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Report from the Federal Republic of Germany under Article 19(2) of Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

Article 19(2) of Directive 2009/28/EC reads as follows:

By 31 March 2010, Member States shall submit to the Commission a report including a list of those areas on their territory classified as level 2 in the nomenclature of territorial units for statistics (NUTS) or as a more disaggregated NUTS level in accordance with Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics (NUTS) [23] where the typical greenhouse gas emissions from cultivation of agricultural raw materials can be expected to be lower than or equal to the emissions reported under the heading 'Disaggregated default values for cultivation' in part D of Annex V to this Directive, accompanied by a description of the method and data used to establish that list. That method shall take into account soil characteristics, climate and expected raw material yields.

1. List of regions

In all NUTS2 regions in the Federal Republic of Germany the typical greenhouse gas emissions from the cultivation of agricultural raw materials are probably below the emissions given under the heading 'Disaggregated default values for cultivation' in Annex V Part D of Directive 2009/28/EC.

The regions are as follows:

- Schleswig-Holstein
- Hamburg
- Braunschweig
- Hannover
- Lüneburg
- Weser-Ems
- Bremen
- Düsseldorf
- Cologne
- Münster
- Detmold
- Arnsberg
- Darmstadt
- Gießen
- Kassel
- Koblenz
- Trier
- Rheinhessen-Pfalz
- Stuttgart
- Karlsruhe
- Freiburg
- Tübingen
- Upper Bavaria
- Lower Bavaria
- Oberpfalz
- Oberfranken
- Mittelfranken
- Unterfranken
- Swabia
- Saarland
- Berlin
- Mecklenburg-Western Pomerania
- Chemnitz

- Dresden
- Leipzig
- Saxony-Anhalt
- Thuringia
- North-East Brandenburg
- South-West Brandenburg

2. Calculation

2.1 Relevant biomass raw materials

The following biomass raw materials grown in Germany are relevant for the report under Article 19(2):

- Wheat
- Grain maize
- Sugar beet
- Rape

2.2 Approach

The greenhouse gas emissions were calculated by including emissions from the cultivation and harvesting of raw materials as well as greenhouse gas emissions from the material and energy inputs used for production and for cultivation by means of accurately measured data using the following formula:

Ernteertrag = Crop yield; Dünger = Fertiliser; Strom = Electricity; Ertrag = Yield; Haupterzeugnis = Main product

The main product is the product of a stage of the production chain from which the biofuel or the liquid biomass is produced in the subsequent stages of the production chain. The formula components are set out in detail below:

Herstellung = Production; Feld = Field;

All data for the input parameters were made in mass units on the basis of the main product (e.g. diesel [kg]/ rape seed [kg]).

To convert greenhouse gas emissions from e' to e, the conversion factors (CF) – calculated on the basis of the JRC tables [1-2] – corresponding to the end product were used for each intermediate product. The conversion was made using the following formula:

Zwischenprodukt = Intermediate product

The allocation factor AF is the proportion of emissions allocated to the main product. Using the allocation factor, emissions 'de-allocated' from rape seed to by-products of later stages of the process were re-allocated to rape seed. To convert the reference MJ of refined rape seed oil to the reference kg of rape seed, the conversion factor CF is required. The conversion factor for e_{ec} indicates the quantity of rape seed (in kg) required for 1 MJ of refined rape seed oil.

3. Data basis

The following data are required to calculate the regional greenhouse gas emissions during cultivation:

- Fertiliser [kg/(ha*yr)] – Total quantity of N, P_2O_5, K_2O, CaO fertiliser used per hectare and year
- Diesel [l/(ha*yr)] – Total quantity of diesel used for e.g. tractors and water pumps per hectare and year
- Crop yield [kg of crop yield /(ha*yr)] – Annual yield in kg per hectare and year.
- Ef_{Diesel} – Emission factor for diesel [kg of CO_2/l of diesel]
- $Ef_{Production}$ – Emission factor for fertiliser production [kg of CO_2/kg of N fertiliser]
- Ef_{Field} – Emission factor for fertiliser field emission [kg of CO_2/kg of N fertiliser] (this emission factor corresponds to N_2O emissions)

No regional values are available for most of the data required.

The water contents, N_2O emissions and drying costs were therefore taken from the JRC tables [1-2].

