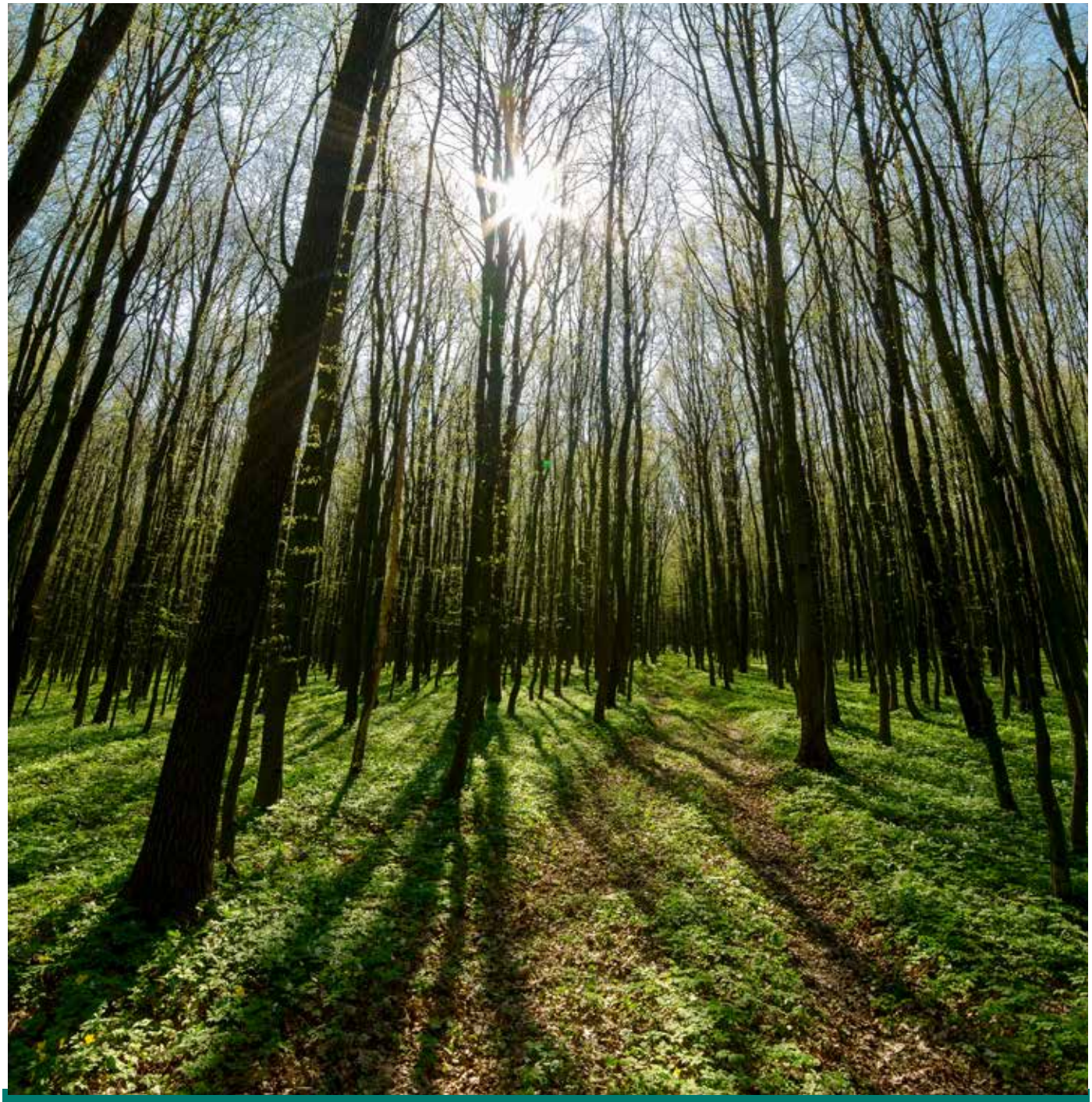

WBA GLOBAL BIOENERGY STATISTICS 2016

WORLD BIOENERGY ASSOCIATION

www.worldbioenergy.org

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ACKNOWLEDGEMENT

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DISCLAIMER

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

MESSAGE FROM THE PRESIDENT

Dear readers,

It gives me great pleasure to bring you the 3rd version of our flagship report – WBA Global Bioenergy Statistics 2016.

During COP21 in Paris, renewables were the headlines. The increasing share of renewable electricity in the energy mix, the dropping of solar PV prices and innovations in electric mobility were highly discussed. It seemed as if we have found the solution to our energy and climate crisis.

Unfortunately, energy is not electricity. The largest consumption of energy is in the heating sector and we are slow in progress in greening our transportation system. Moreover, no one was talking about the largest renewable energy source globally – bioenergy. One of the major reasons was lack of information and awareness among not just the general public but among policy makers as well. This is unfortunate and we are trying our best to fix this. This lack of awareness arises out of lack of good data on bioenergy and our WBA Global Bioenergy Statistics 2016 report is one way of solving this.

As you can see from the report, the supply of renewable energy has increased from 13.5% to 13.8%. In final energy consumption, the renewable share was 18.3% in 2013 - a modest increase of 0.2% over last year. The consumption of bioenergy increased to 49.5 EJ which is almost 14% of the global final energy consumption. It shows the significance of bioenergy in the energy mix. Bioenergy is growing steadily and will continue to do so in the future.

We at WBA strongly believe that bioenergy will play a key role in the future energy mix. Bioenergy from agriculture, forestry and wastes sector along with renewables is the future. In the transition to a green world, all renewables have to be considered and none left behind!

Happy reading!

Dr. Heinz Kopetz

President

World Bioenergy Association

June 2016

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, presenations in conferences and exhibitions etc.

What kind of membership is possible

Full members

Bioenergy 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 lobbying 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

BIOENERGY IS GROWING STEADILY

In 2013, the supply of bioenergy was 57.7 EJ – 10% of the global energy supply. In terms of final energy consumption, bioenergy share increased by 1.2 EJ accounting for 13.9% of the global energy consumption and a modest increase of 0.05% over the previous year.

The share of renewables has increased to 18.3% - a slight increase of 0.2%. Such a slow pace of renewables is unsettling. The use of renewables in end sectors varies significantly. In electricity, the renewables share is 22% dominated by large scale hydro and wind. Renewables contribution in derived heat (heat generated in power plants) was only 7%. Renewables in direct heat was 28% - mostly because of biomass and minor contributions from solar thermal and geothermal technologies. The renewables share is even lower in transportation – only 2.5% is renewable largely because of use of biofuels.

Energy and electricity are not the same. Bioenergy is the 3rd largest renewable electricity generating source. It is the largest derived and direct heat generating renewable energy source. It is also the leading renewable source for contribution in the transportation sector.

BIOMASS SUPPLY - FORESTRY, AGRICULTURE AND WASTE

Global agriculture area reduced by 0.53% since 2000. In agriculture sector, yields are crucial for food and fuel production. Increasing yields of crops is crucial. The increasing yields of three major crops – maize, rice and wheat – has reduced land demand by 295, 123 and 152 million ha respectively. For Africa, if the continental yields are the same as global yields, the land demand can be reduced by half.

Agricultural residues have significant potential for energy generation. Use of residues reduces environmental pollution, provides added income to the farmers and reduces demand on fossil fuels. An estimate of the potential of agricultural residues shows a range of 17 EJ to 128 EJ.

Forestry area reduced by 1.23% since 2000. EU – 28 countries increased their forestry area by 3.62%. The supply of biomass was dominated by the forestry sector. Fuelwood and charcoal contribute 68% and 10% of the total biomass supply. The supply is predominantly from Africa and Asia for use in heating and cooking sectors. Forestry residues can also be used for energy purposes. European countries, for e.g. Sweden and Finland already utilize significant residues from the forestry sector. Globally, an estimated potential of using forestry residues ranges from 4.6 EJ to 7.6 EJ.

Waste sector is the third contributor to biomass supply. In 2013, 1.3 EJ of municipal solid waste was generated – mostly in Europe. However, there is significant lack of data in this sector.

BIOMASS USE - ELECTRICITY, HEAT AND TRANSPORTATION

In 2013, 462 TWh of bioelectricity was produced annually – a 6% increase over the previous year. The electricity generated was in electricity only and combined heat and power plants. Outside EU - 28 countries, USA and China are the largest bioelectricity producers. Asia is one of the fastest growing continents in the bioelectricity sector. During 2000 – 2013, countries like China, India and Thailand have increased their bioelectricity production by 20, 17 and 13 times respectively. Europe produces most of its electricity in combined heat and power plants leading to higher efficiencies of conversion. Asia produces most of its electricity in electricity only plants and heat is often ignored.

In 2013, about 0.9 EJ of derived bioheat was generated globally. Derived heat is heat generated in power plants i.e. heat only and combined heat and power plants. 77% of all the derived bioheat was produced in Europe. Apart from EU – 28 countries, Russia, China and the USA are the leading producers of derived bioheat. Sweden is the world's largest producer of derived heat from biomass.

In 2013, 48.5 EJ of direct bioheat was produced. This is the use of biomass directly in end use sectors, for e.g. residential, commercial, agriculture etc. for cooking and heating purposes. Almost half of the direct bioheat was generated in Asia.

In 2015, 133 billion litres of biofuels were produced. In energy terms, biofuels contribution to total biomass supply was 5%. 62% of all biofuel produced was in the form of bioethanol, 24% as biodiesel and rest as other biofuels. 87% of all bioethanol produced was in Americas – corn in USA and sugarcane in Brazil. 43% of all biodiesel produced was in Europe and 38% in Americas.

Protein is a major byproduct during biofuel production. In 2013, 71.1 million tonnes of protein was produced. The total use of land for biofuels was 71 million ha of agricultural land.

BIOMASS SECONDARY PRODUCTS - BIOGAS, PELLETS, CHARCOAL

In 2013, biogas production increased to 59 billion m^3 which is an increase of about 5.5% over previous year. Almost 45% of the production occurs in EU – 28 countries.

Pellet production increased to 26.4 million tonnes in 2014. Europe produced 61% of global pellet production while consuming 78%.

Charcoal is an often underestimated sector. In 2014, 52 million tonnes of charcoal was produced. In volume terms, it is twice as much as pellets and in energy terms almost four times as much as pellets.

8.1 million jobs were generated in renewable energy sector in 2015. Bioenergy sector (for e.g. the sugarcane industry in Brazil) employed 3.7 million people. However, this excludes jobs in traditional biomass.

COUNTRY STATISTICS

Five countries are selected to analyse the energy situation and the role of bioenergy – Turkey, Sudan, Malaysia, Sweden and Canada. The share of renewables in energy supply varies from a low of 5% in Malaysia to 68% in Sudan. Renewable electricity in the grid is the highest in Sudan at 81% and lowest in Malaysia at 9%. Due to lack of policy incentives, there is no derived bioheat generation in Malaysia and Sudan while Sweden generates 75% of all derived heat from biomass mainly due to the introduction of carbon tax. Biomass supply is the highest in Sudan at 63% and lowest in Malaysia at 4.1%.

In the forestry sector, the forest area decreased the most in Sudan (10.4%). The potential of forest residues ranged from a low of 3 PJ for Sudan to 479 PJ for Canada. The agricultural area increased the highest for Malaysia at 11.7% during 2000 – 2013. The potential of agricultural residues varied from 29 PJ in Sweden to almost 2.4 EJ for Malaysia.

The use of agricultural residues (predominantly palm oil) in Malaysia can theoretically satisfy 63% of all energy supply in the country. In the waste sector, Sweden produced 57 PJ of municipal solid waste for energy. Bioelectricity generation had a share of 8.3% in Sweden – the highest among the five countries.

Bioenergy is growing at a steady pace. There is rapid growth in pellets and biofuels sector. Charcoal production is highly underestimated and should be produced more sustainably in the supply chain. Sustainable forestry practices in countries like Sweden and Finland have to be replicated in other parts of the world. There is a lot of potential of using agricultural and forestry residues for energy generation. There is still a significant lack of updated and reliable data for bioenergy. Bioenergy will continue to be a major contributor to the global energy mix and part of the solution for a future sustainable society.

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INTRODUCTION

Data is crucial for sustainable development. In a post COP21 climate along with the UN Sustainable Development Goals (SDG's), updated and reliable data should be the first priority. Data is the lifeline for decision making – without which designing, implementation and monitoring of policies is unachievable.

Secondly, the lack of awareness on renewables is concerning. Such ignorance often leads to impartial observations on the role of renewables in the global energy mix. This is especially true for bioenergy. Bioenergy is the largest renewable energy source. This is not well communicated!

The WBA Global Bioenergy Statistics report is one way of plugging the gaps in data and knowledge. The report aims to provide updated data on renewables and bioenergy in the global, continental and regional energy mix covering all sectors of bioenergy.

Terminology: For the readers, it would be useful to familiarize with certain key terminology before reading 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. However, it is recommended to analyse the amount of biomass used for converting to these secondary energy products.

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 m^3 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 clarification, Russia is included in Europe while Turkey is mentioned in Asia. 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 well reported and can be obtained from the annual statistical publication of AEBIOM or Eurostat.

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), USDA FAS (e.g. agriculture crop data) 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 figures is 2013. Supply data includes 2014 data while special sectors like biofuels and jobs have data for 2015.

The chapter structure follows a similar order as the previous reports. Chapter 1 provides an overview of the global energy system. It includes the supply and consumption of all energy sources, renewables and

then bioenergy. Electricity and heat generation is also included. Chapter 2 is about supply of biomass. The supply is categorized into three sectors: agriculture, forestry and waste. The chapter also includes data on crops – production volume, area harvested and yields. The theoretical potential for using crop residues for energy is updated while a new section on forest residues potential is added. Chapter 3 deals with the generation of electricity from biomass in electricity only plants and combined heat and power plants. Chapter 4 is about the generation of heat from biomass in heat only plants and combined heat and power plants along with the production of direct heat. Chapter 5 deals with the production and consumption of liquid biofuels. A separate subsection on the use of land and production of protein is included. Chapter 6 has data on special sectors of biogas, pellets and charcoal. Chapter 7 has data on renewable jobs. Chapter 8 has updated tables on global bioenergy plants of pyrolysis oil, torrefaction plants and advanced biofuels plants. Chapter 9 has statistics on certain countries – Turkey, Sudan, Malaysia, Sweden and Canada.

Further information is available on our website (www.worldbioenergy.org). For any queries, please send a mail to info@worldbioenergy.org

1. GLOBAL OVERVIEW

- *The share of renewables in the primary energy supply increased to 13.8% in 2013*
- *In final energy consumption, renewables share increased to 18.3% - a modest 0.2% increase over the past year.*
- *The supply of renewables increased by 78.1 EJ in 2013 – a 3.7% increase during 2012 – 2013*
- *Bioenergy supply increased to 57.7 EJ*
- *China, India and USA lead the world in renewables supply.*
- *Share of renewables in electricity, derived heat, direct heat and transportation sector globally were 22%, 7%%, 28% and 2.5% respectively.*
- *Biomass is the 3rd largest renewable electricity generating source with total global bioelectricity production of 462 TWh in 2013*
- *The heat production from renewables is dominated by bioenergy with bioheat production of 0.9 EJ (derived heat) and 48.5 EJ (direct heat)*

1.1 GLOBAL ENERGY SYSTEM

The global energy system is dominated by fossil fuels. Coal, oil and gas have been the main contributors to the energy supply. Although renewable energy sources have gained momentum in recent years, still, more than 80% of the energy demand is satisfied by fossil fuels.

1.1.1. TOTAL PRIMARY ENERGY SUPPLY (TPES)

Total Primary Energy Supply (TPES) is defined as the production of energy sources, including imports, excluding exports and including the storage in international aviation and marine fuel bunkers. It is represented in terms of energy content of the fuel. Since 2000, the energy demand increased by 35% to 567 EJ by 2013 (Table 1). Renewables account for only 13.8% of the energy supply. Renewables supply grew by an annual growth rate of 2.75%. Nuclear energy had a share of 5% (Figure 1) and is the only energy source to have decreased in supply since the turn of the century.

Table 1. Total Primary Energy Supply – World

	Total	Coal	Oil	Natural gas	Nuclear	Renewables	Renewables (%)
2000	421	98.1	153	86.5	28.3	54.9	13.0%
2005	481	124	168	98.5	30.2	60.7	12.6%
2010	535	147	173	115	30.1	71.0	13.3%
2011	550	159	173	117	28.2	72.8	13.3%
2012	558	161	176	119	26.9	75.3	13.5%
2013	567	164	177	121	27.1	78.1	13.8%
Av. growth	2.3%	4.0%	1.1%	2.6%	-0.3%	2.8%	

All values in EJ. (Source: IEA)

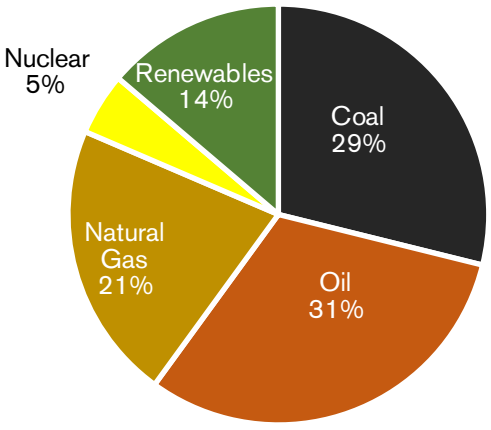

Figure 1. Total primary energy supply globally in 2013.

(Source: IEA)

Asia has the highest primary energy supply – largely because of the production of oil from the Middle East and coal in the sub continent (Table 2). It also has the highest supply of renewables in the primary energy supply with 33.7 EJ.

African continent has the highest percentage of renewables in the energy mix (48.6%) – largely due to the high use of hydropower for electricity and biomass for cooking and heating purposes.

Table 2. Total Primary Energy Supply – Continents in 2013

	Total	Coal	Oil	Natural Gas	Nuclear	Renewa-bles	Renewa-bles (%)
Africa	31.9	4.36	7.66	4.18	0.15	15.5	48.6%
Americas	140	20.6	55.0	37.5	10.4	16.9	12.0%
Asia	267	116	75.2	38.7	3.77	33.7	12.6%
Europe	121	20.7	36.2	39.7	12.7	11.4	9.44%
Oceania	6.44	1.98	2.41	1.41	0.00	0.65	10.1%
World	567	164	177	121	27.1	78.1	13.8%

All values in EJ. (Source: IEA)

Asia has significant dependence on coal for energy supply (Figure 2). The energy supply of coal in Asia is 116 EJ which is slightly less than the energy supply of all energy sources in Europe (121 EJ).

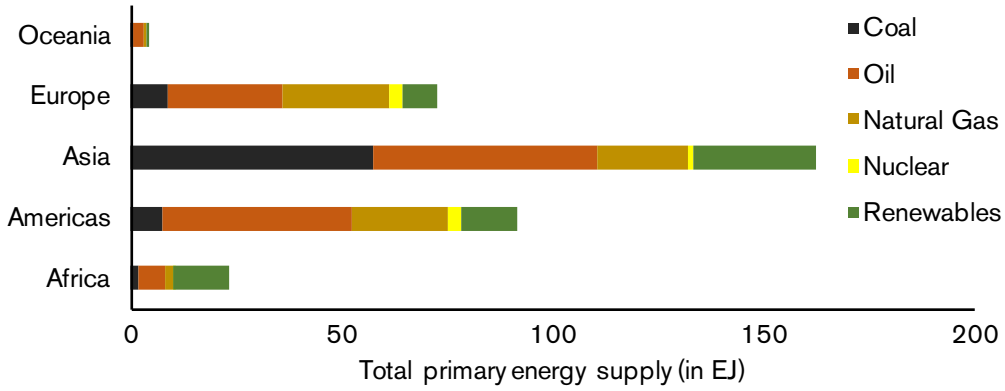

Figure 2 Total primary energy supply for continents in 2013.

(Source: IEA)

China leads the top 10 countries in primary energy supply (Table 3). The dominant energy source varies for different countries in the top 10 list. The dependence of China and India on coal is very significant. USA gets most of its energy from oil while Russia is dependent on natural gas. Among the top 10, Brazil has the highest share of renewables in their energy supply.

Table 3. Total Primary Energy Supply – Top 10 Countries in 2013

	Country	Total	Coal	Oil	Natural Gas	Nuclear	Renewa-bles	Renewa-bles %
1	**China**	126	84.8	20.3	5.88	1.22	13.8	11.0%
2	**USA**	91.4	18.1	32.7	25.5	8.97	6.15	6.72%
3	**India**	32.4	14.3	7.37	1.86	0.37	8.55	26.4%
4	**Russia**	30.7	4.54	6.70	16.5	1.90	0.97	3.18%
5	**Japan**	19.0	5.08	8.48	4.45	0.10	0.93	4.89%
6	**Brazil**	12.1	0.69	5.10	1.34	0.16	4.86	40.0%
7	**Korea**	11.0	3.26	4.04	1.99	1.51	0.23	2.09%
8	**Canada**	10.8	0.73	3.28	3.64	1.12	2.01	18.6%
9	**Iran**	9.59	0.05	3.95	5.45	0.06	0.08	0.80%
10	**Indonesia**	8.93	1.32	3.21	1.37	0.00	3.04	34.0%
Total (Top 10)		352	133	95.1	68.1	15.4	40.7	11.5%

	Total	Coal	Oil	Natural Gas	Nuclear	Renewa-bles	Renewa-bles %
EU-28	68.0	12.0	21.5	16.2	9.57	8.74	12.9%
World	567	164	177	121	27.1	78.1	13.8%

All values in EJ. (Source: IEA). Top 10 excluding EU - 28

1.1.2. ENERGY TRADE

Asia is the largest importer and exporter of energy (Table 4, Table 5). The trade of energy is dominated by the import and export of oil and oil products.

