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Final Report

Implementing the GBEP Indicators for Sustainable Bioenergy in Germany

established as German contribution accompanying the **Working Group on Capacity Building (WGCB)** of the **Global Bioenergy Partnership (GBEP)**

on behalf of the Federal Ministry for Economic Affairs and Energy (BMWi) in cooperation with the Federal Ministry of Food and Agriculture (BMEL)

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Content

Acronyms

AGEE-Stat	Working Group on Renewable Energy Statistics
BMBF	German Federal Ministry for Education and Research
BMELV	Federal Ministry of Food and Agriculture
BEFSCI	Bioenergy and Food Security Criteria and Indicators
BfN	German Federal Agency for Nature Conservation
BLE	German Federal Agency for Agriculture and Food
BMU	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BMWi	Federal Ministry for Economic Affairs and Energy
CBD	Convention on Biological Diversity
DDA	Federation of German Avifaunists
Destatis	German Federal Statistical Office
EC	European Commission
ER	Energy ratio
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FNR	German Agency for Renewable Resources
GBEP	Global Bioenergy Partnership
GBO	German Land Registration Code
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographic information system
GEMIS	Global Emissions Model for integrated Systems
HNVF	High nature value farmland
IACS	Integrated Administration and Control System
IEA	International Energy Agency
IFEU	Institute for Energy and Environmental Research
IINAS	International Institute for Sustainability Analysis and Strategy
ILO	International Labour Organization
ILUC	Indirect land-use change
IOT	Input-output tables
IRENA	International Renewable Energy Agency
JRC	Joint Research Centre
LAWA	Government / German Länder Water Working Group
LCA	Lifecycle analysis
LUC	Land-use change
LULUC	Land Use and Land Use Change
NIR	National Inventory Report
NGO	Non-governmental organisation
RED	European Renewable Energy Directive
REDD	Reducing Emissions from Deforestation and Forest Degradation
R&D	Research and development
SOC	Soil organic carbon
SOM	Soil organic matter
SRC	Short Rotation Coppices
TARWR	Total actual renewable water resources
TAWW	Total annual water withdrawals
TI	Heinrich-von-Thünen-Institute
UBA	Federal Environment Agency
UN CCD	United Nations Convention to Combat Desertification

UN DESA United Nations Department of Economic and Social Affairs
UNDP United Nations Development Programme
UNECE United Nations Economic Commission for Europe
UNEP United Nations Environment Programme
UNFCCC United Nations Framework Convention on Climate Change
WGCB Working group on Capacity Building

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1 Executive Summary

1.1 Key findings

General applicability and data background

In general, the GBEP indicators are mostly applicable and cover the whole scope of bioenergy sustainability in Germany.

In principle, the full set of GBEP indicators should be applied in a country for the pilot testing. Yet, the German case excluded five indicators (13, 14, 15, 21, 23) from the beginning due to their clearly proven low relevance for the German bioenergy situation. The assessment shows that five more indicators (5, 9, 10, 19, 24) are of minor relevance in Germany.

In general, the database in Germany is of good quality and data for many indicators are collected on a regular basis. However, many indicators lack of an evidence-based approach to attribute effects of bioenergy against effects from biomass used for food, feed or other purposes. It is beyond this study to track back the origin of biomass for bioenergy in a way to attribute local or regional impacts, and current data available in Germany would not allow doing so.

Attribution to bioenergy

At represent, effects can only be allocated by a simple proportionality between bioenergy and other uses of the same feedstock (e.g. rapeseed, maize, wood). It should be made clear by GBEP on which unit this proportionality should be based (mass or energy content).

How to deal with imported bioenergy

For those indicators with low relevance for German bioenergy it has to be considered that German bioenergy policy induces relevant imports from abroad, especially for liquid biofuels. This mechanism transfers impacts to the exporting countries, where other indicators may be extremely relevant (e.g. food prices, water resources, traditional collection and use of biomass).

The only indicators where the scope has been extended from the national to the global level are GHG balances (due to the global scale of the impact) and non-GHG air emissions (due to the inherent transboundary character of the applied emission factors).

For some indicators, environmental impacts occur at a strongly regionalised level (soil and water quality, water quantity). Here, the identification of and focus on hot spots or high risk areas is a good alternative if data availability at national level is insufficient.

Additional information proposed

The authors propose two new sub-indicators:

- “Intensified use” of grasslands for bioenergy (biogas) and forests should be considered as a further GBEP sub-indicator for biological diversity impacts in the landscape (Indicator 7).
- For Indicator 3: “Harvest level of wood resources” the suggested new sub-Indicator 3.4 "Bioenergy as share of annual increment" to reflect that (typically) the annual wood

increment is more stable as a base for the percentage. Harvest levels might fluctuate due to non-energy demands, and natural disturbances such as droughts, storms etc.

- Furthermore it is recommended to add two (sub-)indicators that allow reflecting changes in farm structures (sizes and ownership structures) and the influence on land rentals and prices.

The way forward

The authors recommend concentrating working on these proposals within the Activity Group 2 of the GBEP Working group on Capacity Building (WGCB), since this problem concerns all parties implementing the GBEP indicators.

Furthermore the authors recommend extending the scope of the respective GBEP indicators within the upcoming review stage, to be carried out by GBEP's Sustainability Task Force.

1.2 Synopsis of results

Table 1 shows a synopsis of the results of each indicator supplemented by a rough judgement on validity and by comments reflecting the key findings.

Table 1 Synopsis of the results of GBEP indicators applied in Germany

	Indicator	Result	Validity	Remarks
Environmental indicators				
1	GHG	- 65,678 Mt CO^*_{2eq}	good	Upstream emissions from imported biomass are included; emissions from land use change in Germany (grassland conversion) are included
2	Soil quality		low	Not enough data on soil enhancing measures available; the obligation for a balanced humus content ensures a minimum soil quality threshold
3	Harvest level of wood resources	• Volume: 52.3 Mm³/year • Share of annual increment: 55 % • bioenergy as share of harvest: 42%	medium	Sub-indicator "Bioenergy as share of annual increment" should be added to reflect that the annual wood increment is more stable as a base for the percentage. Harvest levels might fluctuate due to non-energy demands.
4	Air pollutants [kt/year]	SO_{2eq}: 181 SO_2: 49 NOx: 170 Particulates: 17 CO: 243 NMVOC: 28	good	Upstream emissions from imported biomass are included

	Indicator	Result	Validity	Remarks
5	Water resources	<1%	good	Proved to be not relevant in Germany
6	Water quality	1) **Nitrogen**: 77,400 t/year from bioenergy cultivation (2011) **Phosphorous**: 12 kt/year from agriculture (2005) **pesticide**: no data 2) **processing effluents** from bioenergy production: no data	low	Difficult to exactly link contribution from bioenergy feedstock production to pollutant loadings in water bodies; allocation to agricultural sector is modelled for pollutant loadings in rivers;
7	Biodiversity	few data available invasive species: no		Issue needs further discussion with competent authorities
8	Land use, LUC	1) 2.21 Mha (5.9 % of national surface). 2) 12.7 % agricultural land; 19.1 % managed forests 3.a) bioenergy from yield increases cannot be determined; 3.b) 65% of bioenergy production from residues and waste 3.c) No relevant bioenergy production on degraded or contaminated land 4.) conversion for bioenergy feedstock cultivation cannot be quantified	good to low	2) Comparison of the total land area used for bioenergy feedstocks with agricultural and managed forest areas might be misleading, as the total land use for bioenergy feedstocks consists of both crops from agricultural land and from forest biomass from managed forests. It might be more appropriate to disaggregate this, i.e. to compare the land use for agricultural bioenergy feedstocks to the agricultural land area, and the land use for forest bioenergy feedstocks to the land area of managed forests. 3) Not possible to distinguish between residues and waste
Social indicators				
9	Allocation and tenure of land	1) 100% 2) 100%	good	Proved to be not relevant in Germany; recommendation to add indicator on changes in farm and ownership structure
10	Price and supply of national food basket	No influence of bioenergy crop production on food prices in Germany	good	Proved to be not relevant in Germany; recommendation to indicator on changes in land prices and rentals

	Indicator	Result	Validity	Remarks
11	Change in income			Even though there is data on wages in Germany these data do not differentiate between bioenergy and other activities (e.g. agricultural and forest workers). Similarly, there is no reliable data on sub-indicator 11.2 so that indicator 11 has not been assessed.
12	Jobs in the bioenergy Sector	1) 128 900 jobs 2) All skilled 3) All permanent and full-time 4) See 1.) 5) All adhere to ILO	good	
13	Unpaid time spent by women and children collecting biomass			Not relevant in Germany: biomass is not collected by women and children, at least not for covering the demand
14	Bioenergy used to expand access to modern energy services			Not relevant in Germany: energy services are covering all regions of Germany, access is available by everybody
15	Change in mortality and burden of disease attributable to indoor smoke			Not relevant in Germany: Even though there is again an increase of wood-stoves in Germany, these mostly pellet fired equipment don't cause indoor smoke at a relevant level.
16	Incidence of occupational injury, illness and fatalities	Database does not allow to differentiate between agricultural/forest operations and those for bioenergy	low	German statistical data do not differentiate between bioenergy and other agricultural/forest activities
Economic indicators				
17	Productivity	1) 46.5 t maize/ha/yr 3.7 t rapeseed/ha/yr 7.3 t wheat/ha/yr 64.4 t beet/ha/yr 2) Rapeseed biodiesel: 13.7 GJ/t Wheat ethanol: 7.8 GJ/t	good	

	Indicator	Result	Validity	Remarks
		Sugar beet ethanol: 2.2 GJ/t Rapeseed oil: 13.8 GJ/t 3) Rapeseed biodiesel: 50.8 GJ/ha Wheat ethanol: 57 GJ/ha Sugar beet ethanol: 152.6 GJ/ha Rapeseed oil: 51.2 GJ/ha		
18	Net energy balance	1-3): see result tables 4) bioelectricity: 0.10 bioheat: 0.07 biofuels 0.37 Ratio: MJ_{prim}/MJ_{end}	good to medium	The non-renewable energy input per renewable energy output should be reported instead of the energy ratio (ER), as the ER does not make sense for non-renewable (fossil) systems
19	Gross value added	total bioenergy investment (2012): 2.55 M€; total turnover: 10,730 M€	good	German national accounts do not allow to disaggregate GVA effects of bioenergy; suggested proxy for GVA: investment and economic turnover
20	Change in the consumption of fossil fuels and traditional use of biomass	1a) 496 TWh 1b) not relevant 2) not relevant	good	
21	Training and re-qualification of the workforce			Not relevant in Germany: although some data on training of the labour force in Germany is available, these data do not differentiate between bioenergy and other activities. Therefore, this indicator has not been assessed.
22	Energy diversity	Herfindahl Index 2012: 0.227 (with bioenergy), 0.279 (without bioenergy)	good	
23	Infrastructure and logistics for distribution of bioenergy			Not relevant in Germany: there is sufficient logistics and infrastructure for energy in place
24	Capacity and flexibility of use of bioenergy	no relevant data available	low	Data on capacity exists, but for flexibility, only few studies are currently being carried out.

2 Introduction

2.1 Objectives

In November 2011, the Global Bioenergy Partnership (GBEP) adopted a set of 24 indicators to assess and monitor the sustainability of modern bioenergy. The indicators shall provide a tool for policy-makers and other stakeholders that informs on the development of the bioenergy sector and that allows monitoring the impact of related policies and programs.

The indicators are published together with a multi-page methodology sheet for each indicator providing in-depth information on its evaluation[1]. The indicators are now being pilot tested in different countries. At the GBEP level this work is accompanied by the Working Group on Capacity Building for Sustainable Bioenergy (WGCB) that was founded in 2011. It promotes the dissemination, use, and implementation of the indicators. At the same time it serves as a platform for sharing lessons learned from the pilots and for disseminating helpful tools and resources. All together this will help enhancing the applicability and practicality of the indicators and ensures their broad dissemination.

The pilot testing in Germany is funded by the Federal Ministry for Economic Affairs and Energy (BMWi)[2] and started in 2011. Its objective is to assess the feasibility of evaluating the 24 indicators in Germany. The assessment reveals which of the indicators are difficult to be applied and where the methodologies may need adaptation. A focus is put on describing deficits and on deriving proposals on how to deal with them. These lessons learned are mirrored back into the GBEP process.

Besides assessing the indicators, the project gives insight into the state of sustainability of the bioenergy sector in Germany. It summarises the availability and reliability of the data base for relevant sustainability aspects and shows data gaps and needs for further research.

The assessment is guided by following questions:

- Can the GBEP indicators and their methodologies be applied in Germany? What are gaps and which requirements for improving the methodologies exist?
- Is the data base sufficient to evaluate the indicators? What are data gaps? Is the data quality sufficient?
- Can a link with bioenergy production be established?
- Do the indicators cover all relevant sustainability aspects in Germany?

1 GBEP 2011: The Global Bioenergy Partnership Sustainability Indicators for Bioenergy; available at http://www.globalbioenergy.org/programmeofwork/task-force-on-sustainability/gbep-report-on-sustainability-indicators-for-bioenergy/en/

2 Formerly Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

2.2 Approach

The indicator evaluation is based on a desktop study. No primary data where assessed but only existing data from Ministries and research institutions are used. For each indicator relevant legal regulations, political goals and data reporting commitments are identified and listed in a first step. In a second step, relevant data sources are identified and summarised. The link to the bioenergy sector was established in a transparent manner.

Where the data basis was not sufficient and / or where no direct link to the bioenergy sector could be established, alternative approaches and methodologies are developed. These have been discussed in workshops with experts from political and scientific institutions in order to base them on a broad consensus. Where possible, data were collected for the years 2010 to 2012. In the main report, data referring to 2012 are presented while the remaining 2010-2011 data are given in the Annex.

Recommendations are derived both for feedback into the GBEP process in terms of indicator enhancement and for German institutions in terms of further research need.

2.3 Selection of Indicators for Analysis

Not all indicators were evaluated in the project. The selection was guided by the relevance for Germany. In total out 19 of the 24 indicators were evaluated. The selection is shown in Table 2.

Five indicators are not assessed since these are not relevant for the situation in Germany based on reasonable considerations:

Indicator 13: Biomass is not collected by women and children, at least not for supply to the market. It can be assumed that dependency on this type of energy supply is no relevant in Germany.

Indicator 14: Energy services are covering all regions of Germany; access is available by everybody; thus bioenergy is not needed to expand access to modern energy services.

Indicator 15: Even though there is again an increase of wood-stoves in Germany, these mostly pellet-fired systems do not cause indoor smoke at a relevant level.

Indicator 21: Not relevant in Germany: although some data on training of the labour force in Germany is available, these data do not differentiate between bioenergy and other activities. Therefore, this indicator has not been assessed.

Indicator 23: This indicator is not relevant in Germany, since there is sufficient logistics and infrastructure for energy in place

Table 2 GBEP indicators selected for evaluation in Germany

ENVIRONMENTAL PILLAR	SOCIAL PILLAR	ECONOMIC PILLAR
1. Lifecycle greenhouse gas (GHG) emissions	9. Allocation and tenure of land for new bioenergy production	17. Productivity
2. Soil quality	10. Price and supply of national food basket	18. Net energy balance
3. Harvest levels of wood resources	11. Change in income	19. Gross value added
4) Emissions of non-GHG, air pollutants, including air toxics (NOx, SO_2, ...)	12. Jobs in the bioenergy Sector	20. Change in the consumption of fossil fuels and traditional use of biomass
5. Water use and efficiency	~~13. Change in unpaid time spent by women and children collecting biomass~~	~~21. Training and re-qualification of the workforce~~
6. Water quality	~~14. Bioenergy used to expand access to modern energy services~~	22. Energy diversity
7. Biological diversity in the landscape	~~15. Change in mortality and burden of disease attributable to indoor smoke~~	~~23. Infrastructure and logistics for distribution of bioenergy~~
8. Land use and land-use change related to bioenergy feed stock production	16. Incidence of occupational injury, illness and fatalities	24. Capacity and flexibility of use of bioenergy

Remark: the crossed indicators are considered to be not relevant for the situation in Germany, as explained in the text.

3 The Bioenergy Sector in Germany

3.1 General Information

Germany is located in the centre of Europe, sharing approx. 3,600 km of borders with 9 EU Member States, and covers an area of 357,093 km^2 (DESTATIS 2008). In 2011, Germany had a population of 81.8 million living in 40 million households (DESTATIS 2012).

Forest in Germany cover approx. 11 million ha (Mha), representing 31% of its land area, with 7.5 Mha (20%) of managed forests[3]. The agricultural area covers approx. 17 Mha (48%), of which some 12 Mha are arable land and about 5 Mha pasture and grassland. The agroforestry sector in Germany had a share of 1 % of the gross value added in 2010.

3.2 Bioenergy Data for Germany

The following sections present an overview on the bioenergy sector in Germany. A more detailed description of Germany's bioenergy sector is given in the IEA Bioenergy Task 40 Country Reports[4].

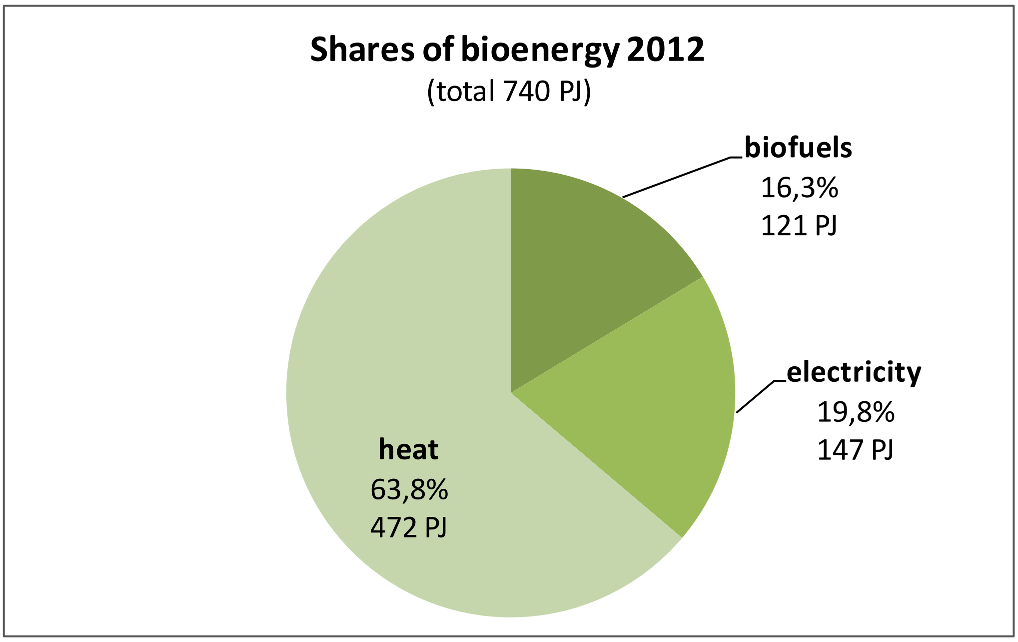
3.2.1 Shares of bioenergy and cultivation areas

In 2012 12.6 % of the final energy consumption was provided by renewable energies, out of which 66 % where produced from biomass (in total numbers: 205 TWh or 737 PJ bioenergy). The shares of bioenergy are shown in Figure 1.

3 The forest sector and subsequent timber and wood industries had an annual turnover of approx. 170 billion € in 2010, and employed approx. 1.2 million people.

4 Germany reports annually to the IEA Bioenergy Task 40 (see www.bioenergytrade.org). The latest report for 2011 is available at http://www.bioenergytrade.org/downloads/iea-task-40-country-report-2011-germany.pdf

Figure 1 Shares of bioenergy (final energy) in Germany 2012

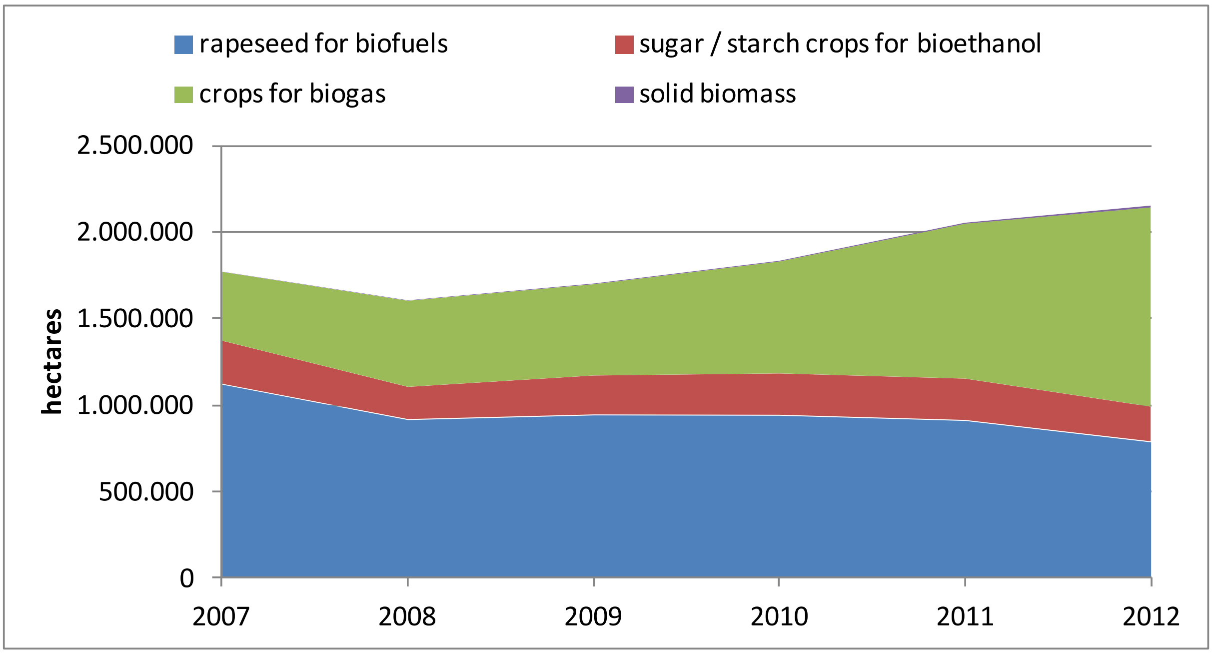


Source: FNR (2013)

Among the annual crops, rapeseed is the most important feedstock that is used for biodiesel production. 62.8 % of biodiesel is made from rapeseed, however out of this only about 37% is produced within Germany. Rapeseed also is a major feedstock for pure vegetable oils and is used for about 37% of the whole production (the rest is produced from palm oil). Most important crops in bioethanol production are maize (48%), wheat (24.47 %) and sugar beet (18%). 34% of the maize used is imported from the USA (BLE 2013).

The amount of agricultural land used for bioenergy feedstock production has been steadily increased over the past years as can be seen in Figure 2. According to FNR (2013) about 2.1 million ha of bioenergy crops have covered German cropland in 2012. This corresponds with 12.3 % of the agricultural area and 18.3 % of the arable land.

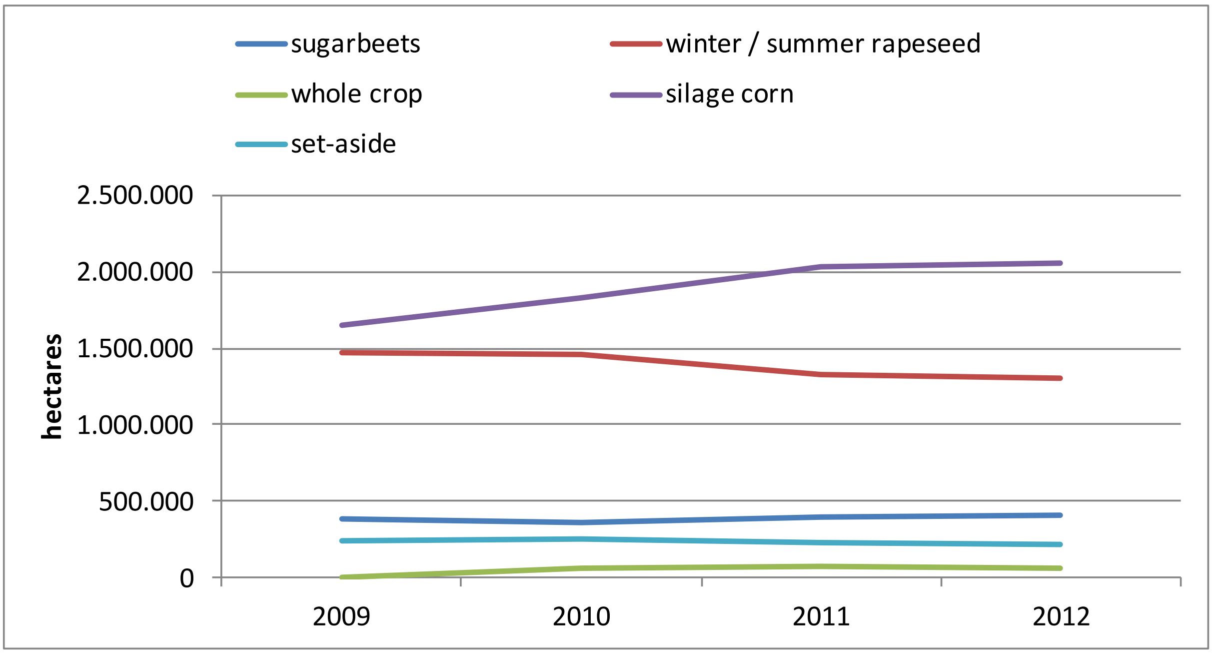
Figure 2 Agricultural land used for bioenergy feedstock production 2007 to 2012



Source: FNR (2013)

Some of the environmental problems arise from the fact that increased bioenergy production induced a shift in the combination of agricultural crops. The development of the cultivation area of crops that potentially can be used for bioenergy production is shown in Figure 3.

Figure 3 Agricultural land used for crops that can potentially be used as bioenergy feedstock 2009 to 2012



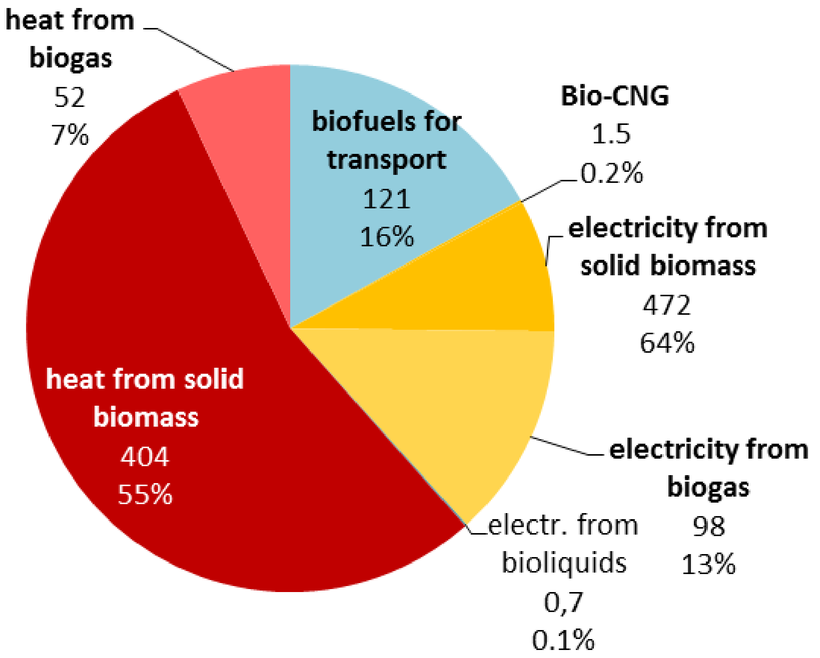
Source: DESTATIS (2013)

3.2.2 Shares of imported biomass

For those indicators that cover the whole life cycle of a bioenergy carrier (e.g. greenhouse gas emissions, see section 4.1) a differentiation between imported biomass and those produced nationally is important. As the indicators are to be assessed at a national level, in a strict sense those emissions and impacts that arise elsewhere should be omitted. The following paragraph will give an overview for which bioenergy carriers this is a relevant issue.

As a start, Figure 4 shows the bioenergy shares differentiated into solid, liquid and gaseous energy.

Figure 4 Shares of bioenergy (final energy) in Germany 2012



Source: FNR (2013)

The amount and origin of **liquid biomass** has to be reported to the Federal Agency for Agriculture and Food (BLE) within the framework of the EU Renewable Energy Directive (RED) and its German implementation. According to their evaluation report in 2012 (BLE 2013), only 33% of the reported biofuels / bioliquids have been produced in Germany (based on the energy content). 21 % / 27 % where imported from EU countries / third countries and for 19 % there were no information on the country of origin.

Gaseous bioenergy can be assumed to be produced mainly from domestic biomass. The main feedstocks are maize and manure which usually are not transported over long distances. Only in border areas a significant share may stem from abroad.

Solid bioenergy in Germany is currently mainly woody material which comes primarily from domestic sources (forests residues, sawmill residues, post-consumer wood etc.). According to national statistics (DESTATIS), Germany exported about 0.85 Mt wood pellets in 2012 while importing 0.35 Mt, i.e. Germany is a net pellet exporter. DESTATIS also reports that on the other hand, Germany imports significant amounts of waste wood (about 0.77 Mt in 2012, 0.9 Mt in 2011, and 1 Mt in 2010).

