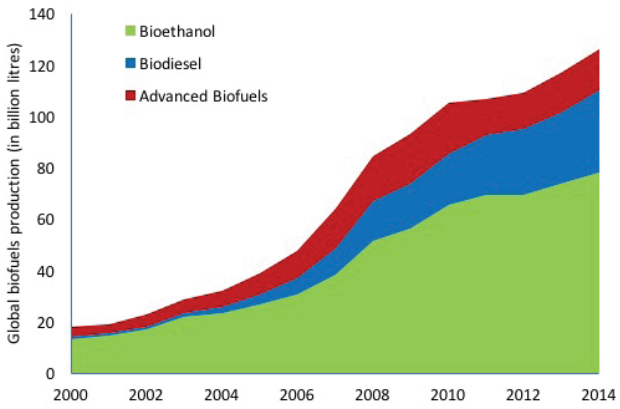

Figure 47 Liquid biofuels production globally

One continent dominates the liquid biofuels production sector (Table 55). 95.1 billion litres of biofuels are produced in Americas – predominantly in USA and Brazil. The feedstock varies with corn ethanol dominating USA and sugarcane ethanol in Brazil.

Table 55 Liquid biofuels production in continents in 2014

	Biofuels	Bioethanol	Biodiesel	Advanced Biofuels
Africa	0.06	0.06	0.00	0.00
Americas	95.1	68.5	11.0	15.6
Asia	11.4	4.53	6.54	0.29
Europe	19.4	4.57	14.3	0.53
Oceania	0.40	0.28	0.12	0.00
World	126	78.0	32.0	16.4

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

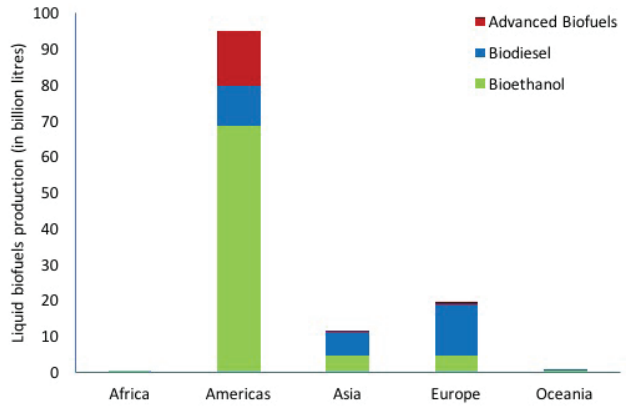

Figure 48 Liquid biofuels production in continents in 2014

USA and Brazil are the leading biofuels producing countries (Table 56). Apart from EU – 28 nations, Argentina, Indonesia and China make up the top 5.

Table 56 Liquid biofuels production in top 5 countries in 2014

	Biofuels	Bioethanol	Biodiesel	Advanced Biofuels
United States	58.6	53.3	4.67	0.63
Brazil	29.4	12.0	2.47	14.9
Argentina	3.99	0.50	3.49	0.00
Indonesia	3.34	0.00	3.34	0.00
China	3.11	2.66	0.45	0.00
Total (Top 5)	98.5	68.5	14.4	15.6
EU - 28	19.3	4.54	14.3	0.52
World	126	78.0	32.0	16.4

All values in billion liters. Top 5 excludes EU – 28. Source: IEA Key World Energy Statistics

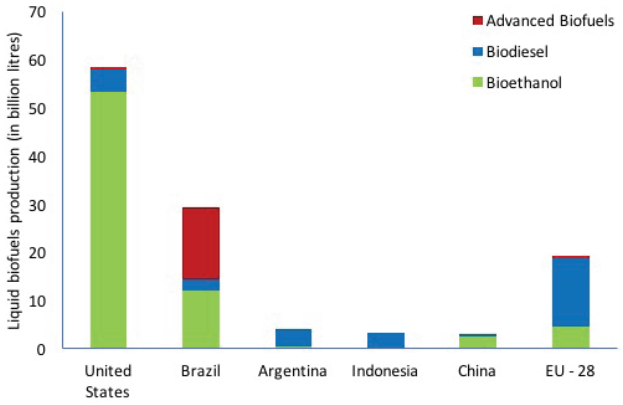

Figure 49 Liquid biofuels production in top 5 countries in 2014

5.1. LAND USE AND PROTEIN PRODUCTION

Land is a critical factor in biofuel production. An estimate of the production of biofuels shows that biofuel production covers 2.9% of the land area used for production of major biofuel crops including wheat, maize, other coarse grains, sugarbeet, sugarcane, palm oil and other vegetable oils (Table 59). In 2014, the total production of the crops was 4.2 billion tonnes out of which 124 million tonnes was used for biofuel production.