Table 4. Total imports of energy in 2013

	Total	Coal	Oil	Natural Gas	Renewa-bles	Electricity
Africa	6.37	0.25	5.71	0.28	0.00	0.13
Americas	38.8	1.55	30.8	5.89	0.06	0.53
Asia	102	24.8	63.7	13.2	0.04	0.28
Europe	68.2	8.20	40.9	17.0	0.57	1.57
Oceania	3.16	0.01	2.21	0.93	0.00	0.00
EU - 28	60.8	6.90	37.6	14.4	0.56	1.26

All values in EJ. (Source: IEA)

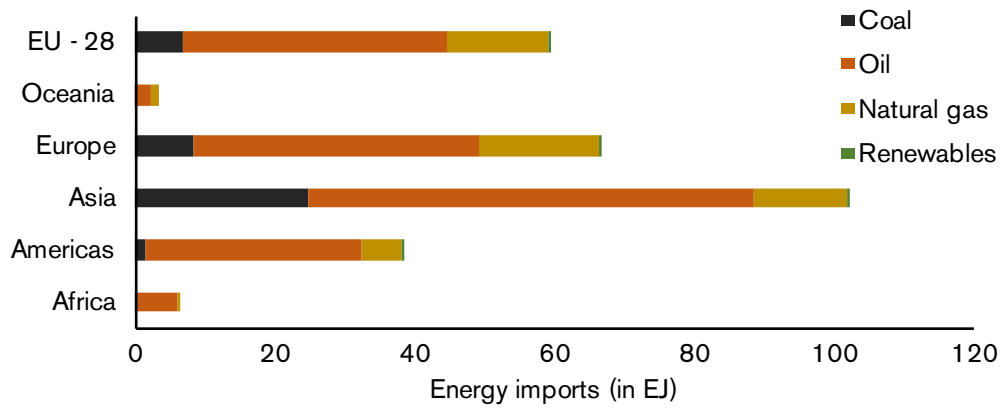

Figure 3 Total global energy imports in 2013.

(Source: IEA)

Table 5. Total exports of energy in 2013

	Total	Coal	Oil	Natural Gas	Renewa-bles	Electricity
Africa	22.2	2.20	16.1	3.19	0.58	0.10
Americas	40.4	6.10	27.6	6.00	0.15	0.47
Asia	81.1	12.3	59.3	9.28	0.06	0.17
Europe	65.5	6.39	39.3	17.8	0.35	1.64
Oceania	11.0	9.15	0.73	1.17	0.00	0.00
EU - 28	22.6	1.62	15.5	3.87	0.34	1.21

All values in EJ. (Source: IEA)

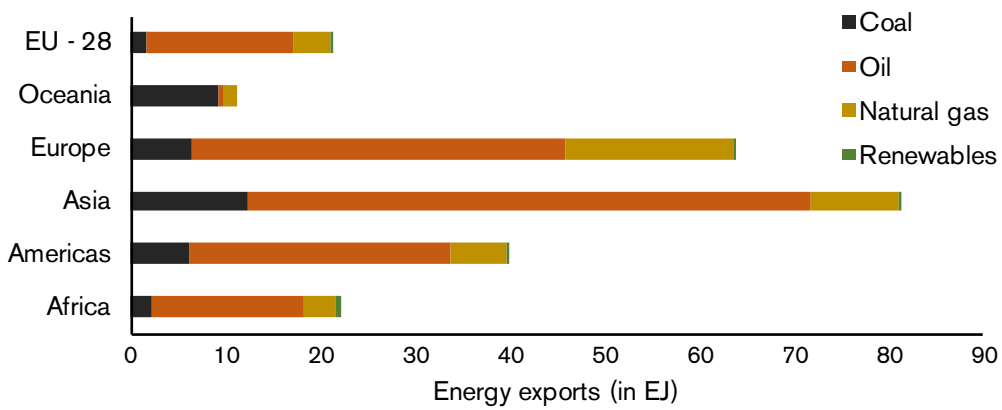

Figure 4 Total global energy exports in 2013.

(Source: IEA)

1.1.3. GROSS FINAL ENERGY CONSUMPTION (GFEC)

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

The total primary energy supply in 2013 was 567 EJ while the gross final energy consumption was 355 EJ. The difference in supply and consumption is predominantly losses during the generation, transmission and distribution of energy.

In 2013, the gross final energy consumption was 355 EJ (Table 6). The largest annual increase in energy consumption was for coal at a rate of 4.2%.

Table 6. Gross Final Energy Consumption – World

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
2000	271	44.4	115	55.8	7.64	47.6	17.6%
2005	302	55.1	126	60.9	8.21	51.9	17.2%
2010	332	65.1	130	69.2	8.24	59.7	18.0%
2011	344	73.9	131	70.4	7.72	61.1	17.7%
2012	347	73.5	133	71.0	7.37	62.7	18.1%
2013	355	75.8	134	72.3	7.44	65.0	18.3%

All values in EJ. (Source: IEA)

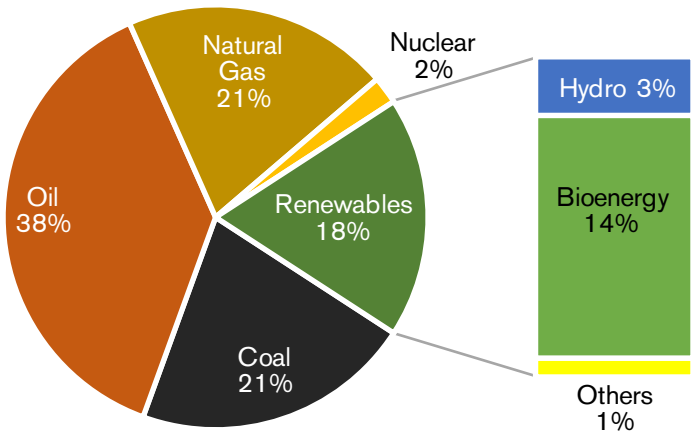

Figure 5. Gross final energy consumption in World 2013. (Source: IEA)

The share of renewables in the energy mix was 18.3% which is a 0.7% increase since 2000 (Figure 6). To achieve the SE4All target of 36% renewables, significant investments are needed in renewables to replace fossil fuels.

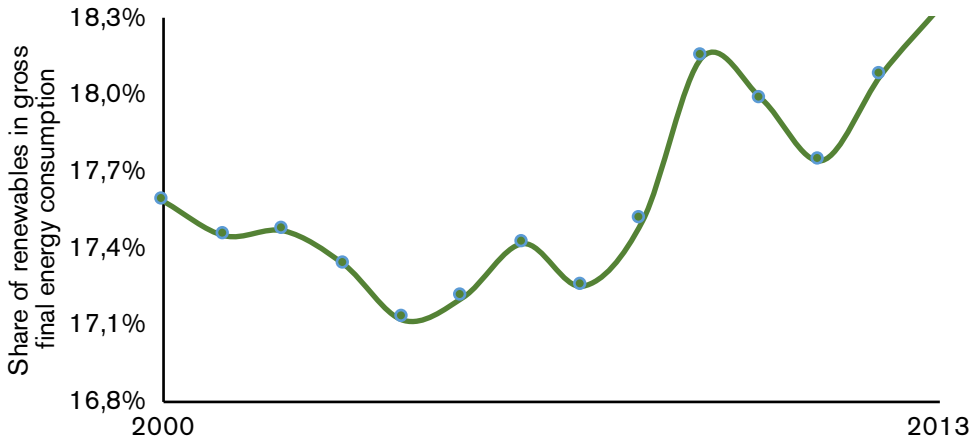

Figure 6 Share of renewables in the energy mix.

(Source: IEA)

The gross final energy consumption of energy sources is the highest in Asia followed by Americas and Europe (Table 7, Figure 7). The share of renewables among the continents is highest in African continent due to their high dependence on biomass for heating and hydropower for electricity generation.

Table 7. Gross Final Energy Consumption – Continents in 2013

	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
Africa	23.0	1.60	6.62	1.75	0.04	13.0	56.5%
Americas	91.3	7.48	44.6	23.0	2.92	13.3	14.6%
Asia	162	57.3	53.4	21.4	1.04	29.2	18.0%
Europe	72.8	8.86	26.9	25.2	3.41	8.44	11.6%
Oceania	3.88	0.66	2.03	0.77	0.00	0.41	10.7%
World	354	75.9	134	72.1	7.41	64.4	18.2%

All values in EJ. (Source: IEA)

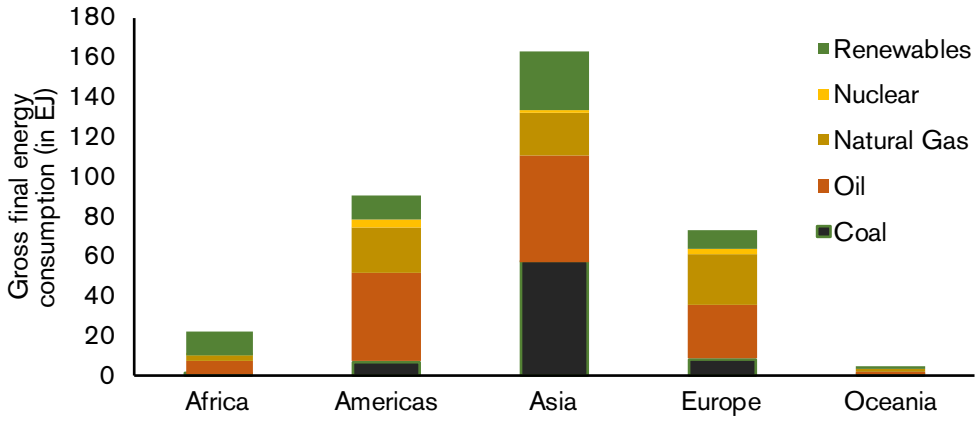

Figure 7. Gross final energy consumption in continents in 2013.

(Source: IEA)

China, USA and India are the largest consumers of energy excluding EU-28 (Table 8).

Table 8. Gross Final Energy Consumption – Top 10 countries in 2013

	Country	Total	Coal	Oil	Natural Gas	Nuclear	Renewables	Renewables (%)
1	China	74.5	42.8	14.9	3.86	0.33	12.6	16.9%
2	USA	57.3	6.28	26.4	17.1	2.55	5.03	8.77%
3	India	20.6	6.7	5.40	0.71	0.09	7.73	37.6%
4	Russia	15.1	1.84	3.80	8.30	0.46	0.68	4.52%
5	Japan	11.4	2.2	5.85	2.72	0.03	0.63	5.50%
6	Brazil	8.76	0.38	3.96	0.70	0.04	3.67	41.9%
7	Canada	7.17	0.17	3.20	2.02	0.04	1.74	24.2%
8	Indonesia	6.31	0.54	2.71	0.72	0.00	2.35	37.1%
9	Iran	6.24	0.00	2.44	3.71	0.02	0.07	1.06%
10	Korea	5.20	1.15	1.83	1.55	0.45	0.23	4.33%
Total (Top 10)		213	61.8	70.5	41.5	3.95	34.9	16.4%
EU-28		43.4	4.91	16.1	12.9	2.67	6.83	15.7%
World		355	75.8	134	72.3	7.44	65.0	18.3%

All values in EJ. (Source: IEA). Top 10 excluding EU – 28 countries

Among the top 10, Brazil, India and Indonesia lead the way in high share of renewables in their energy mix (Figure 8). 42% of the energy consumption in Brazil comes from renewables – predominantly from bioenergy and large scale hydropower generation.

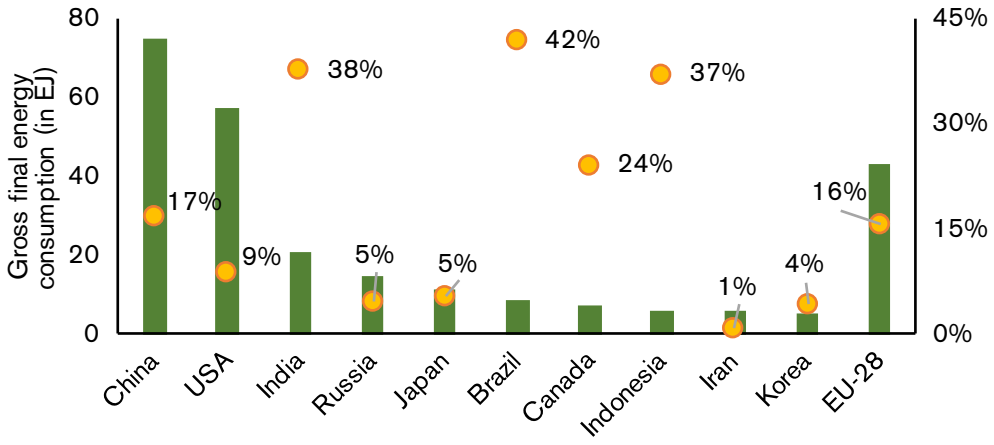

Figure 8. Top 10 countries in energy consumption and share of renewables (%) in 2013.

(Source: IEA)

1.1.4. TOTAL PRIMARY ENERGY SUPPLY TO GROSS FINAL ENERGY CONSUMPTION

Table 9 shows the conversion of energy sources from primary energy supply to final energy consumption. In 2013, primary energy supply of fossil fuels was 462 EJ while the final energy consumption was 282 EJ – leading to a conversion efficiency of 61.1%. The remainder is lost in energy generation, transmission and the use of energy for non energy purposes etc. Nuclear energy has a conversion efficiency of only 27.5% due to

losses in electricity generation and transmission.

Table 9. Primary energy supply to Final energy consumption of all Energy sources in 2013

Fuels	Primary energy	Final energy				
		Total	Electricity	Derived heat	Direct heat	Transport
Fossil fuels	462	282	47.1	10.7	120	105
Nuclear	27.1	7.44	7.41	0.02	0.00	0.00
Renewables (total)	78.1	65.0	15.5	0.77	46.0	2.70
Bioenergy	57.7	49.5	1.38	0.74	44.6	2.70
Hydro	13.6	11.6	11.6	0.00	0.00	0.00
Wind	1.90	1.90	1.90	0.00	0.00	0.00
Solar PV	0.42	0.42	0.42	0.00	0.00	0.00
Solar thermal	1.19	1.10	0.02	0.0004	1.09	0.00
Geothermal	2.77	0.32	0.21	0.03	0.08	0.00
Tidal, wave etc.	0.00	0.00	0.00	0.00	0.00	0.00
Total	567	355	70.0	11.5	166	107

All values in EJ. (Source: IEA)

The consumption of energy globally can be classified into four sectors - electricity, direct heat, derived heat and transport. The highest use of energy is in direct heating (Figure 9) followed by transport and electricity.

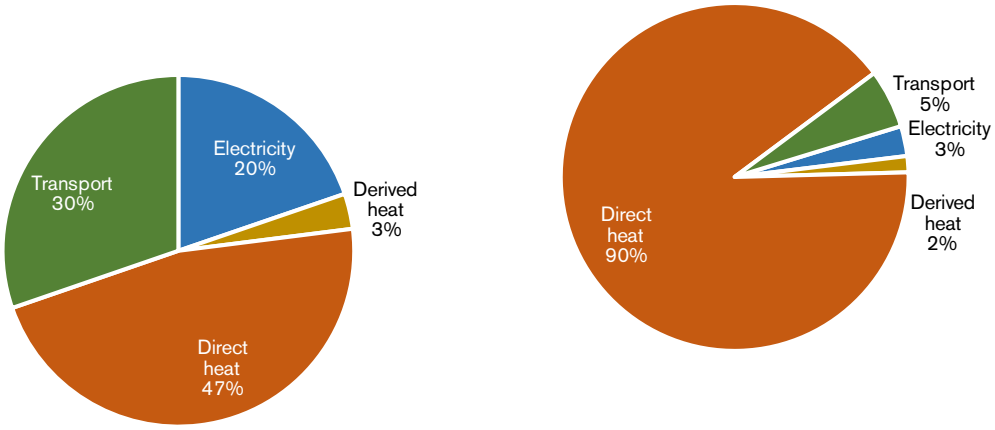

Figure 9. Global consumption of energy and bioenergy in end use sectors in 2013

(Source: IEA and WBA)

In electricity, heat and transport fuel sectors, fossil fuels still dominate (Figure 10). Renewables have made some inroads into the electricity sector while there is little share of renewables in transport and direct heat.

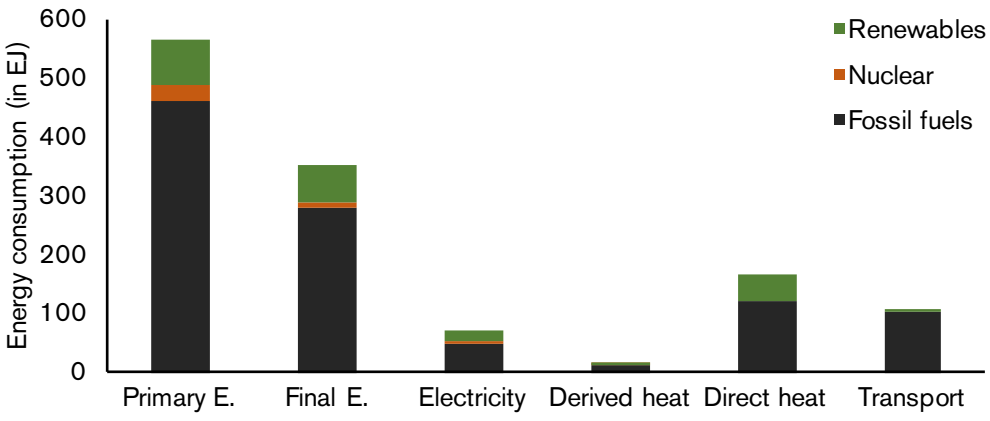

Figure 10. Primary energy to final energy conversion for all energy sources globally in 2013 (Source: IEA)

Among renewables, it is evident, that bioenergy is the largest contributor in both supply and consumption of energy (Figure 11). In the electricity sector, the renewable share is dominated by large scale hydro and wind energy resources. In direct heating (for e.g. in residential and commercial sectors), bioenergy dominates as well as in the transport sector.

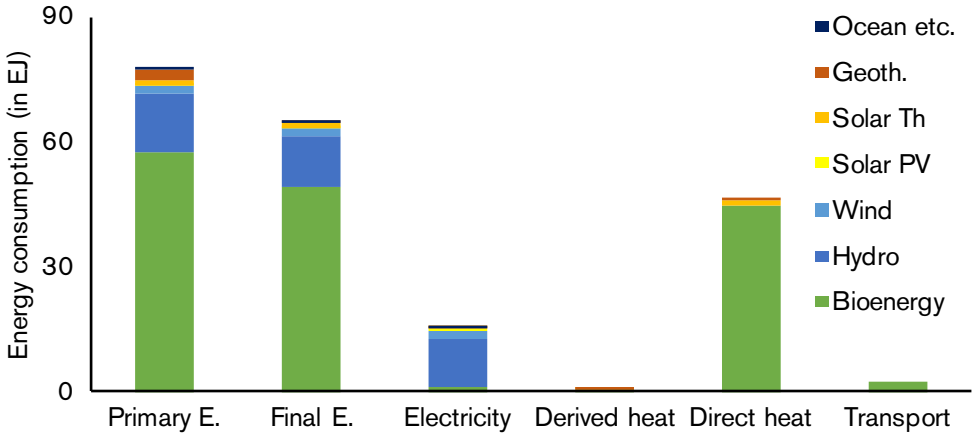

Figure 11. Primary energy to final energy conversion for renewables in 2013

(Source: IEA)

Among the continents, Africa uses energy mostly for heating purposes, while transport sector plays a major role in the energy mix for Americas (Table 10).

Table 10. Primary Energy Supply to Final Energy Consumption - Continents 2013

	Primary energy	Final energy			
		Total	Electricity	Heat	Transport
Africa	31.9	23.0	2.12	16.8	4.04
Americas	140	91.3	19.8	34.4	37.1
Asia	267	162	32.3	98.8	31.3
Europe	121	72.8	14.9	39.3	18.7
Oceania	6.44	3.88	0.88	1.50	1.50
World	567	354	70.0	191	92.6

All values in EJ. (Source: IEA)

1.2. GLOBAL RENEWABLE ENERGY SYSTEM

The primary energy supply of renewables is dominated by bioenergy (Figure 12)

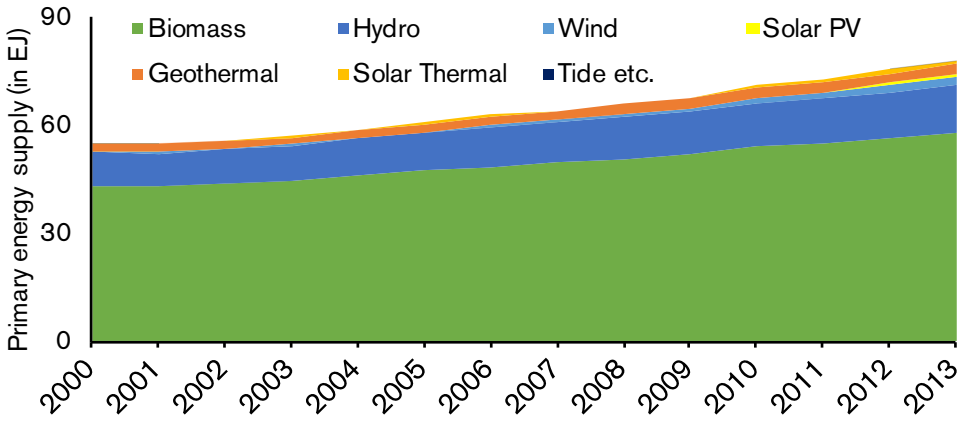

Figure 12. Primary energy supply of renewables globally

(Source: IEA)

1.2.1. TOTAL PRIMARY ENERGY SUPPLY OF RENEWABLES

Total Primary Energy Supply (PES) is defined as the production of energy sources, including imports, excluding exports and including the storage in international aviation and marine fuel bunkers. It is represented in terms of energy content of the fuel. For fuels like bioenergy, the primary energy supply is the energy content of the fuel whereas for solar, wind etc. it is the electricity generation from each source. For geothermal and solar PV, heat generation is included as primary energy supply.

