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Update of the Implementation report of the GBEP Indicators for Sustainable Bioenergy in Germany – 2nd Reporting

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

on behalf of the Federal Environment Agency (UBA)
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Update of the Implementation report of the GBEP Indicators for Sustainable Bioenergy in Germany – 2nd Reporting

Authors:

Susanne Köppen, Horst Fehrenbach, Dr. Mascha Bischoff

ifeu - Institut für Energie- und Umweltforschung gGmbH
Wilckensstr. 3, D – 69120 Heidelberg
Tel.: +49/(0)6221/4767-0 – direct: -16
Fax: +49/(0)6221/4767-19
E-mail: horst.fehrenbach@ifeu.de,
Website: www.ifeu.de

ifeu – Institut für Energie- und Umweltforschung Heidelberg GmbH

Ulrike Eppler, Uwe R. Fritsche

IINAS - International Institute for Sustainability Analysis and Strategy GmbH
Heidelberger Str. 129 ½, D-64285 Darmstadt
Tel.: +49/(0)6151/ 850-6077
Fax: +49/(0)6151/ 850-6080
E-mail: uf@iinas.org
Website: www.iinas.org

IINAS International Institute for Sustainability Analysis and Strategy

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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
NBS	National Biodiversity Strategy
NBSAP	National German Biodiversity Strategy and Action Plan
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 Objectives

In 2014, the GBEP Sustainability Indicators (GSI) were applied for the first time in Germany (Köppen et al. 2014). Four years later, the application was repeated in order to implement one of the core objectives of the indicators: to enable **monitoring** of the impacts of bioenergy production and use at the national level. Monitoring of course means: assessing the development of measured indicators **over time**. Thus, a key objective of this assessment is to provide time series for the indicators.

Another goal of this 2nd reporting is to deepen the lessons learned from the first application, as well as to incorporate experiences shared with other GBEP partners through the work in *Activity Group* 2 of the *Workings Group on Capacity Building* (WGCB) and the *Task Force on Sustainability*. The first report has revealed some difficulties according to precise application of some of the GSI. The authors made recommendations where the methodologies may need adaptation on the one hand and improvement of availability and reliability of the data base for relevant sustainability aspects on the other hand.

1.2 Key questions and answers

As a summary of the main findings, we would like to provide the following answers to the key questions of the study:

Are we able to identify and to interpret developments of the GSI results?

Yes, the GSI results give a meaningful picture of the development within the bioenergy sector in Germany with regard on sustainability aspects.

Is the 2nd application more efficient in terms of effort compared to the first time, in order to facilitate repeated assessments?

Yes, data bases are familiar, efforts are much better calculable.

Have we learned from the analysis regarding difficult application during the first application?

A number of indicators are still complicated to measure, although there are many data and progress in measurements (in particular indicator soil quality (2) and water quality (6)).

Has the data base improved where we identified gaps or quality sufficiency before?

There is improvement – however, there is still work to do to gain a one-to-one translation into the GSI description in a few cases.

Will a periodic assessment of the GSI be feasible and how can it be connected with other established reporting schemes?

Yes, we deem a periodic measuring of the GSI feasible, with a frequency of 4 – 5 years. There are options to further improve data connections with other regular reporting schemes. However, this needs still more work and communication. In particular, we recognize added value in relation to work on SDG reporting for which the GSIs may prove beneficial, and for the ongoing development of a federal monitoring scheme for the bioeconomy.

1.3 Further findings

General applicability and data background

In order to continue the discussion of results from Köppen et al. (2014) this study repeats the general finding: that the GBEP indicators are mostly applicable and still cover the whole scope of bioenergy sustainability in Germany.

In 2014 five GSI have been excluded from the beginning (13, 14, 15, 21, 23) due to their clearly proven low relevance for the German bioenergy situation. The reasons for excluding these indicators are still valid.

Moreover the first assessment has shown the minor relevance of five further indicators (5, 9, 10, 19, 24) in Germany. Nonetheless these GSI have been applied also within this second assessment.

Köppen et al. (2014) have already stated the broad availability of data in Germany. For indicators data are collected on a regular basis presenting a good and reliable quality. However, still a number of indicators lack of an evidence-based approach to attribute effects of bioenergy against effects from biomass used for food, feed or other purposes. In some cases a vast amount of data are existing on a regionally highly disaggregated level. However currently these data are not available for sectorial evaluations as needed for this study: on the one hand the large number of data would need interpretation and compilation on a level which is beyond the scope of this study; on the other hand the volume of data relating to specific local areas is currently still subject to data protection. This is in particular true for soil related data.

Attribution to bioenergy

At the same time as this study is being processed, ifeu and IINAS have prepared a paper on attribution as an input for the work in the *Task Force on Sustainability*. The recommendations of that paper have been anticipated by this study.

How to deal with imported bioenergy

This cross-cutting issue is also intensively discussed within the *Task Force on Sustainability.* It still is essential to state, that German bioenergy policy induces relevant imports from abroad, which might lead to relevant impacts under those indicators with low or minor relevance for German bioenergy but transfers impacts to the exporting countries, where these indicators may be extremely relevant (e.g. food prices, water resources, traditional collection and use of biomass).

In line with the first study (Köppen et al. 2014) 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).

The way forward

The authors see the special value of this second study in the initiation of a repeated measurement of the GSI and the possibility of a future monitoring. The following section offers a conceivable way how repeated measurements can be prepared for a descriptive interpretation.

The results have been presented at the 10th meeting of the GBEP Working Group on Capacity Building (WGCB) on 27th November 2018 in Rome as an input for the continuous discussion on GSI implementation.

1.4 Synopsis of results

It is a challenge to give a synopsis of 24 indicator results and their development. It is not only a large number but a high diversity of meanings, propositions, and contexts.

We, therefore, worked out a draft scheme to translate the results and the indicator development over time into **synopsis tables**, briefly explained as follows:

Trend: In a first step, each indicator is evaluated according to the **trend**: is there a relevant increase or decrease of the particular GSI result? This are illustrated by following icons:
↘ ➔ ↗

State: In a second step, the contribution of bioenergy to the indicated sustainability aspect is evaluated: is the sustainability aspect measured by the indicator a significant problem in Germany and does bioenergy significantly contribute to this aspect?
This refers to the **state** of the actual situation and will be illustrated by following colour code:

relevance/contribution:	low	(green)
	medium: needs observation	(yellow)
	high: action needed	(red)

The following table shows the application of this approach.

Table 1 Overall synopsis of the results of GBEP indicators applied in Germany – state and trend

	ENV		SOC		ECO
1	↘	9		17	
2	→	9.1	→	17.1	→
3		9.2	→	17.2	↗
3.1	→	10	→	17.3	↗
3.2	→	11	→	17.4	
3.3	→	11.1	→	18	
4		11.2	→	18.1	↗
4.1	→	12		18.2	↗
4.2	→	12.1	↘	18.3	↗
4.3	→	12.2	→	18.4	↗
4.4	↗	12.3	→	19	→
4.5	↘	12.4	→	20	
5		12.5	→	20.1a	↗
5.1a	→	16	↘	20.1b	
5.1b	→			20.2	
5.2	→			22	→
6				24	
6.1	→			24.1	↗
6.2	→			24.2	↗
7					
7.1	↘				
7.2					
7.3	↗				
8					
8.1	↘				
8.2	↘				
8.3a	→				
8.3b	↗				
8.3c	↗				
8.3d	↗				
8.4	↘				

Table 2 Detailed synopsis of the results of GBEP environmental indicators applied in Germany – state and trend

Environmental Indicators	Evaluation	Remarks
1. Lifecycle GHG emissions	➘	official data, slight reduction
2. Soil quality	➔	data for soil quality exist, but no attribution to measures, insufficient frequency of measurements
3. Harvest levels of wood resources	·	
3.1 Annual harvest of wood resources by volume	➔	More or less stable
3.2 Annual harvest of wood resources as a percentage of net growth or sustained yield	➔	Very stable, regulated by law
3.3 Percentage of the annual harvest used for bioenergy	➔	
4. Emissions of non-GHG air pollutants, including air toxics, from	·	
4.1 bioenergy feedstock production	➔	varies… liquid and gaseous increasing but solid decreasing
4.2 processing,	➔	low share of total
4.3 transport of feedstocks, intermediate products and end products, and	➔	low share of total
4.4 use;	➚	major share, urban pollution from fuel use for transport and heating = key problem
4.5 in comparison with other energy sources.	➘	Positive compared to coal, moderate compared to oil, higher compared to natural gas (except biogas)
5. Water use and efficiency	·	
5.1a Water withdrawn from nationally determined water-shed(s) for the production and processing of bioenergy feed-stocks, expressed as the percentage of total actual renewable water resources (TARWR)	➔	small volumes, without attribution to bioenergy
5.1b Water withdrawn from nationally determined water-shed(s) for the production and processing of bioenergy feedstocks, expressed as the percentage of total annual water withdrawals (TAWW), disaggregated into renewable and non-renewable water sources	➔	small volumes, without attribution to bioenergy
5.2 Volume of water withdrawn from nationally-determined watershed(s) used for the production and processing of bio-energy feedstocks per unit of bioenergy output, disaggregated into renewable and non-renewable water sources	➔	small volumes, without attribution to bioenergy
6. Water quality	·	
6.1 Pollutant loadings to waterways and bodies of water attributable to fertilizer and pesticide application for bioenergy feedstock production	➔	actually a large problem in Germany, but some values decrease, others increase, large time variation, moni-toring schemes under development (but no attribution to bioenergy)
6.2 Pollutant loadings to waterways and bodies of water attributable to bioenergy processing effluents	➔	Only small input from bioenergy
7. Biological diversity in the landscape	·	
7.1 Area and percentage of nationally recognized areas of high biodiversity value or critical ecosystems converted to bioenergy production;	➘	data exist, but without attribution to bioenergy. In general, pressure on biodiversity is high in Germany
7.2 Area and percentage of the land used for bioenergy production where nationally recognized invasive species, by risk category, are cultivated;	·	no invasive species yet

7.3 Area and percentage of the land used for bioenergy production where nationally recognized conservation methods are used	➚	small area still, but without attribution to bioenergy.
8. Land use and LUC related to bioenergy feedstock production	·	
8.1 Total area of land for bioenergy feedstock production and as compared to total national surface	➘	small reduction
8.2 Total area of land for bioenergy feedstock production and as compared to agricultural land and managed forest area	➘	small reduction
8.3a Percentage of bioenergy from yield increases	➔	high annual variation
8.3b Percentage of bioenergy from residues	➚	Increasing trend
8.3c Percentage of bioenergy from wastes	➚	Increasing trend
8.3d Percentage of bioenergy from degraded or contaminated land	➚	Positive, but very small area still
8.4 Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production	➘	little data, but downward trend

Table 3 Detailed synopsis of the results of GBEP social indicators applied in Germany – state and trend

Social Indicators	Evaluation	Remarks
9. Allocation and tenure of land for new bioenergy production		
9.1 Percentage of land – total and by land-use type – used for new bioenergy production where a legal instrument or domestic authority establishes title and procedures for change of title	➔	safe 100% due to enforced land registration code
9.2 Percentage of land – total and by land-use type – used for new bioenergy production where the current domestic legal system and/or socially accepted practices provide due process and the established procedures are followed for determining legal title	➔	safe 100% due to enforced land registration code
10. Price and supply of a national food basket	➔	very low influence
11. Change in income		
11.1 Change in income due to wages paid for employment in the bioenergy sector in relation to comparable sectors	➔	no change in wages but rising land cost
11.2 Change in income due to net income from the sale, barter and/or own-consumption of bioenergy products, including feedstocks, by self-employed households/individuals.	➚	farms with biogas plants gain additional income
12. Jobs in the bioenergy sector	·	
12.1 Net job creation as a result of bioenergy production and use, total	➘	Slight decrease of **gross** employment
12.2 Net job creation as a result of bioenergy production and use, disaggregated by skilled/unskilled	➔	all skilled
12.3 Net job creation as a result of bioenergy production and use, disaggregated by indefinite/temporary.	➔	all indefinite
12.4 Total number of jobs in the bioenergy sector	➔	rather stable
12.5 Percentage adhering to nationally recognized labor standards consistent with the principles enumerated in the ILO Declaration on Fundamental Principles and Rights at Work, in relation to comparable sectors	➔	No attribution to bioenergy, but German labor laws apply to all sectors
16. Incidence of occupational injury, illness and fatalities	➘	Accidents decrease; data for agriculture and forest sector, no attribution to bioenergy

Table 4 Detailed synopsis of the results of GBEP economic indicators applied in Germany – state and trend

Economic Indicators	Evaluation	Remarks
17. Productivity		
17.1 Productivity of bioenergy feedstocks by feedstock or by farm/plantation	➔	rather stable
17.2 Processing efficiencies by technology and feedstock	➚	small improvement
17.3 Amount of bioenergy end product by mass, volume or energy content per hectare per year	➚	small improvement
17.4 Production cost per unit of bioenergy.	·	no data available
18. Net energy balance	·	
18.1 Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of feedstock production	➚	small improvement
18.2 Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of processing of feedstock into bioenergy	➚	small improvement
18.3 Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of bioenergy use	➚	small improvement
18.4 Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of lifecycle analysis	➚	small improvement
19. Gross value added	➔	rather stable
20. Change in the consumption of fossil fuels and traditional use of biomass	·	
20.1a Substitution of fossil fuels with domestic bioenergy measured by energy content	➚	increasing
20.1b Substitution of fossil fuels with domestic bioenergy measured in annual savings of convertible currency from reduced purchases of fossil fuels	·	no data
20.2 Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content	·	No “traditional” use in Germany
22. Energy diversity	➚	Improved by bioenergy, stable trend
24. Capacity and flexibility of use of bioenergy	·	
24.1 Ratio of capacity for using bioenergy compared with actual use for each significant utilization route	➚	for biogas & biomethane
24.2 Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity.	➚	for biogas & biomethane

2 Introduction

2.1 Background

In November 2011, the Global Bioenergy Partnership (GBEP) adopted a set of 24 indicators to assess and monitor the sustainability of modern bioenergy.[1] These GBEP sustainability indicators (GSI) 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.

Up to now eleven countries have completed the measurement of the GSI at national or at least regional level. In five more countries the measurement is in process. At the GBEP level this work is accompanied by the Working Group on Capacity Building for Sustainable Bioenergy (WGCB). 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.

Germany is the first country which has repeated the measurement. The pilot testing in Germany resulted in the report "Implementation report of the GBEP Indicators for Sustainable Bioenergy in Germany" (Köppen et al. 2014).

2.2 Objectives

Five years later, the application was repeated in order to implement one of the core objectives of the indicators: to enable **monitoring** of the impacts of bioenergy production and use at the national level. Monitoring of course means: assessing the development of measured indicators **over time**. Thus, a key objective of this assessment is to provide time series for the indicators.

Another goal of this 2nd reporting is to deepen the lessons learned from the first application, as well as to incorporate experiences shared with other GBEP partners through the work in *Activity Group* 2 of the *Workings Group on Capacity Building* (WGCB) and the *Task Force on Sustainability*. The first report has revealed some difficulties according to precise application of some of the GSI. The authors made recommendations where the methodologies may need adaptation on the one hand and improvement of availability and reliability of the data base for relevant sustainability aspects on the other hand.

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/

The second reporting is guided by following questions:

- Are we able to identify and to interpret developments of the GSI results?
- Is the second application more efficient in terms of effort compared to the first time, in order to facilitate repeated assessments?
- Have we learned from the analysis regarding difficult application during the first application?
- Has the data base improved where we identified gap or quality sufficiency before?
- Will a periodic assessment of the GSI be feasible and how can it be connected with other established reporting schemes?

2.3 Linkages between the GSI and the SDG

Since the adoption of the GSI in 2011, the sustainability discussion evolved further: in September 2015 during the United Nations General Assembly, more than 180 countries adopted the Sustainable Development Goals (SDG) as part of the UN 2030 Agenda for Sustainable Development[2].

A GBEP paper[3] identified conceptual linkages between the SDGs and the GSI, and a recent report analyzed the links between GSIs and national SDG implementation in selected countries[4].

The German Government adopted the first national Sustainable Development Strategy in 2002. Since then the German government publishes progress reports in 2004, 2008 and 2012 with detailed information about developments in the core areas of sustainability policy inside Germany.

In 2016, the German government radically revised the strategy to align it with the SDGs. After a dialogue process with non-state and subnational actors the Federal Government adopted on 11 January 2017 the new version of the national Sustainable Development Strategy (NSDS) which represents the most extensive enhancement[5]. Moreover, it details how Germany wants to contribute to reaching the SDGs through measures with effects in Germany, measures by Germany with a global impact through measures in cooperation with others.

A peer review[6] conducted by international experts in June 2018 pointed out that further changes are still needed. Experience to date in implementing the SDGs at the national level shows that there is still

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[2] The SDGs are part of the Resolution adopted by the UN General Assembly on 25 September 2015 "Transforming our world: the 2030 Agenda for Sustainable Development", see https://sustainabledevelopment.un.org/content/documents/7891Transforming%20Our%20World.pdf

[3] Fritsche, Uwe et al. (2018) Linkages between the Sustainable Development Goals (SDGs) and the GBEP Sustainability Indicators for Bioenergy (GSI). Technical Paper for the GBEP Task Force on Sustainability. IINAS & ifeu. Darmstadt, Heidelberg http://iinas.org/tl_files/iinas/downloads/bio/IINAS_IFEU_2018_Linkages_SDGs_and_GSIs.pdf

[4] Iriarte, Leire & Fritsche. Uwe (2019) SDG implementation in selected Latin America and Caribbean countries and possibilities to link with the GBEP Sustainability Indicators. Technical Report by IINAS for the GBEP Task Force on Sustainability. Pamplona, Darmstadt

[5] Federal Government (2017) German Sustainable Development Strategy New Version 2016. Berlin https://www.bundesregierung.de/resource/blob/998220/455740/7d1716e5d5576bec62c9d16ca908e80e/2017-06-20-langfassung-n-en-data.pdf

[6] Clark, Helen et al. (2018) The 2018 Peer Review on the German Sustainability Strategy. Report by the International Peer Group. Berlin https://www.nachhaltigkeitsrat.de/wp-content/uploads/2018/05/2018_Peer_Review_of_German_Sustainability_Strategy_BITV.pdf

scope to become more sustainable - and that there is still a lot of work ahead. The regular **complete revision** of the German NSDS is planned **for 2020**.

As a controlling instrument, the NSDS also includes indicators and targets that together depict the status of sustainable development. The previously 38 and now 63 indicators with their associated targets allow an objective check of the status of development towards the SDGs. The new version of the NSDS reformulates outdated objectives with reference to the year 2030 and defines new targets in line with the UN 2030 Agenda.

For every SDG, at least one indicator-backed political target is listed, which identifies relevant need for action in the area without describing it comprehensively.

Instead, the indicators are like keys; they open up the topic area and reveal its relevance for the further development of German policy. They are linked to considerably more extensive and detailed indicator systems or data collections on the website of the Federal Statistical Office[7].

Within Germany's NSDS – and also within the SDGs, and the UN Agenda 2030 – the term "bioenergy" is not used. Instead, the NDSD refers several times to the "bioeconomy" – a broader concept that included bioenergy, but also food&feed, materials, textiles and other bio-based products.

It is beyond the scope of this report to address the bioeconomy and the SDGs, but will be an issue of future work to do so[8].

2.4 Approach

The 2nd measuring of the GBEP indicators for Germany is based on a desktop study. No primary data where assessed but only existing data from ministries, national agencies and research institutions are used (see acknowledgement).

In some cases experts from these institutions have been consulted. 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.

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 5.

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7 https://www.destatis.de/EN/Themes/Society-Environment/Sustainable-Development-Indicators/_node.html

8 See Section 7.

Table 5 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

Source: own compilation; note that the crossed indicators are considered to be not relevant for the situation in Germany, as explained in the text.

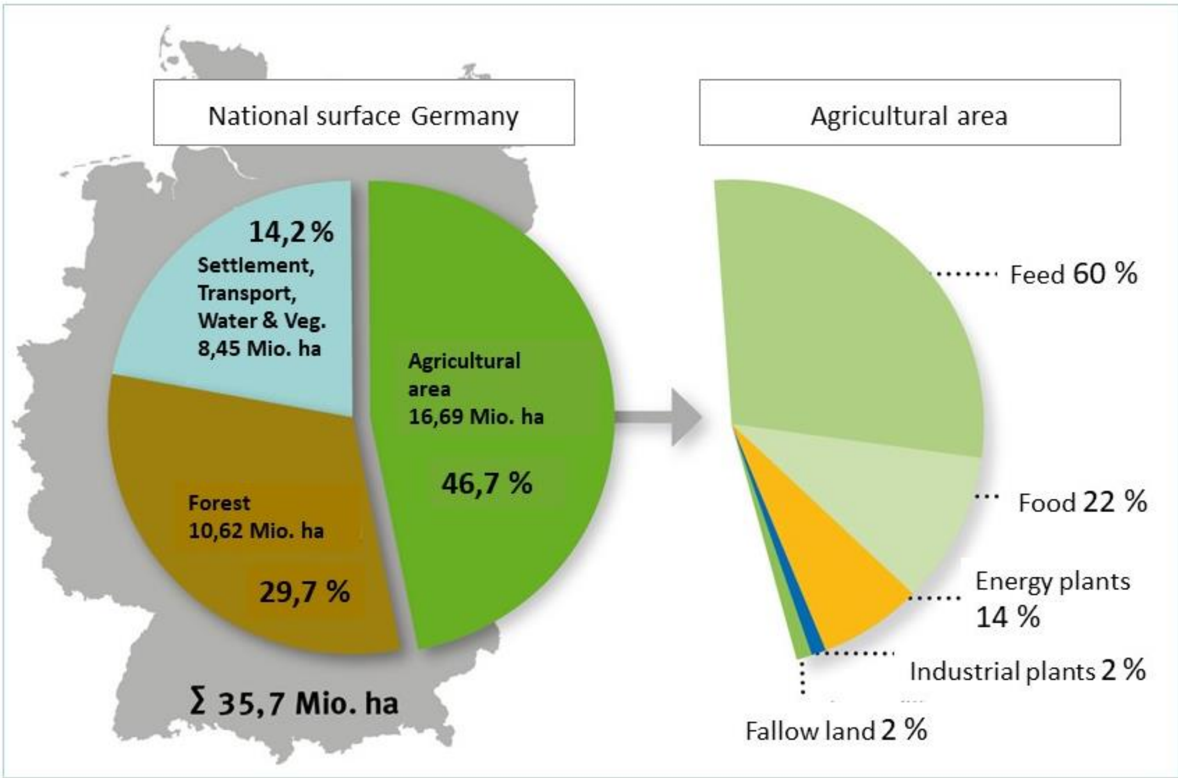
3 The Bioenergy Sector in Germany

3.1 General Information

Germany is located in the center of Europe, sharing approx. 3,600 km of borders with 9 EU Member States and covers a total of 35.7 million hectares (Mha). This total area includes, inter alia, agricultural and forest land, settlement and transport areas and water bodies such as rivers, lakes and channels. The population in 2018 was 82.5 million people living in 41 million households (DESTATIS 2019).

- About 51 % of the total land is under agricultural use, covering approx. 17 Mha (47%), of which some 12 Mha are arable land and about 4.5 Mha pasture and grassland.
- Forest cover 30 % of the total area in Germany, i.e. 10.6 Mha

Figure 1 Land use in Germany 2017



Source: compilation by IINAS based on FNR & BMEL (2018) & DESTATIS (2017)

3.2 Bioenergy Data for Germany

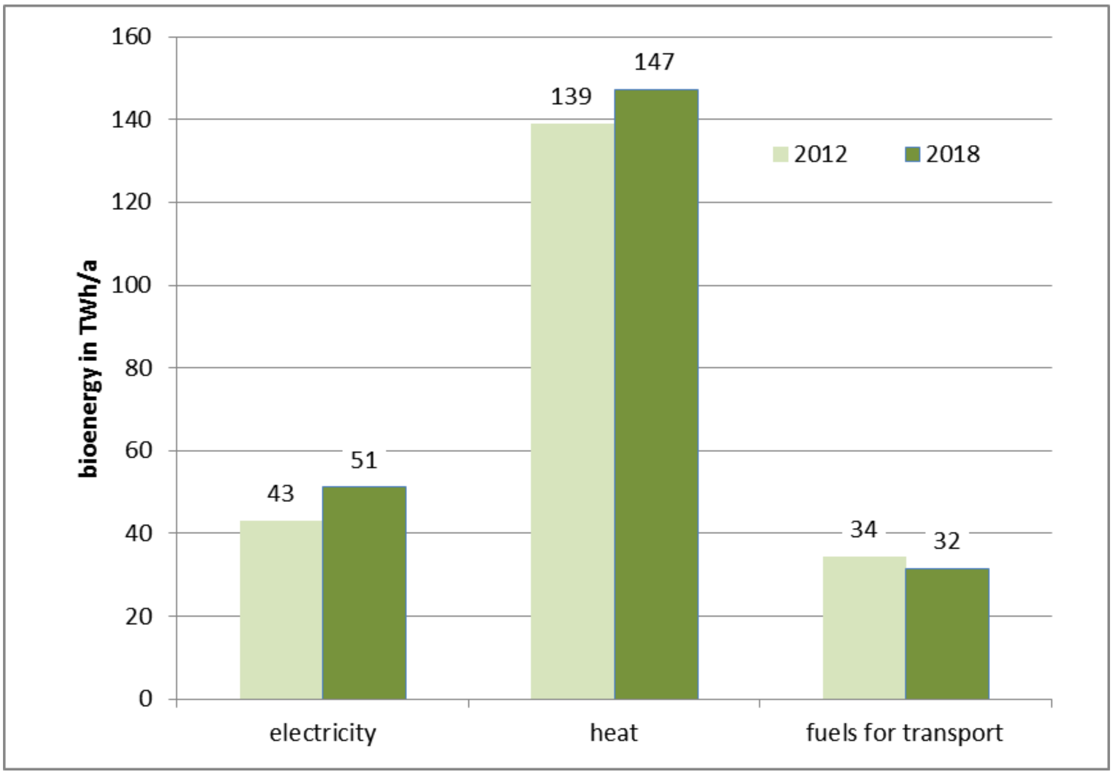
The following sections present an overview on the bioenergy sector in Germany. A more detailed description of Germany's bioenergy sector is given in the IEA Bioenergy Country Reports[9], and in the Annex (Table 50 to Table 60).

[9] See https://www.ieabioenergy.com/wp-content/uploads/2018/10/CountryReport2018_Germany_final.pdf

3.2.1 Shares of bioenergy and cultivation areas

In 2018, 16.7 % of the final energy consumption came from renewable energies, out of which 53.8 % where produced from biomass (in total numbers: 230 TWh, or 829 PJ of bioenergy) (UBA 2019). The development of the types of bioenergy is shown in Figure 2, indicating increases in heat and electricity from bioenergy as well as slight decreases of biofuels in the transport sector.

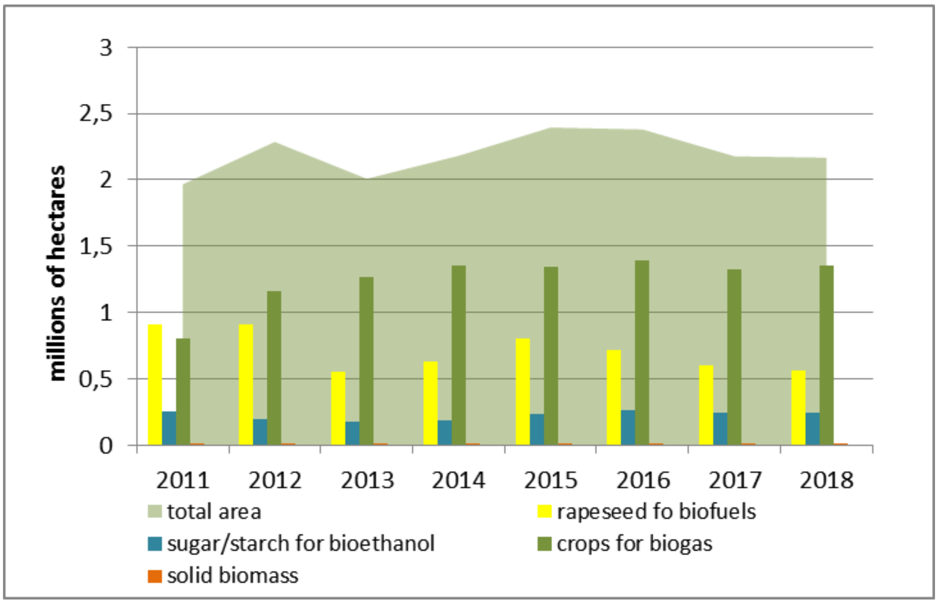
Figure 2 Shares of bioenergy (final energy) in Germany 2012 and 2018



Source: compilation by ifeu based on UBA (2019)

The amount of agricultural land used for bioenergy feedstock production has been steadily increased until 2014, when it starts to level off (Figure 3). According to FNR (2019), about 2.2 Mha of bioenergy crops have covered German cropland in 2018. This corresponds with 20% of the cropland or 13 % of the agricultural area.

Figure 3 Agricultural land used for bioenergy feedstock production 2011 to 2018



Source: compilation by ifeu based on FNR (2019)

3.2.2 Shares of imported biomass

For those indicators that cover the whole life cycle of a bioenergy carrier (e.g. GHG emissions), a differentiation between domestically produced and imported biomass is important, as the GBEP indicators are to be assessed at a national level.

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 for 2017 (BLE 2018), only 20.8% (based on energy content) of the reported biofuels/bioliquids have been produced in Germany. 43 % where imported from EU countries, 6 % from non-EU European countries, and 27 % from outside of Europe.

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 come from abroad. Yet, with rising cross-border trade in biomethane through existing natural gas pipelines, imported biomethane will become relevant.

Solid bioenergy in Germany is currently mainly woody material which comes **primarily from domestic** sources (forest and sawmill residues, post-consumer wood etc.). According to national statistics, Germany is a net exporter of wood pellets, but a net importer of waste wood.

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4 GBEP Indicator update: 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

Against the background of the expansion of renewable energies Germany has to fulfil different reporting obligations. Under the Directive 2009/28/EC (Renewable Energies Directive; RED) there are annual reporting requirements which are met by the Federal Environment Agency (UBA). It compiles an annual so-called emission balance report that includes the information on the greenhouse gas emission reductions due to the expansion of renewable energies. According to this Directive 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).

Additionally, 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 under the Directive 525/2013. The National Inventory Report (NIR) is also compiled by the UBA and reports the national greenhouse gas emissions since 1990 at a detailed sectoral level.

Both reporting requirements serve the monitoring of climate protection. However, due to their different goals and objectives, they both include different system boundaries and methodologies.
The Greenhouse Gas Inventory reports aim at quantifying all greenhouse gas emissions that are emitted on the territory of the Federal Republic of Germany. Emissions occurring outside this territory are not taken into account (territoriality principle). The balancing is done according to the source principle: the greenhouse gas emissions are assigned to the sector where they occur physically. This means that bioenergy is covered only by its emissions (e.g. occurring during biomass combustion).

On the contrary, the emission balance wants to cover the emission reductions due to the use of renewable energies replacing fossil energy in the electricity, heat and transport sector. This is done by comparing and balancing emission factors for renewable and fossil energies (for further details are dealt with in the section below). The emission balancing reports will be the basis for answering this indicator. It has to be noted, however, that using this methodology means that the GHG emissions include those emissions that take place outside Germany. As reported in section 3.2.2 a considerable amount of biomass is imported. This means that its cultivation and some transport steps take place elsewhere (e.g. in Indonesia). The emission factors used for calculating the emission savings includes also the emissions from the cultivation of imported biomass.