3.2.3 References

BLE (Bundesanstalt für Landwirtschaft und Ernährung) 2013: Evaluations- und Erfahrungsbericht für das Jahr 2012 (Biomassestrom-Nachhaltigkeitsverordnung, Biokraftstoff-Nachhaltigkeits-verordnung). Bonn, 2012. http://www.ble.de/SharedDocs/Downloads/02_Kontrolle/05_NachhaltigeBiomasseerzeugung/Evaluationsbericht_2012_2_Auflage.pdf?__blob=publicationFile (accessed April 2014)

DESTATIS (Statistisches Bundesamt) 2013, Spezielle Bodennutzung und Ernte; https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaftFischerei/FeldfruechteGruenland/Tabellen/AckerlandHauptfruchtgruppenRAUS.html (accessed March 2014)

FNR (Fachagentur für nachwachsende Rohstoffe) 2013: Basisdaten Bioenergie August 2013; Gülzow http://mediathek.fnr.de/media/downloadable/files/samples/b/a/basisdaten_9x16_2013_web_neu2.pdf (accessed July 2014)

3.3 Legal Reporting and Statistical Data on Bioenergy in Germany

Germany has reporting commitments under the European Renewable Energy Directive (RED) Article 22 (EU 2009)[5] to provide information on its use of renewable energies, including bioenergy[6].

Furthermore, key data is provided annually by the Federal Statistical Office (DESTATIS)[7], the Working Group on Renewable Energy Statistics (AGEE-Stat)[8] and the Federal Agency for Renewable Resources (FNR)[9] which all report under several national laws.

These official key data sources were used to derive the quantitative base for all indicators. Additional calculations and data sources needed for some of the indicators are presented in the respective sub-sections.

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5 All EU Member States are required to submit a report to the EC on progress in the promotion and use of energy from renewable sources by 31 December 2011, and every two years thereafter. The respective reporting requirements for bioenergy are detailed in RED Article 22 (1) (g).

6 For liquid and gaseous biofuels, there is a detailed reporting obligation: *"(…) Development and share of biofuels made from wastes, residues, non-food cellulosic material, and ligno-cellulosic material" (RED Art. 22 (1) (i)*

7 see https://www.destatis.de/EN/Homepage.html

8 AGEE-Stat was established in collaboration of the Federal Ministry of Economic Affairs and Energy (BMWi), the Federal Ministry of Food and Agriculture (BMEL) and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) to ensure that all statistics and data relating to renewable energies are part of a comprehensive, up-to-date and coordinated system (http://www.erneuerbare-energien.de/en/topics/data-service/agee-stat/).

9 FNR was founded to coordinate research, development and demonstration projects in the field of renewable raw materials. The main task of FNR is technical and administrative support for research projects on the use of renewable raw materials, and the provision and maintenance of statistics on bioenergy in Germany. FNR provides a yearly update of facts and figures on gaseous, liquid and solid bioenergy (http://mediathek.fnr.de/media/downloadable/files/samples/b/a/basisdaten_engl_web_neu.pdf).

4 Environmental Indicators

4.1 Indicator 1: Life-Cycle Greenhouse Gas Emissions

The GBEP Indicator 1 reads as follows:

Lifecycle greenhouse gas emissions from bioenergy production and use, as per the methodology chosen nationally or at community level, and reported using the GBEP Common Methodological Framework for GHG Lifecycle Analysis of Bioenergy 'Version One'.

Unit: grams of CO_2 equivalent per Mega Joule (g CO_{2eq}/MJ)

4.1.1 Legal regulations and reporting commitments

As a signer of the UNFCCC, Germany has to fulfil the greenhouse gas reduction goals defined in the Kyoto Protocol and implemented with European level regulation. This entails annual reporting commitments on greenhouse gas emissions towards the European Commission. Part of this information is also reported to Eurostat and the IEA.

The reporting commitments are dealt with centrally via the Federal Environment Agency (UBA). The data on renewable energy, and therefore on bioenergy, is the responsibility of the Working Group on Renewable Energy Statistics (AGEE-Stat).

The data collected for the aforementioned emission reporting is used as input for further national reporting commitments (e.g. for the national energy balance of the Federal Ministry of Economic Affairs and Energy) and for public relation work.

According to Directive 2009/28/EC (Renewable Energies Directive; RED) a proof of sustainable biomass production is needed for liquid biomass / biofuels in Germany. It includes minimum requirements for greenhouse gas emission savings along the entire production and supply chain (currently 35 % less compared to fossil fuel). The data of sustainable biomass is controlled by the Federal Office of Agriculture and Food (BLE).

4.1.2 Results and methodological approach

Table 3 shows the greenhouse emissions from bioenergy production and use in 2012. Additional information is the amount of substituted non-renewable energy, avoided emissions from non-renewable energy replacement as well as net GHG emission savings. Data for 2011 and 2010 are listed in Table 38 and Table 39 in the Annex.

The overall result for the year 2012 is:

	20,617 Mt CO_{2eq} emitted throughout the life cycle of bioenergy
minus	86,226 Mt CO_{2eq} replaced
equals	**65,678 Mt CO_{2eq} total savings**

The emission calculation mainly follows the principles and methodologies of life cycle analysis (LCA). The calculation steps for the net balancing are:

1. Avoided emissions = amount of bioenergy [GWh / year] * SF * EF_{fossil}
2. Emissions from bioenergy use = amount of bioenergy [GWh / year] * EF_{Bio} + LUC
3. Net emission balance = avoided emissions – emissions from bioenergy use

Table 3 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2012

		Amount of bioenergy [GWh]	Emissions from bioenergy use [Mt CO_{2equ}]	Avoided emissions [Mt CO_{2equ}]	Balance / GHG emission savings [Mt CO_{2equ}]
Solid	Electricity	11,600	294	9,494	9,200
	Heat	102,700	2,890	32,549	29,659
Liquid	Electricity	400	127	325	199
	Heat	800	48	240	192
	Transport	34,924	5,153	10,536	5,383
Gaseous	Electricity	31,550	10,555	25,924	15,369
	Heat	23,100	1,459	7,070	5,670
	Transport	350	29	88	59
Land use change (LUC) [a)]			54		
TOTAL		**205,424**	**20,617**	**86,226**	**65,678**

Source: compilation by IFEU based on UBA (2013)
a) explanation see text

Table 4 shows the comparison of bioenergy life cycle greenhouse gas emissions with those from other renewable energy sources and those from fossil energy.

The **substitution factors (SF)** in the electricity, heat and transport sectors are calculated based on the following methodologies. More details on the methodological approach and data basis can be found in UBA 2013.

- Substitution in the electricity sector: the type of substituted fossil energy carriers (lignite, hard coal, natural gas) are derived from a model calculation of the electricity market that takes into account the power plant scheduling for each hour in a year. The substitution factors are derived from simulating the market with and without renewable energy (including bioenergy).
- Substitution in the heat sector: individual substitution factors are derived for each heat provision pathway based on different reports and studies.
- Substitution in the transport sector: 1 MJ biofuel substitutes 1 MJ of the respective fossil fuel. By-product allocation is based on the lower heating value in order to be in line with the RED methodology. Different production technologies and plants are taken into account.

Regarding emissions covered emission balancing takes into account the whole life cycle of the products as well as direct and indirect (upstream) emissions. Emissions from forest carbon stock changes are not included. Also emissions from a change in soil carbon due to changed management are not covered (see also section 4.2).

Land use change (LUC) emissions are considered partly by following approach:

- There are topical data on conversion from grassland to arable land in Germany (BfN 2014): 37,000 hectares have been converted as an annual average from 2008 until 2013.
- Since 18.3 % of the arable land is covered by bioenergy plants, 18.3 % of the grassland conversion is attributed to bioenergy production in Germany, corresponding with 6,700 hectares.
- Following the EU Decision 2010/335/EU (based on IPCC 2006) emissions from grassland conversion to cropland ranges from 0 to 15 tonnes CO_2e per hectare under German conditions.
- A value of 8 tonnes CO_2e per hectare can be presumed to serve as a useful proxy representing clay soil, moderate moist climate, improved grassland and intensive cultivation on cropland.
- Multiplying 8 tonnes CO_2e per hectare with 6,700 hectares converted grassland attributed to bioenergy results in 53.6 Mt of CO_2e from LUC.

This approach should be understood as an estimation of the minimal value to be charged on bioenergy in Germany due to land use. It is estimated to be a minimal value because:

- It does only include the conversion of grassland in Germany, not considering any LUC from imported bioenergy.
- It does not consider that the area for bioenergy plants cultivated on arable has annually increased by 100,000 hectares during the same time period, which is three times more than the whole area of converted grassland.
- It does not consider any further market effects due to the promotion of bioenergy.

On the other hand people can argue that direct land-use change has never been caused by feedstocks for liquid biofuels falling under the RED and the national implementing regulations. In order to avoid this relevant increment of GHG emissions and to allow the use of default values economic operators are incentivised to prevent any feedstock within their certified supply chain taken from land converted after 2008. This argument may be dispelled by the fact, that solid and gaseous energy carriers used for electricity production do not fall under this regulation, but are responsible for the overall increase in cropland for bioenergy in Germany as Figure 2 shows clearly (see also section 4.8).

Thus, this approach is an approximate consideration of reported LUC activities in Germany attributed to domestically grown bioenergy in order not to exclude what at least has to be in charge. It is not covering the whole complex of land use change at all.

Table 4 Specific life cycle greenhouse gas emissions from bioenergy in comparison with other renewable energy sources and with fossil energy in 2012

Electricity [g CO_{2eq} / kWh_{el}]		Heat [g CO_{2eq} / kWh_{th}]		Transport [g CO_{2eq} / $kWh_{transport}$]	
BIOENERGY					
Solid bioenergy				**Liquid biofuel**	
woody bioenergy	25.36	wood stove, residential	16.10	SVO rapeseed	126.00
demolition wood	17.83	wood logs, residential	12.30	biodiesel - soy	180.00
wood in cogeneration	42.92	pellets, residential	32.00	biodiesel - rapeseed	165.60
		wood mix, industry	51.30	biodiesel - palm oil	115.20
		woody biomass, CHP	77.40	biodiesel - org. wastes	57.60
Liquid bioenergy				EtOH - wheat	182.5
bio-liquids	316.78	bioliquids, industry	2.30	EtOH - sugar beet	118.80
		SVO	154.10	EtOH - sugarcane	73.10
Gaseous bioenergy				**Gaseous biofuel**	
biogas	422.63	biogas-mix ICE	109.10	biomethane	81.70
sewage gas	26.20	sewage gas ICE	14.90		
landfill gas	25.74	landfill gas ICE	14.90		
org. wastes	5.15	org. wastes	8.90		
OTHER RENEWABLES					
hydro	2.69	solar thermal mix	24.70		
wind	8.76	heat pumps, mix	211.80		
solar-PV	55.20	geothermal heat	34.80		
geothermal	217.15				
FOSSIL FUELS					
lignite	1080.00	oil, residential	314.40	diesel	301.70
coal	922.92	natural gas, residential	248.10	gasoline	301.70
natural gas	445.57	coal, residential	419.10	CNG	251.10
oil	789.47	lignite, residential	428.70		
		district heat	300.20		
		electric heat	626.10		
		oil, industry	341.40		
		natural gas, industry	276.80		
		coal, industry	393.40		
		lignite, industry	456.50		

Source: compilation by IFEU based on UBA (2013)

4.1.3 Data basis

All data are collected annually by the Working Group on Renewable Energy - Statistics (AGEE-Stat) to meet the reporting commitments listed in section 4.1.1. Various data sources are used. Information on the amount and type of energy used (both for fossil and bioenergy) are collected by statistical offices, the Federal Network Agency, associations, research projects and the German Federal Agency for Agriculture and Food (BLE). Direct and indirect emission factors are derived from the data bases GEMIS and ecoinvent as well as from different research projects. The substitution factors for the electricity sector are from UBA (2013) based on a German research project.

Although the data basis has been improved continuously since the beginning of the work, there are still major data gaps and uncertainties. Uncertainties prevail for the agricultural upstream emissions and for emissions from direct and indirect land use changes. The main data gaps related to the use of solid, gaseous and liquid biomass have been identified during a workshop organised by UBA in July 2011.

Further difficulties arise from the fact that in Germany, great shares of energy carriers (be it fossil or biomass) are imported (see section 3.2.2). The greenhouse gas emission factors include the whole life cycle, i.e. also emissions from those steps that take place outside Germany. As a result, the total emissions do not only refer to national emissions.

4.1.4 Recommendations

For Germany: In order to quantify the emissions caused and avoided within Germany, the amount of imported energy carriers versus those produced within Germany should be distinguished. On this data base the production steps taking place inside and outside Germany can be disaggregated. The BLE strives to improve the data base to do so and some indicative figures are available. However this covers only liquid and gaseous energy carriers and not solid ones where also significant amounts are imported.

For GBEP: Reporting only the emissions occurring from bioenergy production and use (as is suggested by the indicator) are only of limited informative value when it comes to assess the climate relevance of the bioenergy sector in a country. One of the reasons for bioenergy implementation is the saving of greenhouse gases due to the replacement of non-renewable energy carriers. This should be reflected in the GBEP indicator. We therefore recommend adding information on the amount of non-renewable energy carriers replaced, the emission avoidance from this replacement as well as the overall net greenhouse gas savings.

4.1.5 References

BfN (Bundesanstalt für Naturschutz) 2014: Grünland-Report – alles im grünen Bereich? Juli 2014 http://www.bfn.de/fileadmin/MDB/documents/presse/2014/PK_Gruenlandpapier_30.06.2014_final_layout_barrierefrei.pdf

IPCC Guidelines for National Greenhouse Gas Inventories Volume 4; Agriculture, Forestry and Other Land Use; http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

UBA (Umweltbundesamt) 2013: Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2012; Climate Change 15/2013; Dessau https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_15_2013_emissionsbilanz_erneuerbarer_energietraeger.pdf

4.2 Indicator 2: Soil Quality

The GBEP Indicator 2 reads as follows:

Percentage of land for which soil quality, in particular in terms of soil organic carbon, is maintained or improved out of total land on which bioenergy feedstock is cultivated or harvested.

Unit: percentage (%)

4.2.1 Legal regulations and reporting commitments

German Federal Soil Protection Act (BBodSchG, 1998)

The objective is the sustainable protection and restoration of soil functions. It states the obligation to take precaution against adverse changes of soil characteristics. § 17(1) introduces Codes of Good Practice for agriculture of which the most relevant in this context is to "preserve the site-typical organic matter content, especially through a sufficient supply of organic matter or the reduction of management intensity".

Since there are no definitions or reference values for site-typical organic matter contents, the actual supply status has to be assessed with humus balancing. The Ministry of Agriculture advises to balance humus input and output or, if there is a shortage in organic matter supply, that the balance should be positive. Conservation tillage is mentioned as an appropriate measure to increase soil organic matter content.

Cross Compliance

The cross compliance regulation on European level is implemented in Germany via the Direct Support Scheme Obligations Law (DirektZahlVerpflG) and the Direct Support Scheme Obligation Regulation (DirektZahlVerpflV). Direct payments in agriculture are linked to the Codes of Good Practice. The regulation formulates the obligation to maintain a good agricultural and ecological condition. Among others, this means the preservation of soil organic matter. There are three possibilities to comply with the regulation:

1) Maintain a tripartite crop rotation
2) Annually calculate a humus balance
3) Analyse the soil organic matter content at least every 6 years

If the humus balance or the soil organic matter content is below a certain threshold (provided in the regulation), the farmer has to participate in a consultation and has to restore the soil organic matter content. Besides the crop specific ratios of humus changes, the regulation lists minimum humus contents depending on the clay content. Furthermore, the loss of soil organic matter is regulated by measures to avoid erosion.

Proposal for a European Soil Framework Directive (COM(2006) 232)

In 2006, the European Commission adopted a Soil Thematic Strategy (COM(2006) 231) and a proposal for a Soil Framework Directive (COM(2006) 232) in order to protect soils across the EU. The proposal explicitly names the soil function as carbon storage and gives the obligation to protect soils against the loss of soil organic carbon. Each Member State has to identify priority areas that need special protection. However, despite the efforts of several presidencies, the Council has so far been unable to reach a qualified majority on this legislative proposal due to the opposition of a number of Member States.

4.2.2 Results and methodological approach

For answering the indicator it is necessary to link information on areas where soil improving measures are applied with those on areas where bioenergy feedstocks are cultivated. Additionally, information on the development of soil organic carbon on agricultural land is helpful. In Germany, the following difficulties prevail:

- *Soil improving measures:* different soil improving measures are integrated in the management and subsidised as part of agri-environmental measures (e.g. no till farming / sowing, catch crops). However, since the measures are regulated at federal level there are no centrally available data. There is no information on the proportion of agricultural area under each of these measures let alone the proportion that can be allocated to bioenergy feedstock cultivation.
- *Soil organic carbon:* the content of soil organic carbon is measured regularly, however, also at federal level (see chapter 4.2.3). Therefore, no central information on long-term development of soil organic carbon is available.
- *Area of bioenergy feedstock cultivation:* the cultivation of bioenergy feedstocks cannot be located exactly so that an allocation of soil organic carbon contents to certain bioenergy feedstock is not possible (see also section 3).

Generally, the obligation to have a balanced humus supply (see section 4.2.1) should assure a minimum safeguard in terms of soil quality across the whole agricultural sector. However, the regulations and methodologies show certain weaknesses: humus balancing itself is criticised for not always leading to appropriate conclusions and management measures, the thresholds presented are not soil specific enough and there is no definition of “site-typical organic matter content” (Hüttl et al. 2008).

Therefore, only indirect conclusions can be drawn on the impact of bioenergy feedstock production on soil quality, such as e.g. through the identification of high risk areas. This approach concentrates on those developments caused by an increased bioenergy production that bear risks of having adverse impacts on soil quality. As has been shown in section 3, the area of corn cultivation has increased significantly in the last years. At the same time, a decline of grassland was observed which was significant for certain regions (see also section 4.8). TLL 2011 has shown that the biogas boom caused an expansion of corn cultivation. Partly, the additional area came from reducing set-aside areas, partly from grassland conversion. Although not the only one, corn cultivation for biogas production is one of the main drivers of grassland conversion in Northeast Germany (Schramek et al. 2012).

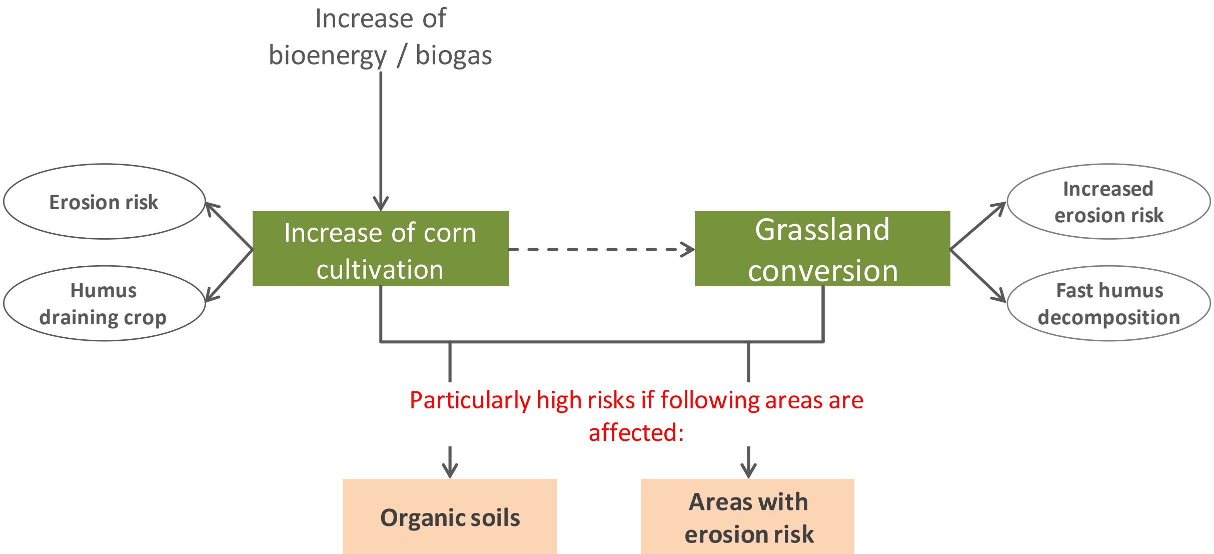
Identification of high risk areas

The above mentioned conversion of grassland leads to higher erosion risk as well as to a faster decomposition of soil organic carbon. This is particularly critical if grassland conversion takes place on erosion risk areas and on organic soils. The loss in organic substance also leads to high carbon emissions which are relevant for greenhouse gas balancing (see also section 4.1). As grassland conversion is limited by law, no large scale conversion is likely to happen (see also section 4.8). However, on a local and regional scale, significant adverse impacts can be caused if the conversion takes place on risk areas.

Besides the impact via grassland conversion, corn cultivation itself shows risks. Areas under corn cultivation have an increased erosion risk and corn is a strongly humus draining crop. This means that more humus is decomposed than formed. Brandhuber & Treisch 2012 showed the link between the increase of corn cultivation and the increase of soil loss for a smaller German region. Only part of the loss could be stopped by applying agri-environmental measures. Given the above mentioned characteristics, corn cultivation could be especially harmful on areas with high erosion risks and on organic soils.

Figure 5 shows the links between the above described factors.

Figure 5 Risk factors for soil quality



More research is needed to specify the above mentioned relationships and mechanisms. It also has to be quantified (and monitored) which share of corn cultivation and grassland conversion takes place on organic soils and areas with erosion risk. Some of the data sources that could be useful are listed in section 4.2.3.

4.2.3 Data basis

Data on soil organic carbon

In Germany different measurement and data collection activities are ongoing that aim at identifying the soil organic carbon at agricultural land.

First, soil data are currently collected managed by Thünen Institut (so-called “German agricultural soil inventory”)[10] which asses 3200 plots under agricultural use (grassland, agricultural land and gardens). Mainly information on soil carbon stocks of the upper soil layer is collected. At the same time, farm structures and management practices are assessed to gain further insight on their impact on soil organic carbon. The results are to be

10 http://www.ti.bund.de/en/startseite/institutes/climate-smart-agriculture/research-projects/german-agricultural-soil-inventory.html

used for the UNFCCC emission reporting but also to run models on the influence of climate change on soil carbon stocks. It is not yet decided whether these assessments will be repeated on a regular basis.

A similar assessment has been carried out in German forests from 2006 – 2008 (“forest soil condition survey”). At 2000 plots information in the forest status (soil, vegetation, nutrients) where collected. As this is the second survey (following the one in 1987 – 1993) changes in soil structure could be detected and evaluated. Furthermore, data are used for emission reporting purposes and to inform forest policy decisions and strategies. The survey will not be done on a regular basis, however, it is planned to do it roughly all 15 years.

Besides the periodic assessments soil organic carbon content is monitored regularly since the 1990ies by each Federal State[11]. Data from 700 permanent observation plots on grassland and agricultural land are assessed regularly. However, the responsibility, and therefore all data, lies at federal level. The federal approach also causes differences in methodologies applied and in the continuity of data collection. This makes a comparative analysis of data quite difficult.

All data sets do not allow to draw conclusion on the impact bioenergy production has on soil organic carbon as long as the cultivation of bioenergy feedstocks cannot be exactly located and linked to the data collection. Moreover, conclusions on the impact of management practices on soil organic carbon are difficult to be drawn. As the soil organic carbon content reacts to impacts only very slowly, smaller changes in management practices such as different cropping systems (e.g. a shift to energy crops) hardly will be visible. This requires more drastic changes such as grassland conversion. Assessment results will, however, allow to draw general conclusions on the status quo of German soils and on which measures to apply for increasing soil quality. This will also increase the sustainability of bioenergy feedstock production.

Data for risk assessment

Different data sources have to be used to assess and monitor the cultivation of bioenergy feedstocks on risk areas. The combination of the following information is helpful:

- Map on corn cultivation area
- Map with erosion risk areas
- Map on areas with organic soils
- Map on grassland conversion

It is impossible to link corn cultivation and grassland conversion on risk areas to bioenergy production. However, bioenergy production is known to be a major driver for the expansion of corn cultivation areas and therefore, its cultivation on risk areas should be quantified and monitored.

[11] http://www.umweltbundesamt.de/boden-und-altlasten/boden/bodenschutz/dauerbeobachtung.htm

4.2.4 Recommendations

For Germany: Due to a lack of data the indicator cannot be evaluated in its strict sense. However, indirect and qualitative conclusions could be drawn from a risk area approach.

The evaluation of soil quality and soil organic carbon and the obligation for a balanced humus content ensures a minimum soil quality threshold. Generally, a close monitoring on bioenergy feedstock production and its influence on soil quality should take place. This concerns especially corn cultivation on organic soils and the influence of cultivation intensification.

Moreover, data collection on the amount of soil improving measures could enhance transparency and reveal the need for further action.

For GBEP: Measuring soil organic carbon on a large scale is time consuming and therefore usually too difficult to be put into practice. Also in many countries, areas where bioenergy production takes place cannot be easily identified. Therefore, the focus should be put more on alternative ways such as identifying areas at high risks and drawing lessons learned from key projects and best practices.

Furthermore, soil quality is also an issue in forests where residues are harvested for energy purposes. The removal of part of or all residues has an influence on soil organic carbon that should be covered by the indicator. Therefore it should be clearly stated that the indicator should also be applied to forested areas.

4.2.5 References

Brandhuber & Treisch 2012: Brandhuber, R.; Treisch, M. (2012): Bodenabtrag in Abhängigkeit von der Maisanbaufläche in Bayern: Vergleich 2005 mit 2011.

DESTATIS (Statistisches Bundesamt) 2013, Feldfrüchte und Grünland; https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaftFischerei/FeldfruechteGruenland/Tabellen/AckerlandHauptfruchtgruppenFruchtarten.html

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4.3 Indicator 3: Harvest Levels of Wood Resources

The GBEP Indicator 3 reads as follows:

Annual ***harvest of wood resources***

3.1 by volume and

3.2 as a ***percentage of net growth*** *or sustained yield, and*

3.3 the ***percentage of the annual harvest used for bioenergy***

Units: m^3/ha/year, tonnes/ha/year, m^3/year or tonnes/year; percentage

4.3.1 Legal regulations and reporting commitments

The general regulations and reporting obligations of Germany regarding bioenergy are presented in Section 3.3. For wood resources from forests, Germany also reports regularly to the UNECE. The German Forest Law requires forest operators to re-plant harvested trees so that the level of forested area remains at least stable.

4.3.2 Results and methodological approach

With regard to the available data sources there are two different cases to compile the results, described as

- the "standard" case (using the official DESTATIS data) and
- the "refined" case (using data from TI 2013)

Table 5 shows the results for the GBEP Sub-Indicators 3.1-3.3.

Table 5 Results for Sub-Indicators 3.1-3.3: Annual harvest of wood resources by volume and as percentage of net growth and percentage of annual harvest used for bioenergy in Germany 2010-2012 ("standard" version and "refined" version)

No.	Indicator	2010		2011		2012	
		standard	refined	standard	refined	standard	refined
3.1	Wood harvest, [Mm^3/year]	54.4	67.7	56.1	68.2	**52.3**	**66.6**
3.2	harvest as share of annual increment	57%	71%	59%	72%	**55%**	**70%**
3.3	bioenergy as share of harvest	39%	38%	36%	36%	**42%**	**40%**
3.4*	bioenergy as share of annual increment	22%	27%	21%	26%	**23%**	**28%**

*Source: compilation by IINAS based on DESTATIS (2013) and TI (2013); *= suggested additional sub-indicator, see Section 4.3.4*

The methodology for deriving the indicator values was to extract the annual wood harvest volumes, expressed in total annual fellings (million m^3 = Mm^3), from the respective data sources (see Section 4.3.3 for respective discussion).The annual increment data are from TI (2013) and reportedly constant.

The "standard" results for GBEP sub-indicator 3.1 use official DESTATIS data which are provided annually, and use the TI (2013) shares of wood for bioenergy to determine the respective shares given in sub-indicators 3.2 and 3.3 as well for the suggested additional sub-indicator 3.4 (see Section 4.3.4).

The “refined” results for GBEP sub-indicator 3.1 use the TI (2013) data which are also determined annually.

4.3.3 Data basis

Forest area in Germany comprises currently 11.1 Mha, i.e. about 31 % of the total national surface (BMELV 2013). Raw wood harvest has significantly increased in the last years, caused by storms on the one side and by increased energy use on the other (BMELV 2008). In Germany in 2010, 135.5 Mm^3 (forest wood and wood residues) were used, approx. 67.1 Mm^3 (49.5 %) as material and 68.4 Mm^3 for energy (50.5 %) according to UBA (2013b).

Wood fellings in Germany increased nearly continuously since 1991 and practically independent from economic fluctuations. This is evident from official harvesting statistics (DESTATIS 2013) as well as from estimates of TI (2013) (see Annex Figure 17).

