IEA Bioenergy Task 40: Country Report Germany 2014

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1 General Introduction

1.1 Germany: A Brief Profile

Germany is located in the centre of Europe, sharing approx. 3,600 km of borders with 8 EU Member States[1] plus Switzerland. At the end of 2013, Germany had a population of 80.8 million living in 40 million households, and generated a GDP of approx. 2.9 billion $€_{2014}$. (DESTATIS 2015). Germany covers a land area of 35.7 million hectares (Mha). A share of approximately 32% (11.4 Mha) of the land is covered by forests. Agricultural land covers 16.8 Mha (47%), of which approx. 12 Mha are arable land, and about 5 Mha pasture and grassland (FNR 2014a).

1.2 The German Energy System

1.2.1 Primary Energy Supply and Targets

In 2013, Germany used 13.8 EJ of primary energy – of that, 4.6 EJ came from oil, 3.2 EJ from natural gas, 1.8 EJ from coal, 1.6 EJ from lignite, and 1.1 EJ from nuclear (primary energy equivalent). All renewables contributed 1.5 EJ, i.e. 10.4% of all primary energy (BMWi 2014).

Preliminary data for 2014 indicate a reduced primary energy consumption of 13.1 EJ, with again 4.6 EJ from oil, 2.7 EJ from natural gas, 1.6 EJ from coal, 1.6 EJ from lignite, 1.1 EJ from nuclear. All renewables contributed 1.5 EJ, representing 11.1% of all primary energy used in Germany (AGEB 2014a).

The development of the German primary energy since 1990 is shown in the following figure which also indicates the official 20% reduction target by 2020 (compared to 1990).

Germany has also a target of reducing the primary energy demand by 80% until 2050, compared to the 2008 level (BMWI 2014).

[1] AT, BE, CZ, DK, FR, LU, NL, PL

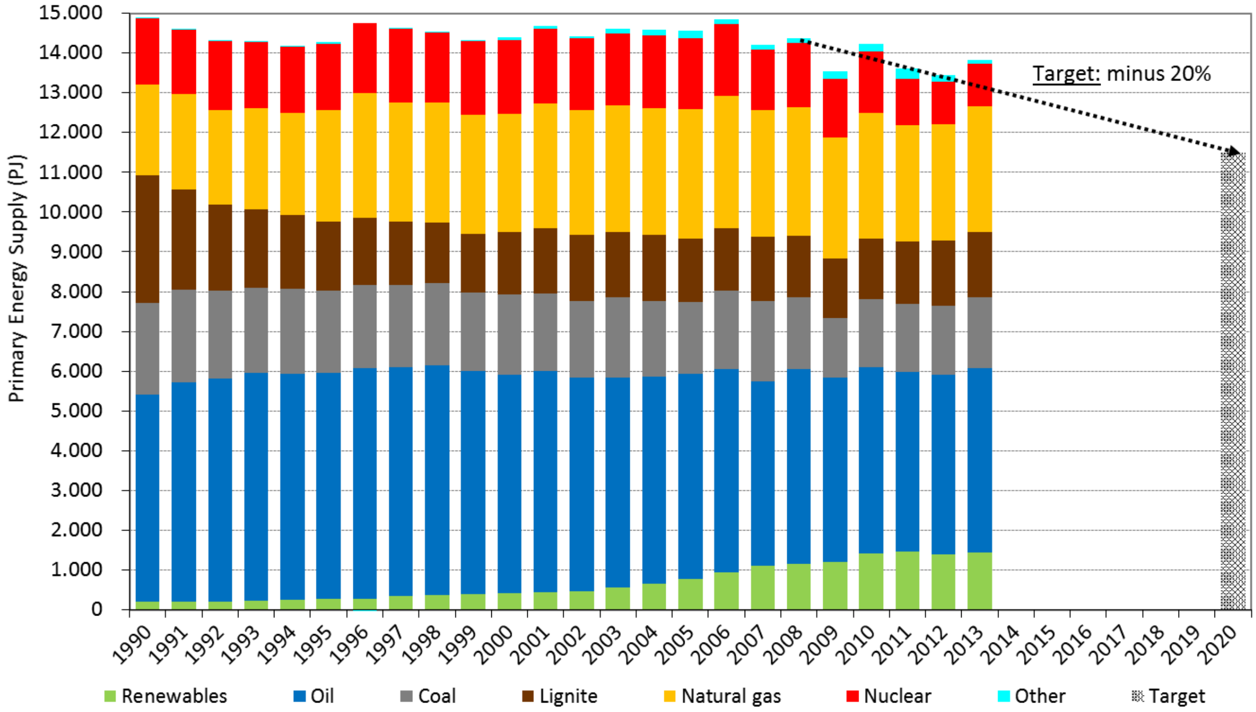

Figure 1-1: Primary Energy Supply by Source in Germany 1990-2013, and Target for 2020 (BMWi 2014)

1.2.2 Final Energy by Sector, and Targets in Germany

The final energy demand in Germany is rather stable since 1990 at about 9 EJ (see following figure), with about equal shares of 28% for the industry, residential and transport sectors, and 15% for the commercial sector.

The share of industry decreased from 31% in 1990 to 28% in 2013, while the residential and transport sectors increased from 25% in 1990 to 28% in 2013, and the commercial sector decreased from 18% in 1990 to 15% in 2013.

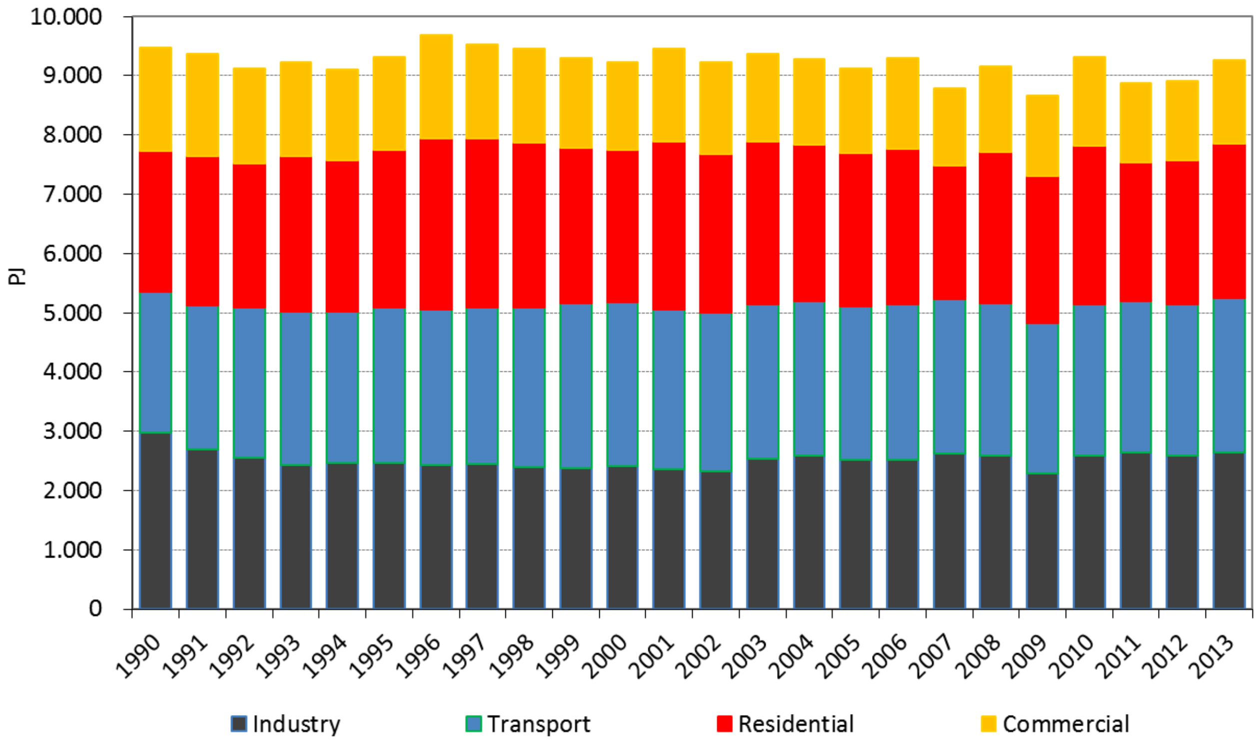

Figure 1-2: Fina Energy Demand by Sector in Germany 1990-2013 (BMWi 2014)

The official target of Germany is to increase the share of renewables in the final energy consumption to 18% by 2020 (BMWi 2014) – in 2013, this share was 12% (see following figure).

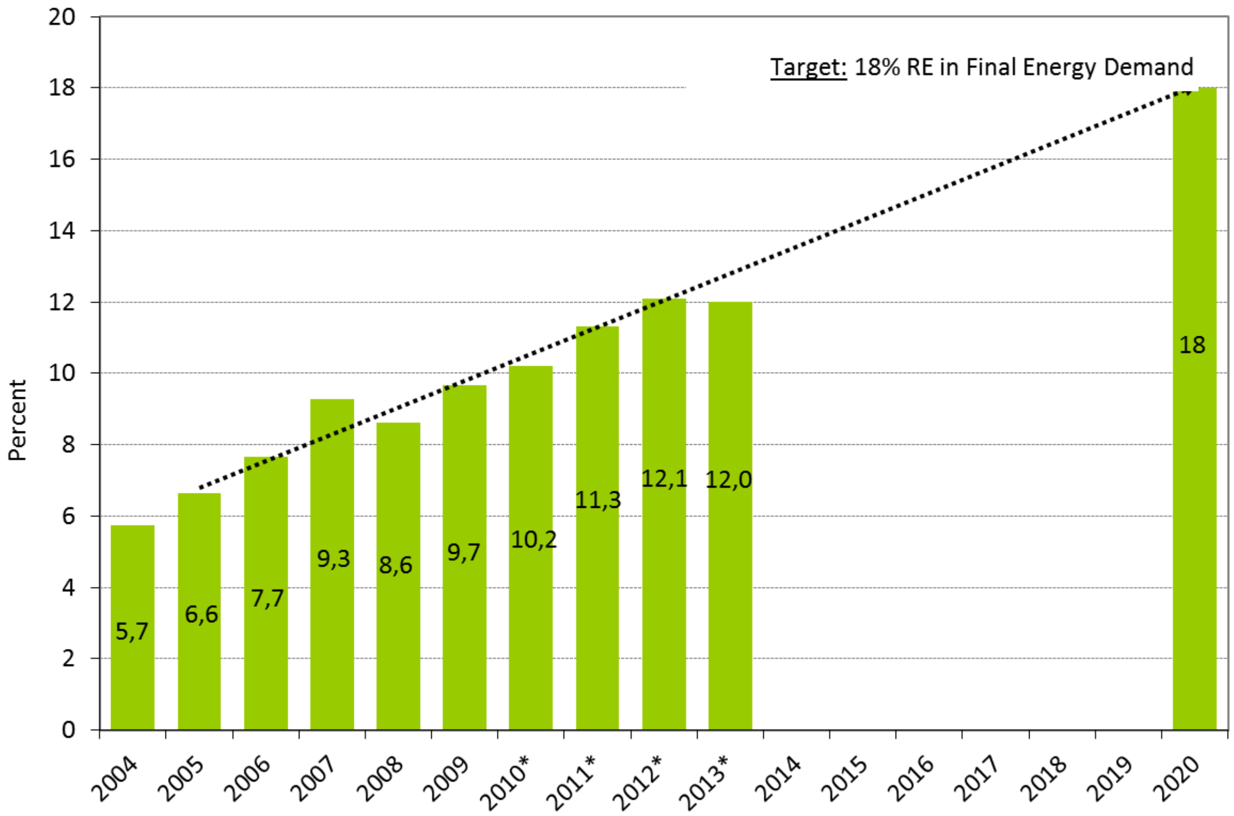

Figure 1-3: Renewable Shares in Final Energy Demand in Germany 2004-2013, and Target for 2020 (BMWi 2014)

1.2.3 GHG Reduction Targets

Germany has a domestic GHG reduction target of 40-50% by 2020 and 80-95% by 2050, both compared to the 1990 level. These targets were part of the Integrated Energy and Clmate Programme of the German Government which was agreed upon in 2007, and have been confirmed in the Coalition Treaty for the current Federal Government.

In addition, the EU burden-sharing agreement to the Kyoto Protocol requires Germany to reduce its GHG emissions during the average of 2008-2012 by 21%, which was more than achieved (see following figure).

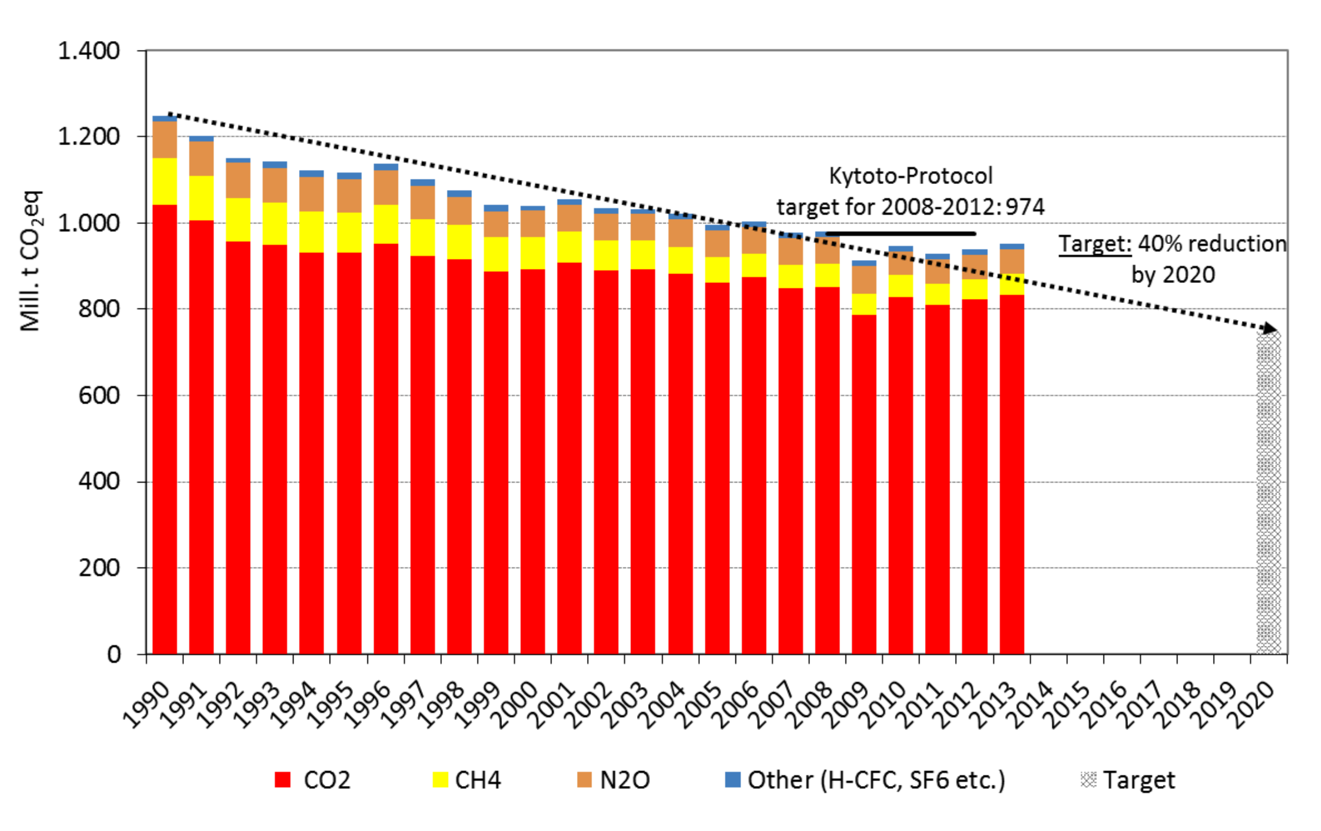

Figure 1-4: GHG Emissions in Germany 1990-2013, and Target for 2020 (BMWi 2014)

Preliminary data for 2014 indicate a **CO_2 reduction** of about 5% compared to 2013, mainly due to a mild winter[2], and half of the reduction from recuded coal use and increasing renewables in electricity generation (AGEB 2014b).

To ensure that Germany achieves its 2020 GHG reduction target, the Federal Government agreed on December 3, 2014 on the „Climate Action Programme 2020", as current projections indicate that the existing measures for GHG mitigation can achieve only a 33-34% GHG reduction by 2020 so that additional measures are needed.

[2] The climate-corrected value – i.e. normalized to standard heating-degree days - for the CO_2 reduction is about 1%.

The programme consists of several elements, especially concerning increased energy efficiency measures, a strategy for climate-friendly buidlings, GHG reductions in transport, increased renewables in electricity, among others (BMUB 2014).

The sources of GHG emissions in Germany are given in the following figure.

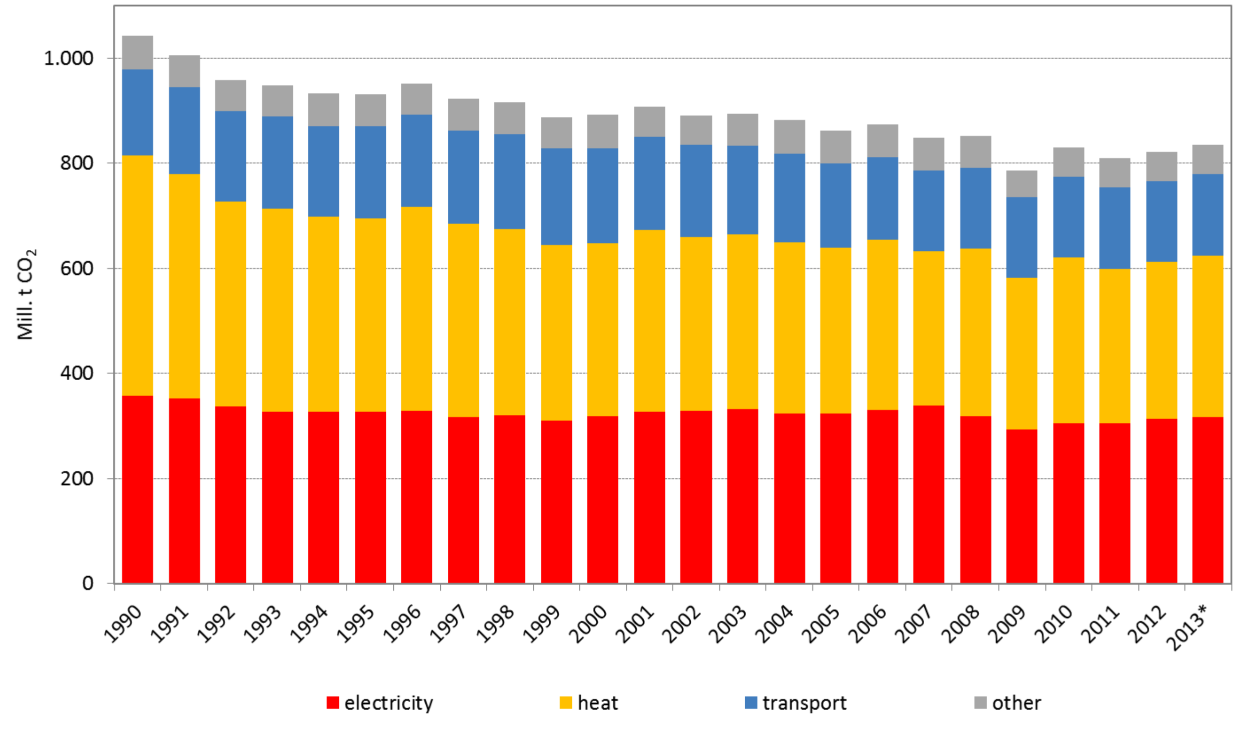

Figure 1-5: Sources of CO_2 Emissions in Germany 1990-2013 (BMWi 2014)

The sector most relevant for the German GHG emissions is **electricity generation**, which accounts for 38% of all German CO_2 emissions in 2013, followed by heating (37%), transport (19%), and others (7%).

1.2.4 Electricity Demand and Supply

The German demand for electricity by sector at its target for 2020 is shown in the following figure.

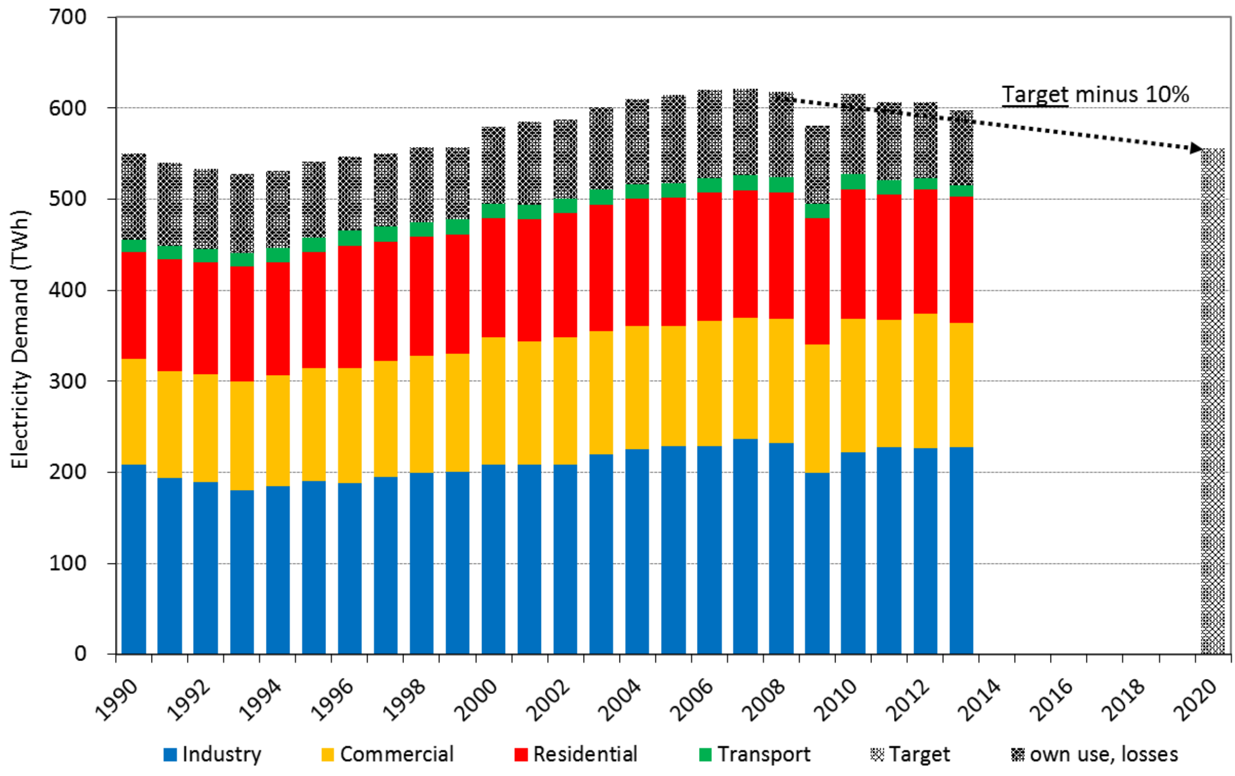

Figure 1-6: Electricity Demand by Sector in Germany 2000-2013 (BMWi 2014)

The German electricity demand is dominated by industry which has a rather stable share of 44%, followed by the commercial and residential sectors (27% each), and transport (2%). The German Federal Government has a target to reduce electricity demand by 10% until 2020 (BMWi 2014). Most recent figures for 2014 indicate a further reduction of about 4% compared to 2013 (AGEB 2014) so that it seems possible to achieve the target.

On the supply side, the German electricity system has been dominated by coal (hard coal and lignite) which had combined shares of 57% in 1990, falling to 45% in 2013. The share of nuclear fell from 28% (1990) to 15 (2013), while oil (1%) and gas (11%) play a minor role (data for 2013).

The renewable share rose significantly from 4% in 1990 to 24% in 2013, and preliminary data for 2014 indicate that the share increased to 26%, i.e. renewables are now the **dominant resources** for German electricity, followed by lignite (25.6%), coal (18%), nuclear (16%), and natural gas (10%).