The overall result for the year 2017 is:

	19 112 678 t CO_{2eq} emitted throughout the life cycle of bioenergy
minus	83 980 793 t CO_{2eq} replaced
equals	**64 868 114 t CO_{2eq} total savings**

Figure 4 GHG emissions and emission savings from bioenergy in Germany 2010 - 2017

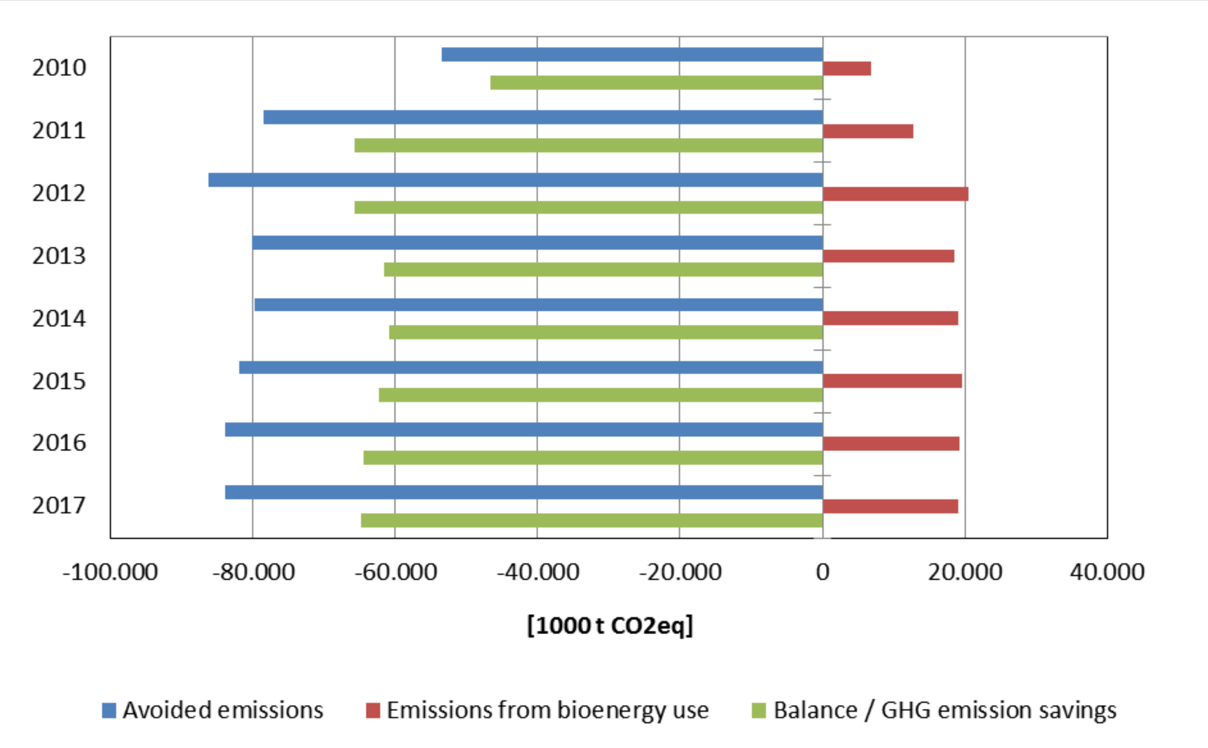

Figure 4 shows the greenhouse emissions from bioenergy production and use in 2017. Additional information is the amount of substituted non-renewable energy, avoided emissions from non-renewable energy replacement as well as net GHG emission savings. Data for 2013 to 2016 are listed in Table 42 to Table 45 in the Annex.

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 6 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2017

		Amount of bioenergy [GWh]	Emissions from bioenergy use [1000 t CO_{2equ}]	Avoided emissions [1000 t CO_{2equ}]	Balance / GHG emission savings [1000 t CO_{2equ}]
Solid	Electricity	10 658	793	7 902	7 109
	Heat	113 841	2.544	27 864	25 320
Liquid	Electricity	437	89	324	235
	Heat	2 125	125	605	480
	Transport	29 864	1 704	8 999	7 295
Gaseous	Electricity	39 836	11 189	29 528	18 339
	Heat	31 458	2 610	8 647	6 037
	Transport	445	12	111	99
Land use change (LUC) a)			47		
TOTAL		**228 663**	**19 113**	**83 981**	**64 868**

Source: compilation by IFEU based on UBA (2018)
a) explanation see text

Table 7 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 2018.

- 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.

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

- There are topical data on conversion from grassland to cropland in Germany (see section 4.8): 34,108 hectares have been converted as an annual average from 2013 until 2016.
- Since 18.5 % of the arable land is covered by bioenergy plants (see section 4.8), 18.5 % of the grassland conversion is attributed to bioenergy production in Germany, corresponding with 5,836 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 5,836 hectares converted grassland attributed to bioenergy results in 47 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 3 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 7 Specific life cycle greenhouse gas emissions from bioenergy in comparison with other renewable energy sources and with fossil energy in 2017

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	74.39	wood stove, residential	23.35	biodiesel	58.81
		wood log boiler, residential	20.50	straight vegetable oil	108.32
		pellets, residential	22.28	bioethanol	52.48
		woody biomass, district heating	23.75		
		woody biomass, industry	22.19		
Liquid bioenergy					
bio-liquids	203.11	straight vegetable oil	119.68		
		bioliquids	3.89		
		biodiesel agriculture	62.38		
Gaseous bioenergy				**Gaseous biofuel**	
biogas	345.46	biogas	150.54	biomethane	27.97
biomethane	291.56	biomethane	157.85		
sewage gas	125.86	sewage gas	34.76		
landfill gas	126.43	landfill gas	36.07		
org. wastes	4.75	org. wastes	1.45		
OTHER RENEWABLES					
hydro	3.93	solar thermal mix	22.35		
wind, onshore	10.71	environmental heat	183.68		
wind, offshore	6.09	geothermal heat	33.85		
solar-PV	66.76				
geothermal	183.00				
FOSSIL FUELS					
lignite	1054.45	heating oil, light	317.93	diesel	301.34
coal	881.26	natural gas	246.43	gasoline	301.33
natural gas	423.36	lignite briquet	442.86	CNG	250.51
oil	840.73	hard coal	427.76		
		district heat	304.20		
		electricity	552.08		

Source: compilation by IFEU based on UBA (2018)

4.1.2 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. Emission factors for bioenergy are taken from the ifeu report „Aktualisierung der Eingangsdaten und Emissionsbilanzen wesentlicher biogener Energienutzungspfade (BioEm)“ (IFEU 2016).

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.

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.

4.1.3 References

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UBA (2018) Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2017. Dessau

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) and Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV, 1999)

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) of the BBodSchG introduces the Codes of Good Practice in 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”. However, to date there are no nationwide reference values for site-typical organic matter contents.

Cross Compliance / Codes of Good Practice

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. After the reform of the Common Agricultural Policy (CAP) in 2015 the regulations regarding crop rotation, humus balancing and soil organic matter analyses are no longer viable. Instead, farmers are obliged to fulfil certain criteria in order to receive direct payments. They maintenance of soil quality is now covered by the diversification of cultivation (BMEL 2015).

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, which was withdrawn in 2014; however, the Seventh Environment Action Programme, which entered into force on 17 January 2014, recognises that soil degradation is a serious challenge. The proposal explicitly names the soil function as carbon storage and gives the obligation to protect soils against the loss of soil organic carbon (cf. BBodSchG 1998). Each EU 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.

Soil organic carbon as SDG-Indicator

Soil organic carbon is discussed as possible indicator for the goal “Land Degradation Neutrality (LDN)“ (SDG 15.3) as part of the UN Sustainable Development Goals (SDG) 2015. The loss of organic carbon has been identified as relevant for Germany and is seen as one of eight possible threats to German soils. Currently, there are discussions on establishing a regular soil quality monitoring system in Germany.

4.2.2 Results and methodological approach

Soil organic matter (SOM) content is influenced by different factors that show a great regional variability. Besides site characteristics (e.g. climate, soil type) management cultivation methods play an important role (e.g. crop choices, fertilising methods). Therefore, it is impossible to define universal thresholds of organic matter contents. However, a critical threshold of min. 2% SOM should be given in an intensively used agricultural soil (see EU Soil Thematic Strategy[10]). Moreover, different studies draw conclusions on whether the organic matter content in Germany actually decreases (or remains stable) and whether this should actually be a matter of concern. Regardless of the actual development, the loss of organic matter is rated as one of various threats for German soils (UBA 2015). Therefore, there should be a regular monitoring of improvement and degradation dynamics.

The indicator can be approached in two ways: first, maintain a good soil quality via soil improving measures and second, describe the risks for cultivated energy crops and the implemented land use/land management.

Soil improving measures

Generally, the obligation to maintain a diversified crop cultivation within the cross compliance (see section 4.2.1) should assure a minimum safeguard in terms of soil quality across the whole agricultural sector. Besides the general cross compliance obligations there are a number of additionally subsidised agri-environmental measures. Among others, they include soil improving measures such as no till farming / sowing, catch crops. However, since the measures are regulated at federal level there is 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.

Risk-based approach

Regarding the impact of bioenergy feedstock production on soil quality, only indirect conclusions can be drawn on its risks of having adverse impacts on soil quality. Capriel & Seiffert 2009 identified crop rotation as one of the main reasons for the declining organic matter content in certain areas in Bavaria. Possibly this is due to a decrease in cultivation of clover and cereals and an increase of silage maize and rapeseed cultivation in this region. In maize and rapeseed cultivation there are less harvest and root residues. According to Hüttl et al. 2008 and Warnecke et al. 2008 a future increase of energy crop cultivation could lead to a further SOM decline in the respective areas. In Germany as a whole the area of corn cultivation has increased significantly in the last years (see section 3). This development bears two types of risks: risks that are associated with grassland conversion and risks from the corn crop itself.

At the same time with increased silage corn cultivation, 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

10 https://ec.europa.eu/environment/soil/three_en.htm

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). Grassland conversion leads to higher erosion risks 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.

4.2.3 Data basis

German agricultural soil inventory

In 2018 the most extensive inventory on soil data carried out by Thünen Institut[11] has been accomplished. In total 3200 plots under agricultural use (grassland, agricultural land and gardens) have been assessed and analysed. Mainly information on soil carbon stocks of the upper soil layer is collected. The influence of site factors as well as cultivation practices on the soil carbon stock has been analysed. Furthermore, German wide future changes of SOM in cultivated mineral soils have been modelled. The results are to be used for the UNFCCC emission reporting and shall serve as a basis for future regular soil monitoring in Germany (Thünen 2018).

Permanent observation plots

Soil organic carbon content is monitored regularly since the 1990ies by each Federal State[12]. 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. In a project financed by Umweltbundesamt (UBA) these data have been brought together for the first time. They have been combined with climatic data and data from long-term field experiments. The objective was deriving conclusions on the influence of climate (change) and agricultural practices on soil carbon contents. (UBA 2016).

Forest soil condition survey

A similar assessment to the German agricultural soil inventory has been carried out in German forests from 2006 – 2008. In 2000 plots information about the forest status, i.e. soil type and texture, vegetation type and soil nutrients, where collected. As this is the second survey (following the one in

[11] https://www.thuenen.de/de/ak/projekte/bodenzustandserhebung-landwirtschaft-bze-lw/

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

1987 – 1993) changes in soil structure could be detected and evaluated. Furthermore, data is used for emission reporting purposes and to inform forest policy decisions and strategies (Wellbrock et al. 2016).

Soil information system / Maps on soil properties

The core activity of the Federal Institute for Geosciences and Natural Resources (BGR) soil team is the development of national soil maps and data bases. It manages a soil information system (FISBo BGR[13]) that is part of the national soil information network. The objective is to make soil information accessible at national and international level and to interpret and further develop this information for research and policy support. The core components of the FISBo BGR consist of a set of map data bases, a soil profile and analytical database and a method base. In 2007 a map was published on the organic matter content in the top soils of Germany (BGR 2007). Furthermore, maps have been published in the German Soil Atlas[14] (BGR 2016).

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 drawing 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.

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13 https://www.bgr.bund.de/DE/Themen/Boden/Informationsgrundlagen/informationsgrundlagen_node.html;jsessionid=F71B3192D53D1F32D7C4C50852409169.1_cid284

14 Digital version: https://www.bodenatlas.de/

Thünen 2018: Landwirtschaftlich genutzte Böden in Deutschland - Ergebnisse der Bodenzustandserhebung, Johann Heinrich von Thünen Institut, Braunschweig.

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Warnecke, S.; Overesch, M.; Brauckmann, H.-J.; Broll, G.; Höper, H. (2008): Auswirkungen des Energiepflanzenanbaus und der Düngung mit Gärresten auf den Kohlenstoffgehalt im Boden – erste Modellierungsergebnisse.

Wellbrock et al. 2016: Wellbrock, N., Bolte, A., Flessa, H. (eds) (2016): Dynamik und räumliche Muster forstlicher Standorte in Deutschland : Ergebnisse der Bodenzustandserhebung im Wald 2006 bis 2008, Johann Heinrich von Thünen Institut, Braunschweig.

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. 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, the key source is the official data from DESTATIS (2019) Table 8 shows the results for the GBEP Sub-Indicators 3.1-3.3.

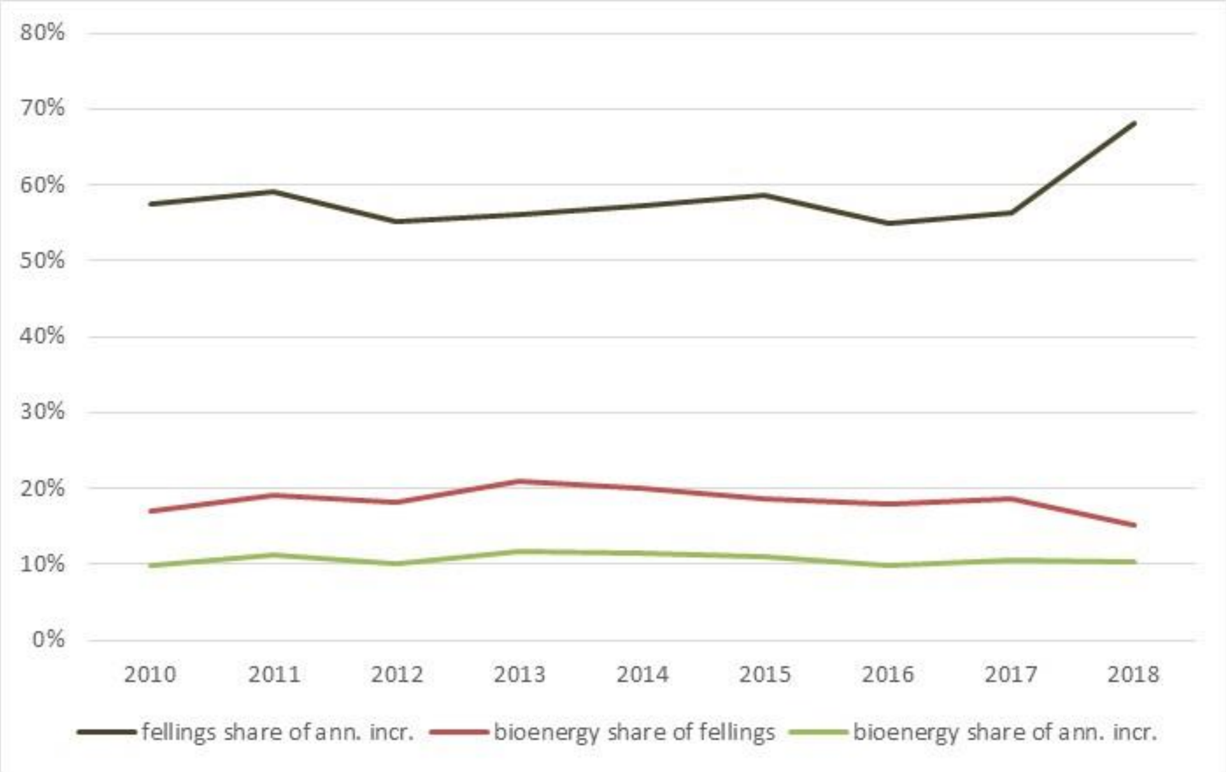
The share of bioenergy in total fellings (Indicator 3.3a) peaked in 2013 at 21%, and was reduced to 15% in 2018 due to an increase in fellings (Indicator 3.2), and stable volumes for bioenergy. The share of wood use for bioenergy of the annual increment (Indicator 3.3b) varies between 10 and 11 %.

Table 8 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 2010-2018

GBEP Sub-Indicators	2010	2011	2012	2013	2014	2015	2016	2017	2018
3.1 total fellings [Mm^3]	54.4	56.1	52.3	53.2	54.4	55.6	52.2	53.5	64.6
3.2 share fellings of annual increment [%]	57.4	59.2	55.2	56.1	57.3	58.7	55.1	56.4	68.1
3.3a share fellings for bioenergy [%]	17.0	19.2	18.1	21.0	20.0	18.7	18.0	18.6	15.2
3.3b share annual increment for bioenergy [%]	9.8	11.4	10.0	11.8	11.5	11.0	9.9	10.5	10.4

Source: compilation by IINAS based on data from DESTATIS (2019)

Figure 5 Shares of fellings and bioenergy in annual increment in Germany, 2010-2018



Source: compilation by IINAS based on data from DESTATIS (2019)

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 DESTATIS data which are provided annually, and the annual increment and use of harvested wood for bioenergy, all from the same source.

4.3.3 Data basis

The managed forest area in Germany covers currently 10.6 Mha, i.e. about 30 % of the total national surface (DESTATIS 2019). Wood harvest was rather stable in the last years, fluctuating between 17 and 21 % of the annual increment. The fluctuations are caused by storms on the one side and by variations in energy use on the other: Since 2010, wood use for heating varies between 10 and 11 Mm^3, practically independent from economic fluctuation (DESTATIS 2019).

4.3.4 References

DESTATIS (2019) Holzeinschlagsstatistik. Fachserie 3 Reihe 3.3.1. Statistisches Bundesamt. Wiesbaden https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaftFischerei/WaldundHolz/WaldundHolz.html

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 4.1), the air emission balances of renewable energies are reported annually in the so-called emission balancing reports. These reports are compiled and published by the Federal Environmental Agency (UBA). The air emissions are reported together with the greenhouse gas emissions. For further details see section 4.1.

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 following tables cover the emissions in the year 2016. Data on the period 2012 to 2016 are listed in Table 46 to Table 49 the Annex.

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 (2018). It has to be kept in mind, though, that in GHG reporting usually emissions and savings are reported whereas in the case of non-GHG air pollutants only emissions are taken into consideration.

Table 9 Results for Indicator 4.1a-4.4a: Life-cycle air emissions of electricity from bioenergy in Germany 2017

In 1000t / year	solids*	liquids	biogas & biomethane**	sewage gas	landfill gas	org. wastes	total
SO2eq	10.875	0.615	58.089	1.531	0.386	2.624	74.120
SO2	2.243	0.199	18.732	0.411	0.133	0.225	21.944
NOx	12.403	0.597	56.548	1.609	0.363	3.446	74.967
Particulates	0.538	0.068	1.652	0.057	0.004	0.016	2.334
CO	3.921	0.172	48.993	2.295	0.571	0.338	56.291
NMVOC	1.785	0.026	3.264	0.215	0.031	0.017	5.338

Source: IFEU compilation based on UBA (2018); data given in 1000 t/year;
**= mainly woody biomass; **= mainly from maize*

Table 10 Results for Indicator 4.1b-4.4b: Life-cycle air emissions of heat from bioenergy in Germany 2017

In 1000 t / year	solids*	liquids**	biogas & biomethane***	sewage gas	landfill gas	org. wastes	total
SO2eq	37.480	2.905	11.315	0.904	0.054	1.701	54.360
SO2	4.573	0.190	3.999	0.236	0.019	0.146	9.163
NOx	47.280	3.900	10.511	0.959	0.051	2.235	64.936
Particulates	19.853	0.466	0.368	0.034	0.000	0.010	20.730
CO	395.338	2.869	8.188	1.396	0.082	0.219	408.091
NMVOC	33.808	0.567	0.747	0.132	0.004	0.011	35.269

Source: IFEU compilation based on UBA (2018); data given in 1000 t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included
= mainly woody biomass; **= mainly biodiesel; *= mainly from maize*

Table 11 Results for Indicator 4.1c-4.4c: Life-cycle air emissions of transport fuels from bioenergy in Germany 2017

In 1000 t / year	biodiesel*	SVO	bioethanol**	biomethane***	total
SO2eq	9.557	0.011	4.365	0.077	14.010
SO2	4.587	0.007	1.795	0.022	6.412
NOx	7.111	0.006	3.676	0.078	10.871
Particulates	0.737	0.002	0.355	0.005	1.099
CO	1.920	0.004	1.076	0.042	3.041
NMVOC	1.193	0.002	0.530	0.006	1.731

Source: IFEU compilation based on UBA (2018); data given in 1000 t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

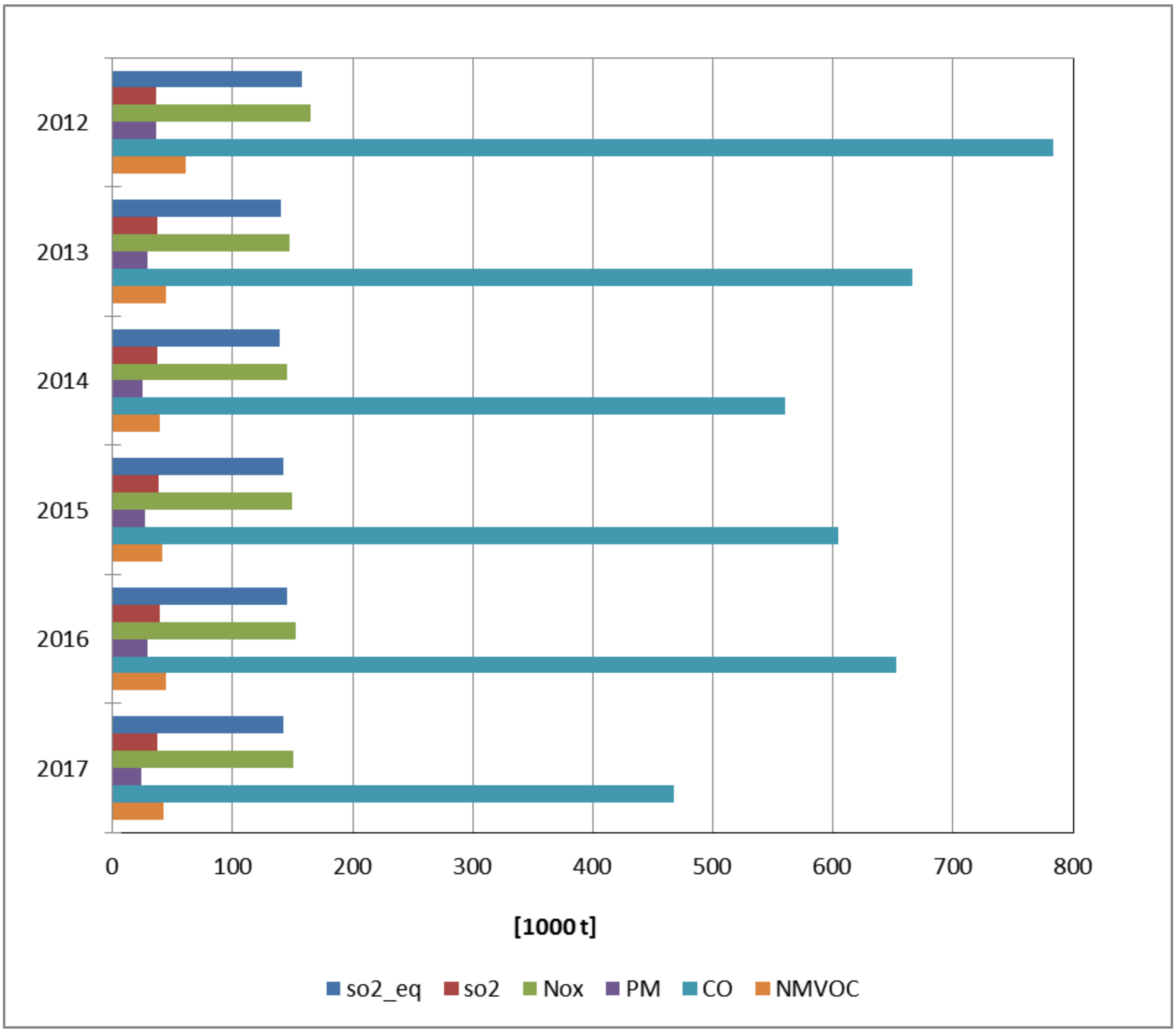
= mainly from rapeseed; **= mainly from wheat; *= mainly from maize*

Table 12 Results for Indicator 4.1d-4.4d: Life-cycle air emissions of total bioenergy use in Germany 2017

In 1000 t / year	electricity	heat	biofuels	total
SO2eq	74.120	54.360	14.010	142.490
SO2	21.944	9.163	6.412	37.519
NOx	74.967	64.936	10.871	150.773
Particulates	2.334	20.730	1.099	24.164
CO	56.291	408.091	3.041	467.424
NMVOC	5.338	35.269	1.731	42.337

Source: IFEU compilation based on UBA (2018); data given in 1000 t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

Figure 6 Development of non-GHG air emissions in Germany between 2012 and 2017



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 13 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 2017

In g / kWh_{el}	SO_2eq	SO_2	NO_x	particulates	CO	NMVOC
bioenergy						
woody biomass	1.020	0.210	1.164	0.050	0.368	0.167
bioliquids	1.406	0.456	1.365	0.157	0.394	0.059
biogas	1.929	0.632	1.863	0.055	1.637	0.107
biomethane	0.550	0.069	0.690	0.017	0.360	0.047
sewage gas	1.049	0.282	1.102	0.039	1.572	0.147
landfill gas	1.143	0.394	1.076	0.011	1.692	0.091
org. wastes	0.441	0.038	0.579	0.003	0.057	0.003
other renewables						
hydro	0.008	0.002	0.009	0.003	0.015	0.000
wind onshore	0.030	0.014	0.022	0.010	0.124	0.002
wind offshore	0.015	0.008	0.011	0.005	0.071	0.001
solar-PV	0.125	0.065	0.087	0.032	1.227	0.006
geothermal	0.251	0.099	0.218	0.014	0.146	0.008
fossil fuels						
lignite	0.990	0.482	0.729	0.022	0.439	0.013
coal	0.703	0.346	0.512	0.018	0.120	0.027
natural gas	0.289	0.013	0.396	0.013	0.219	0.026
oil	2.215	0.632	2.274	0.089	0.730	0.140

Source: UBA (2018); 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 14 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 2017

In g / kWh_{th}	SO_2eq	SO_2	NO_x	particulates	CO	NMVOC
bioenergy						
wood stove, residential	0.23	0.04	0.28	0.33	7.70	0.65
wood log boiler, residential	0.36	0.03	0.47	0.11	1.55	0.06
pellets, residential	0.34	0.05	0.42	0.07	0.50	0.02
woody biomass, district heating	0.44	0.05	0.56	0.05	0.20	0.10
woody biomass, industry	0.45	0.08	0.53	0.06	0.20	0.11
straight vegetable oil	1.31	0.25	1.51	0.09	0.23	0.03
bioliquids	0.71	0.00	1.02	0.02	0.14	0.01
biodiesel agriculture	1.51	0.09	2.04	0.28	1.74	0.35
biogas	0.79	0.30	0.70	0.03	0.58	0.05
biomethane	0.30	0.04	0.39	0.01	0.20	0.03
sewage gas	0.42	0.11	0.45	0.02	0.65	0.06
landfill gas	0.43	0.15	0.41	0.00	0.65	0.03
org. wastes	0.13	0.01	0.18	0.001	0.02	0.001
other renewables						
solar thermal mix	0.07	0.04	0.04	0.02	0.12	0.01
environmental heat	0.24	0.10	0.20	0.02	0.27	0.01
geothermal heat	0.0380	0.0158	0.0319	0.0019	0.0273	0.0013
fossil fuels						
heating oil, light	0.31	0.13	0.26	0.02	0.14	0.05
natural gas	0.14	0.01	0.18	0.01	0.14	0.04
lignite briquet	1.84	1.59	0.36	0.38	8.51	0.57
hard coal	1.83	1.52	0.44	0.07	12.63	0.24
district heat	0.37	0.16	0.31	0.06	0.18	0.05
electricity	0.60	0.25	0.51	0.02	0.33	0.02

Source: UBA (2018); 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)

Table 15 Results for Indicator 4.5c: Specific life-cycle air emissions for transport fuels from bioenergy in comparison to fossil fuels in Germany 2017

In g / kWh_{fuel}	SO_2eq	SO_2	NO_x	particulates	CO	NMVOC
biofuels						
biodiesel	0.45	0.22	0.33	0.03	0.09	0.06
straight vegetable oil	0.26	0.17	0.13	0.04	0.10	0.05
bioethanol	0.51	0.21	0.43	0.04	0.13	0.06
biomethane	0.17	0.05	0.18	0.01	0.09	0.01
fossil transport fuels						
diesel	0.34	0.21	0.19	0.03	0.09	0.09
gasoline	0.41	0.25	0.23	0.03	0.10	0.09
natural gas (compressed)	0.16	0.02	0.20	0.01	0.13	0.02

Source: UBA (2018); data given in g/kWhfuel; 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 (2018) which is based on results from the ifeu report „Aktualisierung der Eingangsdaten und Emissionsbilanzen wesentlicher biogener Energienutzungspfade (BioEm)“ (IFEU 2016). Further details on the data basis see section 4.1.2.

4.4.4 References

IFEU 2016: Aktualisierung der Eingangsdaten und Emissionsbilanzen wesentlicher biogener Energienutzungspfade (BioEm); Heidelberg.

UBA 2018: Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2017; Dessau.

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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.

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 28 in the Annex). The quantitative status of groundwater bodies is measured with an extensive measuring network (1200 measuring points).

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

The renewable water resources cover the amount of surface and groundwater that theoretically can be used and are calculated on an annual basis. They include precipitation and evaporation as well as inflows into outflows from Germany. The water resources remain relatively stable over the years with slight fluctuations in single years due to weather conditions and partly significant regional differences.

Cultivation of bioenergy feedstock

The overall water resources and withdrawals in 2013 are reported as follows (UBA 2017):

- the total annual **renewable water resources (TARWR)** were 188 billion m^3
  the total annual **water withdrawal (TAWW)** was 25.1 billion m^3

In general the contribution of agriculture to the overall water withdrawal in Germany is low in comparison with other sectors. In 2013 only 0.3 billion m³ have been withdrawn for irrigation (UBA 2017) which equals to

- **0.16 % of TARWR** or
- **1.2 % of TAWW**

In comparison to that around 54.2% of TAWW were withdrawn by thermal power plants as cooling water and 24.3 % for mining and manufacturing industries (UBA 2017).

There is no information available on which amount of the water withdrawn in agriculture is applied to bioenergy crops. In 2013, 11.9 % of the agricultural land was used to cultivate bioenergy feedstocks (see section 4.8.1). As a rough estimate to indicator 5.1a we calculated a proportional contribution of production of biofuel feedstocks to water withdrawal, assuming that 11.9% of agricultural water withdrawal is applied to biofuel feedstock cultivation:

- **0.019 % of TARWR** for agriculture are withdrawn for production of bioenergy feedstocks in Germany
- **0.142 % of TAWW** for agriculture are withdrawn for production of bioenergy feedstocks in Germany

Since the amount of water withdrawn for agriculture in Germany is equal or 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. Although most bodies of groundwater are in a good quantitative status, in 2016, 4.2 % of all groundwater bodies where in a bad quantitative status (UBA 2017; see Figure 29). This is 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 2015 BLE has issued sustainability certificates for 2.2 billion litres of biodiesel and 1.5 billion litres of ethanol (BLE 2016). Taking into account the numbers above this would make 0.00807 billion m³ of water used in production of biofuels, meaning that

- **0.0043 % of TAWW** are withdrawn for biofuel processing and
- **0.031 % of TARWR** are withdrawn for biofuel processing.