Table 11. Total Primary Energy Supply of renewables – World

	Total	Biomass	Hydro	Wind	Solar PV	Geo-thermal	Solar Thermal	Tide, wave and ocean
2000	54.9	42.9	9.43	0.11	0.00	2.19	0.21	0.002
2005	60.7	47.2	10.6	0.37	0.01	2.25	0.30	0.002
2010	71.0	53.9	12.4	1.23	0.12	2.70	0.64	0.002
2011	72.8	54.9	12.6	1.57	0.23	2.76	0.78	0.002
2012	75.3	56.1	13.2	1.88	0.36	2.78	0.92	0.002
2013	78.1	57.7	13.6	2.29	0.50	2.77	1.19	0.003

All values in EJ. (Source: IEA)

Table 12. Total Primary Energy Supply of renewables – Continent 2013

	Total	Biomass	Hydro	Wind	Solar PV	Geo-thermal	Solar Thermal	Tide, wave and ocean
Africa	15.5	15.0	0.42	0.01	0.00	0.07	0.01	0.000
Americas	16.9	10.4	5.01	0.70	0.06	0.64	0.10	0.000
Asia	33.7	25.5	5.06	0.69	0.13	1.43	0.91	0.002
Europe	11.4	6.61	3.01	0.86	0.30	0.46	0.16	0.002
Oceania	0.65	0.26	0.15	0.03	0.01	0.18	0.01	0.000
World	78.1	57.7	13.6	2.29	0.50	2.77	1.19	0.003

All values in EJ. (Source: IEA)

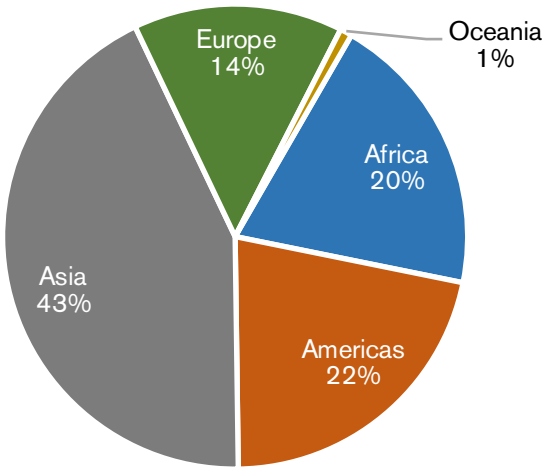

Figure 13. Total primary energy supply of renewables in continents in 2013

(Source: IEA)

China, India and USA are the top 3 countries with the highest primary energy supply of renewable energy sources (Table 13). Bioenergy is the largest renewable energy source in all the top 10 countries except for Canada with a higher share of hydropower in their energy mix (Figure 14).

Table 13. Total Primary Energy Supply of renewables – Top 10 Countries 2013

	Country	Total	Bio-mass	Hydro	Wind	Solar PV	Geo-thermal	Solar Thermal	Tide, wave and ocean
1	China	13.8	9.03	3.28	0.51	0.06	0.19	0.78	0.00
2	India	8.55	7.89	0.51	0.12	0.01	0.00	0.02	0.00
3	USA	6.15	4.08	0.98	0.61	0.05	0.36	0.07	0.00
4	Brazil	4.86	3.40	1.41	0.02	0.00	0.00	0.02	0.00
5	Nigeria	4.58	4.56	0.02	0.00	0.00	0.00	0.00	0.00
6	Indonesia	3.04	2.30	0.06	0.00	0.00	0.68	0.00	0.00
7	Canada	2.01	0.55	1.41	0.04	0.00	0.00	0.00	0.00
8	Ethiopia	1.90	1.87	0.03	0.00	0.00	0.00	0.00	0.00
9	Pakistan	1.38	1.27	0.11	0.00	0.00	0.00	0.00	0.00
10	Thailand	1.06	1.03	0.02	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. (Source: IEA) Top 10 excluding EU – 28 countries

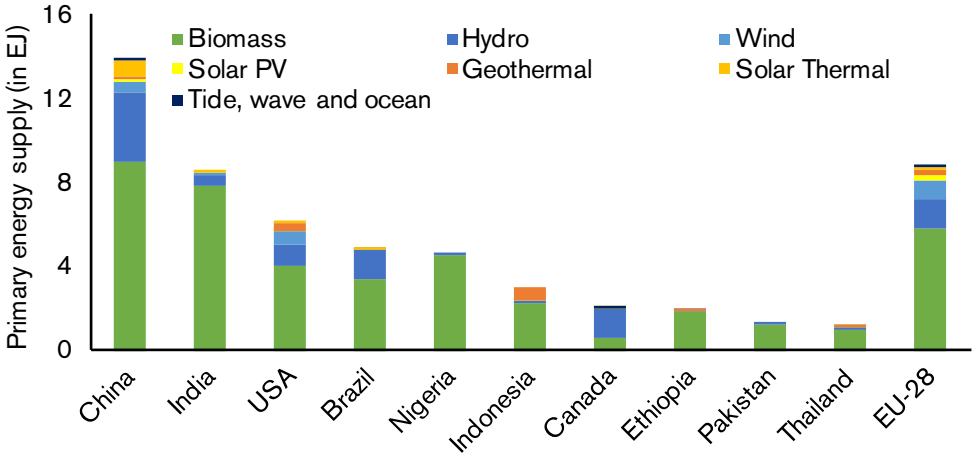

Figure 14. Total primary energy supply of renewables in top 10 countries - 2013

(Source: IEA)

1.2.2. ELECTRICITY GENERATION FROM RENEWABLES

The electricity generation from renewables is dominated by large hydro (Table 14). 3 874 TWh of renewable electricity was generated by large scale hydro. This accounted for 75% of all renewable electricity and 17% of all electricity generated globally. Electricity from biomass increased from 170 TWh in 2000 to 462 TWh in 2013. Bioenergy is now the 3rd largest renewable electricity generating source after hydro and wind. It generates more than 3 times as much electricity as generated by solar.

Table 14. Electricity generation from renewables – World

	Total	Total - Renewa-bles	Biomass	Hydro	Wind	Solar PV	Solar Thermal	Geo thermal	Tide, ocean and wave
2000	15 505	2 954	170	2 699	31.4	1.03	0.53	52.0	0.55
2005	18 367	3 421	237	3 017	104	4.04	0.60	58.3	0.52
2010	21 549	4 354	380	3 530	341	32.3	1.65	68.1	0.51
2011	22 244	4 572	409	3 592	435	63.2	2.86	69.3	0.51
2012	22 740	4 885	435	3 753	523	98.7	4.77	70.2	0.50
2013	23 406	5 190	462	3 874	637	139	5.46	71.6	0.93

All values in TWh. (Source: IEA)

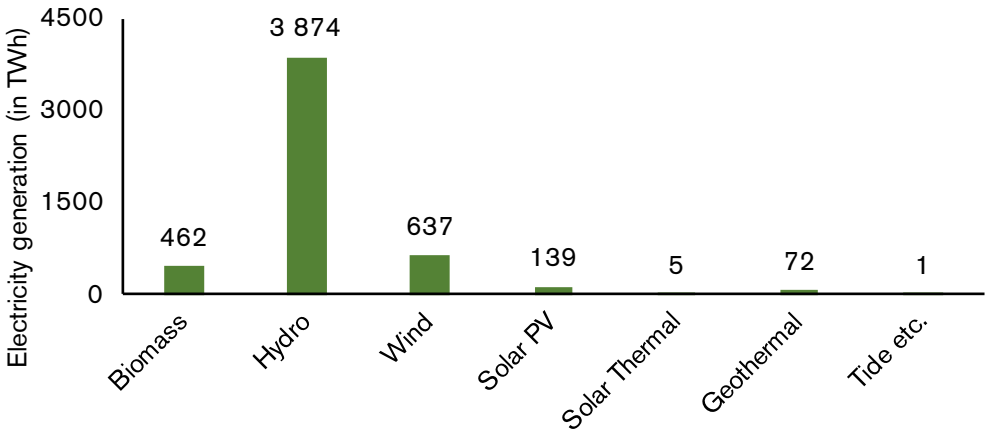

Figure 15. Electricity generation from renewables globally in 2013

(Source: IEA)

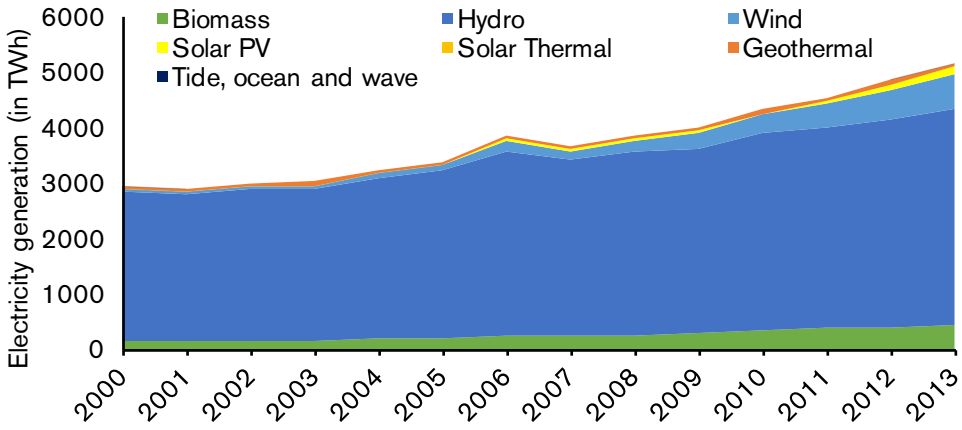

Figure 16 Electricity generation from renewables globally since 2000

(Source: IEA)

Solar energy has seen a tremendous increase in the past few years. In 2000, the electricity generation from solar (PV and thermal) was 1.56 TWh – barely 0.05% of the renewable electricity generation. This has increased to 2.7% share in 2013. During 2000 – 2013, solar PV had an annual growth rate of 45.8%, wind had 26.1% while solar thermal increased by 19.7%. In contrast, the average annual growth rate of electricity generation was 3.2%. Hydro electricity dominates the electricity generation among continents (Table 15, Figure 17).

Table 15. Electricity generation from renewables – Continent 2013

	Total	Total - Ren.	Bio-mass	Hydro	Wind	Solar PV	Solar Th.	Geoth.	Tide etc.
Africa	735	127	1.27	119	3.62	0.53	0.00	2.02	0.00
Americas	6 511	1 795	142	1 412	195	15.5	1.04	28.5	0.02
Asia	10 772	1 812	131	1 429	191	37.2	0.03	23.1	0.49
Europe	5 095	1 393	185	872	238	82.0	4.40	11.6	0.42
Oceania	292	63.5	2.58	41.3	9.35	3.82	0.00	6.42	0.00
World	23 406	5 190	462	3 874	637	139	5.46	71.6	0.93

All values in TWh. (Source: IEA)

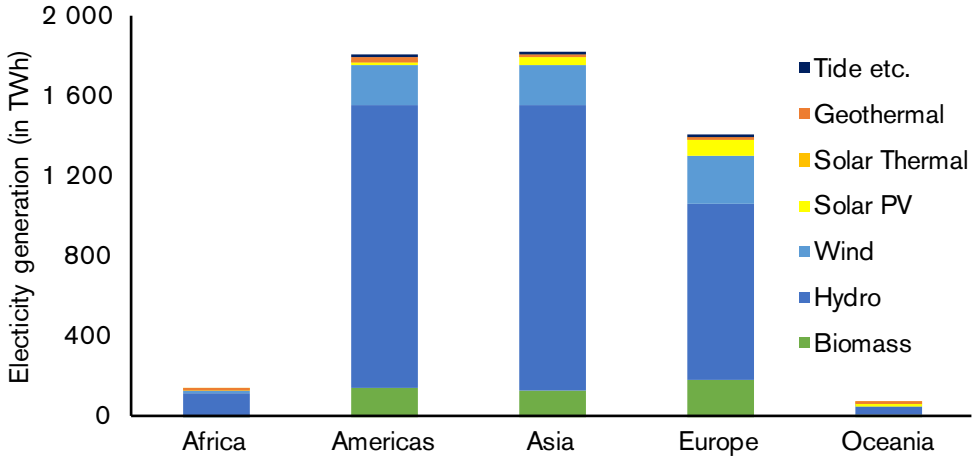

Figure 17 Electricity generation from renewables in continents in 2013.

(Source: IEA)

The top 5 countries in renewable electricity generation are China, USA, Brazil, Canada and India (Table 16). China generated 1 128 TWh of renewable electricity – 21% of all electricity generated in that country. In 2013, 98% of all electricity generated in Norway was from renewables – predominantly large scale hydro power. Brazil had a renewable share of 77% while Venezuela was third at 68% (Figure 18).

Table 16. Electricity generation from renewables – Top 10 Countries 2013

	Country	Total	Total - Ren.	Biomass	Hydro	Wind	Solar PV	Solar Thermal	Geoth.	Tide etc.
1	**China**	5 447	1 128	50.6	920	141	15.5	0.03	0.11	0.01
2	**USA**	4 306	572	78.2	290	170	14.6	1.01	18.4	0.00
3	**Brazil**	570	438	40.4	391	6.58	0.00	0.00	0.00	0.00
4	**Canada**	652	409	5.45	392	11.6	0.36	0.00	0.00	0.02
5	**India**	1 193	202	23.1	142	33.6	3.43	0.00	0.00	0.00
6	**Russia**	1 059	186	2.93	183	0.01	0.00	0.00	0.44	0.00
7	**Japan**	1 045	148	40.7	84.9	5.20	14.3	0.00	2.60	0.00
8	**Norway**	134	131	0.55	129	1.89	0.00	0.00	0.00	0.00
9	**Venezuela**	123	83.5	0.00	83.5	0.00	0.00	0.00	0.00	0.00
10	**Turkey**	240	69.3	0.98	59.4	7.56	0.00	0.00	1.36	0.00
	Total (Top 10)	14 771	3 367	243	2 674	377	48.2	1.04	22.9	0.02
	EU-28	3 262	907	178	402	235	80.9	4.40	5.94	0.42
	World	23 406	5 190	462	3 874	637	139	5.46	71.6	0.93

All values in TWh. (Source: IEA) Top 10 excluding EU – 28 countries

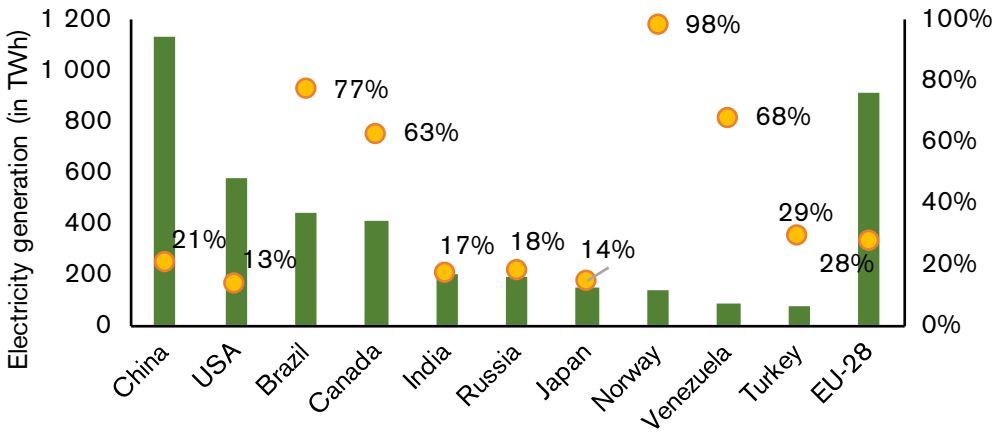

Figure 18 Electricity generation and share of renewables in electricity in top 10 countries in 2013.

(Source: IEA)

1.2.3. HEAT PRODUCTION FROM RENEWABLES

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

In 2013, total renewable heat was 50.8 EJ out of which derived heat was only 1.8% while the remaining was direct heat (Table 17).

Table 17. Derived and direct heat production

	Total heat	Total renewable heat	Renewable direct heat	Renewable derived heat	Renewable heat (%)	Ren. (%)
2000	241	40.9	40.4	0.43	17.0%	17.7%
2005	272	44.0	43.4	0.56	16.2%	16.8%
2010	306	48.1	47.2	0.81	15.7%	16.2%
2011	315	48.7	47.9	0.81	15.5%	16.0%
2012	321	49.6	48.7	0.88	15.5%	15.9%
2013	323	50.8	49.9	0.92	15.8%	16.2%

All values in EJ (Source: IEA and WBA)

Direct heat

Direct heating is the direct consumption of energy resources in the end use sectors – residential, commercial, agriculture etc. Biomass dominates the direct heating sector among renewables. Out of the total direct heating of 309 EJ, renewables share was 49.9 EJ ~ 16%.

Table 18 Direct heat generation from renewables

	Total	Total Ren.	Biomass	Solar Th.	Geoth.	Ren. (%)
2000	229	40.4	40.1	0.21	0.16	17.7%
2005	259	43.4	42.9	0.29	0.22	16.8%
2010	292	47.2	46.4	0.62	0.27	16.2%
2011	300	47.9	46.9	0.75	0.29	16.0%
2012	306	48.7	47.5	0.85	0.30	15.9%
2013	309	49.9	48.5	1.10	0.32	16.2%

All values in EJ. (Source: IEA and WBA)

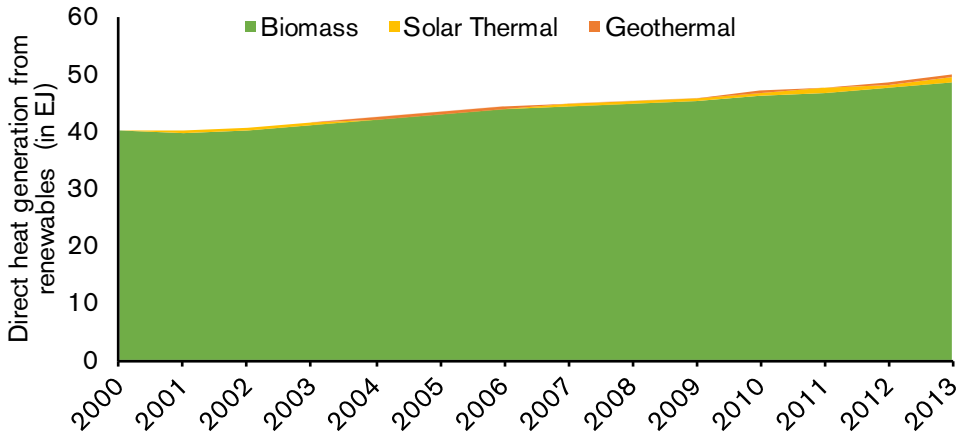

Figure 19 Direct heat generation from renewables globally.

(Source: IEA and WBA)

For direct heating, Asia is the largest producer of direct heating (Table 19). Renewables use for direct heating amounts to 24.4 EJ in Asia – 95% of it is derived from biomass.

Table 19 Direct heat generation from renewables - Continents 2013

	Total	Total Ren.	Biomass	Solar The.	Geoth.	Ren (%)
Africa	22.7	14.9	14.9	0.01	0.00	65.8%
Americas	65.0	6.82	6.72	0.09	0.01	10.5%
Asia	154	24.4	23.2	0.91	0.26	15.8%
Europe	64.4	3.51	3.39	0.08	0.04	5.45%
Oceania	2.82	0.24	0.22	0.01	0.01	8.69%
World	309	49.9	48.5	1.10	0.32	16.2%

All values in EJ. (Source: IEA and WBA)

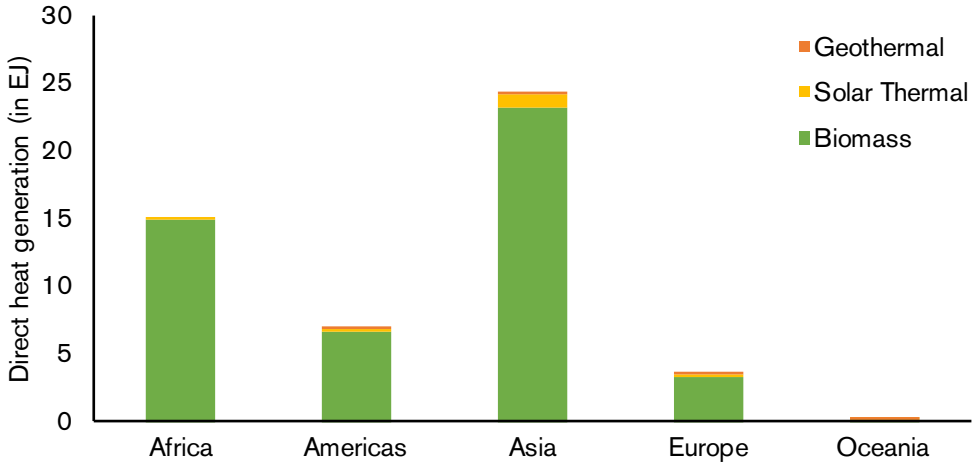

Figure 20 Direct heat generation from renewables in continents in 2013.

(Source: IEA and WBA)

China, India and Nigeria are the top producers of direct heating using renewables. The top 10 country list of direct renewable heating is dominated by Asian and African continents. Some of the African countries are largely dependent on biomass for direct heating. For e.g., Nigeria generates almost 90% of its direct heating using biomass while the share in Ethiopia is even higher at 93.1%.

Table 20 Direct heat generation from renewables - Top 10 countries 2013

	Country	Total	Total - Renewables	Biomass	Solar Thermal	Geothermal	Renewables (%)
1	**China**	81.0	9.14	8.17	0.78	0.18	11.3%
2	**India**	20.3	7.36	7.34	0.02	0.00	36.3%
3	**Nigeria**	5.07	4.56	4.56	0.00	0.00	89.8%
4	**Brazil**	7.29	2.54	2.52	0.02	0.00	34.8%
5	**Indonesia**	4.61	2.26	2.26	0.00	0.00	49.0%
6	**USA**	39.6	2.05	1.98	0.06	0.01	5.19%
7	**Ethiopia**	2.00	1.87	1.87	0.00	0.00	93.1%
8	**Pakistan**	2.52	1.27	1.27	0.00	0.00	50.5%
9	**Thailand**	2.93	0.83	0.83	0.00	0.00	28.4%
10	**Canada**	5.46	0.42	0.42	0.00	0.00	7.73%
Total (Top 10)		171	32.3	31.2	0.89	0.19	
	EU-28	36.5	3.07	2.97	0.08	0.02	8.42%
	World	309	49.9	48.5	1.10	0.32	16.2%

All values in EJ. (Source: IEA and WBA)

Derived heat

Derived heating is heat generated in power plants especially in combined heat and power plants and heating only plants. The share of renewables in global derived heating is 6.6%, the rest is by fossil fuels (Table 17). Among renewables, bioenergy is the largest renewable energy source for heating. In 2013, the heating from biomass was 892 PJ (~ 0.9 EJ) – 97% of all renewable derived heating (Figure 18).

Table 21. Derived heat production from renewables – World

	Total	Total Ren.	Biomass	Solar Th.	Geothermal	Ren. (%)
2000	12 224 175	432 877	414 539	24	18 314	3.54%
2005	13 356 403	555 311	531 434	55	23 822	4.16%
2010	14 058 676	806 327	779 958	192	26 177	5.74%
2011	14 462 170	809 514	783 492	276	25 746	5.60%
2012	14 755 663	879 114	849 892	421	28 801	5.96%
2013	13 816 102	924 398	892 835	535	31 028	6.69%

All values in TJ. (Source: IEA)

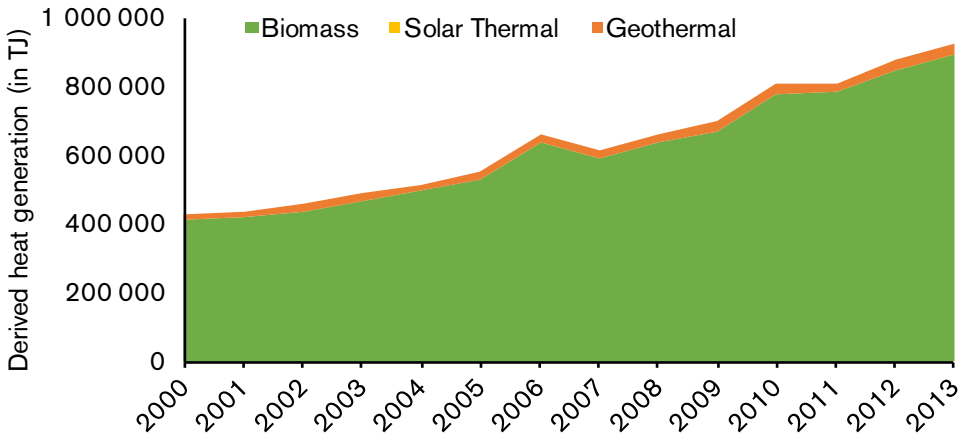

Figure 21 Derived heat generation from renewables globally.