It should be noted that Germany is a **net electricity exporter** – in 2014, the largest in the EU: about 74 TWh of electricity was exported, a plus of 1.5 TWh compared to 2013. The imports in 2014 were about 40 TWh (38 in 2013), i.e. the net export balance increased slightly to 34 TWh which represents nearly 6% of the overall electricity generation (Agora 2014).

The main electricity trading partner is Austria with its pumped storage facilities. Yet, in 2014 Austria imported 20 TWh more than it exported to Germany. Compared to that, the Netherlands imported about 18 TWh of electricity from Germany, with nearly no export. The third most relevant electricity trading partner of Germany is France which imported approx. 10 TWh from Germany while exporting only 4 TWh to Germany in 2014 (see following figure).

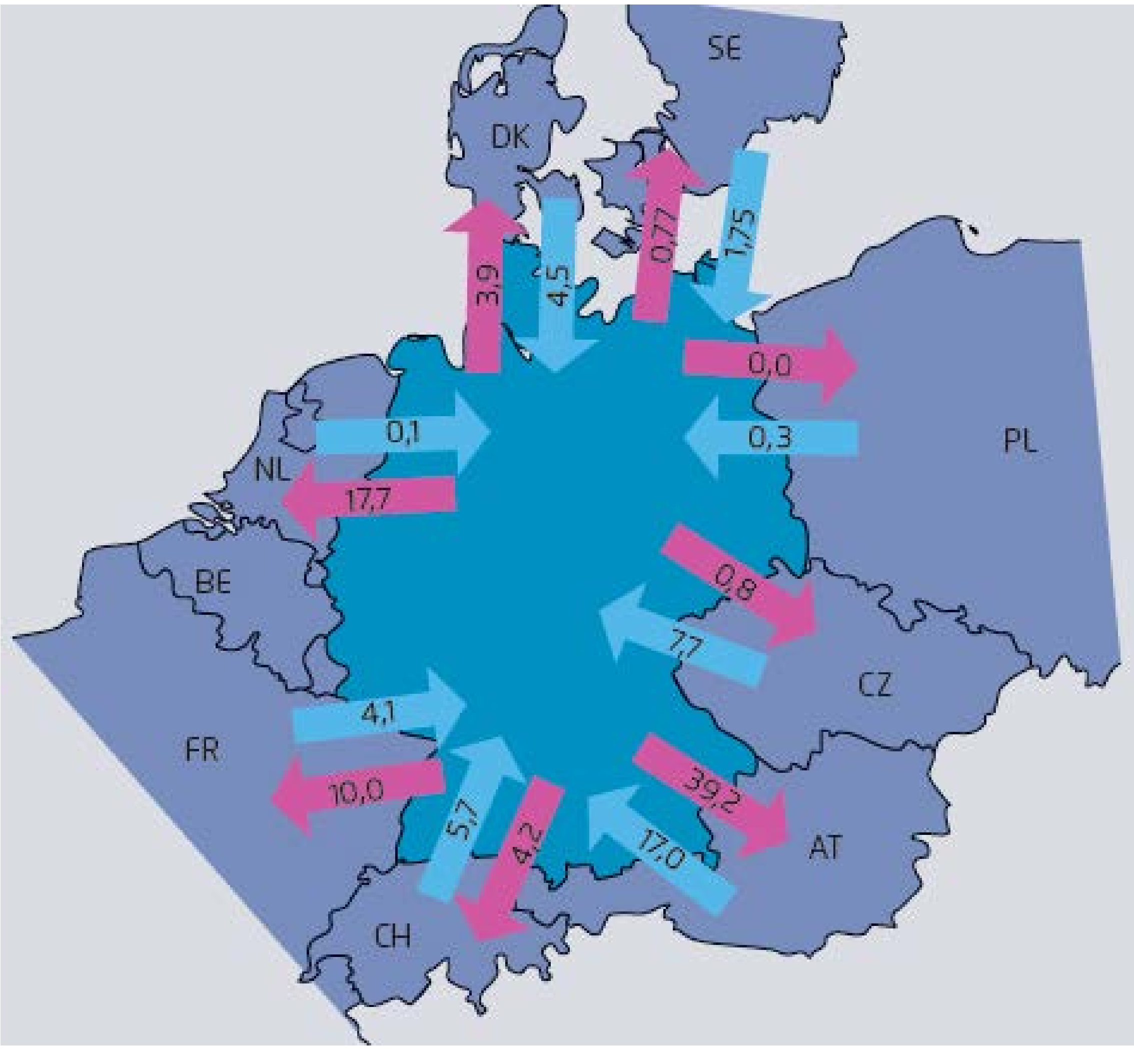

Figure 1-7: German Electricity Ex- and Imports to and from Neighboring Countries in 2014 (Agora 2015)

The overall German electricity generation mix over time is shown in the following figure.

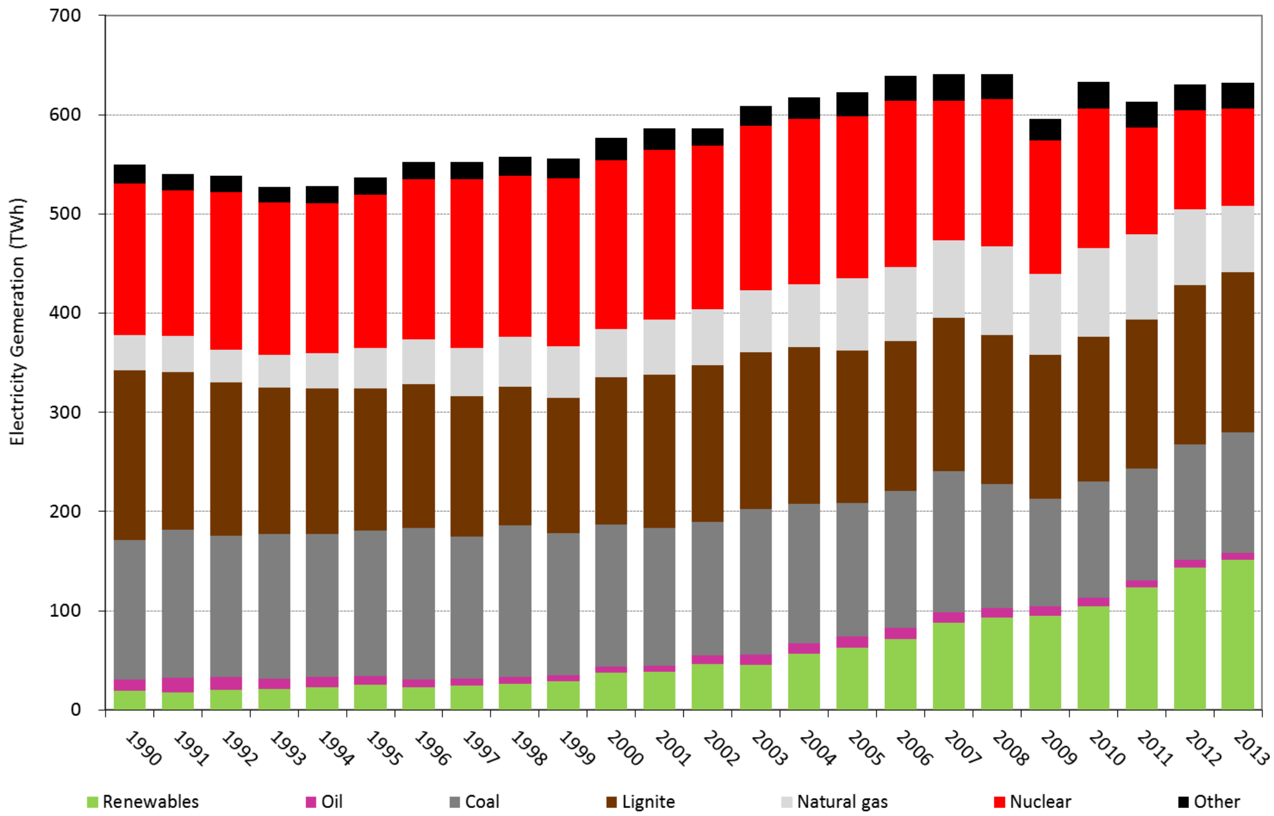

Figure 1-8: Electricity Generation by Source in Germany 1900-2013 (BMWi 2014)

The renewable generation consists mainly of wind, bioenergy, solar (PV) and hydro (see following figure). Since 2011, the contribution of solar-PV became larger than from hydro, wind electricity grew nearly 5-fold since 2000, while **bioelectricity increased 10-fold** in the same period.

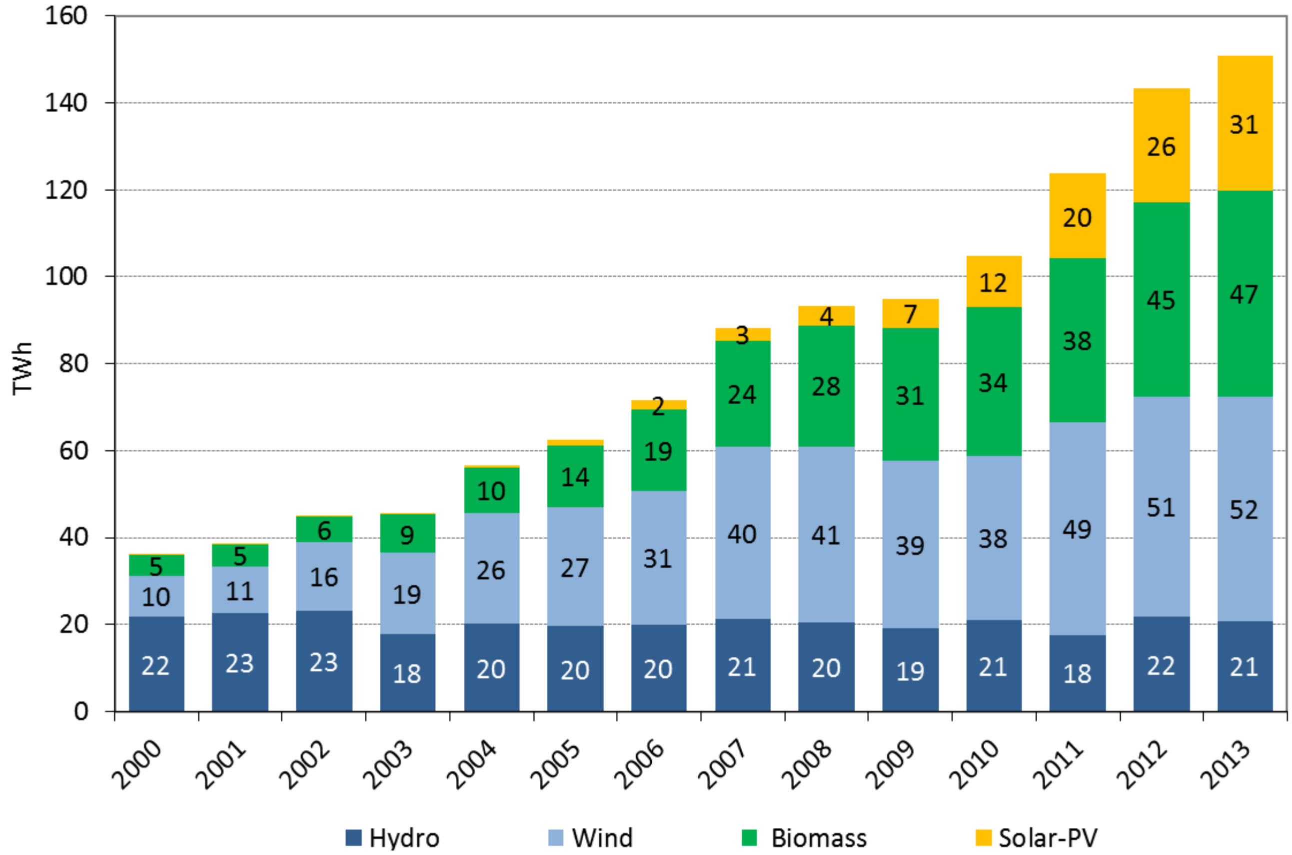

Figure 1-9: Renewable Electricity Generation by Source in Germany 2000-2013 (BMWi 2014)

Sections 2.1 through 2.3 present a more disaggregated view on the role of bioenergy for electricity production, differentiating between gaseous, liquid and solid bioenergy and their respective feedstocks.

1.2.5 Heat

Due to climate conditions, industrial structure and building stocks, Germany has a comparatively high heating & cooling demand: according to BMWI (2014), about 3 EJ were used for this in 2013 (out of approx. 9 EJ final energy demand), with the residential sector accounting for 66%, followed by the commercial sector (25%), and industry (9%) of the overall heating and cooling demand. Water heating accounted for an additional demand of 0.5 EJ, with more than 80% from the residential sector (BMWi 2014).

The German Federal Government has a target to reduce the overall heat demand by 20% until 2020 (compared to the 2008 level). The total German heat demand of approx. 3.5 EJ in 2013 (about 900 TWh) was mainly supplied by natural gas and oil, and minor shares of district heating, electricity, and renewables (approx. 9%).

The overall shares of renewables c and the respective sources are shown in the following figure.

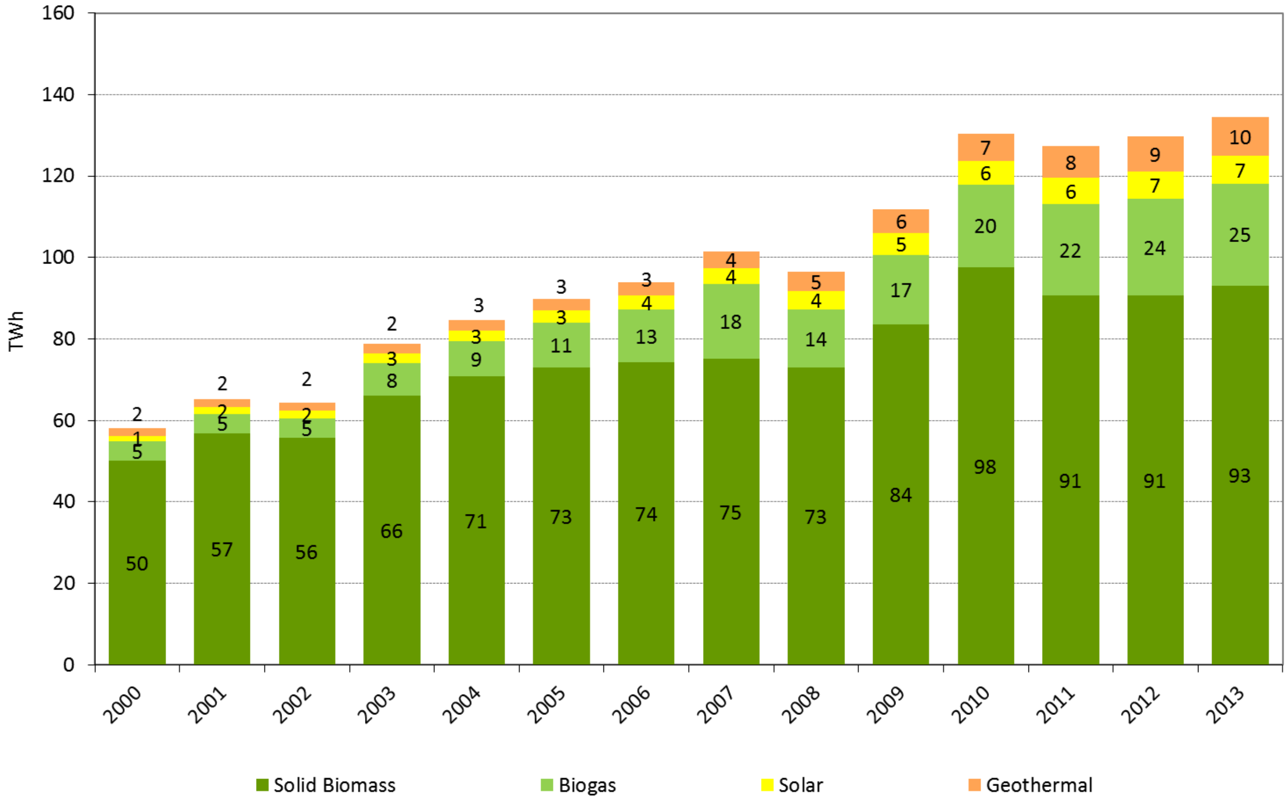

Figure 1-10: Renewable Heat Supply by Source in Germany 2000-2013 (BMWi 2014)

Bioenergy – mainly solid biomass – provides the largest renewable heat contribution, followed by heat from biogas (mainly from cogeneration). Geothermal and solar thermal deliver only comparatively small shares. Section 2.3 presents more data on bioheat from solid bioenergy.

1.2.6 Transport

The German transport sector is dominated by road transport which has a share of 83% of the total transport energy demand in 2013, followed by aviation with 14% (see following figure).

The German Federal Government has a target of 10% reduction of the final energy demand for transport by 2020, and a 40% reduction by 2050, both compared to the 2005 level (BMWi 2014).

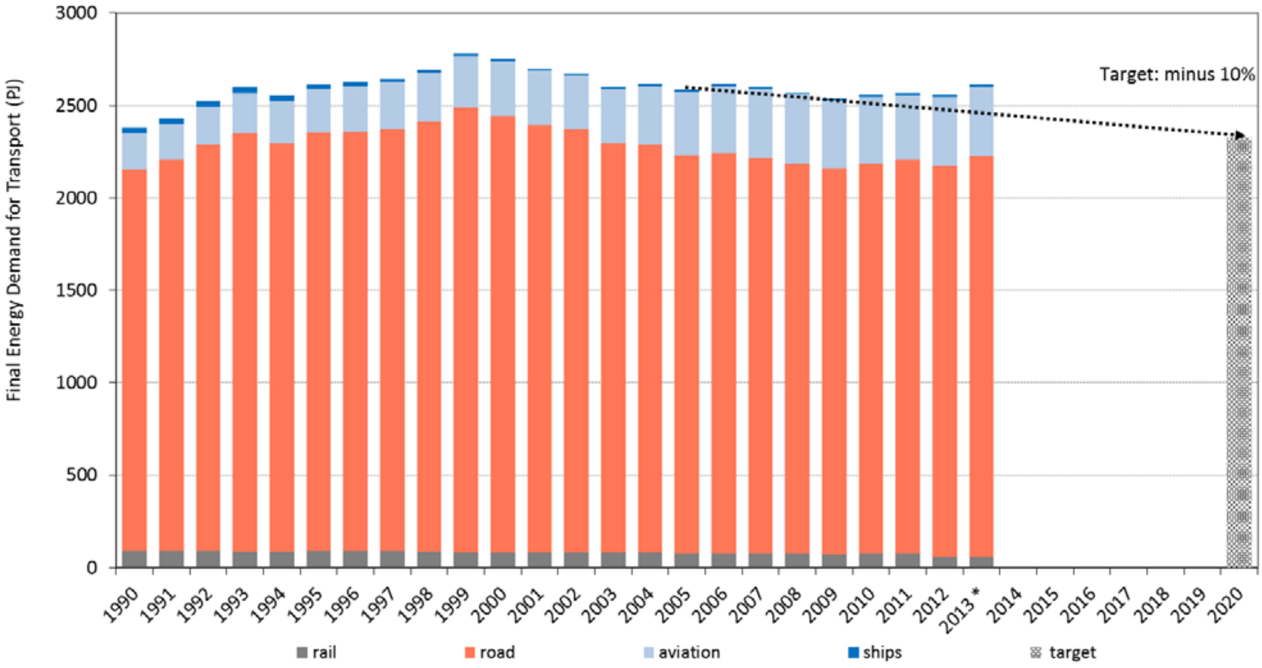

Figure 1-11: Final Energy Demand for Transport by Mode in Germany 1990-2013 (BMWi 2014)

The sector is still dominated by oil use (mainly diesel, kerosene and gasoline), but renewables are slowly gaining, as shown in the following figure.

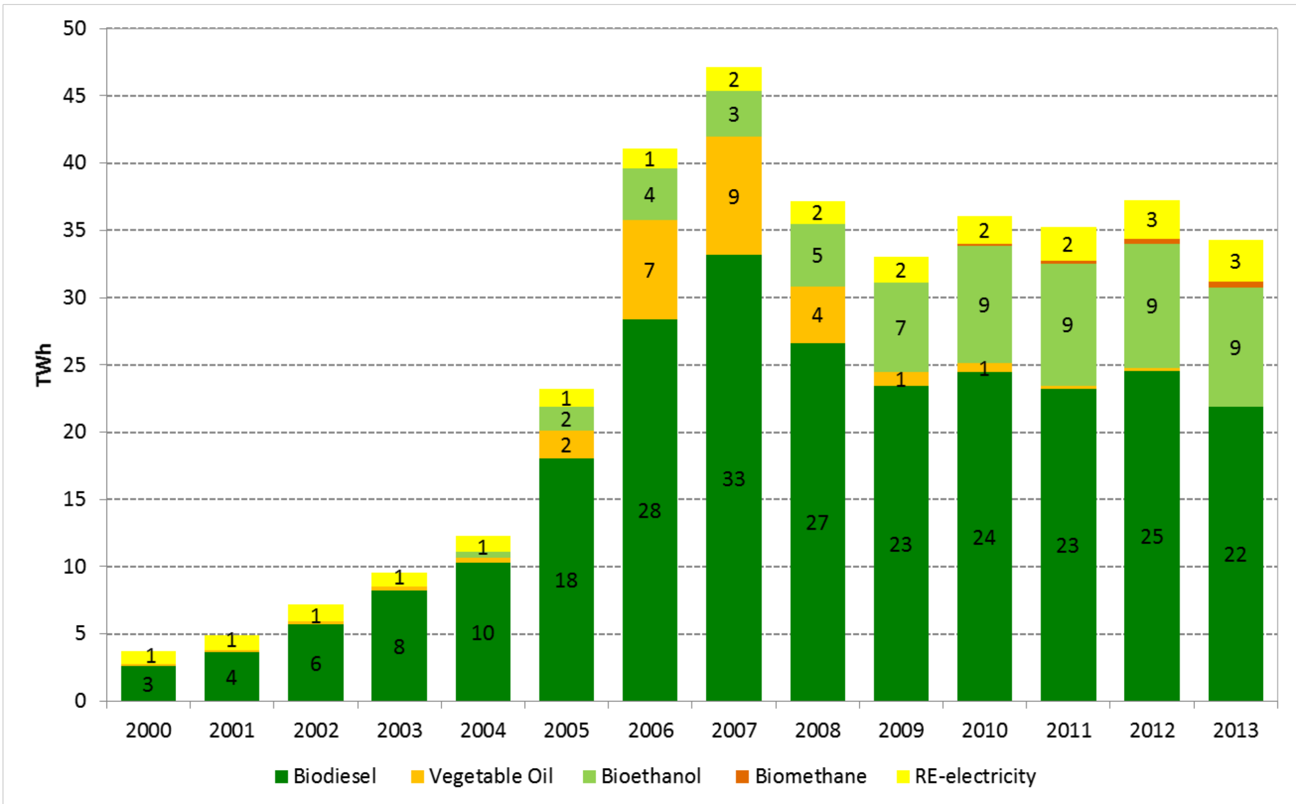

Figure 1-12: Renewables in the German Transport Sector 2000-2013 (BMWi 2014)

The current share of biofuels is 5.5% based on the energy content (BMWi 2014), for more detailed data on sources and use see Section 2.3.

It should be noted that in 2015, the current energy-based quota system for biofuels is replaced by a "GHG quota" system (see Sections 2.3 and 3.1.4).

1.2.7 Overall Contribution of Bioenergy to the German Energy System

Since 1990, bioenergy in total provides a rising share to the German energy system, with continuous growth in electricity and heat supply, and – since 2009 – a more or less stable contribution in the transport sector, as shown in the following figure.