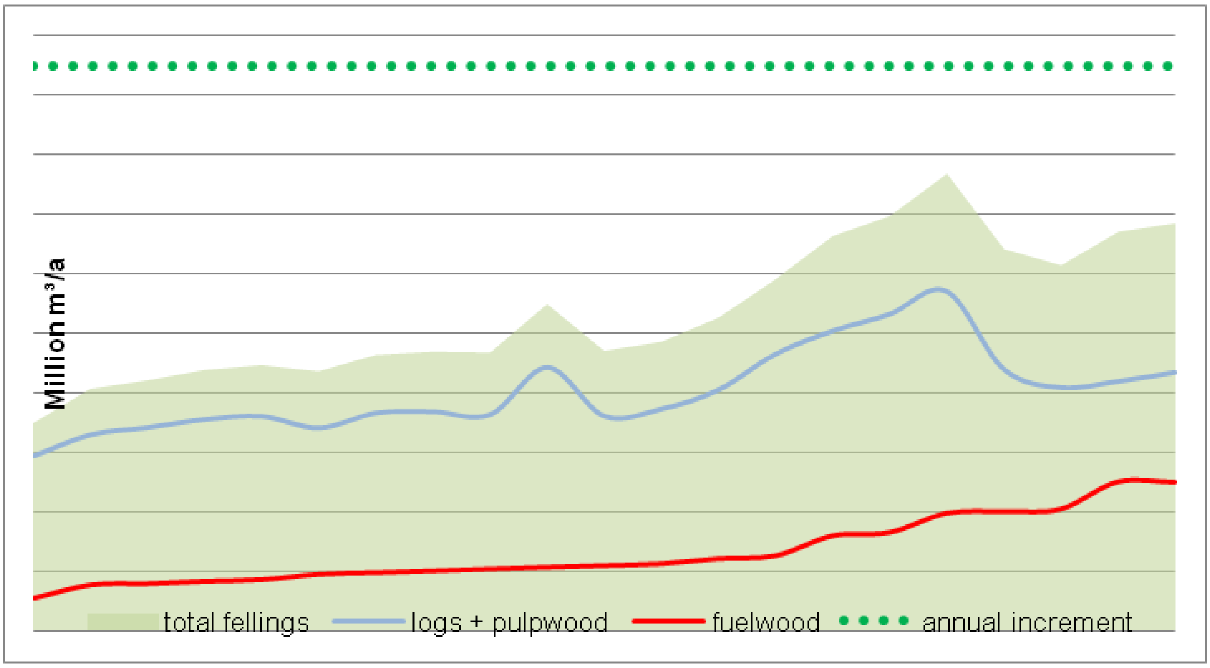
Due to differences in calculation methods the official DESTATIS (2013) data are **lower** than those given in TI (2013):

While DESTATIS determines annual harvests on the **supply** side (i.e. based on reports from forest operators), the TI data come from estimates for wood **use** (Dieter et al. 2004), i.e. TI “back-calculated” harvest levels from demand-side data (amount of timber and pulp & paper products).

The TI data allow compensating for systematically incomplete DESTATIS data which do not consider harvests from approximately 2 million small-scale forest owners and respective use for small-scale residential heating, and also provides shares for the different uses of wood from forests (TI 2013).

Figure 6 shows the development of fuelwood, logs and pulpwood, and total fellings and the annual increment in Germany for the last 20 years. In this period, total fellings reached a maximum in 2007, but even then were below the annual increment.

Figure 6 Development of fellings in Germany compared to annual increment



Source: IINAS calculations based on TI (2013)

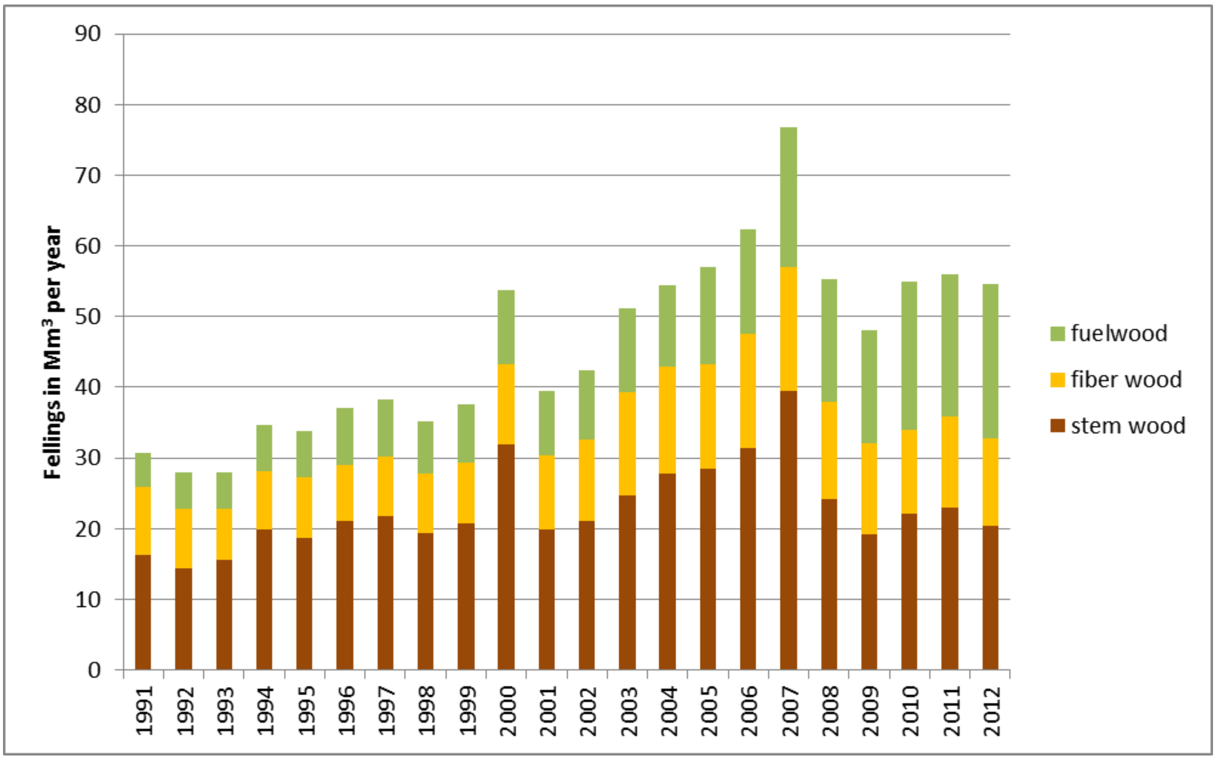
As the official DESTATIS data are lower than the refined TI (2013) data, the GBEP Indicator 3 was determined for **two cases**:

- The “standard” case uses the DESTATIS data and re-calculated the use of wood based on the TI (2013) patterns.
- The “refined” case fully uses TI (2013) data.

Both cases use the same annual increment, though. To indicate the different results derived for both cases, the following figures present the respective time series.

The “standard” case gives slightly lower figures for total fellings, and the respective shares of woody bioenergy (fuelwood).

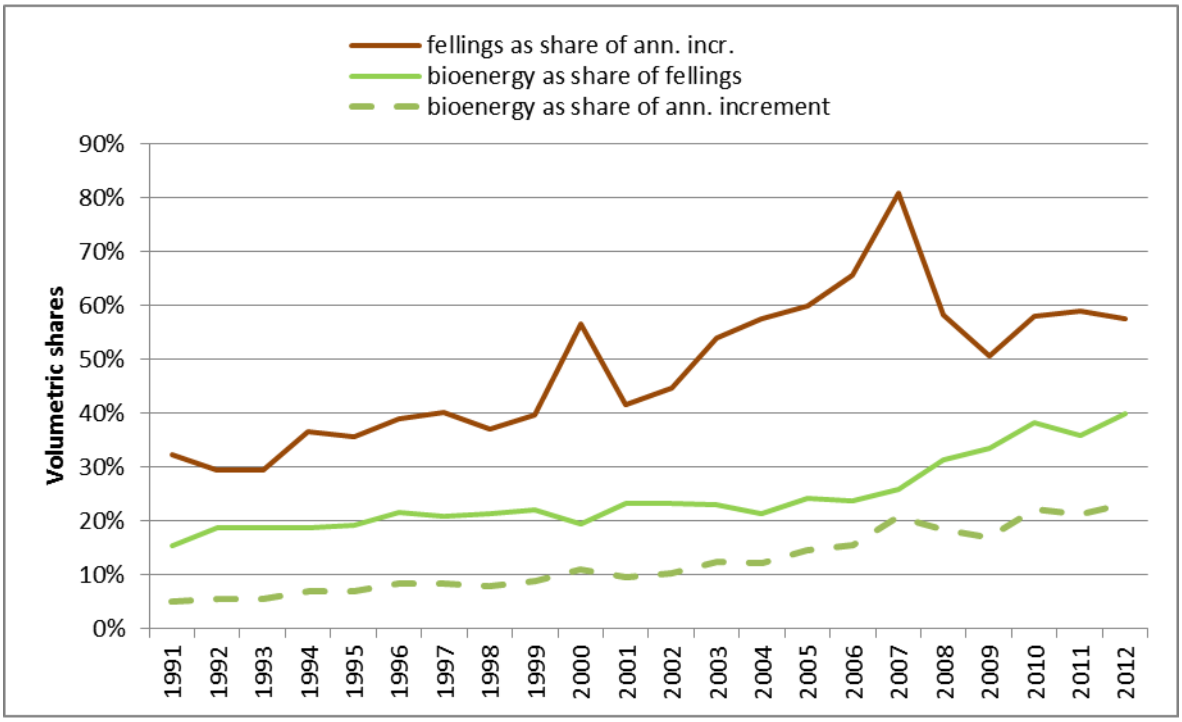
Figure 7 Use of fellings in Germany 1991-2012 (standard case)



Source: IINAS calculations based on data for fellings from DESTATIS (2013), data for bioenergy shares were calculated using the TI (2013) shares and re-computed by IINAS based on the DESTATIS (2013) data

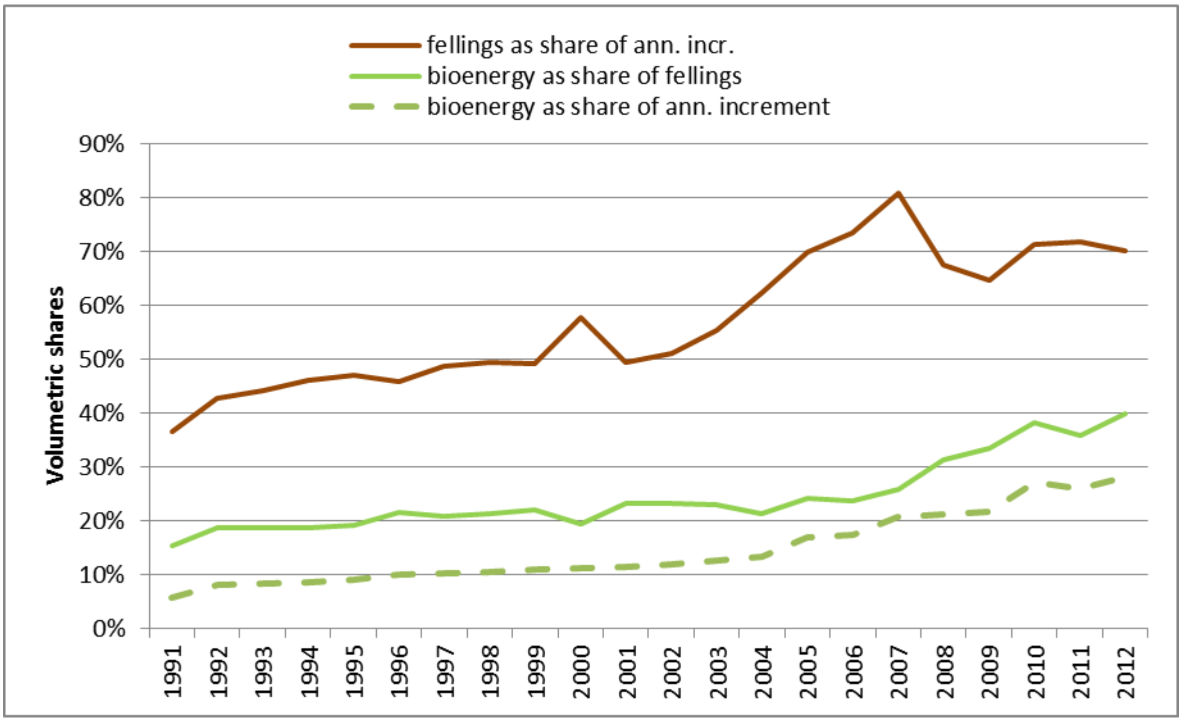
For the refined case of the use of fellings, see Annex Figure 18.

Figure 8 Woody Bioenergy Use as Shares of total fellings, and of annual increment in Germany 1991-2012 (standard case)



Source: IINAS calculations based on data for fellings from DESTATIS (2013), data for bioenergy shares were calculated using the TI (2013) shares and re-computed by IINAS based on the DESTATIS (2013) data

Figure 9 Woody Bioenergy Use as Shares of total fellings, and of annual increment in Germany 1991-2012 (refined case)



Source: IINAS calculations based on TI (2013)

4.3.4 Recommendations

For Germany: To allow for an improved database and respective monitoring, a continuation of the surveys on the demand-side and a better statistical scope for the supply side (small-scale forest operations) is needed. The upcoming revision of the Energy Statistics Law in Germany is an excellent opportunity to legally require a differentiated data collection for the whole wood value chains in Germany.

For GBEP: It should be considered to add the sub-Indicator 3.4 "Bioenergy as share of annual increment" to reflect that (typically) the annual wood increment is more stable as a base for the percentage. Harvest levels might fluctuate due to non-energy demands.

4.3.5 References

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4.4 Indicator 4: Emissions of non-GHG Air Pollutants, including Air Toxics

The GBEP Indicator 4 reads as follows:

*Emissions of **non-GHG air pollutants**, including air toxics, from*
(4.1) bioenergy feedstock production,
(4.2) processing,
(4.3) transport of feedstocks, intermediate products and end products, and
(4.4) use;
(4.5) and in comparison with other energy sources.
Units: mg/ha; mg/MJ; percentage; mg/m3 or ppm;

4.4.1 Legal regulations and reporting commitments

In Germany, no legal requirement exists to monitor or report air emissions from bioenergy, but UNECE and EU treaties require to report on **overall** air emissions and to maintain respective inventories.

As a special section of BMUB’s national reporting on renewable energies (AGEE-Stat, see Section 3.3), the GHG and air emission balances of renewable energies are reported annually. The background data for the emission balance is provided by UBA.

4.4.2 Results and methodological approach

The German UBA reports total life-cycle air emissions for bioenergy, disaggregated into bioenergy for electricity, heat and transport fuels, and also for other renewables, and fossil energy.

Thus, the GBEP indicators 4.1-4.4 can be reported for Germany only as totals, but broken down into the shares from the different bioenergy use sectors, as indicated with a - c, and d for total.

The calculation methodology regarding emission factors is the same as is used for national GHG balancing and reporting. It is described in more detail in section 4.1.2.

More details can be found in UBA (2013).

Table 6 Results for Indicator 4.1a-4.4a: Life-cycle air emissions of electricity from bioenergy in Germany 2012

In t / year	solids*	liquids**	biogas***	sewage gas	landfill gas	org. wastes	total
SO_2eq	8,315	888	42,724	1,005	405	2,240	**55,577**
SO_2	1,508	145	13,478	295	138	194	**15,758**
NO_x	9,780	1,068	42,020	1,020	383	2,940	**57,211**
Particulates	782	112	2,169	36	4	30	**3,133**
CO	4,179	282	28,833	1,490	617	290	**35,691**
NMVOC	2,042	130	3,615	141	33	15	**5,976**

Source: IINAS compilation based on UBA (2013); data given in t/year;
= mainly woody biomass; **= mainly biodiesel from rapeseed and palm; *= mainly from maize*

Table 7 Results for Indicator 4.1b-4.4b: Life-cycle air emissions of heat from bioenergy in Germany 2012

In t / year	solids*	liquids**	biogas***	sewage gas	landfill gas	org. wastes	total
SO_2eq	70,856	543	12,157	789	44	7,157	**91,546**
SO_2	18,375	117	1,698	231	13	620	**21,054**
NO_x	75,403	612	5,293	801	45	9,392	**91,546**
Particulates	10,478	138	273	28	2	95	**11,014**
CO	194,031	167	3,632	1,170	65	927	**199,992**
NMVOC	19,481	174	455	111	6	47	**20,274**

Source: IINAS compilation based on UBA (2013); data given in t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included
= mainly woody biomass; **= mainly biodiesel from rapeseed and palm; *= mainly from maize*

Table 8 Results for Indicator 4.1c-4.4c: Life-cycle air emissions of transport fuels from bioenergy in Germany 2012

In t / year	biodiesel*	SVO	bioethanol**	biomethane***	total
SO_2eq	10,182	72	6,594	16,879	**33,727**
SO_2	3,887	22	2,169	6,089	**12,167**
NO_x	9,044	72	6,357	5,504	**20,977**
Particulates	955	9	491	1,457	**2,912**
CO	2,280	17	1,627	3,939	**7,863**
NMVOC	611	3	269	884	**1,766**

Source: IINAS compilation based on UBA (2013); data given in t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

= mainly from rapeseed; **= mainly from wheat; *= mainly from maize*

Table 9 Results for Indicator 4.1d-4.4d: Life-cycle air emissions of total bioenergy use in Germany 2012

In t / year	electricity	heat	biofuels	total
SO_2eq	55,577	91,546	33,727	**180,850**
SO_2	15,758	21,054	12,167	**48,979**
NO_x	57,211	91,546	20,977	**169,734**
Particulates	3,133	11,014	2,912	**17,059**
CO	35,691	199,992	7,863	**243,546**
NMVOC	5,976	20,274	1,766	**28,016**

Source: IINAS compilation based on UBA (2013); data given in t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

With regard to the comparison of bioenergy life-cycle air emissions with other energy sources (GBEP Indicator 4.5), the same break-down into sectors of bioenergy use (electricity, heat, transport) was used, and indicated by the numbering addition a-c.

Table 10 Results for Indicator 4.5a: Specific life-cycle air emissions of electricity from bioenergy in comparison to electricity from other renewable energies and fossil fuels in Germany 2012

In g / kWh_{el}	SO_2eq	SO_2	NO_x	particulates	CO	NMVOC
bioenergy						
woody bioenergy	0.717	0.13	0.843	0.067	0.36	0.176
demolition wood	0.654	0.121	0.766	0.055	0.298	0.178
wood in CHP	0.862	0.151	1.022	0.097	0.506	0.171
bio-liquids	2.22	0.362	2.67	0.28	0.704	0.325
biogas	1.723	0.543	1.694	0.087	1.163	0.146
sewage gas	0.773	0.227	0.785	0.027	1.146	0.108
landfill gas	0.736	0.251	0.696	0.007	1.122	0.06
org. wastes	0.457	0.04	0.6	0.006	0.059	0.003
other renewables						
hydro	0.007	0.001	0.007	0.002	0.014	0
wind	0.027	0.013	0.02	0.009	0.121	0.002
solar-PV	0.113	0.06	0.077	0.032	1.221	0.005
geothermal	0.278	0.124	0.22	0.019	0.213	0.011
fossil fuels						
lignite	1.09	0.6	0.7	0.03	0.56	0.01
coal	0.85	0.47	0.55	0.03	0.11	0.03
natural gas	0.39	0.01	0.54	0.07	0.37	0.07
oil	1.52	0.91	0.87	0.08	0.3	0.15

Source: UBA (2013); data given in g/kWh_{el}; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included; CHP = combined heat & power (cogeneration)

Table 11 Results for Indicator 4.5b: Specific life-cycle air emissions for heat from bioenergy in comparison to heat from other renewable energies and fossil fuels in Germany 2012

In g / kWh_{th}	SO_2eq	SO_2	NO_x	particulates	CO	NMVOC
bioenergy						
wood stoves, residential	0.211	0.037	0.251	0.437	11.413	0.751
wood logs, residential	0.295	0.028	0.384	0.25	8.735	0.121
pellets, residential	0.382	0.116	0.383	0.118	0.711	0.029
wood mix, industry	1.884	0.348	2.207	0.158	0.858	0.513
woody biomass CHP	0.773	0.134	0.918	0.129	0.76	0.504
bioliquids, industry	0.437	0.128	0.445	0.193	0.127	0.254
SVO	1.08	0.176	1.299	0.136	0.342	0.158
biogas-mix ICE	1.005	0.14	0.437	0.023	0.3	0.038
sewage gas ICE	0.438	0.128	0.445	0.016	0.65	0.062
landfill gas ICE	0.438	0.128	0.445	0.016	0.65	0.062
org. wastes	0.786	0.068	1.032	0.01	0.102	0.005
other renewables						
solar thermal mix	0.072	0.04	0.046	0.019	0.135	0.007
heat pump mix	0.232	0.104	0.185	0.014	0.11	0.009
geothermal heat	0.044	0.02	0.035	0.003	0.027	0.002
fossil fuels						
oil, residential	0.505	0.33	0.252	0.019	0.144	0.049
natural gas, residential	0.134	0.011	0.176	0.006	0.136	0.052
coal, residential	1.794	1.482	0.448	0.075	12.499	0.235
lignite, residential	0.641	0.381	0.373	0.428	8.554	0.596
district heat	0.496	0.26	0.338	0.029	0.143	0.019
electric heat	0.686	0.306	0.545	0.041	0.326	0.027
oil-mix, industry	0.578	0.349	0.328	0.022	0.07	0.067
natural gas, industry	0.164	0.008	0.223	0.004	0.067	0.017
coal, industry	1.879	1.478	0.575	0.049	0.146	0.034
lignite, industry	1.74	1.395	0.496	0.179	0.14	0.019

Source: UBA (2013); data given in g/kWh_{th}; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included; CHP = combined heat & power (cogeneration); ICE = internal combustion engine with cogeneration

Table 12 Results for Indicator 4.5c: Specific life-cycle air emissions for transport fuels from bioenergy in comparison to fossil fuels in Germany 2012

In g / kWh_{fuel}	SO_2eq	SO_2	NO_x	particulates	CO	NMVOC
biofuels						
SVO rapeseed	0.28	0.08	0.28	0.04	0.06	0.01
biodiesel - soy	1.68	0.83	1.22	0.09	0.18	0.05
biodiesel - rapeseed	0.36	0.12	0.35	0.04	0.09	0.02
biodiesel - palm oil	0.92	0.42	0.72	0.05	0.19	0.06
biodiesel - org. wastes	0.13	0.07	0.09	0.01	0.03	0.01
EtOH - wheat	0.53	0.12	0.58	0.05	0.12	0.02
EtOH - sugarbeet	0.32	0.07	0.36	0.03	0.11	0.02
EtOH - sugarcane	1.71	0.68	1.47	0.15	0.67	0.23
biomethane	0.09	0.03	0.09	0.01	0.05	0.01
fossil transport fuels						
diesel	0.16	0.1	0.09	0.01	0.04	0.04
gasoline	0.19	0.12	0.11	0.01	0.05	0.05
natural gas (compressed)	0.08	0.01	0.1	0	0.06	0.01

Source: UBA (2013); data given in g/kWh_{fuel}; note that for imported fuels (soy, palm, sugarcane, fossil), life-cycle emissions from outside Germany (production, processing, transport) are included

4.4.3 Data basis

The total (in t/year) and specific data (in g/kWhout) life-cycle air emissions are taken from UBA (2013) which is based on results from a 2012 study for all renewables in Germany (Fritsche, Rausch 2012). This study used **direct** emissions from bioenergy and fossil fuels combustion in Germany from the UBA database, and GEMIS (www.gemis.de) for upstream emissions.

4.4.4 Recommendations

For Germany: The total life-cycle data include not only emissions occurring in Germany, but also “upstream” emissions from imports, e.g. international sea transport, production and processing in exporting countries (see section 3.2.2). Thus, a disaggregation of total emissions from bioenergy into “domestic” and “foreign” parts should be considered. For comparing bioenergy life-cycle emissions with other energy sources (indicator 4.5), this disaggregation is **not needed**, as e.g. fossil energy systems in Germany show high import shares

4.4.5 References

Fritsche U, Rausch L 2012: Aktualisierung von Ökobilanzdaten für Erneuerbare Energien im Bereich Treibhausgase und Luftschadstoffe; Endbericht zum BMU-Vorhaben FKZ 0325188, Öko-Institut in Kooperation mit DBFZ, DLR, GZB, IFEU, IWES, ESU services und GreenSmartScans; Darmstadt http://www.oeko.de/files/forschungsergebnisse/application/octet-stream/download.php?id=1621

UBA (Umweltbundesamt) 2013: Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2012; Climate Change 15/2013; Dessau.

4.5 Indicator 5: Water Use and Efficiency

The GBEP Indicator 5 reads as follows:

(5.1) Water ***withdrawn*** *from nationally-determined watershed(s) for the production and processing of bioenergy feedstocks, expressed*

(5.1a) as the ***percentage of total actual renewable*** *water resources (TARWR) and*

(5.1b) as the ***percentage of total annual*** *water withdrawals (TAWW), disaggregated into* ***renewable and non-renewable*** *water sources;*

(5.2) Volume of ***water withdrawn*** *from nationally-determined watershed(s) used for the production and processing of bioenergy feedstocks* ***per unit of bioenergy output****, disaggregated into* ***renewable and non-renewable*** *water sources*

Units: m^3/MJ or m^3/kWh; m^3/ha or m^3/

4.5.1 Legal regulations and reporting commitments

The European Water Framework Directive (2000/60/EC) commits the European Member States to achieve good qualitative and quantitative status of all water bodies until 2015. The quantity of all water bodies is monitored in Germany on a yearly basis with an extensive measuring network.

4.5.2 Results and methodological approach

In Germany there is no distinction between renewable and non-renewable water resources. Instead the water resources that can potentially be used are determined. They comprise precipitation, evaporation as well as water inflow and outflow. In reporting this parameter is set equal to the renewable water sources.

4.5.2.1 Sub-indicator 5.1a: Percentage of actual renewable water resources

Cultivation of bioenergy feedstock

The overall water resources and withdrawals in 2010 are reported as follows:

- The total annual **renewable water resources (TARWR)** were 190 billion m³ (108 km^3 internal + 71 km^3 external i.e. water flowing into country) (BfG 3013).
- The total annual **water withdrawal (TAWW)** was 32.8 billion m^3 (UBA 2014).

In general the contribution of agriculture to the overall water withdrawal in Germany is low in comparison with other sectors. In 2010 only 0.2 billion m³ have been withdrawn for irrigation (UBA 2013) which equals to

- **0. 105 % of TARWR** or
- **0.609 % of TAWW**

In comparison to that around 63% of TAWW were withdrawn by thermal power plants as cooling water and 20.7 % for mining and manufacturing industries (UBA 2013).

There is no information available on which amount of the water withdrawn in agriculture is applied to bioenergy crops. In 2010, 15.5 % of the cropland was used to cultivate bioenergy feedstocks (FNR 2011). As a rough estimate to indicator 5.1a we calculated a proportional contribution of production of biofuel feedstocks to water withdrawal, assuming that 15.5% of agricultural water withdrawal is applied to biofuel feedstock cultivation:

- **0.02 % of TARWR** are withdrawn for production of bioenergy feedstocks in Germany
- **0.09 % of TAWW** are withdrawn for production of bioenergy feedstocks in Germany

There are six nationally determined watersheds in Germany: Donau, Rhein, Ems, Weser, Elbe, Oder, Eider, Schlei/Trave, Warnow/Peene, Maas which are subdivided in 50 sub-watersheds (UBA 2012) (see Figure 19 in the Annex). Since the amount of water withdrawn for agriculture in Germany is less than 1 % of the water resources (TARWR) and water withdrawals (TAWW) we conclude that water withdrawal in the agricultural production of bioenergy crops currently is not of relevance in Germany.

For this reason indicator 5.1b which indicates the percentage of renewable and non-renewable water withdrawals is not relevant for bioenergy feedstock production in Germany either.

However, there could be a future risk from establishing short rotation forestry. Due to their higher transpiration coefficient they could reduce the renewal of ground water and thus lead to lower ground water tables. As Figure 20 in the Annex shows there are some groundwater bodies which are in a bad quantitative status – often due to mining activities or salt mines. Currently there are only small areas with short rotation forestry, however with a future growing demand the regional ground water availability has to be taken into account in identifying suitable areas.

Processing of bioenergy feedstock

Biodiesel production requires about 1 litre of water per litre of biodiesel (WSTB 2008). Ethanol production from maize requires about 4 litres of water per litre of ethanol (WSTB 2008).

In 2011 BLE has issued sustainability certificates for 0.0032 km^3 of biodiesel and 0.0493 km^3 of ethanol (BLE 2011).

Taking into account the numbers above this would make 0.20 km^3 of water used in production of biofuels. This means that in Germany water withdrawal for processing is about 12 times higher than water withdrawal for irrigation of biofuel feedstocks. However, in terms of total numbers water withdrawn for bioenergy processing is below 1% of water resources (TARWR) and water withdrawals (TAWW) in Germany.

- **0.62 % of TAWW** are withdrawn for bioenergy processing.
- **0.13% of TARWR** are withdrawn for bioenergy processing.

4.5.2.2 Sub-indicator 5.2: Water withdrawn for bioenergy feedstock production and processing per unit of bioenergy output

Sub-indicator 5.2 aims at efficient water use in biomass production and processing. It is meant “as a tool to monitor current water use efficiency and compare it with best practice data, so as to optimise the use of water resources for bioenergy production”.

Bioenergy feedstock production: Since the vast majority of bioenergy feedstock production (>99.7% as elaborated for indicator 5.1) is from rainfed agriculture, this indicator is not applicable.