The specific N_2O emission factor, based on the particular amount of N fertiliser, was derived from JRC table 1 for each product. This ‘product-specific’ emission factor was applied to the relevant quantity of N fertiliser. This goes some way towards alignment with the JRC method, although any geographically relevant factors available could be disregarded. The effective N_2O factors range from 1% to 1.75%, depending on the fertiliser nitrogen applied, and are therefore close to the IPCC default value of 1%.

Since the methodology of the JEC consortium has been followed, these values also include the corresponding indirect emission levels from agricultural crop residues and nitrogen leaching. To estimate the possible effect of regional differences in soil properties on the emission factors, the findings of the von Thünen Institute (vTI) on the level of organic soils in land in arable use were included. These show that some NUTS2 regions have relatively high levels (up to 20% in the government region of Osnabrück) of cultivated organic soils.

However, such land should not be seen as ‘typical’ for the entire NUTS2 region. At over 80%, mineral soils always represent the typical case. Organically cultivated holdings therefore need to be considered separately in order to prove actual greenhouse gas emissions.

In addition, other emission factors are required in order to calculate specific greenhouse gas emissions from the consumption of diesel, fertiliser and electricity. The JRC tables do not indicate any emission factors for most of the input data (particularly for fertiliser) [1-2]. One entry with the quotation ‘Kaltschmitt, Reinhardt (1997)’ relates to data compiled by the IFEU institute, but no actual values are given. Meanwhile, under the EU-funded BioGrace project, the data on which the calculations of the default values of Directive 2009/28/EC Annex V are made have been analysed and published [6]. For reasons of uniformity and conservatism, these data were used as the basis for the present calculation. The corresponding values for these emission factors are given in Table 1.

The regional data were compiled with the support of the Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (Agricultural Engineering and Construction Association – KTBL) and of the Federal Statistical Office as follows:

- The yield data for the abovementioned biomass raw materials were compiled statistically [3]; the values correspond to the average annual values from 2004 to 2008.
- The specific fertiliser consumption was calculated according to the nutrient requirements (N, P, K) of the plants after extraction. The extraction is derived from the nutrient content of the harvest products, which is documented in the German Fertilisation Order [4].
- Diesel consumption was calculated as follows: For each operation, the amount of diesel required was calculated as a function of the particular engine load in the individual operating phases (time periods). Key factors included:
    - size of plot and farm-to-field distance
    - degree of mechanisation (engine capacity, working width, etc.)
    - tillage resistance
    - throughput (harvest or application rate)
    - rates of operation and transportation

Regional data for lime applications are available only at NUTS1 (German federal state) level, although eight states are also at NUTS2 level. In addition, the data make no reference to the various biomass raw materials. Consequently, for the biomass raw materials that were taken into account according to the JRC [1-2] for the liming default values (rape, sugar beet), the average lime application for each federal state was used.

Table 1
Emission factors for the production and use of diesel and fertiliser

Rape	Unit	Value	Source
Diesel / Heavy fuel oil EL	g of CO_2 eq./kg	3 777	BioGrace (2010)
Fertiliser			
Nitrogen	g of CO_2 eq./kg of N	5 917	BioGrace (2010)
Phosphorus	g of CO_2 eq./kg of P_2O_5	1 014	BioGrace (2010)
Potash	g of CO_2 eq./kg of K_2O	579	BioGrace (2010)
Calcium	g of CO_2 eq./kg of CaO	130	BioGrace (2010)
Pesticide	g of CO_2 eq./kg	11 026	BioGrace (2010)

The calculation of greenhouse gas emissions from cultivation for a biomass raw material is always based on the mass in kg of the biomass raw material (wheat, maize grain, sugar beet, rape seed). However, the default values of Directive 2009/28/EC were calculated on the basis of the energy content of the biofuel, which is only obtained after further conversion processes. The conversion from a mass-based value to an energy-based value depends essentially on the further stages of these processes and the resulting by-products (the values primarily presented in ‘kg of CO_2 eq./kg of agricultural product’ converted in a further stage into ‘g of CO_2 eq./MJ of biofuel’). To that end, where available the conversion rates and allocation factors (see above) derived from the JRC tables [1, 2, 5] are used. However, since not all assumptions used to calculate the default value of the Directive have been disclosed, we have had to make other assumptions of our own.

To achieve comparability with the default values, the calculation of the stages following cultivation was completed by including our own assumptions for the cultivation default values of Annex V and a control value was calculated. The relevant data were taken from [1-2] where available. The regional values for the greenhouse gas emissions were then compared with these control values. It emerged that in all cases, the regional values for the greenhouse gas emissions were below the control value.