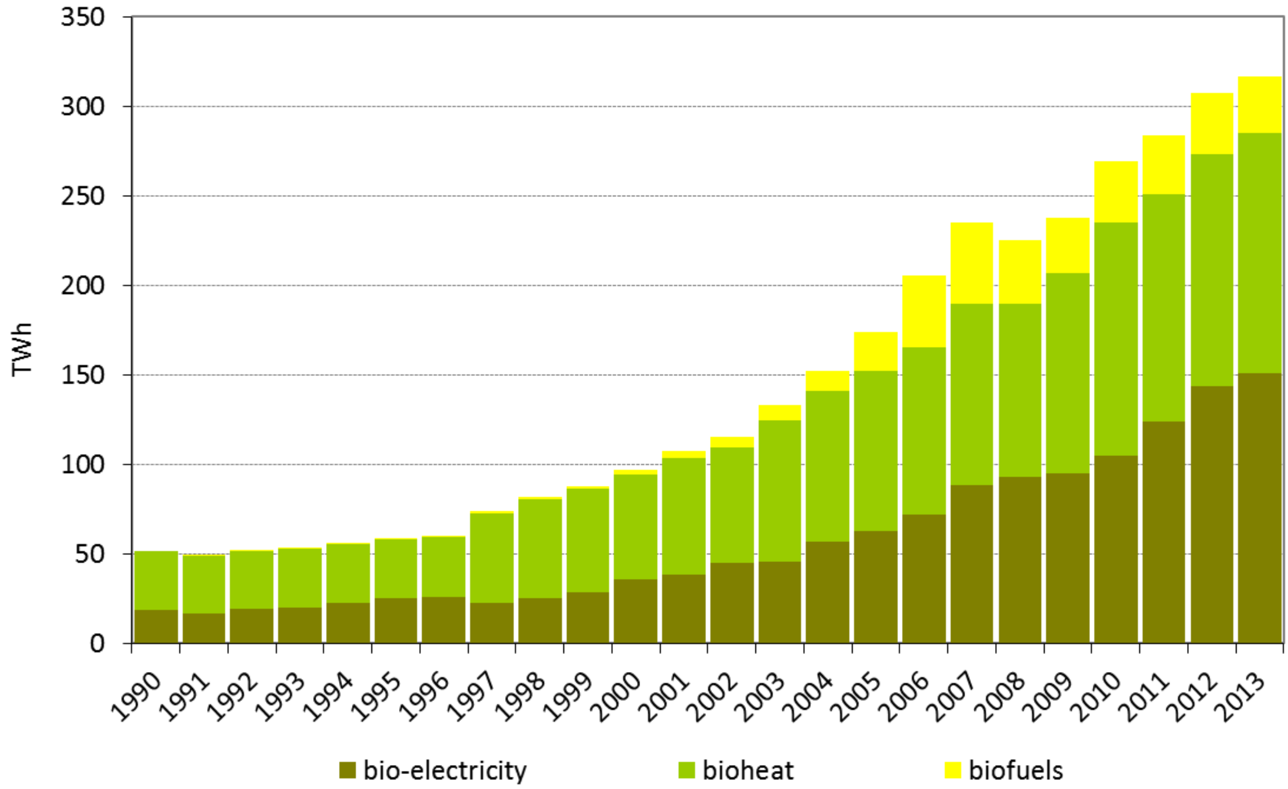

Figure 1-13: Contributions of Bioenergy to the German Energy Supply 1990-2013 (BMWi 2014)

For a brief discussion of the future developments of bioenergy in Germany, see Section 3.

1.3 Bioenergy and Land Use

The overall growth of bioenergy use in Germany since 2000 is reflected in the significant increase of agricultural land being used for feedstock production, especially for biogas (maize), and biodiesel (rape), as shown in the following figure.

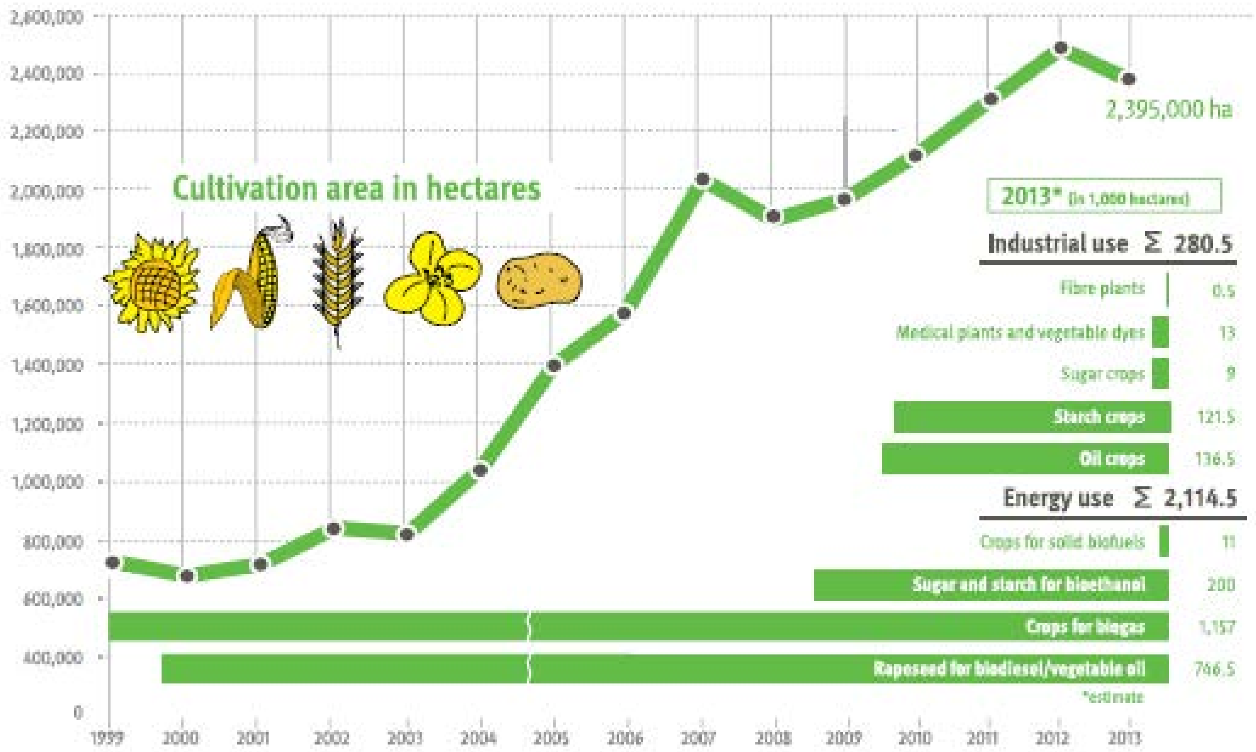

Figure 1-14: Land Use for Bioenergy and Biomaterials in Germany (FNR 2014a)

As can be seen, the dominant use of biomass from land-based production is for bioenergy.

With yields for specific biogas crops such as sugarbeet expected to increase, and demand for domestic biodiesel production expected to shrink, the “land peak” may have occurred already in 2012, and the future land use may be more on the side of feedstocks for biomaterials, and possibly advanced biofuels and biorefineries.

2 Domestic biomass resources, current use, main users and trends

2.1 Gaseous bioenergy

2.1.1 Biogas

Electricity

Gaseous biofuels (in particular biogas) are predominantly used for electricity generation as well as for the combined heat and power (CHP) generation in Germany. Biogas is mostly produced in small-scale installations on farms, in larger plants for bio-waste digestion and in larger landfill and sewage gas plants. Most of the biogas plants are designed for electricity generation and a corresponding feed-in into the electricity grid. In order to use the resulting heat in the best possible way biogas installations are directly built where the need of energy arises. In the recent years alternative options for biogas utilization became more popular. Technologies for the upgrading of biogas to biomethane with subsequent feed-in into the natural gas grid or the use of micro gas grids for the central conversion of biogas to electricity became more and more important.

The number of biogas plants has increased continuously in Germany since the Renewable Energy Sources Act (EEG) came into force in 2000. Due to the amendments of the Renewable Energy Sources Act in 2004 and 2009, the development of biogas plants (number and installed electric capacity) has received significant impetus. Its amendment in 2012, however, increasingly decelerated the construction of new biogas facilities in Germany. Hence, the implementation of new biogas projects was already highly limited in 2012. This is mainly due to an overall lower level of funding for the construction of new biogas facilities. In 2013 the development of new biogas plants was reduced to 200 new biogas facilities with the overall installed capacity of 200 MW_{el}. Thus, by the end of 2013 about 7,700 biogas plants with an overall installed capacity of 3,400 MW_{el} were in operation. The average electric capacity of biogas plants in Germany amounted to 441 kW_{el}. Site expansions through additional CHP modules or through the set-up of satellite CHPs off-site became common in the past years.

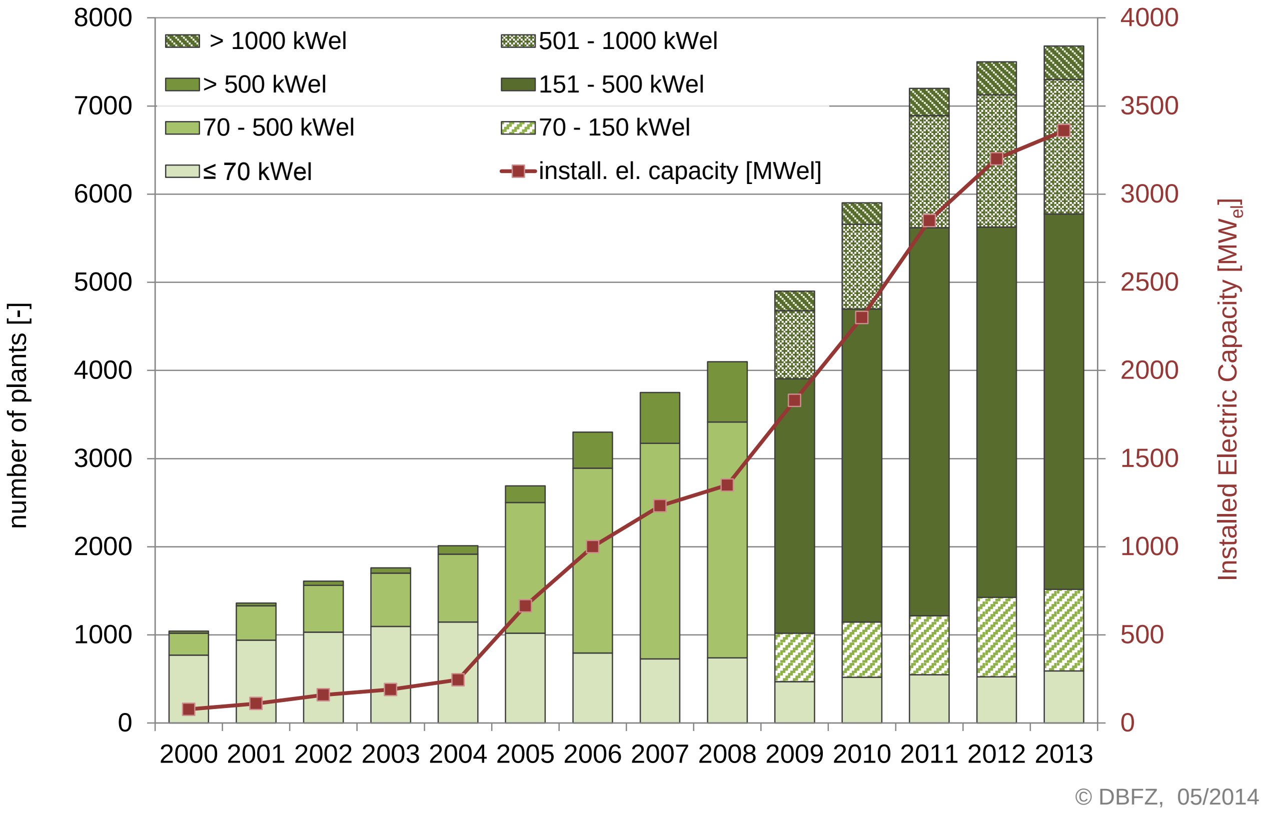

Figure 2-1: Development of biogas plants in Germany (number of plants and installed electric capacity in MW_{el}) from 2000 to 2013, without biogas upgrading plants, landfill and sewage gas plants (DBFZ, 2014)

The new feed-in tariffs for electricity generation from small-scale (up to a maximum of 75 kW_{el}) biogas plants based on manure (§ 27a EEG 2012) as well as the bonus payments for biowaste based biogas plants (§ 27b EEG 2012) were crucial for the realization of the new biogas projects in 2013. According to the data of the federal state ministries, between 50 and 80 small-scale biogas plants went into operation in 2013.

The introduction of so-called flexibility and market premium (§ 33b to f EEG 2012) has offered financial incentives for flexible power generation and the direct marketing of the produced electricity either on the European Energy Exchange or cumulated via direct marketing associations.

Regarding the regional distribution, biogas plants are mainly built in North-western and Southern Germany. Figure 2-2 gives an overview of the regional distribution of biogas plants in Germany by the end of 2013.

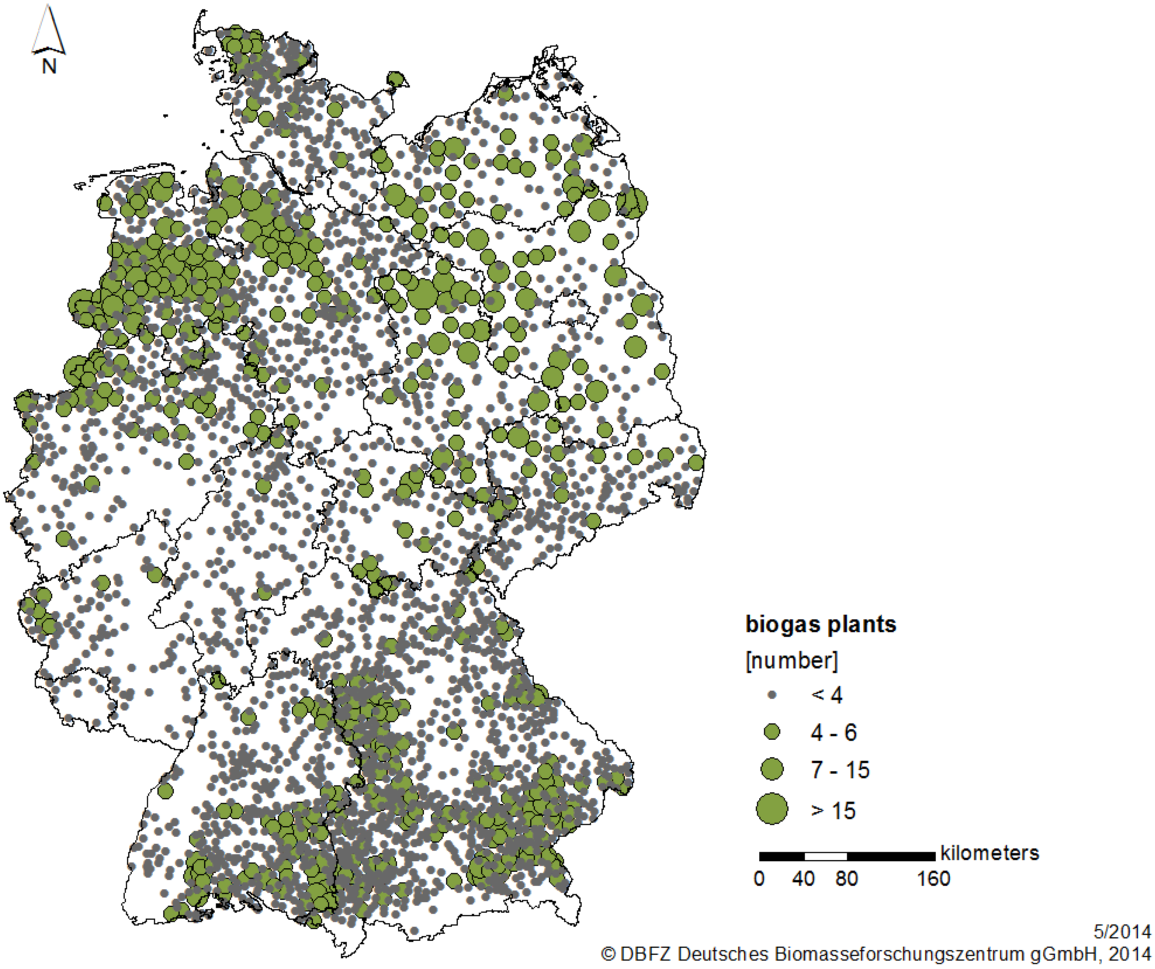

Figure 2-2: Distribution of biogas plants in Germany in 2013 (DBFZ, 2014)

In Southern Germany there are a large number of small- to medium-scale biogas plants with average capacities below 325 kW_{el}. Whereas in Northern and Eastern regions (Lower Saxony, Brandenburg and Saxony-Anhalt) facilities with higher average capacities (> 588 kW_{el}), in Mecklenburg-Western Pomerania even of 688 kW_{el}, exist.

Table 2-1: Number and installed electric capacity of biogas plants by federal state in Germany in 2013 (DBFZ, 2014)

Federal state	Plants in operation [number]	Total installed electric capacity [MW_{el}]	Average installed electric capacity [kW_{el}]
Baden-Wuerttemberg	858	295.8	345
Bavaria	2,312	732.0	314
Berlin	0	0.0	-
Brandenburg	335	182.0	543
Bremen	0	0.0	-
Hamburg	1	1.0	1,020
Hesse	187	63.4	339
Mecklenburg-Western Pomerania	247	170.0	688
Lower Saxony	1,500	800.0	533
North Rhine-Westphalia	597	263.0	441
Rhineland-Palatinate	142	58.4	411
Saarland	13	4.3	333
Saxony	220	92.2	419
Saxony-Anhalt	296	174.2	588
Schleswig-Holstein	570	304.9	429
Thuringia	247	113.8	461
Total	**7,477**	**3,254.9**	**424**

Biogas plants are operated to a large extent by agricultural holdings. Agricultural biogas plants are small- to medium-size installations with a capacity of 300 - 400 kW_{el} on average. The main biomass resources used are animal excrements as manure and dung and renewable raw materials as maize silage. The generated electricity is fed into the electricity grid. In many cases the produced heat is used for supplying residential buildings and buildings for livestock on the farms. The amount of heat used in relation to the total produced amount of energy lies on average between 30 and 73 %.

In general, the type of biomass resources used in biogas plants has been influenced by the introduction of a bonus payment for the use of renewable raw materials as energy crops within the Renewable Energy Sources Act of 2004. Since then the share of renewable raw materials has been increasing continuously. The amendments of the law in 2009 and 2012 have supported this tendency. Today manure/dung and renewable resources account for more than 90 % of the biomass resources that are used in German biogas plants referring to the mass content (Figure 2-3). According to the operators of biogas plants, the use of biowaste and leftovers amounts to about 8 %.

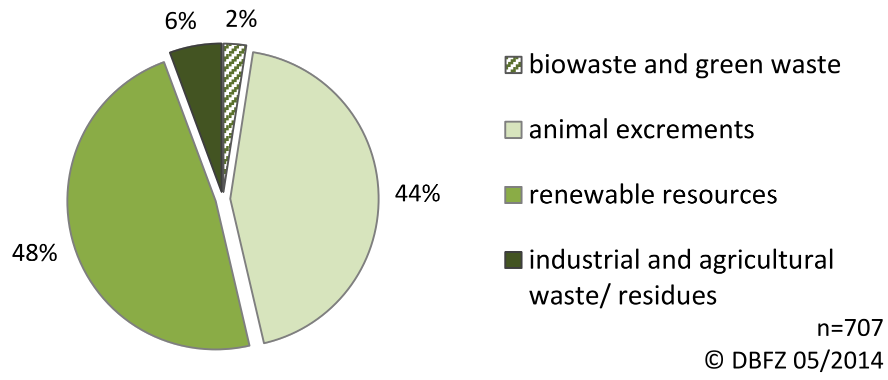

Figure 2-3: Biomass resources in biogas plants referring to the mass content

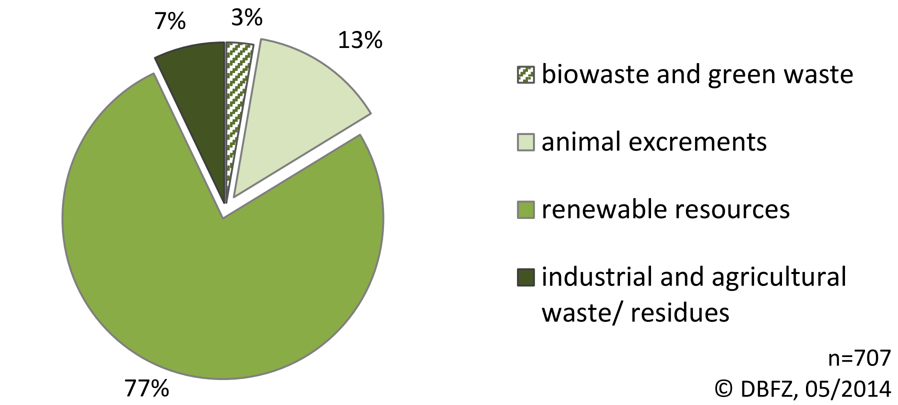

Figure 2-4: Biomass resources in biogas plants referring to the energy content

Regarding the energy content of biomass resources used about 80 % of the energy supply results from renewable resources (Figure 2-4). Among the renewable resources (energy crops) maize silage is by far the main biomass resource used in relation to the mass content (73 %) as shown in Figure 2-5. Grass silage contributes with a share of about 12 % to the total amount of renewable raw materials used in biogas plants. Compared to maize silage and grass silage whole-plant cereal silage and cereal grain are of minor importance (9 % in total). Today, sugar beet accounts for just 2 % of the renewable resources. For comparison Figure 2-6 shows the biomass resources used in relation to the energy content.

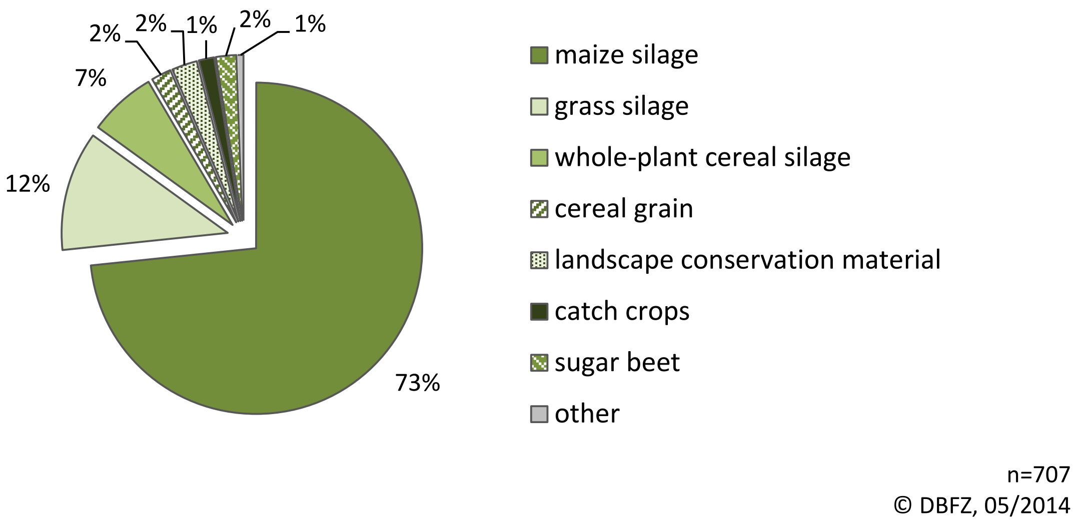

Figure 2-5: Biomass resources in biogas plants, focus energy crops, referring to the mass content

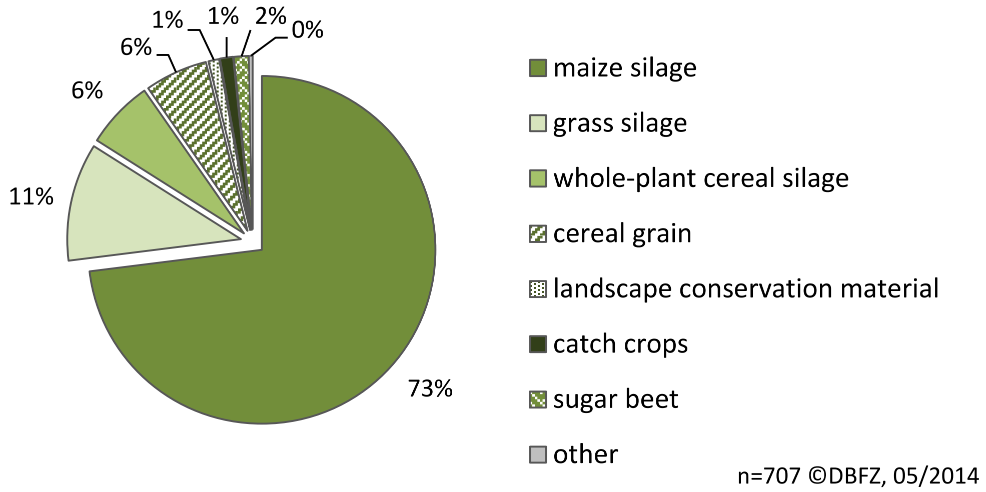

Figure 2-6: Biomass resources in biogas plants, focus energy crops, referring to the energy content

Currently, the utilization of biowaste from separate waste collection as well as industrial organic waste (leftovers from canteens, company restaurants, or catering) and waste from the food industry are of little significance for biogas generation in Germany. Nevertheless, the number of biogas plants that exclusively or predominantly digest biowaste and organic waste continues to grow. By the end of 2013, about 130 plants generating biogas from organic waste digestion have been in operation (Figure 2-7). This comprises biogas plants that use biowaste from separate waste collection as well as biogas plants that use industrial organic waste and waste from the food industry. 77 of these facilities use municipal biowaste from separate waste collection.

