Country report: Germany

1. Renewable energy in Germany

Renewable energies provided 12.2 % (bioenergy 8.2 %) of the total energy consumption in Germany in 2011. Figure 1 shows the share of bioenergy in the fields of electricity, heat and biogenic fuels. As you can see, bioenergy is the main renewable energy source for heat and fuels.

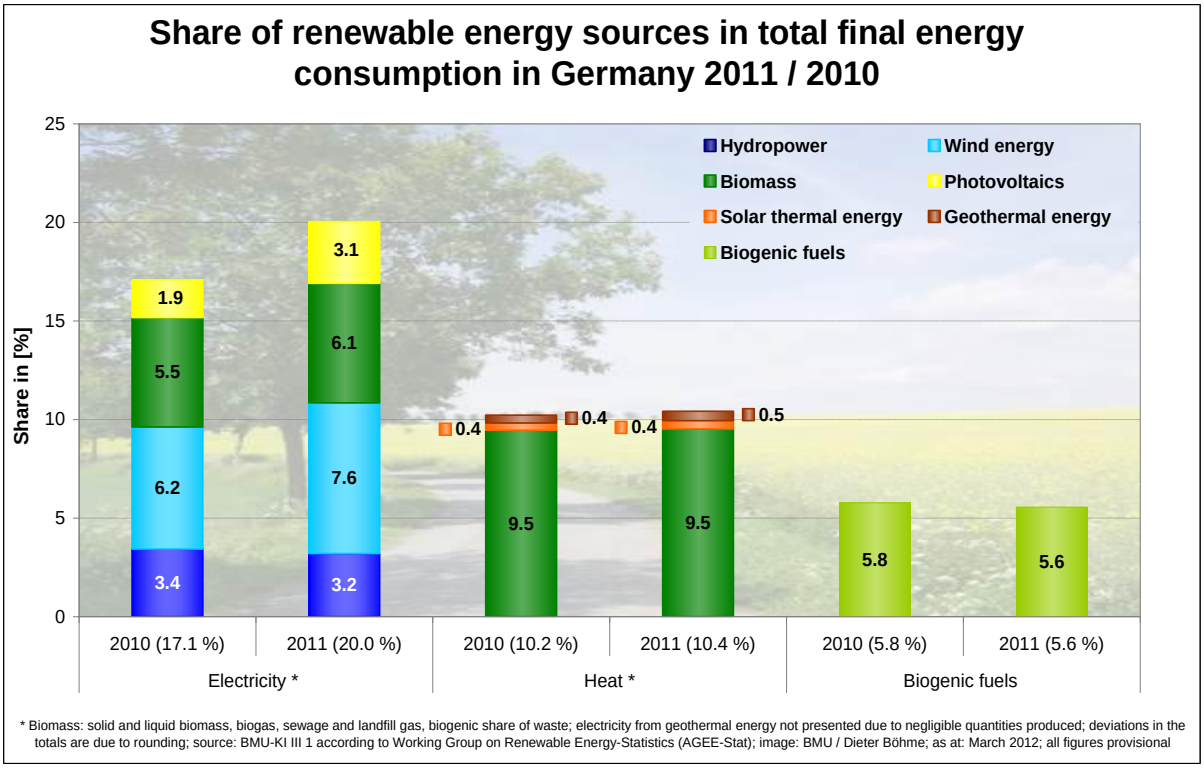

Figure 1: share of renewable energy sources in Germany [source: BMU 2012]

Biogas shares 14.4 % of the renewable energy production in the field of electricity and 11.9 % of renewable heat production in Germany.