In terms of total numbers water withdrawn for bioenergy processing is below 1% of water resources (TARWR) and water withdrawals (TAWW) in Germany.

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 optimize 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 References

WSTB (2008): Water Implications of Biofuels Production in the United States. The National Academies Press. http://books.nap.edu/openbook.php?record_id=12039&page=46 Cited by Winrock 2009

BLE (2016): Evaluations- und Erfahrungsbericht für das Jahr 2015; Bonn

UBA (2017): Wasserwirtschaft in Deutschland – Grundlagen, Belastungen, Maßnahmen; 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 **fertilizer 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 fertilizer 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 fertilizers. Furthermore, the European Water Framework Directive (2000/60/EC) commits the European Member States to achieve good qualitative and quantitative status of all water bodies. To meet the reporting requirements the quality of water bodies in Germany is monitored on a yearly basis with an extensive measuring network. Every four years the state of surface and groundwater has to be reported. Up to now, three so-called nitrate reports exist (2008, 2012, 2016) that cover the nitrate and phosphorous loads for surface and groundwater bodies. Additionally, pesticide loads in surface and groundwater bodies are reported on an irregular basis.

4.6.1.2 Results and methodological approach

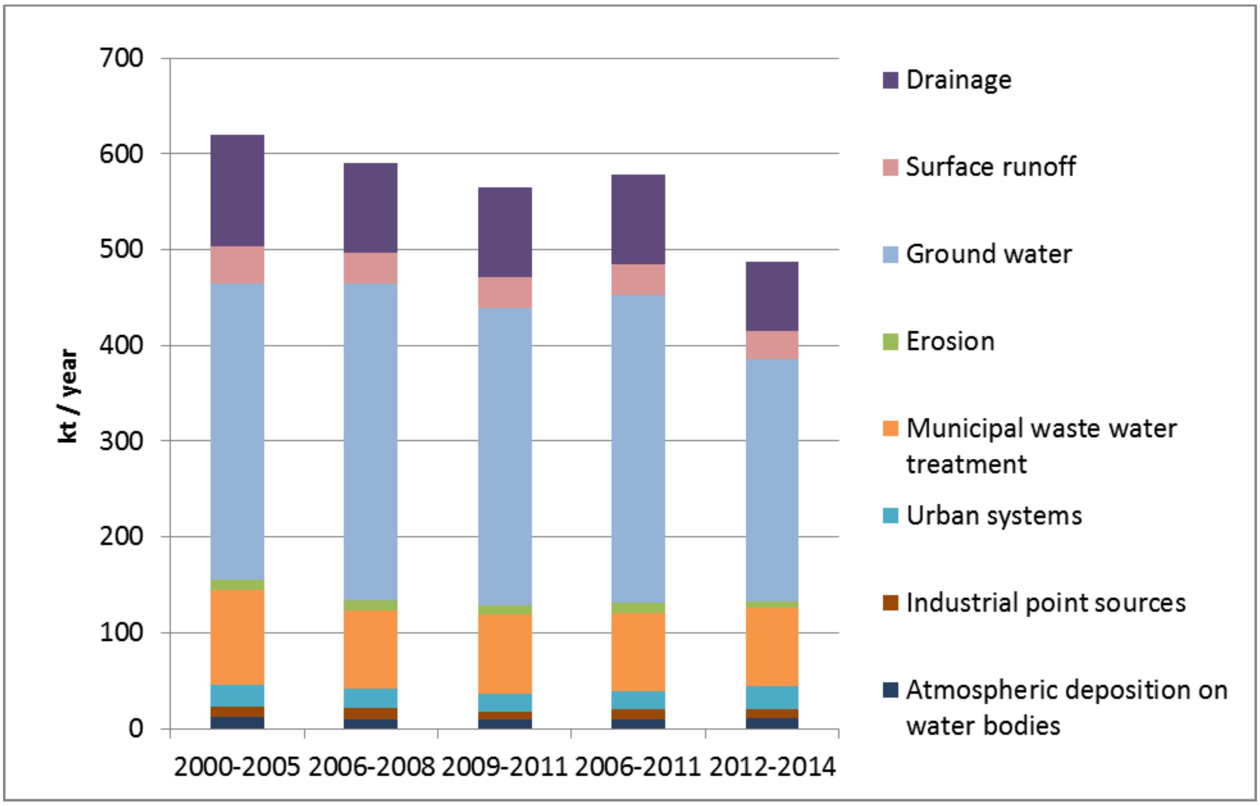
Nutrient and pollutant concentrations in water bodies are measured and reported on a regular base ensuring a close monitoring of water quality. Different institutions are responsible for different water body types (ground and surface water, rivers and lakes) causing differences in approaches and data availabilities. Only for rivers the allocation of pollution inputs (nitrates and phosphorous) to their sources is modelled. For all other water bodies (lakes, groundwater) and for pesticides only concentrations are measured. For all water bodies, the nitrate load threshold laid down in the Drinking Water Ordinance is at >50 mg N / l. The following sections provide an overview on the approaches for all water types.

Pollutant loadings in surface water (rivers and lakes)

The phosphorous and nitrate concentrations are measured in rivers (256 measuring points) and lakes (68 measuring points). Based on the pollutant concentration both water body types are classified into seven chemical water quality classes (both according to their nitrate and phosphorous loads). Figure 31 to Figure 32 in the Annex show the distribution of measuring points in the respective quality classes for rivers and lakes and for nitrate and phosphorous, respectively (BMUB & BMEL 2017). Compared to the previous reporting period, the current reporting period (2011-2014) shows a slight to strong decrease of nitrate loads in rivers whereas the nitrate situation on lakes remains constant with a generally very good water quality. Regarding phosphorous there is a decrease in the pollutant loadings in rivers as well as in lakes. Especially measuring points with high or very high loads (quality classes III and IV) are clearly decreasing in number.

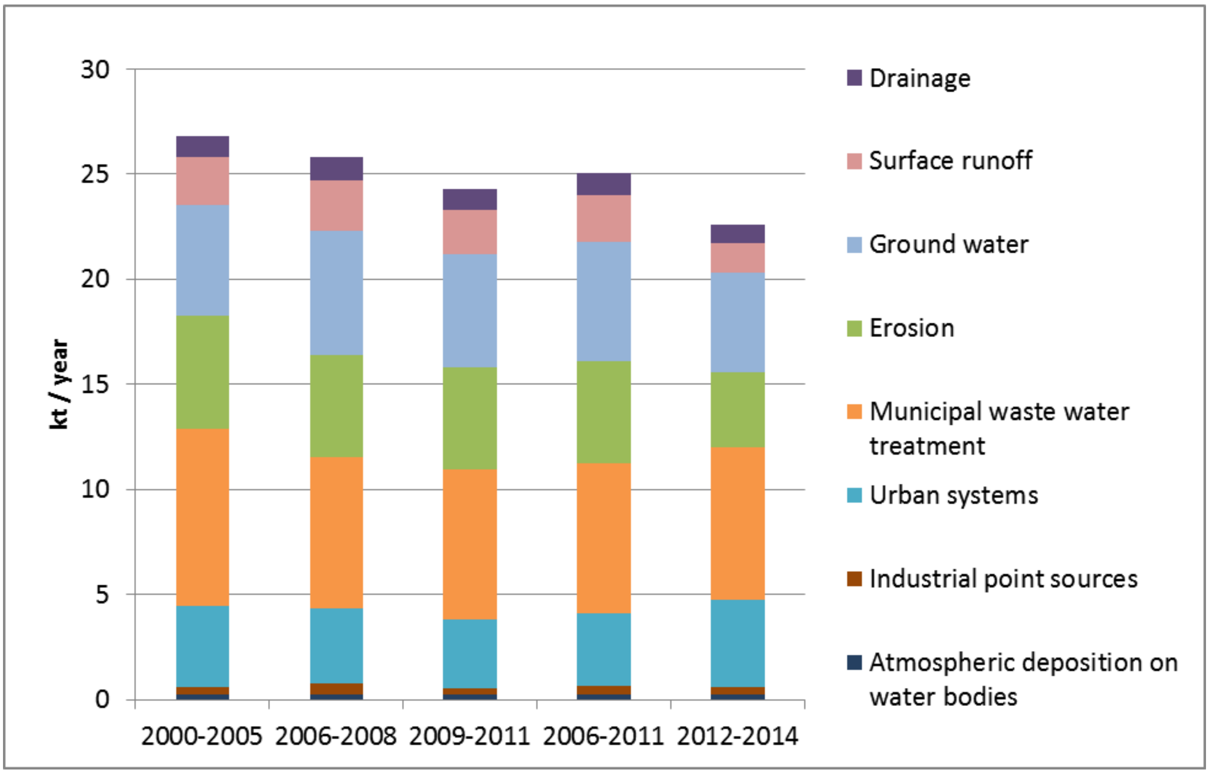
Only for river basins an allocation of pollutants to their entry paths has been done. This is realized with the MoRE model (Modelling of Regionalized Emissions) and allows quantifying the contribution of agriculture to the nitrate and phosphorous inputs (for a description of methodology, see UBA 2017a). Latest data are available for the period 2012 to 2014. The allocation of inputs to the different sources is displayed in Figure 7 and Figure 8. Agriculture covers inputs from erosion, groundwater, surface runoff and drainages. This means that in the period of 2012 to 2014, 74% of the nitrate input (equalling about 360 000 tonnes) and about 47% of the phosphorous input (equalling about 10 600 tonnes) can be attributed to agriculture.

Figure 7 Distribution of nitrogen sources



Source: UBA (2017)

Figure 8 Distribution of phosphorous sources



Source: UBA (2017)

A further exact disaggregation into bioenergy feedstocks is not feasible with the current data base as there is no information on the distribution and exact localisation of bioenergy feedstock production.

The allocation of environmental impacts is done based on the share of bioenergy feedstock area. In 2014, approximately 2.074 million ha where used for bioenergy crop cultivation (see 4.8), which is about 17.5 % of the arable land. On this basis, about 63,148 tonnes of nitrogen input can be allocated to bioenergy feedstock production.

Pollutant concentration in groundwater

The monitoring network for nitrate concentration in ground water bodies has been revized in 2014 and 2015. The groundwater quality monitoring and reporting since 1996 had been based on a nitrate load measuring network not being representative for Germany as a whole. Therefore, in a first step the German wide European Environment Agency (EEA) measurement network has been adapted and extended (now covering 1200 measuring points). Based on this network a new EU nitrate measuring network has been established that only covers measuring points with a clear agricultural influence. This subnetwork includes around 700 measuring points and describes the influence of agricultural influence on the groundwater nitrate load in a representative way.

Due to the measuring network revision the current nitrate report (BMUB & BMEL 2017) covers only the period 2012-2014 as the data series from the new network is still too short. These data are compared with the data from the last reporting period (2008-2011).

Figure 30 in the Annex compares the frequency distribution of the average nitrate contents during the current and the past reporting periods. Although there are more measuring points with a decreasing nitrate load than with an increasing one the developments of strongly decreasing and increasing loads are almost the same. Generally speaking, there is no deterioration of the nitrate situation and only small improvements towards lower nitrate loads. This means that the chemical conditions of groundwater bodies in Germany remain bad for about 35 % and thus only about 65 % are in a good enough condition for being used as a drinking water reserve (see Figure 34 in the Annex; UBA 2017).

Although the strong influence of agriculture on the groundwater nitrate load is evident 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 nitrate and phosphorous. There is not a single aggregated figure but the loads of 61 substances are monitored. Specific thresholds are published for each substance subject to the Water Framework Directive. Figure 35 in the Annex shows an overview on the number of measuring points where the thresholds are met or exceeded in the period 2013 to 2015 (UBA 2017). A comparison with the last reporting period / the last GBEP report is difficult as data are presented in different ways. Whereas in the last report, an exceedance has been reported for 13 substances (BMU & UBA 2010), in the current report 15 substances exceed the thresholds.

Reports on the pollution of **groundwater** with pesticides are published at irregular intervals, the latest one in 2015. Up to now, the time frame 1990 to 2012 has been covered by the 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 36 in the Annex. Compared to the last GBEP report the status can be regarded as constant: in the period 2006-2008, 4.7% of the measuring points exceeded the threshold, in 2009-2012 it was 4.6% (UBA 2017).

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.

4.6.1.3 Data basis

Data on nitrate, phosphorous and pesticide loads in 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 organized 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.

4.6.1.4 Excursus: Nitrate loads and drinking water

At present, over 34.8 % of German groundwater bodies exceed the nitrate limit of 50 mg/l (see Figure 34 in the Annex; UBA 2017). There is a documented spatial link between poor water quality and livestock farming, i.e. regions with a high concentration of livestock and consequently high quantities of manure are associated with increased nitrate leaching into the groundwater, particularly in sandy soils (BMEL 2016). Evidence suggests that biogas production plants are increasingly built in regions with a steady supply of manure, thus reflecting the principle of supply and demand and ensuring short transport distances. In addition to manure, maize is a common feedstock for biogas production. In consequence, maize is frequently imported into regions with a high density of biogas plants. Moreover, biogas plants can also alter the local and regional crop regime in their surroundings, e.g. maize cultivation commonly increases in proximity to biogas plants. In principle, cultivation of energy crops, particularly maize, is associated with a number of detrimental effects on the agricultural environment, e.g. high levels of mineral and/ or organic fertilisation, erosion and damage of the humus layer of organic soil matter and high levels of pesticides (see also section 4.2). In consequence, soil fertility and soil water retention potential are lost and the ecosystem service of nutrient regulation fails. Thus, a shift toward large-scale maize monoculture is clearly a concern, yet the most pressing matter in the context water quality is the local excess supply of digestate arising from biogas production (UBA 2013).

The agricultural application of digestate is a controversial practice. Although it is a valuable resource of nutrient and organic matter content that qualifies it as an alternative to mineral fertilizer (EBA 2015), there is also a growing debate on the risk of nitrogen pollution and nitrate leaching associated with biogas production (Paolini et al. 2018). The clustering of biogas production in regions with already high levels of nitrate pollution, associated with the import of feedstocks that are processed into considerable quantities of organic residues, create a critical feedback loop that exacerbates pressure on waterbodies in these areas. If arising residues are deposited locally or regionally, overfertilisation and nitrate leaching into the groundwater cannot be prevented. There is arguably a long history of nitrate pollution of waterbodies in Germany. A recent European Court of Justice ruling stated that the German government has failed to take sufficient action to curb high nitrate levels in groundwater in accordance with EU-wide directives. In light of this and in combination with the incentives for the cultivation of energy crops provided by the German Renewable Energy Sources Act, there is growing concern about the spatial link between nitrate pollution and biogas production plants (Grüne Liga 2014). The revised German Fertilizer Ordinance came into effect in 2017 and for the first time includes and regulates digestate as an organic fertilizer, which is a major step forward. However, due to the short timespan since its introduction, there is very little research to date on the effectiveness of the revised ordinance to prevent nitrate pollution (Kuhn 2017). Overall, the application of agricultural nutrient inputs through organic fertilizers (both livestock manure and digestate) requires strict regulation (Bicking et al. 2018).

In addition to the environmental costs of nitrate pollution detailed above, there is also a potential impact on the general public. In areas with poor water quality, e.g. due to industrial livestock farming and / or intensive biogas production, water providers may have to switch to more elaborate treatment methods, which could increase drinking water prices for consumers by 32 % to 45 % (UBA 2017b). Biogas production sites are thus prime suspects for increases in drinking water costs and should be monitored very carefully to protect both the environment and public health and safety.

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.

4.6.3 References

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UBA 2017b: Quantifizierung der landwirtschaftlich verursachten Kosten zur Sicherung der Trinkwasserbereitstellung; Dessau.

Paolini, V.; Petracchini, F., Segreto, M.; Tomassetti, L.; Naja, N.; Cecinato, A. (2018): Environmental impact of biogas: A short review of current knowledge, Journal of Environmental Science and Health, Part A, 53:10, 899-906.

4.7 Indicator 7: Biological Diversity in the Landscape

The GBEP Indicator 7 reads as follows:

(7.1) Area and percentage of nationally ***recognized 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 recognized invasive species****, by risk category, are cultivated;*

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

Using 50% of the land, agriculture today is the largest land user in Germany. As such, it massively influences the condition and development of biodiversity. Biomass production for bioenergy in

Germany takes place on agricultural land.[15] Hence, the focus in handling this indicator in Germany is on **biodiversity in agricultural landscapes**.

Agricultural biodiversity is in dramatic and widespread decline at ecosystem level. This is underscored by the findings of the current German Red Data Book on Endangered Habitats and high nature value farmland monitoring. Approximately 80% of habitat types of open landscapes that directly depend on farming are now classified as threatened (Finck et al. 2017). Moreover, the negative impacts of agriculture do not stop at the boundaries of protected areas, as relevant studies have shown (Vogel 2017; Vischer-Leopold et al. 2018).

The indicators for most targets of the National Strategy on Biological Diversity (NBS) relevant to agricultural landscapes show a negative trend. Without nature-friendly farming, the NBS targets will be unattainable.

The European Union's Common Agricultural Policy (CAP) and national agricultural policy in Germany, even after the most recent reform in 2013, still do not contribute substantially and effectively towards countering the ongoing loss of biodiversity (BfN 2017a).

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

4.7.1.1 Legal regulations and reporting commitments

The Federal Government adopted a comprehensive agenda for the conservation and development of biodiversity in Germany in the **National Strategy on Biological Diversity (NBS)** in 2007 (BMU 2007). This extends into numerous policy areas and contains a substantial number of targets relevant to agricultural landscapes and agricultural land use.

Biodiversity targets directly related to agricultural land use are also formulated in supranational and international agreements. The **European Union's Biodiversity Strategy** calls for a measurable improvement in the conservation status of species and habitats that depend on, or are affected by, agriculture (EC 2011). The **Aichi Targets** adopted under the international **Convention on Biological Diversity (CBD)** require party states to ensure that all areas under agriculture are managed sustainably by 2020 (BfN 2017a).

There is no reporting system in Germany to collect information on the conversion of land dedicated to bioenergy production. Further, most of the biomass for energy is produced on existing agricultural land or from managed forests, but the **management intensity** on agricultural land and forest has risen along increased 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

[15] Bioenergy in Germany is also supplied through wood extraction from forested land (and use of woody residues and wastes), but – so far – woody bioenergy demand did not change German forestry practices. Thus, biodiversity impacts of bioenergy use on forest operations are insignificant (so far). Bioenergy from short rotation forestry is cultivated on agricultural land, but respective land use is still small (see Table 21 for Indicators 8.1 and 8.2).

that feedstocks be not obtained from land with high biodiversity value such as forests, grassland, and land with relevant protection status.

On **International and European level**, there are conventions and regulations to protect and monitor biological diversity in the landscape. In particular:

- the Sustainable development goals (SDG),
- the UN Convention on Biological Diversity (UN CBD),
- the OECD Agri-environmental Indicators
- the EU Habitats Directive and Birds Directive within the Natura 2000 network.

On **national level in Germany** are, besides the **Red List on Endangered habitat types**, four indicator-based strategies:

- German National Strategy on Biological Diversity **(NSB)**
- German Sustainable Development Strategy **(GSDS)**
- The German Environment Agency introduced 2005 a set of 50 **Important Environmental Indicators** (yearly)
- German Strategy for Adaptation to Climate Change **(DAS)** since 2008.

Table 16 German indicator reporting systems for biodiversity relevant for GEPB Indicator 7

Indicators relevant for GBEP Indicator 7 on Biological Diversity	GSDS	NSB	Important Environmental Indicators	DAS
Species diversity and landscape quality	X	X	X	-
High nature value farmland	-	X	-	-
Organic agriculture	X	X	X	-
Grasslands	-	-	X	X
Protected area	-	X	-	-
Agro-environmental measures	-	-	-	X

Source: compilation by IINAS

Under the **UN Convention on Biological Diversity (UN CBD)** and the relevant **National German Biodiversity Strategy and Action Plan** (NBSAP)[16]) Germany established an indicator based monitoring system, the **National Biodiversity Strategy** (NSB) (see Table 16). Every 4 years Germany reports under the **UN CBD** (report 4/2014 with data from 2010/11, and 6th national report of 31 December 2018[17]) with regard to the national implementation of the **Action Plan** (latest indicator report 2014[18] and the

16 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.

17 See: https://www.cbd.int/nr6/default.shtml

18 See: https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/indikatorenbericht_biologische_vielfalt_2014_bf.pdf

accountability report from 2017[19] without any concrete data).

The indicator on **'High Nature Value Farmland'** (HNVF) is biannual reported to the EU under the **EAFRD Regulation** (European Agriculture Fund for Rural Development) and at national level in Germany as one of the reporting requirements for the NBS[20]. The concept of HNV farmland ties together biodiversity to the continuation of farming on certain types of land and the maintenance of specific farming systems.

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

- **'Protected area'**, this indicator is a figure for the total area of strictly protected areas in Germany.
- '**Species diversity and landscape quality**'[21] is the index (measure in %) of nationwide populations of 59 representative bird species in six main habitat and landscape types in Germany[22].

The indicators on *Organic agriculture* and *Sustainable forestry* are relevant for the GBEP sub-indicator 7.3.

The German Environment Agency yearly report on "Data on the Environment" with the **Important Environmental Indicators** (see Table 16) gives a comprehensive overview of the state of the environment, the causes of environmental pollution and leverage points for improvement. Fifty indicators are selected from all environmental domains (land use, climate, energy, consumption, etc.) and underpinned by policy targets, as defined in documents such as the German Sustainable Development Strategy or EU directives. Thus, the environmental indicator system is also a record of environmental policy. For the GSI 7.1 the indicators on: '**Species diversity and landscape quality**' and on '**Grassland**' are relevant. Organic agriculture and Sustainable forestry are as well in this set.

In order to provide climate change adaptation in Germany with a political framework, the federal government adopted the **"German Strategy for Adaptation to Climate Change" (DAS)** in December 2008. For GSI 7.1 the **'Grasslands'** development indicator is of relevance.

Besides these reporting systems, a major part of nationally recognized areas of high biodiversity value are **protected areas**, as protected areas belong to the most important instruments of nature conservation. Several types of **protected areas** are designated in Germany based on the Federal Nature Conservation Act (BNatSchG). They are classified by size, protection and conservation objective, and by the resulting restrictions on land use. The main types are National parks[23], Nature conservation

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[19] See: https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Naturschutz/nationale_strategie_rechenschaftsbericht_2017_bf.pdf

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

[21] 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.

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

[23] 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. 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.

areas, Biosphere reserves, Landscape protection areas, Nature parks and Natura 2000 sites (see Annex: Indicator 7). 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, with the exception of Nature protection areas where farming and forestry is not restricted.

Besides these indicators based Strategies the **Red lists** of endangered species and habitats

- provide a readily available reference for spatial and environment-related planning,
- highlight the need for nature conservation measures,
- push nature conservation up the policy agenda,
- are a source of data concerning legislative measures and international Red Lists,
- serve in coordinating international nature conservation activities and
- serve in checking the degree of implementation of the National Biodiversity Strategy.

Red lists are drawn up and published by nature conservation agencies.

The **German Red Data Book on Endangered Habitat Types** has been published by the Federal Agency for Nature Conservation (BfN) at approximately ten-yearly intervals since 1994. It differs from the red lists of species in its even greater focus on the spatial planning and practice of habitat conservation. It has a correspondingly wider area of application. The 3rd edition of the German Red List of Threatened Habitat Types (Rote Liste der gefährdeten Biotoptypen) was published in 2017 (Finck et al. 2017).

The threat status and rarity of habitat types is a key parameter alongside degree of naturalness in evaluating the nature conservation needs. Lists of threatened habitat types parallel and complement the Red Lists of species and have the added benefit of full spatial coverage. This means the Red List of Threatened Habitat Types can be used as an evaluation tool for all habitats. The threat status levels also indicate any current need for action and can help in prioritizing. (BfN 2018d)

Supplementary Germany has a well-established observation system for habitats to safeguard biological diversity within the frame of the **EU Habitats Directive and Birds Directive** and the **Natura 2000 network**[24] (EU 1992). Germany has the legal obligation to report every six years (latest reporting period: 2013-2018, published in 2019) by the 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 habitat quality (biodiversity; land conversion). For the GBEP indicator reporting, two habitats are relevant: grassland and forest.

[24] 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.

Landscape rating

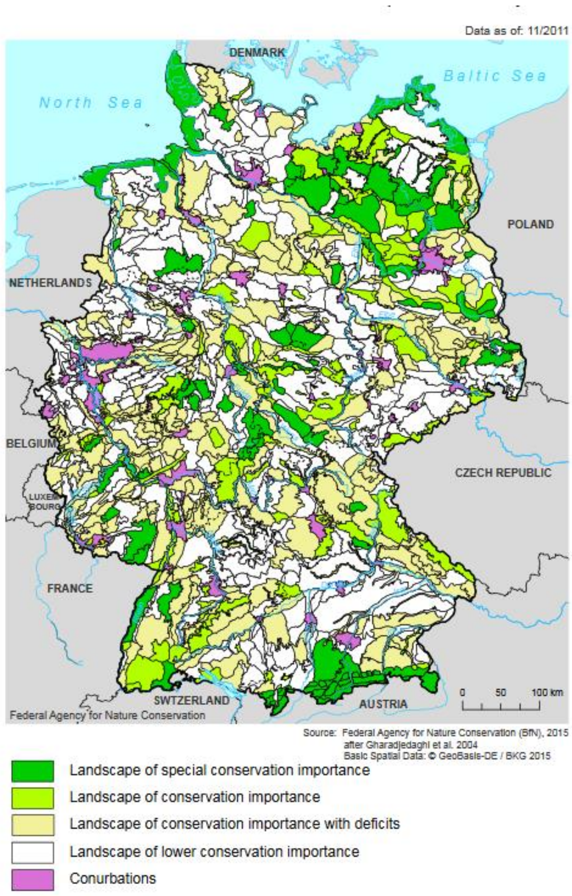
Landscapes, like for example “*Cultural landscape rich in woodlands/forests and dominated by grasslands*” are an important part of the environment, but have so far received too little attention as conservation targets in Germany. Nationwide landscape demarcation, classification and assessment provides an important basis for identifying conservationally important landscapes in Germany.

The criteria used for landscape demarcation include physiographic boundaries, current land use as indicated by data from the CORINE Land Cover satellite-imaging project, and other locally applicable landscape boundaries.

Landscapes of conservation value are identified in a two-stage assessment process. Each landscape is first assigned a 'type' rating according to its landscape type classification. This general rating is then refined by giving the landscape a 'unit' rating based on its individual character.

The landscape assessment ratings were updated in 2011. Three factors went into the unit rating: landscape fragmentation, importance for habitat and species conservation based on the percentage of land accounted for by protected areas (national parks, nature conservation areas, Natura 2000 sites and core zones of biosphere reserves), and percentage of land accounted for by historical old forest. The type and unit rating are combined to give an overall rating (Figure 9).

Figure 9 Map on conservational evaluation of landscapes in Germany in 2011



Source: BfN (2015), after Gharadjedaghi et al. (2004)

4.7.1.2 Results and methodological approach

The main causes of the decline in species diversity – which differ by region – are intensive use for agriculture and forestry (narrow crop rotations, grassland conversion), landscape fragmentation and urban sprawl, sealing of land surfaces, and inputs of substances, e.g. nutrients and pesticides (BMUB 2015a, UBA 2015, UBA 2018b).

High Nature Value Farmland

High nature value (HNV) farmland monitoring is a permanent monitoring programme established in 2009 that involves regular surveys of habitat types and landscape elements in agricultural landscapes that are distinguished by more extensive management and greater biodiversity than under common intensive farming. The indicator on High nature value farmland[25] (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). The surveys are currently carried out on a quarterly basis on approximately 1,300 sample plots throughout Germany. The findings are extrapolated to federal and Länder level and must be reported to the European Commission regularly. The identified HNV farmland structures were assigned nature values on a scale:

- HNV I: Exceptionally high nature value
- HNV II: Very high nature value
- HNV III: Moderately high nature value

So besides quantitative information on HNV farmland changes also evaluation of the state of quality and potential quality and monitoring of potential quality changes in HNV farmland over time are now possible. As at January 2018 data for the total surveys of 2009 and the subsequent survey of 2010 to 2013 of 2014 to 2017 are complete and available. On national level, this adds up to five data points with the following values shown in Table 17 (HNV farmland percentage of agricultural area and absolute amount):

Table 17 High Nature Value Farmland categories and percentage share in Germany 2009-2017

Year	HNV rel %	Sampling error	HNV abs. (Mha)
2009	13.1 %	± 0.5%	2.562
2011	12.4 %	± 0.5%	2.437
2013	11.6 %	± 0.4%	2.269
2015	11.3 %	± 0.4%	2.219
2017	11.4 %	± 0.4%	2.235

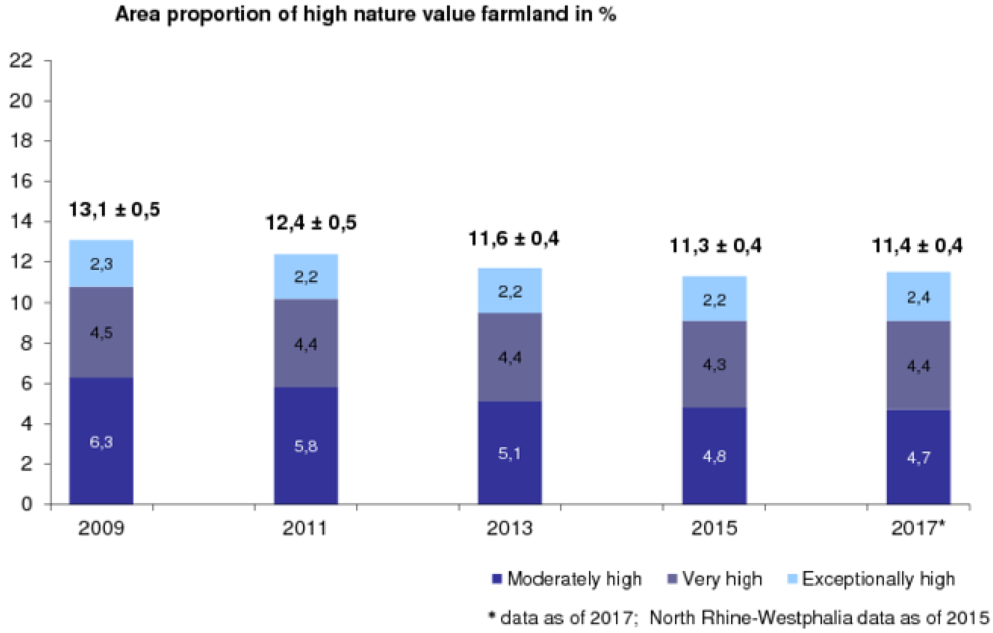
Source: BfN (2017b)

HNV farmland was found to account for 13.2 (±0.5) % of total farmland in Germany in 2009 and 11.4 (±0.4) % in 2017. The comparison of the values shows a sharp decline. Thus, the indicator value tends to decrease with the highest decline in the lowest quality level. The highest quality level remains static with a low value. A more differentiating view on the gained data illustrates that the decrease is mainly caused by loss of HNV grassland, HNV arable and fallow land, while in e.g. landscape elements, no noteworthy changes occur. These findings underline the fact, that the present measures to preserve agricultural biodiversity are not sufficient to reverse the current trend (BfN 2019).

25 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).

The proportion of HNV is unequally distributed with regard to the quality levels (see **Figure** 10):

Figure 10 Trend in aggregate indicator value and the three HNV farmland quality levels, 2009 - 2017



Source: BfN (2017b)

German Red Data Book on Endangered Habitats

The findings of the current German Red Data Book on Endangered Habitats and of high nature value (HNV) farmland monitoring show that biodiversity in agricultural landscapes is also in sharp decline on a large scale at ecosystem level. The German Red Data Book on Endangered Habitats assesses the threat status of 863 habitat types. More than 65% of these habitat types have a risk of loss to varying degrees or are already classified as 'destroyed' (Finck et al. 2017; BfN 2017a).