According to the DBFZ database, 62 biogas plants are digestion plants that exclusively or predominantly use biowaste under the terms of § 27a Renewable Energy Sources Act of 2012.

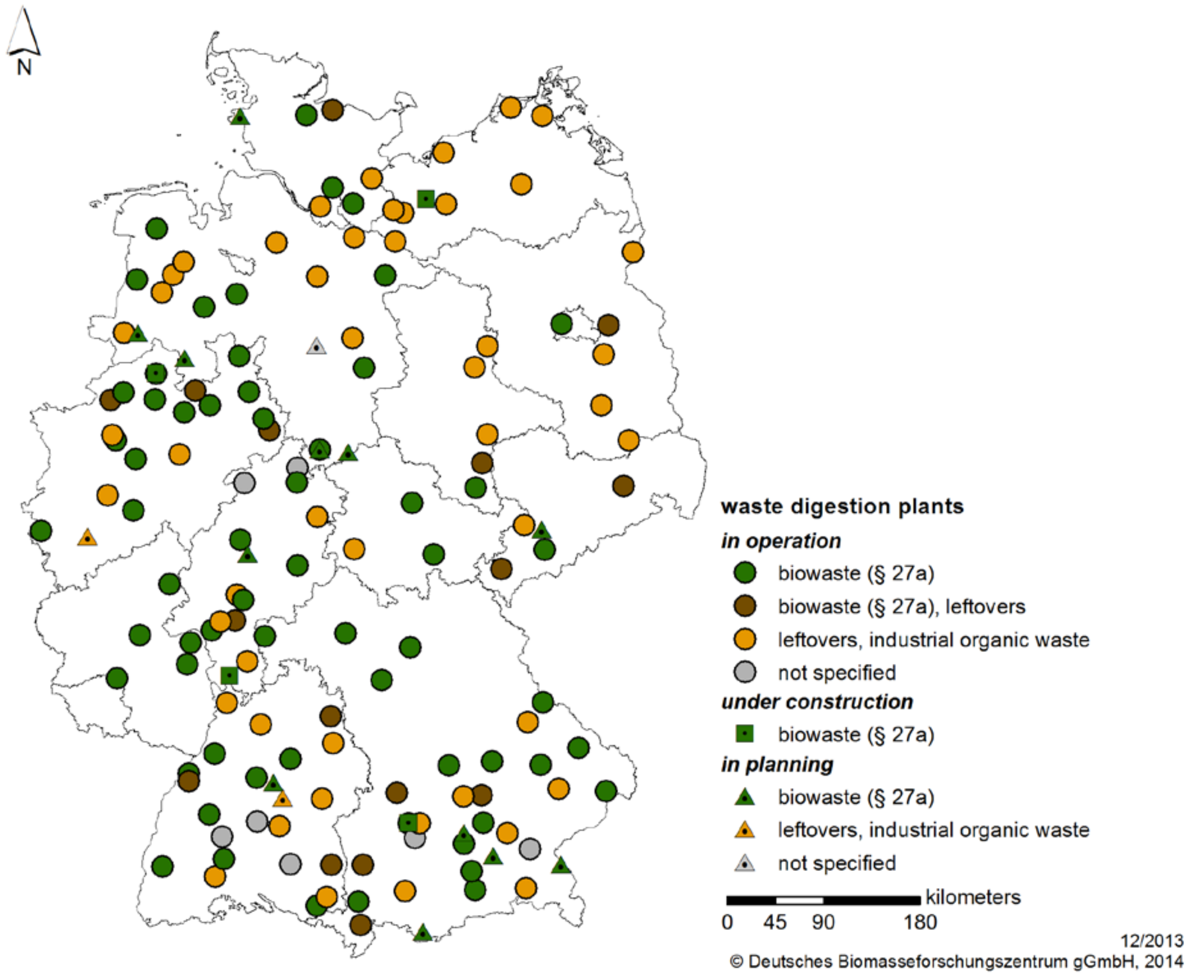

Figure 2-7: Distribution of waste digestion plants in Germany in 2013

Municipal biowaste from separate collection and green waste from gardens and parks represents by far the largest portion (79 %) of resources in new biogas plants that have come into operation since 2012. In total, more than 430,000 tonnes of biowaste and green waste can be digested in these facilities. The average installed electric capacity of new waste digestion plants is about 900 kW_{el}. With regard to the biogas plants that have come into operation since 2012 as well as plants that are still under construction or in planning, it becomes apparent that the utilization of biowaste from separate collection and green waste (under the terms of § 27a Renewable Energy Sources Act of 2012) for biogas generation plays an increasingly important role. From 2015 onwards, a separate collection of biowaste is imposed by law. Thus, it is expected that the amount of biowaste available for digestion in biogas plants will increase considerably in the coming years.

Heating

In Germany biogas is predominantly used for electricity generation as well as for the combined heat and power (CHP) generation. The implementation of a bonus payment for a combined heat and power generation (CHP bonus) and the requirement of a minimum heat utilization within the feed-in tariff system as of 2012 have provided incentives for the improvement of the overall efficiency of biogas plants. This resulted in an increasing implementation of concepts for heat utilization. The available heat is mainly used for the plant’s own heat demand as well as for heating and hot water supply of residential buildings, office buildings on-site. Furthermore district heating and heating of public buildings have become new ways of heat utilization.

2.1.2 Biomethane

Next to on-site electricity generation, 144 biogas upgrading plants with an overall feed-in capacity of about 87,000 $m^3_{STP}/h_{biomethane}$ were in operation by the end of 2013 (Figure 2-6). 24 new plants for upgrading biogas to biomethane with subsequent feed-in into the natural gas grid came into operation in 2013, 6 of them located in Saxony-Anhalt. The highest upgrading capacities are installed in Eastern Germany. At two plant sites the upgraded biomethane is directly used as vehicle fuel. By the end of 2014, 171 biogas upgrading units with an overall feed-in capacity of 101 583 $m^3_{STP}/h_{biomethane}$ are expected to be in operation

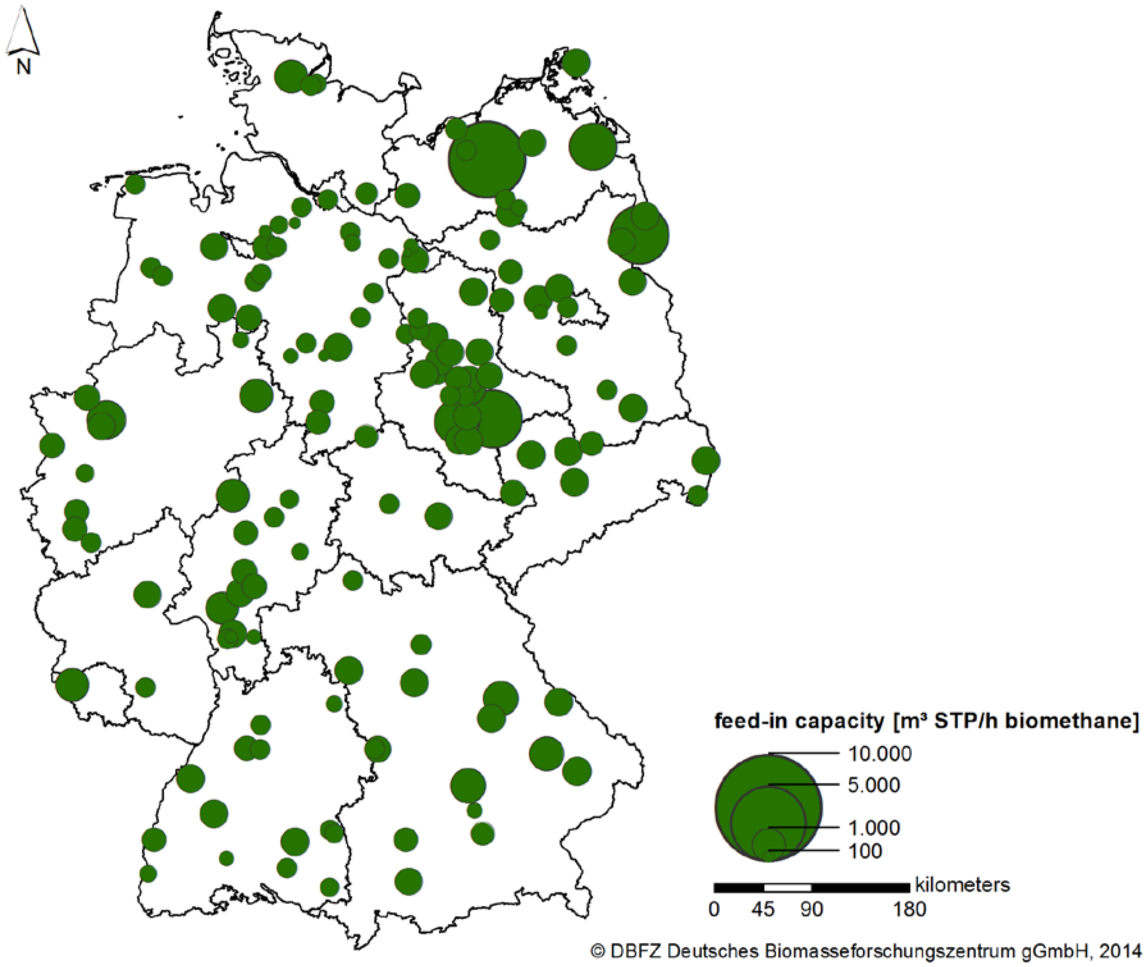

Figure 2-8: Distribution of biogas upgrading plants in Germany in 2013 (DBFZ, 2014)

Table 2-2 shows the number and feed-in capacity of biogas upgrading plants by federal state in Germany by the end of 2013.

Table 2-2: Distribution of biogas upgrading plants (number and feed-in capacity in m^3 STP/h biomethane) by federal state in Germany in 2013 (DBFZ, 2014)

Federal state	Plants in operation [number]	Total feed-in capacity [m^3 STP/h biomethane]	Average feed-in capacity [m^3 STP/h biomethane]
Baden-Wuerttemberg	14	6 410	458
Bavaria	15	9 727	648
Berlin	1	400	400
Brandenburg	12	8 668	722
Hamburg	1	350	350
Hesse	11	5 800	527
Mecklenburg-Western Pomerania	10	11 205	1 121
Lower Saxony	29	11 450	395
North Rhine-Westphalia	10	6 088	609
Rhineland-Palatinate	4	1 720	430
Saarland	1	1 000	1 000
Saxony	6	3 650	608
Saxony-Anhalt	21	16 045	764
Schleswig-Holstein	4	2 110	528
Thuringia	5	2 790	558
Total	144	87 413	607

For upgrading biogas produced by anaerobic digestion to biomethane it is necessary to capture carbon dioxide (as well as H_2S, O_2, H_2O etc.) and to raise the level of CH_4-content. As shown in Figure 2-7, chemical scrubber, water scrubber and pressure swing adsorption are the most prevalent technologies in German biomethane upgrading units.

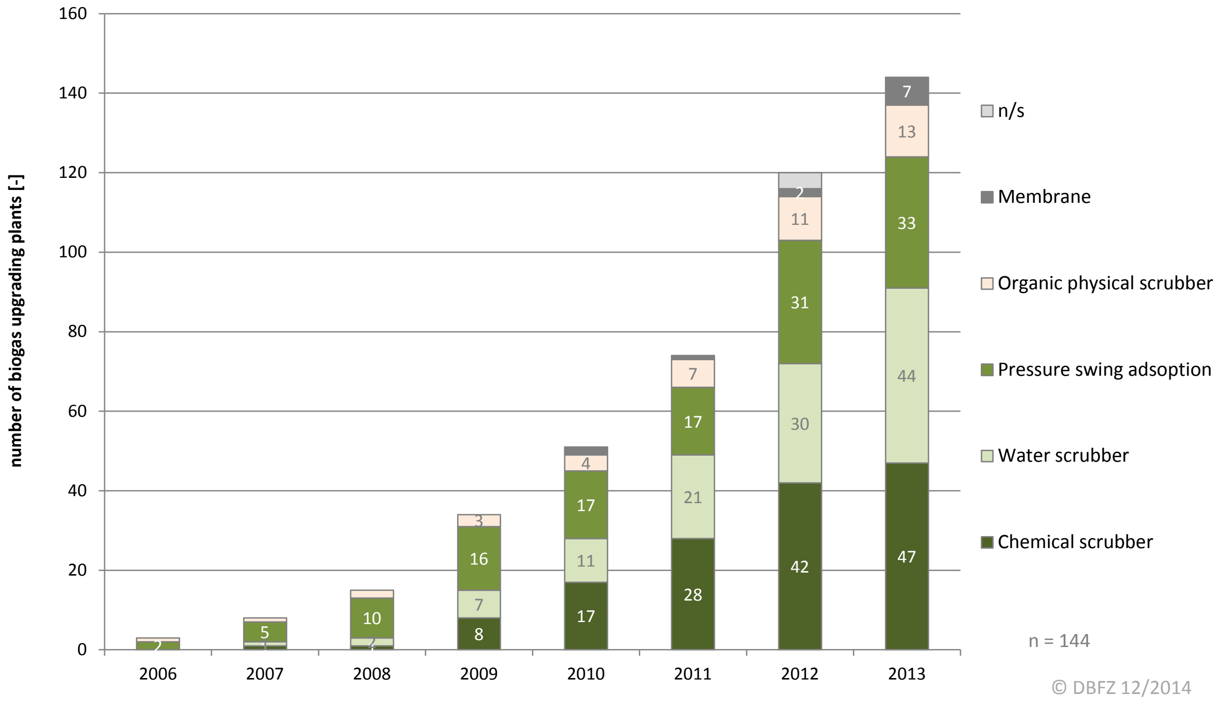

Figure 2-9: Biogas upgrading technologies in Germany from 2006 to 2013 (DBFZ, 2014)

Energy crops are the most prevalent biomass resource used for biomethane production. Manure/dung is used only in combination with energy crops or with organic waste. Table 2-3 shows the biomass resources used for biomethane production and the corresponding volume.

Table 2-3: Biomass resources for biomethane production units and the amounts of the produced biomethane [$m^3_{STP}/h_{biomethane}$] in Germany in 2013 (DBFZ, 2014)

Biomass resource	Number of biomethane plants [n]	Biomethane volume after upgrading [$m^3_{STP}/h_{biomethane}$]
Energy crops	80	50,375
Energy crops + manure	43	21,555
Energy crops + organic waste	2	980
Organic waste	11	10,968
Organic waste + manure	5	2,185
Sewage sludge	1	650
Sewage sludge + organic waste	1	350
Not specified	1	350
Total	144	87,413

Biomethane utilization pathways

According to the data of the German Energy Agency (dena) the upgraded biomethane is predominantly used for the combined heat and power generation funded by the Renewable Energy Sources Act. Only 9 % of the produced biomethane is used for heating purposes and 1 % as transportation fuel. For more than one third of the produced biomethane (about 35 % referring to the total amount of 6,447 TWh_{Hs}) the utilization is not specified (Figure 2-8).

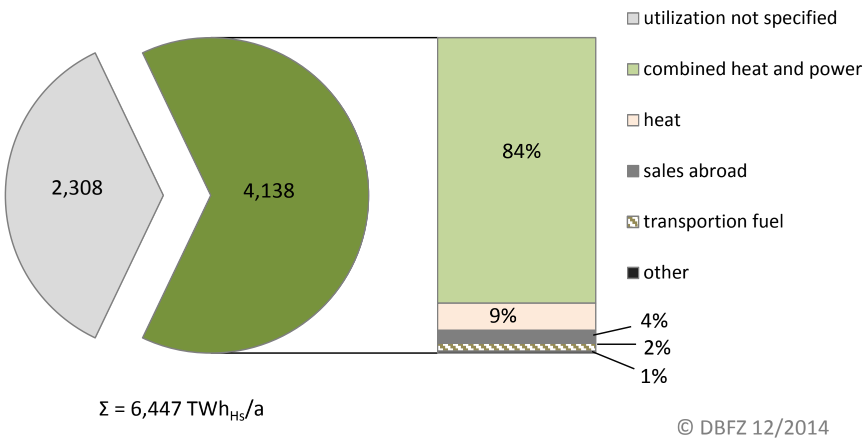

Figure 2-10: Biomethane utilization pathways in 2013 [TWh_{Hs}] (own illustration based on the data of the German Energy Agency (dena) (Edel et al., 2014))

Electricity and heating (CHP)

According to the data of German transmission system operators ((50hertz Transmission GmbH, 2014), (Amprion GmbH, 2014), (TenneT TSO GmbH, 2014), (Transnet BW GmbH, 2014)) the number of biomethane CHP units in Germany accounts to 600 to 700. The overall installed electric capacity is about 200 MW_{el}. By the end of 2013, 520 million m^3_{STP} biomethane were fed in into the German gas grid (5.87 TWh_{Hs}) (Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, 2014). Assuming that the produced biomethane is used to at least 80 % in CHP units (Figure 2-5), the amount of electricity generated from biomethane in 2013 can be estimated to 1.5 TWh_{el}[3] and the heat generation to 1.6 TWh_{th}.

Transport

Despite the fact that only 1 % of the total biomethane production is utilized as transport fuel at the moment in Germany, there are a number of economic incentives for distributing biomethane in the transport sector. A mineral oil tax relief (§ 50 of the German Energy tax law) can be claimed when substituting natural gas by biomethane (*Energiesteuergesetz (EnergieStG)*, 2006). In addition, credits for using biomethane can be received in terms of the national biofuel quota (§37a of the Federal

[3] Further assumptions: annual utilization ratio 32.9%, electricity coefficient 0.91.

immission control law, BImSchG 2013). For biomethane produced from organic waste, manure or dung can be double counted for the national biofuel target (36. BImSchV).

According to the data of the Fachagentur Nachwachsende Rohstoffe e.V. only 32,000 t of 3.4 million tonnes biofuels used in the transport sector are biomethane (FNR, 2014b).

2.2 Solid bioenergy

Electricity

Next to gaseous bioenergy, solid bioenergy is the second main biomass source for electricity generation in Germany. By the end of 2013, about 640 registered combined heat and power (CHP) plants, using solid biomass as feedstock, were in place (DBFZ, 2014). The corresponding accumulated installed electric capacity amounted to 1,537 MW_{el}. These facilities are eligible for funding under the Renewable Energy Sources Act (EEG). Due to this act the number of bioenergy plants increased significantly in Germany. Compared to the year 2000 when the EEG was introduced, the number of plants has increased tenfold, and the respective installed power eightfold.

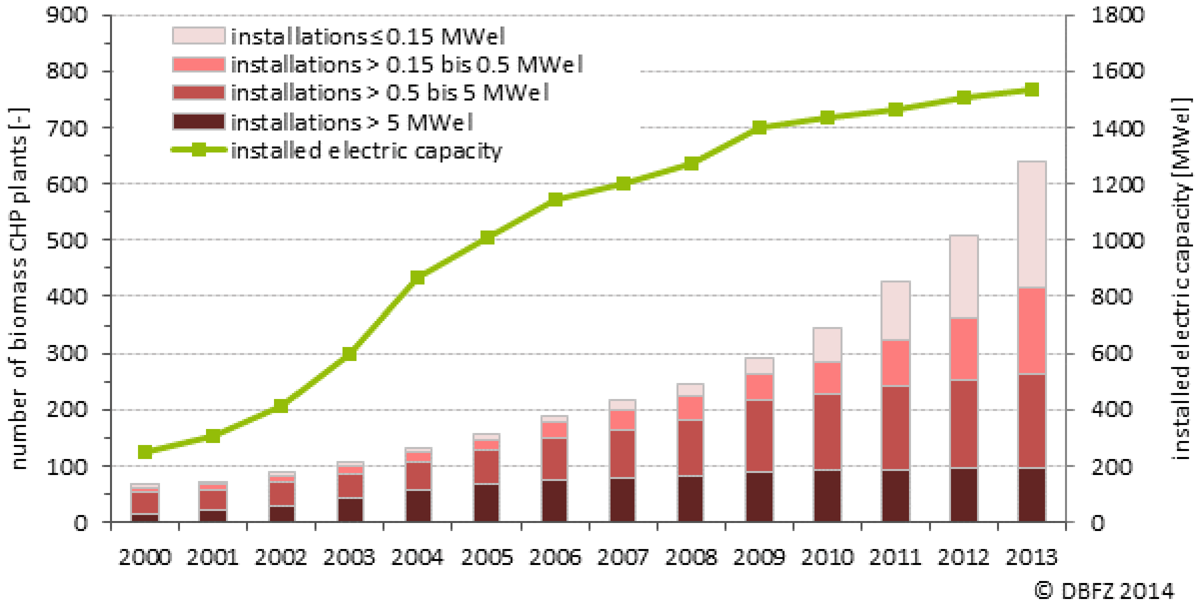

Figure 2-11: Development of solid biomass CHP plants in Germany from 2000 to 2013 (number of plants and installed electric capacity in MW_{el}), without installations of the pulp and paper industry and small-scale CHP plants (< 10 kW_{el}) (DBFZ, 2014)

From 2000 until 2009, a significant increase in the installed electric capacity occured. Since 2009, a larger share of small-scale plants (< 1 MW_{el}), mainly using wood gasification, can be noted resulting in a smaller annually installed electric capacity.

In 2013 this trend continues: 126 wood gasification plants with a total installed electric capacity of 13 MW_{el} were built. The majority of these plants have a capacity of up to 200 kW_{el}. Additionally, 5 cogeneration plants with a total electric capacity of 18 MW_{el} were commissioned. These figures amount to a quarter of the average newly installed facilities compared to the previous years. The decreasing number and size of new installations is due to a lower level of funding and due to the type of installations promoted within the feed-in tariff system of 2012. For this reason, plant operators focused on implementing small- to medium-sized installations. Regarding the regional distribution, biomass CHP plants are mainly built in Southern Germany (Table 2-1).

Table 2-4: Number and installed electric capacity of solid biomass CHP plants by federal state in Germany in 2013 (DBFZ, 2014)

Federal state	Plants in operation [number]	Total installed electric capacity [MW_{el}]	Average installed electric capacity [MW_{el}]
Baden-Wuerttemberg	56	178	3.2
Bavaria	136	248	1.8
Berlin	1	20	20
Brandenburg	25	178	7.1
Hamburg	2	22	10.9
Hesse	24	86	3.6
Mecklenburg-Western Pomerania	11	50	4.5
Lower Saxony	21	141	6.7
North Rhine-Westphalia	44	217	4.9
Rhineland-Palatinate	19	105	5.5
Saarland	5	7	1.4
Saxony	23	95	4.1
Saxony-Anhalt	14	81	5.8
Schleswig-Holstein	7	12	1.7
Thuringia	16	84	5.2
Total	404	1 524	3.8
Total incl. gasification installations	640	1 537	2.4

According to a survey among operators the main biomass resource used is wood waste. Wood waste is primarily used in CHP plants built until 2006. Back then plant operators received sufficient payment for using this feedstock within the feed-in tariff system. In the following years the level of funding for wood waste has been reduced and a switch towards forest residues and other residual material was pursued. An overview on the currently used solid biomass resources in CHP plants is provided in Figure 2-10.