2. Biogas in Germany

In Germany 7.215 biogas plants with an energy generation capacity of 2.904 MW are installed in 2011. The majorities of these plants are generating electricity from manure and energy crops and are operated and owned by farmers or farmers cooperatives. Nearly 1.000 biogas plants are owned by communities and the main substrate in this field is sewage sludge and organic fraction municipal solid waste (OFMSW). Only 200 plants are operated by the sector “industry” using waste water. In the field of organic waste the main material flows are utilized in composting plants (approx. 11 Mio t capacity) only approx. 100 biogas plants are operating with 2.6 Mio t capacity (Kern, 2011). Besides traditional feeding of biogas into gas engines, 80 gas processing installation with a capacity of 460 million Nm³ are

connected to the natural gas grid in Germany in 2011. Table 1 shows the facts and the forecast for the German biogas sector (*FACHVERBAND BIOGAS E.V., 2012)*.

Table 1: Biogas sector statistics [source: Fachverband Biogas e.V., 2012]

	2010	**2011**	**Forecast 2012**	**Forecast 2013**
Number of biogas plants (of these feeding biomethane)	4905 (45)	7215 (80)	7521 (100)	7895 (120)
Installed electric output [MW	2291	2904	3185	3312
Net electricity production [MWh/a]	15 Mio.	18.4 Mio.	21.57 Mio.	22.43 Mio.
Proportion of electricity consumption [%]	2.5	3.03		
Jobs	39,100	54,000	48,500	51,800
Export rate [%]	10	10	30	36

The German Energy Concept and the decisions on accelerating the energy transformation of summer 2011 describe the road towards the new energy era. By 2020, the intention is the share of renewables in final energy consumption to reach 18%, and then gradually increase further to 30% by 2030 and 60% by 2050. The German government will strive to ensure the share in electricity production is 35% in 2020, 50% by 2030, a figure that should rise to 60% by 2040, then 80% by 2050.

In the National Biomass Action Plan for Germany (2009) the bioenergy use is expected an increase from 792 PJ by 2007 to 1.309 PJ in 2020 in solid, liquid and gaseous form to produce electricity and heat and to manufacture biofuels. In 2011 the acreage used to grow energy crops already amounted to 2 million ha which is almost 17 % of the arable land. Most prominent are rape seed as crop for biodiesel production (910,000 ha), the provision of substrates for biogas production (800,000 ha) and the cultivation of plants for bioethanol production (250,000 ha). There is also a certain potential for the expansion of agricultural biomass production. The results of various studies show that from 2020 onwards it will be possible to use 2.5 to 4 million hectares of agricultural land for the cultivation of energy crops. Therefore the biogas provides a central element of the future energy supply.

The size of the biogas plants increased over the last two decades. In 1992 there were only some small plants established. But since the introduction of the Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG) in the year 2000 the biogas sector has been becoming more and more important and the size of the plants grew steadily. Especially the amendment to the EEG in 2004 and 2009 supported the construction of agricultural biogas plant operating with energy crops. In 2011 the average plant is about 390 kW_{el} and nearly 92 % plants base on wet fermentation, only 8 % operated with dry fermentation. Figure 2 shows the development of the German biogas sector since 1992.

