BIOGRACE

Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

Harmonisation of EU-27 Biofuel Greenhouse Gas Performance Calculations

Per Godfroij
NL Agency
Workshop GHG experts
September 23, 2010 - Heidelberg

Contents

Introduction

GHG calculations under Renewable Energy Directive (RED) and Fuel Quality Directive (FQD)

- RED and FQD: same sustainability criteria including GHG
- RED article 19:
  - Economic operators may use
    - default values (19.1.a)
    - actual values calculated according to Annex V.C (19.1.b)
    - sum of actual value and disaggregated default value (19.1.c)
  - In Europe default values only when feedstock is produced in area on list (19.2) or from waste/residue
- RED article 18:
  - Independent auditors must check information (18.3)
  - Can be part of voluntary certification schemes (18.4)

Introduction

- o Input data
- o Standard values ("conversion factors")

Cultivation of rapeseed			Calculated emissions			
			Emissions per MJ FAME			
Yield			$g\ CO_2$	$g\ CH_4$	$g\ N_2O$	$g\ CO_{2,\ eq}$
Rapeseed	3.113	$kg\ ha^{-1}\ year^{-1}$				
Moisture content	10,0%					
By-product Straw	n/a	$kg\ ha^{-1}\ year^{-1}$				
Energy consumption						
Diesel	2.963	$MJ\ ha^{-1}\ year^{-1}$	6,07	0,00	0,00	6,07
Agro chemicals						
N-fertiliser	137,4	$kg\ N\ ha^{-1}\ year^{-1}$	9,08	0,03	0,03	18,89
CaO-fertiliser	19,0	$kg\ CaO\ ha^{-1}\ year^{-1}$	0,05	0,00	0,00	0,06
K_2O-fe						
P_2O_5-						
Pestic						
Seeding material						
Seeds- rapeseed	6	$kg\ ha^{-1}\ year^{-1}$	0,06	0,00	0,00	0,10

STANDARD VALUES	GHG emission coefficient			
parameter:				
unit:	gCO_2/kg	gCH_4/kg	gN_2O/kg	$gCO_{2\text{-}eq}/kg$
N-fertiliser	2827,0	8,68	9,6418	5880,6

Contents

Why harmonisation of biofuel GHG calculations?

1. Significant variation possible in actual GHG values (RED 19.1.b) following RED Annex V.C
   - Using same input values
   - Caused by variation in standard values (or "conversion factors" / "background processes") to convert kg, MJ or m^3 into $CO_{2,eq}$
2. This causes a problem using actual GHG values
   - Auditors can not check if standard values are correct
   - Economic operations can enhance the GHG performance of their biofuel without decreasing actual GHG emissions
3. Several GHG experts and MS policy makers…
   - …agree that harmonisation of standard values is best solution
   - …intend to implement this solution

Why harmonisation of biofuel GHG calculations?

EXAMPLE: Different results from same biofuel
(same input values but different standard values)

Production of FAME from Rapeseed

Overview Results

Parameter

Nitrogen Fertilizer

P fertilizer

K fertilizer

CaO fertilizer (85%CaCO3+15%CaO,Ca(O

Pesticides

Diesel (direct plus indirect emissions)

Natural gas (direct plus indirect emissions)

Methanol (direct plus indirect emissions)

Production of FAME from Rapeseed

Overview Results

All results in g $CO_{2,eq}$ / MJ_{FAME}	Total	Default values RED Annex V.D
Cultivation e_{ec}	**27,7**	**29**
Cultivation of rapeseed	**27,29**	28,51
Rapeseed drying	**0,42**	0,42
Processing e_p	**16,5**	**22**
Extraction of oil	**3,29**	3,82
Refining of vegetable oil	**0,85**	17,88
Esterification	**12,39**	
Transport e_{td}	**1,3**	**1**
Transport of rapeseed	**0,15**	0,17
Transport of FAME	**0,73**	0,82
Filling station	**0,44**	0,44
Land use change e_l	**0,0**	0
$e_{sca} + e_{ccr} + e_{ccs}$	**0,0**	0
Totals	**45,6**	**52**

Emission reduction
Fossil fuel reference (diesel)
83,8 g $CO_{2,eq}$/MJ
GHG emission reduction
46%

Contents

Project BioGrace

Biofuel **Gr**eenhouse Gas emissions:
alignment of **c**alculations in **E**urope