(Source: IEA)

Europe is the largest continent in the production of renewable derived heating (Table 22). 86% of all renewable heat generated globally occurs in Europe. This is largely due to biomass and slightly less contribution from geothermal and solar thermal heating (Figure 19).

Table 22. Derived heat production from renewables – Continent 2013

	Total	Total Ren.	Biomass	Solar Th.	Geothermal	Ren (%)
Africa	3 748	0	0	0	0	0.00%
Americas	484 277	44 001	44 001	0	0	9.09%
Asia	3 966 240	84 771	84 771	0	0	2.14%
Europe	9 360 987	795 626	764 063	535	31 028	8.50%
Oceania	850	0	0	0	0	0.00%
World	13 816 102	924 398	892 835	535	31 028	6.69%

All values in TJ. (Source: IEA)

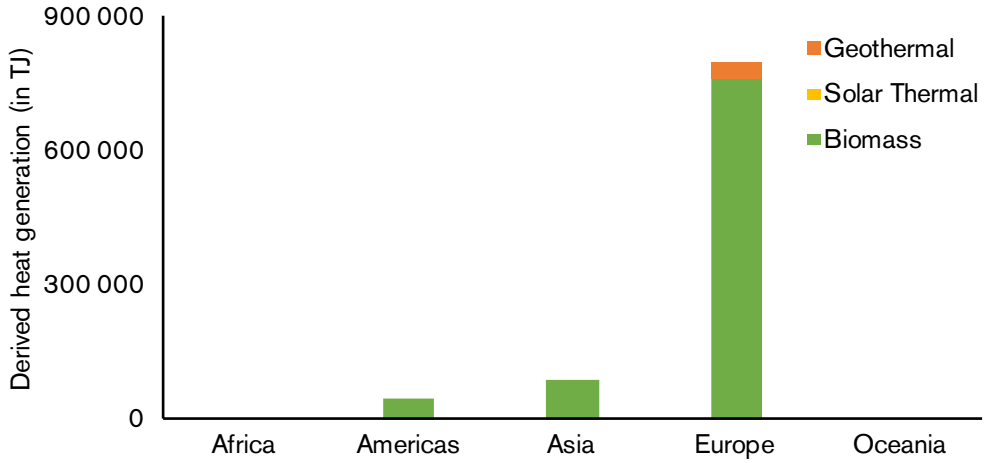

Figure 22 Derived heat generation from renewables in continents in 2013.

(Source: IEA)

Sweden is the world's largest producer of derived heat from renewables. In 2013, 141 508 TJ of derived heat was generated – all from biomass based sources (Table 23). Russia follows with 111 068 TJ of biomass and geothermal based derived heat generation. As EU – 28 countries make up a huge share of derived heat generation from renewables, they are also reported.

Table 23 Derived heat production from renewables – Top 10 Countries 2013

	Country	Total	Total - Renewables	Biomass	Solar Thermal	Geothermal
1	**Russia**	5 413 017	111 068	109 587	0	1 481
2	**China**	3 646 157	46 455	46 455	0	0
3	**USA**	453 413	41 842	41 842	0	0
4	**Korea**	200 831	36 817	36 817	0	0
5	**Iceland**	23 835	23 160	0	0	23 160
6	**Norway**	25 694	17 506	17 506	0	0
7	**Switzerland**	21 039	13 975	13 975	0	0
8	**Ukraine**	586 234	11 381	11 381	0	0
9	**Canada**	26 886	2 159	2 159	0	0
10	**Turkey**	55 626	1 499	1 499	0	0
	Total (Top 10)	10 452 732	305 862	281 221	0	24 641
	EU-28	**2 453 336**	**598 345**	**591 423**	**535**	**6 387**
1	**Sweden**	190 148	141 508	141 508	0	0
2	**Germany**	488 311	93 594	93 386	1	207
3	**Finland**	185 476	78 717	78 717	0	0
4	**Denmark**	135 851	68 719	68 131	474	114
5	**Austria**	87 925	43 916	43 266	57	593
6	**France**	124 226	39 445	35 433	0	4 012
7	**Italy**	216 409	38 794	38 142	2	650
8	**The Netherlands**	128 992	18 112	18 112	0	0
9	**Poland**	303 872	16 383	16 383	0	0
10	**Lithuania**	43 625	11 912	11 877	0	35
	World	13 816 102	924 398	892 835	535	31 028

All values in TJ. (Source: IEA)

1.2.4. TRANSPORT FUELS FROM RENEWABLES

The contribution of renewables to transport sector is about 2.5% - almost all of it from biofuels. The contribution of electricity to transport sector is slowly growing. However, as the contribution is still low, global statistics are not available and hence not reported. Data for biofuels use in transport is discussed in Chapter 5.

1.3. GLOBAL BIOENERGY SYSTEM

This section provides an overview of the global bioenergy system. The primary energy supply of bioenergy increased from 42.9 EJ in 2000 to 57.7 EJ in 2013 (Table 24). In 2013, 3.65 EJ was used in the electricity only plants, 2.33 EJ in CHP plants and 0.47 EJ in heat only plants for generating electricity and heat. 3.27 EJ was transformed predominantly into charcoal for energy purposes (other transformation). In the final energy consumption, 47.3 EJ of bioenergy was consumed – 35.1 EJ in residential (74%), 8.1 EJ in industries (17%), 2.7 EJ in transportation sector (5.7%) while the remaining in commercial, agriculture, fishing sectors etc. (Figure 23).

Table 24 Primary energy supply to Final energy consumption for bioenergy – World

	TPES	Energy transformation						Final energy					
		Elec.	CHP	Heat	Other	Own use	Los-ses	Total	Indus.	Trans.	Res.	Com.	Oth.
2000	42.9	1.13	1.05	0.24	2.10	0.24	0.01	38.1	6.77	0.42	29.9	0.66	0.39
2005	47.2	1.77	1.37	0.31	2.56	0.35	0.01	40.8	6.99	0.81	31.8	0.77	0.42
2010	53.9	2.90	1.79	0.45	2.94	0.57	0.01	45.2	7.62	2.38	33.9	0.85	0.46
2011	54.9	3.19	1.91	0.45	3.11	0.48	0.01	45.7	7.72	2.47	34.2	0.87	0.45
2012	56.1	3.37	2.22	0.47	3.23	0.50	0.01	46.3	7.63	2.52	34.7	0.95	0.49
2013	57.7	3.65	2.33	0.47	3.27	0.58	0.01	47.3	8.10	2.70	35.1	0.94	0.51

All values in EJ. (Source: IEA)

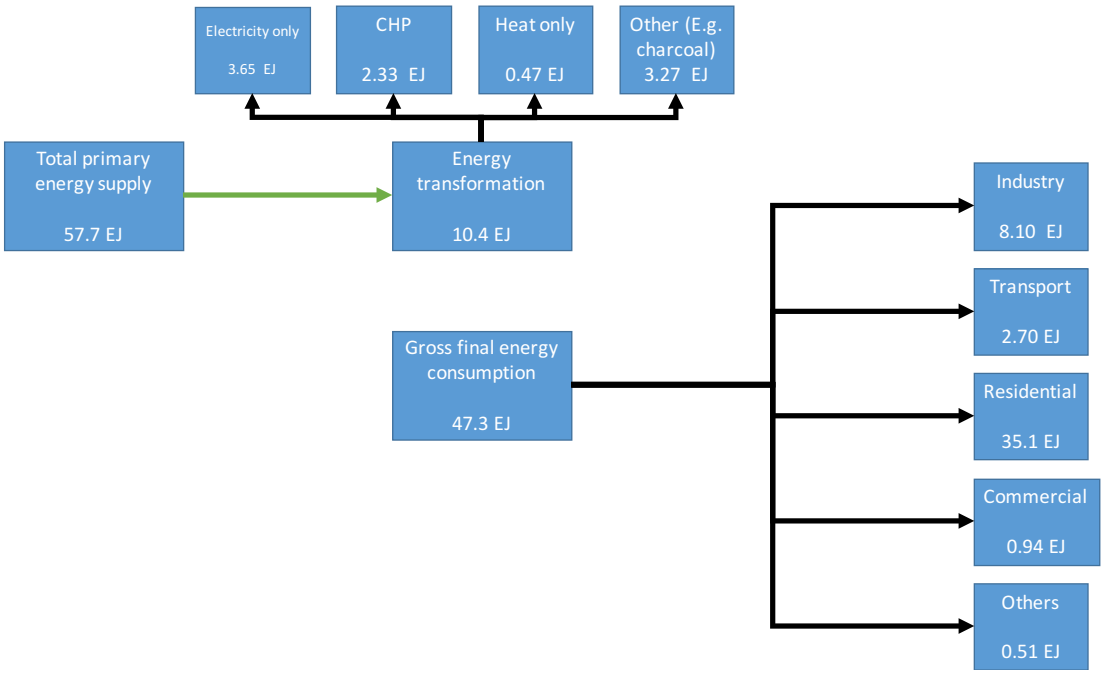

Figure 23 Primary energy to final energy conversion for bioenergy globally in 2013.

(Source: IEA)

Table 25 and Table 26 provide an overview of bioenergy conversion from primary energy to final energy in continents and in top 10 countries. For e.g., in 2013, among the continents, Europe used 2.68EJ of biomass in energy transformation in power plants – 0.81 EJ in electricity only plants, 1.48 EJ in CHP plants and 0.37 EJ in heat only plants. In comparison, Africa uses 2.34 EJ in energy transformation – mostly in other sectors i.e. conversion of biomass to charcoal (Figure 24).

Table 25 Primary energy supply to final energy consumption for bioenergy - Continents 2013

	TPES	Energy transformation						Final energy					
		Elec.	CHP	Heat	Other	Own use	Los-ses	Total	Indu-stry	Trans.	Res.	Com.	Oth.
Africa	15.0	0.02	0.02	0.00	2.30	0.00	0.00	12.6	0.84	0.00	11.4	0.27	0.17
Americas	10.4	0.92	0.80	0.00	0.25	0.53	0.00	7.84	3.55	1.91	2.05	0.12	0.20
Asia	25.5	1.88	0.02	0.10	0.70	0.00	0.00	22.7	2.54	0.22	19.6	0.35	0.04
Europe	6.61	0.81	1.48	0.37	0.02	0.05	0.00	3.87	1.02	0.56	2.00	0.20	0.10
Oceania	0.26	0.02	0.01	0.00	0.00	0.00	0.00	0.23	0.16	0.01	0.06	0.00	0.00
World	57.7	3.65	2.33	0.47	3.27	0.58	0.01	47.3	8.10	2.70	35.1	0.94	0.51

All values in EJ. (Source: IEA)

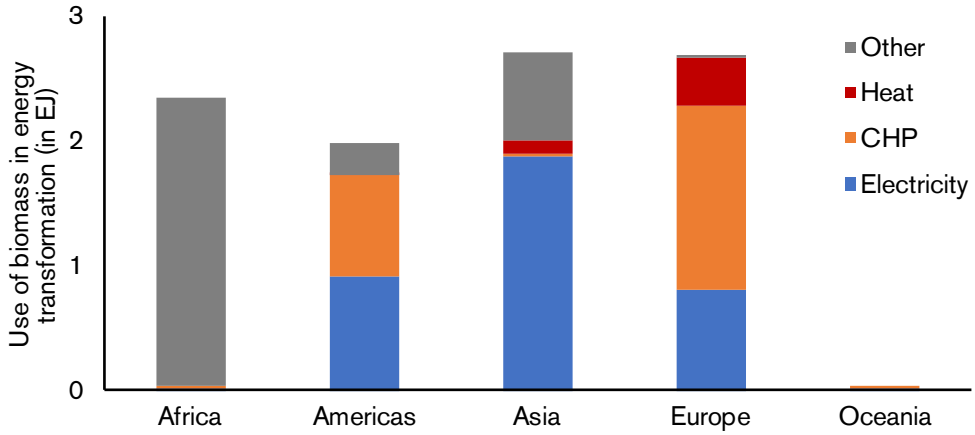

Figure 24 Use of biomass in energy transformation sector in continents 2013.

(Source: IEA)

Table 26 Primary energy supply to final energy consumption for bioenergy - Top 10 countries 2013

		TPES	Energy transformation						Final energy					
			El.	CHP	Heat	Other	Own use	Los-ses	Total	Indus.	Trans.	Res.	Com.	Oth.
1	**China**	9.03	0.73	0.00	0.06	0.00	0.00	0.00	8.24	0.00	0.07	8.17	0.00	0.00
2	**India**	7.89	0.54	0.00	0.00	0.18	0.00	0.00	7.17	1.27	0.01	5.61	0.28	0.00
3	**USA**	4.56	0.00	0.00	0.00	0.35	0.00	0.00	4.21	0.29	0.00	3.82	0.10	0.00
4	**Brazil**	4.08	0.60	0.31	0.00	0.00	0.01	0.00	3.16	1.38	1.19	0.46	0.10	0.04
5	**Nigeria**	3.40	0.01	0.30	0.00	0.16	0.51	0.00	2.41	1.46	0.58	0.26	0.01	0.11
6	**Indonesia**	2.30	0.00	0.00	0.00	0.00	0.03	0.00	2.26	0.27	0.03	1.95	0.01	0.00
7	**Canada**	1.87	0.00	0.00	0.00	0.38	0.00	0.00	1.48	0.00	0.00	1.47	0.01	0.00
8	**Ethiopia**	1.27	0.00	0.00	0.00	0.03	0.00	0.00	1.25	0.14	0.00	1.11	0.00	0.00
9	**Pakistan**	1.03	0.15	0.00	0.00	0.23	0.00	0.00	0.65	0.33	0.05	0.27	0.00	0.00
10	**Thailand**	0.84	0.00	0.00	0.00	0.11	0.00	0.00	0.73	0.11	0.00	0.57	0.00	0.06
Total (Top 10)		36.3	2.02	0.61	0.06	1.43	0.56	0.00	31.6	5.24	1.93	23.7	0.51	0.21
EU-28		5.87	0.80	1.31	0.23	0.01	0.04	0.00	3.46	0.95	0.55	1.74	0.13	0.08
World		57.7	3.65	2.33	0.47	3.27	0.58	0.01	47.3	8.10	2.70	35.1	0.94	0.51

All values in EJ. (Source: IEA)

2. BIOENERGY SUPPLY

• In 2013, the primary energy supply of biomass was 57.7 EJ

• Africa and Asia continents dominate the bioenergy supply with a global contribution of 26% and 44% respectively.

• 88% of all the biomass supply comes from forestry – predominantly as fuelwood (68%) and charcoal (10%).

• The global agricultural area has reduced by 0.53% during 2000 – 2013.

• Increasing yields is crucial for biofuel and food production. Half of land demand in Africa for maize, rice and wheat could be reduced by increasing yields to global average yield

• 17 EJ to 128 EJ is the theoretical potential for utilizing agricultural residues for energy globally

• During 2000 – 2013, global forest is reduced by 1.23% while EU – 28 countries increased forest area by 3.62%.

• 4.64 – 7.64 EJ is the theoretical potential for utilizing forest residues for energy globally

• 1.3 EJ of municipal solid waste is produced for energy.

2.1. OVERVIEW

In 2013, the total primary energy supply from biomass was 57.7 EJ – almost half of it is in Asia (Table 27). Europe has seen the highest annual increase in biomass supply during 2000 – 2013 (Figure 25).

Table 27 Total primary energy supply of biomass – Continents

	World	Africa	Americas	Asia	Europe	Oceania
2000	42.9	10.4	7.30	21.6	3.33	0.26
2005	47.2	11.9	8.21	22.6	4.20	0.27
2010	53.9	13.7	9.67	24.3	5.96	0.22
2011	54.9	14.3	9.70	24.7	6.01	0.22
2012	56.1	14.6	9.69	25.0	6.48	0.26
2013	57.7	15.0	10.4	25.5	6.61	0.26

All values in EJ. (Source: IEA)

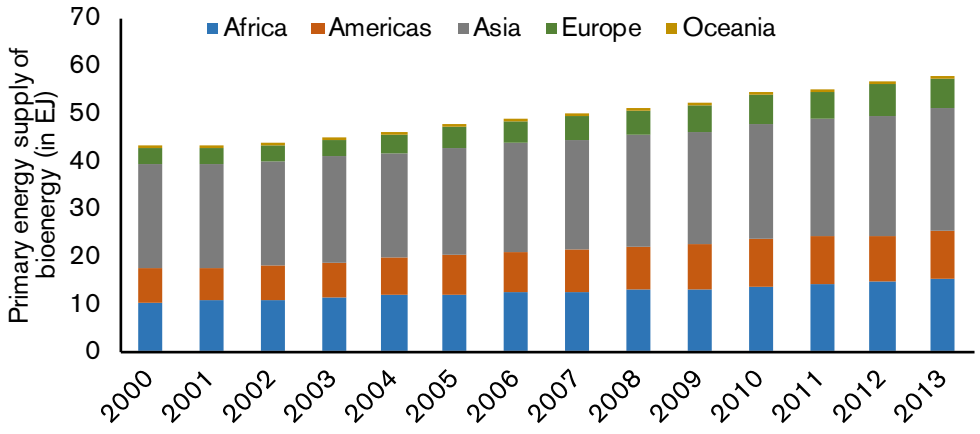

Figure 25 Total primary energy supply of biomass globally

(Source: IEA)

China, India and Nigeria have the highest supply of biomass in 2013 (Table 28). Among the top 10 countries, the biomass supply increased the highest in Brazil (74.2%). EU – 28 countries more than doubled the supply of biomass during 2000 – 2013.

Table 28 Total primary energy supply of biomass - Top 10 countries in 2013

	Countries	TPES(2013)	2000 - 2013
1	China	9.03	6.36%
2	India	7.89	26.6%
3	Nigeria	4.56	56.2%
4	USA	4.08	32.9%
5	Brazil	3.40	74.2%
6	Indonesia	2.30	9.82%
7	Ethiopia	1.87	60.9%
8	Pakistan	1.27	26.6%
9	Thailand	1.03	68.8%
10	Tanzania	0.84	60.9%
Total (Top 10)		36.3	-
EU - 28		5.87	113%
World		57.7	34%

All values in EJ (Source: IEA)

The supply of biomass can be classified into three broad sectors – forestry, agriculture and waste. Forestry sector is the largest contributor to the supply of biomass. In 2013, the share of biomass originating from forestry was at 88% - predominantly in the form of woodfuel (Table 29). Charcoal was the second largest fuel category at 10% followed by black liquor and bioethanol from energy crops (Figure 26).

Table 29 Overview of biomass supply sources globally

Sector	Fuel	Share	
Forestry	Fuelwood	68%	88%
	Pellets	0.8%	
	Charcoal	10%	
	Forest residues	1.8%	
	Black Liquor	6.8%	
	Wood industry residues	0.8%	
Agriculture	Bioethanol from crops	4.0%	9%
	Biodiesel from crops	2.1%	
	HVO	0.3%	
	Biogas from crops/animal	2.6%	
Waste	Municipal waste	2.6%	3%

All values in EJ. (Source: WBA)

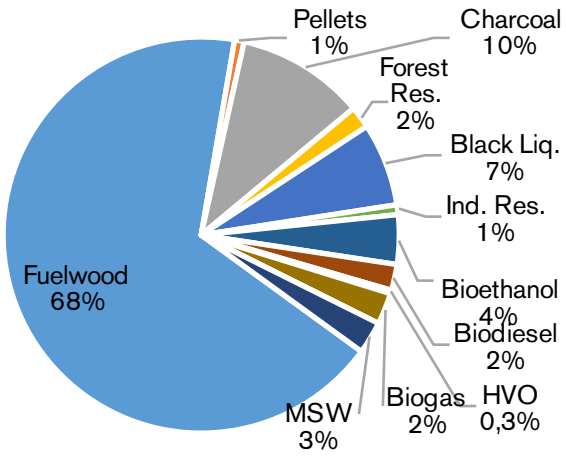

Figure 26 Overview of global supply of biomass.

(Source: WBA)

2.2. LAND

The total land area globally is about 13 billion ha (Table 30). The largest use of land is for agriculture at 4.9 billion ha while forest area covers 4 billion ha. Most of the agriculture land is in the form of permanent pastures and meadows. Other land includes built-up and related land, barren land, other wooded land, etc.

Table 30 Overview of land area in 2013

Land area		Classification of land area		Classification of agri, forest and other land	
Land area	13 009 337	Agriculture area	4 928 929	Arable land	1 407 843
				Permanent crops	164 661
				Permanent pastures and meadows	3 353 666
		Forest area	4 005 749	Primary forests	1 281 582
				Other naturally regenerated forests	2 437 258
				Planted forests	286 934
		Other land	4 089 540		

All values in 1000ha. (Source: FAO)

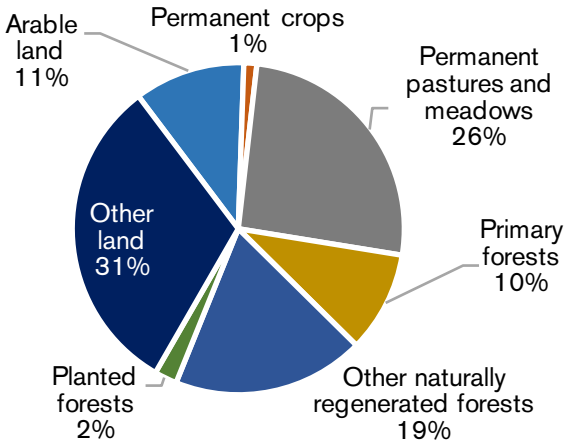

Figure 27 Total land area globally (in 1000 ha).