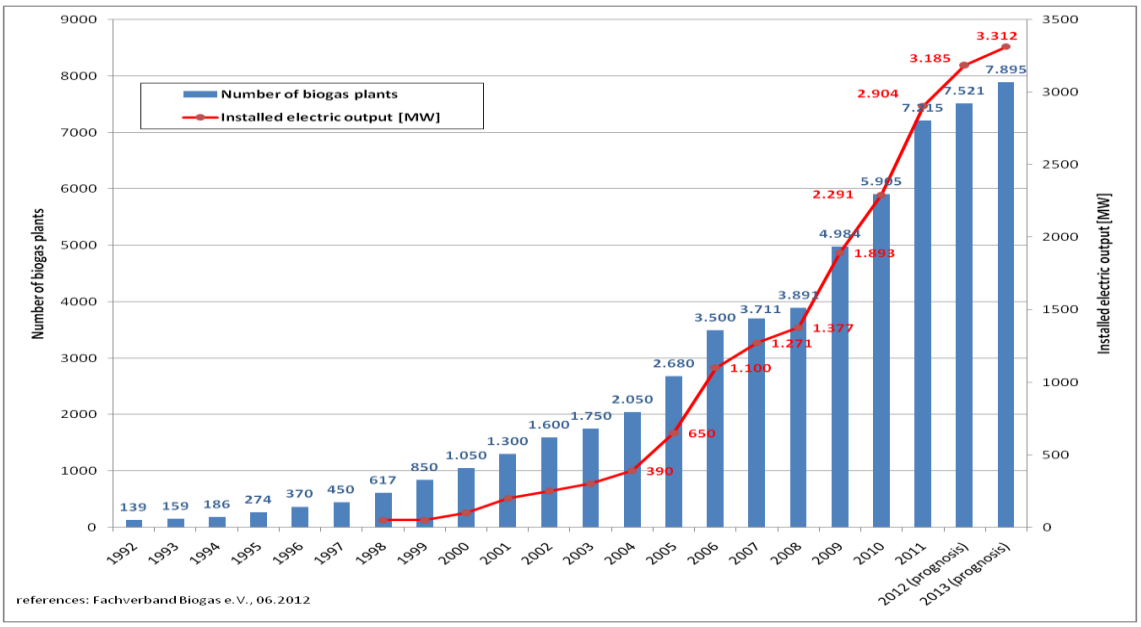

Figure 2: Development of the biogas sector since 1992 to 2013 [source: Fachverband Biogas e.V., 2012]

The biogas plants are dispersed throughout Germany with a concentration in regions with intensive livestock farming. Figure 3 shows the installed electric biogas capacity per 1.000 hectare agricultural land and gives an overview of the situation in Germany.

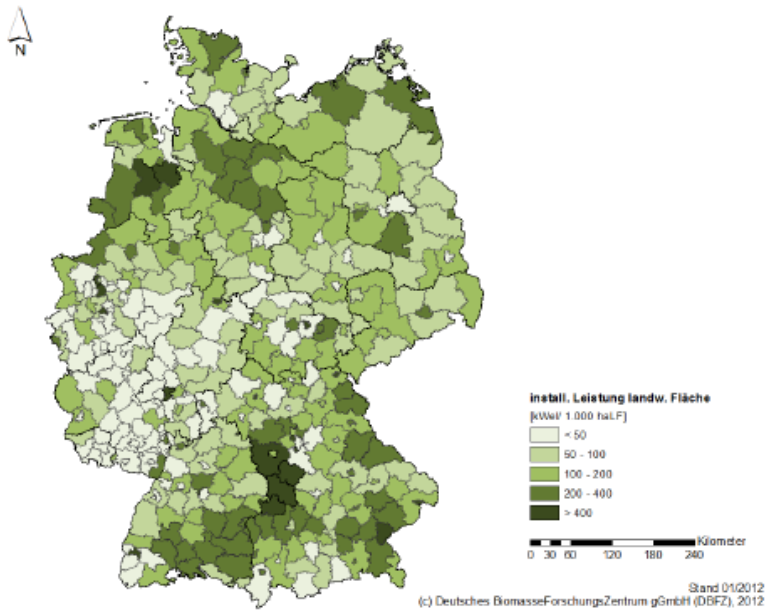

Figure 3: Installed biogas electric output per 1.000 hectare agricultural land [source: DBFZ, 2012]

Cause to the EEG the main input materials in biogas plants are energy crops with nearly 50 %, followed by excrements with 43 %. Organic waste and agricultural residues have only a limited weight with fewer than 10 %. Table 2 shows the detailed input materials in biogas plants in Germany.