Bioenergy feedstock processing: No national data on current water withdrawals from oil mills, ethanol plants, biogas plants and esterification plants is available. Therefore, no results can be generated for this indicator. However, the share of water withdrawals in bioenergy processing is not significant (<1%) in Germany.

4.5.3 Recommendations

For Germany: The evaluation of water use and water efficiency in this report describes the effects of bioenergy production in Germany. However, roughly 60% of bioenergy used in Germany was made from feedstocks cultivated outside of Germany (BLE 2011). This means that around 60% of the ecological impacts occur outside of the country and are not covered by this GBEP study. This is of special relevance for the water indicator because agriculture accounts worldwide for around 70% of total water withdrawals (compared to 0.3% in Germany). Hence the impacts of bioenergy use in Germany will be underestimated when a large share of this bioenergy is covered by imports.

For GBEP: As the goal of the GBEP indicators is to analyse the sustainability of the bioenergy sector and provide guidance to national policy makers, the effects of national bioenergy consumption on worldwide water availability (i.e. the virtual water import) should be taken into account in the further development of the GBEP indicators.

4.5.4 References

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DESTATIS (Statistisches Bundesamt) 2014: Entnahme von Wasser aus der Natur in Millionen Kubikmeter https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Umwelt/UmweltoekonomischeGesamtrechnungen/EnergieRohstoffeEmissionen/Tabellen/EntnahmeWasser.html (download June 2014)

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UBA (Umweltbundesamt) 2012: Wasserwirtschaft in Deutschland – Teil I: Grundlagen; Dessau.

4.6 Indicator 6: Water Quality

The GBEP Indicator 6 reads as follows:

(6.1) Pollutant loadings to waterways and bodies of water attributable to ***fertiliser and pesticide application*** *for bioenergy feedstock production, and expressed as a percentage of pollutant loadings from total agricultural production in the watershed*

(6.2) Pollutant loadings to waterways and bodies of water attributable to ***bioenergy processing effluents****, and expressed as a percentage of pollutant loadings from total agricultural processing effluents in the watershed*

Unit: kg/year or (per watershed area) in kg/ha/year; percentage

4.6.1 Sub-indicator 6.1: Pollutant loadings from fertiliser and pesticide application

4.6.1.1 Legal regulations and reporting commitments

The European Nitrates Directive (91/676/EEC) was implemented in 1991 and shall protect water against pollution by nitrates from agricultural sources. The German national implementation is done by the fertilisation ordinance (Düngeverordnung, DüV) that among others regulates the use of fertilisers. Every four years the state of surface and groundwater has to be reported. Up to now, two nitrate reports exist (2008, 2012). The nitrate concentration in water bodies is measured annually by the German Länder. There exist 800 measuring points for ground water and 180 measuring points for surface water.

The European Water Framework Directive (2000/60/EC) commits the European Member States to achieve good qualitative and quantitative status of all water bodies until 2015. The quality of all water bodies is monitored in Germany on a yearly basis with an extensive measuring network.

4.6.1.2 Results and methodological approach

Nutrient and pollutant concentrations in water bodies are measured and reported on a very regular base ensuring a close monitoring of water quality. Different institutions are responsible for different water body types (ground and surface water, rivers and lakes) causing differences in approaches and data availabilities. Only for rivers the allocation of pollution inputs (nitrogen and phosphorous) to their sources is modelled. For all other water bodies (lakes, groundwater) and for pesticides only concentrations are measured. The following sections provide an overview on the approaches for all water types.

Pollutant loadings in surface water

The phosphorous and nitrogen concentrations are measured regularly in rivers and lakes. Based on the pollutant concentration the water bodies are classified into seven chemical water quality classes. This information is used for reporting requirements under the Water Framework Directive and to monitor the development in water quality.

Only for river basins an allocation of pollutants to their entry paths has been done. This was realised in a project commissioned by UBA where the input of different substances into German water bodies was modelled with MONERIS (UBA 2010). This allows quantifying the contribution of agriculture to the nitrogen and phosphorous input. Latest data are available for the years 2003 to 2005.

The total input of nitrogen and phosphorous at watershed level is shown in Table 18. The watersheds in Germany are displayed in Figure 19 in the Annex.

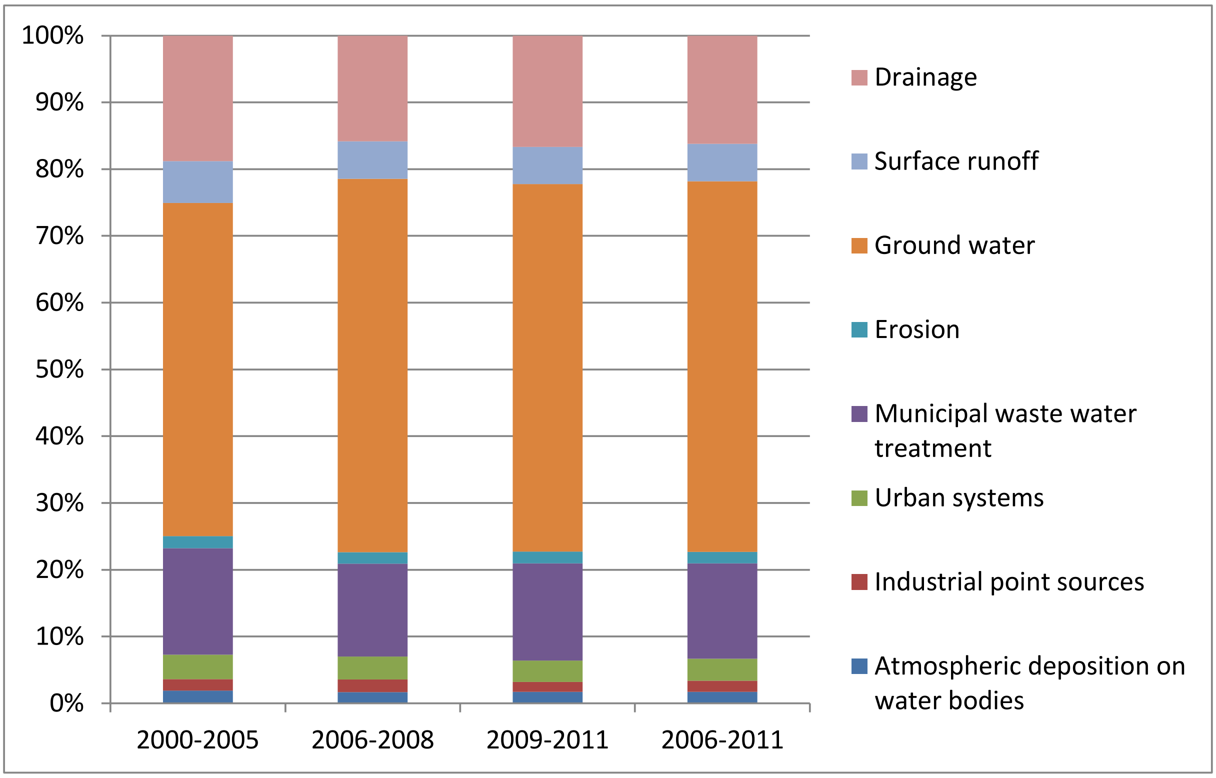
Table 13 Nitrogen and phosphorous input in the German parts of watershed in the balancing timeframe 2002 to 2005

Watershed	Nitrogen [kt/year]	Phosphorous [kt/year]
Danube	115.3	3.9
Rhine	201.5	9.4
Ems	26.3	0.9
Weser	69.2	3.0
Elbe	104.2	3.8
Oder	12.8	0.4
North sea	16.8	0.2
Baltic sea	18.6	0.5
TOTAL	**564.8**	**22.2**

Source: UBA (2010)

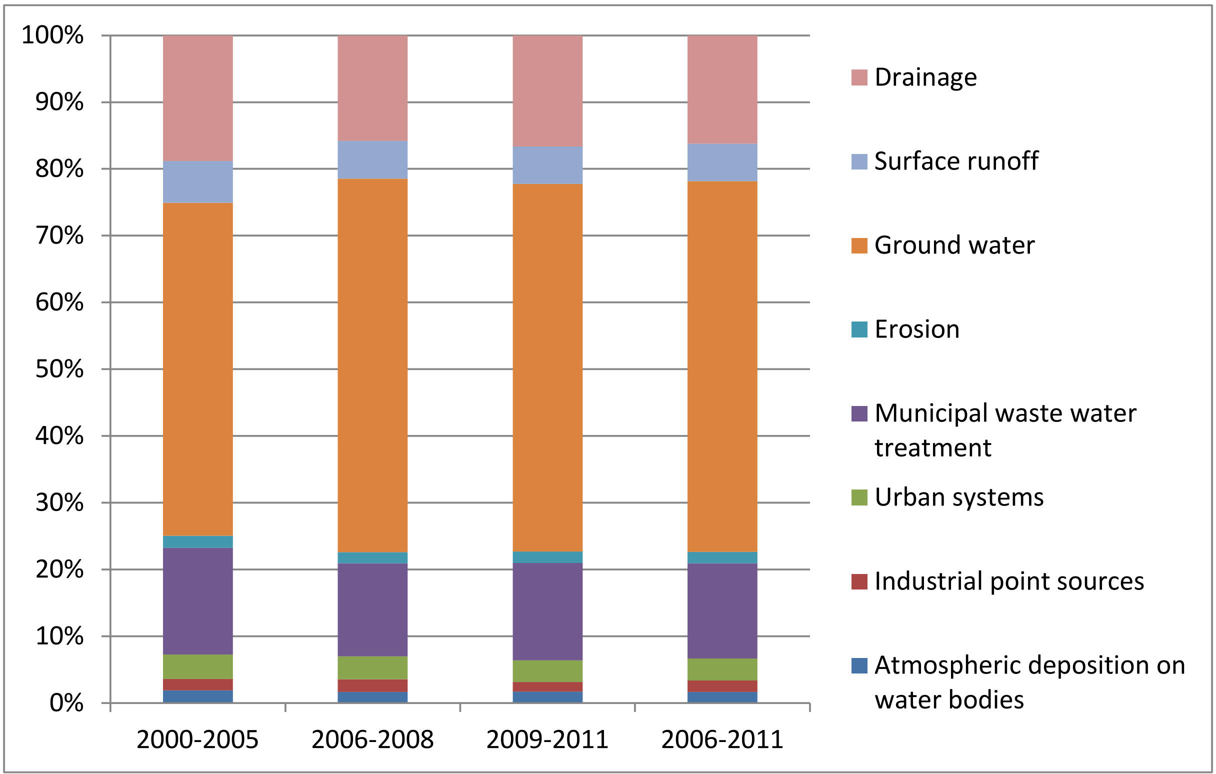
The allocation of inputs to the different sources is displayed in Figure 10 and Figure 11. Agriculture covers inputs from erosion, groundwater, surface runoff and drainages. This means that in the period of 2009 to 2011, 79% of the nitrogen input (equalling about 447 000 tonnes) and about 56% of the phosphorous input (equalling about 13 527 tonnes) can be attributed to agriculture.

Figure 10 Distribution of nitrogen sources



Source: own compilation based on BMU & UBA (2010)

Figure 11 Distribution of phosphorous sources



Source: BMU & UBA (2010)

A further exact disaggregation into bioenergy feedstocks is not feasible with the current data base. For doing so an additional module would have to be implemented in MONERIS with crop specific nitrogen leaching factors. A further difficulty is missing information on the distribution and exact localisation of bioenergy feedstock production.

At one of the expert workshops it was agreed that a linear allocation of environmental impacts based on the share of bioenergy feedstock area is a suitable proxy. In 2011, approximately 2.06 million ha where used for bioenergy crop cultivation (FNR 2012), which is about 17.3 % of the arable land. On this basis, about 77,398 tonnes of nitrogen input can be allocated to bioenergy feedstock production.

Pollutant concentration in groundwater

Nitrogen concentration in ground water bodies is measured with two different monitoring networks. A special network exists for monitoring impacts from agriculture. The measuring points are distributed on agricultural land and allow supervising the impacts from the action program that has been established to fulfil the requirements of the EU Nitrates Directive. However, the results are not representative for the general nitrate situation in Germany. For the latter purpose there is a second network covering 739 measuring points. The data are aggregated into the same water quality classification system as for surface water. The threshold laid down in the Drinking Water Ordinance is at >50 mg N / l.

The distribution of the measuring points within the general monitoring network is displayed in Figure 21 in the Annex. Figure 22 in the Annex shows the results only for those measuring points that are influenced by agriculture (fields, grassland, fruit-growing). The comparison of both figures shows the significant influence agriculture has on the nitrate loading of ground water. However, as for the surface water the exact allocation of the results to the cultivation of bioenergy feedstocks is not possible.

Pesticide concentration in surface water and groundwater

Pesticides concentration in **surface water bodies** is measured with the same measuring network as nitrogen and phosphorous. There is not a single aggregated figure but data on different substances are monitored. Specific thresholds are published for each substance subject to the Water Framework Directive. Figure 23 in the Annex shows an overview on the number of measuring points where the thresholds are met or exceeded.

Every four years LAWA together with the UBA publishes a report on the pollution of **groundwater** with pesticides. Up to now, the time frame 1990 to 2008 has been covered by four reports. The thresholds are 0.1 µg/l for single substances and 0.5 µg/l for the total load. The results are shown in Figure 24 in the Annex.

As for nitrate and phosphorous it is not possible to allocate the influence of bioenergy feedstock cultivation due to a lack of respective data. Furthermore, the levels of pesticides in groundwater show a strong delayed reaction. There are still measurable loadings of chemicals that have been abolished quite some years ago. However, they show steadily decreasing concentrations.

4.6.1.3 Data basis

Data on nitrogen, phosphorous and pesticides into ground and surface water bodies are measured regularly at extensive measuring networks. Different networks exist subject to different reporting requirements. The measuring is done by the German Länder that are organised in a Government / Länder Water Working Group (LAWA). The data are administered centrally by the Federal Environmental Agency (UBA) that is also responsible for reporting.

As data are measured directly, data quality can be regarded as good. For the allocation of nitrogen and phosphorous inputs to different sources the MONERIS model is used. As it does not contain a module for bioenergy, the contribution from bioenergy production can only be quantified as a rough approximation.

4.6.1.4 Recommendations

For Germany: The current data base regarding the contribution of bioenergy feedstock cultivation to nitrogen and phosphorous is low. This could be solved by adding a specific module to the MONERIS model. Furthermore, special attention should be paid to regional differences, i.e. the additional contribution from biogas plants in regions with extensive cattle breeding.

4.6.1.5 References

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BMELV & UBA 2012: Nitratbericht 2012; Bonn.

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4.6.2 Sub-indicator 6.2: Pollutant loadings attributable to bioenergy processing effluents

There is no official and regular data collection on pollutant loadings from bioenergy processing. Data on the amount of treated and untreated waste water are collected by DESTATIS, however, only for the industrial sector as a whole.

The German **Waste Water Ordinance (Abwasserverordnung, AbwV)** specifies the requirements for the discharge of waste water into water bodies. It lists thresholds for different substances specifically for different industry sectors (e.g. oil seed processing, oil refining). The compliance with the regulation is monitored by Federal State authorities. As waste water is only to be discharged when it complies with the thresholds, no harmful environmental effects are to be expected from the bioenergy sector.

As for several other indicators, difficulties arise from the fact that a certain amount from biomass is imported. As only processing plants within Germany are monitored, the impacts from processing that takes place outside Germany are not covered.

4.7 Indicator 7: Biological Diversity in the Landscape

The GBEP Indicator 7 reads as follows:

*(7.1) Area and percentage of nationally **recognised areas of high biodiversity value** or critical ecosystems **converted** to bioenergy production;*

*(7.2) Area and percentage of the **land used for bioenergy production where nationally recognised invasive species**, by risk category, are cultivated;*

*(7.3) Area and percentage of the **land used for bioenergy production where nationally recognised conservation methods** are used*

4.7.1 Legal regulations and reporting commitments

4.7.1.1 Sub – Indicator 7.1 Area and percentage of nationally recognised areas of high biodiversity value or critical ecosystems converted to bioenergy production

There is no reporting system in Germany, which collects information on the conversion of land especially for bioenergy production, since most of the biomass for energy is produced on existing agricultural land or managed forests, but the **management intensity** on agricultural land and forest is risen associated with bioenergy production.

However, the EU RED (**2009/28/EC** Article 17 - Sustainability criteria for biofuels and bioliquids) and the relevant German **Biomass Electricity Sustainability Regulation** (BioSt-NachV) of 29 July 2009 require that feedstocks are not obtained from land with high biodiversity value such as forests, grassland, and land with relevant protection status.

In Germany, several types of **protected areas** are designated based on the Federal Nature Conservation Act (BNatSchG). They can be classified by size, protection and conservation objective, and by the resulting restrictions on land use. The main types are (for detailed description see Annex: Indicator 7):

- National parks
- Nature conservation areas
- Biosphere reserves
- Landscape protection areas
- Nature parks and
- Natura 2000 sites

Two or more protected areas of different types can overlap or even cover the same area of land. For most of this areas management plans are existing and farming and forest is restricted. In **National parks** commercial exploitation of natural resources by farming, forestry, water use, hunting or fishing is largely prevented or only allowed subject to strict requirements laid down by the nature conservation authorities. Whereas in Nature protection areas farming and forestry is not restricted. Therefore, the status 'National park' is the only one that **ensures** that the conversion of areas of high biodiversity value or critical ecosystem is prohibited.

Supplementary Germany has in the frame of the **EU Habitats Directive and Birds Directive** within the **Natura 2000 network**12 (EU 1992) a well-established observation system for habitats to safeguard biological diversity. For the GBEP indicator reporting, two habitats are relevant: **grassland and forest**. Germany has the legal obligation to report every six years (latest: 2007-2012, published 2014[13]) by the Federal Agency for Nature Conservation (BfN) on the conservation status of habitats and species of Community interest. Therefore, the Natura 2000 network has a monitoring tool to control and inform on land conversion.

Under the **UN Convention on Biological Diversity (UN CBD) and the relevant National German Biodiversity Strategy and Action Plan** (NBSAP)[14]) Germany established an indicator based monitoring system in which the following indicators are relevant for the GBEP Indicator 7.1.

First and most suitable, the **High Nature Value Farmland Indicator** is biannual reported to the EU under the **EAFRD Regulation** and at national level in Germany as one of the reporting requirements for the **National Biodiversity Strategy** (NBS)[15].

Other **Indicators** compiled **for the NBS**, which are relevant for Sub-Indicator 7.1, are:

- **'*Area protection***', this indicator is a figure for the total area of strictly protected areas in Germany.
- '***Species diversity and landscape quality***'[16] is the index (measure in %) of nationwide populations of 59 representative bird species in six main habitat and landscape types in Germany[17].

Every 4 years Germany reports under the **UN CBD** (latest report 2014 with data from 2010/11) with regard to the national implementation of the **Action Plan** (latest indicator report 2010[18] followed by accountability report 2013 with data until 2011/12, report for 2014 pending; see BfN 2014a).

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12 Together with the Council Directive on the conservation of wild birds, the Council Directive on the conservation of natural habitats and of wild fauna and flora constitutes the European Union's central nature conservation legislation platform. Areas protected under both directives make up Natura 2000, an EU-wide network of conservation areas geared towards conserving habitats and species endangered in the EU. To comply with the stringent provisions applied to Natura 2000 sites, mandatory reports are required every six years to document the conservation measures taken in areas protected under Article 17 of the EU Habitats Directive. The reports must also contain the key findings of the monitoring activities prescribed under Article 11 of the EU Habitats Directive.

13 German only: http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Naturschutz/natur_deutschland_bericht_bf.pdf

14 According to article 6 of the CBD each member state needs to develop a National Biodiversity Strategy and Action Plan (NBSAP) for the implementation of the COP decisions, in order to integrate the CBD objectives into national policies and in order to report about progress, success and failure. In this way, each member state integrates conservation and sustainable use of biodiversity into national plans and decisions.

15 By agreement between the Federal Ministry of Food and Agriculture (BMEL), the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the German Länder, the indicator is developed and coordinated by the Federal Agency for Nature Conservation (BfN).

16 The size of the populations (by number of territories or breeding pairs) reflects the suitability of the landscape as a habitat for the selected bird species. Since not only birds, but also other species depend on a many-faceted landscape with intact, sustainably used habitats, the indicator also provides an indirect picture of the development of numerous other species in the landscape and the sustainability of land use.

17 Landscape and habitat types in Germany: farmland, forests, settlements, rivers and lakes, coasts/seas and the Alps.

18 See: http://www.biologischevielfalt.de/fileadmin/NBS/indikatoren/Indicator_Report_2010_NBS_Web.pdf

4.7.1.2 Sub – Indicator 7.2 Area and percentage of the land used for bioenergy production where nationally recognised invasive species, by risk category, are cultivated

In the German Federal Nature Conservation Act (BNatSchG) (§40) the handling of invasive species is regulated. However, there is an exception for agricultural and forestry operations. Therefore, there is a need of action to find relevant regulations and controlling systems if the cultivation of invasive energy plants such as e.g. Giant reed may play a role in the future.

4.7.1.3 Sub – Indicator 7.3 Area and percentage of the land used for bioenergy production where nationally recognised conservation methods are used

Since in Germany bioenergy production is more or less to hundred percent embedded in the agricultural and forestry production, it is impossible to distinguish between biomass production for food, feed or energy. However, some nationally recognised conservation methods are measured within the **National Biodiversity Strategy (NBS) (see Sub-Indicator 7.1),** where Germany reports every 4 years to the following indicators:

- **Agro-environmental measures** - The indicator is an overall figure for the total area of land receiving assistance under agro-environmental measures and the assistance paid for it. Conserving and developing biological diversity in cultural landscapes is a fundamental task of agro-environmental programs and one goal of the National Strategy on Biological Diversity.
- **Organic farming** - The indicator provides information on the area covered by organic farming operations that are subject to the control procedures of the EU legislation on organic farming.
- **Sustainable forestry** - The indicator shows the percentages of Germany's total forest area accounted for by forests certified by PEFC and FSC.

In November 2007 the Ministry of Agriculture put forward an **agro-biodiversity strategy** under the title “Conservation of Agricultural Biodiversity, Development and Sustainable Use of its Potentials in Agriculture, Forestry and Fisheries”. As a sectoral strategy, it supports and supplements the National Strategy on Biological Diversity.

4.7.2 Results and methodological approach

4.7.2.1 Sub – Indicator 7.1 Area and percentage of nationally recognised areas of high biodiversity value or critical ecosystems converted to bioenergy production

The main causes of the decline in species diversity – which differ by region – are intensive use for agriculture and forestry, landscape fragmentation and urban sprawl, sealing of land surfaces, and inputs of substances (acidifiers or nutrients) (BMUB 2014).

Of particular importance in the bioenergy context is **grassland conversion** and the **intensification of grassland** (fertilization, number of cuttings)[19]. The qualitative, but as well as quantitative degradation of species-rich grassland is documented in the BMUB-BfN national report for the reporting under Article 17 of the Habitats Directive. The report presents the conservation status of species and natural habitats of Annex I, II, IV and V.

The evaluation of the results show that species-rich grassland is in an ‘unfavourable’ to ‘unfavourable-bad’ conservation status in the Atlantic and Continental biogeographical regions in Germany (BfN 2014b).

The **indicator on High Nature Value Farmland**[20] (HNVF) delivers meaningful results to contribute to **sub-indicator 7.1** and documents very clear the tendency to intensification of the land use systems (agriculture and forestry).

HNV farmland has been identified at EU level by pooling CORINE Land Cover, agroeconomic, Natura 2000 and Important Bird Area data. However, the EU-level distribution of HNV farmland does not match its national-level distribution in Germany, for example it leaves out small areas (under 25 ha) and near-natural grassland accounting for a large share of the total (Paracchini et al. 2008).

The German federal government and the Länder agreed on a uniform methodology for extrapolate the indicator using a stratified random sample design.

Data for the HNV farmland indicator are gathered in field surveys, using some 900 sample plots throughout Germany each covering one kilometre square and comprising at least five percent open countryside. The sample design is the same as that already used for many years by the Federation of German Avifaunists (DDA) in monitoring common species of breeding birds.

The BfN developed the survey design for the initial nationwide survey of HNV farmland in consultation with the German Länder. This survey was carried out jointly by the German government and the Länder in 2009 and coordinated by the BfN. The subsequent surveys were carried out by the Länder.

The identified HNV farmland structures were assigned nature values on a scale, as shown in Table 14.

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19 In some regions over 50% of the plough grassland was for the cultivation of maize (Nitsch, H. u. a., 2010)

20 The high nature value (HNV) farmland indicator is one of 35 indicators that incorporate environmental concerns into the EU Common Agricultural Policy. It is an ‘objective-related’ baseline indicator under the EAFRD Implementing Regulation (Regulation No 1974/2006/EC, Annex VIII), where it is defined as one of three biodiversity indicators in Axis 2 (Improving the Environment and the Countryside). The indicator is also included in the indicator set for the German National Strategy on Biological Diversity and in the German Länder’s core indicator set (LIKI).

Table 14 High Nature Value Farmland categories and percentage share in Germany 2009-2013

	HNV I: Exceptionally high nature value	HNV II: Very high nature value	HNV III: Moderately high nature value	HNV total	HNV absolute
	%				ha
2009	2,1	4,5	6,3	13,2	2.593.461
2011	2,2	4,1	5,8	12,1	2.380.387

Source Federal Agency for Nature Conservation (BfN), 2013 http://www.bfn.de/0315_hnv+M52087573ab0.html

HNV farmland was found to account for 13.2 (±0.5) percent of total farmland in Germany in 2009 and 11.8 (±0.5) percent in 2013. The latter value is calculated on basis of the mean on a gliding scale with 50 percent of the samples remapped.

The comparison of the values shows a sharp decline. The highest decline appears in the moderately high-nature value category, whereas farmland with exceptionally high nature value stagnated on comparable low level. A closer look on the results highlights that the decline on HNVF is mostly attributed to a drop in grassland quality. Grassland has the highest share on HNV farmland, but at the same time the highest decline in size from 2009 to 2013. Within this 4 years HNV grassland regressed 7.4 %, which complies an absolute reduction of 0.4% (82.000 ha) of the total agricultural area.

Results from the relevant Indicators under the **National Biodiversity Strategy (NBS)[21] :**

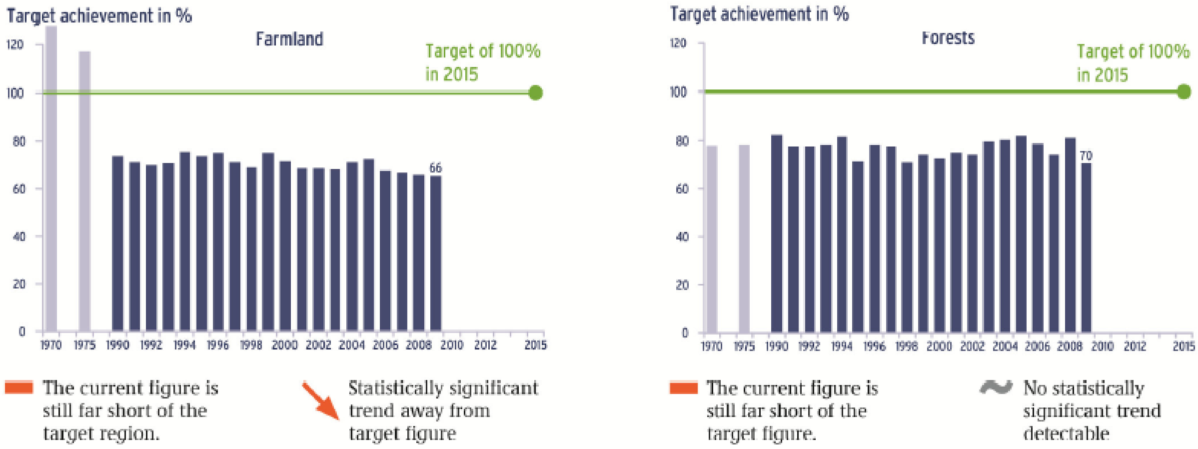
Area protection: The indicator is a figure for the total area of strictly protected areas in Germany. To this end, the percentage share of Germany's total land area is calculated for nature conservation areas (NSG) and national parks (NLP). The area covered by strictly **protected areas in 2014 are 1.545.887 ha** (BfN 2014c), i.e. 4.33 % of the German land area.

The designation of the **Natura 2000** network in Germany under the Habitats Directive was finalized during the reporting period (2007-2012). The network comprises 4617 sites covering a total area of 54452 km² (without marine parts 33231 km²) (Annex A under Article 17 reporting 2013).

Species diversity and landscape quality: The calculation of the indicator is based on the development of the populations of 59 bird species representing the main landscape and habitat types in Germany. For GBEP indicator 7.1 farmland and forests are relevant. Over the last ten-year observation period (1999-2009) there was a statistically significant deterioration in the indicator. In 2009 it fell to 67%, the lowest figure yet recorded.

21 Indicator results with data from 2010/11 as the 2014 report is still pending.

Figure 12 Species diversity and landscape quality indicator for farmland and forests 2009



Source: BMUB (2014)

4.7.2.2 Sub – Indicator 7.2 Area and percentage of the land used for bioenergy production where nationally recognised invasive species, by risk category, are cultivated

With regard to **sub-indicator 7.2**, here is **no evidence** that nationally recognised invasive species were used for any bioenergy feedstock cultivation in Germany in the last years. Only in field trials species like e.g.: Miscanthus, Sorghum or Topinambour are tested.