Another important aspect in biofuel production is the generation of protein products during the biofuels processes. Protein is obtained in the form of DDGS (Distillers Dried Grain with Soluble) which can be utilized as feed ingredient and as oil cake which is commonly used for animal feed. The global production of biofuels also produced 75.3 million tonnes of protein production.

Table 57 Land use and protein production for biofuels

		Production (Mt)	Biofuels (Mt)	% of Biofuels Use	Protein Production (Mt)
Bioethanol	**Wheat**	720	2.62	0.4%	2.64
	Maize	1 014	53.2	5.2%	48.8
	Other Grains	299	4.16	1.4%	0.00
	Sugarbeet	257	1.11	0.4%	0.00
	Sugarcane	1 812	25.3	1.4%	0.00
Biodiesel	**Palm Oil**	61	23.2	38%	23.9
	Vegetable Oils	113	14.1	12%	0.00
Total		4 276	124		75.3

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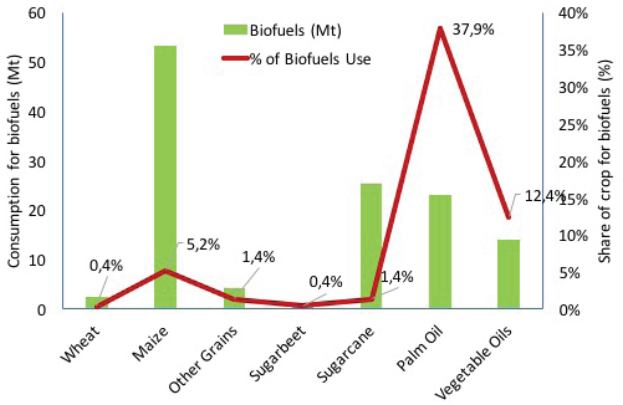

Figure 50 Biofuels consumption and share of biofuels in major crops production

6. SPECIAL SECTORS

KEY FINDINGS

Biogas

- During 2000 – 2014, the average growth of production of biogas was 11.2%.
- In 2014, the production of biogas was 58.7 Nm3.
- Almost half of the global biogas production occurs in Europe
- EU – 28 nations dominate biogas production with more production than the rest of the top 5 combined

Pellets

- In 2015, 28 million tonnes of pellets were produced globally
- 59% of the production happens in Europe followed by 34% in Americas – predominantly South East USA.
- South Korea is the largest pellet importer outside EU followed by Japan to meet their increasing demand of pellets for electricity generation

Charcoal

- Globally, 52.2 million tonnes of charcoal were produced – almost twice the amount of pellets produced
- 62% of global charcoal production occurs in Africa
- Charcoal production in top countries is dominated by Asian and African countries

6.1. 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.

Global biogas generation has increased rapidly since 2000. During 2000 – 2014, the average growth of production was 11.2%. In 2014, the production of biogas was 58.7 Nm^3. Using an average energy density factor of 21.6 MJ/Nm^3, the total biogas production was 1.27 EJ.

Table 58 Biogas production globally

	World (EJ)	World	Africa	Americas	Asia	Europe	Oceania
2000	0.28	13.2	0.000	6.13	2.33	4.41	0.33
2005	0.50	23.1	0.000	7.75	6.95	7.93	0.46
2010	0.84	38.7	0.004	6.20	14.9	16.9	0.73
2014	1.27	58.7	0.018	9.79	18.3	29.7	0.89

All values in billion Nm^3. Source: IEA Key World Energy Statistics

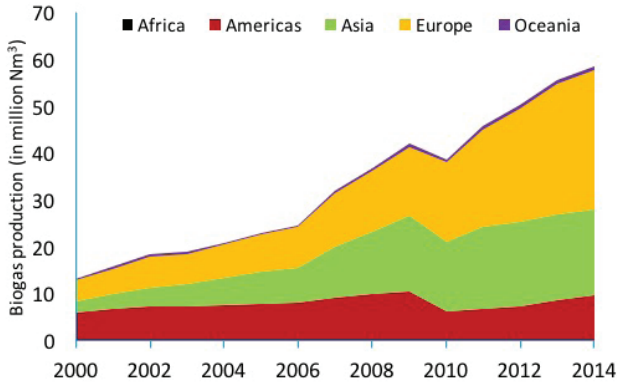

Figure 51 Biogas production during 2000 - 2014

Almost half of the global biogas production occurs in Europe (Figure 52), 32% in Asia and 17% in Americas. Less than 2% of the production occurs in Africa and Oceania continents.