Table 2: mass- and energy-based substrate distrubtion in biogas plants in Germany in 2011 [source: DBFZ, 2012]

Input Material		Substrate Distribution in [%] mass-based		enegy-based	
energy crops	corn	38.9	48.9	59.7	76.9
	gras	4.6		6.7	
	whole plant silage (grain)	2.9		4.4	
	grain	1		4.5	
	catch crop	0.8		0.9	
	sugar beet	0.4		0.5	
	others	0.3		0.2	
excrements	cow manure	31.3	42.9	7.7	13.8
	solid cow dung	3.4		2.6	
	pig manure	6.2		1.1	
	poultry solid manure	2		2.4	
organic waste	organic waste	7.2	7.2	7.7	7.7
agricultural residues	agricultural residues	0.9	0.9	1.4	1.4

3. Law in the field of biogas

For construction and operation of an agricultural biogas plant the constructer must apply for permission. Depending on size (rated thermal input >1MW), input material (organic waste), slurry storage capacity (>2.500m³) and storage period and extent of waste (> 10 t /day) a permission under building (*German Construction Law)* or an approval procedure under Federal Immission Control Act (BImSchG) is required. Starting from a dimension of > 1MW also an environmental impact assessment is to carry out.

German Construction Law (Deutsches Baugesetz): According to German Construction Law Biogas Plants are permissible within municipal qualified development plans if the area is legally defined (special area for renewable energy usage or within housing area in the context of an agricultural or forest holding or within housing area as other industrial undertaking or within mixed area as other industrial undertaking or within core area as not essential impacting industrial undertaking or within trading estate area as industrial undertaking of any kind) or priviliged in outside-areas without any municipal development plan if the biogas plant does use biomass for energy production within a holding that keep livestock and is for public power supply and -is local-functional interlinked with holding and

the biomass input is originated mainly from this or neighbouring holdings and there is only one plant per holding and the installed electrical power is not above 0,5 MW.

According to the size of biogas plants (themal input), the permit authorization is either granted by a single building permit (simple permit procedure) (< 10 MW), a simplified emission controll permit with concentration of all other necessary permits (without public involvement) (> 10 - < 50 MW) or an emission controll permit with concentration of all other necessary permits (inclusive public involvement) (> 50 MW). Within the emission controll permit other permits are integrated if applicable: planning and construction permission (location verification), environmental impact assessment, public hearings (raising fundamental objections), safety and health related requirements, water law: substances hazardous to water, waste law: treatment of waste in plants, natur conservation law (offset mechanisms, etc.), diposal and use of fertilizers regulations and removal of animal by products (hygienic requirements Art. 15 EG-VO Nr. 1774/2002 - here treshholds related to output-fertilizer utliziation (according to bio-waste law) and Environmental Impact Assessment hygienic and phyto-hygienic pretreatment with min. 55°C for 24 h 20 days within fermenter (thermophil plant).

The specific investment costs vary according to the size and the system of the biogas plant. Table 3 shows specific investment cost.

Table 3: specific investment cost [source: FNR, 2012]

System	Size	Costs
biogas plant	75 kW_{el}	7000 €/kW_{el}
	150 kW_{el}	5000 €/kW_{el}
	350 kW_{el}	4000 €/kW_{el}
	500 kW_{el}	3400 €/kW_{el}
	1 MW_{el}	2700 €/kW_{el}
biomethane upgrading plant	500 Nm³/h	7500 €/Nm³*h
ORC-unit	75 kW_{el}	4000 €/kW_{el}
micro gas turbine	65 kW_{el}	2000 €/kW_{el}
biomethane production	500 Nm³/h	8.3 ct/kWh
	2000 Nm³/h	6.8 ct/kWh

Biogas plants produce electricity and heat. The generated electricity is fed into the public grid, reimbursed in line with the Renewable Energy Source Act "EEG". The heat is partly used by the system itself. The heat demand of the system in smaller facilities (<70 kW_{el}) is nearly 60 % for heating the fermenter, etc., in plants <1000 kW_{el} this is only 30 %. According to the DBFZ survey 45 % of the surplus of heat is used for e.g. district heating, heating of buildings, greenhouses or stables and drying. [DBFZ, 2012]