4.7.2.3 Sub – Indicator 7.3 Area and percentage of the land used for bioenergy production where nationally recognised conservation methods are used

Results from the relevant Indicators under the **National Biodiversity Strategy (NBS)**[22] **:**

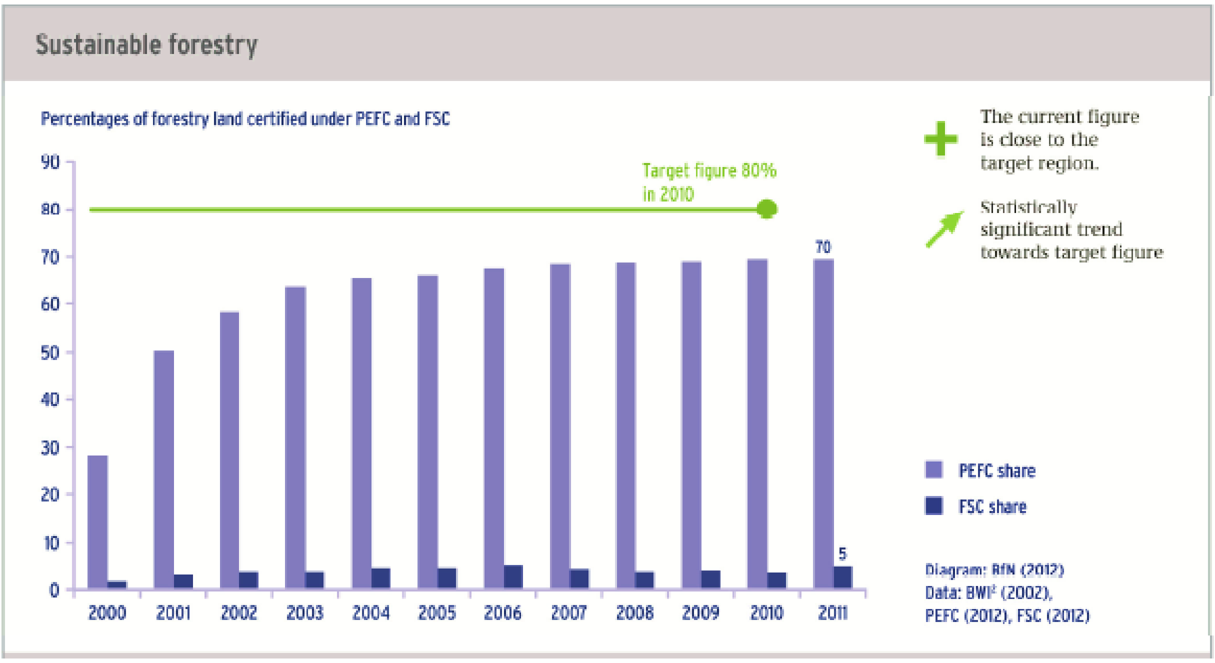
Organic farming: The indicator provides information on the area covered by organic farming operations that are subject to the control procedures of the EU legislation on organic farming. This area has steadily increased since 1994. At the end of 2010, some 22,174 farms with a total area of 990,702 ha were operating in accordance with the provisions on organic farming. This represents 7.3% of farms, on 5.9% of total farmland (BMUB 2014). However, there is no evidence that land used for bioenergy production is farmed organically.

Agro-environmental measurements: The indicator is an overall figure for the total area of land receiving assistance under agro-environmental measures and the assistance paid for it. Conserving and developing biological diversity in cultural landscapes is a fundamental task of agro-environmental programs and one goal of the National Strategy on Biological Diversity. To this end, there is a need to increase the percentage of land receiving assistance. The area receiving assistance was around 5.4 million ha in 2010, which was almost as high as the previous record level of 5.5 million ha in 1997. During the current assistance period, assistance payments first showed a marked drop from 2007 to 2009, but rose again slightly to 577 million € in 2010 (BMUB 2014).

[22] Indicator results with data from 2010/11 as the 2014 report is still pending.

Sustainable forestry: The following figure shows the percentages of Germany's total forest area accounted for by forests certified by PEFC and FSC. Due to overlaps between PEFC and FSC areas, the "net" certification is unknown, but the figure shows the areas side by side. In 2011, PEFC-certified forests had a share of about 70%, and FSC-certified forests accounted for about 5% of the total forest area in Germany.

Figure 13 Sustainable forestry certification shares 2000-2011



Source: BfN (2012)

4.7.3 Data basis

The data basis for the GBEP **sub-indicators 7.1 and 7.3** are the national reports under the **EU Habitats Directive and Birds Directive** and the indicator reports under the **UN Convention on Biological Diversity** and the relevant **Indicator report 2010 under the National Biodiversity Strategy**[23] mentioned in Section 4.7.1. The indicator report 2014 under the NBS is currently being compiled.

For the HNV Farmland indicator a regular surveying of sampling plots (every 2 year) will make it possible to establish nationwide monitoring of open countryside that identifies both areas of special nature value and areas with potential for improvement on the HNV scale.

Future surveys will be carried out by the Länder. Some will survey a quarter of sampling plots each year while others will cover half of the sampling plots every two years. This means full regional and nationwide coverage is achieved after four years. BfN collates the Länder data and extrapolates the national indicator every 2 years.

23 See: http://www.biologischevielfalt.de/fileadmin/NBS/indikatoren/Indicator_Report_2010_NBS_Web.pdf

BfN provides various ways of accessing maps and spatial information. Besides conventional, static maps, there are also interactive online maps (web mapping applications).

4.7.4 Recommendations

For Germany: Data on the geographical location of biomass production in Germany are only hardly available and not freely assessable. For example, it is unknown which part of the total maize or rapeseed production area can be allocated to energy crop production.

Main restriction for this indicator is the lack of information on the geographical location of the biomass feedstocks harvested for bioenergy use. The use of GIS is highly recommended for this indicator.

For GBEP: In addition to the conversion of grasslands (see Section 4.8.5), possible effects of **intensified use** of grasslands for bioenergy (biogas) and forests should be considered as a further GBEP sub-indicator for biological diversity impacts in the landscape.

4.7.5 References

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2013: Gemeinsam für die biologische Vielfalt - Rechenschaftsbericht 2013 zur Umsetzung der Nationalen Strategie zur biologischen Vielfalt; Bonn http://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Natur_Arten/130423_rechenschaftsbericht__biologische_vielfalt_bf.pdf

BMUB 2014: Fifth National Report. Convention on Biological Diversity. Germany. March 2014 http://www.cbd.int/doc/world/de/de-nr-05-en.pdf

BfN (Federal Environment Agency) 2013: Protected areas. http://www.bfn.de/0316_natura2000+M52087573ab0.html

BfN (Federal Environment Agency) 2014a: Indikatoren http://www.biologischevielfalt.de/bilanz_nbs.html

BfN (Federal Environment Agency) 2014b: BfN Grünland-Report: Alles im Grünen Bereich? Juli 2014

BfN (Federal Environment Agency) 2014c: National Parks. http://www.bfn.de/0308_nlp.html

EU (European Union) 1992: Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora; Brussels http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1992L0043:20070101:EN:PDF

EU (European Union) 2009: Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds; Brussels http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:020:0007:0025:EN:PDF

Nitsch H.; Osterburg B.; Laggner B.; Roggendorf R: Wer schützt unser Grünland? - Analysen zur Dynamik des Dauergrünlands und entsprechender Schutzmechanismen. In: JOHANN HEINRICH VON THÜNEN-INSTITUT (Hrsg.) (2010)

Paracchini et al. 2008: High Nature Value Farmland in Europe. An estimate of the distribution patterns on the basis of land cover and biodiversity data. European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra http://agrienv.jrc.ec.europa.eu/publications/pdfs/HNV_Final_Report.pdf

4.8 Indicator 8: Land use and land-use change related to bioenergy feedstock production

The GBEP Indicator 8 reads as follows:

(8.1) *Total area of land for bioenergy feedstock production and as compared to total national surface*
(8.2) *and as compared to agricultural land and managed forest area*
(8.3) Percentage of bioenergy from:

(8.3a) yield increases,
(8.3b) residues,
(8.3c) wastes,
(8.3d) degraded or contaminated land

(8.4) *Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production, including the following (amongst others):*

- *arable land and permanent crops, permanent meadows and pastures, and managed forests*
- *natural forests and grasslands (including savannah, excluding natural permanent meadows and pastures), peat lands, and wetlands*

Units: hectares, percentages

4.8.1 Sub-Indicators (8.1) Total area of land for bioenergy feedstock production, and as compared to total national surface and (8.2) as compared to agricultural land and managed forest area

4.8.1.1 Legal regulations and reporting commitments

The national statistical data from FNR and AGEE-Stat (see Section 3.3) provide the core information for the GBEP sub-indicators 8.1 and 8.2.

4.8.1.2 Results and methodological approach

The result of the data compilation for the GBEP Indicator 8.1 is given in Table 15.

Table 15 Results for Sub-Indicator 8.1: Total area of agricultural land for bioenergy feedstock production in Germany 2010-2012 compared to national surface area

	2010	2011	2012	Unit
Total agricultural land for bioenergy feedstocks	1.83	1.97	2.12	Mha
- compared to national surface	5.1	5.5	5.9	%

Source: compilation by IINAS based on FNR (2012)

The methodology to derive the indicator values was to determine the total land use for bioenergy feedstock production per year based on national statistics (FNR 2012), and to divide these values by the respective data for the national surface, agricultural area, and managed forest area, respectively, which were also taken from national statistics (DESTATIS 2013; FNR 2012).

The result of the data compilation for the GBEP Indicator 8.2 is given in Table 16.

Table 16 Results for Sub-Indicator 8.2: Total area of land for bioenergy feedstock production in Germany 2010-2012 compared to agricultural land, arable land and managed forest area

	2010	2011	2012	Unit
Total agricultural land for bioenergy feedstocks	1.83	2.06	2.12	Mha
- compared to agricultural land	11.0	11.8	12.7	%
- compared to arable land	15.5	16.6	18.0	%
- compared to managed forest area	17.0	18.2	19.1	%

Source: compilation by IINAS based on FNR (2012)

The methodology to derive the indicator values was the same as for Indicator 8.1.

4.8.1.3 Data basis

The statistical data for land used for bioenergy feedstock production per year is based on FNR (2012) and are given in Table 17.

Table 17 Crop area for bioenergy feedstock production in Germany 2010-2012

Agricultural land for bioenergy feedstocks [ha]	2010	2011	2012
Rapeseed (for RME and SVO)	940,000	910,000	913,000
Sugar beets, other cereals (for EtOH)	240,000	250,000	243,000
Maize, other cereals (for biogas)	650,000	800,000	962,000
SRC (for heat)	4,000	6,000	6,500
Total	**1,834,000**	**1,966,000**	**2,124,500**

Source: compilation by IINAS based on FNR (2012); RME = Rapeseed Methyl Ester; SVO = Straight Vegetable Oil; EtOH = ethanol; SRC = short-rotation coppices

4.8.1.4 Recommendations

For Germany: In Germany, all information for the indicator 8.1 and 8.2 are directly available from annual national statistical data. Thus, no change is needed here.

For GBEP: With regard to the formulation of Indicator 8.2 it should be noted that a comparison of the total land area used for bioenergy feedstocks with agricultural and managed forest areas **might be misleading**, as the **total** land use for bioenergy feedstocks consists of **both** crops from agricultural land and from forest biomass from managed forests.

It might be more appropriate to **disaggregate this**, i.e. to compare the land use for **agricultural** bioenergy feedstocks to the **agricultural** land area, and the land use for **forest** bioenergy feedstocks to the land area of **managed forests**.

4.8.1.5 References

FNR (Fachagentur für nachwachsende Rohstoffe) 2013: Cultivation of renewable resources in Germany; Gülzow http://mediathek.fnr.de/media/downloadable/files/samples/r/l/rl_fnr4_0184_grafik_nawaro_.jpg

4.8.2 Sub-Indicator 8.3a: Percentage of bioenergy from yield increases

4.8.2.1 Legal regulations and reporting commitments

The national statistical data from AGEE-Stat, DESTATIS and FNR (see Section 3.3) provide the core information for the GBEP sub-indicator 8.3a.

In addition, reporting commitments exist for data on crop area, harvest and yield levels which are collected by DESTATIS, and the Federal Ministry for Food and Agriculture (BMEL) collects respective statistical data and reports national figures to the FAO.
To date there is no requirement to differentiate between agricultural crops for food/feed, material and energy use, though.

4.8.2.2 Results and methodological approach

For the GBEP sub-indicator 8.3a the most relevant crops used as bioenergy feedstock in Germany were compiled to illustrate yield increases in the last years. Yield increases can, however, not be directly linked to bioenergy production.

Given the significant variation in yield changes - both positive and negatve - reported for key crops from 2008 to 2012 (see Section 4.8.2.3 below), **no bioenergy share from yield increases** can be determined with reasonable certainty.

4.8.2.3 Data basis

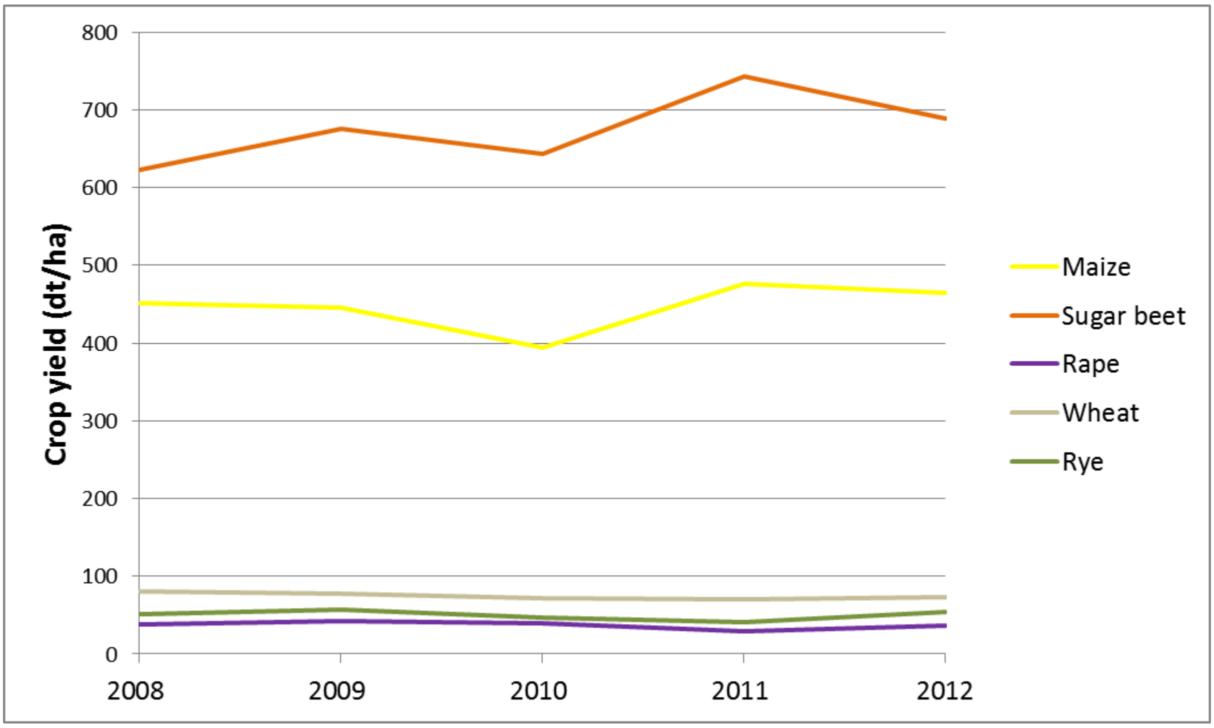
The yearly data on crop yields does not distinguish between food/feed crops, and bioenergy crops (DESTATIS 2013). The data on yield developments in Germany are given in Table 18.

Table 18 Data for crop yields in Germany 2008-2012

In dt/ ha	2008	2009	2010	2011	2012
Maize	451.4	445.0	393.8	476.1	464.3
Sugar beet	622.9	675.6	643.5	743.0	688.5
Rape	37.7	42.9	39.0	29.3	37.0
Wheat	80.9	78.1	72.1	70.1	73.3
Rye	50.9	57.0	46.3	41.1	54.7

Source: IINAS compilation based on DESTATIS (2013)

Figure 14 Data for the development of yields for key crops in Germany 2008-2012



Source: IINAS compilation based on DESTATIS (2013)

Table 19 Data for Crop Yield Changes in Germany 2009-2012 compared to 2008

Yield change relative to 2008	2009	2010	2011	2012
Maize	-1.4%	-12.8%	5.5%	2.9%
Sugar beet	8.5%	3.3%	19.3%	10.5%
Rape	13.8%	3.4%	-22.3%	-1.9%
Wheat	-3.5%	-10.9%	-13.3%	-9.4%
Rye	12.0%	-9.0%	-19.3%	7.5%

Source: IINAS compilation based on DESTATIS (2013)

As can be seen, there is no significant yield improvement for key crops, as weather conditions (precipitation, droughts, frosts) significantly varied within the last 5 years, impacting on all yields.

4.8.2.4 Recommendations

For Germany: Since there is no specific data collection for bioenergy crops in Germany, yield improvement data for bioenergy must rely on food/feed crops for which statistical data is available. It should be considered to collect specific data from main suppliers (e.g. larger farms) and project-based information from field trials carried out by FNR and several universities to develop some time series from which specific data could be derived in the future.

4.8.2.5 References

BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz) 2013: Statistik und Berichte Holz -und Forstwirtschaft; Bonn, Berlin http://www.bmelv-statistik.de/de/fachstatistiken/forst-und-holzwirtschaft/

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Mantau U 2012: Holzrohstoffbilanz Deutschland, Entwicklungen und Szenarien des Holzaufkommens und der Holzverwendung 1987 bis 2015: Hamburg

UBA (Umweltbundesamt) 2013: Daten zur Umwelt - Nachwachsende Rohstoffe; Dessau http://www.umweltbundesamt-daten-zur-umwelt.de/umweltdaten/public/theme.do?nodeIdent=2281

4.8.3 Sub-Indicators 8.3b+c: Percentage of bioenergy from residues and wastes

4.8.3.1 Legal regulations and reporting commitments

The national statistical data from BMUB, AGEE-Stat and FNR (see Section 3.3) provide the core information for the GBEP sub-indicator 8.3b+c.

To date there is no differentiation on biogenic residues and waste in the German statistical system.

4.8.3.2 Results and methodological approach

The results for the contribution of residues and waste to energy supply in Germany and the respective shares in 2012 are given in the following table (data for 2010 and 2011 see Annex).

Table 20 Results for Indicators 8.3b+c: Contribution and percentages of bioenergy from residues and wastes in Germany 2012

	Total	from residues & wastes	
Bioenergy	**TWh**	**TWh**	**Share**
- electricity	43.6	12.5	26%
- heat	126.6	74.7	59%
- transport fuels	34.2	3.4	10%
total	**204.4**	**89.5**	**44%**

Source: calculation by IINAS based on BMU (2012a); BLE (2012); DBFZ (2012)

German statistical data currently distinguish only between **some** residues and wastes used for bioenergy (e.g. landfill and sewage gas), but not for solid bioenergy. To derive respective data, the following approach was used:

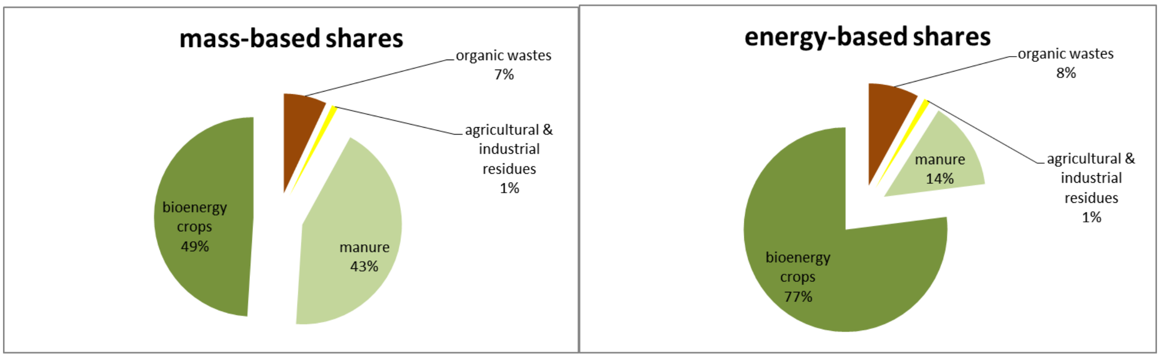
It is assumed that all solid biomass **for electricity**[24] comes from post-consumer (waste) wood and industrial woody residues and wastes, while **for heat**, forest products (thinnings, harvesting residues)[25] and some wood industry wastes are used plus a small contribution from Short Rotation Coppices (SRC) which was cultivated on 6,500 ha in 2012 with an average yield of 12 t per ha per year (FRN 2012), i.e. 78,000 t of woody biomass. With an average heating value of 15.4 MJ/kg (@ 15% moisture) the SRC energy share is about 0.33 TWh per year.

4.8.3.3 Data basis

The data used for this indicator was compiled from statistical information (BLE 2012; BMU 2012a+b; FNR 2012) and results from a German research project on monitoring biomass use for electricity generation (DBFZ 2012). The following tables gives the respective values for 2012. The 2010 and 2011 values are in Table 43 and Table 44 in the Annex.

The shares of residues & waste in biogas were calculated from data given in Figure 15, the share of biodiesel from residues and wastes was calculated from BLE (2012).

Figure 15 Mass and Energy-based Substrate Shares in Biogas Plants



Source: DBFZ (2012)

24 This is based on the fact that nearly all liquid biofuels in Germany come from annual agricultural crops, and only a minor share from waste oils (AGEE-Stat 2012; BLE 2012; BMU 2012a+b; FNR 2012). Thus, **no** solid feedstocks (e.g. straw, forest residues, SRC) are used for liquid biofuels.

25 For forest products, the bioenergy share of the overall harvest (see Section **Fehler! Verweisquelle konnte nicht gefunden werden.**) is used to determine the amount used for heat. In this, all woody forest products are considered as “products”, not as residues or wastes.

Table 21 Calculation of residue and waste shares in renewable energy supply in Germany 2012

	Renewable Energy Source	TWh	
		all	biomass residues & wastes
Electricity	**Hydropower**	**21.793**	
	Wind power	**50.67**	
	Biomass for electricity	**43.55**	
	of that:		
	solids	11.6	
	liquids (incl. vegetable oil)	0.4	0.1
	biogas	24.8	5.7
	sewage gas	1.3	1.3
	landfill gas	0.55	0.55
	biogenic fraction of waste	4.9	4.9
	Photovoltaic	**26.38**	
	Geothermal	**0.03**	
	Total electricity	**142.4**	**12.5**
Heat	**Biomass for heat**	**126.6**	
	of that:		
	solids	103	61.3
	liquids (incl. vegetable oil)	0.8	0.1
	biogas	12.1	2.8
	sewage gas	1.8	1.8
	landfill gas	0.1	0.1
	biogenic fraction of waste	9.1	9.1
	Solar thermal	**6.7**	
	Deep Geothermal	**0.3**	
	Near surface geothermal + ambient heat	**6.7**	
	Total heat	**140.4**	**74.7**
Biofuels	Biodiesel (approx. 2.4 Mt)	24.9	3.4
	Vegetable oils (approx. 0.02 Mt)	0.2	
	Bioethanol (approx. 1.2 Mt)	9.1	
	Total transport fuels	**34.2**	**3.4**
Total	**Total bioenergy**	**204.4**	**89.5**
	Total final energy from renewable resources	**317.0**	

*Source: calculation by IINAS based on BMU (2013); BLE (2013); DBFZ (2012); *= note that all forest products used for heat are not considered as "residues" but as commercial products*

4.8.3.4 Recommendations

For Germany: In Germany, the available statistical data currently **does not** allow to consistently distinguish between biogenic residues and respective wastes. Thus, the GBEP Indicators 8.3b+c can be determined only as an aggregate figure.

Given that bioenergy from residues and waste will increase in the next years due to political emphasis given to these resources, Germany should consider to improve the statistical coverage by DESTATIS and AGEE-Stat.

For GBEP: The definition of residues is subject to large differences between countries, which implies significant uncertainties in the interpretation of this sub-indicator. It is highly recommended for develop a “common definition” especially for forest products which reflects the relative market values of each assortment.

4.8.3.5 References

BLE (Bundesanstalt für Landwirtschaft und Ernährung) 2012: Evaluations- und Erfahrungsbericht für das Jahr 2011; Bonn http://www.ble.de/SharedDocs/Downloads/02_Kontrolle/05_NachhaltigeBiomasseerzeugung/Evaluationsbericht_2011.pdf?__blob=publicationFile

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2012a: Erneuerbare Energien in Zahlen. Internet update ausgewählter Daten. Dezember 2012; Berlin http://www.erneuerbare-energien.de/unser-service/mediathek/downloads/detailansicht/artikel/erneuerbare-energien-in-zahlen/

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2012b: Progress report under Article 22 of Directive 2009/28/EC on Promotion of the Use of Energy from Renewable Sources; Bonn, Berlin

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2013: Erneuerbare Energien in Zahlen. Internet update ausgewählter Daten. Juli 2013; Berlin http://www.erneuerbare-energien.de/unser-service/mediathek/downloads/detailansicht/artikel/erneuerbare-energien-in-zahlen/

DBFZ (Deutsches Biomasse-Forschungszentrum gGmbH) 2012: Monitoring zur Wirkung des Erneuerbare- Energien-Gesetz (EEG) auf die Entwicklung der Stromerzeugung aus Biomasse. Endbericht zur EEG-Periode 2009 bis 2011; Leipzig http://www.dbfz.de/web/fileadmin/user_upload/Berichte_Projektdatenbank/3330002_Stromerzeugung_aus_Biomasse_Endbericht_Ver%C3%B6ffentlichung_FINAL_FASSUNG.pdf

4.8.4 Sub-Indicator 8.3d: Percentage of bioenergy from degraded or contaminated land

4.8.4.1 Legal regulations and reporting commitments

The national statistical data from BMUB, AGEE-Stat and FNR (see Section 3.3) provide no information for the GBEP sub-indicator 8.3d.

For liquid biofuels, the German Sustainability Ordinance for Biomass Electricity[26] specifies that a GHG “bonus” of 29 g CO_2eq/MJ can be requested for biofuel feedstocks cultivated on degraded or contaminated land[27]. The definitions for these two terms are given in BioSt-NachV §9 based on respective formulations in RED Art. 18 para. 4 sub-para 4:

[26] Biomassestrom-Nachhaltigkeitsverordnung - BioSt-NachV, see http://www.gesetze-im-internet.de/bundesrecht/biost-nachv/gesamt.pdf

[27] For respective GHG calculations see Section 4.1 of this report.

- "Severely degraded land" is land that, for a significant period of time, has either been significantly salinated, or that has presented significantly low organic matter content and that has been severely eroded.
- "Heavily contaminated land" is land that is unfit for the cultivation of food and feed due to soil contamination.

4.8.4.2 Results and methodological approach

To date, no data on biofuels from feedstocks cultivated on severely degraded or heavily contaminated land is reported. There are extensive post-mining areas in Lower Saxony, Saxony and Thuringia, and some of this land might be used for cultivating SRC on a project base (few 100 ha). Thus, data for this sub-indicator cannot be given with certainty, but own estimates indicate that bioenergy from these land categories is of less than 0.1% of overall bioenergy supply from biomass cultivation.

4.8.4.3 Data basis

No systematic data is available on bioenergy cultivated on degraded or contaminated land in Germany. Degraded land in Germany only matters in size in terms of post-mining land, but there is no national survey on degraded land.

Heavy metal soils or soils polluted with chemicals are administrated within the contaminated land register on State or even county level. The German Länder have data on “land parcel” levels, but no information on the total area or the position of these areas.

Furthermore, there are contaminated wetlands where cultivation of food and feed is not possible, but data and location are not available.

Disclosed GIS data sources are not known for the Federal level, only some proprietary data exist in German Länder. According to experts, the validity of these data for biomass cultivation is low. Maps showing soil erosion potential and pollution with heavy metal are available to some extend nationwide, but it is not possible to draw conclusions on de facto degraded areas from those sources. In a strict sense of degraded land (e.g. desertification or complete soil erosion) there is no relevant area affected in Germany (Krismann u.a. 2009).

4.8.4.4 Recommendations

For Germany: As long as no biofuel production according to RED Art. 18 para. 4 sub-para 4 is reported for Germany and land for SRC cultivation remains comparatively small, this sub-indicator is of no relevance for Germany.

4.8.4.5 References

BioSt-NachV (Biomassestrom-Nachhaltigkeitsverordnung) 2009: Verordnung über Anforderungen an eine nachhaltige Herstellung von flüssiger Biomasse zur Stromerzeugung BioSt-NachV Ausfertigungsdatum: 23.07.2009. Anlage 1 (zu § 8 Absatz 3) Methode zur Berechnung des Treibhausgas-Minderungspotenzials anhand tatsächlicher Werte. http://www.gesetze-im-internet.de/bundesrecht/biokraft-nachv/gesamt.pdf

Krismann A u.a. 2009: GTZ-Vorhaben zur praktischen Umsetzung der BioSt-NachV – Teilprojekt Flächenbezogene Anforderungen (§§ 4-7 + 10) Detailanalyse zu Datenquellen in Deutschland; Öko-Institut u.a.; Singen, Rottenburg, Darmstadt

4.8.5 Sub-Indicator 8.4: Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production

4.8.5.1 Legal regulations and reporting commitments

Under the **Renewable Energy Directive (RED) 2009/28/EC** Article 22 (1) (h)[28], Germany has to report from 2011 onwards every two years on conversion rates between land use types[29].