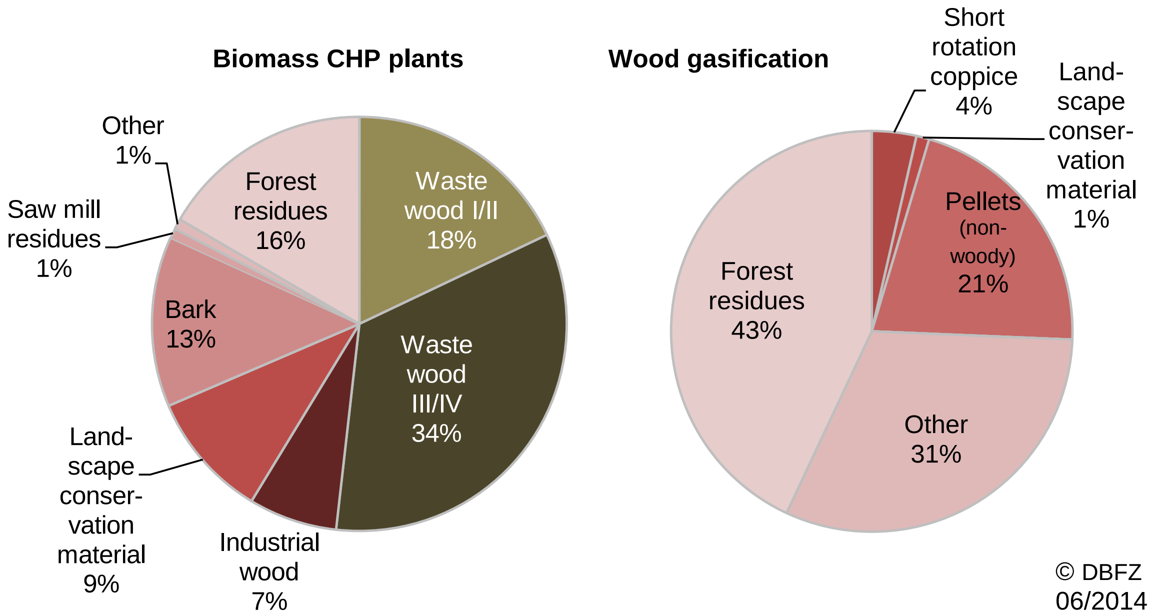

Figure 2-12: Biomass resources in solid biomass CHP plants (DBFZ, 2014)

Heating

In Germany, solid biomass for domestic heating is mainly wood-based and predominantly applied in small- to medium-scale systems in private households, SMEs etc. Major woodfuels for the decentralized heat supply in buildings are logs, pellets, chips and briquettes. Here, the major biomass resource, in terms of volumes consumed, is wood logs; in comparison pellets, chips and briquettes are still a niche market. Wood logs are predominantly used in fireplaces in single- and two-family houses (RWI/forsa, 2013). In the following the consumption figures for wood logs as well as production figures and number of heating systems installed for wood pellets are illustrated.

Wood logs

Wood logs (firewood) are still the most commonly used wood fuel for heating in German households. Thereby it has to be distinguished between the use in central heating systems (incl. stoves) or in fireplaces. The latter is the predominating application in Germany (80 %). A study conducted by forsa (association for social research and statistical analysis) and rwi (Rheinisch-Westfälisches Institut für Wirtschaftsforschung) surveyed and analysed the consumption of wood-based fuels in German households (RWI/forsa, 2013). A time series from 2004 until 2010 is presented in Figure 2-1. More recent data is unfortunately not obtainable in Germany. Besides the numbers are only statistical projections. This is due to the lack of central statistics on wood log installations and the corresponding consumption.

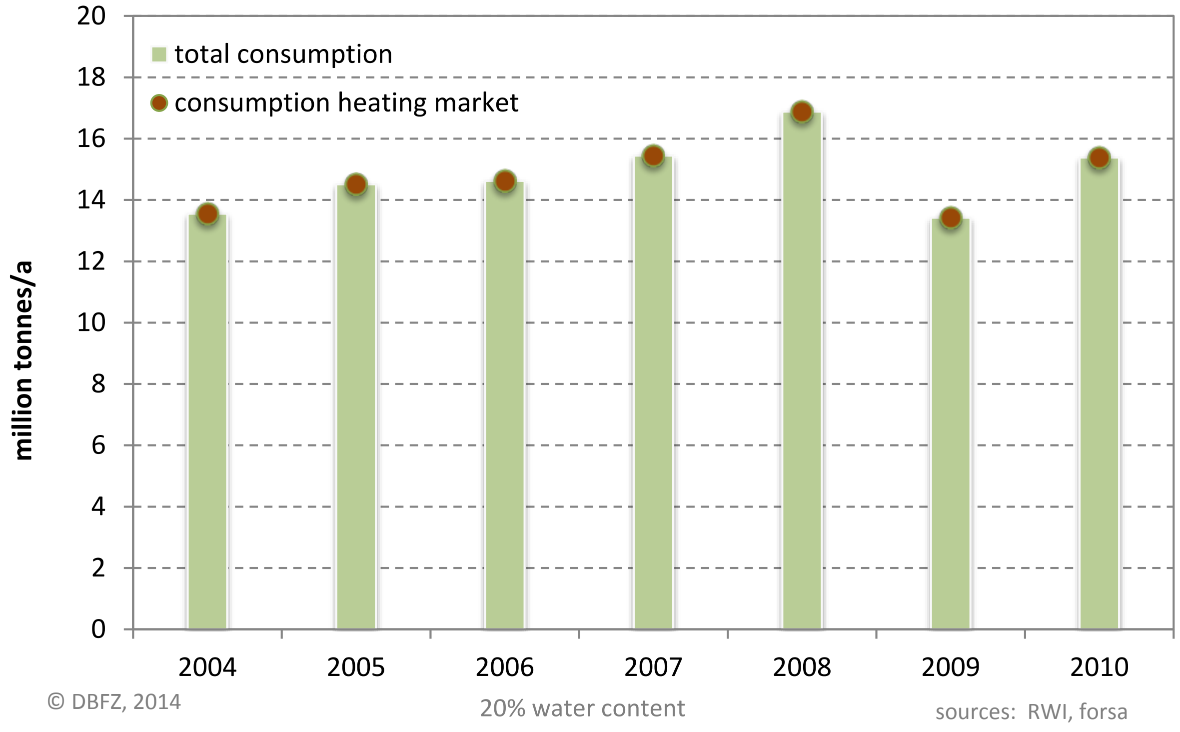

Figure 2-13: Development of the wood log consumption in Germany from 2004 to 2010 (RWI/forsa, 2007) (RWI/forsa, 2011) (RWI/forsa, 2013)

Wood pellets

The number of pellet heating systems (< 50 kW) amounted to 212,500 units in Germany in 2013. The newly installed units during that period amounted to 12,500 units. Figure 2-1 shows the development – both annually and cumulative – from 2000 to 2013.

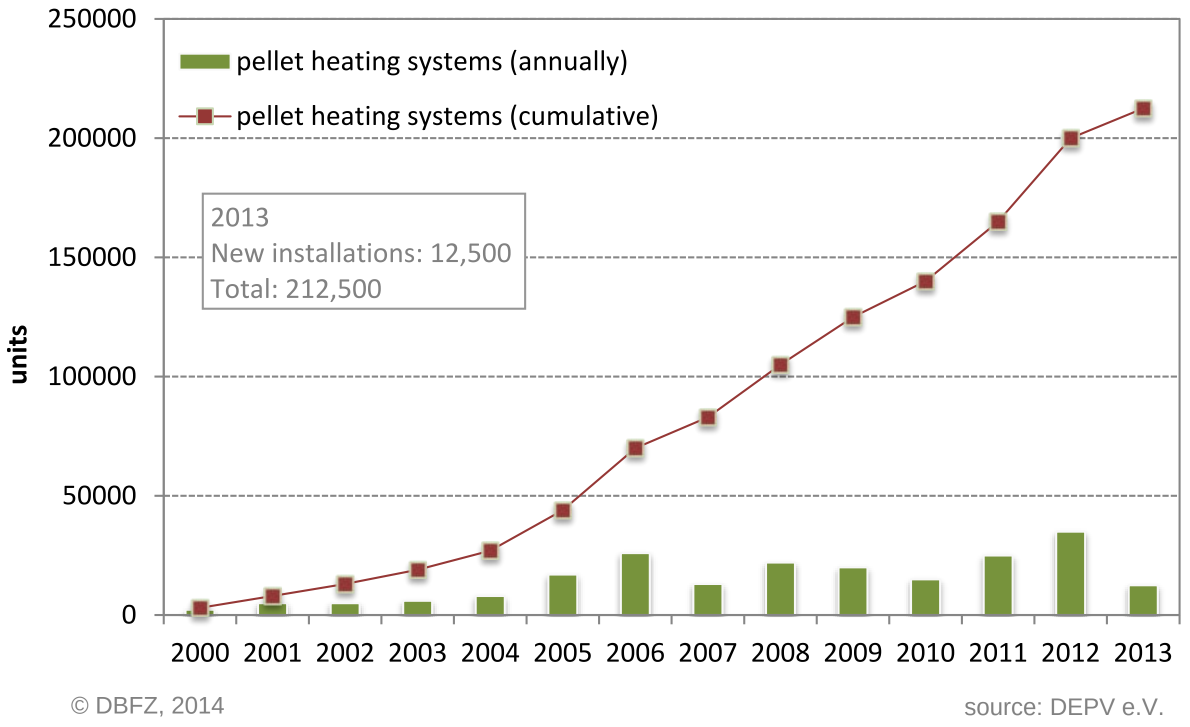

Figure 2-14: Development of installed pellet heating systems (< 50 kW) in Germany from 2000 to 2013 (annually and cumulative) (DEPV e.V., 2014a)

Until 2006 a steady growth can be observed. In 2005 and 2006 the sales figures increased by 60 %, however after that there was a drop with a following market recovery. The reason for this development was a depletion of the budget of the market incentive programme (MAP) in the second half of 2006, a policy instrument promoting heat generation based on renewable energy sources. This was reflected in a rapid decline in pellet stove and boiler sales. A further disturbance of the market could be observed in May 2010 as the programme experienced a budget freeze until July. These stop-and-go measures caused uncertainties among the investors leading to a smaller number of pellet heating systems installed in 2010. Pursuant, a market growth could be observed with significant numbers in annually installed capacities.

The corresponding consumption of wood pellets tonnes on the German heating market amounted to 2 Mt in 2013. Until 2006, meeting the national demand was dependent on imports. Since then the amount produced and demanded broke even. Currently, the crisis of the saw mill industry causes a lack of available raw material for the wood pellet production resulting in shutdowns of production facilities. In Figure 2-13. an overview on the consumption and production figures for the years 2001 to 2013 is given.

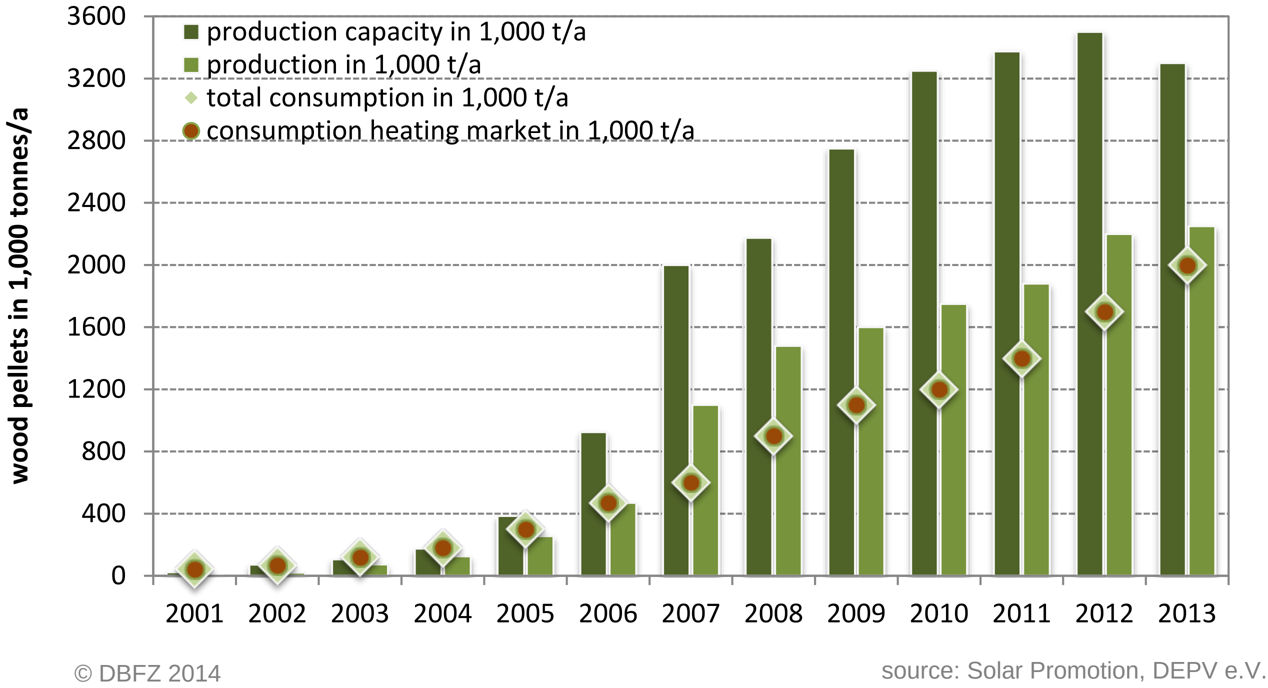

Figure 2-15: Development of the wood pellet consumption, production and production capacity in Germany from 2001 to 2013 (DEPV e.V., 2014b) (Solar Promotion GmbH, 2013)

The production and production capacity of wood pellets in Germany are one of the highest in Europe. In 2013, about 60 production plants have been operating located in Germany with a production capacity of 3.3 million tonnes and a respective production of 2.25 million tonnes (DEPV e.V., 2014b) (Solar Promotion GmbH, 2013). In comparison to 2012, the production capacity has been reduced to the 2010 level in 2013. Mainly small- to medium-sized producers have shut-down their operations. The highly competitive wood pellet market with high feedstock prices has caused this development. In contrast, there also have been a few openings of new production facilities as of 2011. Here, mainly medium- to large-sized production plants have been installed run by corporations. Overall, this incipient market consolidation helped reducing the existing overcapacities. The large gap between production capacity and actual production volume, as observed in the years 2009 until 2011, could be narrowed. Thus, the structure of the German wood pellet market has undergone substantially changes in the past years.

The current average production capacity lies between 20,000 and 100,000 tons – medium- to large-scale installations. The following Figure 2-14 gives an overview of the distribution of the wood pellet production plants in Germany. Main locations are in the Western and Southern part of Germany with large forested areas and corresponding wood-processing industries.

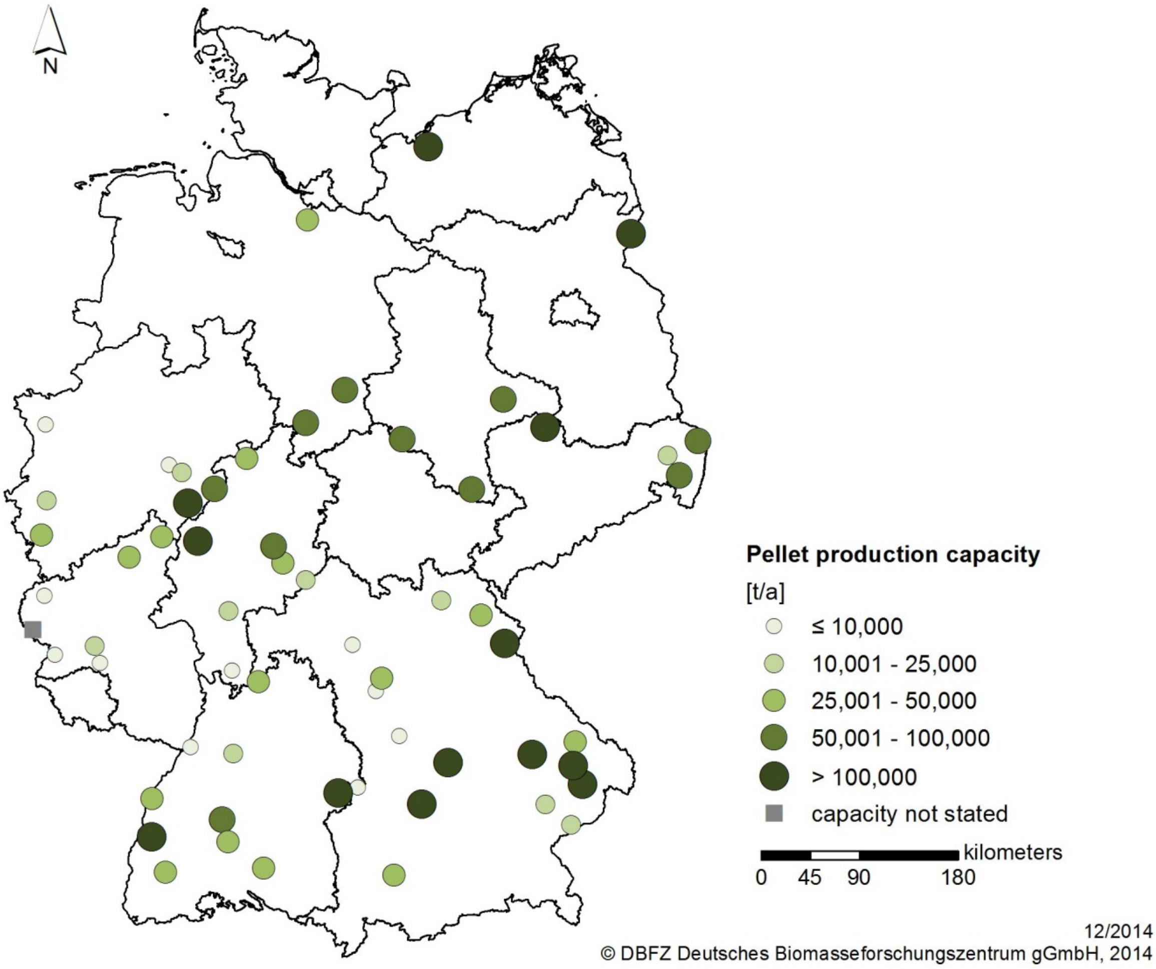

Figure 2-16: Distribution of wood pellet production plants in Germany in 2013 (this overview makes no claim of being complete) (Solar Promotion GmbH, 2013) (C.A.R.M.E.N. e.V., 2014a)

2.3 Liquid bioenergy

Electricity and heating

Vegetable oil is used for the combined electricity and heat generation (CHP). This type of usage has been promoted and introduced by the German feed-in tariff system. However, particularly restrictions have caused a continuous decline in the number of installations and the corresponding installed electric capacity. First the use of certified vegetable oil (that is sustainably produced) was required in order to be eligible for funding from 2011 onwards. Especially the uncertainty concerning the availability and related additional costs for certification had a negative impact on the market. In fact, in 2011 an initial shortage of certified vegetable oil had caused a shutdown of numerous CHP plants based on vegetable oil. Following with the amendment in 2012 vegetable oil was not eligible for funding anymore. As a consequence a range of installations has been put out of operation, temporarily or permanently, or run with another fuel such as heating oil (Figure 2-15). Furthermore, CHP plants have been sold and in some cases also shipped abroad (DBFZ, 2014). Since vegetable oil is not covered by the Renewable Energy Sources Act anymore, additional installations are not expected to be built in the near future.

Mainly due to comparably high prices for vegetable oil on the world market the utilisation of vegetable oil as fuel is not competitive.

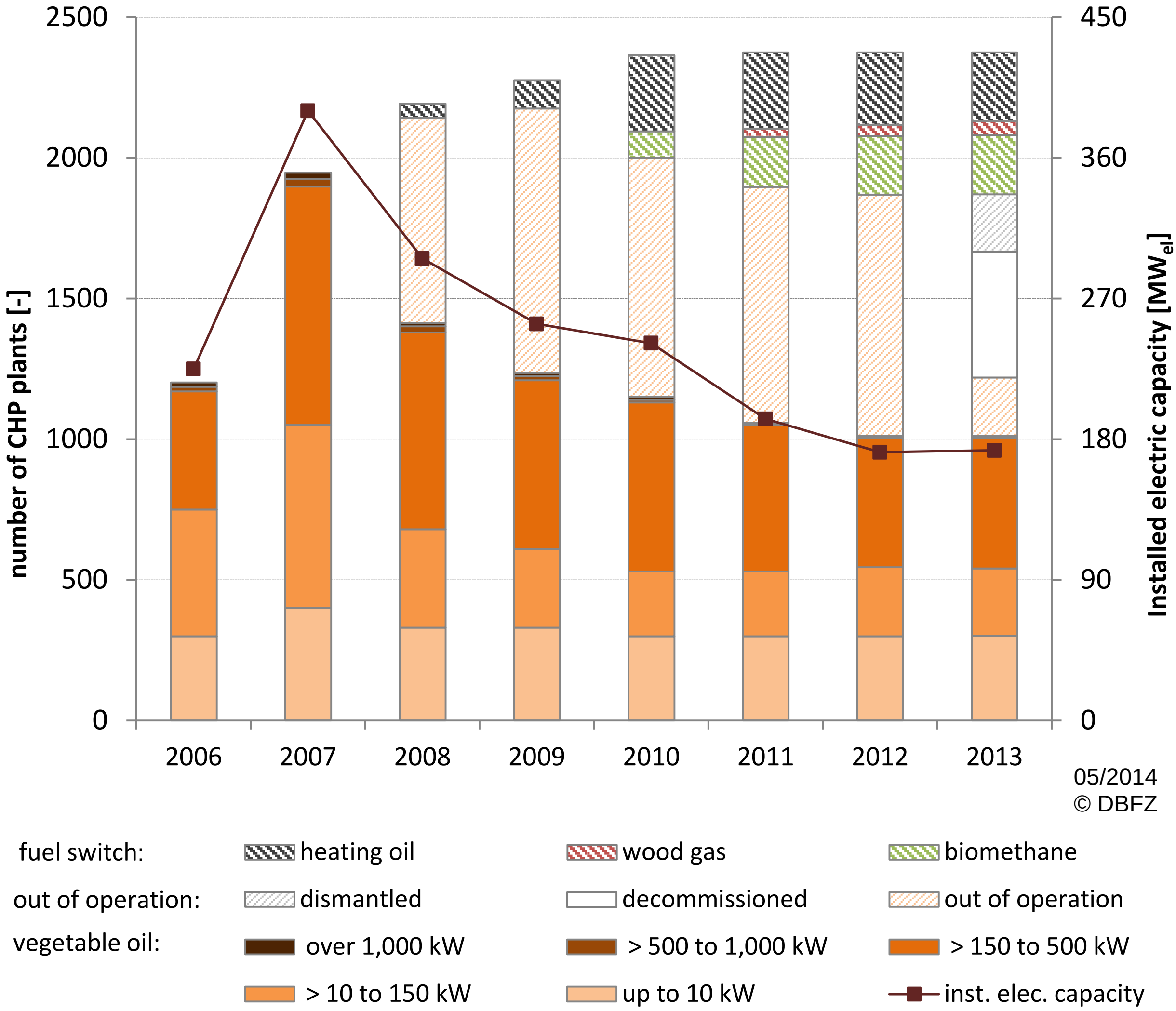

Figure 2-17: Development of vegetable oil CHP plants in Germany from 2006 to 2013 (number of plants and installed electric capacity in MW_{el}) (DBFZ, 2014)

By the end of 2013, about 1,000 installations with an installed electric capacity of 180 MW_{el} were in place. The majority of the plants currently in operation are medium-scale installations (150 to 500 kW).

Transport

Liquid biofuels are predominantly used in the transport sector in Germany where biodiesel, bioethanol and vegetable oil play a role. Figure 2-16 shows the development of biofuel consumption in Germany from 2007 to 2013.