(Source: FAO)

2.3. AGRICULTURE

2.3.1. AGRICULTURE AREA

Agricultural area is the sum of areas under arable land, permanent crops and permanent pastures and meadows. Arable land is land under temporary agricultural crop, 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). Permanent crops land is land cultivated with long-term crops which do not have to be replanted for several years (such as cocoa and coffee); land under trees and shrubs producing flowers, such as roses and jasmine; and nurseries etc. Permanent meadows and pastures is land used permanently (five years or more) to grow herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).

Table 31 Global agriculture area

	Agriculture area	Arable land	Permanent crops	Permanent pastures and meadows
Africa	1 172 201	231 447	33 749	904 245
Americas	1 225 498	369 687	27 797	828 014
Asia	1 651 279	482 250	86 204	1 082 825
Europe	469 910	277 141	15 318	177 453
Oceania	410 042	47 319	1 594	361 129
World	4 928 929	1 407 843	164 661	3 353 666

All values in 1000ha. (Source: FAO)

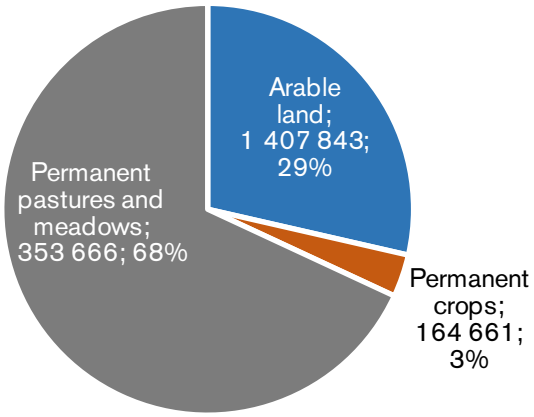

Figure 28 Global agricultural area (in 1000 ha).

(Source: FAO)

Excluding the EU - 28 counties, China, USA and Australia have the largest agricultural area available (Table 32). However, all three countries have shown a decline in the area since 2000 with Australia reducing its agricultural area by 13%. Among the top 10, only Russia and India have more arable land than permanent pastures and meadows.

Table 32 Agriculture area – top 10 countries in 2013

	Countries	Agriculture area	Arable land	Permanent crops	Permanent pastures and meadows	% change since 2000
1	**China**	514 553	105 720	16 000	392 833	-1.43%
2	**USA**	405 437	151 837	2 600	251 000	-2.16%
3	**Australia**	396 615	46 219	392	350 004	-12.9%
4	**Brazil**	278 808	76 008	6 800	196 000	6.66%
5	**Kazakhstan**	216 994	29 394	131	187 467	0.00%
6	**Russia**	216 840	122 240	1 600	93 000	-0.15%
7	**India**	180 280	157 000	13 000	10 280	-0.38%
8	**Saudi Arabia**	173 295	3 068	227	170 000	-0.28%
9	**Argentina**	149 199	39 699	1 000	108 500	16.1%
10	**Mongolia**	113 310	566	5	112 738	-13.2%
	Total (Top 10)	2 645 331	731 751	41 755	1 871 822	
	EU - 28	186 356	108 352	11 894	66 111	-6.91%
	World	4 928 929	1 407 843	164 661	3 353 666	-0.53%

All values in 1000ha. (Source: FAO). Top 10 excluding EU - 28

2.3.2. CROP DATA

Agriculture sector contributed about 9% in biomass supply in 2013. This was predominantly from bioethanol and biodiesel production from sugarcane, maize, soybeans and rapeseed along with biogas production from agricultural residues. However, there is significant potential for agriculture to contribute more to the global bioenergy mix especially in the increasing production of biofuels for transport sector and the use of agricultural residues for energy.

Crop yields are crucial for the production of both food and fuel from agricultural land. Considering maize, the global yield increased from 4.32 tons/ha in 2000 to 5.57 tons/ha in 2014 saving 295 million ha of crop land (Table 33). Similarly, for rice and wheat, the increasing yield has reduced demand for cropland by 123 million ha and 152 million ha respectively.

Considering the case of Africa, the 2014 yields for the three major crops of maize, rice and wheat are less than the global average of the world in 2000. If we consider the yields for Africa to be the same as the world, then that would reduce land demand (for the same amount of production) by 66.2 million ha. In comparison, the total land used in 2014 for growing the crops was 135 million ha i.e. half of the land demand could be reduced with global yields.

Table 33 Overview of crop data in 2014

		World		Africa	Americas	Asia	Europe	Oceania
		2000	2014	2014	2014	2014	2014	2014
Maize	**Area**	592	1 022	77.6	526	304	113	0.64
	Yield	4.32	5.57	2.10	7.70	5.15	6.01	8.21
	Production	2 562	5 693	163	4 052	1 565	678	5.29
Rice	**Area**	599	741	31.2	37.7	667	4.00	0.83
	Yield	3.89	4.54	2.69	5.63	4.63	6.23	10.54
	Production	2 328	3 363	84.0	212	3 087	24.9	8.74
Wheat	**Area**	586	729	26.1	112	316	249	25.7
	Yield	2.72	3.29	2.63	2.93	3.09	4.25	2.03
	Production	1 592	2 398	68.7	329	977	1 058	52.2
Barley	**Area**	133	144	6.02	15.6	19.6	93.6	9.6
	Yield	2.44	2.91	1.38	3.27	1.74	3.70	2.47
	Production	325	420	8.29	51	34.2	346	23.7
Millet	**Area**	27.7	27.8	12.4	0.31	14.3	0.79	0.04
	Yield	0.75	0.89	0.63	1.75	1.33	1.41	1.10
	Production	20.6	24.7	7.80	0.54	18.9	1.12	0.05
Oats	**Area**	26.1	23.0	0.20	5.65	1.12	14.7	1.27
	Yield	2.06	2.39	1.19	2.79	2.17	2.39	1.78
	Production	53.7	55.0	0.24	15.8	2.42	35.1	2.27
Rye	**Area**	20.1	15.3	0.09	0.44	1.15	13.6	0.03
	Yield	2.05	2.92	1.80	1.96	2.75	3.02	0.60
	Production	41.2	44.8	0.17	0.86	3.17	41.2	0.02
Sorghum	**Area**	2.12	1.29	-	-	-	-	-
	Yield	3.40	2.41	-	-	-	-	-
	Production	7.20	3.11	-	-	-	-	-
Olives	**Area**	15.6	15.5	2.75	0.53	2.71	9.43	0.10
	Yield	1.87	1.51	0.87	3.79	1.42	1.87	2.26
	Production	29.2	23.4	2.40	2.01	3.83	17.6	0.22
Rapeseed	**Area**	39.5	71.0	0.25	17.2	20.8	28.9	3.83
	Yield	1.53	1.98	1.35	1.92	1.40	3.17	1.41
	Production	60.5	141	0.34	32.9	29.2	91.6	5.40
Soybeans	**Area**	161	308	2.38	271	25.8	9.00	0.08
	Yield	2.17	2.62	1.28	2.95	1.32	2.00	2.16
	Production	350	808	3.04	801	34.1	18.0	0.17

		World		Africa	Americas	Asia	Europe	Oceania
		2000	2014	2014	2014	2014	2014	2014
Sunflower	Area	26.5	41.3	2.40	3.65	5.78	29.5	0.04
	Yield	1.25	1.67	1.22	1.57	1.42	1.80	1.41
	Production	33.1	69.0	2.92	5.72	8.24	53.0	0.05
Oil palm	Area	2.23	52.8	0.30	2.39	49.0	0.61	0.52
	Yield	-	-	-	-	-	-	-
	Production	-	-	-	-	-	-	-
Cassava	Area	176	270	147	32.8	90.4	-	0.25
	Yield	10.4	11.2	8.38	12.9	21.9	-	11.5
	Production	1 830	3 016	1 230	424	1 975	-	2.89
Sugar beet	Area	250	267	13.5	30.9	32.7	190	-
	Yield	41.6	59.6	53.2	62.4	50.8	61.5	-
	Production	10 404	15 903	716	1 926	1 664	11 673	-
Sugar cane	Area	1 256	1 900	96.7	1 010	760	0.01	32.4
	Yield	64.7	69.9	63.1	71.2	68.8	86.3	77.1
	Production	81 315	132 809	6 101	71 984	52 360	0.47	2 495

Area in million ha, Yield in tons/ha and Production in million tonnes. (Source: FAO)

Agricultural residues

The estimated potential of using agricultural residues for energy ranges from 17 EJ to 128 EJ (Table 34, Table 35). This high range of values is due to the dependence on various factors including moisture content, energy content of the residues etc. The highest potential for using agricultural residues is in Asia and Americas due to the high production of rice and maize respectively.

Table 34 Estimates of agricultural residues energy potential – Low potential

		World	Africa	Americas	Asia	Europe	Oceania
Rice	Straw	1.24	0.05	0.06	1.11	0.01	0.00
	Husk	0.81	0.03	0.04	0.73	0.00	0.00
Maize	Stalk	2.09	0.16	1.08	0.62	0.23	0.00
	Cob	1.37	0.10	0.70	0.41	0.15	0.00
	Husks	1.51	0.11	0.78	0.45	0.17	0.00
Wheat	Straw	2.46	0.09	0.38	1.07	0.84	0.09
Millet/Rye/Oats	Straw	0.16	0.07	0.00	0.08	0.00	0.00
Barley	Straw	0.42	0.02	0.05	0.06	0.27	0.03
Sorghum	Straw	0.32	0.14	0.13	0.05	0.01	0.01
Cassava	Stalks	0.12	0.07	0.02	0.04	0.00	0.00
Groundnut	Husks/Shells	0.15	0.04	0.02	0.09	0.00	0.00
	Straw	0.74	0.22	0.08	0.44	0.00	0.00
Soybean	Straw	1.62	0.01	1.43	0.14	0.05	0.00
Cane	Bagasse	0.29	0.01	0.16	0.12	0.00	0.01
	Tops	0.38	0.02	0.20	0.15	0.00	0.01
Jute	Stalk	0.05	0.00	0.00	0.05	0.00	0.00
Cotton (Lint)	Stalk	0.26	0.01	0.05	0.19	0.00	0.01
Coconut	Husk	0.21	0.01	0.02	0.18	0.00	0.01
	Shell	0.05	0.00	0.00	0.04	0.00	0.00
Oil palm (Fruit)	Shell	0.01	0.00	0.00	0.01	0.00	0.00
	Fibre	0.01	0.00	0.00	0.01	0.00	0.00
	Bunch	0.01	0.00	0.00	0.01	0.00	0.00

		World	Africa	Americas	Asia	Europe	Oceania
Coffee	**Husk**	0.99	0.11	0.55	0.32	0.00	0.01
Rapeseed/Canola	**Straw**	0.88	0.00	0.21	0.26	0.36	0.05
Sunflower seed	**Straw**	0.56	0.03	0.05	0.08	0.40	0.00
Jatropha	**Shells**	0.02	0.00	0.00	0.02	0.00	0.00
Olives	**Kernels**	0.02	0.00	0.00	0.00	0.01	0.00
Sugar beets	**Leaves**	0.21	0.01	0.02	0.03	0.15	0.00
	Total	17.0	1.34	6.02	6.73	2.65	0.22

All values in EJ. (Source: WBA)

Table 35 Estimates of agricultural residues energy potential – High potential

		World	Africa	Americas	Asia	Europe	Oceania
Rice	**Straw**	21.2	0.89	1.08	19.05	0.11	0.02
	Husk	2.32	0.10	0.12	2.09	0.01	0.00
Maize	**Stalk**	38.5	2.92	19.83	11.46	4.25	0.02
	Cob	13.9	1.06	7.17	4.14	1.54	0.01
	Husks	7.55	0.57	3.89	2.25	0.83	0.00
Wheat	**Straw**	9.47	0.34	1.46	4.10	3.24	0.33
Millet/Rye/Oats	**Straw**	0.29	0.13	0.00	0.15	0.01	0.00
Barley	**Straw**	1.48	0.06	0.16	0.20	0.96	0.10
Sorghum	**Straw**	2.64	1.13	1.04	0.37	0.05	0.05
Cassava	**Stalks**	2.01	1.09	0.24	0.67	0.00	0.00
Groundnut	**Husks/Shells**	0.37	0.11	0.04	0.22	0.00	0.00
	Straw	0.95	0.28	0.10	0.57	0.00	0.00
Soybean	**Straw**	6.39	0.05	5.62	0.53	0.19	0.00
Cane	**Bagasse**	12.0	0.61	6.36	4.79	0.00	0.20
	Tops	2.48	0.13	1.32	0.99	0.00	0.04
Jute	**Stalk**	0.08	0.00	0.00	0.08	0.00	0.00
Cotton (Lint)	**Stalk**	1.00	0.04	0.18	0.71	0.01	0.04
Coconut	**Husk**	0.82	0.03	0.07	0.68	0.00	0.04
	Shell	0.56	0.02	0.05	0.46	0.00	0.03
Oil palm (Fruit)	**Shell**	0.04	0.00	0.00	0.04	0.00	0.00
	Fibre	0.05	0.00	0.00	0.04	0.00	0.00
	Bunch	0.04	0.00	0.00	0.04	0.00	0.00
Coffee	**Husk**	0.99	0.11	0.55	0.32	0.00	0.01
Rapeseed/Canola	**Straw**	1.91	0.01	0.46	0.56	0.78	0.10
Sunflower seed	**Straw**	1.14	0.07	0.10	0.16	0.81	0.00
Jatropha	**Shells**	0.03	0.00	0.00	0.02	0.00	0.00
Olives	**Kernels**	0.02	0.00	0.00	0.00	0.02	0.00
Sugar beets	**Leaves**	0.22	0.01	0.03	0.03	0.15	0.00
	Total	128	9.76	49.9	54.7	13.0	1.01

All values in EJ. (Source: WBA)

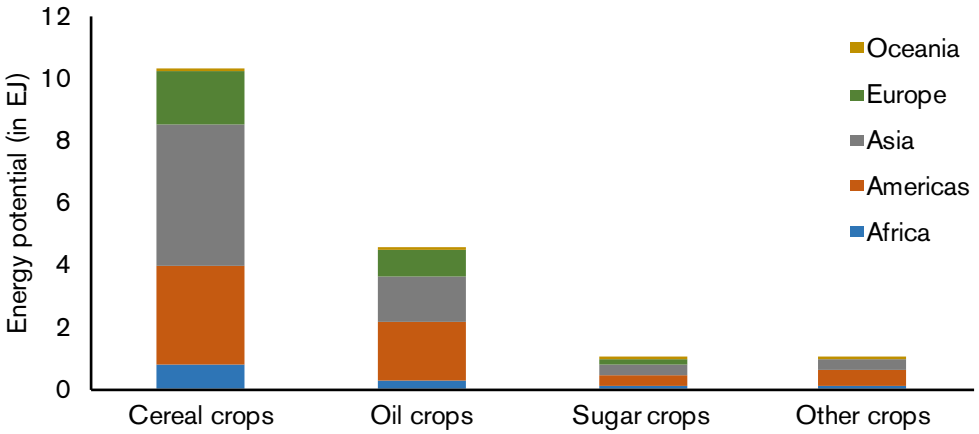

Figure 29 Energy potential of agricultural residues - Low, World 2013. (Source: WBA)

2.4. FORESTRY

The total forest area in the year 2013 was 4 billion ha – primary forests accounted for 32% (Table 36).

2.4.1. FORESTRY 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. . Primary forests are forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. Other naturally regenerated forests are forests where the tree species are predominantly non-native and do not need human help to reproduce/maintain populations over time. Planted forests are composed of trees established through planting and/or through deliberate seeding of native or introduced species. Establishment is either through afforestation on land which has not carried forest within living memory or by reforestation of previously forested land.

Table 36 Forest area data

	Forest land	Primary forests	Other naturally regenerated forest	Planted forest
2000	4 055 602	1 298 633	2 532 749	224 220
2005	4 032 743	1 284 232	2 494 755	253 756
2010	4 015 673	1 288 129	2 450 349	277 195
2011	4 012 365	1 285 947	2 445 985	280 442
2012	4 009 057	1 283 764	2 441 621	283 688
2013	4 005 749	1 281 582	2 437 258	286 934

All values in 1000ha. (Source: FAO)

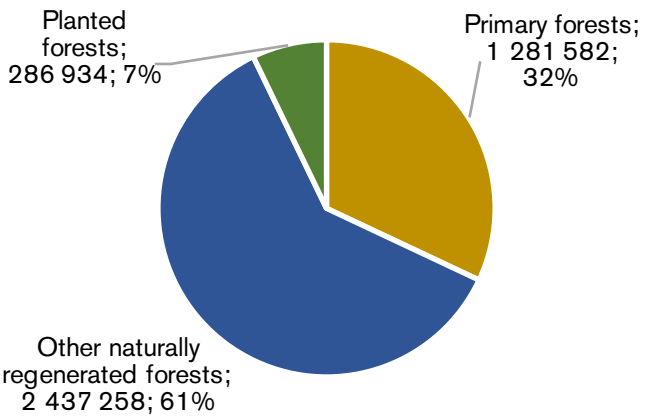

Figure 30 Global forestry area - 2013. (Source: FAO)

The largest annual decrease in forest area occurred in Africa (Table 37). Annually, the forest area decreased by 0.5% in the continent. In comparison, the total forest area increased by 0.09% and 0.34% in Europe and Asia respectively.

Table 37 Forestry area data - Continents 2013

	World	Africa	Americas	Asia	Europe	Oceania
2000	4 055 602	670 372	1 639 376	565 912	1 002 302	177 641
2005	4 032 743	654 679	1 616 564	580 868	1 004 147	176 485
2010	4 015 673	638 282	1 602 412	589 405	1 013 572	172 002
2011	4 012 365	635 446	1 600 462	590 197	1 013 954	172 306
2012	4 009 057	632 610	1 598 512	590 988	1 014 336	172 610
2013	4 005 749	629 774	1 596 563	591 779	1 014 718	172 915

All values in 1000ha. Russia is included in Europe continent. (Source: FAO)

Russia has the largest forest resources and it has increased by 0.71% since 2000 (Table 37). Most of the forests are in the form of naturally regenerative forests. Out of the top 10, China has seen an increase of 16% in their forest area during 2000 – 2013 while Indonesian and Brazil forest area reduced by 7% and 5% respectively.

Table 38 Forest area - Top 10 countries in 2013

	Countries	Forest area	Primary forests	Other naturally regenerative forests	Planted forests	% change since 2000
1	**Russia**	815 013	272 968	522 295	19 750	0.71%
2	**Brazil**	495 506	202 691	285 384	7 430	-4.94%
3	**Canada**	347 162	205 979	126 122	15 060	-0.18%
4	**USA**	309 545	75 298	208 203	26 044	1.98%
5	**China**	205 237	11 632	116 989	76 616	16.0%
6	**DRC**	153 201	102 966	50 175	60	-2.57%
7	**Australia**	124 135	5 039	117 124	1 971	-3.65%
8	**Indonesia**	92 379	46 481	41 008	4 888	-7.07%
9	**Peru**	74 308	66 084	7 133	1 091	-2.41%
10	**India**	70 325	15 701	42 950	11 674	7.55%
Total (Top 10)		2 686 811	1 004 839	1 517 383	164 583	
EU - 28		160 343	4 045	101 031	55 267	3.62%
World		4 005 749	1 281 582	2 437 258	286 934	-1.23%

All values in 1000ha. (Source: FAO)

2.4.2. FORESTRY PRODUCTS

Roundwood is all the wood in the rough, obtained from removals. It includes sawlogs, veneer logs, pulpwood, other industrial roundwood, and fuelwood. Forestry sector is the largest supplier of bioenergy. The production of roundwood globally has increased by 245 million m^3 – predominantly in Africa and Europe (Table 39).

Table 39 Production of roundwood

	World	Africa	Americas	Asia	Europe	Oceania
2000	3 455	613	1 094	1 076	612	59.8
2005	3 585	663	1 110	1 074	676	61.2
2010	3 528	702	973	1 127	659	67.8
2011	3 591	688	1 022	1 127	683	70.4
2012	3 616	714	1 029	1 122	683	68.2
2013	3 654	719	1 041	1 126	698	70.0
2014	3 700	728	1 057	1 119	722	74.2

All values in million m^3. (Source: FAO)

Woodfuel is wood used for energy purposes such as cooking, heating or power production. It includes wood harvested from main stems, branches and other parts of trees. In 2014, 1.8 billion tonnes of woodfuel (Table 40) was produced globally – mostly in Asia and Africa.

Table 40 Production of woodfuel

	World	Africa	Americas	Asia	Europe	Oceania
2000	1 771	542	314	808	93.6	12.7
2005	1 799	589	299	792	107	11.5
2010	1 825	631	290	766	127	10.7
2011	1 822	620	298	758	134	10.7
2012	1 849	643	305	750	141	10.6
2013	1 860	650	309	743	147	10.6
2014	1 864	657	310	737	150	10.6

All values in million tonnes. (Source: FAO)

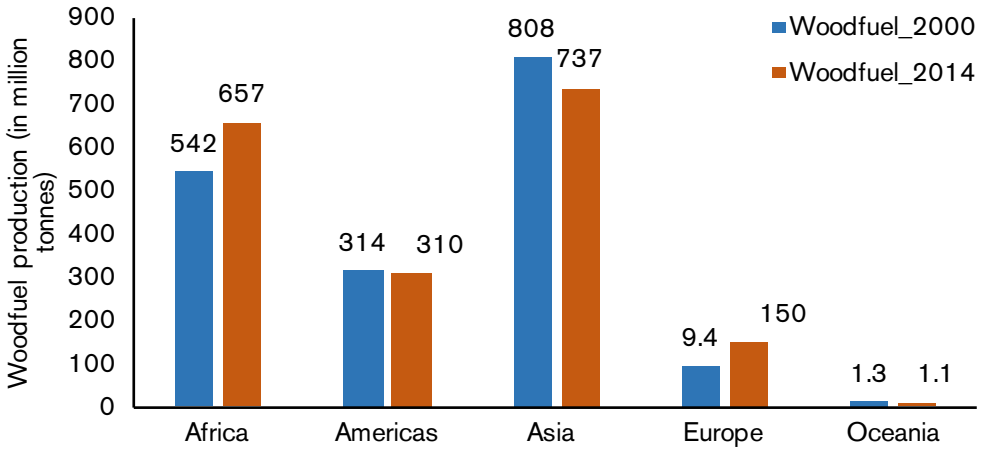

Figure 31 Global woodfuel production change during 2000 - 2014

(Source: FAO)

India is the world's largest producer of woodfuel in 2014 and has increased its production by 10.7% since 2000 (Table 40). China produces about half of India's production but has reduced the production volumes by 23%. The third top woodfuel producer, Brazil, also reduced its production by 11%.