Habitat types of open landscapes, which notably include the various habitat types shaped by agricultural land use forms, shows a disproportionate risk of loss. Within this group, 70% of habitat types are classified as vulnerable, with more than 40% in the high to very high Red List categories (categories '1!' to '2'). An even clearer picture emerges if the habitat types of open landscapes are divided into habitat types groups predominantly with agricultural land use and without agricultural land use: about 13% of the 109 evaluated habitat types are directly dependent on agricultural land use, and of these habitat types about 80% are classified as vulnerable. The risk of loss is especially high for grassland habitat types. A total of 55% of arable habitat types also rank as vulnerable. With the exception of intensive arable land, which accounts for the largest proportion, all agrarian habitat types show a relatively high risk of loss. Extensively farmed land with full segetal vegetation is critically endangered (BfN 2017a).

Area Protection

The indicator on Area protection 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). For many wild fauna and flora species, the living conditions in Germany are unfavorable. Less than one-third of habitat types exhibit the favorable conservation status the EU requires, while more than two-thirds hove an unfavorable conservation status. It is well known that this is due to intensive land use that fails to give (adequate) consideration to nature's needs. (Germany NBSAP 2016)

The indicator is not yet updated since 2014, but the numbers are given by the Federal Agency for Nature conservation. Germany currently has 16 national parks covering 1,047,859 ha. Excluding marine areas, national parks cover 0.60 percent of German territory (BfN 2018b).

With data as of 12/2015, Germany has 8,743 nature conservation areas. A total of 1,4 Mha is given over to nature conservation areas. This represents 3.9 % of the country's land surface (BfN 2018c).

The coherent **Natura 2000** network of protection areas comprises the sites reported under the EU Habitats Directive and the EU Birds Directive. Overlaps between the two are possible. Together, the 5,206 areas cover 15.4 % of Germany's terrestrial surface and 45 % of its marine waters (by 2015).

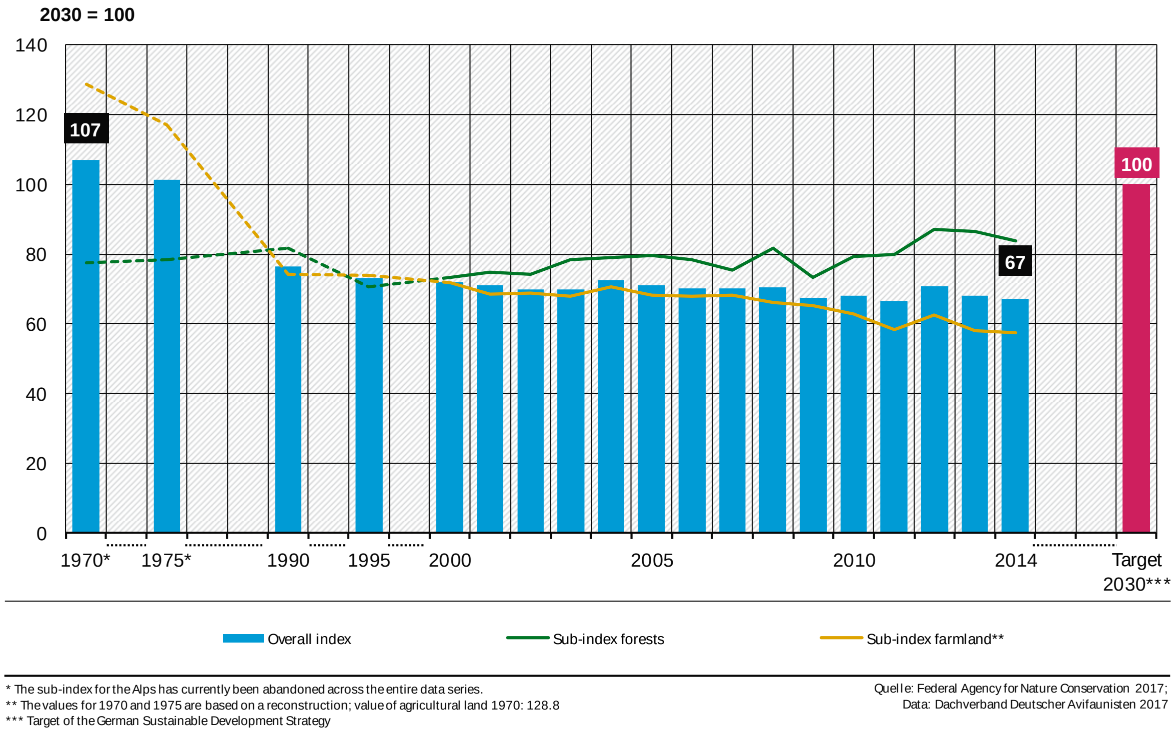
Species diversity and landscape quality

Species diversity is closely linked to the diversity of habitats and landscapes. Sustainable forms of land use across the landscape and a responsible treatment of the natural environment are required to maintain biodiversity.

The indicator shows the development of the populations of 59 bird species representing the main landscape and habitat types in Germany. Highly structured landscapes with intact, sustainably used habitats do not only provide habitats for birds. The indicator thus indirectly reflects trends in many other species living in the landscape and in the sustainability of land-use.

For GBEP indicator 7.1 farmland and forests are relevant. In 1990, the indicator value was already significantly below the values that had been reconstructed for 1970 and 1975. The indicator continued to show a negative trend in the last 10 years of the data series (2004 to 2014). It was as low as 67 % of the target value in 2014. The main causes for this development are intensive agricultural use, landscape fragmentation and urban sprawl, sealing the ground and large-scale input of substances such as nutrients and pesticides (UBA 2018b).

Figure 11 Population of representative bird species in farmland and forest habitats (1970 – 2014)



Source: BfN (2017a)

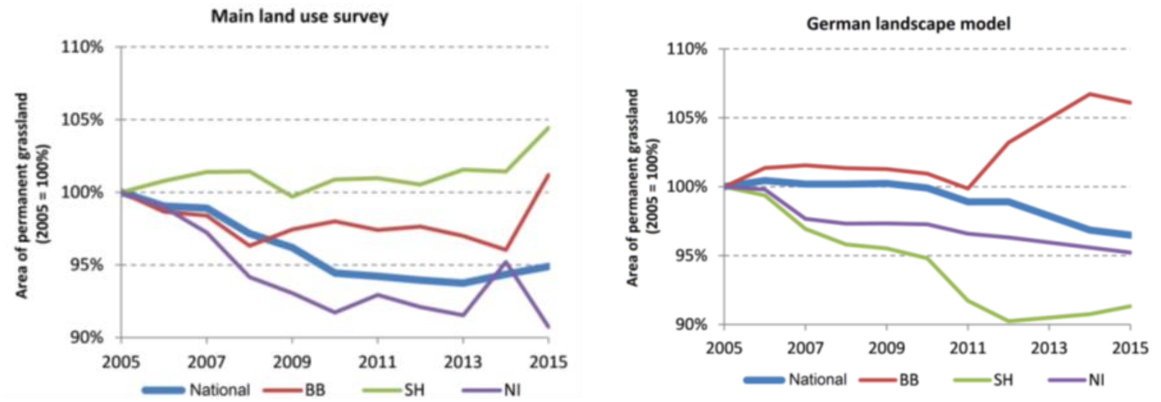
Grassland

Of particular importance in the bioenergy context is **grassland conversion** and the **intensification of grassland** (fertilization, number of cuttings). Since more than half of the entire flora species occurring in Germany are reliant on grassland habitats, but the outlook is far from encouraging: 44% of all species occurring in grassland are endangered or already extinct (BMUB 2015b). Conserving species-rich grassland thus plays a very important role in the attainment of national, supranational and international biodiversity targets. With a total area of some 5 Mha, grassland accounts for more than one third of agricultural land in Germany (BfN 2017a).

The massive decline in the area of grassland in Germany since the turn of the millennium was already a subject of the BfN report on grassland (BfN 2014b). However, recent surveys of permanent grassland show that it has largely stabilized since 2011 (BfN 2017a). There are large regional differences, but the overall trend shows the area decrease to be slowing or even stopping (see Figure 12).

One reason for this is that grassland was only allowed to decrease by a maximum of 5% at Länder level in the last CAP funding period and the Länder were required under EU law to legislate in order to protect permanent grassland if that limit was exceeded. In Schleswig-Holstein, for example, this resulted in an increase in the proportion of grassland (see Figure 12).

Figure 12 Trends in permanent grassland in Germany and three selected Länder a) from the main land use survey (Bodennutzungshaupterhebung) b) from the German landscape model (Deutsches Landschaftsmodell) (BB: Brandenburg; SH: Schleswig-Holstein; NI: Lower Saxony)



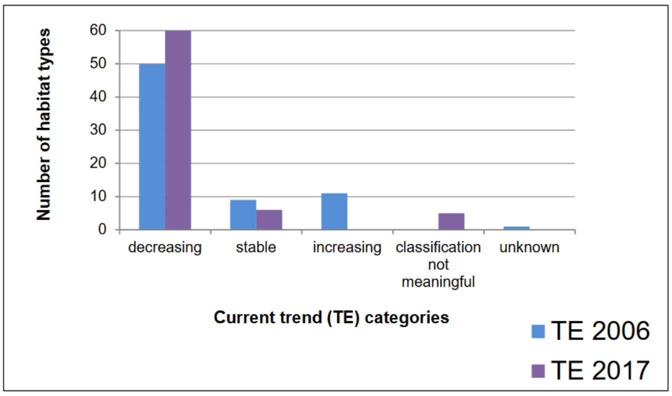
Source: *BfN (2017a)*

Another explanation is that in the new funding period from 2014, ploughing up of permanent grassland is not only subject to approval, but such approval is in most cases granted only on condition that new grassland is created elsewhere. The net outcome is theoretically no change in the area of permanent grassland. However, newly established or newly seeded grassland does not have the same importance for climate change or species diversity as sites that have been under grassland management for many years. Newly seeded grassland is generally species-poor, as most grassland seed mixes contain only a small selection of species geared toward mass productivity.

The slowed or halted decrease in permanent grassland is in contrast to an unchecked and, in some cases, dramatic qualitative deterioration. The inadequate to poor condition of species-rich grassland in Germany was already highlighted in the most recent national report under the EU Habitats Directive in 2013. The number of grassland habitat types with a negative current trend has also increased in the 2017 edition compared with the 2006 Red List. The number of grassland habitat types classified as stable, on the other hand, has decreased, and not a single grassland habitat type shows a positive trend (Figure 13).

This trend towards more intensive management of grassland is confirmed by the high nature value farmland monitoring carried out since 2009 (see above).

Figure 13 Comparison of the classification of current trends



Source: Finck et al. (2017); reference period ± 10 years in grassland habitat types (Groups 34 and 35) in the 2006 and 2017 Red Lists (n = 71; excluding the four habitat types under 'species-poor grassland on moist sites', which have been reclassified)

Landscape rating

The ranking was done for Germany twice, in 2006 and 2011. In the 2011 revision of the landscape ratings, 89 landscapes (12.3 % of the land surface) ranked as Landscapes of Special Conservation Importance, 99 (10.8 %) as Landscapes of Conservation Importance, and 273 (31.6 %) as Landscapes of Conservation Importance with Deficits (see Figure 9). As a result, the percentage of the German land surface accounted for by landscapes in the top three categories increased to 55% towards the 2006 rating assessment yielded 402 individual landscapes (about 49 % of the German land surface) that could be regarded as conservational important. Land uses changed so much in some landscapes (about 11% of the total) between the two references. The most striking change is the decline in grassland-dominated landscapes in Schleswig-Holstein and west of Berlin.

Table 18 Landscape assessment rating* in Germany

Rating	Number Land-scapes	Proportion of the total area of Germany (%)	Characteristics
Landscapes of special conservation importance	89	12,3	Occurrence of valuable habitat types; Home to endangered flora and fauna species; Large share of protected areas; Above-average share of undissected low-traffic areas
Landscapes of conservation importance	99	10,8	Smaller share of protected areas than landscapes of special conservation importance Similar share of protected areas but greater fragmentation by roads and railways
Landscapes of conservation importance, with deficits	273	31,6	Share of protected areas around national average Variable share of undissected low-traffic areas

*Source: BfN (2018a); *Landscapes of low conservation importance (383; 41.7%) and Conurbations (59; 3.6%) are as well in the rating, but not relevant for the GBEP indicator 7.1*

4.7.1.3 Data basis

Within the update of indicator, several possible data sources were used. All of them together give a deliver a clear picture on the status of habitat biodiversity. To define spatially, e.g. grassland conversion, the current data is not sufficient, but Box 1 describes that there are possibilities in the near future. Now the **HNVF** indicator, biannual reported to the EU under the EAFRD Regulation and for the NBS, further the indicator on **Species diversity and landscape quality** and the **grassland** indicator, reported by the German Environment Agency, deliver meaningful results for Indicator 7.1. (see: 4.7.1.1)

High Nature Value Farming

The practiced methodology turned out to deliver statistically sound results. Following integration of survey data up to 2017 a series of three nationwide complete and reliable indicator values are available in the midterm of the actual programming period. Thereby, in an economical manner the HNV farmland indicator supplies solid data on status and development of biological diversity in the agricultural landscape and contributes essentially to the evaluation of national and European agricultural policy measures.

Furthermore, the conceptual design offers an additional potential for analysis, as the data allows a more differentiated view. Qualitative changes in the HNV farmland setting can be assessed in time by addressing the different quality levels separately in their temporal dynamics as well as trends for qualitative development of HNV types as e.g. grassland, fallow land or arable land. Merely in cases of rare HNV types that cannot be assessed in sufficient numbers to guarantee statistical soundness this potential reaches its limit.

In this context it is to appreciate, that some Länder have already enlarged their subsample in line with the sampling concept. This provides a benefit on both, the national and the Länder level, whilst a deeper analysis is possible as well as the sampling error could be minimized in order to identify trends as soon as possible.

Additionally, correlation of HNV data and other biodiversity data sets is possible and is recently tested in several research projects. HNV farmland monitoring therefore offers a new, valuable data basis with a high potential for various advanced research approaches and queries on biological diversity within the agricultural landscape.

For the future it is envisaged to report the HNV farmland indicator values every second year on national level (BfN 2017b).

Species diversity and landscape quality

Populations of representative bird species serve as a proxy for the trend in biodiversity and permit assumptions with regard to landscape quality. This is the basis of the species diversity and landscape quality indicator, which the Federal Government uses to assess the condition of the natural environment under the varied influence of land use in Germany as a whole. Based on the population sizes of the currently selected representative breeding bird species (51 in total), the suitability of the landscape as a habitat is also suggested. If populations of the selected indicator on bird species increase and their breeding population rises accordingly, then it may be assumed that other animal and plant species will also benefit and that a more richly structured, diverse landscape will develop with sustainable and nature-friendly land use. A number of sub-indicators permit inferences about each of the main habitat and landscape types. These are used to calculate the aggregate indicator (BfN 2017a).

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

4.7.2.1 Legal regulations and reporting commitments

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

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

4.7.3.1 Legal regulations and reporting commitments

Since in Germany bioenergy production is more or less to hundred percent embedded in the agricultural and forestry production, it is at this stage virtually impossible to distinguish between biomass production for food, feed or energy. However, data on nationally recognized conservation methods are compiled to feed the indicators of the **National Biodiversity Strategy** (see 4.7.1.3), under which 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.

4.7.3.2 Results and methodological approach

Results from the relevant Indicators under the NBS:

Agri-environmental measurements

Agri-environment measures are a key element for the integration of environmental concerns into the Common Agricultural Policy. They are designed to encourage farmers to protect and enhance the environment on their farmland by paying them for the provision of environmental services. Farmers commit themselves, for a minimum period of at least five years, to adopt environmentally friendly farming techniques that go beyond legal obligations.

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.

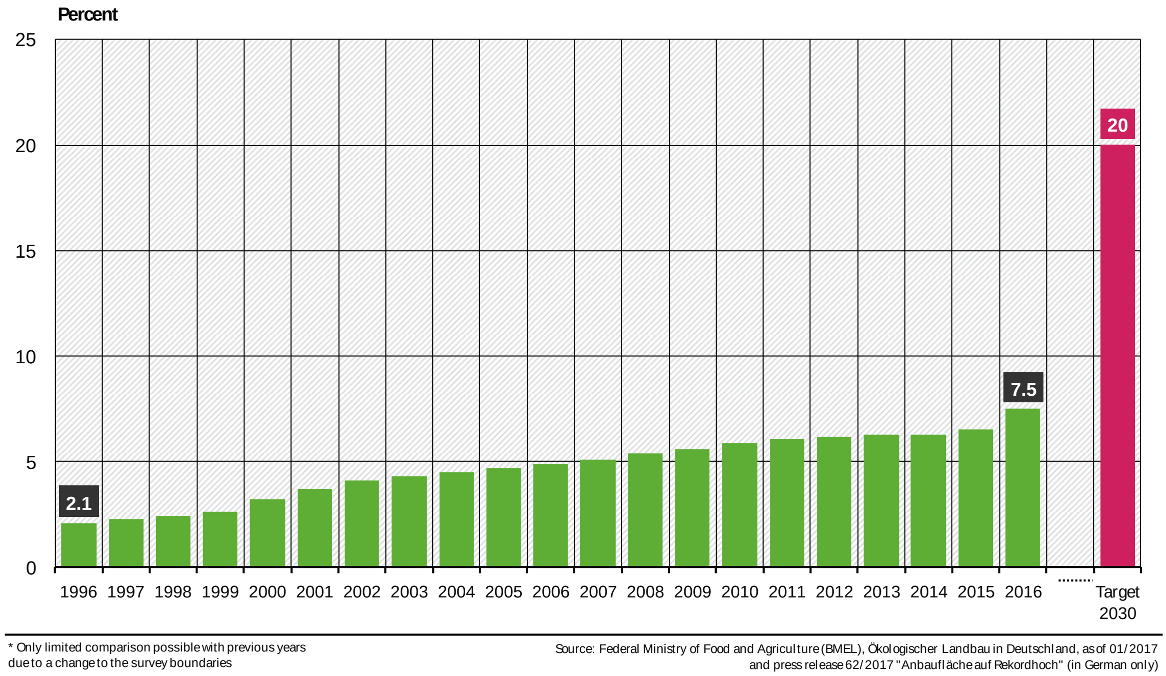
Organic farming

Conventional intensive agriculture causes a range of environmental impacts and is partly responsible for a loss of biodiversity. Organic agriculture, on the other hand, is a more environmentally sustainable and ecologically beneficial type of management. The aim is to close nutrient cycles as far as possible and to manage in harmony with nature. Organic farming does not use any mineral fertilizers. A range of crop rotations with intercropping maintain and support soil organisms and soil fertility. Avoiding the use of synthetic chemical pesticides enhances biological diversity on agricultural land.

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. The proportion of organically managed areas has risen continuously over the last 30 years. The share has increased from 2.1 % to 7.5 % from 1996 - 2016 (see Figure 14). Regarding the last few years, the total area of organic farming has shown a small but steady increase. Even though the income perspective of organic farms has improved in recent years due to a high demand on organic food, it is still not sufficiently competitive[26].

As part of both the German Sustainable Development Strategy and the Biodiversity Strategy, the Federal Government aims to increase the proportion of organically cultivated areas to 20 % (BMEL 2017). According to the latest coalition agreement, this target shall be met by 2030. However, Germany is still a long way from achieving this aim. However, there is no evidence that land used for bioenergy production is farmed organically.

Figure 14 Share of organic farming in total utilized agricultural area in Germany (1996-2016)



Source: UBA (2018)

[26] The sale of organic food is not able to cover the additional costs associated with organic farming and profits often are not sufficient to allow farms to compete with imports or to pay the high rents in some regions.

Sustainable forestry

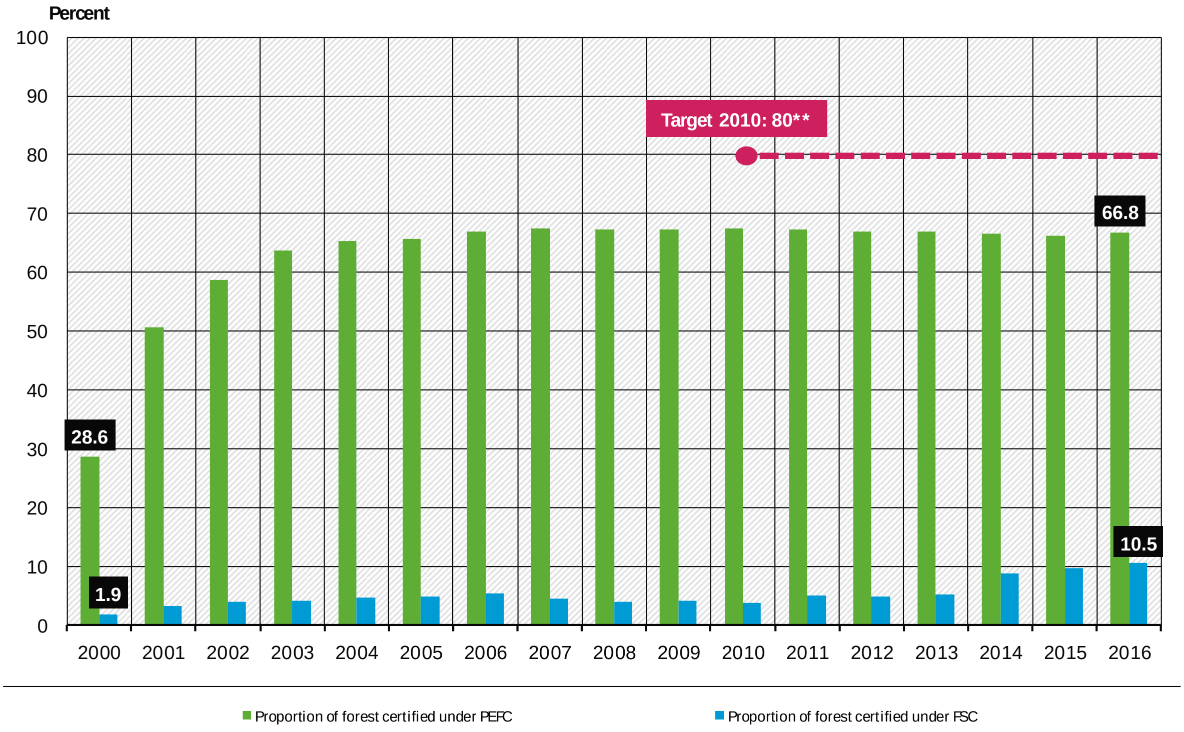
Around a third of the surface of Germany is covered with forests. The majority of German forestry, with exceptions, are planting vast monocultures of fast-growing species. Monocultures are in general more vulnerable to storms, droughts and attacks by pathogens. Soils are degraded by monocultures and the use of heavy machines. Biodiversity in these forests is generally lower than in semi-natural forests. (UBA 2019).

The most important sustainability standards under which forestry companies can be certified are PEFC (Programme for the Endorsement of Forest Certification Schemes) and FSC (Forest Stewardship Council). The enterprises have to meet environmental, economic and social criteria, some of which are above the legal requirements specified in the forest and nature conservation laws. FSC often involves stricter guidelines than PEFC.

Over the last few years, the development of PEFC forests has stagnated at a high level. Since 2006 the value has fluctuated around 67 % with gradually declining values more recently. The proportion of FSC certified areas has developed very positively over the last few years at a low level. Responsible for this is the certification of extensive areas by the regional State Forestry departments in the recent years, particularly in Rhineland-Palatinate and Hesse.

The Federal Government wanted the forested area in Germany certified under high-quality environmental standards to be expanded to 80 % by 2010. This target has not been achieved. However, it can currently not be ascertained how far the forestry is from this target, as some woodland areas (mainly state forests) are certified under both systems. However, what is clear is that it will take time to reach this target. The Federal Government therefore needs to promote sustainable forestry more vigorously. In 2018, 68.6 % of forests were managed under PEFC and 12.3 % under FSC (see Figure 15). (UBA 2019).

Figure 15 Proportion of forest area certified under PEFC or FSC in Germany (2000-2016)



* This refers to the forested area, i.e. the area under permanent use for timber production
** The target cannot be related directly to the two components of the indicator, because it refers to the areas certified according to high-quality environmental standards: areas can be certified under both PEFC and FSC. The extent of double certification is not known. In the case of this indicator it cannot therefore be judged whether the target has been reached.

Source PEFC and FSC certified areas: Federal Agency for Nature Conservation (BfN), Programme for the Endorsement of Forest Certification Schemes (PEFC) and Forest Stewardship Council (FSC); Source total forest area: Forested areas, from BWI 2 up to 2002, from BWI 3 after 2012, linear interpolation between values from BWI 2 and 3 between 2002 and 2012

Source: UBA (2019)

4.7.3.3 Data basis

Agri-environmental measurements

In Germany Agri-environmental measurements are subsidized by the state, the federal Länder and by the EU. The legal basis of the funding period 2014-2020 are the Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD).

Organic farming

To qualify as an area of organic farming requires certification under the EU Regulation on organic production (EC No. 834/2007). The Federal States collect the data and the Federal Office for Agriculture and Food (BLE) publishes the complete figures annually. Along with data on the total agricultural area, the percentage area of organic farming is published annually in the "Statistical Yearbook for food, agriculture and forestry" (BMEL 2018). The DESTATIS indicator for the German Sustainable Development Strategy uses a slightly different data set. Due to methodological differences, this discloses a slightly lower share of organic farming areas within the total utilized agricultural area.

Sustainable forestry

PEFC and FSC establish the extent of certified areas in the course of certification by forestry enterprises and publish these figures. The woodland area is used as a comparative figure. This is the area permanently designated for timber production. This area was determined during the 2nd and 3rd

National Forest Inventories (BWI). To avoid jumps in the indicator value, the two values of the 2nd and 3rd BWI were interpolated linearly. (UBA 2019)

4.7.3.4 References

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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*

Measurement unit(s):

(8.1-2) hectares and percentages

(8.3) percentages

(8.4) hectares per year

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

The total area of Germany amounts to 35.7 Mha, with dominant shares of agricultural land use: about half is on arable land, and the other half is managed forests (Table 19).

Table 19 Land use categories in Germany 2010-2018

Land category [Mha]	2010	2011	2012	2013	2014	2015	2016	2017	2018
Agricultural land	16.70	16.72	16.67	16.70	16.72	16.73	16.66	16.69	16.65
Arable land	11.85	11.87	11.83	11.88	11.87	11.85	11.76	11.77	11.73
Managed forest area	10.77	10.78	11.10	10.82	10.93	10.95	10.62	10.62	10.64
Total national surface	**35.71**	**35.71**	**35.71**	**35.73**	**35.74**	**35.74**	**35.76**	**35.76**	**35.76**

Source: compilation by IINAS based on DESTATIS (2019); note the overlap between agricultural and arable land, i.e. total is smaller than sum of components

4.8.1.1 Legal regulations and reporting commitments

The national statistical data from FNR and BMEL and the regular data from the national statistical office (DESTATIS) 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 Indicators 8.1 and 8.2 are reported for 2010-2018 (Table 20).

Table 20 Results for Sub-Indicator 8.1 and 8.2: Total area of agricultural land for bioenergy feedstock production in Germany 2010-2018 compared to the national surface area

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total area of land for bioenergy production [Mha]	**1.83**	**1.97**	**2.29**	**2.01**	**2.18**	**2.39**	**2.38**	**2.18**	**2.17**
Land for bioenergy compared to national surface	5%	6%	6%	6%	6%	7%	7%	6%	6%
Land for bioenergy compared to agricultural area	11%	12%	14%	12%	13%	14%	14%	13%	13%
Land for bioenergy compared to arable area	15%	17%	19%	17%	18%	20%	20%	18%	18%
Land for bioenergy compared to managed forest area	17%	18%	21%	19%	20%	22%	22%	21%	20%

Source: compilation by IINAS based on FNR (2019) and DESTATIS (2019)

The methodology to derive the indicator values was to determine the total land use for bioenergy feedstock production per year based on national statistics, 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 2019; FNR 2019).

4.8.1.3 Data basis

The calculation is primarily based on the consumption of bioenergy in Germany, which is collected annually by FNR. The statistical data for land used for annual bioenergy feedstock production is based on FNR (2019) and given in Table 21.

Table 21 Crop area for bioenergy feedstock production in Germany 2010-2018

Land for bioenergy [Mha]	2010	2011	2012	2013	2014	2015	2016	2017	2018
Rapeseed (for RME and SVO)	0.94	0.91	0.91	0.56	0.63	0.81	0.72	0.60	0.56
Sugarbeet, other cereals (for EtOH)	0.24	0.25	0.20	0.17	0.19	0.24	0.26	0.25	0.25
Maize, other cereals (for biogas)	0.65	0.80	1.16	1.27	1.35	1.34	1.39	1.32	1.35
short-rotation coppices (for heat)	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	**1.83**	**1.97**	**2.29**	**2.01**	**2.18**	**2.39**	**2.38**	**2.18**	**2.17**

Source: compilation by IINAS based on FNR (2019) and DESTATIS (2019)

4.8.1.4 References

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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 DESTATIS provide the core information for the GBEP sub-indicator 8.3a. Reporting commitments exist for data on crop area, harvest and yield levels, which are collected by DESTATIS, and BMEL collects respective statistical data and reports national figures to the FAO. To date in data reporting there is no differentiation 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 development in the last years. Yield development can, however, not be directly linked to bioenergy production. Given the significant variation in yield changes - both positive and negative - reported for key crops from 2008 to 2018 (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 2019). The data on yield developments in Germany are given in Table 22. As can be seen, there is **no significant yield improvement** for key crops, as weather conditions (droughts, precipitation, temperature) significantly vary, influencing all yields.

Table 22 Data for crop yields in Germany 2008-2018

	Yield [t/ha]								
Crop type	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Maize	39.4	47.6	46.4	39.0	47.3	41.4	43.1	47.5	35.3
Grass (arable land)	6.6	6.8	7.2	6.9	8.1	7.5	7.6	7.6	5.7
Rapeseed	4.5	3.9	3.7	4.0	4.5	3.9	3.5	3.3	3.0
Sugar beet	64.4	74.3	68.9	63.9	79.9	72.2	76.2	83.8	63.3
Wheat	7.2	7.0	7.3	8.0	8.6	8.1	7.6	7.6	6.7

Source: IINAS compilation based on DESTATIS (2019)

4.8.2.4 References

DESTATIS (2019) Zahlen und Fakten, Feldfrüchte und Grünland. Statistisches Bundesamt, Fachserie 3, R 3.2.1, Feldfrüchte. Statistisches Bundesamt. Wiesbaden https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Feldfruechte-Gruenland/Tabellen/liste-feldfruechte-zeitreihe.html

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 BMU, AGEE-Stat and FNR provide the core information for the GBEP sub-indicators 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 for the period 2010 - 2018 are given in the following table.