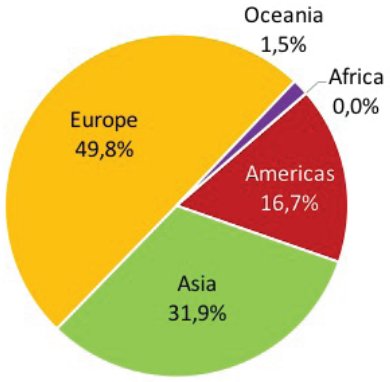

Figure 52 Biogas production in continents in 2014

EU – 28 nations dominate biogas production with more production than the rest of the top 5 combined (Table 59). Apart from them, China and USA are the leading biogas producers.

Table 59 Biogas production in top 5 countries in 2014

	World
China	15.0
USA	8.48
Thailand	1.30
India	0.81
Canada	0.79
Total (Top 5)	26.4
EU - 28	28.9
World	58.7

All values in billion Nm^3. Top 5 excluding the EU – 28. Source: IEA Key World Energy Statistics

6.2. 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. In 2015, 28 million tonnes of pellets were produced globally (Table 60).

Table 60 Pellet production globally

	World	Africa	Americas	Asia	Europe	Oceania
2012	19.7	0.09	6.72	0.30	12.5	0.03
2013	22.3	0.04	7.64	0.62	14.0	0.03
2014	26.0	0.04	8.91	1.50	15.4	0.14
2015	28.0	0.03	9.44	1.99	16.3	0.15

All values in million tonnes. Source: FAOSTAT

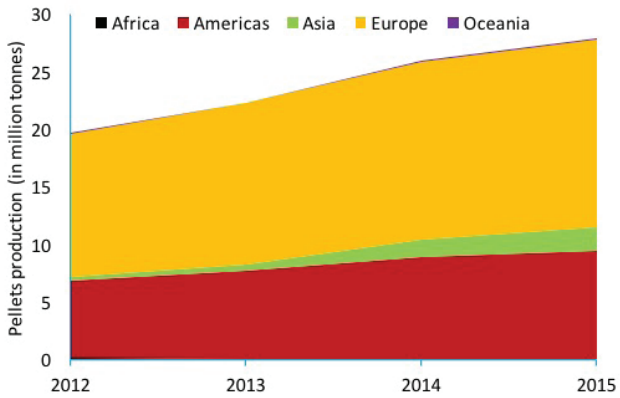

Figure 53 Pellets production during 2012 - 2015

Europe is the world leader in the production of pellets (Table 61). Out of the current global production of 28 million tonnes, 59% of the production happens in Europe followed by 34% in Americas – predominantly South East USA. Europe is also the largest trader of pellets.

Table 61 Pellets production and trade in continents in 2015

	Production	Import	Export
Africa	0.03	0.00	0.02
Americas	9.44	0.24	6.24
Asia	1.99	1.75	1.34
Europe	16.3	13.6	8.56
Oceania	0.15	0.00	0.00
World	28.0	-	-

All values in million tonnes. Source: FAOSTAT

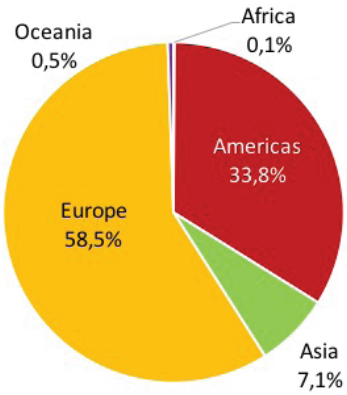

Figure 54 Pellet production globally

The top non-EU nations producing pellets are USA, Canada, Vietnam, Russia and China (Table 62). EU – 28 nations produce 14.2 million tonnes more than the top 5 combined.

Table 62 Pellet production in top 5 countries globally

	Production
USA	7.40
Canada	1.90
Vietnam	1.06
Russia	0.97
China	0.49
Total (Top 5)	11.8
EU - 28	14.2
World	28.0

All values in million tonnes. EU – 28 not included in Top 5. Source: FAOSTAT

Countries in South East Asia including Korea and Japan are showing increasing trade of pellets. South Korea is the largest pellet importer outside EU followed by Japan to meet their increasing demand of pellets for electricity generation to meet their renewable energy targets. USA is the largest exporter of pellets, exporting 4.58 million tonnes in 2015.