Table 41 Production of woodfuel - top 10 countries in 2014

	Countries	Woodfuel production	% change
1	**India**	307	10.7%
2	**China**	176	-22.8%
3	**Brazil**	118	-10.8%
4	**Ethiopia**	107	22.0%
5	**DRC**	81.3	25.2%
6	**Nigeria**	64.8	9.26%
7	**Indonesia**	50.4	-43.3%
8	**Ghana**	42.7	59.8%
9	**USA**	41.9	-8.82%
10	**Uganda**	41.9	22.8%
Total (Top 10)		1 031	
EU - 28		101	44.9%
World		1 864	5.25%

All values in million tonnes. (Source: FAO)

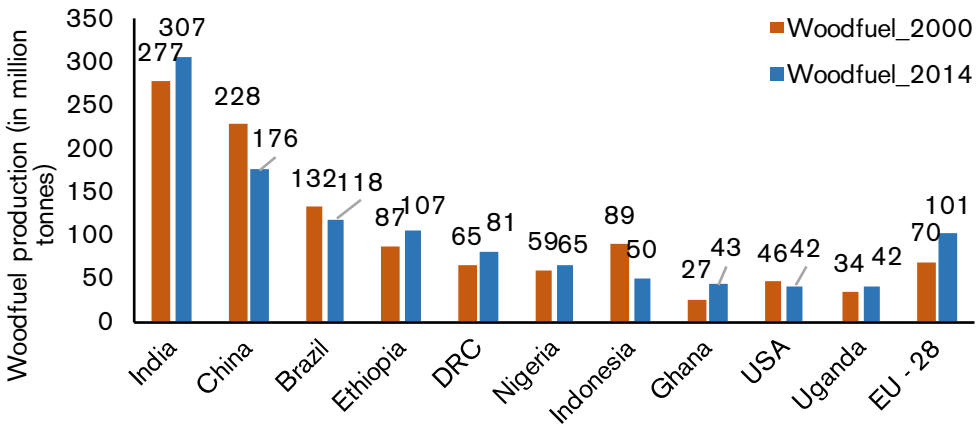

Figure 32 Woodfuel production in top 10 countries.

(Source: FAO)

Forestry residues

WBA has made an attempt at estimating the residues of forestry and wood industry. Different wood resources and their residue recovery rate are estimated. For e.g. the solid residue recovery rate from logging is estimated as 40%. Sawdust from saw milling is estimated at 12% etc. Estimates are made for moisture content, density and heating value of these residues. The low and high potential of residues is based on the varying ranges of these values. A point to note is that this only provides a theoretical estimate of energy potential from residues and this amount might not be available practically due to various reasons. Further research is needed to estimate the sustainable potential of using these residues.

The theoretical potential of using forest residues for energy ranges from 4.64 EJ to 7.64 EJ depending on the moisture content, energy value and density of the wood residue along with the recovery rate (Table 42, Table 43). The highest potential for using residues is during black liquor production – mostly in Americas (Figure 33).

Table 42 Forestry residues energy potential in 2014 – Low potential

		World	Africa	Americas	Asia	Europe	Oceania
Logging	**Solid**	0.89	0.17	0.25	0.27	0.17	0.02
Saw milling	**Solid**	0.14	0.00	0.05	0.03	0.05	0.01
	Sawdust	0.07	0.00	0.03	0.02	0.02	0.00
Plywood	**Solid**	0.17	0.00	0.02	0.14	0.01	0.00
	Dust	0.00	0.00	0.00	0.00	0.00	0.00
Particle board	**Dust**	0.01	0.00	0.00	0.00	0.00	0.00
Chemical pulp	**Black liquor**	3.36	0.03	1.84	0.65	0.80	0.04
Forest based residues		0.89	0.17	0.25	0.27	0.17	0.02
Processing based - Solid wood		0.31	0.01	0.07	0.17	0.06	0.01
Processing based - Fine dust		0.09	0.00	0.03	0.02	0.03	0.00
Processing based - Liquids		3.36	0.03	1.84	0.65	0.80	0.04
Total		4.64	0.21	2.20	1.11	1.06	0.07

All values in EJ. (Source: FAO and IEA)

Table 43 Forestry residues energy potential – High potential

		World	Africa	Americas	Asia	Europe	Oceania
Logging	**Solid**	2.93	0.58	0.84	0.89	0.57	0.06
Saw milling	**Solid**	0.75	0.02	0.28	0.16	0.25	0.03
	Sawdust	0.24	0.01	0.09	0.05	0.08	0.01
Plywood	**Solid**	0.32	0.00	0.03	0.27	0.02	0.00
	Dust	0.01	0.00	0.00	0.01	0.00	0.00
Particle board	**Dust**	0.02	0.00	0.01	0.01	0.01	0.00
Chemical pulp	**Black liquor**	3.36	0.03	1.84	0.65	0.80	0.04
Forest based residues		2.93	0.58	0.84	0.89	0.57	0.06
Processing based - Solid wood		1.07	0.03	0.32	0.43	0.27	0.03
Processing based - Fine dust		0.27	0.01	0.10	0.07	0.09	0.01
Processing based - Liquids		3.36	0.03	1.84	0.65	0.80	0.04
Total		7.64	0.64	3.10	2.03	1.73	0.15

All values in EJ. (Source: FAO and WBA)

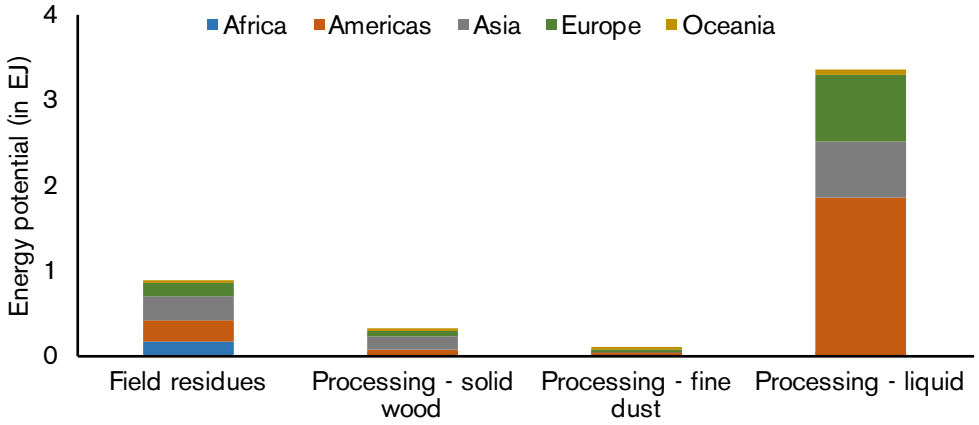

Figure 33 Energy potential of forestry residues - Low, World 2014. (Source: FAO and WBA)

2.5. WASTE

This section only deals with municipal solid waste production. Municipal waste consists of products that are combusted directly to produce heat and/or power and comprises wastes produced by households, industry, hospitals and the tertiary sector that are collected by local authorities for incineration at specific installations. In 2013, 1.3 EJ of MSW was produced and used for energy purposes – predominantly in Europe (Table 44, Figure 34).

Table 44 Production of energy from renewable Municipal Solid Waste (MSW)

	World	Africa	Americas	Asia	Europe	Oceania
2000	0.78	0.00	0.35	0.08	0.35	0.00
2005	1.00	0.00	0.30	0.14	0.56	0.00
2010	1.17	0.00	0.30	0.17	0.71	0.00
2011	1.23	0.00	0.30	0.19	0.73	0.00
2012	1.27	0.00	0.30	0.20	0.76	0.00
2013	1.30	0.00	0.30	0.20	0.80	0.00

All values in EJ. (Source: IEA)

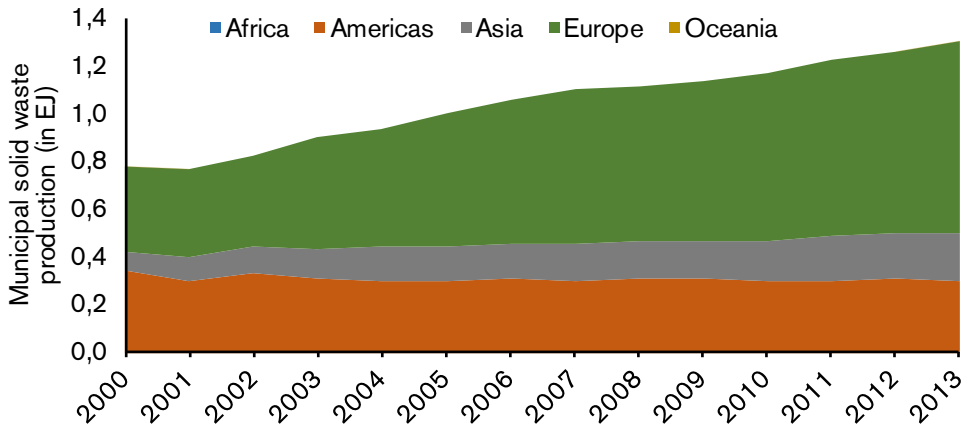

Figure 34 Municipal solid waste production for energy.

(Source: IEA)

2.6. OTHER SUPPLY SOURCES

Another source of biomass supply is algae. Algae is an alternative feedstock which uses sunlight, carbon dioxide, nutrients and water and produces oil which can be used as a feedstock for biofuels production. However, the technology is not yet cost competitive and the production is energy intensive. There are no known global and reliable statistics on algae production for biofuels and hence, not reported.

Peat is an another source of energy. Peat is a soft, porous or compressed, deposit of plant origin with a high water content which can be used for energy purposes. Globally, 16 million tonnes of peat are produced for energy. In northern European countries like Sweden, Finland, Ireland etc., peat under certain conditions and to a limited extent is considered climate positive. Due to lack of global peat data for energy, peat statistics are not currently considered for this report.

3. BIOMASS TO ELECTRICITY

• In 2013, 462 TWh of bioelectricity was produced globally – an increase of 6% over the previous year

• Outside EU-28, USA and China are the largest producers of bioelectricity globally at 78.2 TWh and 50.7 TWh

• Asia is the fastest growing region for bioelectricity generation. Among top 10, China, India and Thailand have increase bioelectricity production by 20, 17 and 13 times.

• Asia produces most of its electricity in electricity only plants with low efficiency of conversion as heat is neglected.

• Europe produces most of its electricity in combined heat and power plants (CHP) leading to higher efficiencies due to heat utilization.

3.1. OVERVIEW

In 2013, 462 TWh of electricity was generated from biomass (Table 45). Biomass is the third largest electricity generating source among the renewables after wind and large scale hydro. The bioelectricity production is more than three times as much as solar PV.

Europe is the largest producer of bioelectricity largely produced in combined heat and power plants. The use of biomass in CHP systems signifies higher efficiencies of conversion as the heat is used in the district heating networks to heat residential and commercial sectors.

During 2000 – 13, the global bioelectricity generation increased by more than 2.5 times – largely due to increasing generation in the Asian continent. In 13 years, Asia increased the electricity generation by almost 6 times.

Table 45 Electricity generation from biomass

	World	Africa	Americas	Asia	Europe	Oceania
2000	170	1.08	93.9	22.2	50.8	1.72
2005	237	1.31	103	38.6	89.4	4.33
2010	380	1.70	131	95.6	149	3.38
2011	409	1.31	136	109	159	2.73
2012	435	1.26	138	116	176	2.97
2013	462	1.27	142	130	185	2.58

All values in TWh. (Source: IEA)

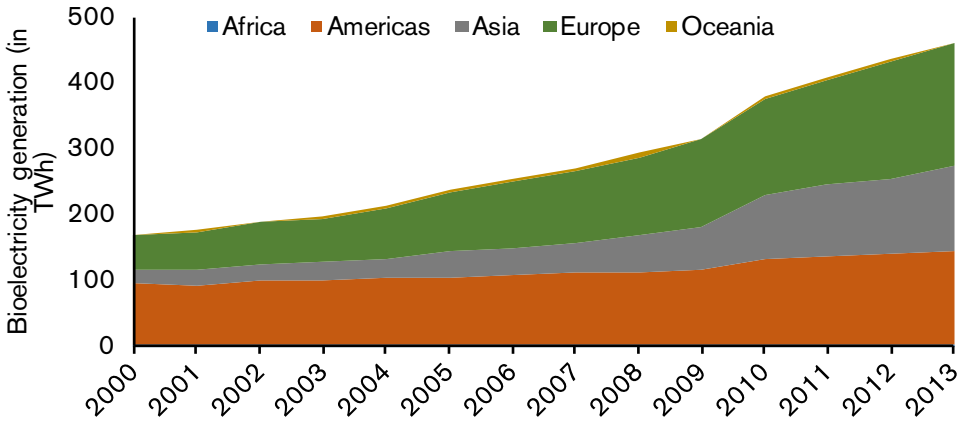

Figure 35 Electricity generation from biomass globally

(Source: IEA)

Among the top 10 countries, USA and China are the largest producers of electricity from biomass outside EU-28 (Table 46). Developing countries like China, India and Thailand have increased their bioelectricity generation exponentially. China increased their bioelectricity production by more than 20 times within 13 years. Similar rapid growth is visible in India and Thailand.

The development in bioelectricity generation is seen globally. Even though developed countries in EU and Americas have shown a decent increase, the highest growth of bioelectricity generation is in developing nations. Favourable policies, rapid economic development and the need for electrifying large populations are some of the main reasons for such a growth.

Table 46 Electricity generation – Top 10 countries 2013

	Countries	Electricity generation in 2013	% change (2000 - 2013)
1	USA	-	9.0%
2	China	50.7	1994%
3	Japan	40.7	162%
4	Brazil	40.4	416%
5	India	23.1	1711%
6	Thailand	6.97	1270%
7	Chile	5.76	512%
8	Canada	5.45	-33.7%
9	Russia	2.93	15.2%
10	Switzerland	2.87	64.2%
	Total (Top 10)	257	
	EU - 28	178	285%
	World	462	172%

All values in TWh. (Source: IEA). Top 10 excluding EU - 28

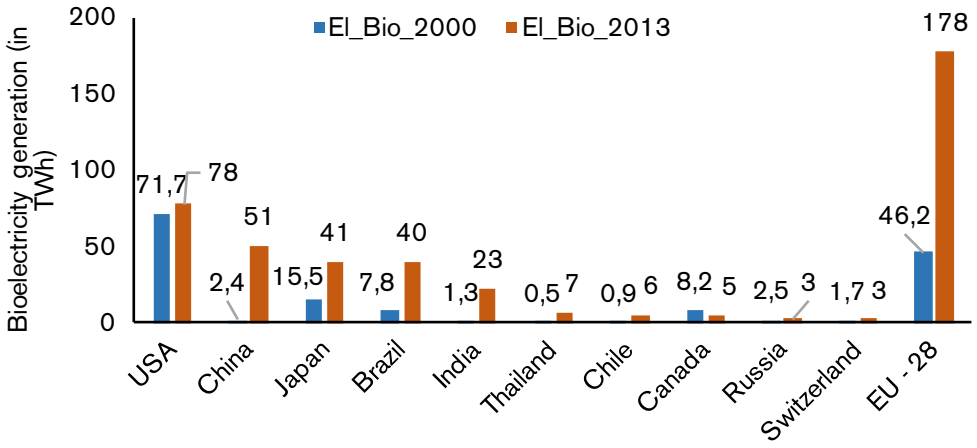

Figure 36 Electricity generation from biomass in top 10 countries.

(Source: IEA)

3.2. ELECTRICITY ONLY PLANTS

3.65 EJ of biomass was used for generating electricity in electricity only plants. WBA does not promote the use of biomass for electricity only plants where only electricity is used and heat is rejected leading to low overall efficiencies of conversion.

Globally, 3.65 EJ of biomass was used in electricity only plants for electricity production. Using an average conversion efficiency for electricity only plants (approx. 32%), the global electricity generation is about 325 TWh in 2013. This is about 70% of all electricity generation while the remaining was generated in combined heat and power plants.

Asia leads the production of electricity in electricity only plants. More than half of globally bioelectricity from electricity only plants was produced in Asia. This might be largely due to the lack of available district heating grids for distributing and utilizing heat from the CHP plants.

Table 47 Use of biomass for electricity in electricity only plants

	World – Biomass use (EJ)	World – Bioelectricity generation (TWh)	Africa	Americas	Asia	Europe	Oceania
2000	1.13	101	0.02	0.57	0.25	0.29	0.00
2005	1.77	158	0.03	0.73	0.49	0.51	0.02
2010	2.90	259	0.04	0.82	1.33	0.71	0.01
2011	3.19	284	0.03	0.86	1.54	0.74	0.01
2012	3.37	301	0.02	0.91	1.66	0.77	0.01
2013	3.65	325	0.02	0.92	1.88	0.81	0.02

All values in EJ. (Source: IEA)

3.3. CHP PLANTS

Combined heat and power is the simultaneous production and utilization of heat and electricity. Such combined use leads to higher efficiencies and lower use of fuel for energy purposes.

In 2013, 2.33 EJ of biomass was used in CHP plants. Using an average conversion efficiency for combined heat and power production (approx. 23%), 146 TWh of bioelectricity was produced from CHP plants. This is about 30% of total electricity generation.

One of the requisites of CHP production is the availability of district heating grids which is prominent in European countries. Hence, Europe is the largest user of biomass for producing electricity in combined heat and power plants. 63% of all bioelectricity generation in CHP plants was in Europe while 33% in Americas.

Table 48 Use of biomass for electricity in combined heat and power plants

	World – Biomass use (EJ)	World – Bioelectricity generation (TWh)	Africa	Americas	Asia	Europe	Oceania
2000	1.05	66	0.00	0.58	0.00	0.43	0.03
2005	1.37	86	0.00	0.57	0.00	0.73	0.07
2010	1.79	112	0.00	0.58	0.01	1.17	0.02
2011	1.91	119	0.02	0.60	0.02	1.25	0.02
2012	2.22	139	0.02	0.75	0.02	1.41	0.03
2013	2.33	146	0.02	0.80	0.02	1.48	0.01

All values in EJ. (Source: IEA)

4. BIOMASS TO HEAT

- *In 2013, 48.5 EJ of direct heat was generated using biomass – almost half of it in Asia*
- *In 2013, 0.9 EJ of derived heat (heat generated in power plants) was generated from biomass*
- *Europe produced 77% of all the derived bioheat*
- *Apart from EU – 28, Russia, China and USA lead the list of top derived bioheat producers*
- *Most of the bioheat (80%) is produced in combined heat and power plants*

4.1. OVERVIEW

Heat is supplied as direct heat or as derived heat. In 2013, total renewable heat was 50.8 EJ out of which derived heat was only 1.8% while the remaining was direct heat (Table 17).

4.2. DIRECT HEAT

Direct heating is the direct consumption of energy resources in the end use sectors – residential, commercial, agriculture etc. The direct use of biomass for domestic heating and cooking is of utmost importance. In the year 2013, 48.5 EJ of biomass was used for direct heating (Table 49). To put it into a context, the total consumption of all energy resources was 355 EJ. In other words, 13.7% of global energy consumption was the use of biomass for direct heat.

Table 49 Direct heat generation from biomass

	World	Africa	Americas	Asia	Europe	Oceania
2000	40.1	10.4	5.76	21.4	2.37	0.22
2005	42.9	11.9	6.27	22.0	2.54	0.18
2010	46.4	13.6	6.58	22.8	3.15	0.17
2011	46.9	14.2	6.50	22.9	3.06	0.17
2012	47.5	14.6	6.31	23.1	3.31	0.21
2013	48.5	14.9	6.72	23.2	3.39	0.22

All values in EJ. (Source: IEA and WBA)

Almost 50% of the use of biomass for direct heat occurred in Asia. This is in the form of traditional biomass such as agricultural residues, charcoal, cowdung etc. Data for such resources are hard to estimate and the actual figures may be significantly higher.

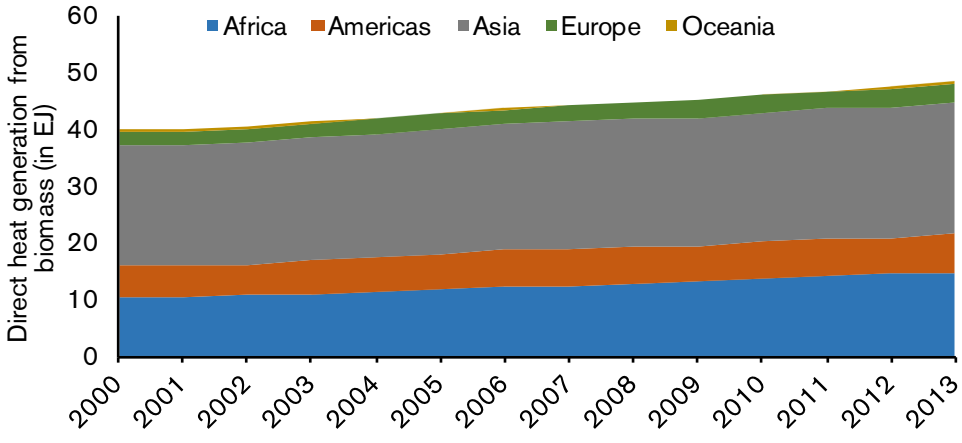

Figure 37 Direct heat generation from biomass.

(Source: IEA and WBA)

Eight of the top 10 countries with high use of biomass for direct heating were either in Asia and Africa (Table 50). Almost all the countries have increased their use of biomass for direct heating since 2000 except

for USA. In the past 13 years, African countries increased their use by more than 50%.

Table 50 Direct heat generation from biomass - Top 10 countries in 2013

	Countries	Heat generation	% change
1	China	8.47	0.32%
2	India	7.34	18.5%
3	Nigeria	4.56	56.2%
4	Brazil	2.52	53.1%
5	Indonesia	2.26	7.96%
6	USA	1.98	-2.76%
7	Ethiopia	1.87	60.9%
8	Pakistan	1.27	26.6%
9	Tanzania	0.84	60.8%
10	Thailand	0.83	46.2%
Total (Top 10)		31.9	
EU - 28		2.94	47%
World		48.5	21%

All values in EJ. (Source: IEA and WBA)

4.3. DERIVED HEAT

Derived heat is heat generated in heat only plants and combined heat and power plants. In 2013, 893 PJ (approx. 0.89 EJ) of derived heat was generated from biomass in power plants (Table 51). The largest producer of derived heat was in Europe – predominantly in combined heat and power plants. 77% of all derived heat from biomass was produced in Europe (Figure 38). There is negligible derived heat generation in both African and Oceania continents.