EEG – Renewable Energy Sources Act (Erneuerbare Energien Gesetz): The EEG promotes the renewable energies in Germany since 2000, because it provides the prioritized feed-in of

electricity from renewable sources and for a 20-year guarantee off remuneration rates. All renewable energy plants, which are installed since 01.01.2012 are relying on the legal regulations of the amendment of Feed-In Tariff Law 2012. Feed-In-Tariff statuated for 20 years starting one year after operation; with an annual degression of 2% and external heat usage obligatory. Germany focuses mainly on manure and energy crops as substrates. The tariff systems base on 4 types of plant size categories with basic tariffs between 6 and 13 ct/kWh (the bigger the less). The basis fee cumulate with Input categories I, II and Biomethan injection. Category I comprises mainly energy crops, category II is dealing with biomass which is not already in use, residues from livestock (e.g. manure) and "new" energy crops. Fee for Biowaste is not cumulative with other fees. Further plant operators can decide to neglect the EEG 2012 Feed-In Tariff but to promote the electricity on market. Acting on free market, plant operators receive the Optional Market Fee by EEG 2012, which comprises the difference between EEG 2012 tariff and the ex-post monthly calculated average electricity stock prices. The following chart summarizes the feed-In tariff system EEG 2012:

Installed capacity	Basic fee	Input-category I	Input category II	Bio waste Input category	Biomethan injection and CHP conversion
≤ 75 kW	25 ct/kWh*			/	3 ct/kWh until 700 Nm^3/h (ca. 1,6 MW) 2 ct/kWh until 1000 Nm^3/h (ca. 2,3 MW) 1 ct/kWh until 1.400 Nm^3/h (ca. 3,2 MW) Nominal capacity of biomethan plant
≤ 150 kW	14,3 ct/kWh	6 ct/kWh	8 ct/kWh	16 ct/kWh	
≤ 500 kW	12,3 ct/kWh	6 ct/kWh	8 ct/kWh	16 ct/kWh	
≤ 750 kW	11 ct/kWh	5,0/2,5 ct/kWh**	8/6 ct/kWh***	14 ct/kWh	
≤ 5.000 kW	11 ct/kWh	4,0/2,5 ct/kWh**	8/6 ct/kWh***	14 ct/kWh	
≤ 20.000 kW	6 ct/kWh	0	0	14 ct/kWh	

*Special tarif for small plants from agricultural holdings, which use mainly (80 %) manure as substrate (75kW); maximal input of crops at 60%.

Basically, the Act for Promoting Closed Loop Management (Kreislaufwirtschaftsgesetz – KrWG 2012) and the Biowaste Ordinance (BioAbfV 2012) govern the conditions of treatment and use of fermentation residues, the digestate. The nutrient rich digestate from the agricultural biogas plant can be successfully used as a fertilizer and can be distributed on fields in liquid form. In this case it is called farm fertilizer (Wirtschaftsdünger) just as slurry, liquid and solid manure and falls under the Regulation of Farm Fertilizer Ordinance (Wirtschaftsdünger-Verordnung – WdüngV). Only the ingredient manure is taken into account in the calculation of the nutrients for the application rate. The nutrients form energy crops and other input material is not considered

Futhermore the Fertiliser Law (Düngemittelgesetz - DüngG 2012), the Fertiliser Ordinance (Düngeverordnung DüV 2012), the Requirements for Fertiliser Ordinance (Düngemittelverordnung DüMV 2012) and the Federal Soil Protection Law (BBodSchG 2012)

regulate the production, composition and application of fertilizer. These regulations focus on the spread of nutrients and nutrient composition. Furthermore they define the difference between fertilizers, soil improvers and growing media.