Furthermore, Germany reports under the **UN FCCC**, especially Article 5.1 of the *Kyoto Protocol* which mandates establishing National Systems for GHG emission inventories (see Section 4.1). Within the respective annual National Inventory Report (NIR), land use changes have to be reported by UBA in collaboration with TI (Heinrich-von-Thünen-Institut).

4.8.5.2 Results and methodological approach

According to RED Article 22 (1) (h), changes in land use are described in the German 2011 progress report as follows.

The increase in land use for bioenergy of the last years is primarily caused by the growth of biogas systems, as biofuels production remained constant after a rapid growth period which ended in 2007, and cultivation of SRC so far required only a small land area. With the growth in biogas, many regions in Germany witness extension of maize cultivation, often in monoculture. As grass cuttings are used also for biogas, the quality of permanent pastures may be adversely affected through intensification, and valuable pasture land is lost through conversion to arable land. According to assessment using integrated administration and control system (IACS) data, roughly half of the converted grassland is used for maize cultivation.

> An increasing loss of permanent pasture has been noted in relation to the evolution of agricultural prices and scarcity of land, and also due to the relocation and concentration of livestock rearing. Increasing cultivation of energy crops and in permanent pasture currently accounts for 29% of agricultural land in Germany, i.e. 4,783,853 ha in total, which, on average, is a drop of 4% from 2009 levels. Some Länder (Baden-Württemberg, Mecklenburg-Western Pomerania, Lower Saxony, North Rhine-Westphalia and Schleswig-Holstein) have, therefore, adopted bans on conversion of permanent pasture (DBFZ 2011).

By the same token, there are many individual voices from different regions linking the growth of biogas plants to increased rental prices and conversion of permanent pasture[30].

In order to safeguard against excessive maize cultivation, the EEG 2012 limits the use of certain biogas feedstocks, e.g. restricting maize to 60% (mass based, see BMU 2012). Table 22 shows the land use change matrix of the German NIR (UBA 2013).

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[28] "Information on any changes in land use within your Member State in the preceding 2 years associated with increased use of biomass and other forms of energy from renewable sources." *(Article 22 (1) (h) of Directive 2009/28/EC)*

[29] See: http://ec.europa.eu/energy/renewables/reports/2013_en.htm

[30] A snapshot of the situation in Schleswig-Holstein: In 2010, roughly 100 new biogas plants were built, resulting in a total of 400. At the same time, the area planted with maize increased by 30,000 ha to 180,000 ha and the amount of pasture fell. The proportion of land planted with maize as share of total arable land increased to 27%, and to over 50% on a regional basis (LAWA 2011).

Table 22 Land use change within each category in Germany 2011

Land-use change [ha per year]	2011	Land-use change [ha per year]	2011
… to forest land		**… to cropland**	
Forest land remaining forest land	**10 930 986**	**Cropland remaining cropland**	**14 203 607**
Cropland to forest Land	430	Forest land to cropland	166
Grassland* to forest land	498	Grassland* to cropland	34 108
Woody grassland to forest land	133	Woody grassland to cropland	498
Wetlands (terrestrial) to forest land	0	Wetlands (terrestrial) to cropland	0
Waters to forest land	0	Waters to cropland	100
Settlements to forest land	298	Settlements to cropland	1 727
Other land to forest land	0	Other land to cropland	0
…to woody grassland		**…to grassland**	
Woody grassland remaining Woody grassland	**604 142**	**Grassland* remaining grassland**	**5 549 557**
Forest land to woody grassland	529	Forest land to grassland*	298
Cropland to woody grassland	6 063	Cropland to grassland*	0
Grassland* to woody grassland	3 694	Woody grassland to grassland*	901
Wetlands (terr.) to woody grassland	33	Wetlands (terr.) to grassland*	67
Waters to woody grassland	133	Waters to grassland*	266
Settlements to woody grassland	732	Settlements to grassland*	5 389
Other land to woody grassland	0	Other land to grassland*	200

*Source: UBA (2013) based on TI (2011); * = in a strict sense*

Remarkable changes are observed from grassland (in a strict way) towards cropland with about 34,000 ha which is also described in the German progress report for the RED. Another trend is cropland to woody grassland and grassland (in strict sense) to woody grassland, i.e. the overall tree cover is increasing.

4.8.5.3 Data basis

The land-use matrix compiled for the German NIR is an annual calculation of the land areas for subcategories "final land use" and "land use change" in each of the categories forest land, cropland, grassland (in a strict sense), woody grassland, terrestrial wetlands, waters, settlements and other land, and, for the full time series, differentiated into mineral and organic soils. The land uses and the specific areas assigned to them were explicitly determined for 1990, 2000, 2005, 2008 and 2011. For the time periods between those years, the data were interpolated linearly.

In the 2012 NIR submission, a consistent, unified method was introduced for taking account of land-use changes in the LULUC and the forestry sector. This expanded the previous sample-based system for determining forest land, and land-use changes to and from forest land, for all land-use categories and changes[31]. The new system is based on the grid of the upcoming 3rd National Forest Inventory (UBA 2013). The following data sources[32] were used:

- Information on forest-oriented LULUCF classes from the National Forest Inventory (Bundeswaldinventur) 1 and 2, for 1987 to 2002 for the old German Länder; and from the National Forest Inventory 2 and the Inventory Study 2008 (TI 2011), for 2002 - 2008
- Basic Digital Landscape Model (Digitales Basis-Landschaftsmodell; Basis-DLM) 2000, 2005, 2008 and 2011 as well as CORINE 1990, 2000, 2006 plus GSE data for 1990, and for 2002 to 2006, for the new German Länder.

4.8.5.4 Recommendations

For Germany: The data on land use change could be improved by simplifying and harmonising the integrated administration and control system (IACS) in Germany.

4.8.5.5 References

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2012: Progress report under Article 22 of Directive 2009/28/EC on Promotion of the Use of Energy from Renewable Sources; Berlin

DBFZ (Deutsches Biomasse-Forschungszentrum gGmbH) 2011**:** Monitoring the impact of the Renewable Energies Act on the development of power generation from biomass. Interim report March 2011; Leipzig

LAWA (Länder-Arbeitsgemeinschaft Wasser und Abfall) 2011: Meeting documents from 141st LAWA plenary assembly, Bautzen, 31 March- 1. April 2011

TI (von Thünen-Institut) 2011: Inventurstudie 2008 und Treibhausgasinventar Wald; Oehmichen K u.a., Band 343. Landbauforschung — vTI Agriculture and Forestry Research; Braunschweig

UBA (Umweltbundesamt) 2013: National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2011. Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2013. Resubmission (changes only related to SEF reporting); Dessau

[31] The methodology used is defined in the NIR 2013, section 7.1.3.2.2 Derivation of LULUCF information (UBA 2013).

[32] These sources are described in detail in the German NIR 2013 (UBA 2013, page 476).

5 Social Indicators

5.1 Indicator 9: Allocation and tenure of land for new bioenergy production

The GBEP Indicator 9 reads as follows:

Percentage of land – total and by land-use type – used for new bioenergy production where: (9.1) a legal instrument or domestic authority establishes title and procedures for change of title; and

(9.2) the current domestic legal system and/or socially accepted practices provide due process and the established procedures are followed for determining legal title

Unit: percentage

5.1.1 Legal regulations

Land tenure in Germany is regulated by the **German Land Registration Code (Grundbuchordnung, GBO)**. All land property is documented in the land title register. The registers are administered by the land registry office and actualised on a regular base. If land properties are separated there is a close cooperation with the land surveying offices.

If land is sold, the transfer of the ownership does not become effective with the sales contact but only with the registration in the land title register. Land ownership can be consulted at the land registry office.

All sale or lease of land that takes within Germany has to be legalised by respective contracts.

5.1.2 Results and methodological approach

Based on the above mentioned facts it can be assumed that there are land titles for 100 % of the land used for bioenergy production that also for 100 % there are due processes that are followed when those titles are changed.

With regard in this **indicator 9 is not relevant in Germany.**

5.1.3 Excursus: structural changes

A shift in farm and ownership structures can be observed in German agriculture. In recent years the number of farms is decreasing while the size of farms is increasing (BMEL 2014) hinting at a strong motivation to lease or buy additional land. Thereby investments by non-agricultural and supra-regional investors are increasingly observed by the public (Forstner et al. 2011; Forstner & Tietz 2013). This development takes place particularly in the New Länder that attract investors due to large area units and relatively low land prices. Furthermore, large areas are now being privatised increasing the supply of land. The background of investors and their reasons for investments are heterogeneous. Either whole farm units are bought or single land areas in order to be leased. There are supra-regional investors who manage large areas with up to 30 000 ha, however, their number is still low. Large investment and internationally operating companies do not play a role (Forstner & Tietz 2013).

Whereas in the past land sales attracted public awareness, now rather the purchase of company shares is focused on. It is getting more difficult to buy agricultural land as a non-farmer but non-agricultural investors can still buy capital shares and thus could take over agricultural companies. The effects of such investors on production, employment and regional value added is diverse and not clearly positive or negative. The perception often varies between stakeholders (fear of competition versus capital inflow). One clear effect, though, is the increasing concentration of income and capital in the hand of few persons (Forstner & Tietz 2013). Another effect are increasing land prices (covered in chapter 5.2).

The role of bioenergy in this development is hard to quantify. However, growing income opportunities from energy crop production in general is one of the drivers for investments in land and a growing willingness to buy land (Latacz-Lohmann et al. 2014; Garvert & Schmitz. 2014).

5.1.4 Recommendations

For GBEP: Land acquisition by large scale operators influences farm structures and may cause a shift from small scale to large scale farms. This influence is independent from the purchase process itself but may have a big influence on income opportunities in a region. It is therefore recommended to add an appropriate (sub-)indicator.

5.1.5 References

BMEL (Bundesministerium für Ernährung und Landwirtschaft) 2014: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2013; http://www.bmelv-statistik.de/de/statistisches-jahrbuch/ (download August 2014)

Forstner, B. & Tietz, A. (2013): Kapitalbeteiligung nichtlandwirtschaftlicher und überregional ausgerichteter Investoren an landwirtschaftlichen Unternehmen in Deutschland – Thünen Report 5.- Thünen-Institut, Braunschweig.

Forstner, B.; Tietz, A.; Klare, K.; Kleinhanns, W.; Weingarten, P. (2011): Aktivitäten von nichtlandwirtschaftlichen und überregional ausgerichteten Investoren auf dem landwirtschaftlichen Bodenmarkt in Deutschland.- von Thünen Institut (vTI), Braunschweig.

Garvert, H. & Schmitz, M. (2014): Die Auswirkungen der staatlichen Biogasförderung auf landwirtschaftliche Pachtpreise in Deutschland. Eine ökonometrische Untersuchung. In: Rentenbank (Eds, 2014): Die Zukunft der Bioenergie. Frankfurt am Main.

Latacz-Lohmann, U.; Hennig, S.; Dehning, R. (2014): Biogas als Preistreiber am Boden- und Pachtmarkt? Eine empirische Analyse. In: Rentenbank (Eds, 2014): Die Zukunft der Bioenergie. Frankfurt am Main.

5.2 Indicator 10: Price and supply of a national food basket

The GBEP Indicator 10 reads as follows:

Effects of bioenergy use and domestic production on the price and supply of a food basket, which is a nationally defined collection of representative foodstuffs, including main staple crops, measured at the national, regional, and/or household level, taking into consideration:

- *changes in demand for foodstuffs for food, feed, and fibre;*
- *changes in the import and export of foodstuffs;*
- *changes in agricultural production due to weather conditions;*
- *changes in agricultural costs from petroleum and other energy prices; and*
- *the impact of price volatility and price inflation of foodstuffs on the national, regional, and/or household welfare level, as nationally determined.*

Units: Tonnes; USD; national currencies; and percentage

5.2.1 Legal regulations and reporting commitments

The statistical yearbook for food, agriculture and forest 2012 published by the German Federal Ministry for Education and Research (BMBF) in 2013 as well as statistics published by the Federal Statistical Office (DESTATIS) provide most of the information regarding prices and supply for foodstuff and main staple crops. Difficulties arise in the determination of changes in the agricultural production due to weather conditions as they are only available in a descriptive manner published by the BMEL.

5.2.2 Results and methodological approach

According to **Step 1** *"Determination of the relevant food basket(s) and of its component"* the food consumption pattern for Germany is provided by the Ministry of Food and Agriculture (BMEL 2013). The data are summarised in Table 23.

The most relevant components of the food consumption pattern are represented by milk, vegetables, cereals, potatoes and meat. The highest share in the consumption of cereals is wheat. Vegetable oils contribute to a minor extent to the consumption pattern.

Table 23 Food basket of Germany in 2009 to 2012 as per capita consumption

Per capita consumption [kg/year]	2009 / 2010	2010 / 2011	2011 / 2012
Cereals	**91.7**	**96.5**	**95.6**
Wheat flower	66.4	70.9	70.2
Barley	8.9	8.8	8.6
Other cereals	16.4	16.8	16.7
Rice, pulses, potatoes	**76.6**	**69.3**	**76.4**
Rice	5	5.4	5.3
Pulses	0.6	1.1	0.4
Potatoes	64.5	56.8	65.7
Sugar & sweeteners	**40.6**	**38.6**	**38.6**
Sugar (raw equivalent)	35.2	33.2	33
Sweeteners (others)	10.2	10.4	10.2
Honey	3.2	3.2	3.8
Vegetables, fruits	**220.3**	**209.5**	**205.9**
Vegetables	94.4	95.1	95.4
Fruits	72.1	68.8	68.2
Citrus fruits	48.3	39.7	36.7
Vegetable oils	**15.1**	**14.9**	**14.9**
Meat	**61.3**	**61.6**	**59.5**
Fish, seafood	**15.5**	**15.4**	**14.1**
Milk products, excl. butter	**119.1**	**121.2**	**119.5**
Animal fats	**4.8**	**5**	**5**
Eggs	**13.3**	**13.1**	**13.3**

Source: BMEL (2013)

According to **Step 2** *"Assessing the links between bioenergy use and domestic production and changes in the supply and/or prices of relevant components of food basket(s)"* the following results of a preliminary indication of relevant changes in price and supply could be derived for Germany:

Considering the crop types used for bioenergy production (see chapter 3.2), direct competition with Germany's food basket could occur for

- wheat, maize and sugar beets (used for the production of bioethanol) and
- vegetable oil (rapeseed) for the production of biodiesel.

A large amount of the food basket consists of meat and dairy products. Therefore, further competition could arise with feedstocks used in animal husbandry, i.e. with silage maize being an important input in biogas production. The uses of wheat and grain maize in Germany are listed in Table 24. The majority of wheat and grain maize is used for feed and food. Only 3-6 % (wheat) and 2-3% (grain maize) are used for energy purposes. Furthermore, it can be supposed that changes in demand are levelled out by adapting the cultivated area and / or exports and imports as Germany is closely connected to the world market (see Table 25 and Table 26).

For sugar beets and rapeseed oil no disaggregated data on their uses are available. For sugar beet, the cultivated area and exports slightly decreased whereas imports increased.

For rapeseed a strong decrease in the cultivated area can be seen that coincides with the decreased demand in the bioenergy sector (see chapter 3.2).

Table 24 Shares of relevant main staple crops used for food, feed, fibre and fuel in Germany on national level 2009-2011

Crop	2009/10	2010/11*
National level	in 1000 t	
Wheat		
Total domestic use	18149	20090
Domestically produced feed	7 568	8 674
Food	6 912	7 370
Industrial utilisation	1 272	1 404
Used for energy	*576*	*634*
Degree of self-sufficiency	138 %	118 %
Grain maize		
Total domestic use	6 261	6 613
Feed	3 975	4 252
Food	1 566	1 637
Energy use	261	247
Used for bioethanol	*148*	*173*
Degree of self-sufficiency	72 %	64 %

Source: BMEL (2013), compilation and calculations by IFEU
**preliminary*

Table 25 Production of relevant main stable crops in Germany on national level 2009-2012

Crop	2009	2010	2011	2012	Increase/decrease 2009-2012
National level	Area under cultivation				[%]
Cereals					
Wheat	3226	3298	3248	3057	-5 %
Maize					
Grain maize	464	467	488	526	+13 %
Silage maize	1647	1829	2029	2038	+24 %
Rapeseed	**1464**	**1457**	**1307**	**1299**	**- 11 %**
Sugar beets	**384**	**364**	**398**	**402**	**-5 %**

Source: BMEL (2013), compilation and calculations by IFEU

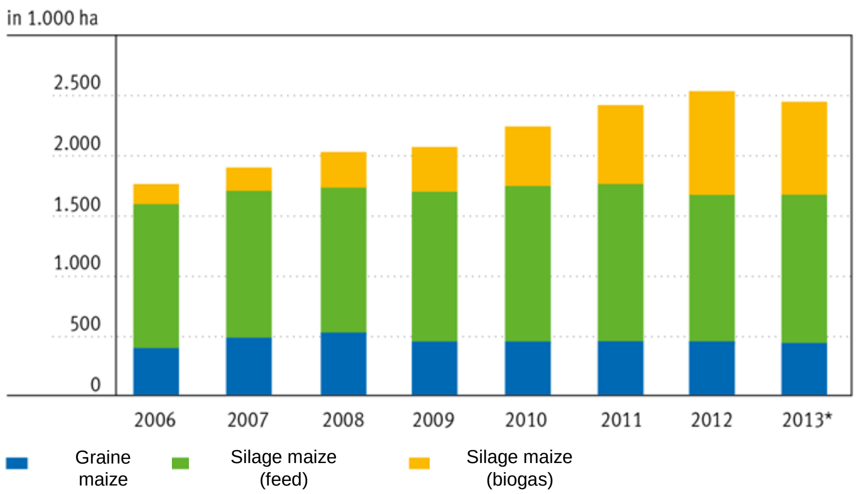
Table 26 Import and exports of relevant main staple crops in Germany 2010 to 2012

	Import [1000 t]			Export [1000 t]		
Crop	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
Wheat	4620	4829	3831	10058	7296	7715
Grain maize	1679	1945	2103	639	799	1063
Sugar	553	616	654	1089	1000	977
sugar-based products	159	156	159	222	239	240
Vegetable oils	2397	2355	1930	1432	1542	1662

Source: BMEL (2013), compilation by IFEU

In contrast to the above mentioned feedstocks, silage maize is marketed only at the regional level as long distance transports are economically not viable. Figure 16 shows the development of maize acreage between 2006 and 2013 and reveals a strong increase of the demand for biogas production and of the cultivation area. Due to the limited availability of agricultural area in Germany it can be assumed that this is at the expense of cultivation area for other crops. However as long as marketable crops are concerned, their decreased cultivation is balanced by increased imports or decreased exports. The influence in terms of land use changes is dealt with in chapter 4.8.

Figure 16 Development of maize acreage in Germany 2006-2012



Source: FNR (2013)

Food price increases have been reported over the last years (Die Welt 2011, Die Welt 2013), however, various reasons are named such as poor weather conditions, increasing production costs and a general increase in demand on the world market. The worldwide demand for bioenergy feedstocks contribute to this development, however, is not being seen as the main driver. As Germany is connected to the world market, bioenergy developments in Germany on the one hand contribute to the developments at the world market and, on the other hand, respective developments are mirrored at a national level. Therefore it can be assumed that food prices in Germany are less impacted by national bioenergy policies than rather by general developments at the domestic and international markets. Overall, German consumers spend a relatively small share of their income for food. In 2012 it was 13.9 % (DESTATIS 2014).

In conclusion it can be stated, that the results of the preliminary indication do not imply an influence of increased demand of feedstock for energy production on the prices for food and feed. According to the described methodology a "*causal descriptive assessment of the role of bioenergy"* is therefore not required for pilot-testing in Germany.

5.2.3 Excursus: Land prices

Besides food prices the changes in land rents and prices are worth to be considered as they have an influence on the economic viability of farms and on farm structures (see also chapter 5.1.3). In countries closely connected to the world market, national bioenergy policies may hardly influence national food prices. However, increased competition could lead to an increased demand for land and thus to increasing prices.

In Germany an increase in farm prices and rentals can be observed whereby the New Länder showed an exceptionally rapid and strong development. Particularly in areas with good soil qualities peak values in auctions are achieved. Whereas average prices are between 10 000 und 12 600 Euro per hectare, offers at up to 20 000 Euros have been reported (Schwers 2014). There are various reasons for the increasing competition for agricultural land. In general, farm sizes have to grow in order to remain competitive. The willingness to pay has increased due to good income opportunities from food crop production and animal husbandry. Further drivers are the rising attractiveness of land as supposedly secure investment opportunity and the privatisation of large land areas in the New Länder. The latter are executed as public tenders which increases transparency and boosts competition (Forstner et al. 2011).

The effects of increasing land rents may be negative for farms that cannot afford expansion any more. Food crop production becomes more expensive and more feed crops have to be imported. Conflicts arise where land under leasing contracts is being privatised and prices become too high for farmers due to competition with large scale investors.

The role of bioenergy in this development cannot be exactly quantified. The subsidisation of bioenergy plays an important role, especially when it comes to biogas feedstock production. Garvert & Schmitz 2014 revealed a strong relationship between land prices and the density of biogas plants in regions with high shares of animal husbandry. The availability of manure is a strong incentive for establishing large biogas plants which then are co-fed with silage maize. That aggravates competition with feed production and leads to increased imports.

5.2.4 Data basis

The statistical yearbook for food, agriculture and forest 2013 published by the German Federal Ministry for Food and Agriculture (BMEL) in 2014 as well as statistics published by the Federal Statistical Office (DESTATIS) provide sufficient quantitative data on crop production, yields, demand and price developments for the determination of the GBEP indicator 10. However, the data do not consistently distinguish between bioenergy crops and crops for food and feed. This is especially valid for data of rapeseed and maize.

5.2.5 Recommendations

For GBEP: Besides prices of food also land prices may play an important role in assessing sustainability. The latter could be decisive for the economic viability of farms. It is therefore recommended to add an appropriate (sub-)indicator.

5.2.6 References

BMEL (Bundesministerium für Ernährung und Landwirtschaft) 2014: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2013; http://www.bmelv-statistik.de/de/statistisches-jahrbuch/ (download August 2014)

DESTATIS 2014: https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/EinkommenKonsumLebensbedingungen/Konsumausgaben/Aktuell_Anteile.html (download August 2014)

Die Welt (2011): Lebensmittel werden um bis zu 40 Prozent teurer. http://www.welt.de/13366770 (download August 2014).

Die Welt (2013): Lebensmittel mit stärkstem Preisanstieg seit 2008. http://www.welt.de/118961054 (download August 2014).

FNR (Fachagentur für nachwachsende Rohstoffe) 2013: Basisdaten Bioenergie Deutschland, Gülzow August 2013 http://mediathek.fnr.de/media/downloadable/files/samples/b/a/basisdaten_9x16_2013_web_neu2.pdf

Forstner, B.; Tietz, A.; Klare, K.; Kleinhanns, W.; Weingarten, P. (2011): Aktivitäten von nichtlandwirtschaftlichen und überregional ausgerichteten Investoren auf dem landwirtschaftlichen Bodenmarkt in Deutschland.- von Thünen Institut (vTI), Braunschweig.

Garvert, H. & Schmitz, M. (2014): Die Auswirkungen der staatlichen Biogasförderung auf landwirtschaftliche Pachtpreise in Deutschland. Eine ökonometrische Untersuchung. In: Rentenbank (Eds, 2014): Die Zukunft der Bioenergie. Frankfurt am Main.

Schwers, O. (2014): Acker als Geldanlage. Märkische Onlinezeitung (http://www.moz.de/artikel-ansicht/dg/0/1/1297235; download August 2014).

5.3 Indicator 11: Change in Income

The GBEP Indicator 11 reads as follows:

Contribution of the following to change in income due to bioenergy production:
(11.1) wages paid for employment in the bioenergy sector in relation to comparable sectors
(11.2) net income from the sale, barter and/or own-consumption of bioenergy products, including feedstocks, by self-employed households/individuals.

Units: local currency units per household/individual per year, and percentages

5.3.1 Results and methodological approach

Even though there is data on wages in Germany these data do not differentiate between bioenergy and other activities (e.g. agricultural and forest workers). Similarly, there is no reliable data on sub-indicator 11.2 so that indicator 11 has not been assessed.

It should be noted, though, that for many German farmers, income from biogas electricity feed-in tariffs constitute a significant share of income.

5.4 Indicator 12: Jobs in the Bioenergy Sector

The GBEP Indicator 12 reads as follows:

Net job creation as a result of bioenergy production and use,
total (12.1) and disaggregated (if possible) as follows
(12.2) skilled/unskilled
(12.3) indefinite/temporary.
(12.4) Total number of jobs in the bioenergy sector; and percentage adhering to nationally recognised labour standards consistent with the principles enumerated in the ILO Declaration on Fundamental Principles and Rights at Work, in relation to comparable sectors (12.5)

Units: number, number per MJ or MW, and percentages

5.4.1 Legal regulations and reporting commitments

The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) sponsored several studies on employment effects of renewable energies since 2005 which use statistics published by the Federal Statistical Office (DESTATIS), especially monetary input-output tables (IOT). The results are regularly reported by AGEE-Stat and BMUB.

5.4.2 Results and methodological approach

A recent study (O'Sullivan et al. 2013) calculated the **gross** employment balance from bioenergy in Germany based on most recent data for 2011 and 2012. The results are shown in the next table.

Table 27 Sub-Indicator 12.1 Employment effects of bioenergy in Germany (gross balance)

	total 2011	total 2012
biogas	50 600	49 500
bioliquids for electricity	2 300	1 500
bioheat	33 800	39 300
bio-cogeneration	14 500	15 900
biofuels	23 200	22 700
total	**124 400**	**128 900**

Source: O'Sullivan M u.a. (2013)

In BMU (2010), the **net** employment balance for 2010 was estimated as 70,000 - 90,000 jobs, but since then, no data on the net balance are available.

The skills of the labour force for bioenergy are not determined per year - the result for the 2010 situation is given in the next table.

Table 28 Sub-Indicator 12.2 Employment skills in the bioenergy sector in Germany

Source	unskilled	skilled	university degree
biogas	2.5%	82.5%	33.1%
bio-liquids	0%	92.2%	57.3%
solid biomass	3.1%	86.5%	29.7%

Source: BMU (2010); percentages reflect shares in total employment

For the other sub-indicators, the results for Germany are as follows:

- Sub-Indicator 12.3 indefinite/temporary labour: all employment given is for full-time equivalent jobs (=permanent employment)
- Sub-Indicator 12.4 Total number of jobs in the bioenergy sector: see sub-Indicator 12.1 (gross data for employment)
- Sub-Indicator 12.5 percentage adhering to nationally recognised labour standards consistent with ILO principles: all employment adheres to ILO standards.

5.4.3 Data basis

The statistical data on employment are available on the national level from DESTATIS, and BMU sponsored several studies on employment effects of renewable energies since 2005 which also give disaggregated data for bioenergy.

5.4.4 Recommendations

For GBEP: There is few data on the **net** employment balance for bioenergy, as this requires a counterfactual scenario not only for the respective country but also for countries to which bioenergy equipment is exported. Thus it is recommended to provide data on the national **gross** employment balance.

5.4.5 References

AGEE-Stat (Arbeitsgruppe Erneuerbare Energien-Statistik) 2013: Erneuerbare Energien 2012; Stuttgart http://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/20130430_erneuerbare_energien_2012_bf.pdf

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) - Hrsg. 2010: Erneuerbar beschäftigt! Kurz- und langfristige Arbeitsplatzwirkungen des Ausbaus der erneuerbaren Energien in Deutschland; Lehr U u.a.; Berlin

DIW (Deutsches Institut für Wirtschaftsforschung e.V.) 2011: Economic Effects of Renewable Energy Expansion: A Model-Based Analysis for Germany; Blazejczak J et al., DIW Discussion Papers 1156/2011: Berlin http://www.diw.de/documents/publikationen/73/diw_01.c.385049.de/dp1156.pdf

GWS (Gesellschaft für Wirtschaftliche Strukturforschung mbH) 2013: Erneuerbar beschäftigt in den Bundesländern: Bericht zur aktualisierten Abschätzung der Bruttobeschäftigung 2012 in den Bundesländern; Ulrich P, Lehr U; F&E-Vorhaben des BMU; Osnabrück http://www.erneuerbare-energien.de/fileadmin/Daten_EE/Dokumente__PDFs_/bericht_erneuerbar_beschaeftigt_bundeslaender_bf.pdf

ISI (Fraunhofer-Institut für System- und Innovationsforschung) u.a. 2011: Einzel- und gesamtwirtschaftliche Analyse von Kosten- und Nutzenwirkungen des Ausbaus Erneuerbarer Energien im deutschen Strom- und Wärmemarkt. Update der quantifizierten Kosten- und Nutzenwirkungen für 2010; Breitschopf B u.a.; i.A. des BMU; Karlsruhe usw. http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/knee_update_2011_bf.pdf

O'Sullivan, M. et al. 2013: Bruttobeschäftigung durch erneuerbare Energien in Deutschland im Jahr 2012 - eine erste Abschätzung; DLR, DIW, ZSW, GWS, Prognos; BMU-F&E-Vorhaben FKZ 0324052B; Stuttgart usw. http://www.erneuerbare-energien.de/fileadmin/Daten_EE/Dokumente__PDFs_/bruttobeschaeftigung_ee_2012_bf.pdf

5.5 Indicator 13: Change in unpaid time spent by women and children collecting biomass

The GBEP Indicator 13 reads as follows:

Change in average unpaid time spent by women and children collecting biomass as a result of switching from traditional use of biomass to modern bioenergy services

Units: hours per week per household, percentage

5.5.1 Results and methodological approach

This indicator is not relevant in Germany as biomass is not collected by women and children, at least not for covering the demand. It can be assumed that dependency on this type of energy supply is no relevant in Germany.