Table 51 Heat production from biomass

	World	Africa	Americas	Asia	Europe	Oceania
2000	415	0.0	29.1	15.7	370	0.00
2005	531	0.0	18.7	20.2	492	0.00
2010	780	0.0	46.2	54.2	680	0.00
2011	783	0.0	44.6	61.0	678	0.00
2012	850	0.0	46.7	74.1	729	0.00
2013	893	0.0	44.0	84.8	688	0.00

All values in PJ. (Source: IEA)

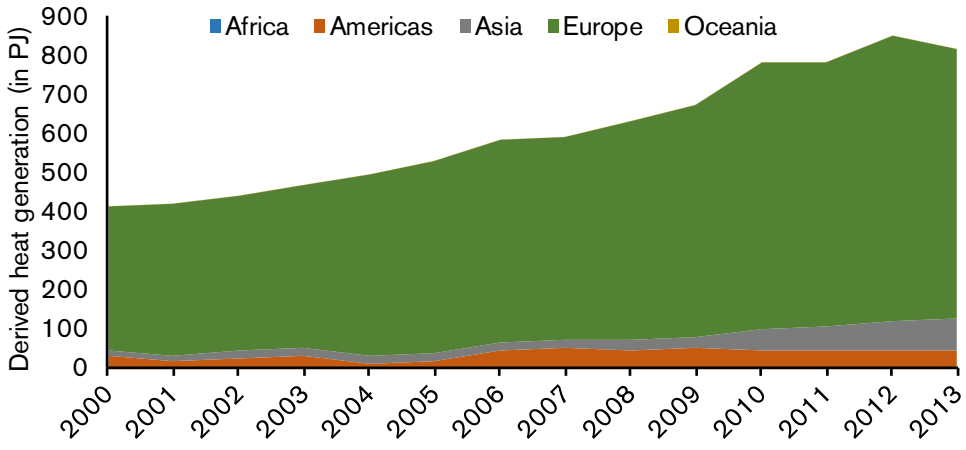

Figure 38 Derived heat generation from biomass

(Source: IEA)

EU countries increased their derived bioheat production by 2.5 times during 2000 – 2013. Sweden is the world's largest producer of derived heat from biomass.

Outside EU - 28 countries, Russia is the largest producer of derived bioheat in 2013 with a total production of 110 PJ (~ 0.1 EJ). There hasn't been much change since 2000. Among top 10, South Korea increased their derived bioheat production by almost 11 times.

Table 52 Derived heat production – Top 10 countries 2013

	Countries	Heat gene-ration	% change
1	**Russia**	110	-2%
2	**China**	46.5	280%
3	**USA**	41.8	54%
4	**Korea**	36.8	998%
5	**Norway**	17.5	287%
6	**Switzerland**	14.0	61.4%
7	**Ukraine**	11.4	-
8	**Canada**	2.16	7.20%
9	**Turkey**	1.50	-
10	**Bosnia**	0.17	-
	Total (Top 10)	281	
	EU - 28	**591**	**148%**
1	**Sweden**	142	56.3%
2	**Germany**	93.4	382%
3	**Finland**	78.7	120%
4	**Denmark**	68.1	119%
5	**Austria**	43.3	342%
6	**France**	35.4	47.7%
7	**Italy**	38.1	-
8	**The Netherlands**	18.1	185%
9	**Poland**	16.4	694%
10	**Lithuania**	11.9	874%
	World	893	115%

All values in PJ. (Source: IEA)

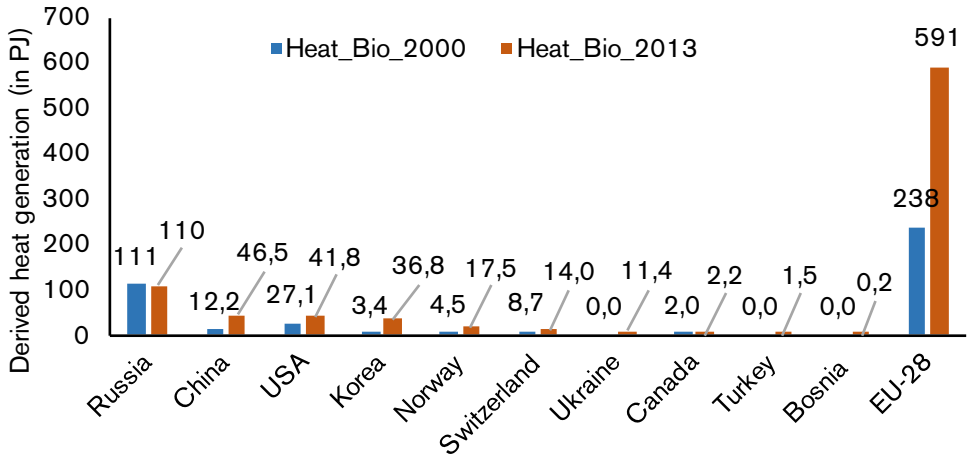

Figure 39 Derived heat production from biomass in top 10 countries.

(Source: IEA)

4.4. HEAT ONLY PLANTS

Heat only plants are plants designed to produce heat only and sell heat to a third party. In 2013, 0.47 EJ of biomass was used in heat only plants for heat generation. This hasn't increased much in the past years. Europe is the world leader in producing derived heat from biomass in heat only plants. Almost 80% of all biomass used in heat only plants were used in Europe alone. In fact, Europe and Asia are the only two continents producing bioheat in heat only plants. Utilizing an average conversion factor for heat generation in heat only plants globally (approx. 40%), 189 PJ of derived bioheat was produced in heat only plants in 2013 which is about 20% of all derived heat production.

Table 53 Use of biomass for heat in heat only plants

	World - Biomass use (EJ)	World - Bioheat production (PJ)	Africa	Americas	Asia	Europe	Oceania
2000	0.24	97.5	0.00	0.0	0.02	0.22	0.00
2005	0.31	126	0.00	0.0	0.03	0.28	0.00
2010	0.45	180	0.00	0.0	0.07	0.38	0.00
2011	0.45	179	0.00	0.0	0.07	0.37	0.00
2012	0.47	189	0.00	0.0	0.09	0.38	0.00
2013	0.47	189	0.00	0.0	0.10	0.37	0.00

All values in EJ. (Source: IEA)

4.5. CHP PLANTS

In 2013, 2.33 EJ of biomass was used in CHP plants for heat production. Utilizing an approximate conversion factor of 30%, 699 PJ of heat was produced which is almost 80% of all bioheat generated. The production of derived heat from biomass is dominated by the combined heat and power plants. Similar to electricity, Europe is the largest user of biomass for heat generation in CHP plants followed by Americas.

Table 54 Use of biomass for derived heat in combined heat and power plants

	World - Biomass use (EJ)	World - Bioheat production (PJ)	Africa	Americas	Asia	Europe	Oceania
2000	1.05	315	0.00	0.58	0.00	0.43	0.03
2005	1.37	412	0.00	0.57	0.00	0.73	0.07
2010	1.79	536	0.00	0.58	0.01	1.17	0.02
2011	1.91	572	0.02	0.60	0.02	1.25	0.02
2012	2.22	666	0.02	0.75	0.02	1.41	0.03
2013	2.33	699	0.02	0.80	0.02	1.48	0.01

All values in EJ. (Source: IEA)

5. BIOMASS TO LIQUID BIOFUELS

- *In 2015, 133 billion litres of biofuels were produced.*
- *In energy terms, biofuel production contributed 5% of the global biomass supply*
- *62% of all biofuel production is in the form of bioethanol followed by biodiesel (24%) and other biofuels including hydrogenated vegetable oil, cellulosic biofuels etc.*
- *87% of all bioethanol produced was in USA and Brazil using corn and sugarcane respectively.*
- *In 2013, 112 million tonnes of biofuel was produced along with 71 tonnes of protein using 71 million ha of agricultural land*

5.1. OVERVIEW

Biofuels for transportation are one of the crucial aspects of climate change mitigation by replacing the use of fossil fuels. In 2013, 118 billion litres of biofuels were produced annually – 90 billion litres produced from Americas – predominantly from sugarcane in Brazil and corn in USA (Table 55). Recent data from REN21 suggest that the production has increased to 133 billion litres by the end of 2015.

Table 55 Global production of biofuels

	World	Africa	Americas	Asia	Europe	Oceania
2000	18.0	0.00	16.9	0.14	0.95	0.00
2005	38.7	0.00	32.3	1.64	4.73	0.04
2010	105	0.01	83.0	5.39	16.7	0.35
2011	106	0.01	83.9	6.99	15.1	0.43
2012	108	0.01	82.3	8.38	16.4	0.40
2013	118	0.01	89.8	9.36	18.2	0.38
2014	127	-	-	-	-	-
2014	133	-	-	-	-	-

All values in billion litres. (Source: IEA and REN21)

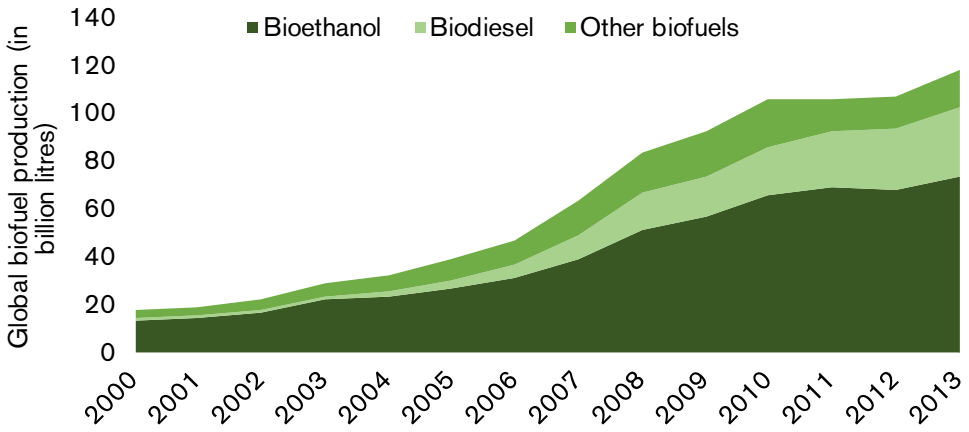

Figure 40 Global biofuel production

(Source: IEA)

Biofuels are classified predominantly into bioethanol, biodiesel and other biofuels or advanced biofuels. Other biofuels include Hydrogenated Vegetable Oil and cellulosic biofuels etc.

In energy terms, the production of biofuel accounted for 3.19 EJ ~ 5% of the global supply of biomass. The largest production was bioethanol (62%) followed by biodiesel (24%) and other biofuels.

Table 56 Global overview of biofuels production

	Biofuels production		Bioethanol		Biodiesel		Other biofuels	
	Volume (Bl)	Energy (EJ)	Volume (Bl)	Energy (EJ)	Volume (Bl)	Energy (EJ)	Volume (Bl)	Energy (EJ)
2000	18.0	0.45	13.2	0.31	0.84	0.03	3.94	0.12
2005	38.7	1.00	26.9	0.63	3.67	0.13	8.14	0.24
2010	105	2.82	65.4	1.53	20.2	0.71	19.8	0.58
2011	106	2.85	69.2	1.62	23.3	0.82	13.8	0.41
2012	108	2.90	68.4	1.60	25.3	0.89	13.8	0.41
2013	118	3.19	73.5	1.72	28.9	1.02	15.4	0.45

(Source: IEA)

USA and Brazil are the leading producers of biofuels. Americas dominate the production of biofuels. 87% of all bioethanol produced globally was produced in Americas. Europe produces the most biodiesel along with Americas. Other biofuels – predominantly cellulosic biofuels and HVO are produced in Americas.

Table 57 Continental overview of biofuels production – in 2013

	Biofuels production		Bioethanol		Biodiesel		Other biofuels	
	Volume (Bl)	Energy (EJ)	Volume (Bl)	Energy (EJ)	Volume (Bl)	Energy (EJ)	Volume (Bl)	Energy (EJ)
Africa	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Americas	89.8	2.32	64.0	1.50	11.0	0.39	14.8	0.43
Asia	9.36	0.28	4.07	0.10	5.22	0.18	0.07	0.00
Europe	18.2	0.58	5.11	0.12	12.5	0.44	0.60	0.02
Oceania	0.38	0.01	0.29	0.01	0.09	0.00	0.00	0.00
World	118	3.19	73.5	1.72	28.9	1.02	15.4	0.45

(Source: IEA)

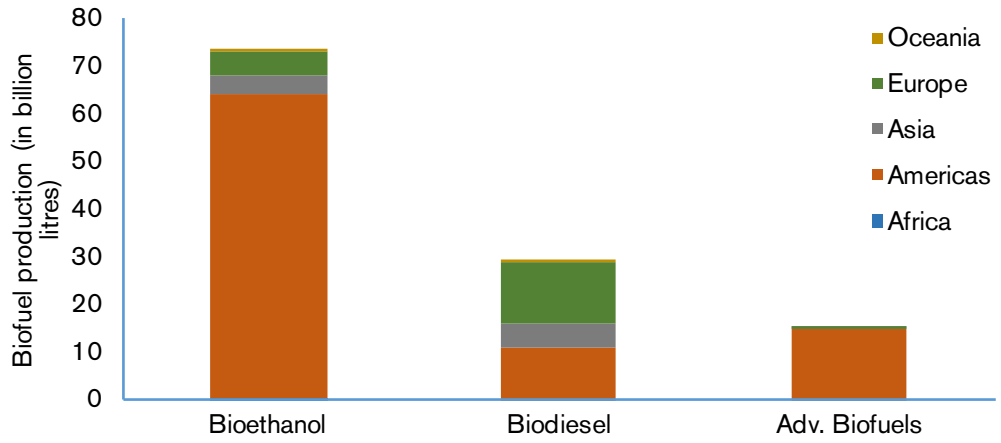

Figure 41 Biofuel production in continents – 2013.

(Source: IEA)

5.2. BIOETHANOL

Bioethanol is predominantly produced from sugarcane, corn, wheat etc. via fermentation. The global production of bioethanol increased from 13.2 billion litres in 2000 to 73.5 billion litres in 2013. In 2000, Americas share of bioethanol production was 98% and this has reduced to 87% while Asia and Europe had a share of 5% and 7% respectively.

Table 58 Bioethanol production – World

	World	Africa	Americas	Asia	Europe	Oceania
2000	13.2	0.00	13.0	0.14	0.12	0.00
2005	26.9	0.00	24.3	1.56	0.94	0.04
2010	65.4	0.01	58.5	2.82	3.85	0.28
2011	69.2	0.01	62.0	3.43	3.44	0.32
2012	68.4	0.01	60.4	3.71	4.00	0.31
2013	73.5	0.01	64.0	4.07	5.11	0.29

All values in billion litres. (Source: IEA)

Recent data for 2015 shows the global ethanol production was 98.3 billion litres. 57% of the bioethanol production globally occurs in USA and 29% in Brazil. The top 5 countries – USA, Brazil, China, Canada and Thailand along with EU – 28 produced 96% of global bioethanol.

Table 59 Bioethanol production – Top 10 countries 2015

	Countries	Volume (Bl)	Energy (EJ)
1	**USA**	56.1	1.31
2	**Brazil**	28.2	0.66
3	**China**	2.8	0.06
4	**Canada**	1.7	0.04
5	**Thailand**	1.2	0.03
6	**Germany**	0.9	0.02
7	**France**	0.9	0.02
8	**Argentina**	0.8	0.02
9	**India**	0.7	0.02
10	**Belgium**	0.6	0.01
Total (Top 10)		93.9	2.19
EU – 28		4.1	0.09
World		98.3	2.30

(Source: REN21)

5.3. BIODIESEL

Biodiesel is a fuel produced from vegetable oils via extraction and esterification. In 2013, 28.9 billion litres were produced globally. 43% of the global production occurs in Europe and 38% in Americas.

Table 59 Biodiesel production – World

	World	Africa	Americas	Asia	Europe	Oceania
2000	0.84	0.00	0.02	0.00	0.81	0.00
2005	3.67	0.00	0.36	0.07	3.23	0.00
2010	20.2	0.00	6.16	2.57	11.4	0.07
2011	23.3	0.00	8.76	3.47	11.0	0.10
2012	25.3	0.00	8.84	4.61	11.8	0.09
2013	28.9	0.00	11.0	5.22	12.5	0.09

All values in billion litres. (Source: IEA)

USA and Brazil again top the list of countries producing the most biodiesel. The top 5 countries (excluding EU - 28) include USA, Brazil, Argentina, Indonesia and Thailand along with EU – 28 produce 85% of all biodiesel.

Table 61 Biodiesel production – Top 5 countries 2015

	Countries	Volume (Bl)	Energy (EJ)
1	USA	4.8	0.17
2	Brazil	4.1	0.14
3	Germany	2.8	0.10
4	France	2.4	0.08
5	Argentina	2.1	0.07
6	Indonesia	1.7	0.06
7	The Netherlands	1.5	0.05
8	Thailand	1.2	0.04
9	Singapore	1.0	0.04
10	Malaysia	0.7	0.02
	Total (Top 10)	22.3	0.79
	EU - 28	11.5	0.40
	World	30.1	1.06

(Source: REN21)

5.4. OTHER BIOFUELS

Other biofuels or advanced biofuels are those biofuels not classified as bioethanol or biodiesel. The definitions broadly cover cellulosic ethanol, hydrogenated vegetable oil etc. In 2013, 15.4 billion litres of other biofuels were produced – 96% of the production was in Americas led by USA and Brazil.

Table 62 Other biofuels production – World

	World	Africa	Americas	Asia	Europe	Oceania
2000	3.94	0.00	3.92	0.00	0.02	0.00
2005	8.14	0.00	7.57	0.00	0.56	0.00
2010	19.8	0.00	18.4	0.00	1.45	0.00
2011	13.8	0.00	13.1	0.09	0.62	0.00
2012	13.8	0.00	13.1	0.06	0.68	0.00
2013	15.4	0.00	14.8	0.07	0.60	0.00

All values in billion litres. (Source: IEA)

5.5. LAND USE AND PROTEIN PRODUCTION

WBA estimated the production of biofuels from various feedstock (Table 63)

Table 63 Global production of biofuels from various feedstock in 2013

Biofuel	Crop	Production
Bioethanol	Wheat	1.99
	Corn	75.8
	Sugar beet	1.31
	Sugarcane	22.8
Biodiesel	Vegetable oils	22.7
	Palm oil	13.4

All values in billion litres. (Source: WBA and FAO OECD)

One of the major by-products from the biofuel production is protein. This often neglected part is a major feedstock for food and feed. In 2013, 112 million tonnes of biofuel were produced. Simultaneously, 70.8 million tonnes of protein in the form of DDGS (Distiller's Dried Grains with Soluble) during bioethanol production and oil cake during biodiesel production (Table 64). DDGS is a nutrient rich co-product of ethanol production and can be used as feed ingredient as an energy and protein supplement. Oil cake is the remaining solids collected after pressing the liquids out of oil seeds.

In all production of biofuels, 71.1 million ha of land was used which produced both biofuel, biodiesel and protein.

Table 64 Land required, protein and biofuel production in 2013

	Land (Mha)	Protein (Mt)	Biofuel (Mt)
Wheat	2.09	1.98	1.57
Corn	38.7	47.1	59.9
Sugar beet	0.26	0.00	1.03
Sugarcane	5.00	0.00	18.0
Vegetable oils	24.2	21.7	20.0
Palm oil	0.85	0.00	11.8
Total	71.1	70.8	112

(Source: WBA and FAO OECD)

Table 65 Overview of biofuel and protein production in 2013

Biofuel production		Protein production	
Bioethanol	80.5	DDGS	49.1
Biodiesel	31.8	Oil cake	21.7
Total	112	Total	70.8

All values in million tonnes. (Source: WBA and FAO OECD)

Out of 71.1 million ha of land used for biofuel production, 66% was used for biofuels while 34% was used for protein production (Figure 42).

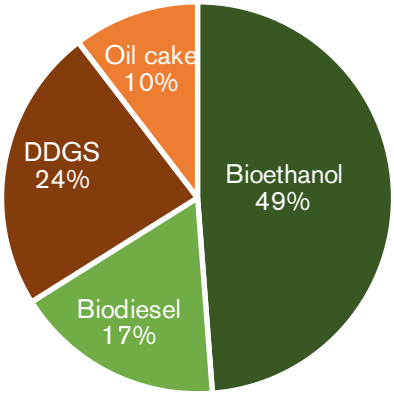

Figure 42 Global biofuel and protein production from energy crops in 2013.

(Source: WBA and FAO OECD)

6. SPECIAL SECTORS

- *In 2013, biogas production increased to 59 billion m³ - an increase of 5.5% over previous year*
- *EU – 28 biogas production was 26.2 billion m³ – almost 45% of global biogas production*
- *Pellet production increased to 26.4 million tonnes in 2014 – European production was 61%*
- *Europe consumed 78% of all pellets produced in 2014*
- *In 2014, 52 million tonnes of charcoal was produced – twice the amount of pellets*

6.1. BIOGAS

Biogas is produced by anaerobic digestion of different organic matter and is mainly composed of methane and carbon dioxide. Typical feedstock includes manure and sewage, agricultural residues and organic fraction of household waste. The contribution of thermal conversion of organic matter to gas to global energy scenario is negligible.

Global biogas production increased by 3.5 times during 2000 – 2013 from 0.28 EJ to 1.28 EJ (Table 66). The increase in production was the highest in Asia (Figure 43). Using an average conversion factor, the current production by volume is at 59 billion m³.

Table 66 Biogas production

	World (EJ)	World (Billion m³)	Africa	Americas	Asia	Europe	Oceania
2000	0.28	13.2	0.00	0.13	0.05	0.10	0.01
2005	0.50	23.1	0.00	0.17	0.15	0.17	0.01
2010	0.94	43.4	0.00	0.24	0.33	0.36	0.02
2011	1.09	50.3	0.00	0.25	0.38	0.44	0.02
2012	1.21	55.9	0.00	0.28	0.39	1.20	0.02
2013	1.28	59.0	0.00	0.28	0.40	0.57	0.02

All values in EJ. (Source: IEA)

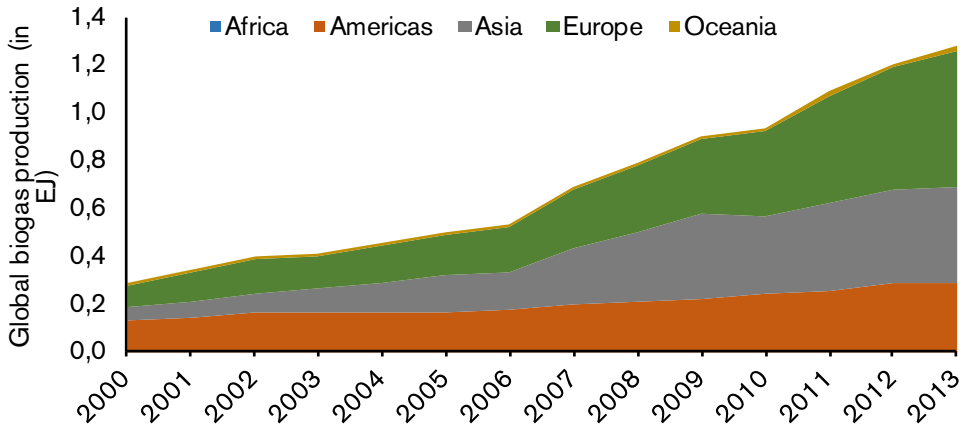

Figure 43 Global production of biogas.