Table 23 Results for Indicators 8.3b+c: Contribution and percentages of bioenergy from residues and wastes in Germany 2010-2018

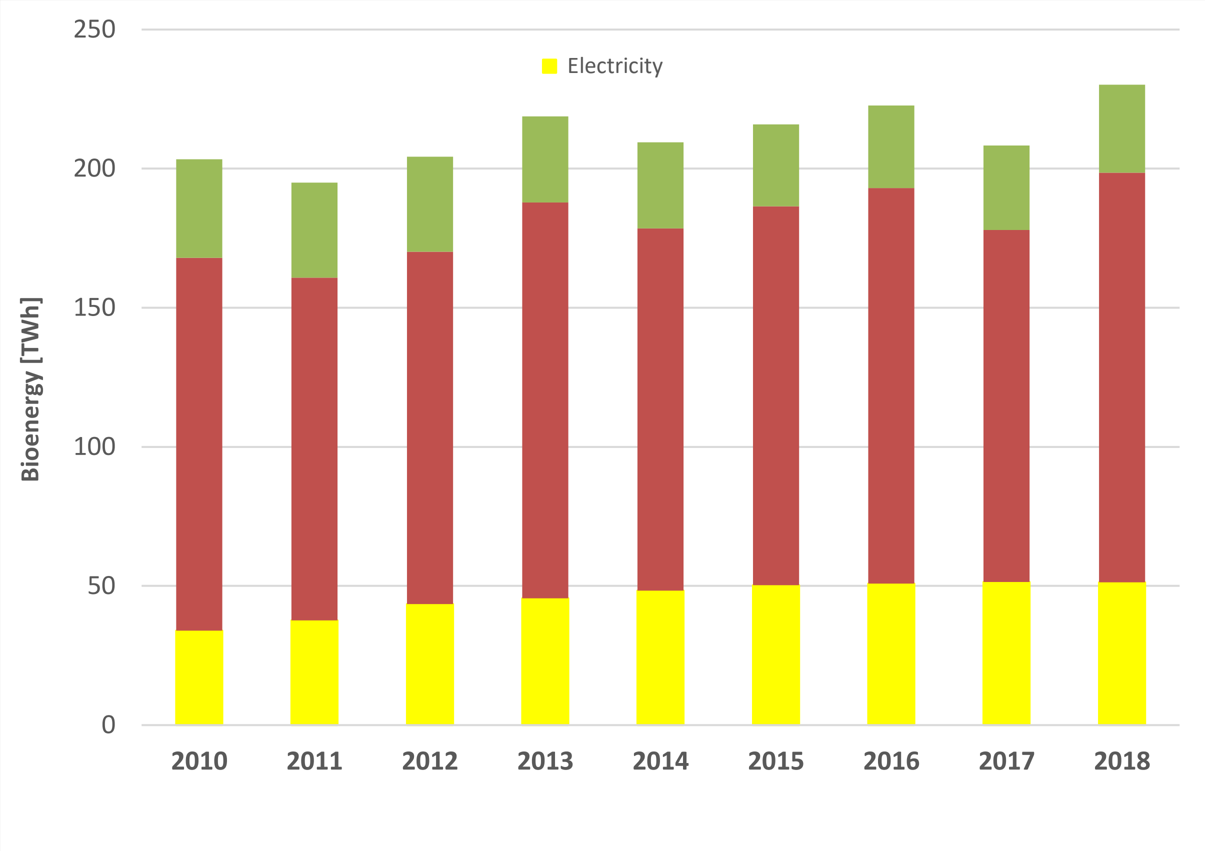
Bioenergy from residues & wastes for	2010	2011	2012	2013	2014	2015	2016	2017	2018
Electricity	29.9%	29.1%	26.2%	27.9%	29.1%	28.7%	30.0%	31.9%	32.1%
Heat	79.3%	82.2%	81.9%	80.6%	78.7%	77.8%	80.0%	82.0%	80.7%
Transport fuels	10.1%	10.0%	10.0%	12.6%	15.2%	18.0%	28.1%	28.2%	28.4%
total	**59.0%**	**59.3%**	**58.0%**	**60.0%**	**57.9%**	**58.2%**	**61.7%**	**61.8%**	**62.7%**

Source: calculation by IINAS

The overall share of bioenergy from residues and wastes increased in Germany from 50% in 2010 to 63% in 2018, especially for transport fuels (from 10% to 28%), while for electricity (from 30% to 32%) and heat (from 79% to 81%) the increase was comparatively small.

Yet, in **absolute figures**, the increase was highest for heat, followed by electricity, while for biofuels, the total is still small (see Figure 16).

Figure 16 Bioenergy from residues and wastes 2010-2018



Source: calculation by IINAS based on FNR (2019) and UBA (2019); for details see Annex (Table 50 to Table 60)

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**[27] comes from post-consumer (waste) wood and industrial woody residues and wastes, while **for heat**, forest products (thinnings, harvesting residues)[28] and some wood industry wastes are used plus a small contribution from Short Rotation Coppices (SRC) which was cultivated on 11,500 ha in 2018 with an average yield of 12 t/ha per year, 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.

[27] 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 (BLE 2018; FNR 2019). Thus, **no** solid feedstocks (e.g. straw, forest residues, SRC) are used for liquid biofuels.

[28] For forest products, the bioenergy share of the overall harvest (see Section 4.3) is used to determine the amount used for heat. In this, **all woody forest products** are considered as "products", **not as residues or wastes**.

4.8.3.3 Data basis

The data used for this indicator was compiled from statistical information (FNR 2019; UBA 2019).

4.8.3.4 References

FNR (2019) Bioenergy in Germany - Facts and figures 2019. Fachagentur Nachwachsende Rohstoffe e. V. Gülzow http://www.fnr.de/fileadmin/allgemein/pdf/broschueren/broschuere_basisdaten_bioenergie_2018_engl_neu.pdf

UBA (2019) Erneuerbare Energien in Deutschland 2018 - Daten zur Entwicklung im Jahr 2018. Umweltbundesamt & Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat). Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/uba_hgp_eeinzahlen_2019_bf.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

At the moment there are no regulations or reporting commitments in Germany on indicator 8.3d - Bioenergy from degraded or contaminated land.

4.8.4.2 Results and methodological approach

Now, no concrete data or results are available.

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).

4.8.4.3 Data basis

Only project based data basis is available. Future possibilities might come from the results of different EU projects (SEEMLA, MAGIC, GRACE), though (see below 4.8.4.4 Excurse).

4.8.4.4 Excurse

In recent decades, the concept of marginal land has gained increasing interest under growing land use pressure owing to the increased demand for biomass for non-food purposes in biobased industries. This resulted in several EU projects which are shortly presented and linked, but which have at the moment no public results available.

SEEMLA[29]: Sustainable exploitation of biomass for bioenergy from marginal lands

The aim of the project SEEMLA is the reliable and sustainable use of biomass on special or marginal locations ('marginal lands'; MagL), neither used nor feed production for the food and pose no danger to the environment. The main target groups are local authorities and public or private owners of MagLs who can share knowledge about the availability of corresponding areas and are responsible for the management of these. In addition, foresters, farmers and civil society, which are affected by the conversion of MagL to cultivation of energy plants, represent important

[29] http://seemla.eu/en/home/

cooperation partners for the success of the project. The project's first challenge is to define MagL. To achieve high yields of MagL locations, it is the aim to develop systems for such special areas of cultivation and to optimize.

The project includes three important objectives: (i) the promotion of a conversion of MagLs for the production of bio-energy through the direct involvement of agriculture and foresters, (ii) the strengthening of the local small supplier chains and (iii) setting out the advantages of areas with bio-energy crops on MagLs and their promotion. This project is funded by the European Union and has a duration of three years (January 2016 to December 2018).

MAGIC[30]: Marginal lands for Growing Industrial Crops: Turning a burden into an opportunity

Several studies agree on the existence of a considerable extension of land in Europe deemed less favorable for conventional agriculture. MAGIC is based on the premise that cultivation of selected industrial crops on areas facing natural constraints (e.g. extreme climatic conditions, low soil productivity, steep slope, etc.) can

i) ensure the production of resource-efficient feedstocks, with low indirect land-use change (iLUC), for a growing bio-based industry, and

ii) increase farmers' incomes through access to new markets and the revalorization of marginal land.

It has been estimated that as many as 2.5 million potentially contaminated sites exist across Europe. In MAGIC a first EU wide map is created to assess options for sustainably use of marginal lands to grow industrial crops. Industrial crops can provide abundant renewable biomass feedstocks for the production of high added-value bio-based commodities (i.e. bio-plastics, bio-lubricants, bio-chemicals, pharmaceuticals, bio-composites, etc.) and bioenergy. The approach builds on the JRC work to identify Areas of Natural Constraints and other land evaluation systems for agronomic suitability. The results describe the location and amount of marginal land area across Europe and what are the main characteristics in terms of biophysical and socio-economic limitations. This classification serves as a basis for developing sustainable best-practice options for industrial cropping in Europe on marginal lands.

GRACE[31]: GRowing Advanced industrial Crops on marginal lands for biorEfineries

The consortium consists of 22 partners from universities, agricultural companies and industry. The University of Hohenheim in Stuttgart (Germany) coordinates the project.

The goal of the project is to produce sustainable products with a strong market potential, to guarantee a reliable and affordable supply of sustainably produced biomass, and to better link biomass producers with the processing industry. In order to avoid competition with the cultivation of food or feed crops, miscanthus and hemp are grown on areas that have been polluted by heavy metals, for example, or are unattractive for food production due to lower yields.

30 http://magic-h2020.eu/

31 https://www.grace-bbi.eu/project/

4.8.4.5 References

GRACE (2018) GRowing Advanced industrial Crops on marginal lands for biorEfineries https://www.grace-bbi.eu/project/

MAGIC (2018) Marginal lands for Growing Industrial Crops: Turning a burden into an opportunity http://magic-h2020.eu/

SEEMLA (2018) Sustainable exploitation of biomass for bioenergy from marginal lands http://seemla.eu/en/home/

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)[32], Germany has to report from 2011 onwards every two years on conversion rates between land use types[33]. The latest EU-wide report was published in 2017 based on the 2015 national reports data.

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). The National Inventory Report for the German Greenhouse Gas Inventory was published in summer 2019 with data from 1990 – 2017.

4.8.5.2 Results and methodological approach

In the German 2015 RED progress report, no comments can be found according direct land use change for bioenergy. There is a remark/reference to the increasing loss of grassland and intensification of its use, but not specific data:

> *"With the increasing demand for biomass for energy-related use, grassland has grown in importance as a supplier of substrate. The intensification of use may compromise the quality of the grassland affected in Germany and reduce its value in terms of biodiversity. On the other hand, valuable areas are sometimes lost when grassland is ploughed up for arable use. Ploughing up grassland produces high CO2 emissions because of the breakdown of humus, is generally unhelpful in terms of safeguarding biodiversity and soil and water quality"* (BfN 2010).

Reported under the Kyoto Protocol in Table 24 the annual areas for land-use changes according to the German NIR[34] report is show. As the data is not yet spatially relatable, nor is the data very clearly interpretable in the sense of land use change, it illustrates that there is land use change existing in a dimension not to be underestimated.

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32 "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)*

33 See: https://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports

34 See: https://unfccc.int/documents/65712

Table 24 Annual areas for land-use changes [ha yr-1] used as a basis for inventory calculations for UNFCCC (20-year transition period) and the Kyoto Protocol

Land-use Change [ha per year]	1990-2000	2001-2005	2006-2008	2009-2012	2013-2016
… to Forest Land					
Cropland to Forest Land	9.715	4.843	5.648	4.274	2.949
Grassland (in the strict sense- i.s.s.) to Forest Land	11.189	6.454	4.454	8.645	9.398
Woody grassland to Forest Land	1.874	922	1.006	1.371	941
Wetlands (terrestrial) to Forest Land	258	610	260	224	48
Waters to Forest Land	1.050	209	276	441	31
Settlements to Forest Land	2.467	1.805	3.035	1.327	703
Other land to Forest Land	1.066	506	368	276	0
… to Cropland	**1990-2000**	**2001-2005**	**2006-2008**	**2009-2012**	**2013-2016**
Forest land to Cropland	3.369	1.543	784	872	466
Grassland (i.s.s.) to Cropland	42.871	17.004	78.703	80.929	50.185
Woody grassland to Cropland	1.552	153	199	78	401
Wetlands (terrestrial) to Cropland	223	11	6	3	0
Waters to Cropland	612	68	35	25	3
Settlements to Cropland	3.517	2.350	2.813	1.008	1.078
Other Land to Cropland	111	847	67	0	0
…to Grassland	**1990-2000**	**2001-2005**	**2006-2008**	**2009-2012**	**2013-2016**
Forest Land to Grassland (i.s.s.)	2.863	3.394	2.826	2.487	1.721
Cropland to Grassland (i.s.s.)	31.127	24.005	17.276	15.596	18.594
Woody Grassland to Grassland (i.s.s.)	3.015	1.670	743	228	317
Wetlands (terr.) to Grassland (i.s.s)	194	382	20	120	464
Waters to Grassland (in a strict sense)	2.227	1.338	920	503	684
Settlements to Grassland (i.s.s.)	5.258	4.330	5.026	4.819	3.194
Other Land to Grassland (i.s.s.)	613	1.771	668	351	0
…to Woody Grassland	**1990-2000**	**2001-2005**	**2006-2008**	**2009-2012**	**2013-2016**
Forest Land to Woody Grassland	1.008	409	1.709	778	857
Cropland to Woody Grassland	3.288	4.102	3.891	2.285	2.217
Grassland (i.s.s.) to Woody Grassland	1.114	5.145	5.620	2.688	5.387
Wetlands (terr.) to Woody Grassland	61	161	26	48	3
Waters to Woody Grassland	197	63	103	7	49
Settlements to Woody Grassland	1.385	2.454	1.638	612	699
Other Land to Woody Grassland	119	319	66	200	0

Source: UBA (2018b)

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 relevant land-use-change categories were derived for each change period (1990-2000, 2001-2005, 2006-2008, 2009-2012 and 2013-2016) and each sample point. Between the reference years, the land-use changes have been linearly interpolated. As a result, constant, average land use changes emerge for the periods between reference years. The values as of the year 2015 were extrapolated from those for 2014. This method conforms to the IPCC guidelines. Between the periods, land-use changes can vary in their intensity and direction.

The process of developing a land-use matrix that takes account of the required 20-year transition period following a land-use change takes place in several sub-steps:

- For all land-use changes that occur within a transition period covered by the included observations (1990-2016), processing is first carried out on a point-oriented basis. At the same time, the land-use changes are spatially correlated with the individual observation points.
- Land-use changes that occurred prior to that period (1970-1990) are extrapolated retroactively from observations carried out during the first measurement period (1990-2000).
- The observation period is divided into transition periods of different lengths (1990-2000, 2001-2005, 2006-2008, 2009-2012, 2013-2016), and the annual changes in those change periods are calculated on a proportional basis, via linear interpolation.

The land-use categories were selected to be in accordance with the relevant definitions pursuant to the UNFCCC, the Kyoto Protocol and the IPCC. Germany uses a range of different definitions for important land-use categories – in particular, agricultural land (Cropland, Grassland) and Settlements. The data on area sizes can vary as a result of differences in definitions and in data-collection methods.

The three most important data sources in Germany, for data on agricultural areas, are as follows:

1. The main soil use survey (Bodennutzungshaupterhebung) of the Federal Statistical Office: It determines land use by surveying agricultural facilities.
2. AKTIS® Basis-DLM: It derives land use from the official land-cover cadaster. The land-use polygons come from topographical maps with scales ranging from 1:5,000 to 1:25,000, and they are corrected and validated via aerial photos.
3. The area survey (Flächenerhebung) of the Federal Statistical Office: It derives land use from the official real estate cadaster and from the AKTIS® Basis-DLM.

4.8.5.4 Excurse on grassland development in Germany

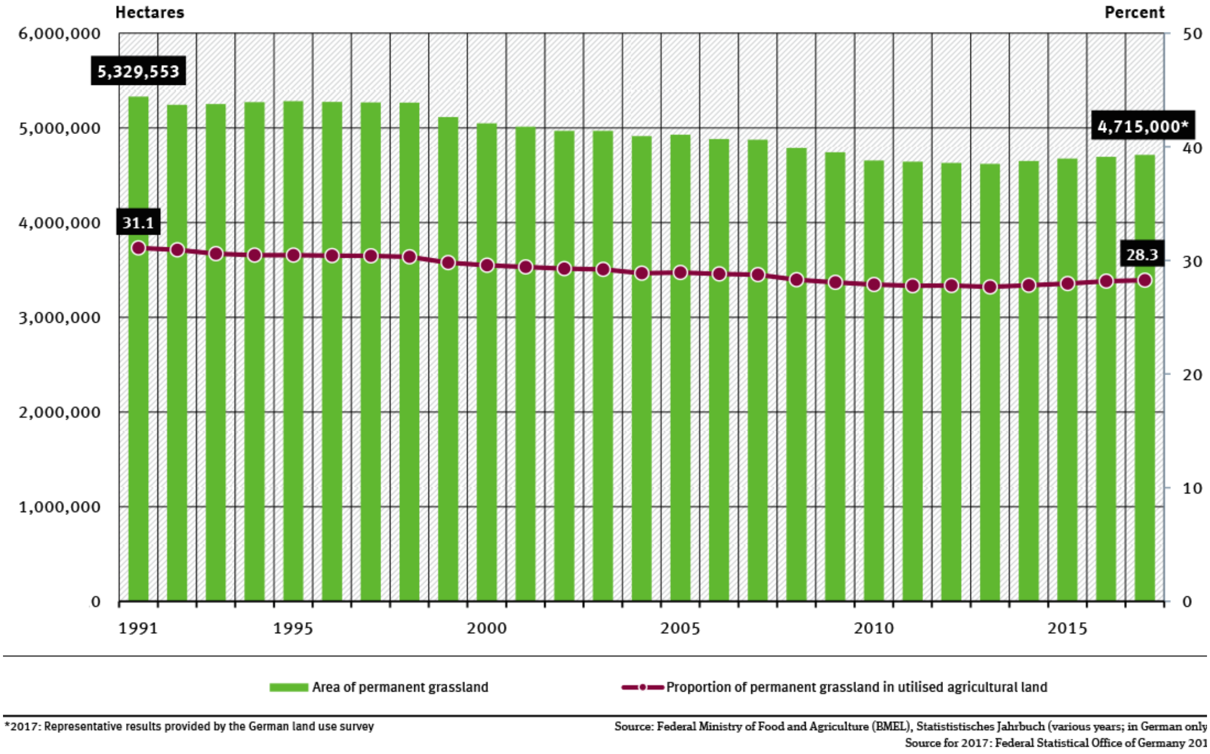
The indicator on grassland, monitored by the German Environment Agency (UBA 2018a) shows the development of permanent grassland in Germany (data until 2016). Permanent grassland in Germany has been under pressure in recent decades. In 1991 there were still over 5.3 Mha of utilized agricultural land managed as permanent grassland. By 2016, the total area of permanent grassland had declined by 12 % to around 4.7 Mha.

The loss of grasslands is due to more intensive agriculture and the associated changes in land use. Particularly valuable sites from an environmental viewpoint such as semi-arid grasslands and humid grasslands are ploughed and converted to arable to cultivate the land for feed and/ or energy plants.

Since the decision of the EU agricultural reform in 2013, the ‘Greening’ obligations regulate the protection of permanent grassland. Farmers must comply in order to qualify for the direct payments system. Various regulations aim at prevention of loss of permanent grassland like a general prior authorization requirement for ploughing up of grassland and the complete prohibition of ploughing up and change of grassland with elevated environmental value.

Although the percentage of grassland has recently risen again slightly, the overall drivers of the loss of grassland remain largely unchanged. Major pressures continue to be exerted on grassland in particular by subsidies for the cultivation of energy plants and intensification of milk production as well as land abandonment (UBA 2018b).

Figure 17 Total area of permanent grassland and percentage on utilized agricultural area in Germany (1991 – 2016)



Source: BMEL and DESTATIS (2019)

Box 1: Grasslands: an area of conflict between agriculture and conservation. Monitoring grassland use intensity via Earth Observation

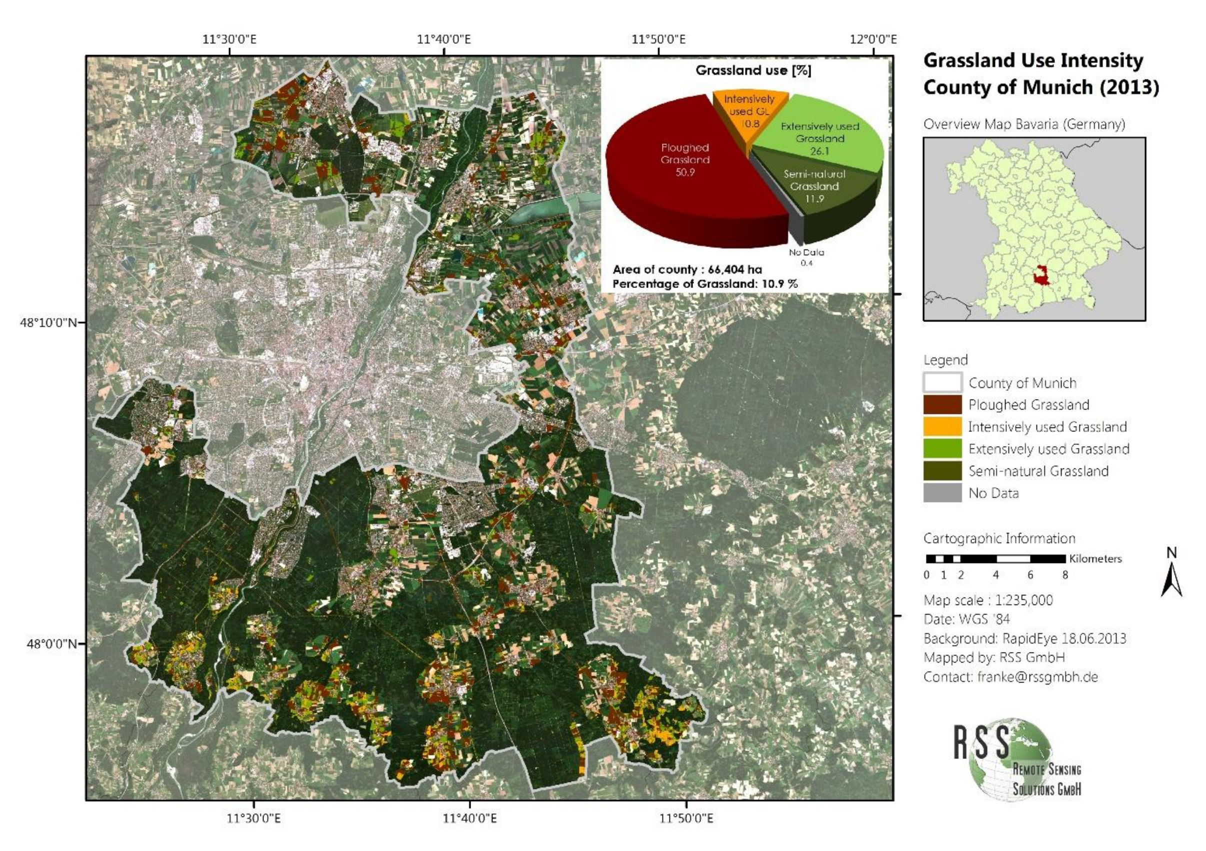
The increased demand in renewable resources for energy production has caused changes in agricultural land use that are a major threat to the conservation of biodiversity in Europe (Stoate et. al 2009). Semi-natural and extensively used grasslands play a particularly important role as habitats with high conservation value (Sullivan et. al 2010; Öster et al 2008). There is an increasing pressure on these ecosystems, mainly through the conversion of grassland into arable land or the intensification of grassland use (Henle et. al 2008). For an ecologically integral implementation of directives, such as the European Renewable Energies Directive (2009/28/EG) or the German Renewable Energy Law (EEG), as well as for an improved documentation of their sustainability criteria, a large-scale and spatially detailed inventory and monitoring of the grassland use intensity is required. Earth Observation data proved to be beneficial to such monitoring [5, 6] and can support evaluations of sustainability criteria of the energy production from biomass.

The project "COP4EE", funded by the German Federal Ministry of Economic Affairs and Energy (BMWi) via the Space Administration of the DLR, is currently investigating how Copernicus can support the energy transition. The Copernicus Programme provides satellite data with high spatial resolution and short revisit times, which allows for new operational monitoring applications. Grassland management activities, such as the amount and dates of mowing, ploughing grasslands to cultivate highly productive grass or crops etc., have an effect on vegetation dynamics. These vegetation dynamics can be monitored by the use of frequently acquired high-resolution Earth Observation data. Such monitoring allows for site-specific assessments, such as if and when a grassland was ploughed, if it was intensively or extensively managed or if it showed semi-natural vegetation dynamics (Franke et. al 2012)

Former grassland areas which have been transformed for crop cultivation can be quantified by comparing current Copernicus data to existing land use data or previous grassland use assessments. Such a study has been completed in administrative units across Germany, where some locations showed a loss in grassland habitats of up to 50% over three years. The results have been verified by continuous field surveys.

The energy transition is a major challenge for the European Union. Its implementation is having more and more impact on regional development. For the first time, this Earth Observation approach allows to not only derive agricultural trends, but provides evidence based spatial decision support for the renewable energy sector which define regionally adopted, sustainable strategies for renewable energy production.

Figure 18 Grassland use intensity in 2013, Landkreis München (Munich)



There are further research projects from the Thuenen Institute on assessing the potential of remote sensing data in the fields of land use, agricultural economics and biodiversity[35]. Satellite remote sensing imagery with a high spatial and temporal resolution can be used to map grassland use intensity or biodiversity components.

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35 See: https://www.thuenen.de/en/bd/projects/assessing-patterns-of-biodiversity-in-grasslands-through-remote-sensing/ or https://www.thuenen.de/en/institutsuebergreifende-projekte/automatic-determination-of-grassland-use-intensities-by-means-of-satellite-image-time-series/

4.8.5.5 References

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5 GBEP Indicator update: 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 actualized 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 legalized 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

The structural change within agriculture remains ongoing. The number of farms has decreased from 321 600 to 269 800 between 2007 and 2017. Whereas the number of small farms (< 100 ha) the number of larger farms is increasing. These cultivate about 60 % of the agricultural area (DBV 2018). This hints 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). Also in 2017 this trend seems to continue (Tietz 2017). 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 (Forstner & Tietz 2013).

Whereas in the past land sales attracted public awareness, now rather the purchase of company shares is focused on. According to German Law (Grundstücksverkehrsgesetz) non-farmers are not allowed to acquire agricultural land. Forstner & Tietz (2013) described that investors foster land deals through buying company shares. These agricultural companies usually encompass agricultural land and make the investors landowners. Hence, they can act as farmers and are allowed to acquire more land. The effects of such investors on production, employment and regional value added is diverse, but it cannot be conclusively evaluated as there are only few investors yet who own a significant amount of land this process needs to be further observed.

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, Emmann et al. 2015). Another effect are increasing land prices (covered in chapter 5.2).

Both effects are supposed to have negative consequences for rural development. 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 References

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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 is published on an annual basis by the Federal Ministry of Food and Agriculture (BMEL). It is based on statistics published by the Federal Statistical Office (DESTATIS) as well as on BMEL data. It provides most of the information regarding prices and supply for foodstuff and main staple crops.

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 2017). The data are summarized in Table 25.

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 25 Food basket of Germany in 2013 to 2016 as per capita consumption

Per capita consumption [kg/year]	2013 / 2014	2014 / 2015	2015 / 2016
Cereals	**77.9**	**77.7**	**79**
Wheat flower	64.4	63.8	65
Barley	7.9	7.7	7.6
Other cereals	5.6	6.2	6.4
Rice, pulses, potatoes	**63.9**	**63**	**64.1**
Rice	5.4	5.3	5.1
Pulses	0.5	0.9	1.1
Potatoes	58	56.8	57.9
Sugar & sweeteners	**44.9**	**46.3**	**45**
Sugar (raw equivalent)	33.9	35.4	34
Sweeteners (others)	9.9	9.9	9.9
Honey	1.1	1	1.1
Vegetables, fruits	**201.1**	**202.3**	**198.3**
Vegetables	96.7	100.4	97.1
Fruits	71.3	66.3	65.1
Citrus fruits	33.1	35.6	36.2
Vegetable oils	**14.6**	**14.6**	**14.4**
Meat	**89.3**	**89.4**	**87.8**
Fish, seafood	**14.4**	**13.5**	**14.1**
Milk products, excl. butter	**116.2**	**116.4**	**120.9**
Animal fats	**4.7**	**5**	**5**
Eggs	**14.1**	**14.4**	**14.5**

Source: BMEL (2017)

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 26. The majority of wheat and grain maize is used for feed and food. Only 3 % - 5 % (wheat) and 6 % - 7 % (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 27 and Table 28).

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

Table 26 Shares of relevant main staple crops used for food, feed, fibre and fuel in Germany at national level 2015-2017

Crop	2015/2016	2016/2017*
National level	in 1000 t	
Wheat		
Total domestic use	19 883	20 842
Domestically produced feed	8 545	9 001
Food	6 685	6 603
Industrial utilisation	1445	1 505
Used for energy (bioethanol)	569	1 114
Degree of self-sufficiency	134 %	117 %
Grain maize		
Total domestic use	6 134	6 365
Feed	4 730	4 850
Food	258	308
Energy use	378	457
Used for bioethanol	*173*	*229*
Degree of self-sufficiency	65 %	63 %

Source: BMEL (2017)
**preliminary*

Table 27 Area of relevant main stable crops in Germany at national level 2013 - 2016

Crop	2013	2014	2015	2016	Increase/decrease 2013 - 2016
National level	Area under cultivation				[%]
Cereals					
Wheat	3 128	3 220	3 283	3 202	2 %
Maize					
Grain maize	497	481	455	416	-16 %
Silage maize	2 003	2 093	2 100	2 138	+7 %
Rapeseed	**1 460**	**1 293**	**1 282**	**1 323**	**- 9 %**
Sugar beets	**357**	**373**	**313**	**334**	**-7 %**

Source: BMEL (2017), compilation and calculations by IFEU

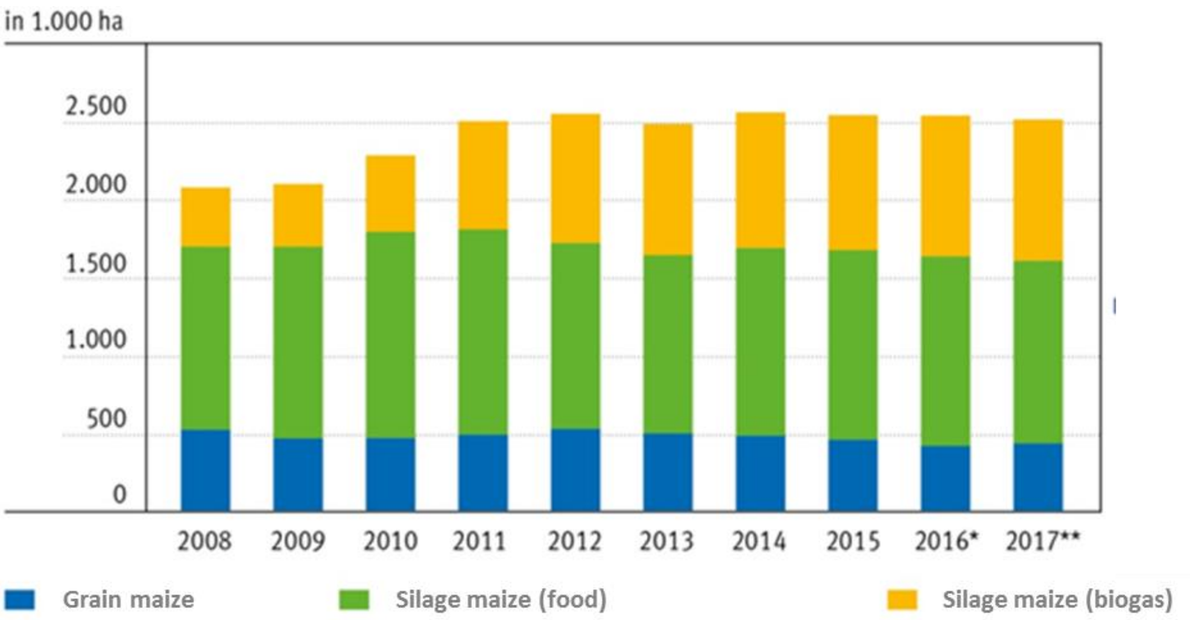
Table 28 Import and exports of relevant main staple crops in Germany 2014 to 2017

	Import [1000 t]			Export [1000 t]		
Crop	**2014/2015**	**2015/2016**	**2016/2017**	**2014/2015**	**2015/2016**	**2016/2017**
Wheat	7 651	6 915	7 754	14 843	12 413	12 913
Grain maize	3 052	2 938	3 003	1 034	832	859
Sugar	661	662	631	1 139	1 032	1 038
Vegetable oils	3 548	3 615	3 638	2 450	2 721	2 689

Source: BMEL (2017)

In contrast to the above mentioned feedstocks, silage maize is marketed only at regional level as long distance transports are economically not viable. Figure 19 shows the development of maize acreage between 2008 and 2017 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 19 Development of maize acreage in Germany 2008-2017



*Source: FNR (2018); *preliminary; ** estimated*

Food price increases have been reported (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 2016 it was 14 % (DESTATIS 2017).