5.6 Indicator 14: Bioenergy used to expand access to modern energy services

The GBEP Indicator 14 reads as follows:

(14.1) Total amount and percentage of increased access to modern energy services gained through modern bioenergy (disaggregated by bioenergy type), measured in terms of
(14.1a) energy and
(14.1b) numbers of households and businesses
(14.2) Total number and percentage of households and businesses using bioenergy, disaggregated into modern bioenergy and traditional use of biomass

5.6.1 Results and methodological approach

This indicator is considered as not relevant in the German context. Energy services are covering all regions of Germany; access is available by everybody; thus bioenergy is not needed to expand access to modern energy services.

5.7 Indicator 15: Change in mortality and burden of disease attributable to indoor smoke

The GBEP Indicator 15 reads as follows:

(15.1) Change in mortality and burden of disease attributable to indoor smoke from solid fuel use
(15.2) Changes in these as a result of the increased deployment of modern bioenergy services, including improved biomass-based cookstoves.

5.7.1 Results and methodological approach

Even though there is again an increase of wood-stoves in Germany, these mostly pellet-fired systems do not cause indoor smoke at relevant levels. Therefore, this indicator has not been assessed.

5.8 Indicator 16: Incidence of occupational injury, illness and fatalities

The GBEP Indicator 16 reads as follows:

Incidences of occupational injury, illness and fatalities in the production of bioenergy in relation to comparable sectors.

5.8.1 Results and methodological approach

Even though there is data on occupational on injuries, illness and fatalities in Germany these data do not differentiate between bioenergy and other activities (e.g. agricultural and forest workers). Furthermore, potential occupational health impacts can occur in other countries due to bioenergy imports (especially biofuels) to Germany, but there is no reliable information available on the impacts in exporting countries. Therefore, this indicator has not been assessed.

6 Economic Indicators

6.1 Indicator 17: Productivity

The GBEP Indicator 17 reads as follows:

(17.1) Productivity of bioenergy feedstocks by feedstock or by farm/plantation
(17.2) Processing efficiencies by technology and feedstock
(17.3) Amount of bioenergy end product by mass, volume or energy content per hectare per year
(17.4) Production cost per unit of bioenergy.

6.1.1 Results and methodological approach

The data for the sub-indicator 17.1 were derived from the German Federal Statistical Office (DESTATIS 2013).

For sub-indicators 17.2-17.2, the database of the life-cycle model GEMIS was used.

Sub-Indicators 17.1 to 17.3: Productivity, processing efficiency and amount of bioenergy feedstocks per hectare of bioenergy feedstocks by feedstock or by farm/plantation

Table 29 Indicator 17.1: Yields of bioenergy feedstocks in Germany

yields in t/ha*a	2010	2011	2012
Maize	39.4	47.6	46.4
Sugar beet	64.4	74.3	68.9
Rapeseed	3.9	2.9	3.7
Wheat	7.2	7.0	7.3
Rye	4.6	4.1	5.5

Source: IINAS compilation based on DESTATIS (2013)

The yields listed in Table 30 have been combined with processing efficiencies from the GEMIS database (German process for 2010) in order to derive the amount of bioenergy that is produced per hectare.
Efficiencies and hectare-based yields are as well listed in Table 30.
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Table 30 Yields, processing efficiencies and area efficiencies by energy carrier and feedstock in MJ / t and MJ / ha

Energy carrier	Feedstock	Yield 2012 [t/ha*a]	Processing efficiency [MJ / t]	Area efficiency [MJ / ha]
Biodiesel	Rapeseed	3.8	14.32	54.4
Plant oil	Rapeseed	3.8	14.46	55,0
Bioethanol	Wheat	8.2	7.76	63.6
	Sugar beet	57	2.40	137.1
Biogas	Maize silage	43.9	3.22	141.2
Biomethane	Maize silage	43.9	3.06	134.1

Source: own compilation based on GEMIS 4.8

Sub-Indicator 17.4: Production cost per unit of bioenergy

Table 31 Production costs of bioenergy

Cost	$US\$_{2010}/GJ$
Rapeseed SVO	38.9
Rapeseed RME	51.7
Sugar beet EtOH	37.6
Wheat EtOH	32.9
Maize biogas	23.0
Maize biomethane	25.0

Source: own compilation based on GEMIS 4.8

6.1.2 Data basis

The yield data and conversion efficiencies as well as the costs are taken from the GEMIS life-cycle database (Version 4.8) for the German data in 2010.

6.1.3 References

IINAS (International Institute for Sustainability Analysis and Strategies) 2013: Global Emissions Model for integrated Systems (GEMIS) version 4.8; Darmstadt http://www.gemis.de

6.2 Indicator 18: Net energy balance

The GBEP Indicator 18 reads as follows:

Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of
(18.1) feedstock production,
(18.2) processing of feedstock into bioenergy,
(18.3) bioenergy use; and/or
(18.4) lifecycle analysis.

6.2.1 Legal regulations and reporting commitments

The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) annually reports through AGEE-Stat the gross and net energy balance of all renewable energies in Germany.

6.2.2 Results and methodological approach

A broad set of energy balances from both bioenergy types and fossil fuel types can be taken from the GEMIS data base. The following table shows the net energy balances of a relevant selection of bioenergy pathways as well as of fossil energy carriers.

The given data comprise the whole life-cycle (Indicator 18.4). Differentiation by life cycle steps is possible in general; however it will raise the complexity of the results without significantly improving conclusions.

On the other hand the authors deem it important to disclose the non-renewable energy input per renewable energy output. This is shown in Table 32 first column while the second column contains the energy ratio literally meant by the GBEP methodology sheet.

Table 32 Indicator 18.4: life cycle net energy balances of selected bioenergy pathways and fossil fuels.

biogenic energy carrier	MJ_{prim}/MJ_{end}	$ER_{non-renew}$
biodiesel (used cooking oil)	0.15	7.3
biodiesel RME	0.39	3.8
EtOH-wheat	0.44	2.1
EtOH-sugarbeet	0.25	6.1
wood-logs, residues	0.00	100.5
wood-chips, residues	0.03	23.7
wood-chips SRC	0.04	18.9
wood-pellets, residues	0.06	13.3
biogas-manure	0.08	1.7
biogas-maize-silage	0.15	1.5

fossil energy carrier	MJ_{prim}/MJ_{end}	$ER_{non-renew}$
coal (imported)	1.13	Not containing relevant share of RE (renewable energy)
lignite (domestic)	1.18	
natural gas (mix)	1.13	
oil-lite (mix)	1.14	
gasoline	1.18	
diesel	1.09	
natural gas (CNG)	1.15	

Source: own compilation based on GEMIS 4.8; $ER_{non\text{-}renew}$ = energy ratio of non-renewable energy, i.e. amount of -renewable energy output per unit of non-renewable energy input)

By weighting the overall shares of bioenergy pathways used in Germany overall averages for bioenergy used for electricity, heat and transport can be figured out (see Table 33).

Table 33 Averages for bioenergy used for electricity, heat and transport

biogenic energy carrier	$MJ_{prim,n}/MJ_{end}$
Electricity	0.10
Heat	0.68
Biofuel for transport	0.37

Source: own compilation based on GEMIS 4.8

6.2.3 Data basis

The life-cycle data for the net energy balances were taken from the GEMIS database (IINAS 2013) which contains typical data for the bioenergy and fossil systems of many countries, including Germany.

The GEMIS database uses IEA and EC statistics as well as UNFCCC and national data to describe energy systems, including upstream fuel and material cycles, and respective imports.

6.2.4 Recommendations

For GBEP: It is recommended to re-define the indicator so that the non-renewable energy input per renewable energy output is reported instead of the energy ratio (ER), as the ER does not makes sense for non-renewable (fossil) systems.

6.2.5 References

UBA (Umweltbundesamt) 2013: Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2012; Climate Change 15/2013; Dessau https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_15_2013_emissionsbilanz_erneuerbarer_energietraeger.pdf

6.3 Indicator 19: Gross value added

The GBEP Indicator 19 reads as follows:

Gross value added per unit of bioenergy produced and as a percentage of gross domestic product.

6.3.1 Results and methodological approach

National statistical data on investments and operational costs for bioenergy exist, but this information does not allow deriving gross value added due, as the GDP calculation in Germany is possible only for whole industry sectors - and bioenergy is part of several sectors. Therefore, this indicator has not been assessed.

As a **proxy** for this indicator, investments and annual turnover for bioenergy can be used, as these are the monetary inputs to economic sectors which generate additional value. The respective data for Germany are given in the following table.

Table 34 German bioenergy investments and turnover as proxy data for Indicator 19 (Gross value added)

Economic category	2010	2011	2012
investment in bio-electricity	2.45	2	1.5
investment in bio-heat	1.15	0.88	1.05
Total bioenergy investment	3.6	2.88	2.55
turnover from bio-el/heat	5,040	5,750	7,050
turnover from biofuels	3,010	3,650	3,680
Total bioenergy turnover	8,050	9,400	10,730

Source: IINAS calculation based on BMU (2011-2013)

6.3.2 Data basis

The data source for the annual investment and economic turnover of bioenergy in Germany is the annual reporting of BMU (2011-2013) which uses AGEEE-Stat data.

6.3.3 Recommendations

For GBEP: It is recommended to re-define the indicator so that investments and annual turnover (expenditures) can be used as a proxy for the gross value added indicator.

6.3.4 References

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2013: Erneuerbare Energien 2012; Berlin

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2012: Erneuerbare Energien 2011; Berlin

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2011: Erneuerbare Energien 2010; Berlin

6.4 Indicator 20: Change in consumption of fossil fuels and traditional use of biomass

The GBEP Indicator 20 reads as follows:

(20.1) Substitution of fossil fuels with domestic bioenergy measured by energy content (20.1a) and
in annual savings of convertible currency from reduced purchases of fossil fuels (20.1b)
(20.2) Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content.

6.4.1 Legal regulations and reporting commitments

The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) annually reports through AGEE-Stat the substitution effects of all renewable energies in Germany.

6.4.2 Results and methodological approach

AGEE-Stat determines the substitution effects of bioenergy using substitution factors determined in UBA (2013). A short description of the underlying methodology for deriving substitution factors can be found in section 4.1.2 (it is the same as is used for the national GHG reporting). The results are shown in the next tables.

Table 35 Indicator 20 Substitution of fossil fuels with bioenergy in Germany

2012, in TWh	lignite	coal	natural gas	oil	diesel	gasoline	total
electricity	10.0	259.8	52.7				322.5
heat	12.6	13.2	68.2	57.6			151.6
transport					15.3	6.6	21.9
total	**22.6**	**273**	**120.9**	**57.6**	**15.3**	**6.6**	**496.0**

Source: BMU (2013)

2011, in TWh	lignite	coal	natural gas	oil	diesel	gasoline	total
electricity	12.5	210.5	58.2				281.05
heat	12.3	13.6	71.3	58.1			155.2
transport					15.7	6.8	22.45
total	**24.75**	**224**	**129.4**	**58.1**	**15.7**	**6.8**	**458.7**

Source: BMU (2012)

2010, in TWh	lignite	coal	natural gas	oil	diesel	gasoline	total
electricity	14.9	161.1	63.6				239.6
heat	12	13.9	74.3	58.6			158.8
transport					16.0	7	23
total	**26.9**	**175**	**137.9**	**58.6**	**16.0**	**7.0**	**421.4**

Source: BMU (2011)

6.4.3 Data basis

The statistical data are available on the national level from DESTATIS, BMUB and UBA, and reported through AGEE-Stat.

6.4.4 Recommendations

For GBEP: There is no data on the substitution from **domestic** bioenergy only, as many countries **import** e.g. biofuels, and net effects can only be determined for all bioenergy. Thus it is recommended to provide data on the national balance, including imports.

6.4.5 References

AGEE-Stat (Arbeitsgruppe Erneuerbare Energien-Statistik) 2013: Erneuerbare Energien 2012; Stuttgart http://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/20130430_erneuerbare_energien_2012_bf.pdf

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2012: Erneuerbare Energien 2011; Berlin

BMU (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit) 2011: Erneuerbare Energien 2010; Berlin http://www.erneuerbare-energien.de/files/bilder/allgemein/application/pdf/ee_in_zahlen_2010_bf.pdf

UBA (Umweltbundesamt) 2013: Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2012; Climate Change 15/2013; Dessau https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_15_2013_emissionsbilanz_erneuerbarer_energietraeger.pdf

6.5 Indicator 21: Training and re-qualification of the workforce

The GBEP Indicator 21 reads as follows:

(21.1) Share of trained workers in the bioenergy sector out of total bioenergy workforce, and (21.2) share of re-qualified workers out of the total number of jobs lost in the bioenergy sector.

6.5.1 Results and methodological approach

Even though there is some data on training of the labour force in Germany, these data do not differentiate between bioenergy and other activities. Therefore, this indicator has not been assessed.

6.6 Indicator 22: Energy diversity

The GBEP Indicator 22 reads as follows:

Change in diversity of total primary energy supply due to bioenergy.

6.6.1 Legal regulations and reporting commitments

The national data from BMU on renewable energies are regularly reported by AGEE-Stat.

6.6.2 Results and methodological approach

The data from Indicator 20 was used to determine the Herfindahl Index for 2010 - 2012, using the approach suggested in the GBEP indicator definition. The hypothetical "w/o bio" case (i.e. without bioenergy) was determined using estimated substitution factors for each bioenergy category:

	substitution shares for bioenergy category		
fossil fuel	**solid**	**gaseous**	**liquid**
coal	33%	50%	0%
oil	67%	0%	100%
gas	0%	50%	0%

Source: estimates by IINAS

The results are shown in the next table.

Table 36 Indicator 22 Energy diversity effects of bioenergy in Germany

Total Primary Energy Supply	2010		2011		2012	
share of	**with bio**	**w/o bio**	**with bio**	**w/o bio**	**with bio**	**w/o bio**
coal	22.7%	24.9%	24.2%	26.2%	24.8%	26.9%
oil	32.9%	37.8%	33.4%	38.5%	33.0%	38.8%
gas	22.3%	23.1%	21.5%	22.2%	21.5%	22.2%
nuclear	10.8%	10.8%	8.7%	8.7%	7.9%	7.9%
others	1.3%	1.3%	1.8%	1.8%	1.3%	1.3%
non-bio RE	2.1%	2.1%	2.6%	2.6%	3.0%	3.0%
solid bioenergy	4.2%	0.0%	3.9%	0.0%	4.1%	0.0%
gaseous bioenergy	1.7%	0.0%	1.4%	0.0%	1.4%	0.0%
liquid bioenergy	2.1%	0.0%	2.5%	0.0%	3.0%	0.0%
Herfindahl Index	**0.224**	**0.271**	**0.227**	**0.275**	**0.227**	**0.279**

	with bioenergy (real data)			without bioenergy (hypothetical)		
in PJ	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
coal	3226	3279	3414	3545	3550	3699
oil	4684	4525	4540	5377	5218	5327
gas	3171	2911	2954	3291	3005	3050
nuclear	1533	1178	1085	1533	1178	1085
others	190	245	173	190	245	173
non-bio RE	293	356	406	293	356	406
solid bioenergy*	593	532	568			
gaseous bioenergy*	241	188	193			
liquid bioenergy*	297	339	408			
total	**14229**	**13552**	**13740**	**14229**	**13552**	**13740**

*= as primary energy equivalent

Source: own calculation by IINAS

6.6.3 Data basis

The statistical data on renewables are available on the national level from DESTATIS, and BMU sponsored several studies on economic effects of renewable energies since 2005 which also give disaggregated data for bioenergy.

6.6.4 References

AGEE-Stat (Arbeitsgruppe Erneuerbare Energien-Statistik) 2013: Erneuerbare Energien 2012; Stuttgart http://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/20130430_erneuerbare_energien_2012_bf.pdf

DIW (Deutsches Institut für Wirtschaftsforschung e.V.) 2011: Economic Effects of Renewable Energy Expansion: A Model-Based Analysis for Germany; Blazejczak J et al., DIW Discussion Papers 1156/2011: Berlin http://www.diw.de/documents/publikationen/73/diw_01.c.385049.de/dp1156.pdf

ISI (Fraunhofer-Institut für System- und Innovationsforschung) u.a. 2011: Einzel- und gesamtwirtschaftliche Analyse von Kosten- und Nutzenwirkungen des Ausbaus Erneuerbarer Energien im deutschen Strom- und Wärmemarkt. Update der quantifizierten Kosten- und Nutzenwirkungen für 2010; Breitschopf B u.a.; i.A. des BMU; Karlsruhe usw. http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/knee_update_2011_bf.pdf

6.7 Indicator 23: Infrastructure and logistics for distribution of bioenergy

The GBEP Indicator 23 reads as follows:

(23.1) Number and
(23.2) capacity of routes for critical distribution systems, along with
(23.3) an assessment of the proportion of the bioenergy associated with each.

6.7.1 Results and methodological approach

This indicator is not relevant in Germany, since there is sufficient logistics and infrastructure for energy in place.

6.8 Indicator 24: Capacity and flexibility of use of bioenergy

The GBEP Indicator 24 reads as follows:

(24.1) Ratio of capacity for using bioenergy compared with actual use for each significant utilisation route
(24.2) Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity.

6.8.1 Results and methodological approach

There is data on the installed capacity for bioenergy systems (e.g. electrical power, thermal power, biogas production power), but no data on the “actual” use for the various bioenergy pathways.

Also there is no national data on the flexibility, and therefore, this indicator has not been assessed. Ongoing research is looking into using biogas and biomethane more flexible for power generation, though.

7 Sustainability in Germany

In 2002 the ‘National sustainability strategy’ was adopted in Germany. It covers mid and long term objectives for 21 sustainability indicators. In contrast to GBEP approach these indicators are not formulated along the three sustainability pillars but clustered into four topics (generational equity, quality of life, social cohesion, international responsibility). Wherever possible, quantitative objectives have been formulated for each indicator. The government publishes reports on a regular basis where the status and progress are reported. The latest report was published in 2014[33].

Table 37 presents the German indicators, grey fields indicate compliance or an overlap with the GBEP indicators.

Table 37 Comparison of the German national sustainability indicators and the GBEP indicators

German national sustainability indicators		**Corresponding GBEP indicators**
I Generational equity		
1 Protection of resources	1a Energy productivity	17 Productivity
	1b Primary energy consumption	18 Net energy balance
2 Climate prototection	2 Greenhouse gas emissions	1 Life-cycle greenhouse gas emissions
3 Renewable energies	3a Share of renewable energy in final energy consumption	20 Change in consumption of fossil fuels and traditional use of biomass
	3b Share of renewable electricity in electricity consumption	20 Change in consumption of fossil fuels and traditional use of biomass
4 Land use	Increase of land used for human settlements and the transport infrastructure	
5 Biodiversity	Biodiversity and landscape quality	7 Biological diversity in the landscape
6 Public debt	6a Public deficit	
	6b Structural deficit	
	6c Debt level	
7 Economic provision for the future	Ratio of gross domestic investment and GDP	
8 Innovation	Private and public investment into research and development	
9 Education	9a 18 to 24 years old without qualification	
	9b 30 to 34 years old with tertiary or post-secondary non-tertiary qualification	
	9c First year student rate	

[33] DESTATIS (2014): Nachhaltige Entwicklung in Deutschland – Indikatorenbericht 2014; https://www.destatis.de/DE/Publikationen/Thematisch/UmweltoekonomischeGesamtrechnungen/Umweltindikatoren/IndikatorenPDF_0230001.pdf?__blob=publicationFile (accessed August 2014)

II. Quality of life		
10 Economic performance	GDP per inhabitant	
11 Mobility	11a Freight transport intensity	
	11b Person transport intensity	
	11c Share of rail transport	
	11 d Share of inland shipping	
12 Agriculture	12a Nitrogen surplus	6 Water quality
	12b Organic farming	2 Soil quality
13 Air pollution	13a Air pollution level	4 Emissions of non-GHG air pollutants, including air toxics
14 Health and nutrition	14a,b Premature mortality	
	14c,d Smoking rate among adolescents and adults	
	14e Share of people with obesity (adiposity)	
15 Criminality	Crimes	
III. Social cohesion		
16. Employment	16a,b Employment rate	12 Jobs in the bioenergy sector
17. Perspectives for families	17a,b Full day care for children	
18. Equality	Gender pay gap	
19 Integration	Foreign school graduates with qualification	
IV. International responsibility		
20 Development cooperation	Share of public development expenses in gross national income	
21 Opening markets	German imports from developing countries	

At first sight, there is only little direct overlap between the German and the GBEP indicators. This is due to their different areas of application. The German indicator set has been established to measure and guide the sustainable development of Germany and the German society as a whole whereas the GBEP indicators aim at assessing a single sector within a country. The fact that many GBEP indicators are tackled at least partly in the German discussion indicates their importance also for an overall national sustainability movement. Those GBEP indicators anchored in the German sustainability discussion mirror relevant and often critical topics in the German context. This may concern only single aspects within one GBEP indicator. For example, within the indicator ‘water quality’ only the nitrogen input is relevant in Germany. As has been shown in chapter 4.6, there are quite some areas with high nitrogen inputs threatening a safe drinking water supply. In contrast water quantity is not a critical issue and therefore not covered by the German indicator set.

Overall it can be stated that the GBEP indicator set covers all relevant sustainability aspects that are discussed in the context of bioenergy production as well as many aspects that are found to be relevant at the highest level.

ANNEX

Indicator 1: Life cycle greenhouse gas emissions

Table 38 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2011

		Emissions from bioenergy use [Mt CO_{2equ}]	Amount of bioenergy [TWh]	Avoided emissions [Mt CO_{2equ}]	Balance / GHG emission savings [Mt CO_{2equ}]
Solid	Electricity	210	12.9	9 348	9 138
	Heat	1 476	100	31 837	30 361
Liquid	Electricity	181	1.48	1 161	869
	Heat	60	3.78	1 107	1 047
	Transport	5 060	34.2	10 323	5 263
Gaseous	Electricity	4 299	24.2	18 931	14 632
	Heat	1 443	19.2	5 878	4 435
TOTAL		**12 727 698**	**12 728**	**195**	**78 585**

Source: compilation by IFEU based on UBA 2012: Emissionsbilanz erneuerbarer Energieträger – Durch Einsatz erneuerbarer Energien vermiedene Emissionen im Jahr 2011 - Aktualisierte Anhänge 2 und 4 der Veröffentlichung „Climate Change 12/2009“- Stand Dezember 2012.

Table 39 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2010 (data on transport not available)

		Emissions from bioenergy use [g CO_{2equ}]	Amount of bioenergy [GWh]	Avoided emissions [g CO_{2equ}]	Balance / GHG emission savings [t CO_{2equ}]
Solid	Electricity	197	11.2	8 918	8 721
	Heat	721	103.4	17 475	16 755
Liquid	Electricity	330	1.68	1 339	1 009
	Heat	92	7.95	2 314	2 222
Gaseous	Electricity	3 576	20.99	16 750	13 174
	Heat	1 982	22.60	6 700	4 718
TOTAL		**6 896 971**	**6 897**	**168**	**53 496**

Source: compilation by IFEU based on UBA 2011: Emissionsbilanz erneuerbarer Energieträger – Durch Einsatz erneuerbarer Energien vermiedene Emissionen im Jahr 2010 - Aktualisierte Anhänge 2 und 4 der Veröffentlichung „Climate Change 12/2009“- Stand Dezember 2011.

Indicator 2: Soil quality

Table 40 Humus carbon loss or gain factors

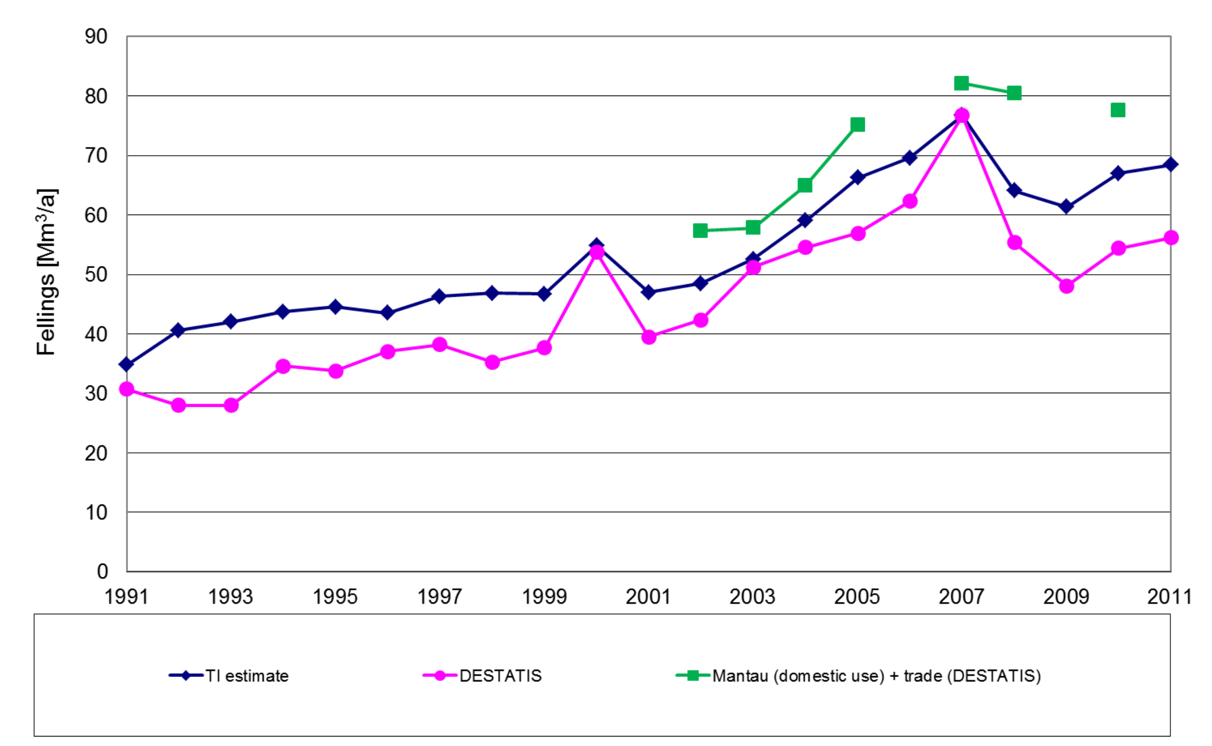
	Min [t humus carbon / ha] Loss (-) or gain	**Max [t humus carbon / ha] Loss (-) or gain**
Sugar and fodder beets	-760	-1300
Potatoes and vegetables	-760	-1000
Silage and grain maize	-560	-800
Cereals, oil and fibre crops	-280	-400
Grain legumes	160	240
Field grass, pulses	600	800
Set-aside area	300	400

Source: VDLUFA 2004

Indicator 3: Harvest Levels of Wood Resources

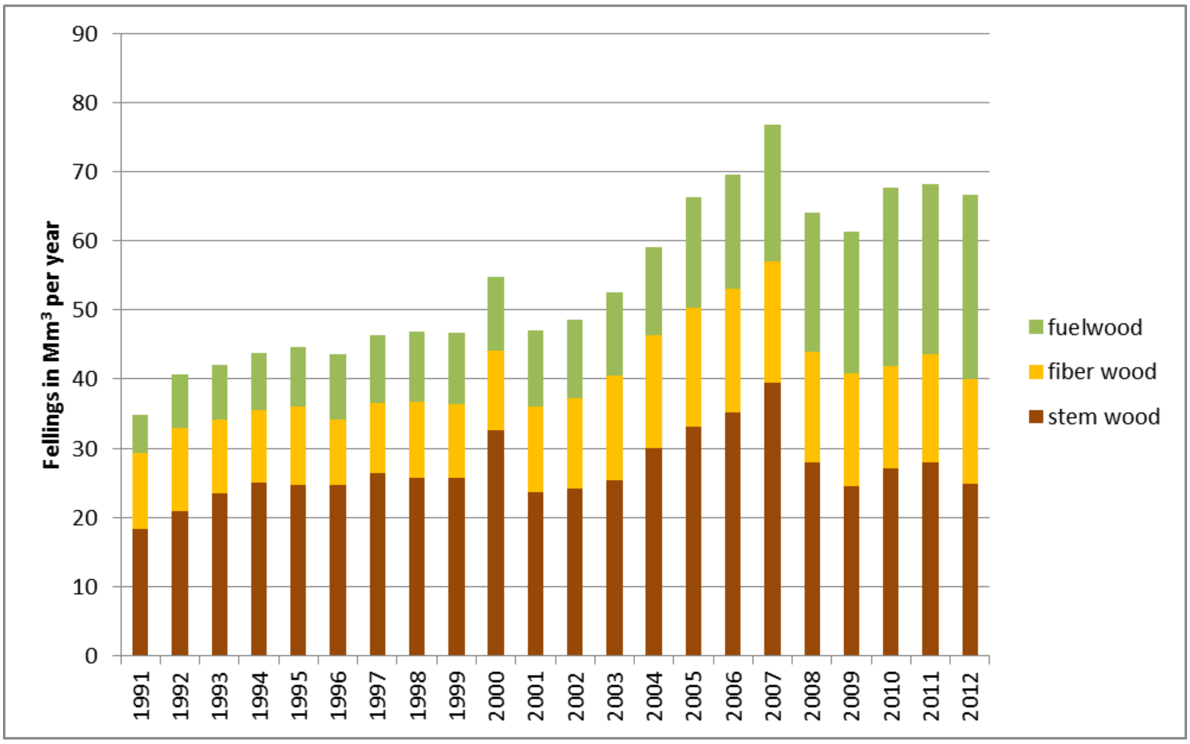
Wood fellings in Germany increased nearly continuously since 1991. This is evident from official harvesting statistics (DESTATIS 2013) as well as from estimates of TI (2013) and shown in Figure 17.