(Source: IEA)

EU – 28 produced 26.2 billion m³, almost 45% of the global biogas production. Apart from EU – 28, China is the leader in biogas production with 15.2 billion m³.

Table 67 Biogas production in top 10 countries

	Country	EJ	billion m^3
1	China	0.33	15.2
2	Germany	0.29	13.3
3	USA	0.27	12.3
4	UK	0.08	3.54
5	Italy	0.08	3.52
6	Thailand	0.03	1.31
7	Czech Republic	0.02	1.11
8	France	0.02	0.85
9	India	0.02	0.77
10	Australia	0.01	0.65
	Total (Top 5)	0.65	30.3
	EU - 28	0.57	26.2
	World	1.28	59.0

(Source: IEA)

6.2. PELLETS

Production

Pellets is one of the fastest growing bioenergy sector. Current global production exceeds 26 million tonnes which saw an increase of 16% during 2013 – 14. (Table 68). The largest increase was in Asia where the production more than doubled within a year although the total share in global production was 5.3%. In terms of production, Europe and Americas (predominantly USA) had a production share of 60% and 34% respectively.

Table 68 Global production of pellets

	World	Africa	Americas	Asia	Europe	Oceania
2012	19.7	0.09	6.72	0.30	12.5	0.03
2013	22.7	0.10	7.62	0.62	14.4	0.03
2014	26.4	0.10	8.90	1.41	16.0	0.03

All values in million tonnes. (Source: FAO)

USA is the world's largest producer of wood pellets amounting to 6.9 million tonnes – more than a quarter of the total production.

Table 69 Pellet production - Top 10 countries in 2014

	Country	Volume (Million tonnes)	Energy (in EJ)
1	USA	6.90	0.12
2	Canada	1.90	0.03
3	Russia	0.89	0.02
4	Ukraine	0.71	0.01
5	Viet Nam	0.65	0.01
6	China	0.37	0.01
7	Belarus	0.30	0.01
8	Serbia	0.21	0.00
9	Malaysia	0.18	0.00
10	Switzerland	0.12	0.00
	Total (Top 10)	12.2	0.21
	EU - 28	**13.5**	**0.23**
1	Germany	2.08	0.04
2	Sweden	1.58	0.03

	Country	Volume (Million tonnes)	Energy (in EJ)
3	Latvia	1.28	0.02
4	France	1.20	0.02
5	Portugal	0.95	0.02
6	Austria	0.95	0.02
7	Romania	0.81	0.01
8	Estonia	0.77	0.01
9	Poland	0.62	0.01
10	Italy	0.45	0.01
	World	26.4	0.46

(Source: FAO)

Consumption

The consumption pattern is different than the production scenario. The production of pellets for Europe was 61% while the consumption share was 78% (Table 70). The increase in consumption is largely defined by imports from Americas. The large increase in consumption of pellets was led by Asia – predominantly with increasing demand in East and South East Asia.

Table 70 Global consumption of pellets

	World	Africa	Americas	Asia	Europe	Oceania
2012	18.8	0.01	3.57	0.42	14.7	0.03
2013	22.1	0.07	3.25	0.92	17.9	0.03
2014	26.0	0.08	3.49	2.23	20.1	0.03

All values in million tonnes. (Source: FAO)

Table 71 Pellet consumption - Top 10 countries in 2014

	Country	Volume (Million tonnes)	Energy (in EJ)
1	USA	3.11	0.05
2	Canada	0.57	0.01
3	Russia	0.29	0.01
4	Ukraine	0.21	0.00
5	Viet Nam	0.18	0.00
6	China	0.18	0.00
7	Belarus	0.18	0.00
8	Serbia	0.13	0.00
9	Malaysia	0.07	0.00
10	Switzerland	0.07	0.00
	Total (Top 10)	5.00	0.09
	EU - 28	**18.9**	**0.33**
1	Czech Republic	4.82	0.08
2	Latvia	3.23	0.06
3	Lithuania	2.17	0.04
4	Germany	1.94	0.03
5	Sweden	1.57	0.03
6	Portugal	1.51	0.03
7	Austria	0.96	0.02
8	Estonia	0.77	0.01
9	Romania	0.65	0.01
10	Poland	0.64	0.01
	World	26.0	0.45

(Source: FAO)

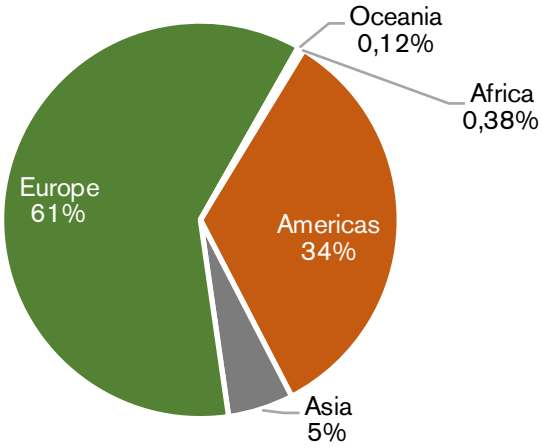

Figure 44 Production of pellets in 2014.

(Source: FAO)

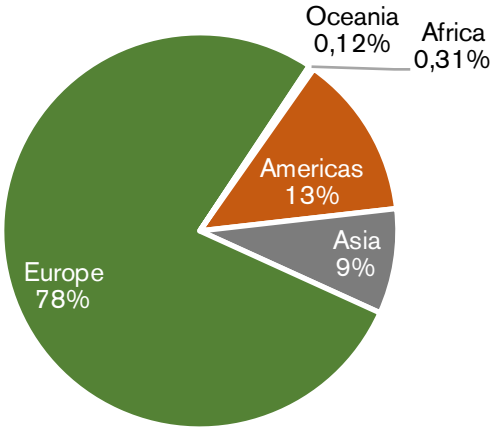

Figure 45 Consumption of pellets in 2014.

(Source: FAO)

6.3. CHARCOAL

Charcoal is a highly underestimated sector. In terms of volume, charcoal production is twice as big as pellets. Moreover, due to low efficiencies of conversion of wood to charcoal and lower energy content of the fuel, the amount of wood used for charcoal production is 4 – 5 times the amount of wood to make pellets. More than 50 million tonnes of charcoal produced annually – mostly in Africa (Table 72, Figure 46).

Table 72 Global production of charcoal

	World	Africa	Americas	Asia	Europe	Oceania
2000	37.0	20.4	9.67	6.54	0.30	0.04
2005	43.9	24.5	10.93	7.96	0.51	0.03
2010	46.8	28.8	9.11	8.34	0.53	0.04
2011	47.7	29.0	9.66	8.55	0.51	0.04
2012	50.1	30.5	10.4	8.78	0.44	0.04
2013	51.8	31.8	10.7	8.80	0.46	0.04

All values in million tonnes. (Source: FAO)

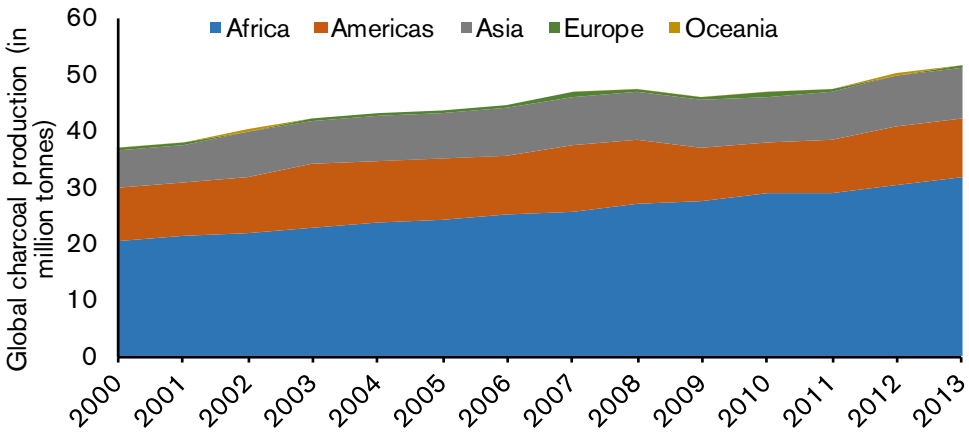

Figure 46 Global production of charcoal.

(Source: FAO)

Table 73 Charcoal production - Top 10 countries in 2013

	Country	Volume (Million tonnes)	Energy (in EJ)
1	Brazil	7.24	0.22
2	Nigeria	4.28	0.13
3	Ethiopia	4.12	0.12
4	India	2.88	0.09
5	DRC	2.32	0.07
6	Ghana	1.83	0.05
7	Tanzania	1.76	0.05
8	China	1.67	0.05
9	Madagascar	1.56	0.05
10	Thailand	1.43	0.04
	Total (Top 10)	29.1	0.87
	EU - 28	0.26	0.01
	World	51.8	1.55

(Source: FAO)

7. RENEWABLE JOBS

- *8.1 million jobs were generated in 2015*
- *Bioenergy sector employed 3.7 million people – 35% of the renewable energy jobs*
- *The sugarcane industry in Brazil is the largest renewable energy employer*

8.1 million people were employed in the renewable energy sector in 2015. Solar energy sector including solar PV, CSP and heating and cooling employed the largest number of people in the renewable energy sector employing 3.7 million people (45%). Bioenergy employed 35% among the renewable energy sector – most of them in the biofuel sector in Americas i.e. sugarcane sector in Brazil.

The following data does not include the traditional biomass sector and hence, the final figure may be a lot higher.

Table 74 Global employment figures in renewable energy in 2015

		World	Americas	Asia	Europe
Bioenergy	**Total**	2 882	1 250	711	482
	Solid Biomass	822	152	299	311
	Biofuels	1 678	1 098	109	105
	Biogas	382	0	303	66
Solar		3 733	423	3 078	193
Wind		1 081	129	560	331
Small Hydro		204	20	117	47
Geothermal		160	35	2	103
Total		8 079	1 687	4 468	1 169

In 1000's. (Source: IRENA)

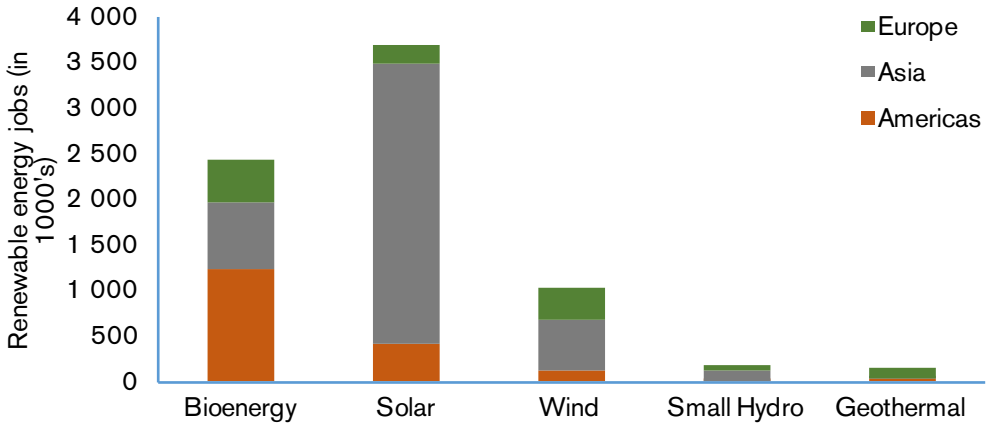

Figure 47 Jobs in renewable energy.

(Source: IRENA)

8. BIOENERGY PLANTS

This section provides an overview of the recent plants constructed for production of pyrolysis oil, torrefied biomass and advanced biofuels.

8.1. PYROLYSIS OIL

Pyrolysis oil is a syntehtic fuel produced from woody biomass or other biomass using the principle of fast pyrolysis. It is an alternative green fuel for use in heating and/or transportation sector.

Table 75 Commercial pyrolysis plants

Plant	Location	Production capacity (per year)	Feedstock	Operational since
Ensyn	Ontario as well as plants in USA	37 million gallons in 160,000 hours operation.	wood residues	2006
Battelle	Ohio	60 gallons/ton of feedstock in 1200 hours operation	Pine chips, shavings and sawdust	2011
Empyro	Hengelo, The Netherlands	20 million litres	Residual wood	2014
Cool Planet	Colorado	10 Million gallons	wood chips, agricultural waste products or other nonfood organic matter	To start in 2016
Green Fuel Nordic Oy	Iisalmi, Finland	82 million litres	Dry wood	To be commissioned
Fortum Joensuu	Joensuu, Finland	50000 tonnes	Forest residues, sawdust etc.	2013

(Source: WBA)

8.2. TORREFIED BIOMASS

Torrefaction is the thermal treatment of biomass including woody and agricultural feedsock. The biomass decomposes to a solid dry material referred to as torrefied biomass.

Table 76 Commercial torrefied biomass plants

Developer	Location	Capacity (tpa)	Remarks	
Stramproy Green	Steenwijk, the Netherlands	90 000	Declared bankrupt	-
Renogen/4Energy-Invest	Amel, Belgium	42 000		https://www.4energyinvest.com/home.aspx
Topell Energy	Duiven, the Netherlands	60 000	Filed for bankruptcy	http://www.topellenergy.com/
Solvay Biomass Energy/New Biomass Energy	Quitman, USA	80 000	Expansion to 250 000 tpa	http://newbiomass.com/
Thermya	Urnieta, Spain	20 000	Company bought by Areva	http://thermya.com/
	Mazingarbe, France	20 000		
Integro Earth Fuels	Greenville, USA	11 000		http://www.integrofuels.com/
River Basin Energy	Wyoming, USA	48 000	Pilot stage	riverbasinenergy.com

Developer	Location	Capacity (tpa)	Remarks	
Torr Coal	Dilsen Stokkem, Belgium	35 000		http://www.torrcoal.com/
BioEndev	Holmsund, Sweden	16 000	To be completed in 2015	www.bioendev.se
Bio Energy Development North AB/ Metso	Övik, Sweden	30 000		

(Source: WBA)

8.3. ADVANCED BIOFUELS

Advanced biofuels are fuels produced from a wide range of biomass feedstock using various technological processes. These include lignocellulosic ethanol, metanol, di methyl ether, bio syngas, synthetic diesel, hydrogenated vegetable oil etc.

Table 77 Commercial advanced biofuel plants

Company	Location	Start of production	Product, Capacity (million litres, MW)	Capital costs ($ million)	Feedstock (1000 tons/yr)	Feedstock
POET DSM	Emmetsburg, Iowa, US	Sep – 14	Ethanol, 95	275	285	Corn cobs, leaves, husk and stalk
Abengoa (non opereational)	Hugoton, Kansas, USA	Oct – 14	Ethanol, 95	500	365	Corn stover, wheat straw, milo stubble, switch grass
Göteborg Energi	Gothenburg, Sweden	Dec – 14	Biomethane, 20 MW	170	50	Wood pellets
GranBio	Sao Miguel dos Campos, Brazil	Sep – 14	Ethanol, 82	265	400	Sugarcane straw and bagasse
DuPont	Nevada, Iowa, USA	Dec – 14	Ethanol, 113	225	700	Corn stover
Enerkem	Edmonton, Canada	June – 14	Methanol, 38	75	100	Municipal waste
UPM	Lappeenranta, Finland	Dec – 14	Biodiesel, 120	210	Not disclosed	Tall oil

(Source: WBA)

9. COUNTRY STATISTICS

Five countries are selected to analyse the situation of bioenergy in each of the countries. These countries include Turkey, Sudan, Malaysia, Sweden and Canada. The data available below is for base year of 2013 unless otherwise specified.

General energy data

Table 78 Country statistics - general country data

	Turkey	Sudan	Malaysia	Sweden	Canada
TPES (TJ)	4 876 994	604 323	3 725 415	2 062 627	10 600 894
Emissions per capita (Mt CO_2/capita)	3.75	0.36	6.97	3.91	15.3
Energy per capita (GJ/capita)	64.4	15.9	125	215	302
Renewables share (%)	12%	68%	5%	36%	19%

(Source: IEA)

Electricity and heat generation

Table 79 Country statistics - electricity and heat generation

	Turkey	Sudan	Malaysia	Sweden	Canada
Renewable electricity	29%	81%	9%	55%	63%
Renewable derived heat	2.7%	0.0%	0.0%	74.4%	8.0%
Renewables direct heat	8.3%	80.7%	8.3%	20.8%	5.5%

(Source: IEA)

Bioenergy contribution

Table 80 Country statistics - bioenergy contribution

	Turkey	Sudan	Malaysia	Sweden	Canada
Bioenergy supply (TJ)	205 028	380 371	154 325	482 696	551 946
Share in energy supply (%)	4.20%	62.9%	4.14%	23.4%	5.21%

(Source: IEA)

Biomass supply – Forestry

Table 81 Country statistics - forestry

	Turkey	Sudan	Malaysia	Sweden	Canada
Forest Area_2013 (1000 ha)	10.2	21.8	21.6	28.2	348
% share of land area	13.2%	11.6%	65.7%	69.1%	38.2%
% change forestry area (2000 – 2013)	13.0%	-10.4%	2.7%	-0.3%	-0.2%
Woodfuel_2014 (million tonnes)	4.30	14.6	2.62	5.90	4.32
% change woodfuel (2000 – 2014)	-22.0%	-12.6%	-21.7%	0.0%	47.8%
Forest residue potential_low (TJ)	7 770	3 853	19 085	222 464	294 033
Low Residues potential (%TPES)	0.16%	0.64%	0.51%	10.8%	2.77%
Forest residue potential_high (TJ)	27 913	12 813	46 827	290 260	479 243
High residue potential %TPES	0.57%	2.12%	1.26%	14.1%	4.52%

(Source: FAO and WBA)

Biomass supply – agriculture

Table 82 Country statistics - agriculture

	Turkey	Sudan	Malaysia	Sweden	Canada
Area_2013 (1000 ha)	38 423	108 815	7 839	3 048	65 251
% share of land area	49.9%	57.7%	23.9%	7.5%	7.2%
% change in agriculture area (2000 – 2013)	-5.08%	5.60%	11.6%	-3.33%	-3.49%
Agriculture residue potential_low (TJ)	366 928	82 056	451 753	29 034	234 477
Low potential (%TPES)	7.52%	13.6%	12.1%	1.41%	2.21%
Agriculture residue potential_high (TJ)	977 878	361 677	2 348 987	1 075	1 305 504
High potential (%TPES)	20.1%	59.8%	63.1%	0.1%	12.3%

(Source: FAO and WBA)

Biomass supply – waste

Table 83 Country statistics - waste

	Turkey	Sudan	Malaysia	Sweden	Canada
MSW production (TJ)	0	0	260	57 233	5 384

(Source: IEA)

Bioelectricity generation

Table 84 Country statistics - bioelectricity

	Turkey	Sudan	Malaysia	Sweden	Canada
Bioelectricity production_2013 (TWh)	0.98	0.00	1.15	12.7	5.45
Share of total electricity (%)	0.41%	0.00%	0.83%	8.32%	0.84%
% change in bioelectricity generation (2000 – 2013)	346%	-	-	193%	-34%
Energy per capita	47.7	29.0	9.66	8.55	0.51
(GJ/capita)	64.4	15.9	125	215	302
Renewables share (%)	12%	68%	5%	36%	19%

(Source: IEA)

Heat generation

Table 85 Country statistics - bioheat generation

		Turkey	Sudan	Malaysia	Sweden	Canada
Derived heat	**Bioheat production_2013 (TJ)**	1 499	0	0	141 508	2 159
	Share of total derived heat (%)	2.7%	0.0%	0.0%	74.4%	8.0%
	% change in bioheat (2000 – 2013)	-	0.0%	0.0%	56.3%	7.2%
Direct heat	**Direct heat from biomass_2013 (TJ)**	270 258	380 371	129 916	222 863	420 062
	Share of total direct heat (%)	8.20%	80.66%	7.79%	18.31%	4.66%
	% change in direct heat (2000 – 2013)	51.3%	-16.4%	11.5%	0.7%	4.9%

(Source: IEA)

Biofuel production

Table 86 Country statistics - biofuels

	Turkey	Sudan	Malaysia	Sweden	Canada
Biofuel production (in million litres)	0	0	654	662	1 744

(Source: IEA)

Special sectors – biogas, pellets and charcoal

Table 87 Country statistics - special sectors

	Turkey	Sudan	Malaysia	Sweden	Canada
Biogas production (million m3)	394	0	15	281	459
Pellet production (million tonnes)	0	0	0.18	1.58	1.9
Charcoal production (million tonnes)	0	0.59	0.03	0.00	0.00

(Source: IEA and FAO)

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 production. It includes wood harvested from main stems, branches and other parts of trees (where these are

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

GENERAL DATA

Table 88 General data on population, GDP and emissions

	Population in 2012 (millions)	GDP (billion USD)	CO2 emissions ($MtCO_2$)
World	7 037	54 588	31 734
Africa	1 083	1 331	1 032
Americas	951	19 086	7 269
Asia	3 938	14 915	14 141
Europe	824	16 776	6 146
Oceania	27.6	1 051	418
China	1 351	4 522	8 206
USA	314	14 232	5 074
India	1 237	1 389	1 954
Russia	144	981	1 659
Japan	128	4 694	1 223
Brazil	199	1 137	440
South Korea	50.0	1 078	593
Canada	34.9	1 293	534
Nigeria	314	14 322	5 074
Indonesia	247	427	435
Ethiopia	91.7	24.7	7.93
Pakistan	179	138	137
Thailand	66.8	224	257
Ethiopia	94.1	24.7	7.93
EU 28	507	14 614	3 505

(Source: World Bank)

Useful conversions

Table 89 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 90 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	kg/l
Biogas			21.6	MJ/Nm3
Pellets	600	kg/m3	17.3	MJ/kg
Charcoal			30.0	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

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ENERSTENA GROUP

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AGRANA

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Raiffeisen-Landesbank Steiermark

energie autonomie Vorarlberg

fortum