Table 63 Pellets trade in top 5 countries in 2015

Import		Export	
Korea	1.47	**USA**	4.58
Japan	0.23	**Canada**	1.63
USA	0.21	**Vietnam**	1.05
Canada	0.03	**Russia**	0.93
Norway	0.03	**Belarus**	0.16
Total (Top 5)	1.97	**Total (Top 5)**	8.35
EU - 28	13.5	**EU - 28**	7.09

All values in million tonnes. EU – 28 not included in Top 5. Source: FAOSTAT

6.3. 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.

Globally, 52.2 million tonnes of charcoal were produced – almost twice the amount of pellets produced (Table 64).

Table 64 Charcoal production globally

	World	Africa	Americas	Asia	Europe	Oceania
2000	37.0	20.4	9.67	6.54	0.30	0.04
2005	43.9	24.5	10.9	7.96	0.51	0.03
2010	46.8	28.8	9.11	8.34	0.53	0.04
2015	52.2	32.4	10.2	8.85	0.63	0.04

All values in million tonnes. Source: FAOSTAT

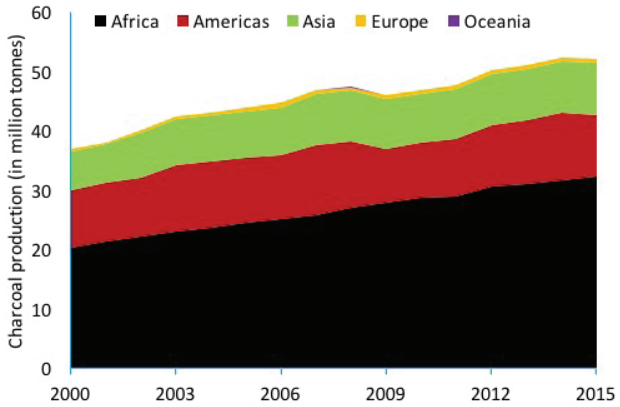

Figure 55 Charcoal production during 2000 - 2015

The charcoal production is dominant in Africa. 62% of global charcoal production occurs in that continent (Table 65). However, the data is insufficient and the production may vary a lot than the reported figures. Americas is the 2nd largest producer of charcoal mainly due to the high use of the product in Brazil in industrial sector which makes the country the largest producer of charcoal.

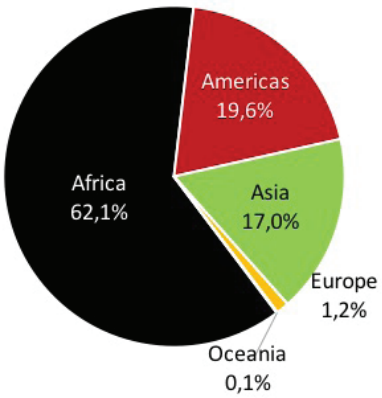

Figure 56 Charcoal production in continents in 2015

Charcoal production in top countries is dominated by Asian and African countries with Brazil as an expectation.

Table 65 Charcoal production in top 5 countries in 2015

	Production
Brazil	6.19
Nigeria	4.37
Ethiopia	4.22
India	2.88
DR Congo	2.40
Total (Top 5)	20.1
EU - 28	0.31
World	52.2

All values in million tonnes. Top 5 does not include EU – 28. Source: FAOSTAT

7. RENEWABLE JOBS

KEY FINDINGS

- It is estimated that 8 million renewable energy jobs were available in 2015 – largely in the solar energy sector in Asia.
- Data does not include traditional biomass use which accounts for 10% of the global energy supply

OVERVIEW

Renewable energy industry has been generating a number of jobs over the years. The pace of growth of renewables in the past has enabled an increasing number of jobs available in the sectors of solar, geothermal, bioenergy, wind and hydropower. However, there has not yet been a comprehensive overview of the renewable energy jobs sector.

It is estimated that 8 million renewable energy jobs were available in 2015 – largely in the solar energy sector in Asia. The large number of jobs in Americas is due to the biofuels industry in USA and Brazil. Unfortunately, this data does not include traditional biomass use which accounts for 10% of the global energy supply.