Sources

[1] 'JRC (2008) Update on Data on pathways for RES Directive.XLS' (semi-public file sent by the European Commission in November 2008 to various interested parties).

[2] 'Input_data_BIO 181108.XLS' (downloadable from: http://ies.jrc.ec.europa.eu/our-activities/support-to-eu-policies/well-to-wheels-analysis/WTW.html).

[3] Federal Statistical Office, Volume 3, Series 3.2.1.

[4] Order on the use of fertilisers, soil improvers, growing media and plant adjuvants based on the principles of good agricultural practice in fertilisation (Fertilisation Order – DüV); Fertilisation Order in the version published on 27 February 2007 (BGBl. I, p. 221), as last amended by Article 18 of the Act of 31 July 2009 (BGBl. I, p. 2585).

[5] JEC (2007) JRC, EUCAR, CONCAWE: Well-to-Wheels analysis of future automotive fuels and powertrains in the European context WELL-TO-TANK Report Version 2c, Appendix 1; March 2007; http://ies.jrc.ec.europa.eu/WTW.

[6] BioGrace: Harmonisation of EU-27 Biofuel Greenhouse Gas Performance Calculations; in cooperation with AgendschapNL, Ademe, Bioenergy 2020+, Bio IS, CIEMAT, Exergia; funded by the EU; contract No IEE/09/736/SI2.558249.

Annex:

Typical values calculated for greenhouse gas emissions from the cultivation of agricultural raw materials by NUTS2 region

No	NUTS2 region	**Wheat** **g of CO_2 eq./ MJ of EtOH**	**Maize (corn)** **g of CO_2 eq./ MJ of EtOH**	**Sugar beet** **g of CO_2 eq./ MJ of EtOH**	**Rape** **g of CO_2 eq./ MJ of RME**
1	Schleswig-Holstein	21.1	14.1	11.7	23.6
2	Hamburg	21.3	14.1	11.6	23.6
3	Braunschweig	21.1	14.2	11.7	23.8
4	Hannover	21.1	14.1	11.6	23.8
5	Lüneburg	21.3	14.2	11.7	24.0
6	Weser-Ems	21.3	14.2	11.7	23.9
7	Bremen	21.4	14.2	11.7	24.8
8	Düsseldorf	21.2	13.9	11.5	23.7
9	Cologne	21.0	14.0	11.5	23.7
10	Münster	21.3	14.0	11.8	23.9
11	Detmold	21.2	14.2	11.6	23.7
12	Arnsberg	21.1	14.1	11.5	23.9
13	Darmstadt	21.2	14.1	11.5	23.6
14	Gießen	21.4	14.3	11.5	23.8
15	Kassel	21.2	14.5	11.6	23.9
16	Koblenz	21.4	14.1	11.7	23.6
17	Trier	21.6	14.1	11.6	23.7
18	Rheinhessen-Pfalz	21.6	14.1	11.5	23.8
19	Stuttgart	21.3	14.0	11.4	23.5
20	Karlsruhe	21.5	14.0	11.5	23.6
21	Freiburg	21.5	14.0	11.5	23.6
22	Tübingen	21.3	14.0	11.4	23.5
23	Upper Bavaria	21.4	14.0	11.3	23.6
24	Lower Bavaria	21.3	13.9	11.2	23.5
25	Oberpfalz	21.3	14.1	11.3	23.8
26	Oberfranken	21.7	14.3	11.7	24.0
27	Mittelfranken	21.6	14.2	11.5	23.9
28	Unterfranken	21.5	14.2	11.5	23.8
29	Swabia	21.2	14.0	11.3	23.5
30	Saarland	21.5	14.4	11.5	23.9
31	Berlin	22.0	14.4	11.7	24.4
32	Mecklenburg-Western Pomerania	21.4	14.3	12.0	23.6
33	Chemnitz	21.4	14.1	11.7	23.8
34	Dresden	21.4	14.2	11.6	23.9
35	Leipzig	22.2	14.1	11.6	23.7
36	Saxony-Anhalt	21.3	14.1	11.6	23.7
37	Thuringia	21.4	14.1	11.1	23.7
38	North-East Brandenburg	21.7	14.4	12.0	23.8
39	South–West Brandenburg	21.8	14.5	12.0	23.9
	Disaggregated default value e_{ec}	**23.0**	**20.0**	**12.0**	**29.0**