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 Data basis

The Statistical Yearbook for Food, Agriculture and Forest (BMEL 2017) provides 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.

5.2.4 References

BMEL (2017): Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten 2017; https://www.bmel-statistik.de/footernavigation/archiv/statistisches-jahrbuch/

DESTATIS 2017: https://www.destatis.de/DE/PresseService/Presse/Pressemitteilungen/2017/12/PD17_463_631.html

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 (2018): Entwicklung der Maisanbaufläche in Deutschland; Gülzow https://mediathek.fnr.de/grafiken/daten-und-fakten/anbau/entwicklung-der-maisanbauflache-in-deutschland.html

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.

Due to the complexity an exact quantification of the change in income for single actors is not possible. Generally, bioenergy production can be seen as an additional source of income for many actors (agriculture, forestry, plant operators), however, it can also lead to adverse indirect effects.

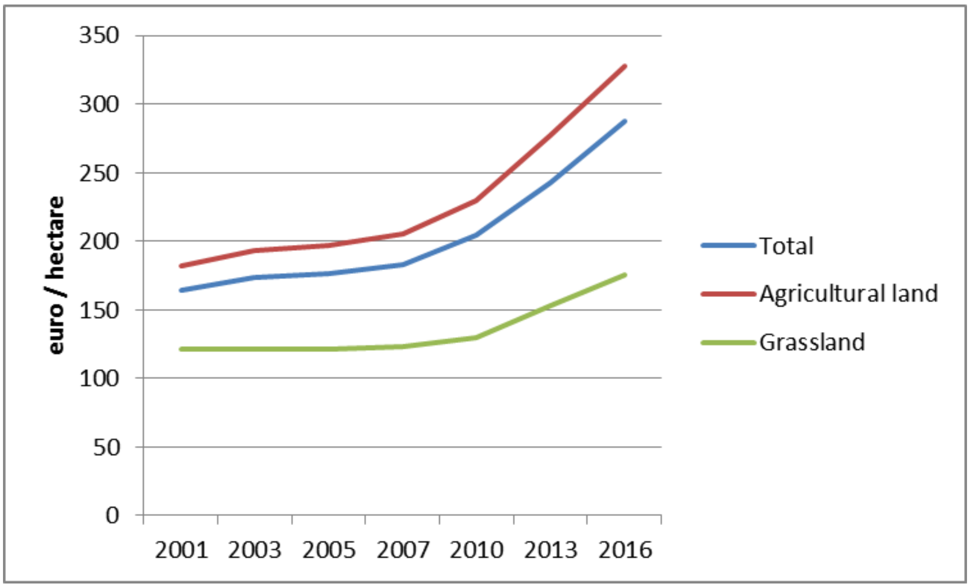
5.3.2 Excursus: Biogas production and land prices

Biogas production is a good example for adverse positive and negative economic effects. At the beginning there was a regular boom with a strong increase of newly installed production plants. To date the growth came to a standstill. However, biogas production still is an important source of income in the agricultural sector, be it for substrates producers or for plant operators. But there are indirect effects that affect the agricultural sector as a whole. Due to high demands for substrates (especially maize) and due to high solvency of plant operators there is a strong influence on the soil market leading to increasing land and rental prices (Guenther-Lübbers & Theuvsen 2015).

The role of bioenergy in this development cannot be exactly quantified and the reasons for increased land prices and rentals are diverse. Generally, the demand for agricultural land rises due to an increased profitability which in turn is due to various reasons (higher agronomic prices, bioenergy subsidies, ecological compensation areas, general land usage for non-agricultural purposes, non-agricultural investors) (DBV 2018). However, there is strong evidence that the subsidisation of bioenergy plays an important role. 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. Also according to Gömann et al. 2015 there is a relationship between the number of biogas plants and land rental prices.

Since the previous GBEP report (Köppen et al. 2014) the trend of increasing land rents has continued, as the agricultural structure survey in 2016 has revealed. Figure 20 shows the trends since 2001.

Figure 20 Data on land rents in Germany between 2001 and 2016



Source: DESTATIS 2016

The trend shows regional differences with the strongest increases being mostly in the New Länder (Mecklenburg-Western Pomerania, Lower Saxony, Brandenburg and Saxony-Anhalt). Prices for new leasing contracts show an increasing trend as well (they are 134% of average land rents).

The development of land rents is parallel to the development of soil prices which also shows large regional differences. Prices increased to 22310 € / ha (in 2010 it has been 11854 € / ha) (DESTATIS 2016). Regions with highest prices are again Mecklenburg-Western Pomerania, Brandenburg and Saxony-Anhalt.

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 (see section 5.1.3 on structural changes)

5.3.3 References

DBV (2018): Situationsbericht 2018/19 - Trends und Fakten zur Landwirtschaft, Berlin.

DESTATIS 2016: Eigentums- und Pachtverhältnisse (https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Landwirtschaftliche-Betriebe/Publikationen/Downloads-Landwirtschaftliche-Betriebe/eigentums-pachtverhaeltnisse-2030216169004.pdf;jsessionid=292E6243674B56173146A84FCCF874AE.internet722?__blob=publicationFile; download July 2019)

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.

Gömann, H., Witte, T. de, Peter, G., Tietz, A. (2013): Auswirkungen der Biogaserzeugung auf die Landwirtschaft, Johann Heinrich von Thünen-Institut, Braunschweig.

Guenther-Lübbers, W. & Theuvsen, L. (2015): Regionalwirtschaftliche Effekte der Biogasproduktion: Eine Analyse am Beispiel Niedersachsens. In: BMEL (2015): Berichte über die Landwirtschaft, Band 93, Ausgabe 2, Berlin. (https://buel.bmel.de/index.php/buel/article/view/74/Guenther-L%C3%BCbbers%2C%20Theuvsen%20-%2093%20-%20B%C3%BCL-html; download July 2019)

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 recognized labor 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 German Government (represented by BMU, BMWi and UBA) sponsored several studies on employment effects of renewable energies since 2005 which use statistics published by DESTATIS, especially monetary input-output tables (IOT). The results are regularly reported.

5.4.2 Results and methodological approach

Three studies (O'Sullivan et al. 2013+2018+2019) calculated the **gross** employment balance from bioenergy in Germany. The results are shown in the next table.

Table 29 Sub-Indicator 12.1 Employment effects of bioenergy in Germany 2011-2017 (gross balance)

	2011	2012	2013	2014	2015	2016	2017
biogas	50,600	49,500	46,533	43,567	40,600	41,100	42,200
bioliquids for el.	2,300	1,500	0	0	0	0	0
bioheat	33,800	39,300	34,633	29,967	25,300	26,400	27,000
bio-cogen	14,500	15,900	15,633	15,367	15,100	18,600	18,100
biofuels	23,200	22,700	22,733	22,767	22,800	25,800	24,700
total	**124,400**	**128,900**	**119,533**	**111,667**	**103,800**	**111,900**	**112,000**

Source: IINAS calculation based on O'Sullivan et al. (2013+2018+2019)

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

- Sub-Indicator 12.3 indefinite/temporary labor: 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 recognized labor standards consistent with ILO principles: all employment adheres to ILO standards.

5.4.3 Data basis

Statistical data on employment are available on the national level from DESTATIS, and BMU, BMWi and UBA sponsored studies on employment effects of renewable energies which give disaggregated data for bioenergy.

5.4.4 References

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

BMU (2010) Erneuerbar beschäftigt! Kurz- und langfristige Arbeitsplatzwirkungen des Ausbaus der erneuerbaren Energien in Deutschland- Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit. Berlin

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

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

ISI et al. (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. et al. Fraunhofer-Institut für System- und Innovationsforschung i.A. des BMU. Karlsruhe etc. http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/knee_update_2011_bf.pdf

O'Sullivan, Marlene 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 etc. http://www.erneuerbare-energien.de/fileadmin/Daten_EE/Dokumente__PDFs_/bruttobeschaeftigung_ee_2012_bf.pdf

O'Sullivan, Marlene; Edler, Dietmar & Lehr, Ulrike (2018) Ökonomische Indikatoren des Energiesystems - Methode, Abgrenzung und Ergebnisse für den Zeitraum 2000 - 2016. Studie im Auftrag des BMWi. GWS RESEARCH REPORT 2018/01. Osnabrück http://www.bmwi.de/Redaktion/DE/Publikationen/Studien/oekonomische-indikatoren-und-energiewirtschaftliche-gesamtrechnung.pdf

O'Sullivan, Marlene; Edler, Dietmar & Lehr, Ulrike (2019) Ökonomische Indikatoren des Energiesystems - Methode, Abgrenzung und Ergebnisse für den Zeitraum 2000 - 2017. Studie im Auftrag des BMWi. DIW Berlin Politikberatung kompakt 135. Berlin, Stuttgart, Osnabrück https://www.bmwi.de/Redaktion/DE/Publikationen/Studien/oekonomische-indikatoren-der-energiebereitstellung.pdf

5.5 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.

5.5.1 Legal regulations and reporting commitments

According to § 25 of the German Social Code Book VII, the Federal Government is required to provide the German Federal Parliament (Bundestag) and the Federal Council (Bundesrat) with an annual statistical report on the state of health and safety at the workplace including information on accidents and occupational illnesses in Germany. This report summarises individual reports of the accident insurance agencies and the annual reports of the state authorities overseeing occupational health and safety. In addition, every four years the summary is required to include an overview of the development of occupational accidents and illnesses, their associated costs and the measures taken to ensure health and safety at the workplace. This report is prepared by the Federal Institute for Occupational Health and Safety (BAUA)[36].

5.5.2 Results and methodological approach

Table 30 illustrates the development of occupational accidents, commuting accidents and fatal accidents between 2010 and 2017, distinguishing between reportable and non-reportable incidents. According to § 193 of the German Social Code, an accident is only reportable if the insured person is killed or injured in such a way that he or she is incapable of working for more than three days. The Social Insurance for Agriculture, Forestry and Horticulture (*Sozialversicherung für Landwirtschaft, Forsten und Gartenbau*, SVLFG) reports all accidents annually. Out of the total, only the number of reportable incidents is passed on to BAUA, which then includes the data in its reports.

Table 30 Number of accidents at work (including commuting accidents) in Germany

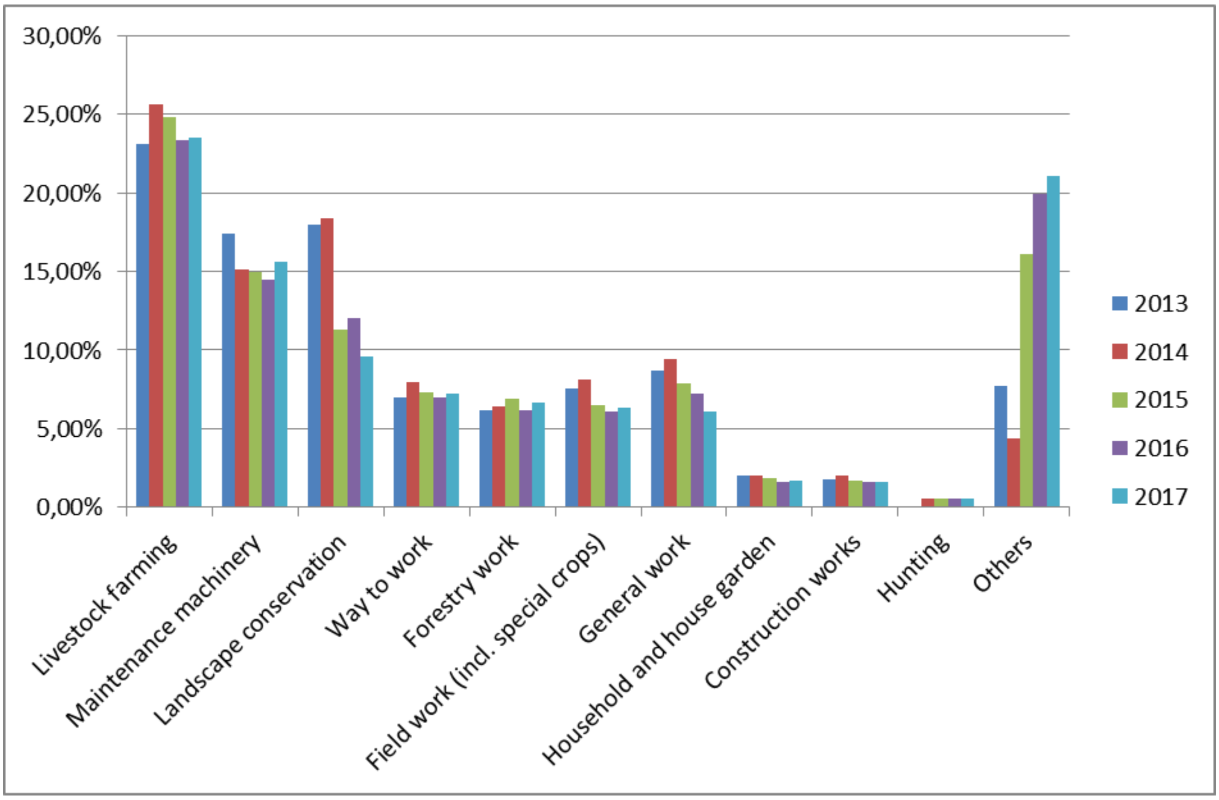
	2010	2011	2012	2013	2014	2015	2016	2017
All accidents at work (incl. commuting accidents)[1]	168 316	171 245	164 541	171 192	169 786	152 463	146 908	143 972
Reportable accidents at work (incl. commuting accidents)[2]	91 357	88 839	84 851	86 933	88 305	80 825	84 520	83 287
Share of reportable accidents	54,3%	51,9%	51,6%	50,8%	52,0%	53,0%	57,5%	57,8%
Fatal accidents at work[2]	na	na	na	160	166	140	138	119

Source: [1] SVLFG 2010 – 2017; [2] BMAS 2016 – 2018

[36] https://www.baua.de/DE/Home/Home_node.html

In addition to the number of accidents, the SVLFG also reports the distribution of reportable accidents at work by the sectors most frequently affected. Figure 21 illustrates the distribution across the time series beginning in 2013.

Figure 21 Distribution of reportable accidents to work sectors



Source: SVLFG 2010 – 2017

The number of occupational incidents cannot be quantified for bioenergy production only. The approximate number of accidents is therefore allocated based on the following assumptions:

- Livestock farming is responsible for the main share of accidents. However, only waste products (liquid manure) are used for biogas production. In consequence, livestock farming is excluded from allocation.
- Furthermore, household and hunting accidents are excluded.
- Green waste products from landscaping and grounds maintenance are partly used for bioenergy and for compost production. Due to a lack of data regarding the share of energy use of these products, related accidents are excluded from allocation.
- Accidents in **forestry** work are allocated to bioenergy according to the bioenergy share of fellings (see section 4.3).
- The remaining categories are allocated to **bioenergy crop** production according to the bioenergy share of arable land (see section 4.8.1.2).

Table 31 Allocated number of accidents at work to bioenergy production in Germany

	2013	2014	2015	2016	2017
Forestry					
Number of accidents in forestry	10 614	10 866	10 520	9 108	9 646
Bioenergy share of fellings	21,0%	20,0%	18,7%	18,0%	18,6%
Accidents allocated to bioenergy	2 229	2 173	1 967	1 639	1 794
Bioenergy crops					
Number of accidents	85 938	79 799	83 092	82 709	83 360
Bioenergy share of arable land	16,7%	17,5%	20,2%	20,2%	20,0%
Accidents allocated to bioenergy	14 352	13 965	16 785	16 707	16 672

Source: own calculations

5.5.3 Data basis

The data on workplace and commuting accidents are taken from the annual report on occupational health and safety referenced above (BMAS 2016 - 2018). The figures are reported annually by the various accident insurance agencies. In agriculture, the Social Insurance for Agriculture, Forestry and Horticulture (SVLFG)[37] is the relevant authority.

5.5.4 References

SVLFG (2010 – 2017): Auf einen Blick. Daten und Zahlen 2010 – 2017, Kassel.

BMAS (2016 – 2018): Sicherheit und Gesundheit bei der Arbeit 2014 – 2017. Unfallverhütungsbericht Arbeit, in cooperation with mit Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA), Berlin & Dortmund.

[37] https://www.svlfg.de/svlfg

6 GBEP Indicator update: 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 Federal Statistical Office (DESTATIS 2019).

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

Table 32 Sub-Indicator 17.1: Yields of bioenergy feedstocks in Germany 2010-2018

Yield [t/ha*a]	2010	2011	2012	2013	2014	2015	2016	2017	2018
Rapeseed	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Maize	3.9	4.8	4.6	3.9	4.7	4.1	4.3	4.7	3.5
Wheat	0.7	0.7	0.7	0.8	0.9	0.8	0.8	0.8	0.7
Sugar beet	6.4	7.4	6.9	6.4	8.0	7.2	7.6	8.4	6.3
Grass (arable land)	0.7	0.7	0.7	0.7	0.8	0.7	0.8	0.8	0.6

Source: IINAS compilation based on DESTATIS (2019)

The yields listed in the following Table 33 have been combined with processing efficiencies from the GEMIS database (German processes) in order to derive the amount of bioenergy that is produced per hectare. Efficiencies and hectare-based yields are as well listed in Table 33.

Table 33 Sub-Indicator 17.2 Processing efficiencies by technology and feedstock

Processing efficiency [GJ_{out}/t_{input}]	2010	2015
Rapeseed oil	14.5	14.6
RME	21.6	21.6
Wheat EtOH	8.7	8.8
Sugar beet EtOH	2.2	2.2
Maize biogas	11.7	11.7
Maize biomethane	11.1	11.5
Grass (arable land) biogas	3.1	3.2

Source: IINAS calculation based on GEMIS 5.0

The values from Table 32 and Table 33 were used to calculate the bioenergy yield in the following table. For this, a linear interpolation between the 2010 and 2015 values from Table 33 was used, and the 2015 values from Table 33 were also used for the years after 2015.

Table 34 Sub-Indicator 17.3 Amount of bioenergy end product by energy content per hectare per year

Biofuel productivity [GJ_{out}/ha*a]	2010	2011	2012	2013	2014	2015	2016	2017	2018
Rapeseed oil	6.5	5.7	5.4	5.7	6.5	5.7	5.1	4.8	4.4
RME	6.4	5.6	5.3	5.7	6.4	5.7	5.0	4.7	4.3
Wheat EtOH	6.3	6.1	6.4	6.9	7.5	7.1	6.7	6.7	5.9
Sugarbeet EtOH	13.8	16.0	14.8	13.7	17.2	16.0	16.9	18.6	14.0
Maize biogas	45.9	55.5	54.1	45.4	55.2	48.6	50.6	55.7	41.4
Grass biogas	2.1	2.1	2.3	2.2	2.5	2.4	2.4	2.4	1.8

Source: IINAS calculation based on GEMIS 5.0

Table 35 Sub-Indicator 17.4: Production cost per unit 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

Source: IINAS calculation based on GEMIS 5.0

6.1.2 Data basis

The yield data were taken from DESTATIS (2019) and conversion efficiencies as well as the costs were taken from the GEMIS life-cycle database (Version 5.0) for the German data in 2010 and 2015, respectively.

6.1.3 References

DESTATIS (2019) Land- und Forstwirtschaft, Fischerei. Bodennutzung der Betriebe (Landwirtschaftlich genutzte Flächen) Fachserie 3 Reihe 3.2.1. Agrarstrukturerhebung. Statistisches Bundesamt. Wiesbaden https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Flaechennutzung/_inhalt.html

IINAS (2019) Global Emissions Model for integrated Systems (GEMIS) version 5.0. International Institute for Sustainability Analysis and Strategies. 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 Economy and Energy (BMWi) and UBA annually report 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 36 first column while the second column contains the energy ratio literally meant by the GBEP methodology sheet.

Table 36 Indicator 18.4: life cycle net energy balances of selected bioenergy pathways and fossil fuels.

	2010		2015	
biogenic energy carrier	MJ_{prim}/MJ_{end}	$ER_{non\text{-}renew}$	MJ_{prim}/MJ_{end}	$ER_{non\text{-}renew}$
AME	0.15	7.3	0.08	9.1
RME	0.39	3.8	0.39	3.8
EtOH-wheat	0.44	2.1	0.38	2.3
EtOH-sugarbeet	0.25	6.2	0.22	7.4
wood-logs	0.00	100.5	0.00	110.0
wood-chips	0.03	23.7	0.03	24.5
wood-chips SRC	0.04	18.9	0.04	19.2
wood-pellets	0.06	13.5	0.05	14.3
biogas-manure	0.08	1.7	0.07	1.9
biogas-maize	0.15	1.5	0.12	1.6

Source: IINAS calculation based on GEMIS 5.0; $ER_{non\text{-}renew}$ = energy ratio of non-renewable energy, i.e. amount of -renewable energy output per unit of non-renewable energy input)

Table 37 Indicator 18.4: life cycle net energy balances of selected fossil fuel pathways

	2010	2015
fossil energy carrier	$MJ_{prim,in}/MJ_{end}$	
coal (imported)	1.11	1.11
lignite (domestic)	1.18	1.18
natural gas for RE+CO	1.13	1.11
oil-lite for RE/CO	1.14	1.14
gasoline at filling station	1.18	1.20
diesel at filling station	1.09	1.14
natural gas (CNG) at filling station	1.15	1.14

Source: IINAS calculation based on GEMIS 5.0; $ER_{non-renew}$ = energy ratio of non-renewable energy, i.e. amount of -renewable energy output per unit of non-renewable energy input)

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 References

UBA (2018) Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2017. Umweltbundesamt CLIMATE CHANGE 23/2018. Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-10-22_climate-change_23-2018_emissionsbilanz_erneuerbarer_energien_2017_fin.pdf

UBA (2019) Erneuerbare Energien in Deutschland 2018 - Daten zur Entwicklung im Jahr 2018. Umweltbundesamt & Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat). Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/uba_hgp_eeinzahlen_2019_bf.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 38 German bioenergy investments and turnover as proxy data for Indicator 19 (Gross value added)

Investment [M€/a]	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
- in bio-electricity	2240	3120	790	700	670	170	260	400
- in bio-heat	1210	1320	1500	1530	1360	1270	1200	1200
total	**3450**	**4440**	**2290**	**2230**	**2030**	**1440**	**1460**	**1600**
Economic impulse [M€/a]	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
from bio-el/th	5490	5870	6780	7090	7070	7450	7690	7800
from biofuels	2930	3700	3720	3100	2690	2490	2620	2700
total bioenergy impulse [M€/a]	**8420**	**9570**	**10500**	**10190**	**9760**	**9940**	**10310**	**10500**
specific [€/GJ]	40.5	47.0	48.5	46.5	46.3	46.0	46.2	47.2

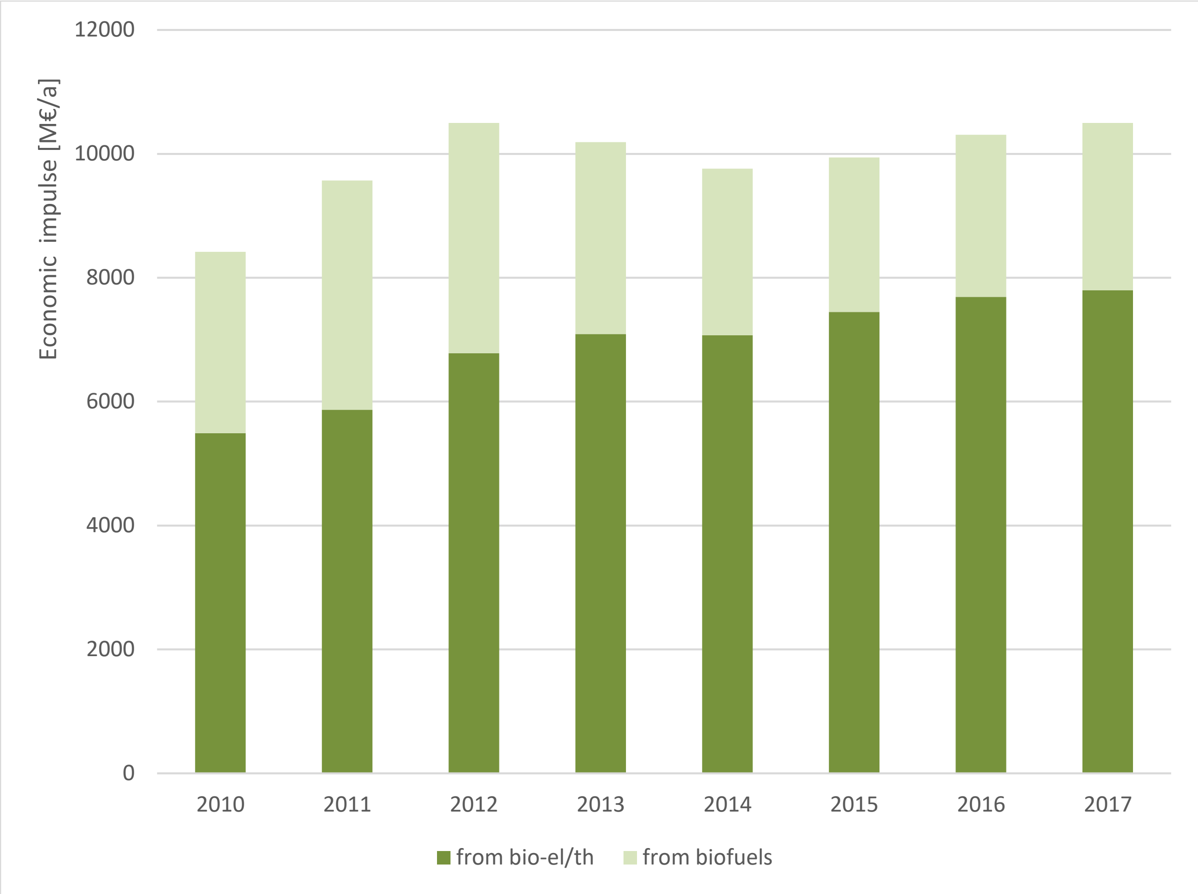
Source: IINAS calculation based on data from BMWi (2019) and UBA (2018+2019)

The “economic impulse” is the average annual turnover from bioenergy expenditures, and is used here as a proxy for the GSI which originally refers to “gross value added”.

Due to restrictions in available data, only this proxy is available for Germany on an annual base.

The data for the economic impulse are shown in the following figure.

Figure 22 Economic turnover for German bioenergy as proxy data for Indicator 19



Source: IINAS calculation based on data from BMWi (2019) and UBA (2018+2019)

6.3.2 Data basis

The data source for the annual investment and economic turnover of bioenergy in Germany is the annual reporting of AGEE Stat (UBA 2018 + 2019) and data from BMWi (2019).

6.3.3 References

BMWi (2019) Gesamtausgabe der Energiedaten. Bundesministerium für Wirtschaft und Energie. Berlin http://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls.xls

UBA (2018) Erneuerbare Energien in Deutschland - Daten zur Entwicklung im Jahr 2017. Umweltbundesamt & Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat). Dessau https://www.umweltbundesamt.de/sites/default/files/medien/376/publikationen/180315_uba_hg_eeinzahlen_2018_bf.pdf

UBA (2019) Erneuerbare Energien in Deutschland - Daten zur Entwicklung im Jahr 2018. Umweltbundesamt & Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat). Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/uba_hgp_eeinzahlen_2019_bf.pdf

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 Government through BMU, BMWi and UBA annually reports AGEE-Stat data on 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 (2018-2019). A short description of the underlying methodology for deriving substitution factors can be found in section 4.1 (it is the same as is used for the national GHG reporting). The results are shown in the next tables.

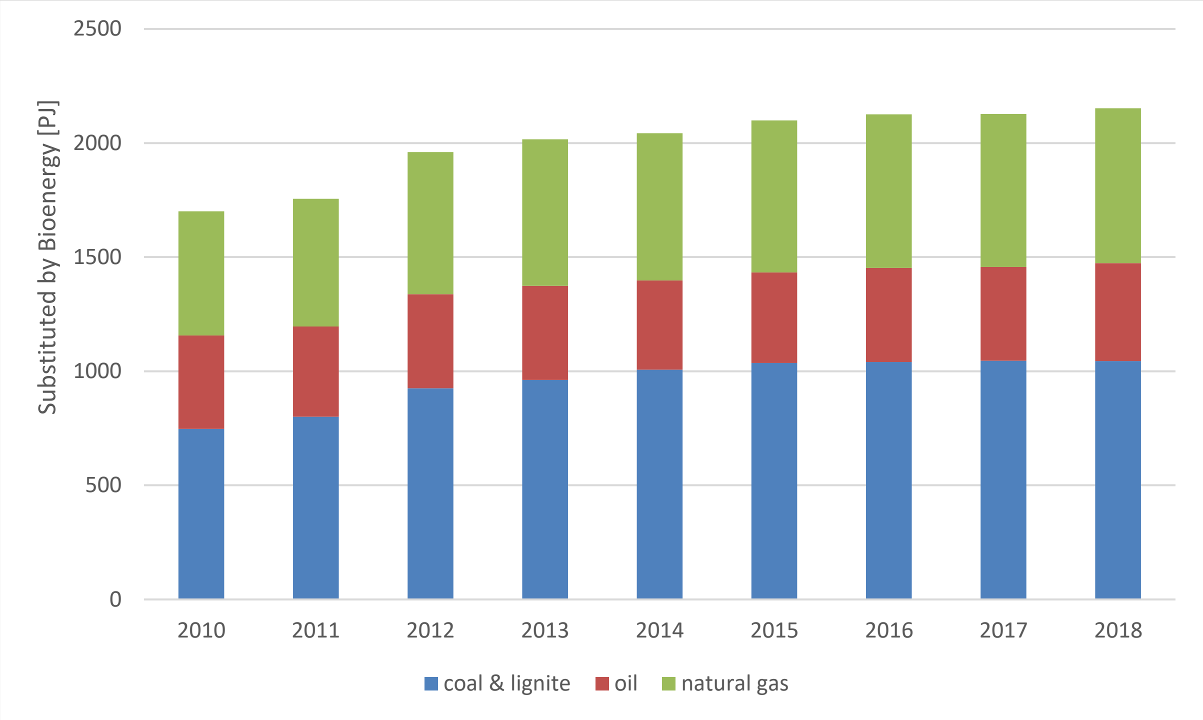
Table 39 Indicator 20.1a Substitution of fossil fuels with bioenergy in Germany

in PJ	2010	2011	2012	2013	2014	2015	2016	2017	2018
in electricity	**1075**	**1155**	**1336**	**1391**	**1459**	**1502**	**1506**	**1511**	**1508**
- coal	733	787	910	947	992	1021	1025	1031	1028
- natural gas	342	368	426	444	466	481	480	481	479
in heat	**504**	**483**	**500**	**513**	**469**	**490**	**512**	**506**	**530**
- oil	287	278	290	299	275	290	304	301	316
- natural gas	201	191	196	198	180	186	193	189	198
- coal	6	5	6	6	5	6	6	6	6
- lignite	9	9	9	9	8	9	9	9	10
in transport	**122**	**117**	**124**	**113**	**116**	**107**	**108**	**109**	**114**
- diesel	90	84	89	79	82	75	75	77	81
- gasoline	32	33	34	34	34	32	33	32	33

Source: IINAS calculation based on data from BMWi (2019) and UBA (2018+2019)

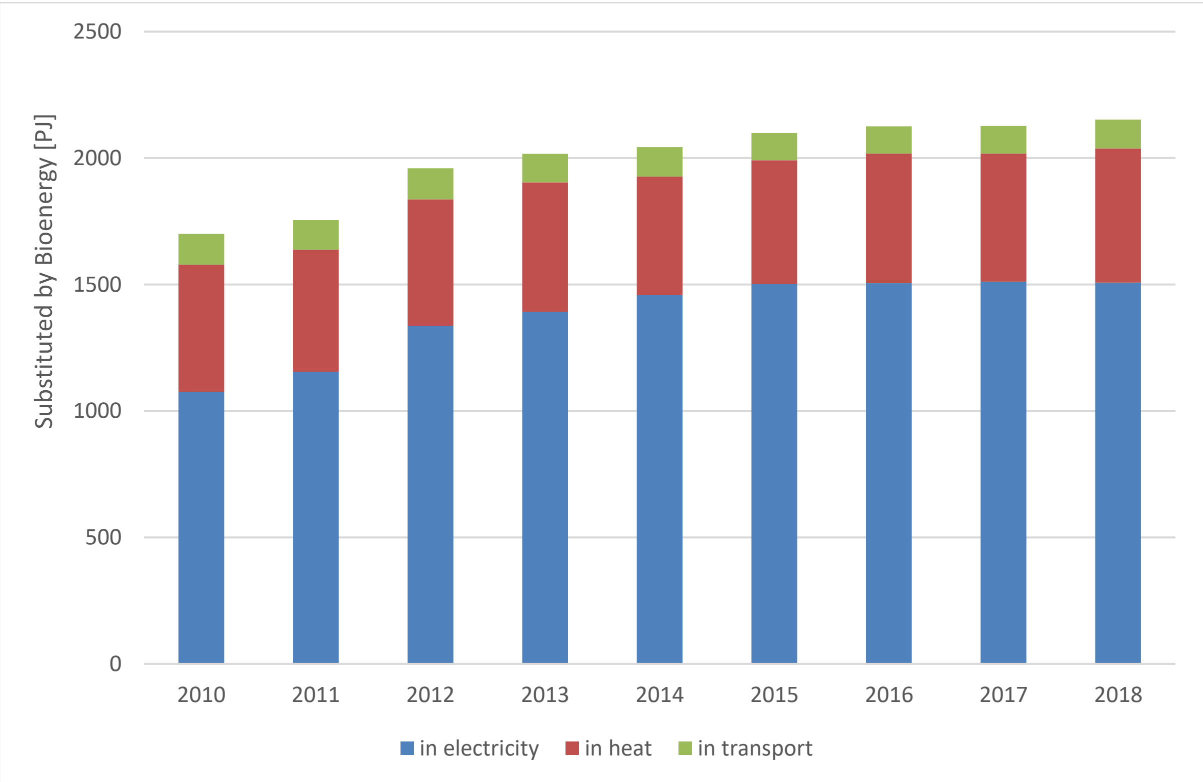
The following figures show the breakdown of fossil energy substituted through bioenergy by fuel, and sector.