Moreover the Animal-by Products Regulation (EU 1069/2009; TierNebV) must be taken into account. This distinguishes between the different input material groups kitchen and catering waste (category 1), other category 3 materials (category 2) and manure and gastrointestinal substances (category 3).

Act for Promoting Closed Loop Management (Kreislaufwirtschaftsgesetz – KrWG 2012)**:** The requirements and the processes of modern waste management are defined in the Act for Promoting Closed Loop Management, which deals with the avoidance, use and disposal of waste. The purpose of the law is to support closed-loop waste management for the protection of natural resources and the assurance of environmentally appropriate disposal of waste. The KrWG entered into force on the first of June 2012.The KrWG is implemented via ordinances for different waste material groups, e.g. for electronic waste or for packaging material or for biocompost/secondary organic raw material. The act includes the obligation of separate collection of biodegradable waste until the 1st January 2015. To promote the material recovery of biodegradable waste biowaste according to the waste hierarchy, a threshold with a heating value of 11 MJ/kg for biowaste is included. Biowaste with a heating value below 11 MJ/kg biowaste shall be recycled materially.

Biowaste Ordinance (BioAbfV 2012): The Biowaste Ordinance (BioAbfV) of 2012 covers the application of treated and untreated bio-wastes and mixtures on land which is used for agricultural, silvicultural and horticultural purposes. It also covers suitable raw materials, quality and hygiene requirements, and treatment and investigations of such biowastes and mixtures. The Biowaste Ordinance regulates – from a precautionary perspective – the waste side (e.g. heavy metals) of the application, whereas the fertiliser law regulates the nutrient part.

Regulation of Farm Fertilizer Ordinance (Wirtschaftsdünger-Verordnung WDüngV 2010): Since 2010 the WDüngV regulates the marketing and transport of solid and liquid manure and digestate. The owner of these materials have record keeping, retention (3 years), reporting and disclosure requirements. Exceptions exist for activities within a farm or between farms of the same authorized person within a 50 km and for companies if the amount is <500 kg N per year, <200 tonnes fresh weight per year or for the delivery of small packages <50 kg for non-commercial customers.

Fertiliser Law (DüV 2012): Gives the frame for the good code of practice of fertilising and shows special requirements for organic fertilisers. It includes the restrictions for the application of fertilisers with essential nitrogen contents in winter periods.

Fertiliser Ordinance (Düngemittelverordnung DüMV 2012): Together with the revision of the law of fertilisers, compost from biodegradable household waste is subject to the fertiliser ordinance as a secondary raw material fertiliser. A spreading of secondary raw material fertiliser will be only possible on agricultural areas if the demands of the Biowaste Ordinance are fulfilled, and the legal standards – here for a secondary raw material fertiliser – are met. A declaration of the fertiliser type, raw material, nutrients and other product properties is obligatory. From 2017 the threshold values for contaminants, included in the Fertiliser Ordinance for biowaste and sewage sludge, are obligatory.

Federal Soil Protection Law (BBodSchG 2012): Ensures the soil function and gives among others precautionary requirements for the contamination of soils. The soil protection law is relevant for the application of compost for landscaping and recultivation.

Animal-by Products Regulation (EU 1069/2009; TierNebV): In Germany the Animal-by Products Regulation is implemented by specific regulations in respect to the different input material groups kitchen and catering waste, other category 3 materials and manure and gastrointestinal substances.

Group 1: Kitchen and catering waste (biobin materials and commercial kitchen and catering waste): For this group does apply the TierNebV, that means that the requirements of the treatment of these materials have to fulfil the requirements of the Biowaste Ordinance. The materials have to be collected and stored separately

Group 2: Other category 3 materials for composting - these are essentially wool, bristles, feathers, eggshells, horn substances etc. For these materials the ABPR does apply, this means pasteurization of the materials (70°C; 1h) and the production plant has to been approved under ABPR.