Table 66 Renewable energy jobs in 2015

	World	Africa	Americas	Asia	Europe
Bioenergy	2 780	0	1 153	572	491
Solar	3 946	0	308	3 229	154
Wind	1 155	0	135	575	330
Hydro (Small)	211	0	21	29	46
Geothermal	182	0	35	2	117
Renewables	9 823	0	1 864	5 068	1 225

All values in 1000's jobs. Source: IRENA

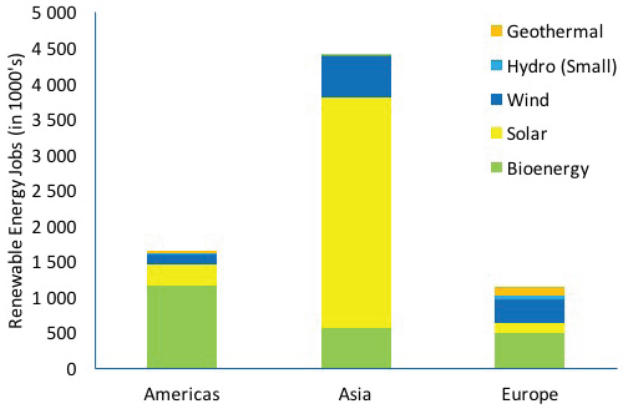

Figure 57 Renewable energy jobs in continents in 2015

8. COUNTRY STATISTICS

Bioenergy data globally is insufficient due to numerous reasons. Lack of knowledge on data collection and gathering, lack of capacity (e.g. finances), and the complexity of the bioenergy system are some of reasons for low availability of updated bioenergy data.

One way to address is to undertake surveys with a questionnaire to different individual countries, harmonize the data and report the information. In 2016, the report had data from 5 countries. This year, WBA undertook the initiative and received responses from 10 countries on updated bioenergy data: China, India, Malaysia, Uganda, Malawi, Japan, Ivory Coast, Iran, Bosnia & Herzegovina and Cape Verde.

The results are presented below for information to the readers.

Table 67 General country information

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Population (million)	1 375	1 211	31.2	34.6	16.8	128	22.7	79.9	3.53	0.52
Urban population (millions)	771	377		4.50	2.69	119	11.4	59.1		0.35
GDP (in billion USD)	9 936	2 488	271	14.8		4 838	29.0	354	15.2	1.56
Country Area (1000 sq.km)	9 478	3 287			119	37.8		1 629	51.2	4.03
Energy Supply (EJ)	105		4.21				0.03	10.2	0.06	0.008
Renewables Supply (PJ)	14 888						4.87	0.11	0.004	0.66
Bioenergy Supply (PJ)	967					415		0.05	0.0003	
Emissions ($MtCO_2e$)		2 432		3.46		1 321		587		0.47

Table 68 Forestry sector data

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Forestry area (1000 sq. km)	2 530	702		26.2		25.1		143	0.03	0.55
Woodfuel (million m3)	172	308			15.0	0.13	9.03	0.20	1.31	0.24
Charcoal (1000 tonnes)	1 678	3 110			295	20.3	488	1.07		0.65
Forestry Residues (million m3)	93.0	389			1.16	6.50		0.02	0.65	
Wood Briquettes (1000 tonnes)	485									

Table 69 Agriculture sector data

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Agriculture Area (mil-lion ha)	166	180		0.93		4.50		6.02		0.05
Production (1000 t):										
Maize	224 632	21 000		2 362		0.19	631	1 168	751	1.07
Rice	208 225	103 610		191		10 549	2 153	2 348		
Wheat	130 185	93 820		20		852		7 893	203	
Pulses		17 330								
Barley						170		2 165	60	
Millets				277		0.23	46			
Oats						0.35				
Rapeseed	14 931	6 840				1.78		52.1		
Sorghum				376			38	225		
Olives								95.0		
Soybeans	15 898	9 130		24		232	1.00	131		
Sunflower				230				7.79		
Oil Palm							400			
Peanuts	16 440									
Sesame	640									
Groundnut		7 180		245						
Cassava				2 894			2 400			
Sugarbeet	8 032					3 567		5 594		
Sugarcane	116 968	346 390				1 159	168	7 406		28 375
Agricultural Residues	160	686							0.33	
Residues to Energy (million t)	80	234								

Table 70 Waste sector data

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Municipal Solid Waste (million t)	191	0.17		0.73		4.40		12.8	1.33	0.17
Energy production from MSW (million t)	62	511*				7895**		5.5*	15672**	