The consumption of biodiesel as pure fuel and blend increased to 3.3 Mt in 2007. Since then the sales figures for biodiesel as pure fuel decreased while the figures for blending continued growing (98 % of the total biodiesel consumption in 2013). The blending of biofuels cannot compensate the decline of pure biofuels utilisation in numbers. In total the consumption of biodiesel has dropped to 2.2 Mt in 2013.

Considering the bioethanol market a similar trend can be noted. In 2013, 1.2 Mt of bioethanol have been used predominantly as blend (88 %) on the German market. The use of vegetable oil as fuel has also dramatically decreased since 2008. It is estimated that only 1,200 t of pure vegetable oil have been consumed in 2013 compared to over 838,000 t in 2007 (Naumann et al., 2014).

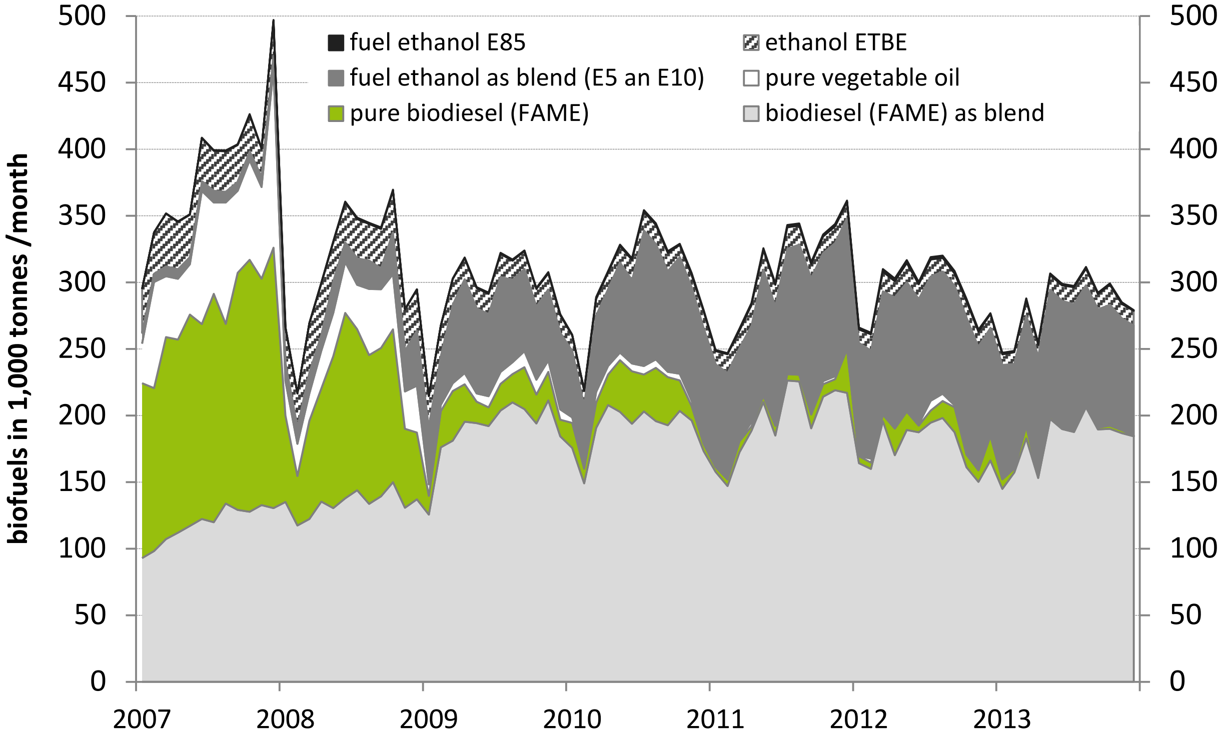

Figure 2-18: Development of the biofuel consumption in Germany from 2007 to 2013 (Naumann et al., 2014)

The share of biofuels of the total fuel consumption dropped from 7.2 % (2007) to 5.2 % (2013) (energy-related). Reasons for this development are seen in legislative changes. The governmental support like tax incentives for the use of biofuels have been constantly reduced in the past years. More importantly, the established option for double counting of biofuels from waste and residues has led to a lower physical amount of biofuels required for meeting the current biofuel quota of 6.25 % of the total volume of fuels put on the market and related to the energy content (compare: Federal Immission Control Act (BImSchG)). Besides, the increasing prices for vegetable oil have resulted in a poor competitiveness on the fuel market.

In order to promote biofuels with greenhouse gas emissions, a GHG reduction quota is going to replace the biofuel quota from 2015 onwards. Then, by law, the GHG emissions resulting from the transport sector have to be reduced by 3 % annually, from 2017 by 4.5 % and from 2020 7 % (compare §37a (3a) BImSchG). According to the biofuel sustainability ordinance (Biokraft-NachV), eligible biofuels have to fulfill certain minimum requirements of which one relates to the GHG mitigation potential. Hence, biofuels have to hold a GHG mitigation potential of 35 % compared to the fossil reference which increases to 50 % from 2017 and 60 % from 2018 onwards (only valid for new installations). Taking into account these legal requirements, the range of biofuel volume needed for meeting the set quota depending on the GHG mitigation potential of the biofuels used is presented in Figure 2-17. Thereby 50 % scenario implies the application of biofuels meeting the minimum GHG emission mitigation requirements of 50 % only (assumption: due to the unfavorable policy conditions no new installations are built, hence the requirement of 60 % GHG mitigation potential does not apply). The 80 % scenario implies the application of biofuels holding the highest GHG mitigation potential of 80 % only (e.g. biofuels from waste and residues) (Naumann et al., 2014).

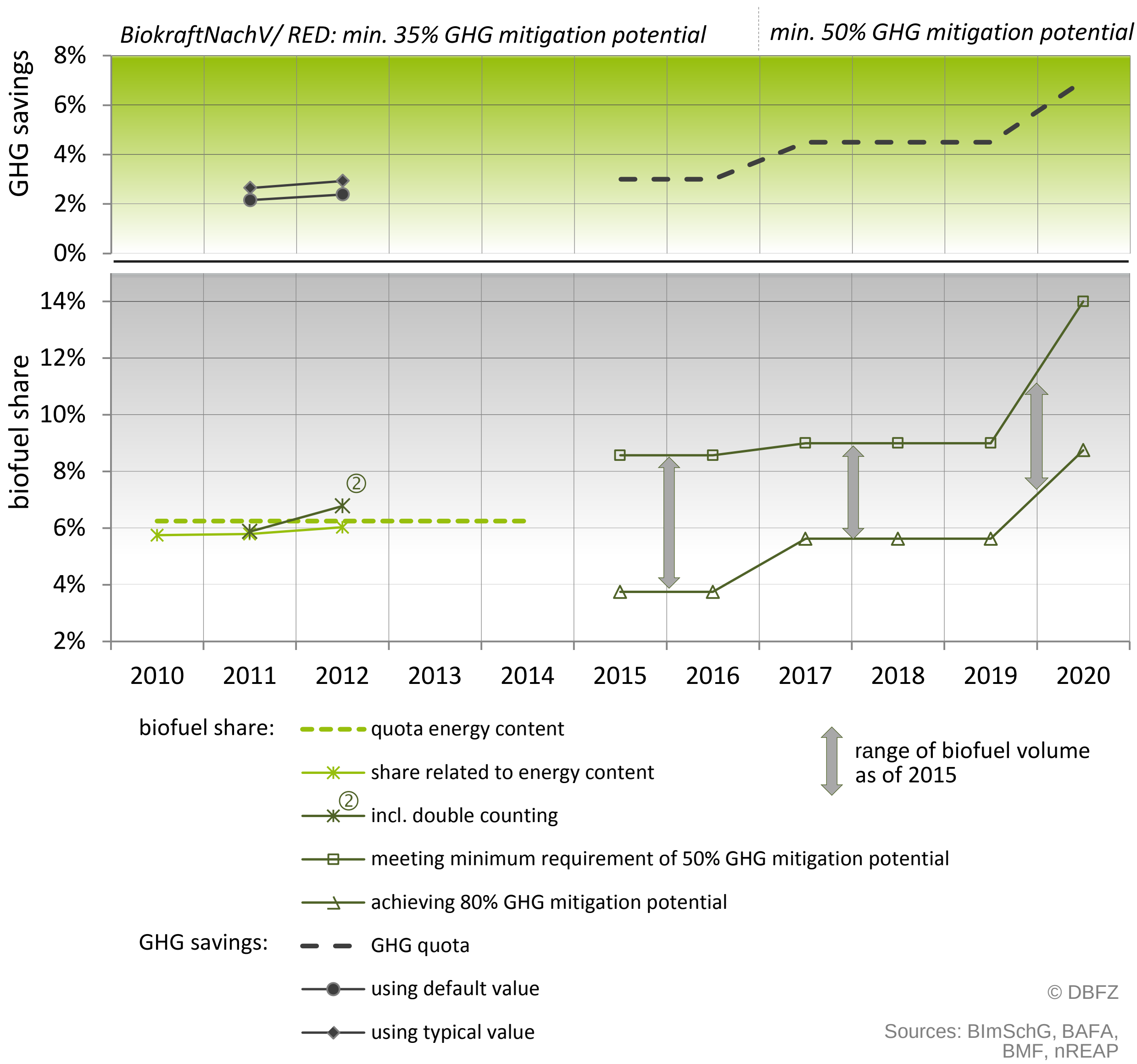

Figure 2-19: Range of biofuel volume for meeting the GHG reduction quota as of 2015, compared to the biofuel volumes used in reference to the biofuel quota from 2010 to 2014 (BImSchG, 2011) (Bundesfinanzministerium, 2013) (*nREAP Germany*, 2010) (BAFA, 2014)

3 Policy support and expected biomass use in 2020 (and beyond)

Bioenergy is part of the overall German renewables policies which in turn are part of the so-called "Energiewende" (energy transition), a governmental policy to phase-out nuclear energy by 2022, to significantly reduce fossil energy use in the longer-term (i.e. by 2050), and achieve GHG emission reductions in parallel (see following table).

Table 3-1: German Energiewende Targets (BMWi 2014)

Category	2011	2012	2020	2030	2040	2050
GHG emissions (vs. 1990)	-25.6%	-24.7%	at least -40%	at least -55%	at least -70%	at least -80% to -95%
Renewable energies						
Share in gross electricity consumption	20.4%	23.6%	at least 35%	at least 50% (2025: 40 - 45%)	at least 65% (2035: 55 - 60%)	at least 80%
Share in gross final energy consumption	11.5%	12.4%	18%	30%	45%	60%

As presented in Section 1, there are several further "sub-targets" established by the Federal Government.

3.1 Sectoral Bioenergy Policies

With regard to bioenergy, Germany employs feed-in tariffs for bioelectricity (see Section 3.1.1), investment support for bioheat systems (in parallel to a renewable heat quota system), and had a renewable transport quota system until end of 2014 which is now changed into a GHG reduction quota system for renewable transport fuels (see Section 3.1.3).

Furthermore, Germany has several policy documents regarding biorefineries and the bioeconomy in general (Section 3.1.4).

3.1.1 Electricity

The he most important legal instrument to promote electricity production from renewable sources in Germany is the Renewable Energy Sources Act (EEG) which was first enacted in April 2000, and revised in 2004, 2009, and 2012. The latest amendment was in 2014 (came into force on 1 August 2014) and, due to drastic changes, is called "EEG 2.0".

The EEG offers fixed payments (feed-in tariffs) for every kilowatt-hour of renewable electricity supplied to the national grid, but in every future year, the tariff is reduced by a certain percentage (dynamic reduction) to account for future cost reductions. There are different tariffs according to type of renewable energy source, conversion technique and plant size.

The 2014 EEG revision responded to the earlier critique (“too much emphasize on land-using maize for biogas”) by introducing a “cap” on additional capacity eligible to feed-in tariffs which restricts **new** bioelectricity to 100 MW_{el} per year until 2017.

The EEG 2.0 also simplified the earlier complex bonus system by introducing “generic” biomass (e.g. wood, straw, other organic wastes) for which systems up to 150 kW_{el} receive 13.66 c/kWh_{el}, systems up to 500 kW_{el} receive 11.78 c/kWh_{el}, systems up to 5 MW_{el} receive 10.55 c/kWh_{el}, and systems up to 20 MW_{el} receive 5.85 c/kWh_{el} – these tariffs are now independent of feedstocks, and conversion technology. Only two “specific” tariffs remain:

- For small-scale biogas systems (up to 75 kW_{el}) using **manure**, the feed-in tariff is 23.73 c/kWh_{el}, but these systems must use at least 80 mass% of manure (annual average), and operate in cogeneration mode.
- For biogas-electricity from **organic wastes**, the feed-in tariff is 15.26 c/kWh_{el} for systems up to 500 kW_{el}, for systems up to 20 MW_{el} it is 13.38 c/kWh_{el}, and all systems must employ composting to treat the digestate.

The EEG 2.0 also strengthened the scheme to “directly market” renewable electricity and to reward dispatchable capacity – both introduced in the 2012 revision.

The newly reduced feed-in tariffs and the “cap” on eligible new capacity led to a **massive decrease in new plants** in 2014 – the German Biogas Association expects that less than 50 MW_{el} of newly-built plants came online, and has a pessimistic view on future electricity produced from biomass. The German Bioenergy Association expects that no new plants for solid biomass will be build. Overall, it is expected that some of the existing companies will go bankrupt in the near future due to lack of markets.

The EEG 2.0 also indicated that by 2017, new renewable electricity systems will not receive a fixed feed-in tariff anymore but will be subject to “auctioning”. A trial for this new mechanism was announced, addressing solar-PV as a pilot case. As in 2017 there will also be federal elections, this may change, though, and many expect that the future “EEG 3.0” could look very different from the current version.

3.1.2 Heat

The existing investment cost support scheme for modern bio-heat systems, especially for pellet boilers, remains – and the budget for this was even increased slightly in 2014.

Germany’s Renewable Energy Heat Act (Erneuerbare-Energien-Wärmegesetz, or EEWärmeG) which came into effect on January 1, 2009 remained also unchanged – a revision is foreseen by the Federal Government in 2015. Its provisions place owners of newly constructed buildings under obligation to use renewable energy to meet a portion of their heat requirements. Along with solar and ambient heat, bioenergy and geothermal heat may also be used.

Under the Act, bioenergy may only be used if it is generated using highly efficient technology (e.g. liquid biomass for conversion to fuel and gaseous biomass in CHP plants). For renewably heat, the Act also allows building owners to use micro-CHP and energy saving measures and to obtain heat from district heating plants if the network is fed from a CHP plant or partially supplied with renewable energy.

3.1.3 Biomethane

The opportunities to feed upgraded biogas (biomethane) into natural gas distribution grids to supply heat or being used in CHP plants and as a transport fuel are regulated unter the German Gas Grid Access Ordinance (GasNZV), the Gas Grid Payment Ordinance (GasNeV) and Incentives Ordinance (AregV). These regulations introduced a 6 % (energy-based) target by 2020 and a 10 % target by 2030 for Germany's gas demand to be met through biomethane.

The regulation also helped to remove barriers against biomethane grid-feed via special provisions, e.g., uniform quality standards, longer balance periods, greater scope for flexibility and special terms.

There are several activities of the German Energy Agency (dena) regarding biomethane, especially online trading platforms, and a federal registry system.

3.1.4 Tranport

The most relevant change of the renewable transport fuel policy is that by January 1, 2015, the previously energy-based quota system for biofuels is replaced by a greenhouse-gas (GHG) reduction quota system (§ 37a BImSchG, as of Nov. 2014). This leads to the following changes:

- From 2015 onwards, there is no more „double counting“ in Germany, as contributions to the required GHG reduction quota is now to be based only on "real" GHG reductions from biofuels
- The GHG reduction targets for biofuels replace the previous admixture values, i.e. from 2015-2016, a net GHG reduction of 3.5 % is required which increases from 2017-2019 to 4 %, and by 2020 it must be 6 %.

The GHG reduction must be calculated against the "reference value" of 83.8 kg CO_2eq/GJ according to § 37a BImSchG, using a calculation method according to §14 of the German Biofuels Sustainability Ordinance (Biokraftstoff-Nachhaltigkeitsverordnung) which also requires to meet the EC sustainability requirements for liquid biofuels.

The new system is yet untested, but it is expected by the German biofuels industry that domestic production may come under pressure from hydrogenated vegetable and waste oils imported from abroad. On the other hand, German producers claim significantly higher GHG reductions from domestic biofuels than from imported 1st generation biofuels (especially for biodiesel) so that their market position might improve.

Given the current uncertainty of the future EU regulation on biofuels (e.g. "cap" on 1st generation biofuels, minimum quota for 2nd generation biofuels, inclusion of GHG emissions from indirect land use change), the parallel uncertainty about the post-2020 energy and climate policy of the EU, and German renewable transport policies currently more in favor of electric (battery and plug-in hybrid) cars running on renewable electricity than biofuels, it can be expected that the current share of biofuels will not increase much until 2020, as investors remain reluctant and overcapacity of 1st generation plants exist.

3.1.5 Bioeconomy

Since 2011, Germany has started several political initiatives addressing biomass in a broader context:

The Federal Ministries for Research (BMBF) and Agriculture (BMEL) developed jointly the “Biorefinery Roadmap” (BMBF et al. 2012) which describes opportunities for multi-output biomass conversion, and especially addresses sustainability requirements, and opportunities for biomass residues and wastes

Both ministries also engage in the Federal Bioeconomy Strategy which runs from 2011 to 2016, covering a budget of more than 2 billion € for R&D in this area (BMBF 2014), and founded the “Bioeconomy Council” (http://www.biooekonomierat.de/english.html) which advises the Federal Government on the issue.

So far, there are no specific policy instruments or regulations in Germany addressing biorefineries or the bioeconomy in general, all incentives are for R&D activities. Yet, there is a growing debate about incentives for bio-based materials, and “advanced” biomass conversion systems such as biorefineries.

3.2 Future Developments

In the years since 2004, bioenergy in Germany has seen significant growth in all sectors – but due to the developments discussed in the previous subsections, it can be expected that this dynamic will change in the coming years.

Preliminary analysis of the EEG 2.0 effects on new net electricity generation indicate that between 2020 and 2030, a net reduction of new electric capacity from biomass can occur, i.e. the overall capacity will shrink due to retirement rates of existing plants being higher than the rate of newly added capacity (Nitsch 2014).

This is shown in the following two figures for electricity from solid biomass, and biogas – the green lines indicate gross new capacity, while the red lines represent net new capacity, i.e. taking into account retirements of existing plants.

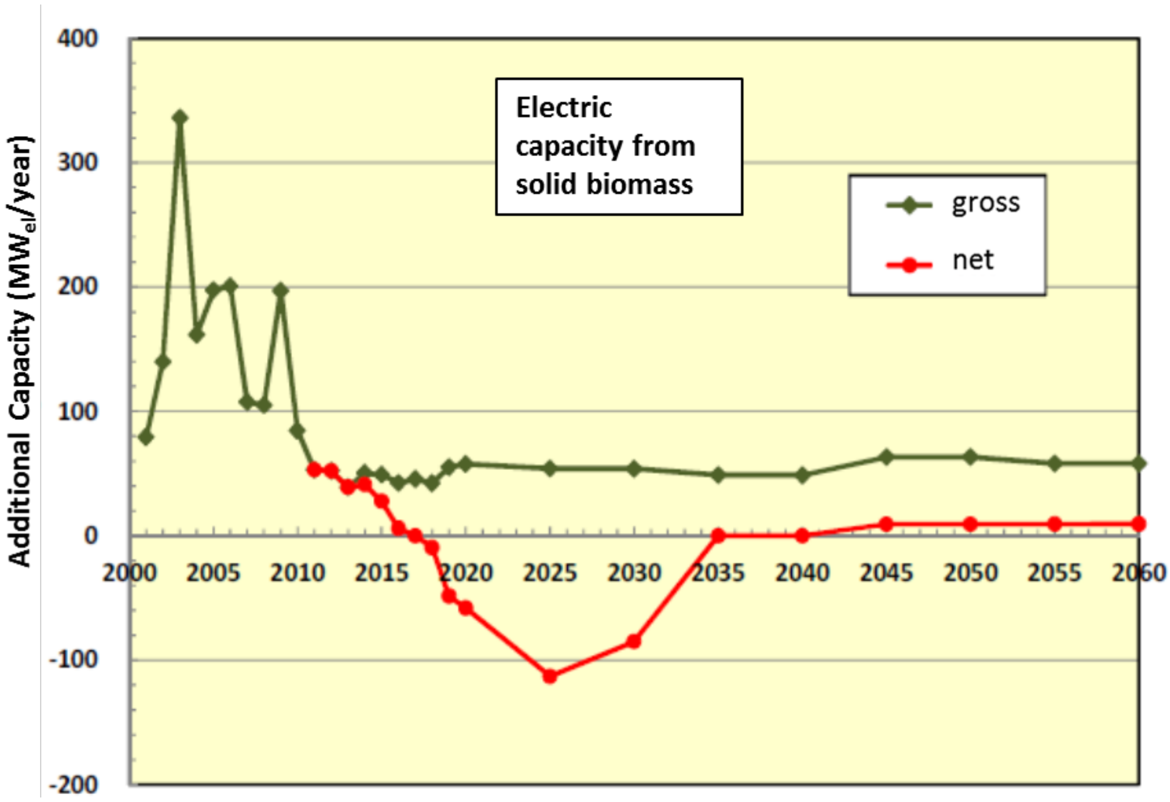

Figure 3-1: Development of New Electric Capacity from Solid Biomass due to the EEG 2.0 (Nitsch 2014)

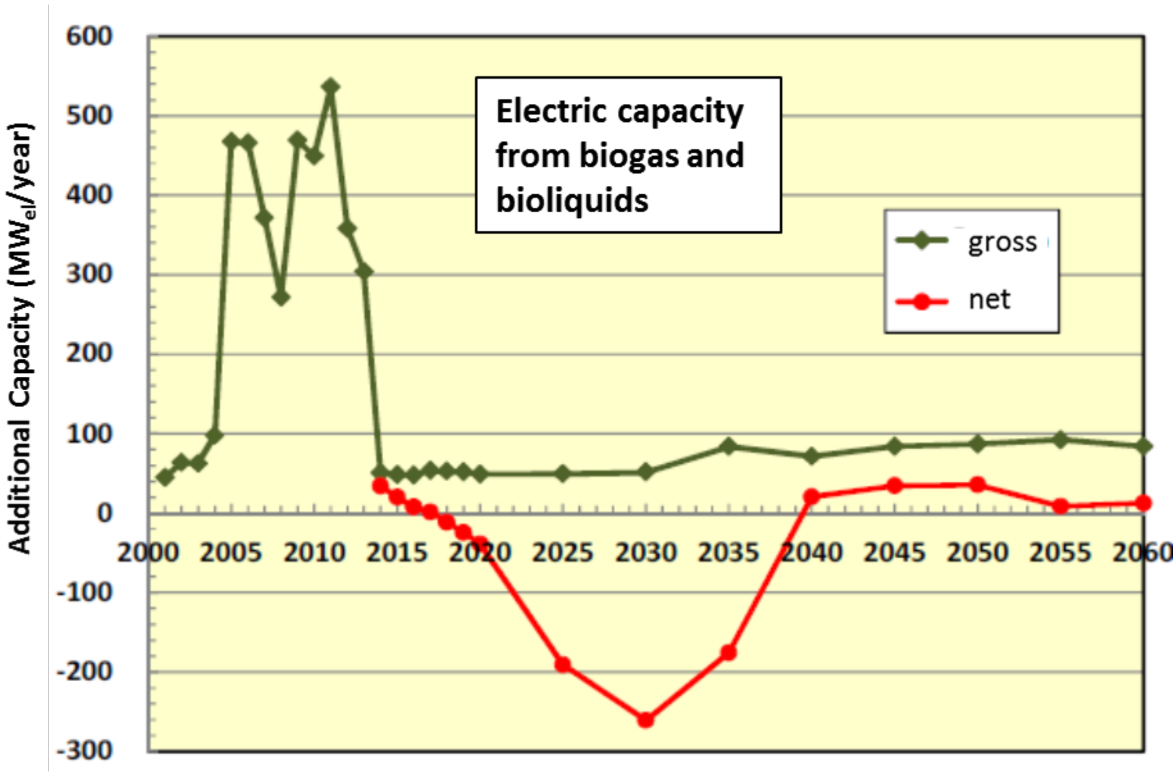

Figure 3-2: Development of New Electric Capacity from Biogad and Bioliquids due to the EEG 2.0 (Nitsch 2014)

The **cumulated** installed bioelectricity capacity under the EEG 2.0 scenario would reach a maximum of 8,200 MW_{el} by the end of 2015, and would then be reduced to 8 GW_{el} by 2020, and to 5 GW_{el} by 2030, i.e. it would reach the level of 2010.