Group 3: Manure and gastrointestinal substances: In this case there are no requirements

In addition, there is a certification system for digestate established in Germany. It is recognized by the RAL, the German Institute for Quality Assurance and Certification, as being the organisation to handle monitoring and controlling of the quality of compost, digestate and humus products of sewage sludge in Germany. With the revision in 2007 the digestate products are divided into two product groups for digestion residuals according to the input materials: the RAL GZ 245 for digestion products and the RAL GZ 246 for digestion products produced from renewable energy materials.

RAL GÜTEZEICHEN Gärprodukt — RAL – GZ 245 digestion products

RAL GÜTEZEICHEN NawaRo Gärprodukt — RAL – GZ 246 from renewable energy materials

Figure 4: Labels for digestion products from RAL, German Institute for Quality Assurance and Certification [source: Gütegemeinschaft Gärprodukte e.V.)

4. Agriculture in Germany

According to an agricultural census in 2010 in Germany 13 million livestock units are hold with an utilised agricultural area of 16,704,000 ha. This corresponds to a livestock density of 0.78 LSU/ha. In relation to the agricultural land of the livestock holdings (12,782,182 ha) the average is 1 LSU/ha.

The biggest part of the livestock units with approx. 9 Mio. LSU is represented by cattle followed by pigs with approx. 3 Mio. LSU. Figure 5 shows that in North Rhine-Westphalia, Lower Saxony and parts of Schleswig-Holstein and Bavaria as well as on the boarders to The Netherlands and Belgium areas with intensive animal husbandry are situated.