Figure 23 Indicator 20.1a Substitution of fossil fuels with bioenergy in Germany, by fuel



Source: IINAS calculation based on data from BMWi (2019) and UBA (2018+2019)

Figure 24 Indicator 20.1a Substitution of fossil fuels with bioenergy in Germany, by sector



Source: IINAS calculation based on data from BMWi (2019) and UBA (2018+2019)

6.4.3 Data basis

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

6.4.4 References

BMWi (2019) Gesamtausgabe der Energiedaten. Bundesministerium für Wirtschaft und Energie. Berlin http://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls.xls

UBA (2018) Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2017. Umweltbundesamt Climate Change 23/2018. Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-10-22_climate-change_23-2018_emissionsbilanz_erneuerbarer_energien_2017_fin.pdf

UBA (2019) Projekt SeEiS – Substitutionseffekte erneuerbarer Energien im Stromsektor - Teilbericht: Methodik und Datengrundlage. ESA² GmbH, TU Dresden, KIT & TEP Energy GmbH i.A. des Umweltbundesamts. UBA Climate Change 31/2019. Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-08-30_climate-change-31-2019_methodenpapier_seeis.pdf

6.5 Indicator 22: Energy diversity

The GBEP Indicator 22 reads as follows:

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

6.5.1 Legal regulations and reporting commitments

The national data from BMWi & UBA on renewable energies are regularly reported by AGEE-Stat.

6.5.2 Results and methodological approach

The data from Indicator 20 was used to determine the Herfindahl Index for 2010 - 2018, using the approach suggested in the GBEP indicator definition. The "w/o bio" case (i.e. counterfactual **without** bioenergy) was determined using estimated substitution factors for each bioenergy category.

Table 40 Substitution shares for bioenergy in Germany

	Bioenergy type		
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 41 Indicator 22 Energy diversity effects of bioenergy in Germany

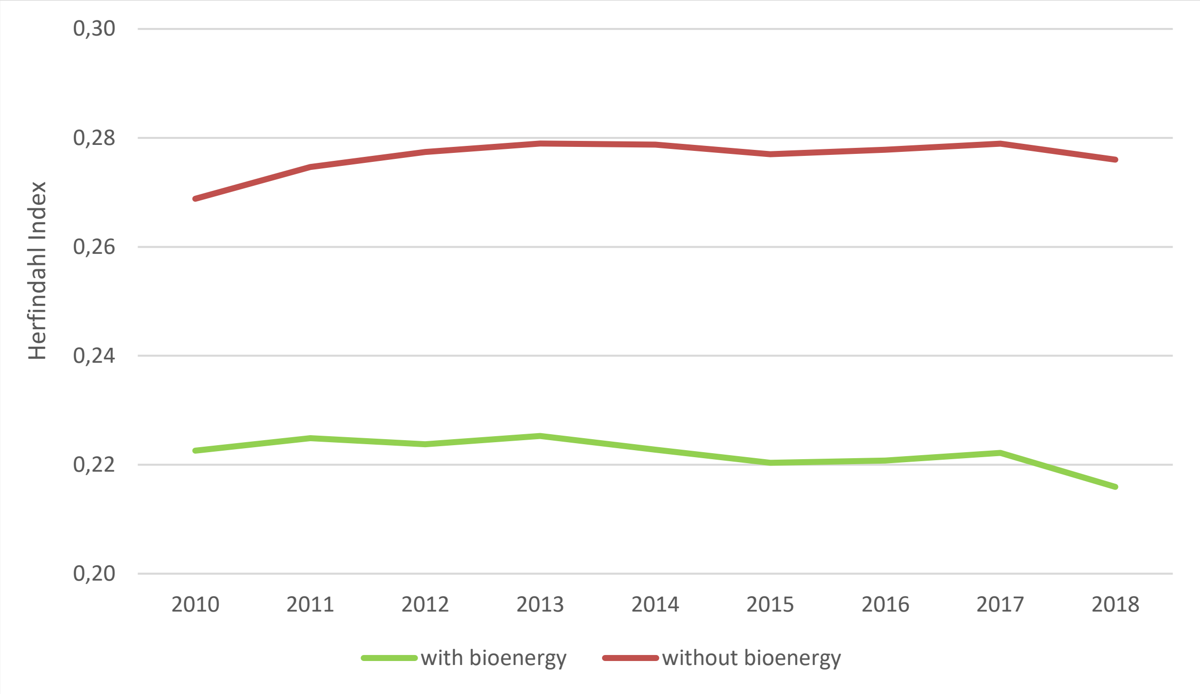
Herfindahl Index	2010	2011	2012	2013	2014	2015	2016	2017	2018
with bioenergy	0.223	0.225	0.224	0.225	0.223	0.220	0.221	0.222	0.216
without bioenergy	0.269	0.275	0.277	0.279	0.279	0.277	0.278	0.279	0.276

Source: Calculation by IINAS

As shown in the following figure, bioenergy allows for a significant improvement of energy diversity in Germany, as expressed in the Herfindahl Index.

The improvement slightly varies over time, but has a rather positive trend.

Figure 25 Indicator 22 Energy diversity effects of bioenergy in Germany



Source: Calculation by IINAS

6.5.3 Data basis

The statistical data are available on the national level from BMWi and UBA reported by AGEE-Stat.

6.5.4 References

BMWi (2019) Gesamtausgabe der Energiedaten. Bundesministerium für Wirtschaft und Energie. Berlin http://www.bmwi.de/Redaktion/DE/Binaer/Energiedaten/energiedaten-gesamt-xls.xls

UBA (2018) Emissionsbilanz erneuerbarer Energieträger - Bestimmung der vermiedenen Emissionen im Jahr 2017. Umweltbundesamt Climate Change 23/2018. Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-10-22_climate-change_23-2018_emissionsbilanz_erneuerbarer_energien_2017_fin.pdf

UBA (2019) Projekt SeEiS – Substitutionseffekte erneuerbarer Energien im Stromsektor - Teilbericht: Methodik und Datengrundlage. ESA² GmbH, TU Dresden, KIT & TEP Energy GmbH i.A. des Umweltbundesamts. UBA Climate Change 31/2019. Dessau https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2019-08-30_climate-change-31-2019_methodenpapier_seeis.pdf

6.6 Indicator 24: Capacity and flexibility of use of bioenergy

The GBEP Indicator 24 reads as follows:

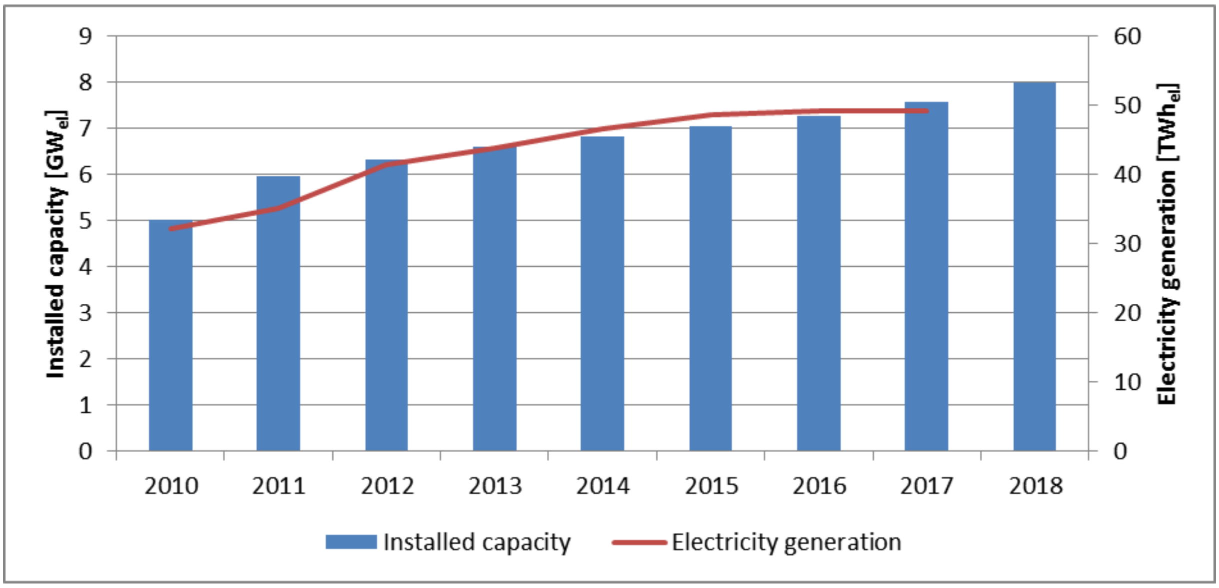
(24.1) Ratio of capacity for using bioenergy compared with actual use for each significant utilisation route
(24.2) Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity.

6.6.1 Results and methodological approach

Data on the installed capacity for of bioenergy systems (e.g. electrical power, thermal power, biogas production power) are available, whereas data on the "actual" use for the various bioenergy pathways are lacking (**indicator 24.1**).

Figure 26 shows the development of the installed capacity of biomass plants as well as the actual amount of electricity generated from biomass.

Figure 26 Installed capacity and gross electricity generation from biomass



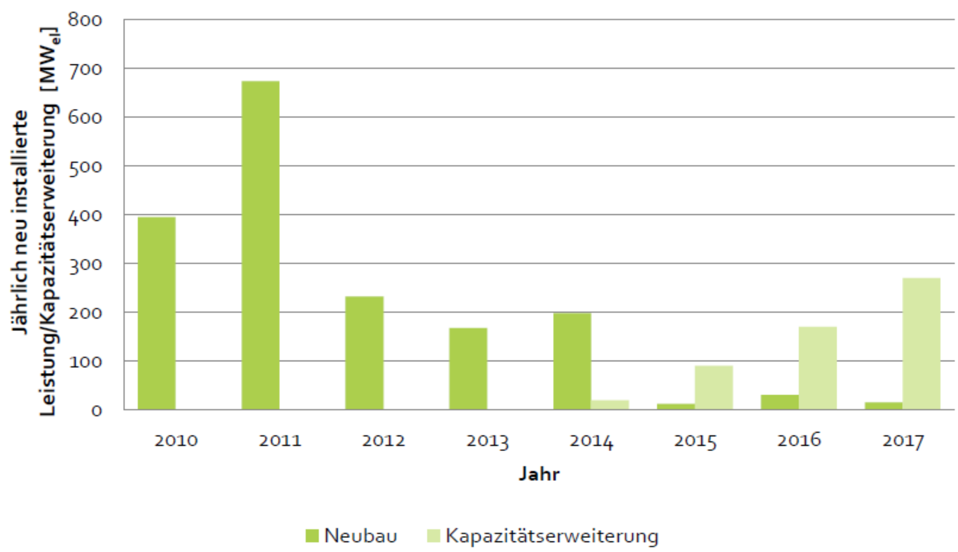
Source: AEE 2018

Moreover, there are no national data on the flexible capacity (**indicator 24.2**). However, options for a flexible use of bioenergy are increasingly important, especially in the electricity sector. As a consequence of the Energy Transition, the energy system is undergoing change, i.e. the share of fluctuating power plants (photovoltaics, wind) is increasing. In consequence, electricity generation does not always match the demand for electricity at a given point in time. The electricity grid must therefore be made more flexible and flexible bioenergy plants represent a key component. This can be achieved both by a shift of the times and periods of service provision and by adjusting the volume of service provided. As a basic prerequisite, bioenergy plants need to be fitted with more installed capacity than they need to generate electricity steadily.

As described in section 3, electricity is mainly generated from solid biomass and biogas, although biogas plants are particularly suitable for flexibilisation. Biogas plants achieve increased flexibility through a decoupling of gas production by fermentation from electricity production in a combined heat and power unit (CHP). This can be realised primarily through the expansion of CHP and gas storage capacities. In addition, gas production can be achieved by adaptation of the feed-in or substrate management. In the case of existing plants, an additional CHP unit is usually installed or the existing one is replaced with a larger CHP model (Trommler et al. 2016).

Since 2012, the flexibility of biogas plants has been promoted through the so-called "flexibility premium" under the Renewable Energy Sources Act (EEG), which will remain in effect despite amendments in 2014 and 2017. This applies to both existing and new plants, although the number of new installations has fallen sharply since the amendment in 2014. The adjustment can be made by installing an additional CHP unit or by replacement with a more powerful model. As a result, the number of registered biogas plants rose sharply (in 2015 there were 3000 plants with an installed capacity of 1700 MWel), but levelled off again in 2017. The reason is that the premium is capped.

Figure 27 Annual newly installed extension of power and capacity (dark green: new construction, light green: capacity extension)



Source: Fraunhofer ISI et al. 2018

In addition to the flexibilisation of biogas plants, they can also play a pivotal role in the expansion of storage technologies, e.g. biogas can be processed into biomethane. This in turn can be fed into the natural gas grid, which has a large storage capacity. As a result, biogas production can be decoupled from its use. Additional flexibility arises from the type of use (electricity, heat, transport) (Trommler et al. 2016).

In theory, the use of solid biomass in CHPs could also be made flexible with an expansion of turbines and boiler capacities. Here, however, the high investment costs pose an economic obstacle, as the flexibility premium does not apply to such plants. Both Hoffstede et al. 2016 and Dotzauer et al. 2018 conclude that flexibilisation is unprofitable and economically non-viable under the current framework.

In contrast to the electricity sector, the flexibility possibilities in the heat sector are considerably more limited. The operation of bioenergy plants is usually controlled by energy prices, so that heat generation in principle does not correspond to heat sinks in the surrounding area. This can be offset at least in part by the construction of additional heat storage capacity, the use of localised small district heating as storage and the flexibilisation of the heating concepts themselves (especially contract drying).

6.6.2 Data basis

Data on the production capacity of bioenergy in the various sectors is collected annually by various institutions and published by the Agency for Renewable Resources (FNR) in the series "Basic data on bioenergy" (FNR 2017).

6.6.3 References

AEE (2018): Bundesländer-Übersicht zu Erneuerbaren Energien (https://www.foederal-erneuerbar.de/uebersicht/bundeslaender/BW|BY|B|BB|HB|HH|HE|MV|NI|NRW|RLP|SL|SN|ST|SH|TH|D/kategorie/bioenergie/auswahl/691-flexibilitaetspraemi/#goto_691.

Dotzauer, M.; Kornatz, P.; Siegismund, D. (2016): Bewertung von Flexibilisierungskonzepten für Bioenergieanlagen. Deutsches Biomasseforschungszentrum (DBFZ), Leipzig.

FNR (2017): Basisdaten Bioenergie Deutschland 2017. Gülzow.

Fraunhofer-Institut für System- und Innovationsforschung ISI, Fraunhofer-Institut für Energiewirtschaft und Energiesystemtechnik IEE, Institut für Klimaschutz, Energie und Mobilität (IKEM) (2018): Wissenschaftlicher Gesamtbericht – EEG-Erfahrungsbericht 2018, Karlsruhe, Kassel, Berlin.

Hoffstede, U.; Hochloff, P.; Holzhammer, P.; Kirchner, D.; Schreiber, M.; Bedenk, K.; Krautz, A.; Romberg, T.; Steindamm, T. (2016): FLEXHKW – Flexibilisierung des Betriebes von Heizkraftwerken. Fraunhofer IWES, Bioenergie Wächtersbach, Next Kraftwerke, Seeger Engineering.

Trommler, M.; Dotzauer, M.; Barchmann, T.; Lauer, M.; Hennig, C.; Mauky, E.; Liebetrau, J.; Thrän, D. (2016): Flexibilisierung von Biogasanlagen in Deutschland; Deutsch-französische Büro für erneuerbare Energien (DFBEE).

7 Summary and recommendations

Following the questions raised in the introduction we would like to summarize following findings:

Are we able to identify and to interpret developments of the GSI results?

Yes, the GSI results give a meaningful picture of the development within the bioenergy sector in Germany with regard on sustainability aspects.

Is the 2nd application more efficient in terms of effort compared to the first time, in order to facilitate repeated assessments?

Yes, databases are familiar, efforts are much better calculable, and updating is less time-consuming.

Have we learned from the analysis regarding difficult application during the first application?

A number of indicators are still complicated to measure, although there are many data and progress in measurements, in particular indicator soil quality (2) and water quality (6).

Has the data base improved where we identified gaps or quality sufficiency before?

As said before, there is improvement – however, there is still work to do to gain a one-to-one translation into the GSI description in a few cases.

Will a periodic assessment of the GSI be feasible and how can it be connected with other established reporting schemes?

Yes, we deem a periodic measuring of the GSI feasible, with a frequency of 4 – 5 years. There are options to further improve data connections with other regular reporting schemes. However, this needs still more work and communication. In particular, we recognize added value in relation to work on SDG reporting for which the GSIs may prove beneficial, and for the ongoing development of a federal monitoring scheme for the bioeconomy.

ANNEX

Indicator 1: Life cycle greenhouse gas emissions

Table 42 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2016

		Emissions from bioenergy use [1000 t CO_{2equ}]	Amount of bioenergy [GWh]	Avoided emissions [1000 t CO_{2equ}]	Balance / GHG emission savings [1000 t CO_{2equ}]
Solid	Electricity	820	10 795	8 247	7.428
	Heat	2 589	110 338	26 704	24.115
Liquid	Electricity	101	497	380	278
	Heat	140	2 129	605	465
	Transport	2 079	29 558	8 907	6.828
Gaseous	Electricity	11 082	39 633	30 281	19.199
	Heat	2 529	30 825	8 654	6.126
	Transport	11	379	95	84
TOTAL		**19 350**	**224 155**	**83 873**	**64 523**

Source: compilation by IFEU based on UBA 2018.

Table 43 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2015

		Emissions from bioenergy use [1000 t CO_{2equ}]	Amount of bioenergy [GWh]	Avoided emissions [1000 t CO_{2equ}]	Balance / GHG emission savings [1000 t CO_{2equ}]
Solid	Electricity	817	11 044	8 438	7 621
	Heat	2 420	103 306	25 168	22 748
Liquid	Electricity	87	424	324	238
	Heat	186	2 091	619	433
	Transport	2 665	29 509	8 892	6 227
Gaseous	Electricity	10 880	38 874	29 701	18 821
	Heat	2 519	30 862	8 655	6 136
	Transport	16	345	86	70
TOTAL		**19 591**	**216 455**	**81 884**	**62 293**

Source: compilation by IFEU based on UBA 2018.

Table 44 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2014

		Emissions from bioenergy use [1000 t CO_{2equ}]	Amount of bioenergy [GWh]	Avoided emissions [1000 t CO_{2equ}]	Balance / GHG emission savings [1000 t CO_{2equ}]
Solid	Electricity	796	10 798	8 251	7.455
	Heat	2 360	99 371	24 539	22.179
Liquid	Electricity	68	333	254	186
	Heat	196	2 202	646	450
	Transport	3 004	31 884	9 608	6 603
Gaseous	Electricity	10 300	37 171	28 404	18 104
	Heat	2 307	28 771	8 045	5 738
	Transport	22	449	112	90
TOTAL		**19 054**	**210 979**	**79 860**	**60 806**

Source: compilation by IFEU based on UBA 2018.

Table 45 Life cycle greenhouse gas emissions from bioenergy production and for avoided emissions in 2013

		Emissions from bioenergy use [1000 t CO_{2equ}]	Amount of bioenergy [GWh]	Avoided emissions [1000 t CO_{2equ}]	Balance / GHG emission savings [1000 t CO_{2equ}]
Solid	Electricity	10 555	8 098	764	7 334
	Heat	112 719	27 436	2 675	24 761
Liquid	Electricity	286	219	59	161
	Heat	2 059	603	186	417
	Transport	30 899	9 311	2 982	6 329
Gaseous	Electricity	34 686	26 614	9 751	16 863
	Heat	27 788	7 712	2 131	5 581
	Transport	483	121	26	95
TOTAL		219 475	80 114	18 574	61 540

Source: compilation by IFEU based on UBA 2018.

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

Table 46 Results for Indicator 4.1d-4.4d: Life-cycle air emissions of total bioenergy use in Germany 2016

In t / year	electricity	heat	biofuels	total
SO2eq	75,768	55,002	14,353	**145,123**
SO2	22,778	9,866	6,354	**38,998**
NOx	76,134	64,849	11,444	**152,428**
Particulates	2,384	25,216	1,152	**28,752**
CO	56,630	592,297	3,354	**652,281**
NMVOC	5,262	37,911	1,821	**44,994**

Source: IFEU compilation based on UBA (2018); data given in t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

Table 47 Results for Indicator 4.1d-4.4d: Life-cycle air emissions of total bioenergy use in Germany 2015

In t / year	electricity	heat	biofuels	total
SO2eq	74,655	52,814	14,431	**141,901**
SO2	22,415	9,551	6,103	**38,069**
NOx	75,057	62,158	11,915	**149,130**
Particulates	2,330	23,339	1,135	**26,804**
CO	55,593	545,021	3,431	**604,044**
NMVOC	5,132	34,908	1,824	**41,864**

Source: IFEU compilation based on UBA (2018); data given in t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

Table 48 Results for Indicator 4.1d-4.4d: Life-cycle air emissions of total bioenergy use in Germany 2014

In t / year	electricity	heat	biofuels	total
SO2eq	71,277	51,309	16,456	**139,042**
SO2	21,285	9,171	7,000	**37,456**
NOx	71,827	60,540	13,526	**145,893**
Particulates	2,175	21,876	1,308	**25,359**
CO	52,770	503,619	3,820	**560,210**
NMVOC	4,763	32,639	1,996	**39,399**

Source: IFEU compilation based on UBA (2018); data given in t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

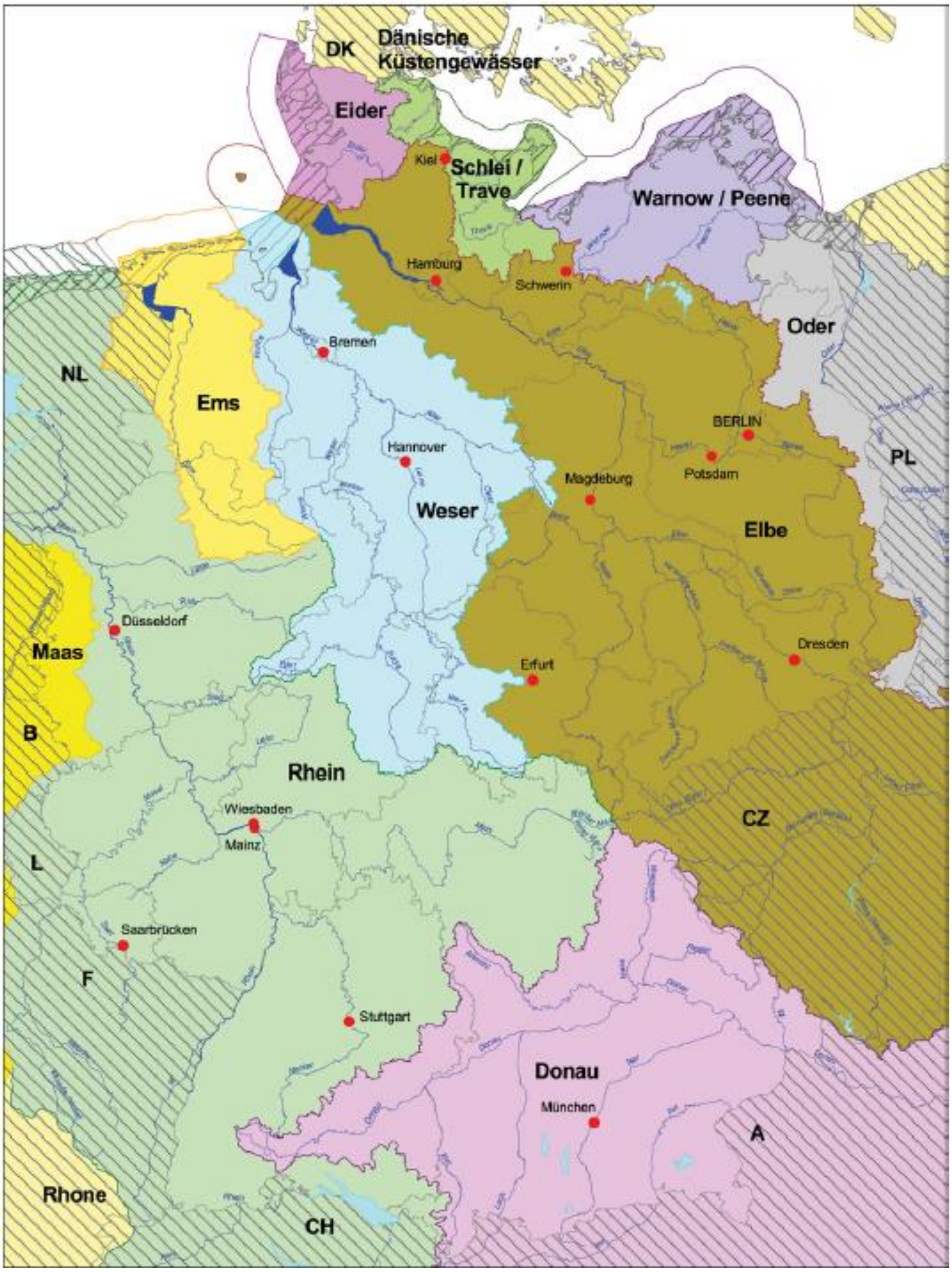
Table 49 Results for Indicator 4.1d-4.4d: Life-cycle air emissions of total bioenergy use in Germany 2013

In t / year	electricity	heat	biofuels	total
SO2eq	55,577	85,375	16,879	157,831
SO2	15,758	14,392	6,089	36,239
NOx	57,211	92,252	15,504	164,967
Particulates	3,133	31,436	1,457	36,026
CO	35,691	743,600	3,939	783,230
NMVOC	5,976	54,261	884	61,121

Source: IFEU compilation based on UBA (2017); data given in t/year; note that for imported fuels, life-cycle emissions from outside Germany (production, processing, transport) are included