* MW **GWh

Table 71 Bioelectricity generation

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Total Installed Capacity (MW)	10 318	9 112	661		0	41 996 ***				
Solid Biomass (MW)	5 304		686*		18	1 280 ***				
Liquid Biofuels (MW)						0.28 ***				
Biogas (MW)	331		65*			4.94 ***		20.8**		
Black Liquor (MW)						31 635 ***				
Municipal Solid Waste (MW)	4 683					9 033 ***		25.6**		

**GWh ***TWh

Table 72 Bioheat generation

	China	India	Malaysia	Uganda	Malawi	Japan***	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Total Installed Capacity (MW)		187				65 475***				
Solid Biomass (TWh)						11 153***				
Biogas (TWh)										
Black Liquor (TWh)						54 322***				

***TWh

Table 73 Biofuels production

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzegovina	Cape Verde
Bioethanol (million litres)	2100*	2 085			23.0	24.4				
Biodiesel (million litres)	800*	140	684**		0.07					
Biogas (million m3)	14 900							11 000		
Pellets (1000 t)	8 000					120		12.0		

*1000 tons **ktoe

Table 74 Prices of biofuels

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Ethanol (USD/litre)		0.61			0.96					
Pellets (USD/t)		140							164	
Wood chips (USD/t)						70.7				

Table 75 Jobs in bioenergy sector

	China	India	Malaysia	Uganda	Malawi	Japan	Ivory Coast	Iran	Bosnia & Herzego-vina	Cape Verde
Bioenergy Jobs									8 678	

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- owing 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 pro-

duction. 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

Table 76 General data on population, GDP and emissions

	Population	GDP (Current US$)	Energy Use (ktoe)	Emissions (ktCO2)
Australia	23 789 752	1 339 140 527 498	126 992	761 686
Bosnia and Herzegovina	3 810 416	16 191 716 215	7 809	27 108
Brazil	207 847 528	1 803 652 649 614	305 846	2 989 418
Canada	35 848 610	1 552 807 652 015	282 274	1 027 064
Switzerland	8 281 430	670 789 928 810	25 341	54 108
Chile	17 948 141	240 796 388 429	36 480	120 688
China	1 371 220 000	11 064 664 793 256	3 067 049	12 454 711
Cote d'Ivoire	22 701 556	31 759 248 868	14 216	33 502
Congo, Dem. Rep.	77 266 814	35 237 742 278	29 637	802 271
Cabo Verde	520 502	1 603 239 233	0	
Ethiopia	99 390 750	61 539 711 687	49 587	185 292
European Union	509 557 762	16 314 942 278 867	1 569 410	4 702 090
United Kingdom	65 128 861	2 861 090 726 740	180 853	585 780
Ghana	27 409 893	37 543 361 204	9 244	107 784
Indonesia	257 563 815	861 933 968 740	228 269	780 551
India	1 311 050 527	2 088 841 351 184	834 777	3 002 895
Iran, Islamic Rep.	79 109 272		240 005	
Iceland	330 815	16 779 598 787	5 927	5 515
Japan	126 958 472	4 383 076 298 082	441 143	1 478 859
Korea, Rep.	50 617 045	1 377 873 107 856	269 441	668 990
Mongolia	2 959 134	11 741 338 841	5 466	
Malawi	17 215 232	6 403 820 949	0	21 632
Malaysia	30 331 007	296 283 190 373	90 990	279 098
Nigeria	182 201 962	486 792 837 971	138 296	301 010
Norway	5 190 239	386 578 443 733	29 043	63 537
Nepal	28 513 700	21 194 888 048	11 830	40 763
Pakistan	188 924 874	271 049 886 673	91 772	369 735
Russian Federation	144 096 870	1 365 865 245 099	712 253	2 803 398
Saudi Arabia	31 540 372	646 001 866 667	218 025	
Thailand	67 959 359	395 168 025 882	135 220	440 412
Tanzania	53 470 420	45 628 247 290	25 624	235 353
Uganda	39 032 383	27 529 249 701	0	80 725
United States	321 418 820	18 036 648 000 000	2 233 639	6 343 841
World	7 346 705 903	74 292 303 725 335	14 174 754	53 526 303

Source: World Bank

USEFUL CONVERSIONS

Table 77 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 78 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/m3	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

LIST OF TABLES

LIST OF FIGURES

OFFICIAL SUPPORTER OF WBA

ENERSTENA GROUP OF COMPANIES

ENERSTENA GROUP

SILVER SUPPORTER OF WBA

AGRANA

GOLD SUPPORTER OF WBA STATISTICS 2017

Stockholm
The Capital of Scandinavia

Stockholms stad