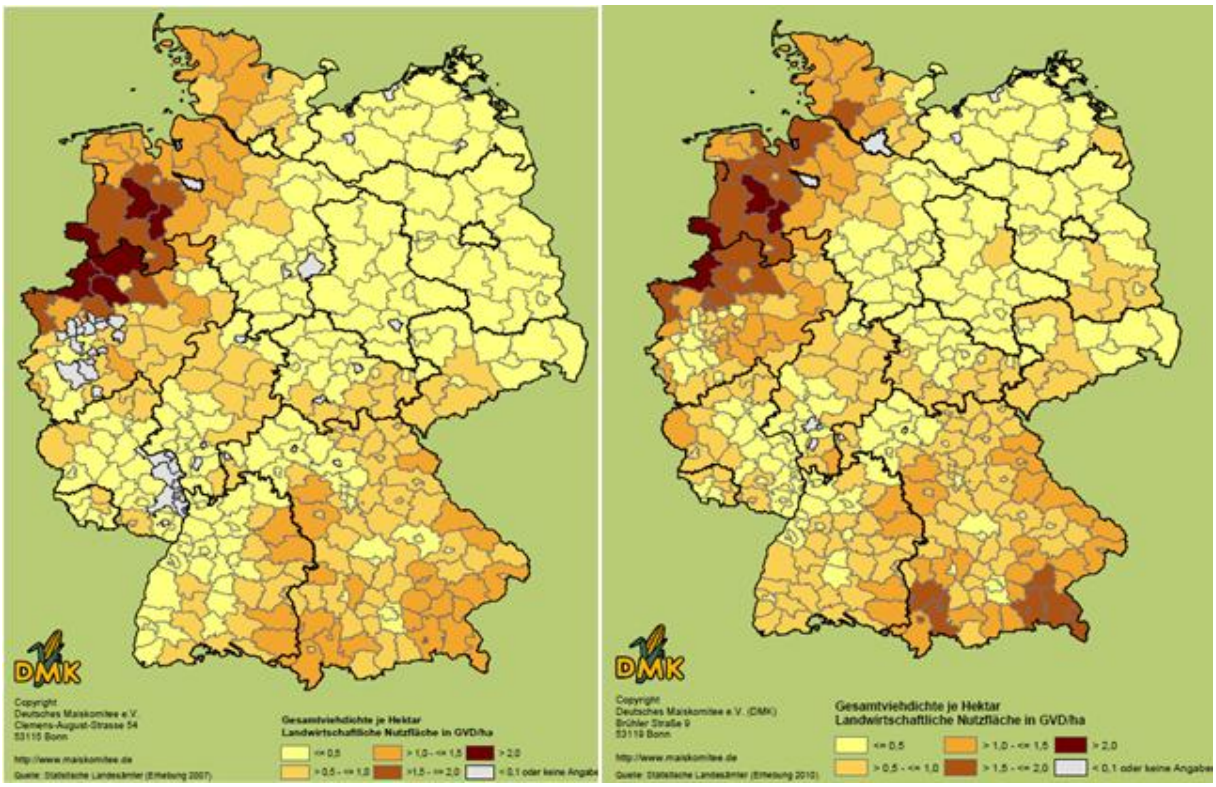

Figure 5: Livestock density in LSU/ha utilised agricultural area 2007 (left) and 2010 (right) [source: Deutsches Maiskomitee (2010)]

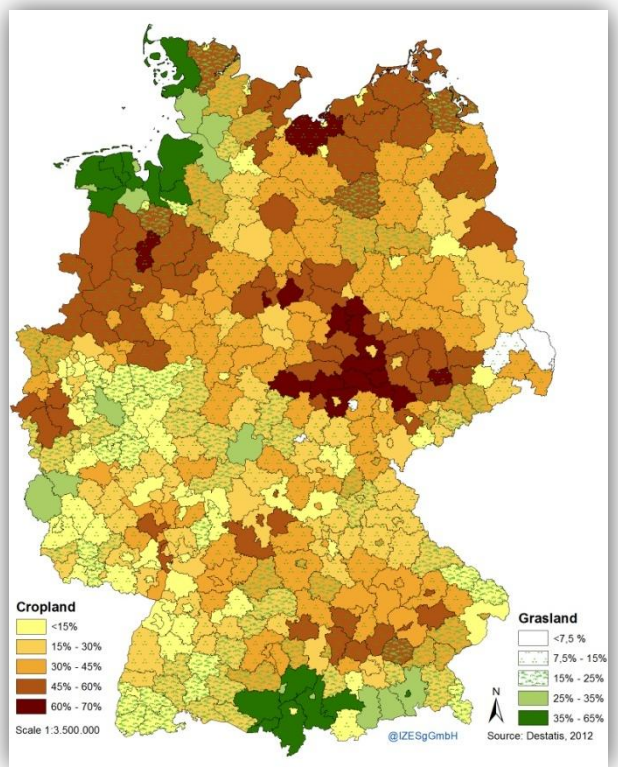

Figure 6: agricultural and grassland area in % of total district area [source: own graph; data: Destatis, 2012]

As you can see in Figure 6 there are agricultural priority areas in Thuringia, Saxony, Saxony–Anhalt, Mecklenburg Pomerania as well as in Lower Saxony, North Rhine-Westphalia and in

parts of Bavaria and Brandenburg. Grassland regions are in southern Germany as well as in Lower Saxony.

According to the BMELV (Federal Ministry of Food, Agriculture and Consumer Protection, 2011) 97.47 kg N/ha mineral fertilizer and 53.38 kg N/ha organic fertilizer have been applied to the agricultural land in 2010. Furthermore 24.2 kg N/ha atmospheric deposition, 13.09 kg N/ha biological nitrogen fixation and 1.37 kg N/ha over seed and propagating material must also be taken into account. This nutrient supply of 189.51 kg N/ha is matched by an export of 67.04 kg N/ha for market fruits and 54.41 kg N/ha for feeding crops and byproducts. The resulting surplus of nitrogen is 68 kg N/ha.

According to the fertilizer ordinance a maximum surplus of 60 kg N/ha (in average over three years) is permitted. According to the heterogenic agricultural structures in Germany, it can be assumed that larger and smaller amounts than this reference value are expected in the different regions.

5. Literature

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