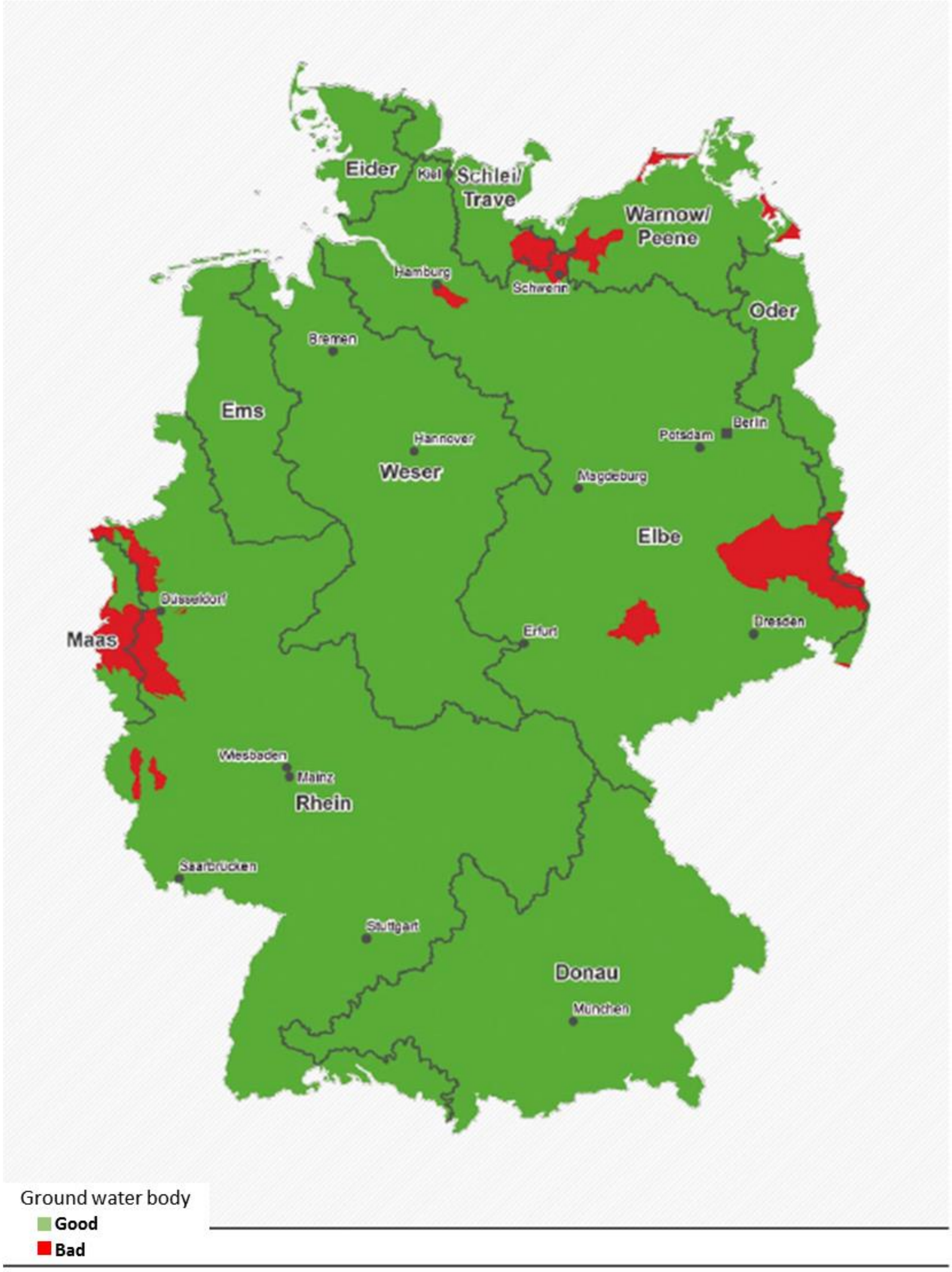
Indicator 5: Water use and efficiency

Figure 28 Watersheds in Germany according to the Water Framework Directive



Source: UBA 2017

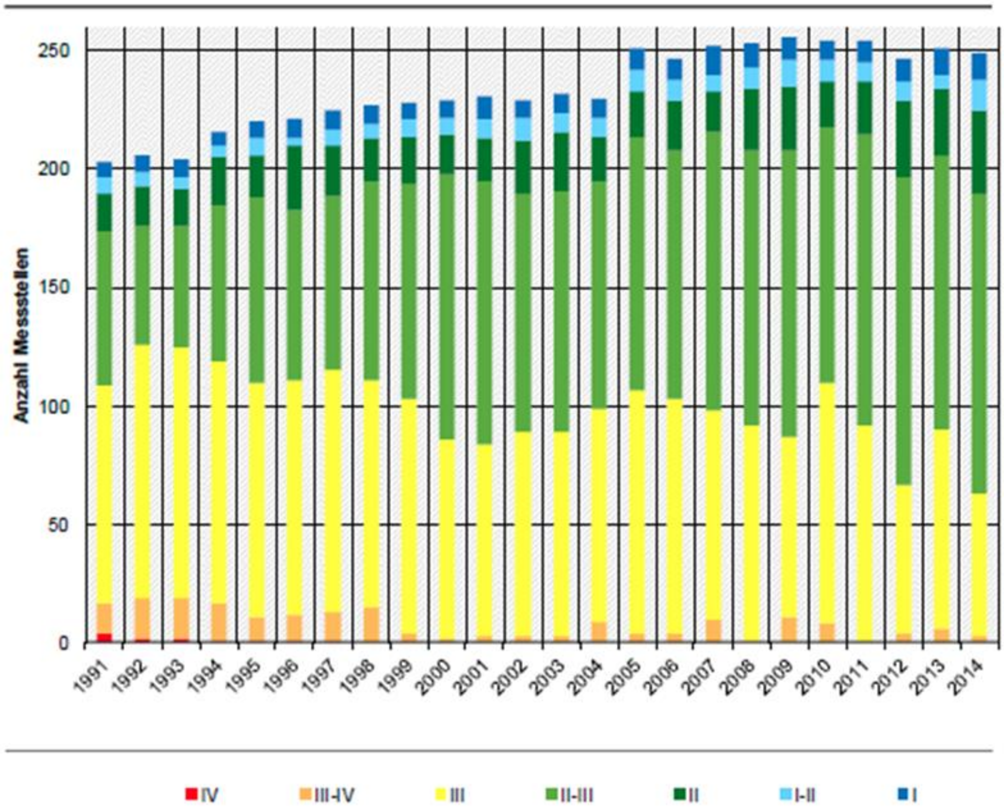
Figure 29 Groundwater quantitative status in Germany



Source: UBA 2017

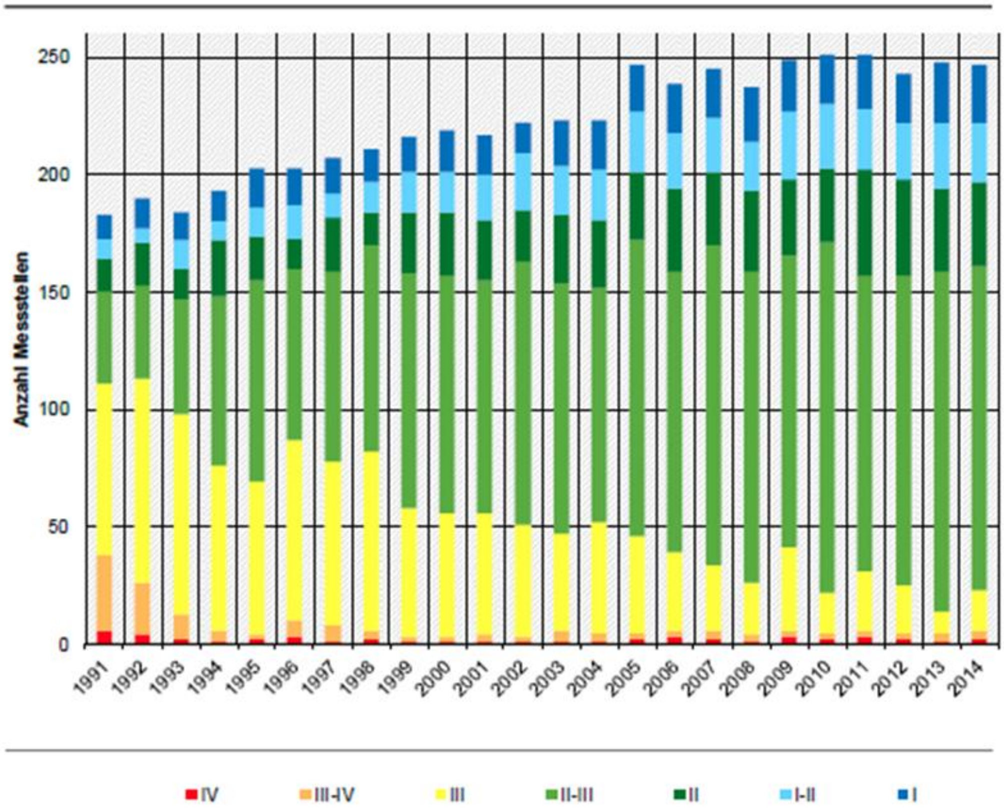
Indicator 6: Water quality

Figure 30 Nitrate load in rivers: distribution of measuring points in the quality classes in the period 1991-2014



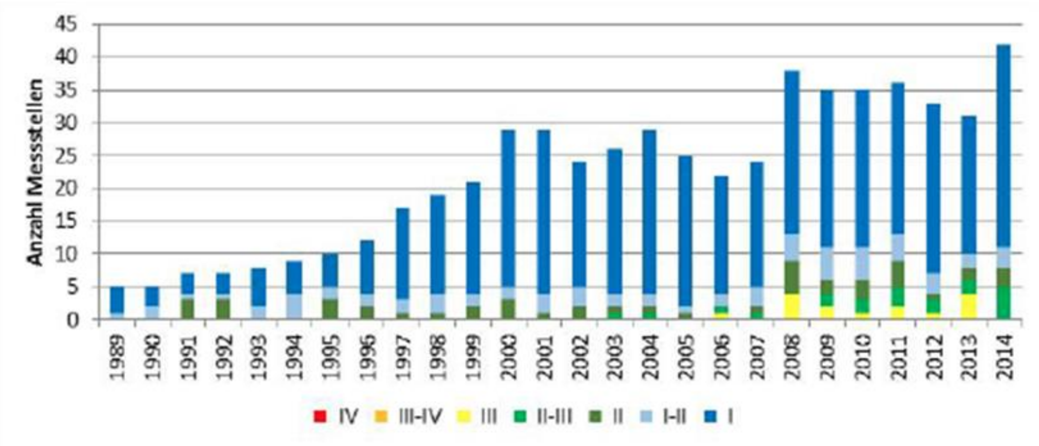
Source: BMUB & BMEL (2017) (I: <1 mg / l; I-II: <1.5 mg / l; II: <2.5 mg / l; II-III: <5 mg / l; III: <10 mg / l; III-IV: <20 mg / l; IV: > 20 mg / l)

Figure 31 Phosphorous load in rivers: distribution of measuring points in the quality classes in the period 1991-2014



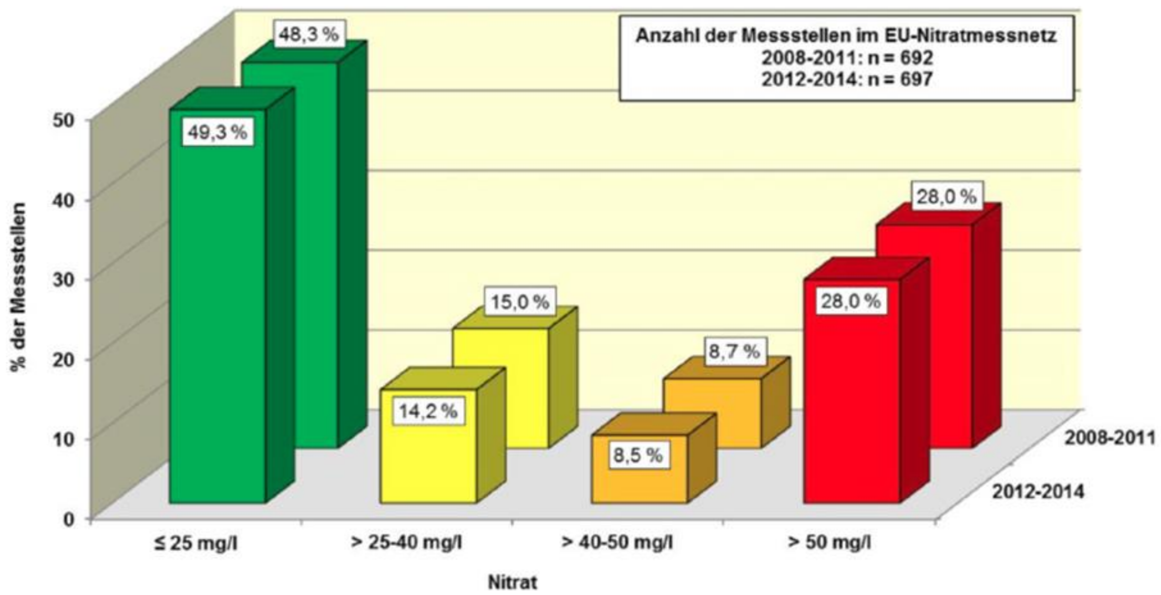
Source: BMUB & BMEL (2017)

Figure 32 Nitrate load in lakes: distribution of measuring points in the quality classes in the period 1989-2014



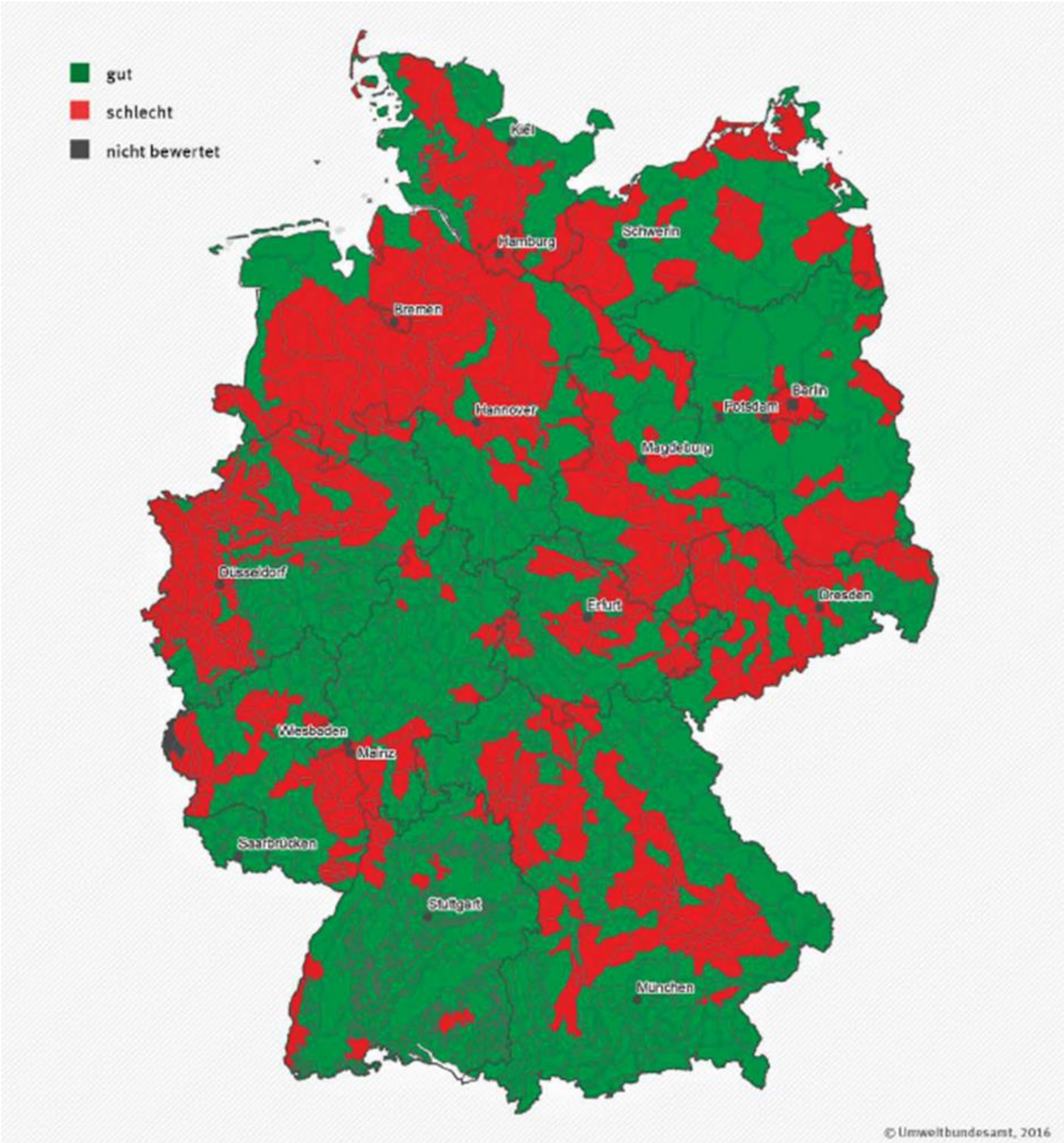
Source: BMUB & BMEL (2017) (I: <1 mg / l; I-II: <1.5 mg / l; II: <2.5 mg / l; II-III: <5 mg / l; III: <10 mg / l; III-IV: <20 mg / l; IV: > 20 mg / l)

Figure 33 Frequency distribution of the average nitrate contents during the periods 2008-2011 and 2012-2014 (groundwater; EU nitrate measuring points representing the agriculture)



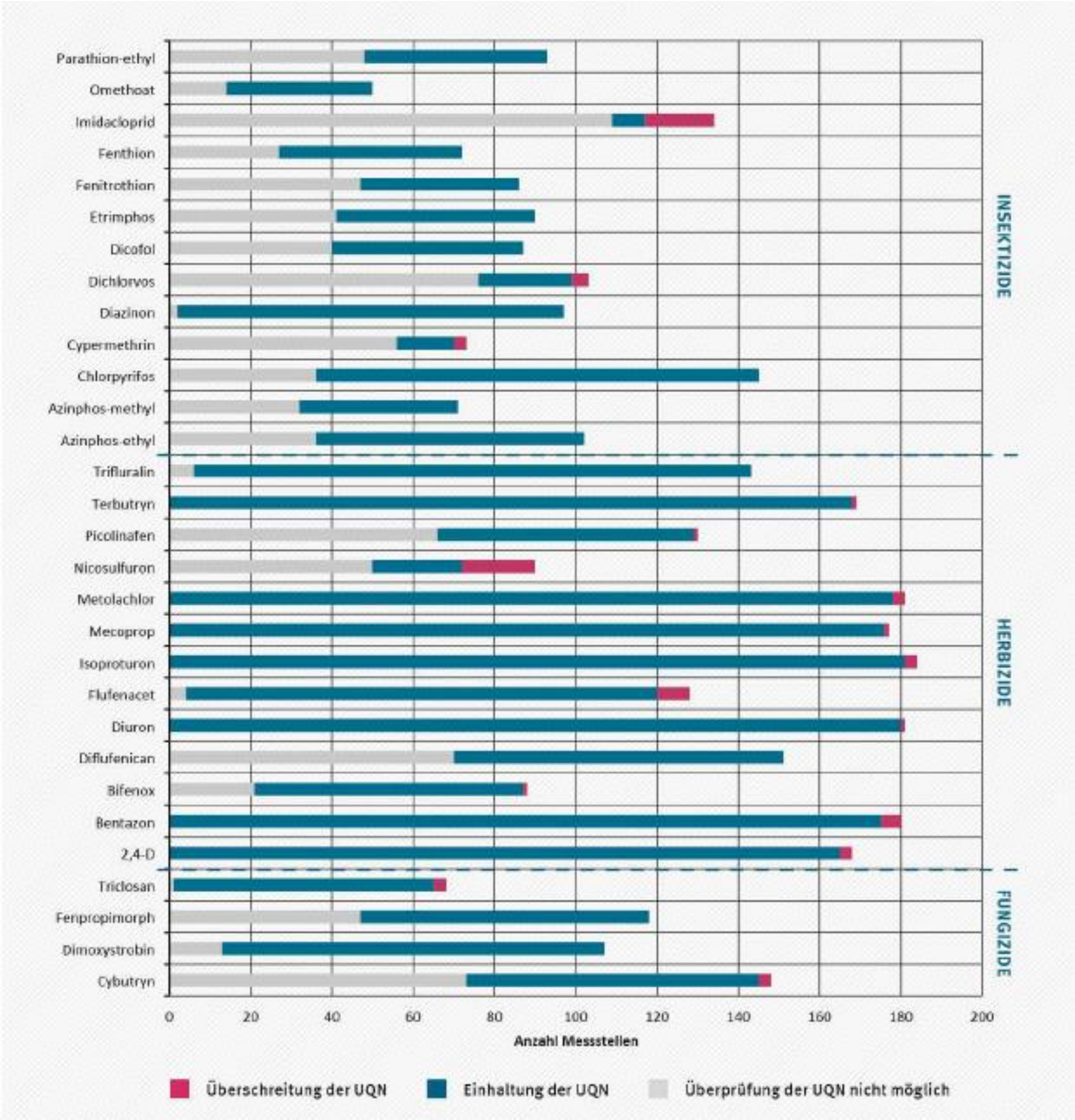
Source: BMUB & BMEL (2017)

Figure 34 Chemical status of groundwater bodies in Germany (green: good; red: bad)



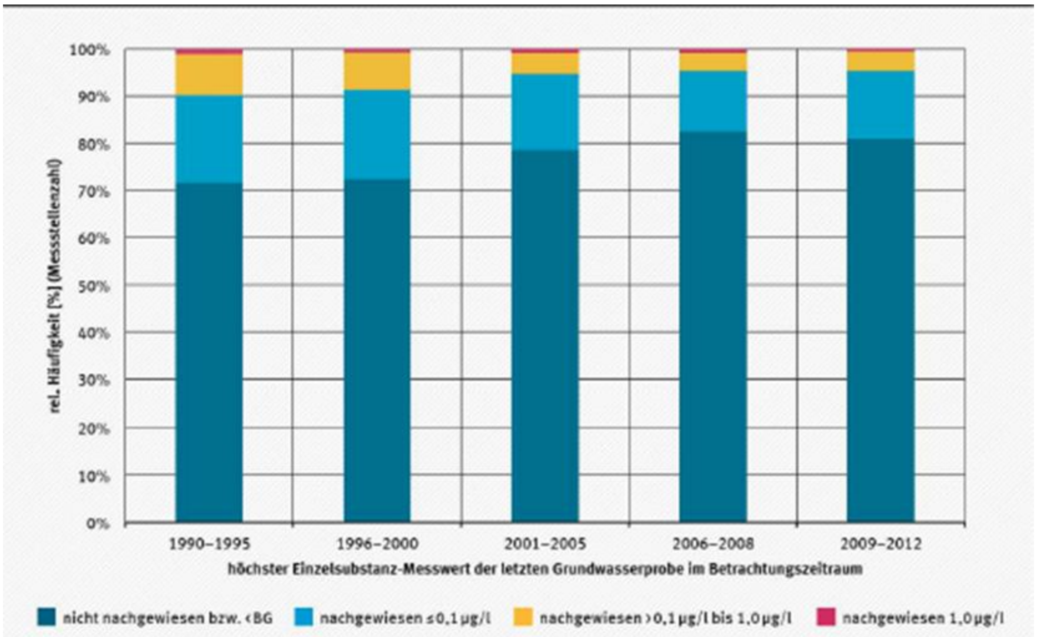
Source: UBA (2017)

Figure 35 Number of measuring points in surface waters where thresholds for specific pesticides are met (blue colour) or exceeded (red colour) in 2013 to 2015



Source: UBA (2017)

Figure 36 Frequency distribution of pesticide loads in groundwater bodies



Source: UBA (2017)

Indicator 7: Biological Diversity in the Landscape

7.1 Area and percentage of nationally recognized 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 50 Results for Indicators 8.3b+c: Contribution of bioenergy from residues and wastes in Germany 2010-2018

Bioenergy from residues & wastes [TWh] for	2010	2011	2012	2013	2014	2015	2016	2017	2018
Electricity	10.2	10.9	11.4	12.7	14.1	14.4	15.3	16.4	16.5
Heat	106.3	101.3	103.7	114.8	102.5	105.9	113.8	103.8	118.9
Transport fuels	3.6	3.4	3.4	3.9	4.7	5.3	8.3	8.6	9.0
total	**120.0**	**115.6**	**118.5**	**131.3**	**121.2**	**125.7**	**137.4**	**128.8**	**144.3**

Source: calculation by IINAS based on FNR (2019), DESTATIS (2019), UBA (2019); woody residues include pre-commercial thinnings from forest management

Table 51 Results for Indicators 8.3b+c: Contribution of bioenergy in Germany 2010-2018

Total bioenergy [TWh] for	2010	2011	2012	2013	2014	2015	2016	2017	2018
Electricity	34.0	37.6	43.6	45.5	48.3	50.3	50.8	51.4	51.3
Heat	134.0	123.2	126.6	142.4	130.2	136.1	142.3	126.6	147.3
Transport fuels	35.4	34.2	34.2	30.9	30.9	29.5	29.6	30.3	31.6
total	**203.4**	**195.0**	**204.4**	**218.8**	**209.4**	**215.9**	**222.6**	**208.3**	**230.2**

Table 52 Calculation of residue and waste shares in renewable energy supply in Germany 2010

	Renewable Energy Source	TWh	
		all	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

Table 53 Calculation of residue and waste shares in renewable energy supply in Germany 2011

	Renewable Energy Source	TWh	
		all	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

Table 54 Calculation of residue and waste shares in renewable energy supply in Germany 2012

	Renewable Energy Source	TWh all	TWh biomass residues & wastes
Electricity	**Hydropower**	**21.793**	
	Windpower	**50.67**	
	Biomass for electricity	**43.55**	
	of that:		
	solids	11.6	4.9
	liquids (incl. vegetable oil)	0.4	0.1
	biogas	24.8	4.6
	sewage gas	1.3	1.3
	landfill gas	0.55	0.55
	biogenic fraction of waste	4.9	4.9
	Photovoltaics	**26.38**	
	Geothermal	**0.03**	
	Total electricity	**142.4**	**11.4**
Heat	**Biomass for heat**	**126.6**	
	of that:		
	solids	103	90.4
	liquids (incl. vegetable oil)	0.8	0.1
	biogas	12.1	2.2
	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**	**103.7**
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**	**118.5**
	Total final energy from renewable resources	**317.0**	

Source: calculation by IINAS

Table 55 Calculation of residue and waste shares in renewable energy supply in Germany 2013

	Renewable Energy Source	TWh	
		all	biomass residues & wastes
Electricity	**Hydropower**	**23.0**	
	Windpower	**51.7**	
	Biomass for electricity	**45.5**	
	of that:		
	solids	10.6	4.9
	liquids (incl. vegetable oil)	0.3	0.1
	biogas	27.5	5.4
	sewage gas	1.3	1.3
	landfill gas	0.5	0.5
	biogenic fraction of waste	5.4	5.4
	Photovoltaics	**31.0**	
	Geothermal	**0.1**	
	Total electricity	**151.3**	**12.7**
Heat	**Biomass for heat**	**142.4**	
	of that:		
	solids	112.7	98.1
	liquids (incl. vegetable oil)	2.1	0.4
	biogas	14.0	2.8
	sewage gas	1.8	1.8
	landfill gas	0.1	0.1
	biogenic fraction of waste	11.6	11.6
	Solar thermal	**6.8**	
	Deep Geothermal	**0.9**	
	Near surface geothermal + ambient heat	**8.7**	
	Total heat	**158.7**	**114.8**
Biofuels	Biodiesel	22.0	3.9
	Vegetable oils	0.0	
	Bioethanol	8.9	
	Biomethane	0.5	
	Total transport fuels	**30.9**	**3.9**
Total	**Total bioenergy**	**218.8**	**131.3**
	Total final energy from renewable resources	**340.9**	

Source: calculation by IINAS

Table 56 Calculation of residue and waste shares in renewable energy supply in Germany 2014

	Renewable Energy Source	TWh	
		All	biomass residues & wastes
Electricity	**Hydropower**	**19.6**	
	Windpower	**57.4**	
	Biomass for electricity	**48.3**	
	of that:		
	solids	10.8	5.0
	liquids (incl. vegetable oil)	0.3	0.1
	biogas	29.3	6.2
	sewage gas	1.3	1.3
	landfill gas	0.4	0.4
	biogenic fraction of waste	6.1	6.1
	Photovoltaics	**36.1**	
	Geothermal	**0.1**	
	Total electricity	**161.4**	**14.1**
Heat	**Biomass for heat**	**130.2**	
	of that:		
	solids	99.0	85.5
	liquids (incl. vegetable oil)	2.2	0.5
	biogas	15.3	3.2
	sewage gas	1.8	1.8
	landfill gas	0.1	0.1
	biogenic fraction of waste	11.4	11.4
	Solar thermal	**7.3**	
	Deep Geothermal	**1.1**	
	Near surface geothermal + ambient heat	**9.6**	
	Total heat	**148.2**	**102.5**
Biofuels	Biodiesel	22.0	4.7
	Vegetable oils	0.0	
	Bioethanol	8.9	
	Biomethane	0.5	
	Total transport fuels	**30.9**	**4.7**
Total	**Total bioenergy**	**209.4**	**121.2**
	Total final energy from renewable resources	**340.5**	

Source: calculation by IINAS

Table 57 Calculation of residue and waste shares in renewable energy supply in Germany 2015

	Renewable Energy Source	TWh	
		all	biomass residues & wastes
Electricity	**Hydropower**	**19.0**	
	Windpower	**79.2**	
	Biomass for electricity	**50.3**	
	of that:		
	solids	11.0	5.0
	liquids (incl. vegetable oil)	0.4	0.1
	biogas	31.3	6.8
	sewage gas	1.4	1.4
	landfill gas	0.4	0.4
	biogenic fraction of waste	5.8	5.8
	Photovoltaics	**38.7**	
	Geothermal	**0.1**	
	Total electricity	**187.4**	**14.4**
Heat	**Biomass for heat**	**136.1**	
	of that:		
	solids	103.3	87.8
	liquids (incl. vegetable oil)	2.1	0.5
	biogas	16.7	3.6
	sewage gas	2.0	2.0
	landfill gas	0.1	0.1
	biogenic fraction of waste	11.8	11.8
	Solar thermal	**7.8**	
	Deep Geothermal	**1.0**	
	Near surface geothermal + ambient heat	**10.4**	
	Total heat	**155.2**	**105.9**
Biofuels	Biodiesel	20.8	5.3
	Vegetable oils	0.0	
	Bioethanol	8.6	
	Biomethane	0.3	
	Total transport fuels	**29.5**	**5.3**
Total	**Total bioenergy**	**215.9**	**125.7**
	Total final energy from renewable resources	**372.1**	

Source: calculation by IINAS

Table 58 Calculation of residue and waste shares in renewable energy supply in Germany 2016

	Renewable Energy Source	TWh	
		all	biomass residues & wastes
Electricity	**Hydropower**	**20.5**	
	Windpower	**78.6**	
	Biomass for electricity	**50.8**	
	of that:		
	solids	11.0	5.1
	liquids (incl. vegetable oil)	0.4	0.2
	biogas	31.8	7.4
	sewage gas	1.4	1.4
	landfill gas	0.4	0.4
	biogenic fraction of waste	5.9	5.9
	Photovoltaics	**38.1**	
	Geothermal	**0.2**	
	Total electricity	**188.2**	**15.3**
Heat	**Biomass for heat**	**142.3**	
	of that:		
	solids	109.1	94.9
	liquids (incl. vegetable oil)	2.1	0.8
	biogas	16.9	3.9
	sewage gas	2.1	2.1
	landfill gas	0.1	0.1
	biogenic fraction of waste	11.9	11.9
	Solar thermal	**7.8**	
	Deep Geothermal	**1.0**	
	Near surface geothermal + ambient heat	**11.3**	
	Total heat	**162.4**	**113.8**
Biofuels	Biodiesel	20.9	8.3
	Vegetable oils	0.0	
	Bioethanol	8.7	
	Biomethane	0.4	
	Total transport fuels	**29.6**	**8.3**
Total	**Total bioenergy**	**222.6**	**137.4**
	Total final energy from renewable resources	**380.2**	

Source: calculation by IINAS

Table 59 Calculation of residue and waste shares in renewable energy supply in Germany 2017

	Renewable Energy Source	TWh all	TWh biomass residues & wastes
Electricity	**Hydropower**	**19.8**	
	Windpower	**106.6**	
	Biomass for electricity	**51.4**	
	of that:		
	solids	10.6	5.1
	liquids (incl. vegetable oil)	0.5	0.2
	biogas	32.5	8.5
	sewage gas	1.5	1.5
	landfill gas	0.3	0.3
	biogenic fraction of waste	5.9	5.9
	Photovoltaics	**39.9**	
	Geothermal	**0.2**	
	Total electricity	**217.9**	**16.4**
Heat	**Biomass for heat**	**126.6**	
	of that:		
	solids	102.7	89.3
	liquids (incl. vegetable oil)	0.8	0.3
	biogas	12.1	3.1
	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**	**103.8**
Biofuels	Biodiesel	21.4	8.6
	Vegetable oils	0.0	
	Bioethanol	8.5	
	Biomethane	0.4	
	Total transport fuels	**30.3**	**8.6**
Total	**Total bioenergy**	**208.3**	**128.8**
	Total final energy from renewable resources	**388.6**	

Source: calculation by IINAS

Table 60 Calculation of residue and waste shares in renewable energy supply in Germany 2018

	Renewable Energy Source	TWh	
		all	biomass residues & wastes
Electricity	**Hydropower**	**16.5**	
	Windpower	**111.6**	
	Biomass for electricity	**51.3**	
	of that:		
	solids	10.7	5.1
	liquids (incl. vegetable oil)	0.4	0.2
	biogas	32.2	8.4
	sewage gas	1.5	1.5
	landfill gas	0.3	0.3
	biogenic fraction of waste	6.2	6.2
	Photovoltaics	**46.2**	
	Geothermal	**0.2**	
	Total electricity	**225.7**	**16.5**
Heat	**Biomass for heat**	**147.3**	
	of that:		
	solids	113.3	98.6
	liquids (incl. vegetable oil)	2.2	0.9
	biogas	16.7	4.4
	sewage gas	2.2	2.2
	landfill gas	0.1	0.1
	biogenic fraction of waste	12.7	12.7
	Solar thermal	8.9	
	Deep Geothermal	1.1	
	Near surface geothermal + ambient heat	13.6	
	Total heat	**170.9**	**118.9**
Biofuels	Biodiesel	22.4	9.0
	Vegetable oils	0.0	
	Bioethanol	8.8	
	Biomethane	0.4	
	Total transport fuels	**31.6**	**9.0**
Total	**Total bioenergy**	**230.2**	**144.3**
	Total final energy from renewable resources	**428.2**	

Source: calculation by IINAS