Given the German ambition to further extend the renewables shares in electricity – including bioenergy – by 2020 and 2030, this indicated that the EEG 2.0 may not remain as it is, and additional or other incentives are needed to achieve the Federal Government targets.

In the heat sector, the development of lower oil (and respective natural gas) prices until 2020 implies that **less biomass** will be used unless more favourable incentives will be available. Nitsch (2014) shows that instead of a 15% renewable heat share by 2020 (and 25% by 2030), the current policies would result in only 11% (2020) and 11.5% (2030), respectively. Bioenergy would remain on the 2015 level until 2020, and then be reduced to a lower level than in 2010.

The transport sector – as discussed in Section 3.1.4 – will most probably be characterized by low fossil fuel prices and missing targets for advanced biofuels, which - together with the uncertainty on the post-2020 regulation - may well lead to a similar dynamic as in the electricity and heat sector, i.e. overall levelling-off, and even net reductions by 2030.

All in all, the future perspectives of the German bioenergy system are **not further growth**, but **restructuring** towards more efficient use of residues and wastes, and less land-intense production.

4 Biomass prices

Statistics on the prices as well as the price development of the different biofuels are gathered and published regularly in Germany. Thereby the data is not mainly gathered centrally by the Federal Statistical Office (destatis) as it is practice for conventional energy sources but rather by research institutions and associations. This is mostly due the smaller market share of bioenergy among the energy sources used in Germany. However, it has to be mentioned that in 2010 initial efforts to include bioenergy carriers in the federal statistics can be observed. For instance a wood pellet price index has been established which has been further developed in the past years.

In the following the prices for the main biofuels are presented. Concerning the heating market which is characterized by mainly small-scale users (private households, small- to medium-sized companies) the prices include all transportation costs to the final consumer and exclude VAT. The time series covers the period of 2003 until 2013.

4.1 Solid biomass

4.1.1 Wood pellets

In Germany, wood pellets are primarily used in the heating sector in small- to medium-scale installations (stoves and boilers). The prices presented here reflect the prices for certified wood pellets (ENplus quality).

Market data on wood pellets price development on the German market is mainly gathered by two associations; the central network for marketing and development of agricultural resources in Germany (C.A.R.M.E.N. e.V.) and the German energy pellet association (DEPV e.V.).

C.A.R.M.E.N. e.V. provides monthly prices based on information from pellet retailers. For price calculations, C.A.R.M.E.N. e.V. refers to a purchase quantity of 5 tonnes delivered within a radius of 50 km. DEPV e.V. refers to a purchase quantity of 6 tonnes delivered within a radius of 100 to 200 km. Figures have been available for the years 2003 to 2013.

In Germany the wood pellet prices have been fairly steady with price levels of 160 to 180 €/t (excl. VAT) till 2005. Mid 2006 prices started to rise with a peak price of 245 €/t (excl. VAT) by the end of the year. From 2008 onwards prices have been increasing steadily every year; followed by another price peak in 2013. During 2013 the monthly average prices for wood pellets ranged between 247 and 268 €/t (excl. VAT), with an all-time peak in December. This development was due to a shortage in national wood pellet supply. In saw mills fewer residues accumulated, constituting the main feedstock for the wood pellet production. Since 2012 the production capacity of saw mills has been reduced in Germany as a result of the financial and economic crises. Within in a year the price for wood pellets rose by 15 %. For the coming year only a gradual easing of this situation is expected. Overall, some seasonally variations with higher prices during the heating period and lower prices in summer can be observed. The average wood pellet prices from 2003 to 2013 are shown in Figure 4-1. The values are average prices derived from the prices provided by C.A.R.M.E.N. e.V. and DEPV e.V. The VAT amounts to 7 %.

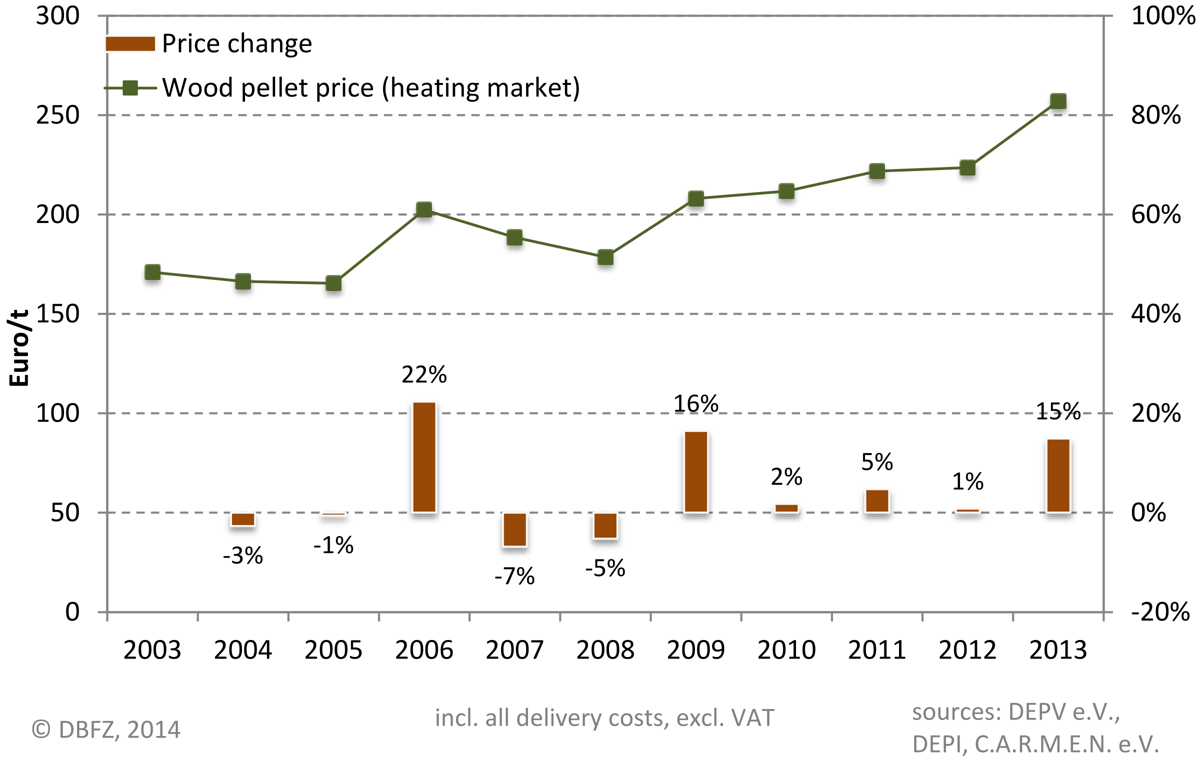

Figure 4-1: Wood pellet price development in Germany from 2003 to 2013 (C.A.R.M.E.N. e.V., 2014b) (DEPV e.V., 2014c)

4.1.2 Waste wood

Information on the price development of waste wood is provided by the scientific journal European economic service (EUWID). The magazine publishes quarterly the prices for the four different categories, that is, qualities of waste wood: I – untreated wood (WW I), II & III – wood treated with paint and glue (WW I/II), IV - wood treated with preservatives (WW IV).

The time series from 2003 to 2013 is shown in Figure 4-2. The prices for each category have steadily risen, in particular for category IV since 2003. This is mainly due to the increased energy-related use of waste wood which is promoted by the Renewable Energy Sources Act (EEG). However, in 2010 a stagnation of the prices can be observed. A reason for this is seen in the problem of running heat and power plants in an economically feasible way due to the increased prices of this wood fuel. The ranges for the average prices for the different categories of waste wood during the year 2013 are: WW I 22.8 to 27.3 €/t; WW II/III: 6.4 to 8.1 €/t; WW IV 4.1 to 4.8 €/t (all excl. VAT). However considering the minimum and maximum prices the ranges are as follows: WW I 10.1 to 46.2 €/t; WW II/III -10.1 to 22.7 €/t; WW IV -16.8 to 22.7 €/t (all excl. VAT). The VAT amounts to 19 %.

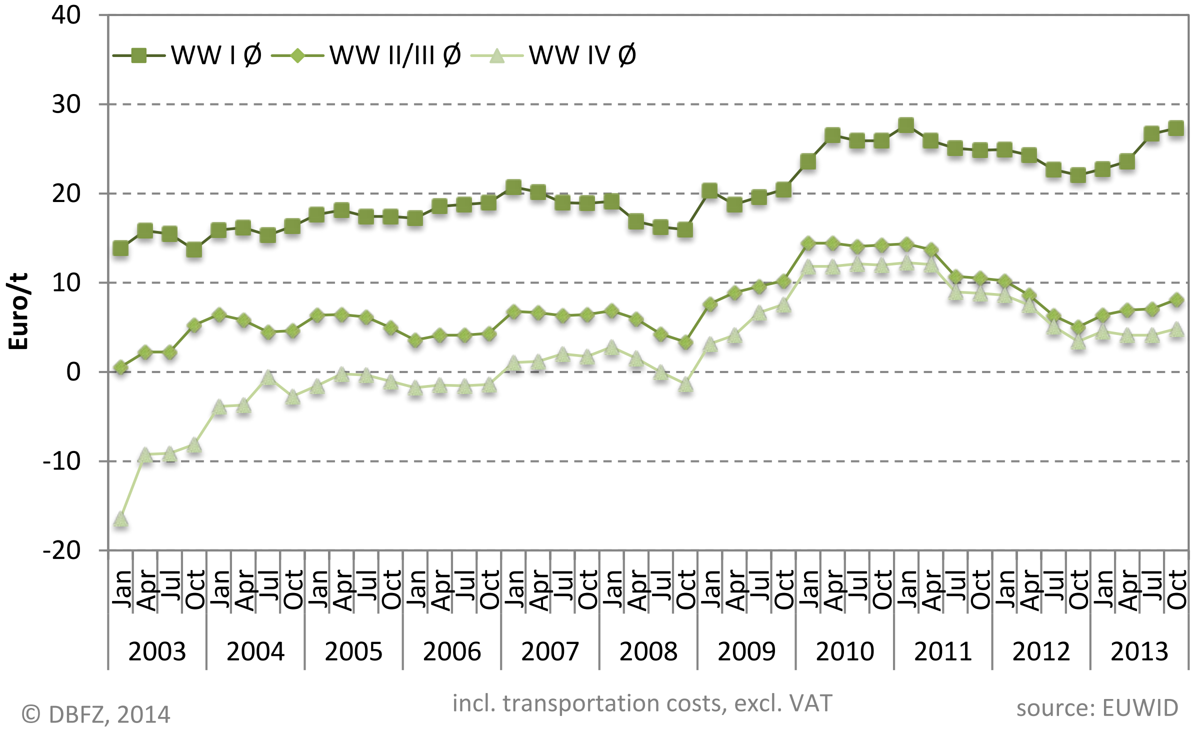

Figure 4-2: Wood waste price development in Germany from 2003 to 2013 (EUWID, 2014a)

4.1.3 Wood chips

Market data on the wood chips price development on the German market is gathered by the associations the central network for marketing and development of agricultural resources in Germany (C.A.R.M.E.N. e.V.). Quarterly, the association publishes the prices for a purchase quantity of 80 cubic meters of wood chips from forest material possessing a water content of 35 % and delivered within a radius of 50 km. The wood chips are mainly used in private households for heat generation in small- to medium-scale installations.

Since the prices have been recorded in 2003 a steady price increase can be noted. Until today a price increase over 100 % could be observed. Overall, some seasonally variations with higher prices during the heating period and lower prices in summer can be observed. In 2013 the average prices for wood chips ranged between 85.7 and 91 €/t (excl. VAT). The time series from 2003 to 2013 is shown in Figure 4-3. The VAT amounts to 7 %.

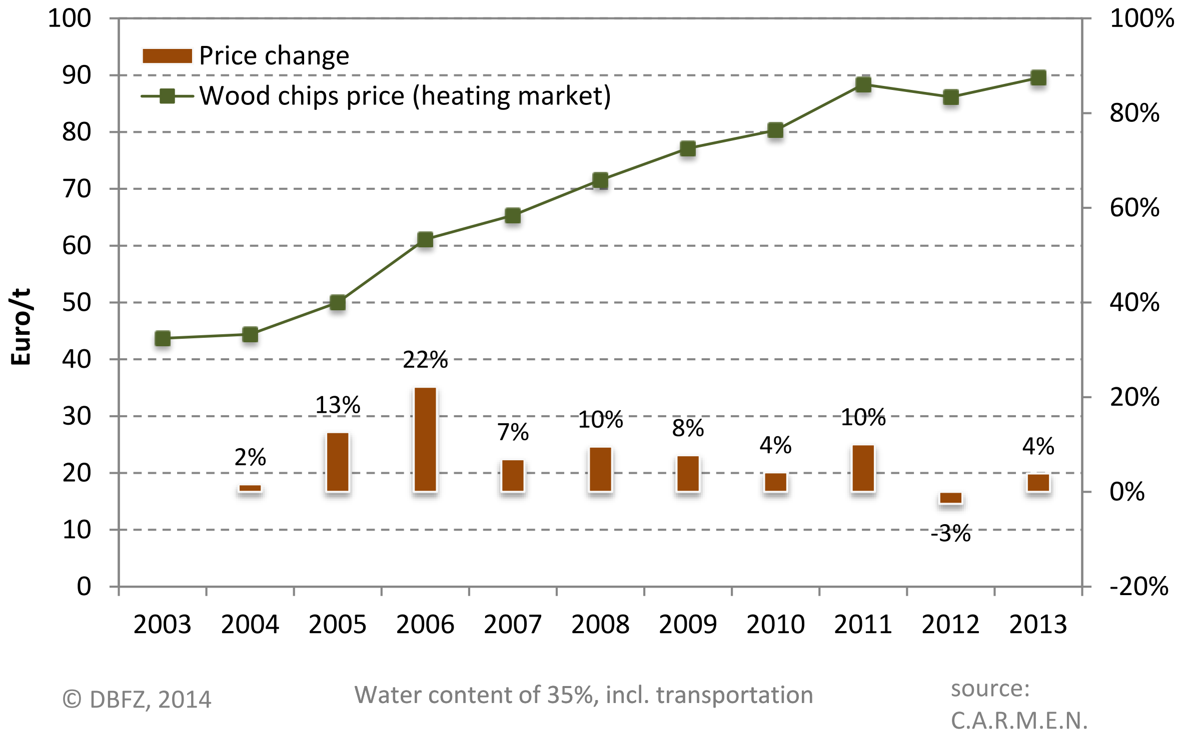

Figure 4-3: Wood chips price development in Germany from 2003 to 2013 (C.A.R.M.E.N. e.V., 2014c)

4.1.4 Wood logs

The Technology and Support Centre (TFZ) publishes biannually the price development of wood logs. The prices refer to the supply of 6 stacked cubic meters (stere) of hardwood made from oak, beech or ash; delivered within a radius of 10 km.

The price for wood logs has been rather stable since recording. An upward movement began in 2006 reflecting an intensified usage of firewood. This was mainly due to the promotion of firewood as fuel within the market incentive programme (MAP), a policy instrument promoting heat generation based on renewable energy sources. The increasing demand resulted in a significant price increase between 2006 and 2007. Compared to the reference year 2005 an increase of roughly 23 % could be observed. The time series from 2003 to 2013 is shown Figure 4-4. The VAT amounts to 7 %.

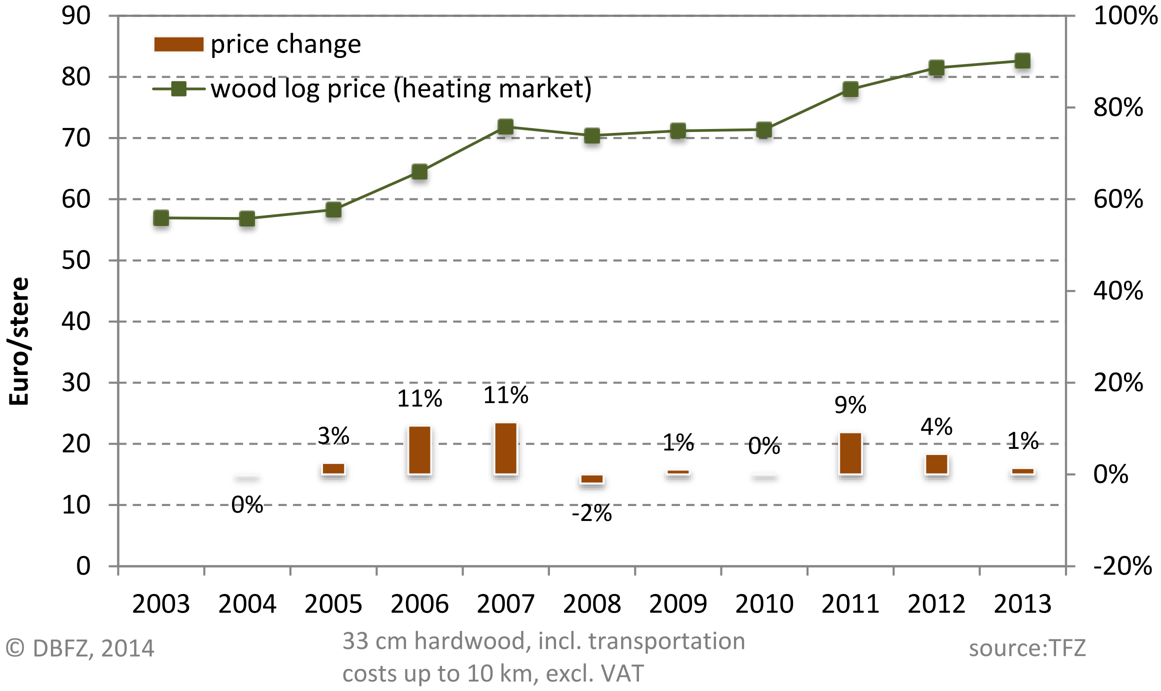

Figure 4-4: Wood log price development in Germany from 2003 to 2013 (TFZ, 2014)

4.1.5 Saw dust

The scientific journal European economic service (EUWID) publishes every two to three months a market review on saw mill residues used e.g. in the wood processing industry and for the production of the energy carrier wood pellets. Hence the overview of prices presents an average price over all the application within the various industries.

The times series dates back until 2007 as shown in Figure 4-5. Over the past years the price for sawdust has risen constantly with a drop in 2008 and 2012. The reason for the overall price rise is seen in a shortage of the national saw dust supply. At the same time the demand went up (increasing number of wood pellet heating installations) resulting in a severe competition among the different industries using saw mill residues as feedstock. In 2013 the price ranged between 11.8 and 14.7 €/m³ (excl. VAT). The VAT amounts to 19 %.

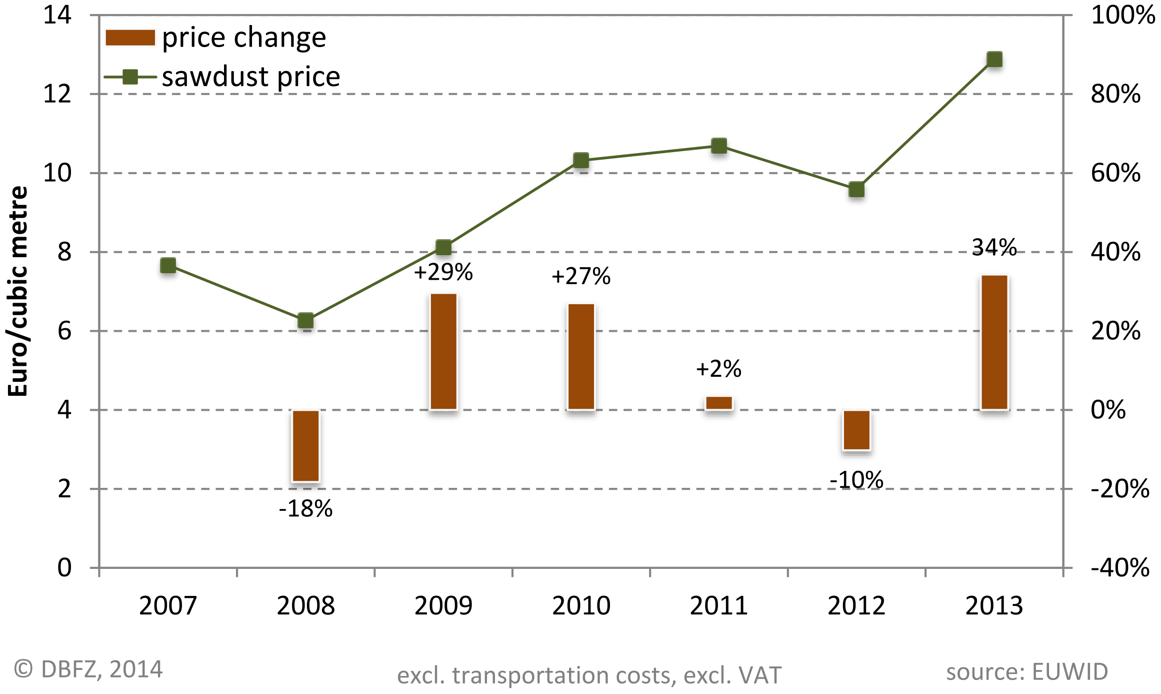

Figure 4-5: Sawdust price development in Germany from 2007 to 2013 (EUWID, 2014b)

4.2 Liquid bioenergy

4.2.1 Vegetable oil

Until 2007 the prices for vegetable oil remained nearly at the same level over the past years as shown in Figure 4-6. However, in 2007/2008 a sharp increase due to a higher demand on the world market could be noted. While the average price for rapeseed oil was 540 €/t (fob Germany, excl. VAT) and for palm oil 340 €/t (cif Netherlands, excl. VAT) in 2005, the prices have doubled until the mid of 2008 and were above 900 €/t for rapeseed oil (fob Germany, excl. VAT) and above 640 €/t for palm oil (cif Netherlands, excl. VAT). This was followed by a decline in the second half of 2008 and another sharp increase from mid-2010 onwards. During 2013 a drop to the price level of 2010 could be noted. One reason for this development is seen in the decreasing demand of rapeseed oil for the biodiesel production. Moreover, the use of vegetable is no longer supported for the combined heat and power production within the Renewable Energy Sources Act (feed-in tariff system) since 2012. Already in the previous years a smaller number of total facilities installed could be observed (Scheftelowitz et al., 2014).

Sun flower oil and rapeseed oil are the most expensive vegetable oils in Germany; in comparison palm oil is by far cheaper. However towards the end of the year 2013 the prices of the various vegetable oils show similar levels. In 2013 the prices for rapeseed oil were between 725 €/t (at the end of the year, excl. VAT) and 920 €/t (at the beginning of the year, excl. VAT), for sunflower oil between 702 €/t (at the end of the year, excl. VAT) and 969 €/t (at the beginning of the year, excl. VAT), for soy oil between 705 €/t (at the end of the year, excl. VAT) and 905 €/t (at the beginning of the year, excl. VAT) and for palm oil between 608 and 689 €/t (excl. VAT).