Figure 17 Development of Fellings in Germany according to different Data Sources



Source: calculations in TI (2013) based on DESTATIS (2013) and Mantau (2012); Mantau, Möller, Jochem (2012); Mantau, Jochem (2012)

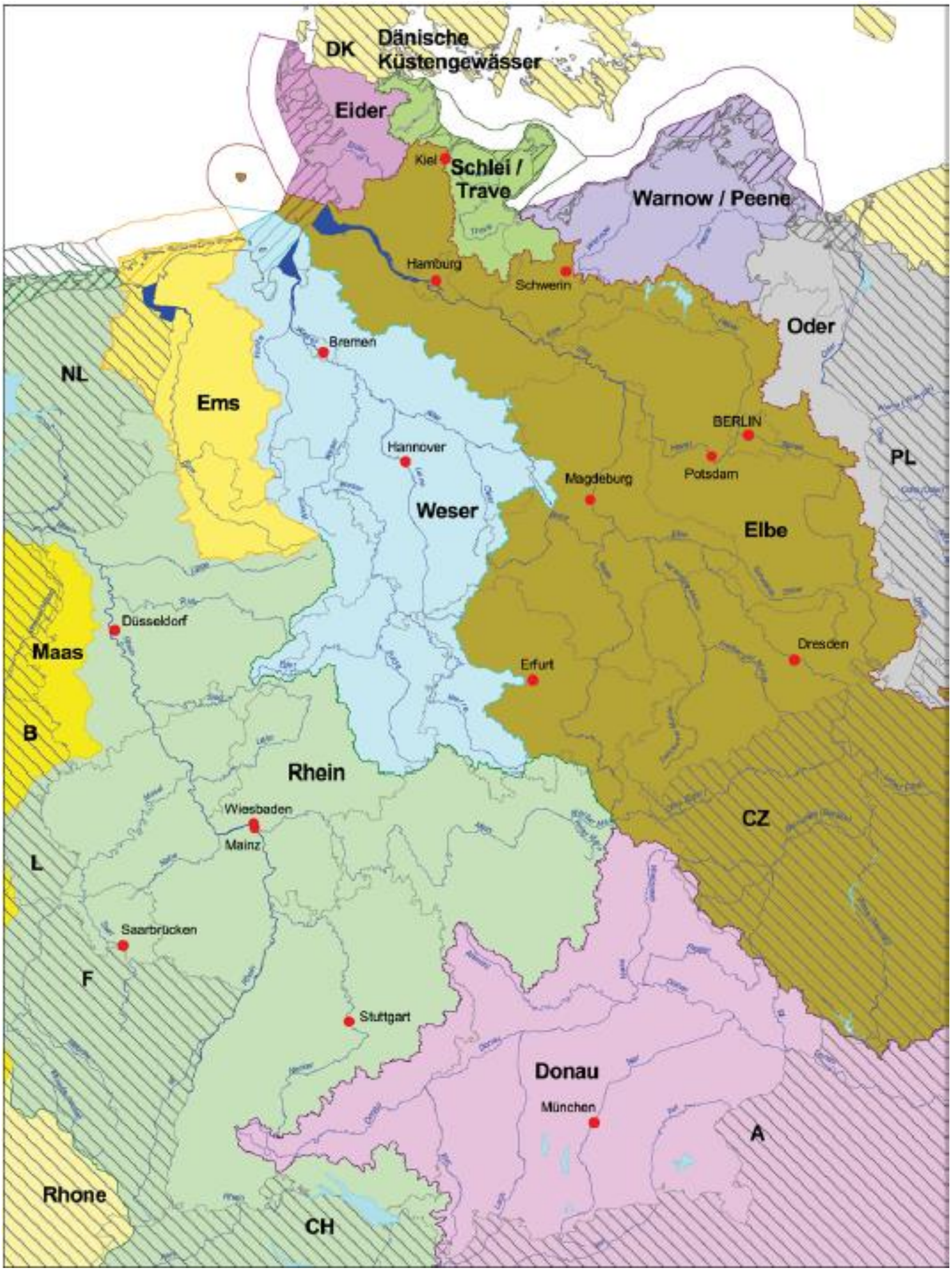
Figure 18 Use of Fellings in Germany 1991-2012 (refined case)



Source: IINAS calculations based on TI (2013)

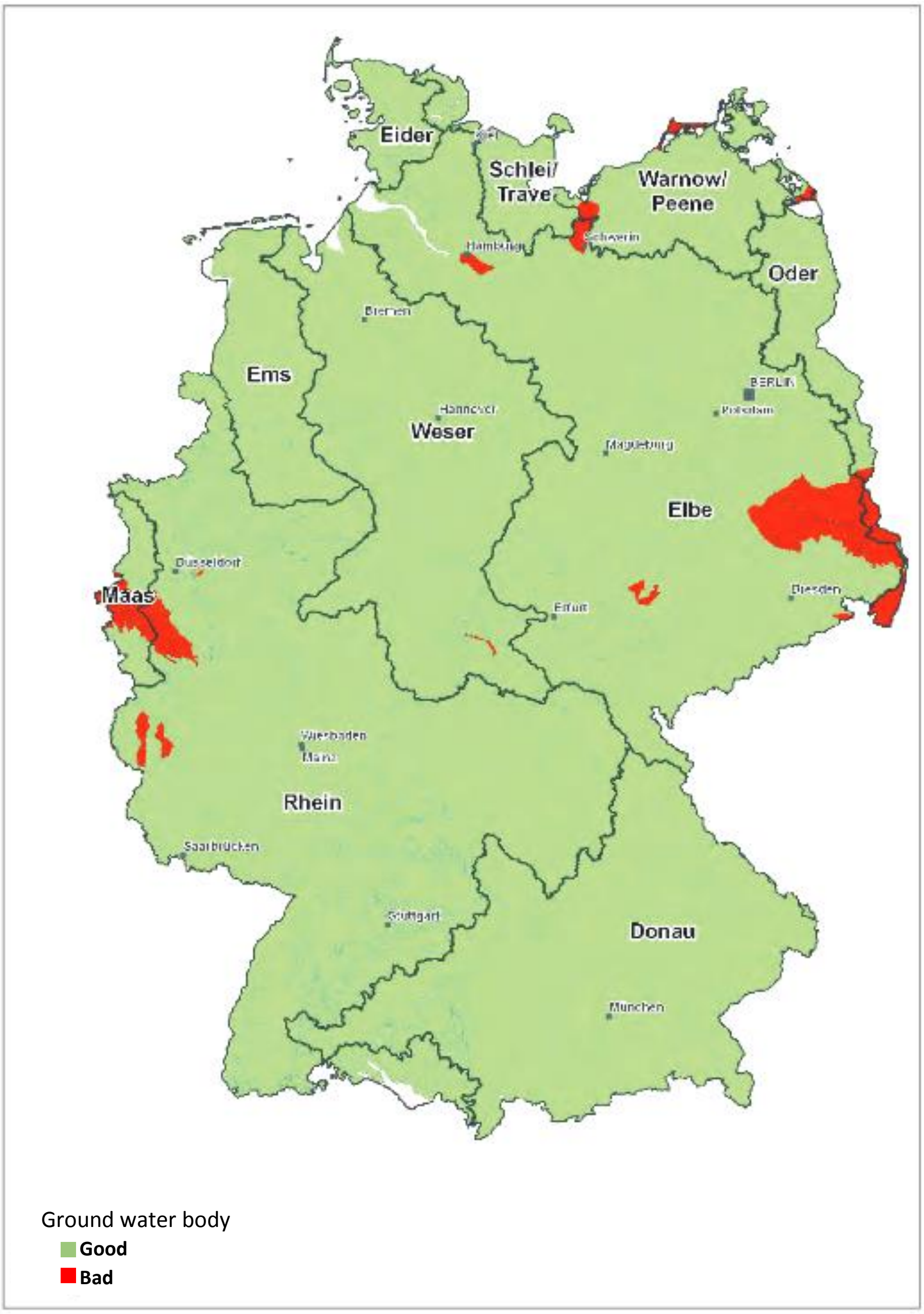
Indicator 5: Water use and efficiency

Figure 19 Watersheds in Germany according to the Water Framework Directive



Source: UBA 2004

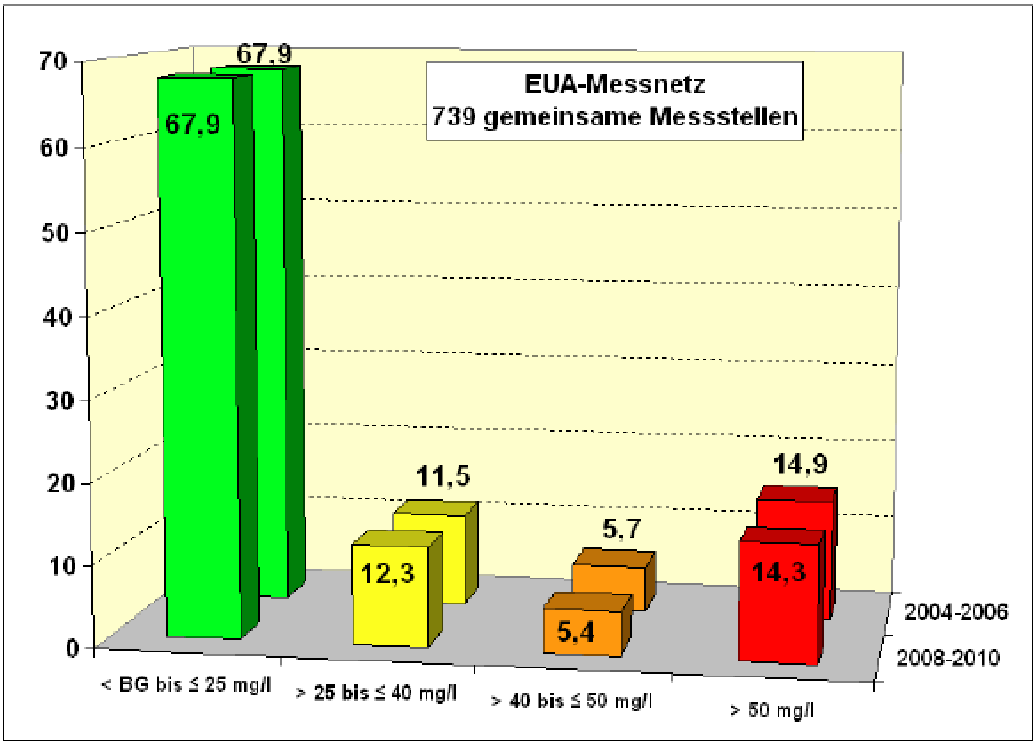
Figure 20 Groundwater quantitative status in Germany



Source: UBA 2010

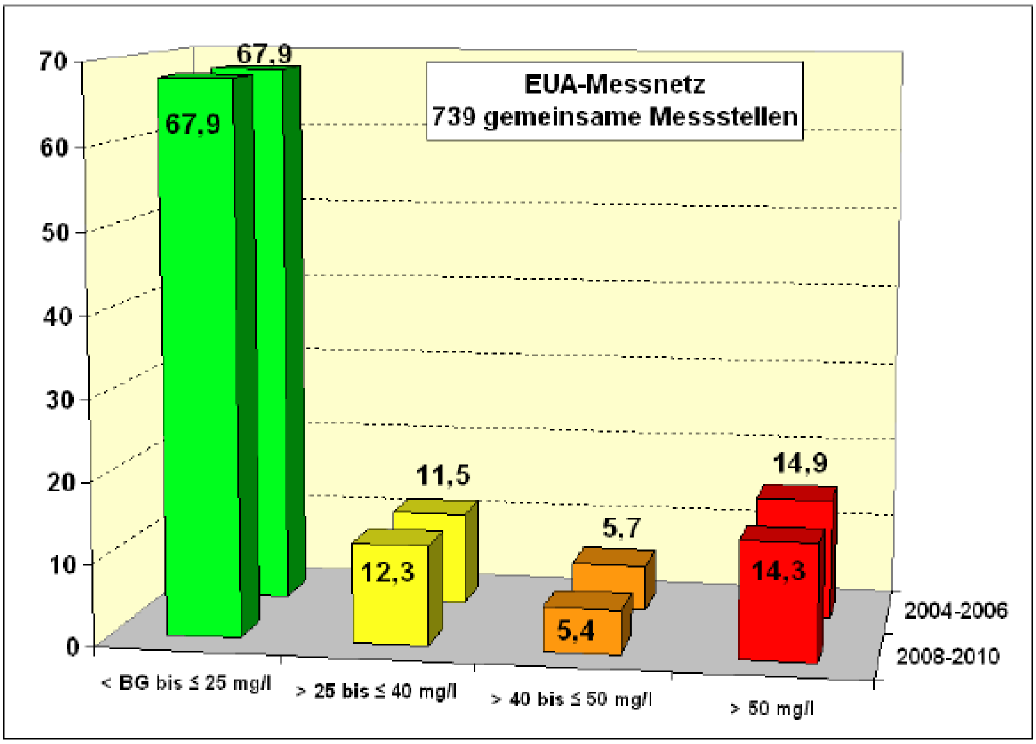
Indicator 6: Water quality

Figure 21 Distribution of the measuring points (total: 739) within the water quality classes between 2004 and 2006 (groundwater)



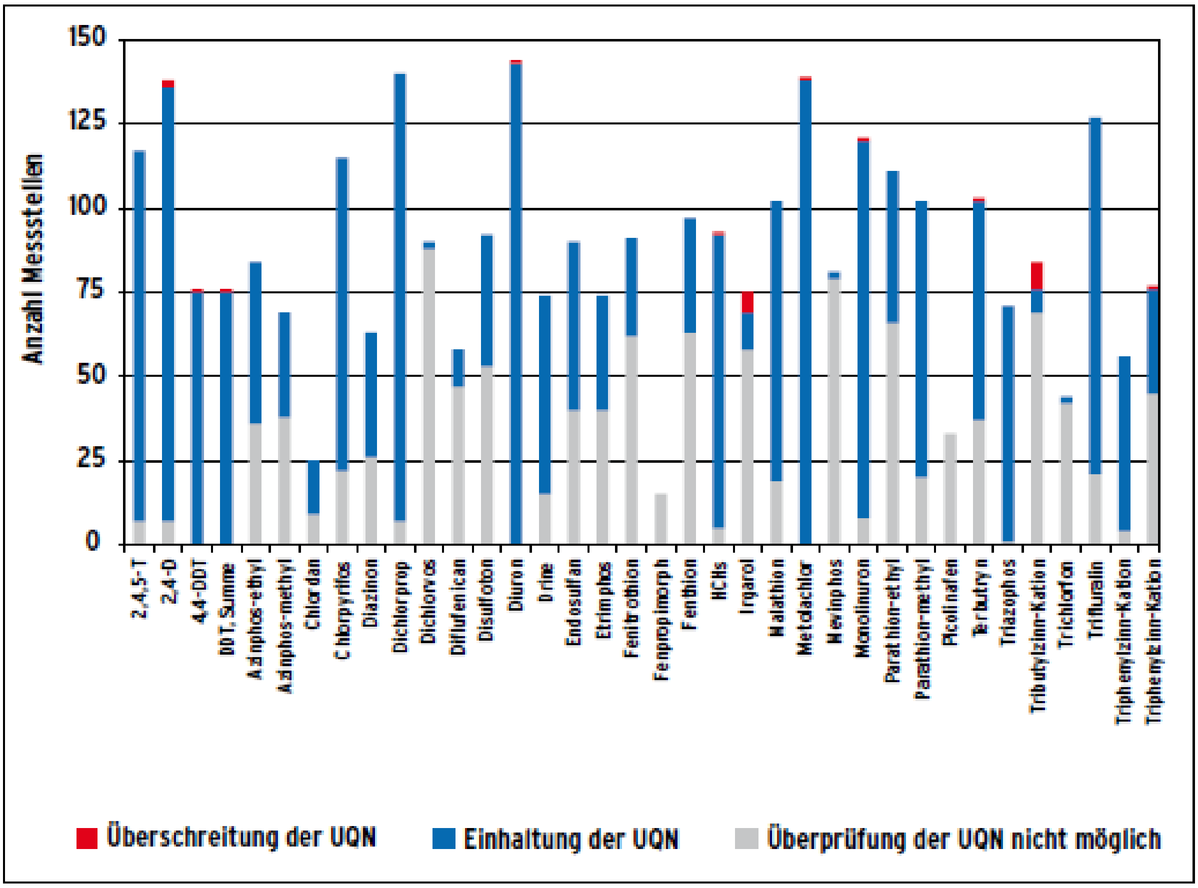
Source: BMU & BMELV (2012)

Figure 22 Distribution of the measuring points (total: 342) within the water quality classes between 2004 and 2006 (groundwater; influenced by agriculture, grassland, fruit growing)



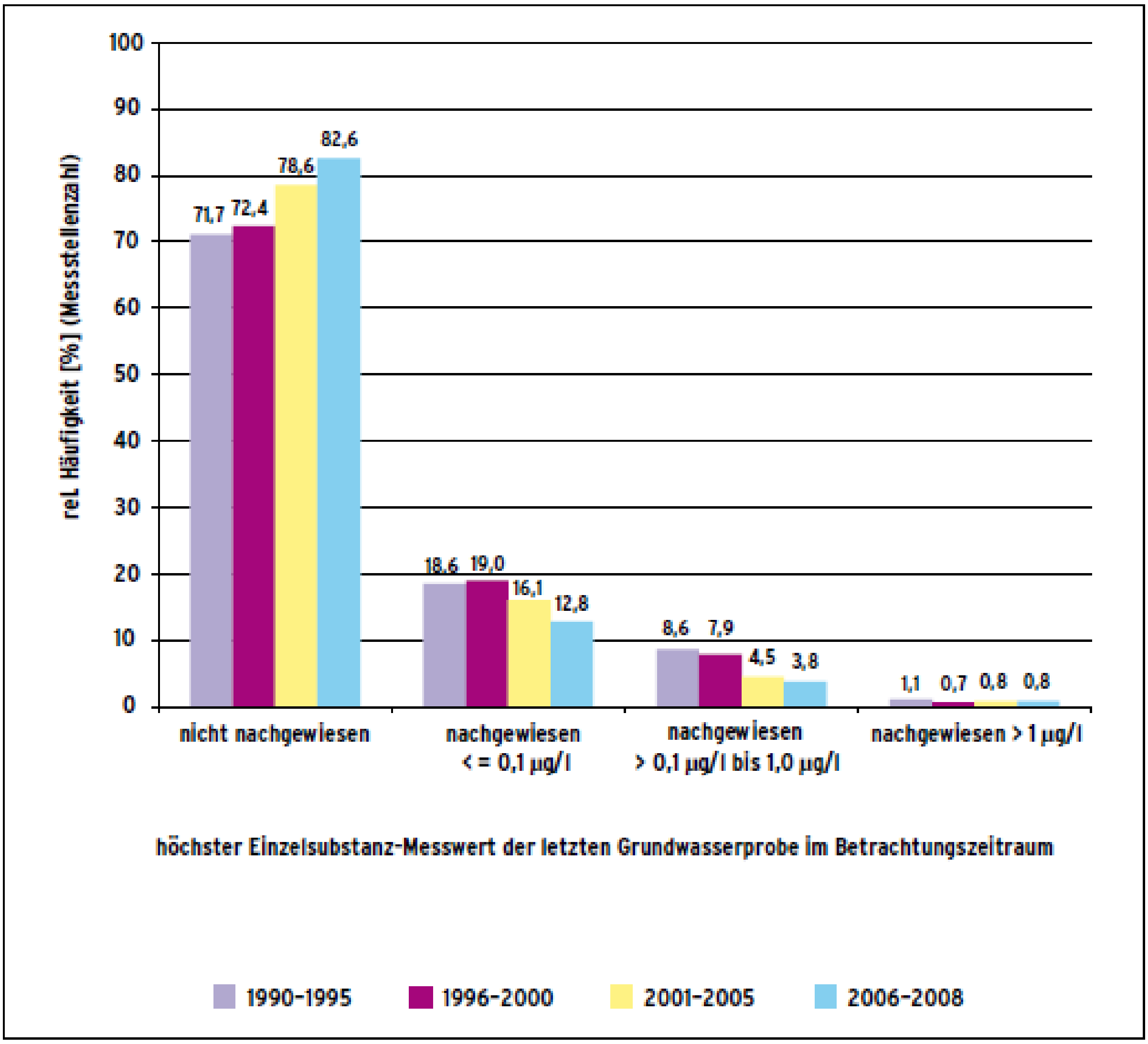
Source: BMU & BMELV (2012)

Figure 23 Number of measuring points in surface waters where thresholds for specific pesticides are met (blue colour) or exceeded (red colour) in 2008



Source: BMU & UBA (2010)

Figure 24 Distribution of measuring points in the ground water where certain amounts of pesticide substance concentration are measured (1990 – 2008)



Source: BMU & UBA (2010)

Indicator 7: Biological Diversity in the Landscape

7.1 Area and percentage of nationally recognised areas of high biodiversity value or critical ecosystems converted to bioenergy production

Nature conservation areas are set up to preserve, develop or restore habitats and their wild flora and fauna. Any activity causing destruction, alteration or damage in a nature conservation area is prohibited. Any land use must be compatible with the protection purpose. Authorities in charge of nature conservation at regional government level designate most nature conservation areas, although state (Länder) or local government-level authorities create some. Their charter takes the form of an order issued under delegated legislative powers. Within such areas, regional planning is required to give priority to nature conservation. Along with national parks, they make up a considerable share of the land area dedicated to maintaining biodiversity in Germany. With data as of 12/2012 Germany has 8,589 nature conservation areas. A total of 1,341,396 ha is given over to nature conservation areas in Germany. This represents 3.8 percent of the country's land surface.

National parks are large-scale landscapes of national importance that are in – or are capable of evolving or being brought into – a state such that they show little or no human impact over most of their area. Nature should be allowed to take its course in them free of human exploitation or intervention. National parks help protect nature and biodiversity and provide safe havens for wild plants and animals. Commercial exploitation of natural resources by farming, forestry, water use, hunting or fishing must therefore be largely prevented or only allowed subject to strict requirements laid down by the nature conservation authorities. Germany currently has 15 national parks covering a total of 1.039.558 ha.

Biosphere reserves are set up to protect large-scale natural and cultural landscapes. Their main aims are to preserve, develop or restore landscapes shaped by traditional diverse uses, along with their historically evolved diversity of species and habitats. They also serve as models for developing and testing sustainable operating methods in all sectors of the economy. The total area of all 16 biosphere reserves in Germany is 1.846.904 ha. Excluding North Sea and Baltic marine and mudflat areas (534.646 ha), this represents 3.7 percent of German territory.

Landscape protection areas are created to maintain, develop or restore the functioning of the ecosystem and its services. They are generally large areas that are also important in human recreation. Landscape protection areas are generally larger than nature conservation areas and have fewer restrictions on land use. Activities that change the 'character' of the area are prohibited. Forestry and farming may be restricted where they change the character of the area or are incompatible with its protection purpose. Germany currently has 8,210 landscape protection areas covering a total of 10.2 million ha, or some 28.4 percent of the country's land surface (information as of 31 December 2012).

Nature parks are large-scale cultural landscapes in which protecting and maintaining habitat and species diversity are closely tied to their recreational function. They support sustainable tourism and sustainable use of the land. According to information provided by the German states (Länder), Germany currently has 104 nature parks. Beyond that the nature park Muldenland (Saxony) is in establishment. With a total area of 9.5 million ha, nature parks cover 27 percent of Germany's land surface. The share of land covered by nature parks increased by 33 percent (about 2.4 million ha) between 1998 and 2011. Protected areas account for some 56 percent of land within nature parks. Nature conservation areas account for about 5 percent of land in nature parks in Germany, although this figure varies across the country.

Indicator 8: Land use and land-use change related to bioenergy feedstock production

Sub-Indicators 8.3b+c: Percentage of bioenergy from residues and wastes

Table 41 Results for Indicators 8.3b+c: Contribution and percentages of bioenergy from residues and wastes in Germany 2010

	Total	from residues & wastes	
Bioenergy	**TWh**	**TWh**	**Share**
- electricity	34.0	10.2	30%
- heat	134.0	116.4	87%
- transport fuels	35.4	3.6	10%
total	**203.4**	**130.2**	**64%**

Source: calculation by IINAS based on BMU (2012a); BLE (2012); DBFZ (2012); woody residues include pre-commercial thinnings from forest management

Table 42 Results for Indicators 8.3b+c: Contribution and percentages of bioenergy from residues and wastes in Germany 2011

	Total	from residues & wastes	
Bioenergy	**TWh**	**TWh**	**Share**
- electricity	37.6	10.9	29%
- heat	123.2	112.0	91%
- transport fuels	34.2	3.4	10%
total	**195.0**	**126.3**	**65%**

Source: calculation by IINAS based on BMU (2012a); BLE (2012); DBFZ (2012) ; woody residues include pre-commercial thinnings from forest management

Table 43 Calculation of residue and waste shares in renewable energy supply in Germany 2010

	Renewable Energy Source	TWh all	TWh biomass residues & wastes
Electricity	**Hydropower**	**21.0**	
	Windpower	**37.8**	
	Biomass for electricity	**34.0**	
	of that:		
	solids	11.2	
	liquids (incl. vegetable oil)	1.7	0.2
	biogas	14.5	3.3
	sewage gas	1.1	1.1
	landfill gas	0.7	0.7
	biogenic fraction of waste	4.8	4.8
	Photovoltaics	**11.7**	
	Geothermal	**0.03**	
	Total electricity	**104.5**	**10.2**
Heat	**Biomass for heat**	**134.0**	
	of that:		
	solids	103.4	103.1
	liquids (incl. vegetable oil)	7.9	1.1
	biogas	13.7	3.2
	sewage gas	1.1	1.1
	landfill gas	0.3	0.3
	biogenic fraction of waste	7.6	7.6
	Solar thermal	**5.2**	
	Deep Geothermal	**0.3**	
	Near surface geothermal + ambient heat	**5.3**	
	Total heat	**144.8**	**116.3**
Biofuels	Biodiesel (approx. 2.6 Mt)	26.1	3.6
	Vegetable oils (approx. 0.1 Mt)	0.6	
	Bioethanol (approx. 1.2 Mt)	8.7	
	Total transport fuels	**35.4**	**3.6**
Total	**Total bioenergy**	**203.4**	**130.0**
	Total final energy from renewable resources	**284.7**	

Source: calculation by IINAS based on BMU (2012a); BLE (2012); DBFZ (2012)

Table 44 Calculation of residue and waste shares in renewable energy supply in Germany 2011

	Renewable Energy Source	TWh all	TWh biomass residues & wastes
Electricity	**Hydropower**	**17.7**	
	Wind power	**48.9**	
	Biomass for electricity	**37.6**	
	of that:		
	solids	11.9	
	liquids (incl. vegetable oil)	1.5	0.2
	biogas	17.5	4.0
	sewage gas	1.3	1.3
	landfill gas	0.6	0.6
	biogenic fraction of waste	4.8	4.8
	Photovoltaics	**19.3**	
	Geothermal	**0.02**	
	Total electricity	**123.5**	**10.9**
Heat	**Biomass for heat**	**123.2**	
	of that:		
	solids	100.1	99.8
	liquids (incl. vegetable oil)	3.9	0.5
	biogas	9.8	2.3
	sewage gas	1.1	1.1
	landfill gas	0.3	0.3
	biogenic fraction of waste	8	8.0
	Solar thermal	**5.6**	
	Deep Geothermal	**0.3**	
	Near surface geothermal + ambient heat	**6**	
	Total heat	**135.1**	**112.0**
Biofuels	Biodiesel (approx. 2.4 Mt)	24.9	3.4
	Vegetable oils (approx. 0.02 Mt)	0.2	
	Bioethanol (approx. 1.2 Mt)	9.1	
	Total transport fuels	**34.2**	**3.4**
Total	**Total bioenergy**	**195.0**	**126.3**
	Total final energy from renewable resources	**292.8**	

Source: calculation by IINAS based on BMU (2012a); BLE (2012); DBFZ (2012)