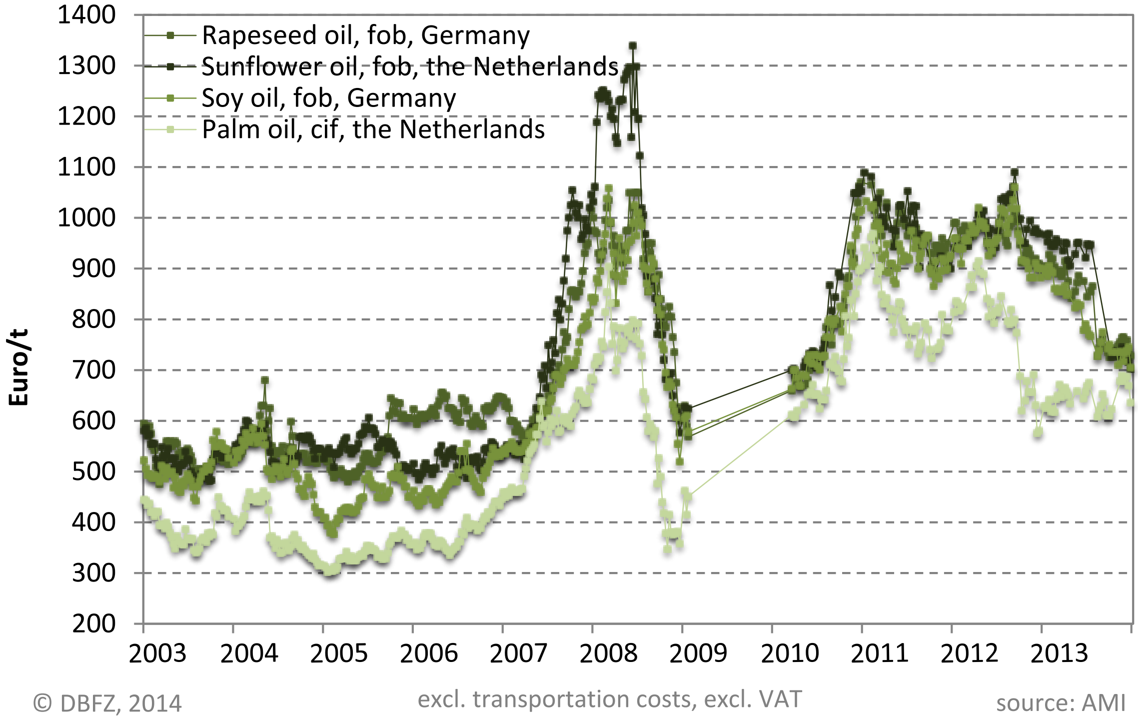

Figure 4-6: Vegetable oil (rapeseed oil, sunflower oil, soy oil, palm oil) price development in Germany from 2003 to 2013 (AMI, 2003)

4.2.2 Biodiesel

The prices for biodiesel (wholesale prices) have been stable in Germany in the years 2009 and 2010. German biodiesel production is mainly based on rapeseed. Since 2010 a significant price increase is reported. Main driver for this development is the higher price for the feedstock rapeseed and rapeseed oil, respectively. During 2013 the average price was 1,450 €/t (Figure 4-7), implying a price increase by 50 % compared to 2010.

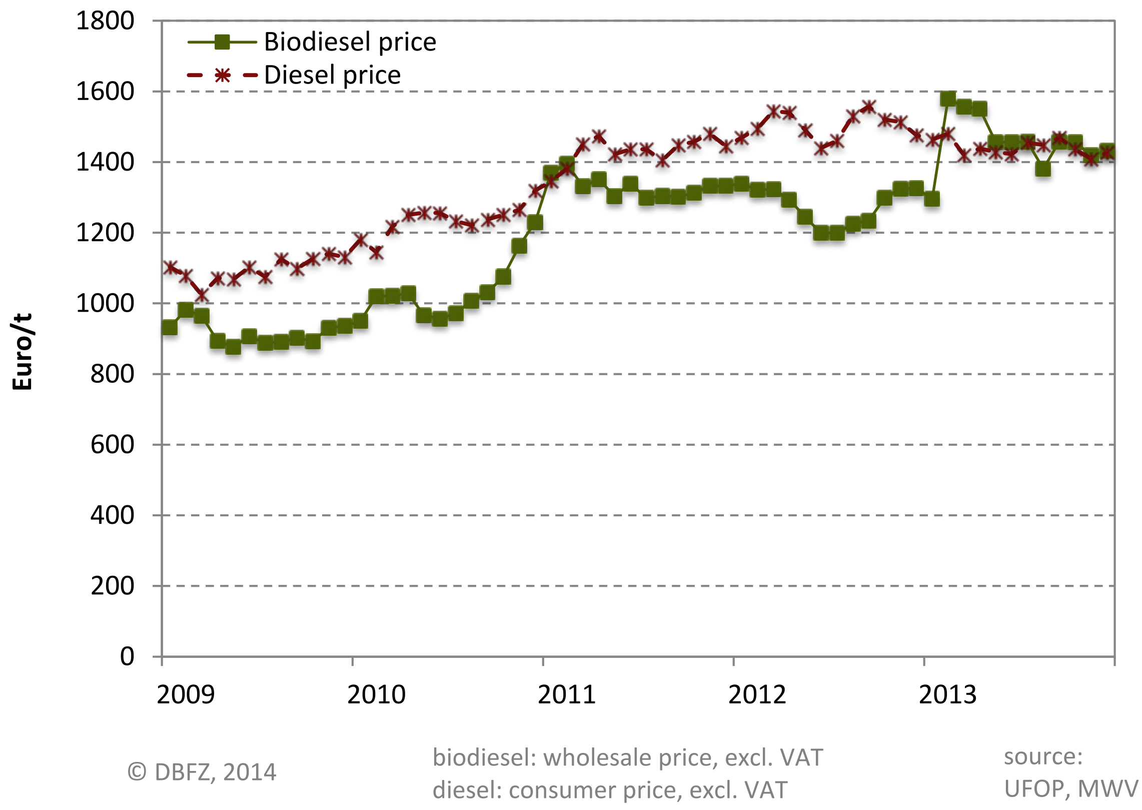

Figure 4-7: Biodiesel and diesel price development Germany from 2009 to 2013 (UFOP, 2014) (MWV, 2014)

4.2.3 Bioethanol

As reference price for bioethanol in Germany, the world market prices from the United States, Brazil and Argentina as the main exporting countries are considered. Since 2009, a rather steady increase from 270 €/m³ in 2009 to 520 €/m³ in 2012 can be noticed (bioethanol from Brazil) (F.O.Licht's, 2013). The price peak for Brazilian bioethanol in March/April 2011 was due to a scarcity of supply in bioethanol. A high world sugar price attracted the use of the sugar cane rather within the sugar than in the ethanol production. In the following months this situation could be defused (Naumann et al., 2014).

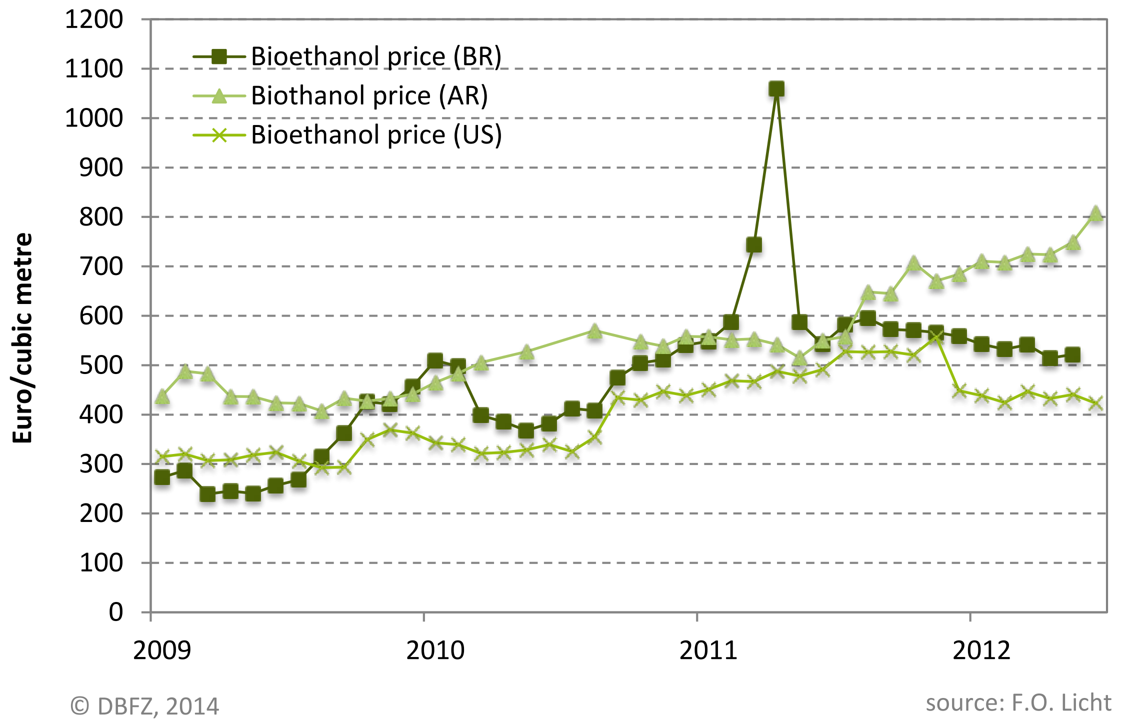

Figure 4-8: Bioethanol international price development from 2009 to 2012 (F.O.Licht's, 2013)

5 International biomass trade for energy

In the following, trading streams and corresponding trading volumes for biomass, which is directly traded for energy-related biomass use, are illustrated. Thereby, the major import and export streams in terms of volumes and the number of trade relations can be noticed for wood pellets and waste wood among the solid fuels and for biodiesel and bioethanol among the liquid fuels on the German market.

5.1 Wood pellets

From the total wood pellet production volume in Germany, it is estimated that about 75 % are intended for the heating market (certified wood pellets) and the remaining for power plants for electricity generation (industrial wood pellets). The majority of the domestic production of certified pellets is consumed nationally. The wood pellets for power generation usage are entirely exported. This is due to the fact that wood pellets are not used in power stations, e.g. in terms of co-firing, in Germany, yet.

The main export countries for industrial wood pellets are the Denmark, Sweden and the United Kingdom. With respect to the trade of certified wood pellets the main trading partners are Austria, Italy, Switzerland and France. In the past the trade of wood pellets mainly took place with bordering countries as Austria and Italy and some trading activities from overseas. However, imports originate increasingly from Eastern European countries like the Baltics and Belarus. Here, it can be noticed that also industrial wood pellets are imported for re-export to other European countries.

Overall, the total volume of wood pellets traded has increased by over 20 % since 2010. In this regard the yearly import volume has increased and the export volume has decreased. This development is a result of both an increasing domestic demand for wood pellets and a shortage of domestic supply. The scarcity of saw mill residues, still resulting from the financial and economic crisis, has caused a severe drop in the national wood pellet production (Solar Promotion GmbH, 2013). Germany has still a positive trade balance. The total export volume for 2013 is estimated at 696,000 tons and the import volume at 527,000 tons (Statistisches Bundesamt Deutschland (destatis), 2014).

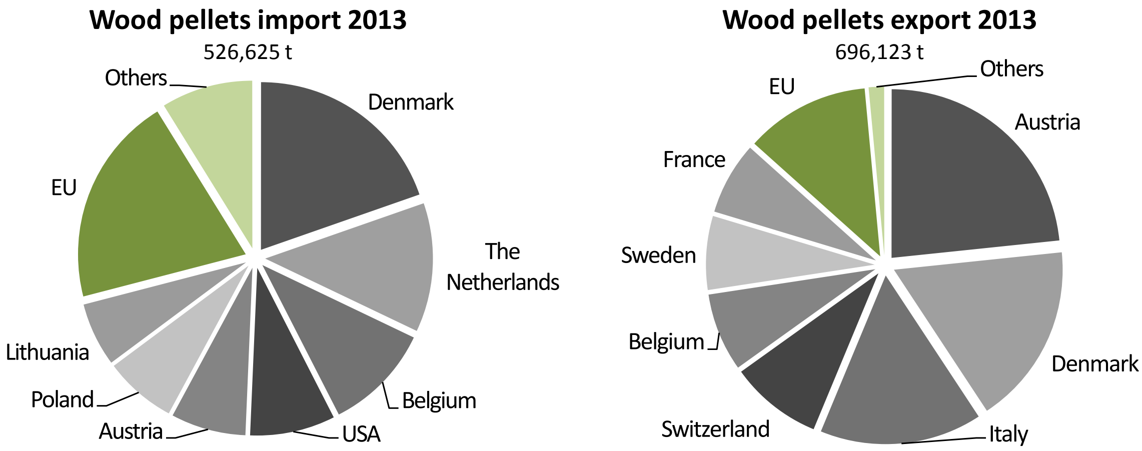

Figure 5-1: Trade of wood pellets: import and export volumes Germany in 2013 (Statistisches Bundesamt Deutschland (destatis), 2014)

5.2 Waste wood

Germany is a net importer of waste wood. The greatest volumes come by far from the Netherlands with an import volume of 333,000 tons amounting to about 50 % of total imports. In contrast, the quantities exported, predominantly to the Netherlands, are very little. The reason for this high demand for waste wood in Germany the use of waste wood for electricity (and heat) production which has been promoted within the feed-in tariff system the Renewable Energy Sources Act with rather rewarding tariffs between the years 2000 and 2008. Overall the trade of waste wood mainly takes place with bordering countries what is due to the fact that a long-distance transportation of waste wood is not economically feasible. Figure 5-2 summarizes the main trading flows.

The total import volume for 2012 is estimated at 650,000 tons and the export volume at 25,000 tons (Umweltbundesamt, 2014).

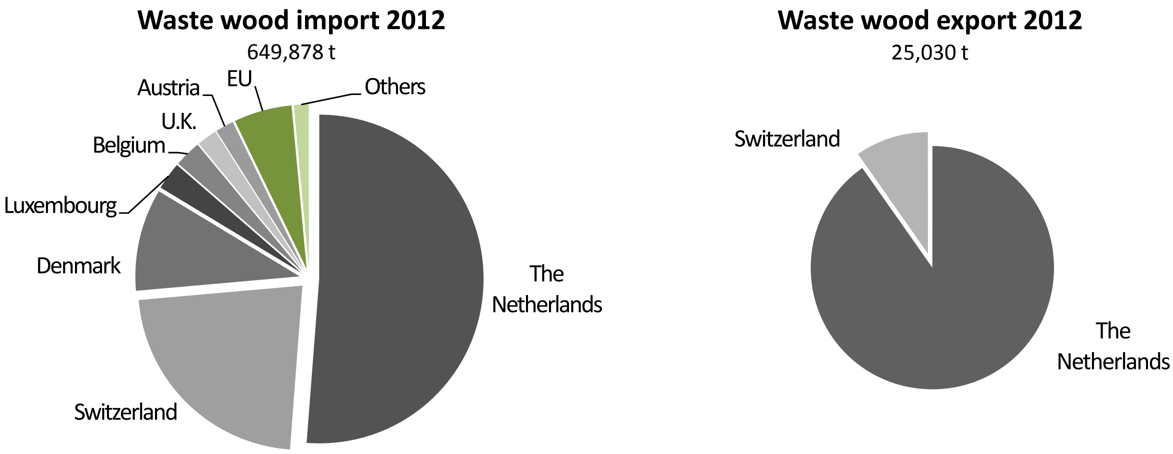

Figure 5-2: Trade of waste wood: import and export volumes Germany in 2012 (Umweltbundesamt, 2014) (data has been compiled according to the disposal code of the Federal Statistics)

5.3 Biodiesel

In 2012, 748,000 tons of biodiesel have been imported and 1,215,000 tons have been exported, hence Germany has a positive trade balance (F.O.Licht's, 2013). The main trading partner is the Netherlands from where about 55 % of the volume is imported. Thereby the majority of the traded biodiesel is processed through the Amsterdam-Rotterdam-Antwerp port, the largest deep sea port in Europe. Countries of origin are mainly Argentina and Indonesia. Further significant import amounts come from Belgium. Considering the exporting flows the Netherlands, Poland, Austria and Belgium are the main receiving countries. Overall the trade of biodiesel happens primarily with bordering countries (Figure 5-3).

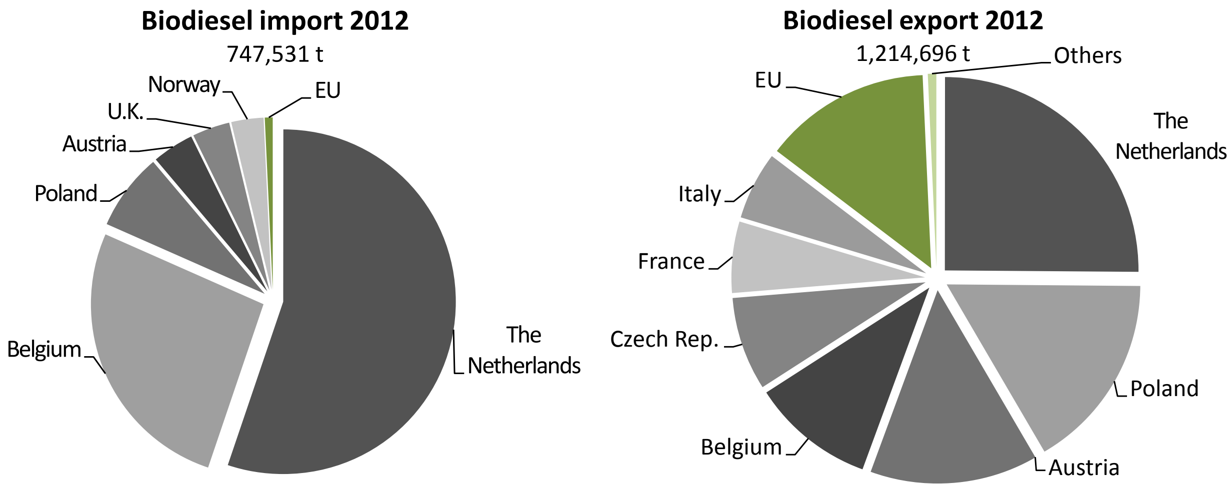

Figure 5-3: Trade of biodiesel: import and export volumes Germany in 2012 (F.O.Licht's, 2013)

5.4 Bioethanol

Figure 5-4 shows the total amounts (energy-related and material use) of bioethanol traded in Germany. The data is only available in an aggregated form for all purposes. In 2012, about 1.4 million m³ of bioethanol have been imported and 200,000 m³ have been shipped abroad. The majority is used for other industrial purposes than fuels. Main trading partners are the Netherlands, Belgium and France and Poland. Thereby the majority of the traded bioethanol is processed through the Amsterdam-Rotterdam-Antwerp port. Countries of origin are in particular Brazil and the United States. Over the past years the import volume has risen due to an increasing domestic demand for bioethanol as fuel. It is estimated that about a half of the bioethanol imports are used as fuel. Germany is a net importer of bioethanol.

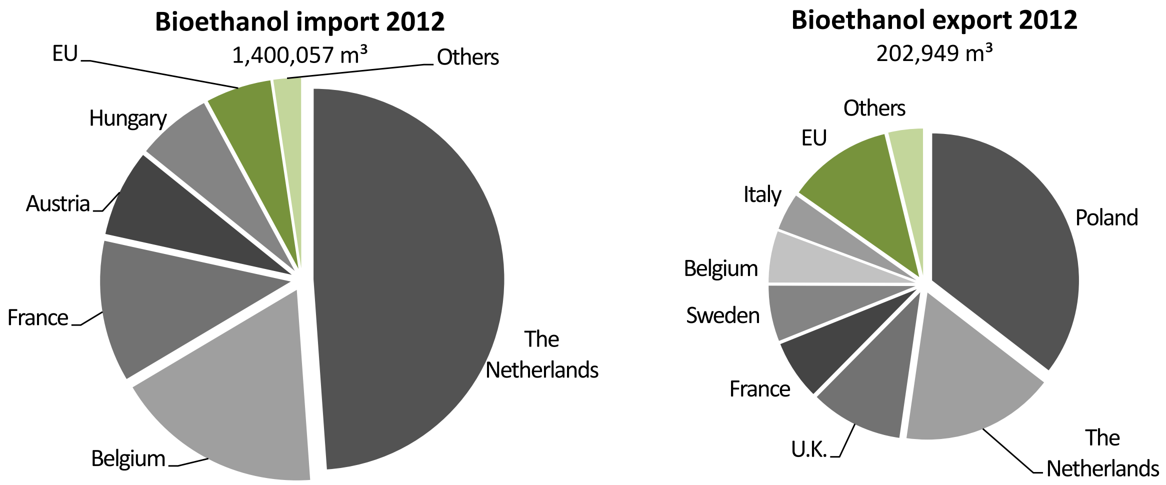

Figure 5-4: Trade of bioethanol: import and export volumes Germany in 2012 (F.O.Licht's, 2013)

6 Drivers, barriers & opportunities

Significant impacts on the international trade of biomass arise essentially from the national policy framework. Here sustainability criteria for liquid biomass and funding instruments, as a feed-in tariff system for electricity generation from renewables and a financial subsidy for the application of renewable energy sources, constrain or support the use of certain biomass resources in Germany. Besides, the national availability of a biomass commodity, its form and related transportability, available standardisation and transportation costs are important drivers.

In the following the focus concerning opportunities and barriers related to biomass trade is on the particular national policies and guidelines for energy-related biomass use in Germany. It is described, how these measures can affect positively or adversely the international biomass trade.

Transport

The Renewable Energy Directive (2009/28/EC) provides the framework for a sustainable use of liquid bioenergy in the transport and electricity sectors in Europe. In Germany this directive has been transposed into national law through the biofuel sustainability ordinance (Biokraft-NachV) for the transport sector. This legal framework asks for additional requirements in the cultivation of biomass as well as the production and trade of liquid biomass. Certification systems verify the compliance with the requirements imposed. For international biofuel producers, primarily producers of palm and soy oil, these guidelines can be an export barrier to the European Union and Germany since additional criteria must be fulfilled. At the same time certification provides the opportunity to achieve a greater social acceptance for an energy-related use of biomass promoting a wide-spread use of biofuels.

Electricity

The electricity provision from biomass is mainly legally supported by a feed-in tariff system the Renewable Energy Sources Act (EEG). The eligibility and amount of financial support depend on the type of feedstock, technology and the size of the installation. In particular, regionally available and produced biomass as energy crops, manure, biodegradable waste and forest residues are eligible for funding. Wood pellets, suitable for transportation from overseas, do not receive financial support. Moreover, the co-firing technology, as a driver for import of large volumes of woody biomass, is not an eligible technology. Additionally, this support measure only applies to biomass-based electricity produced in Germany. Overall, a distributed energy supply is pursued.

As in the case of biofuels, a biomass electricity sustainability ordinance (BioStrom-NachV) for the implementation of sustainability criteria in respect to the use liquid biomass for electricity generation has been introduced.

The above mentioned public policies and guidelines pose a barrier to international biomass trade.

Heating

Biomass for heating is promoted on the basis of a financial subsidy the “Market incentive programme” (MAP) and a building regulation “Renewable Energies Heat Act” (EEWärmeG). These policy instruments aim at the use of renewable energy sources for heating in private households and public buildings. Thus, a rather decentralized provision of energy is supported resulting in small- to medium-scale installations requiring feedstock of certain quality. In the past this has led to a barrier of trade e.g. for wood pellets. Pellets from overseas were not produced according to national quality requirements as a prerequisite for their use in heating installations. Recently, an internationally available standardization system called ENplus has been introduced providing a new opportunity for trade. For example, today there are wood pellet production facilities in the United States which have been certified according to this quality standard.

Outlook

Within the latest amendment of the EEG, which became effective in August 2014, requirements of the EU “Guidelines on State aid for environmental protection and energy 2014-2020”have been transposed into national law. There, the move from feed-in tariff systems towards competitive bidding processes is foreseen. It is argued that the application of competitive bidding processes reduces costs and market distortions for the provision of electricity from renewable energy sources. Moreover, criteria for increasing international energy flows have been established. According to the Renewable Energy Sources Act competitive bidding processes become effective in Germany in the beginning of 2017. A minimum of 5 % of the newly installed capacity every year shall be open for an EU-wide competition (according to § 2 (6) EEG).

Currently, the implementation of the competitive bidding process is discussed on governmental level. Depending on the final implementation[4] and future design of competitive bidding processes, additional feedstock and technologies may become eligible for funding in Germany presenting new opportunities for biomass trade.

[4] The "Guidelines on State aid for environmental protection and energy 2014-2020" allow the continuing support by feed-in tariff regimes under certain conditions, e.g. for smaller installations (123). Considering the current structure and size of biomass installations continuing feed-in tariff system might be an option.

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