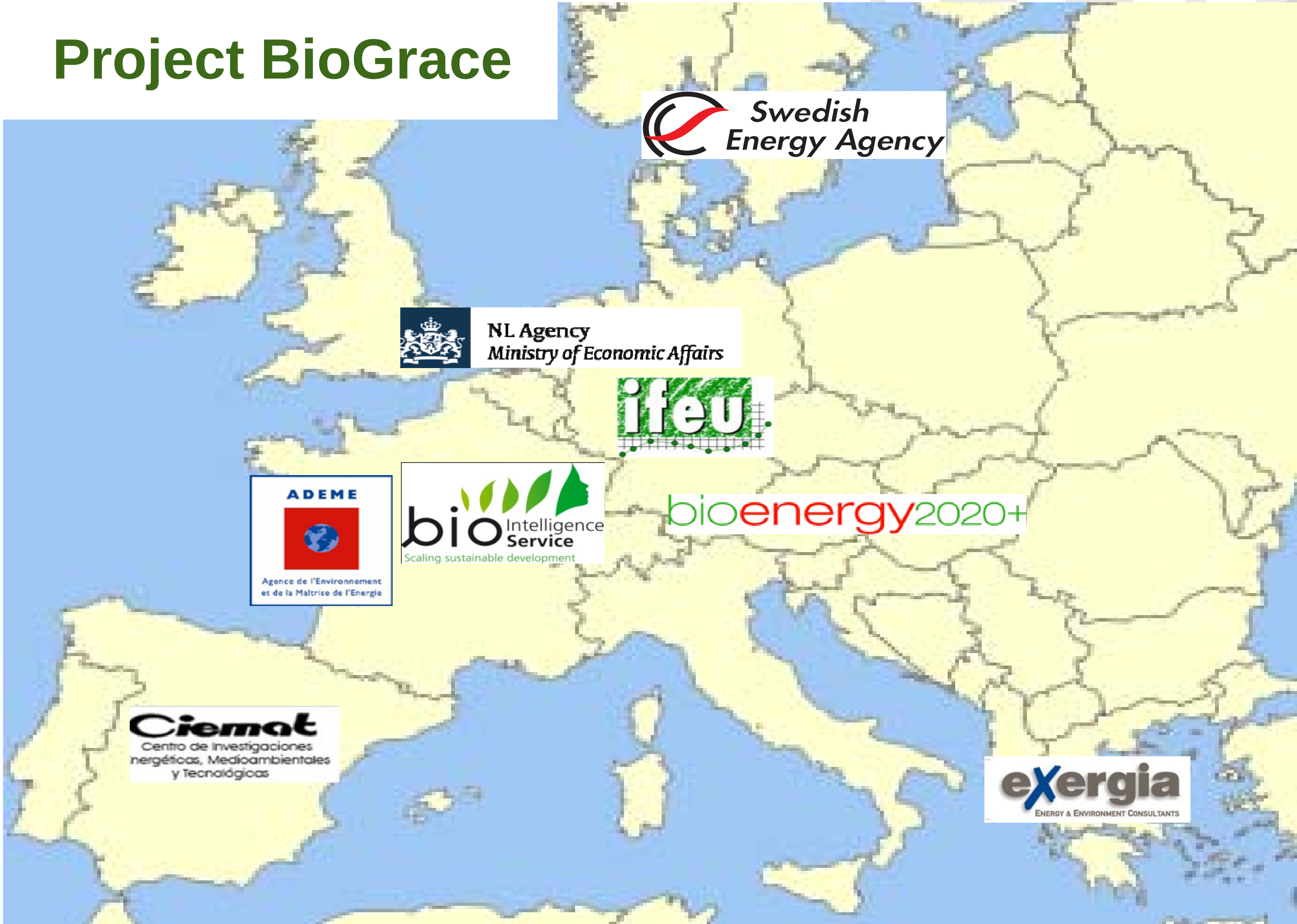
Aim of project:

- **Harmonise** calculations of biofuel greenhouse gas (GHG) emissions performed in EU-27 under legislation implementing the Renewable Energy and Fuel Quality directives

Consortium

- Agencies/organisations close to national governments and experts in GHG calculations
  - Coordinator: NL Agency (formerly SenterNovem)
  - Partners: ADEME, BE2020, BIO-IS, CIEMAT, IFEU, EXERGIA, STEM

Project BioGrace



Project BioGrace

Key objectives are:

1. **Cause transparency**
   Reproduce biofuel default GHG values (Annex V RED)
2. **Cause harmonisation**
   Cause that GHG calculation tools give the same results
3. **Facilitate stakeholders**
   Allow relevant stakeholders to calculate actual values
4. **Disseminate results**
   Make our results public to all relevant stakeholders

Project BioGrace

- Project coordinator: Agentschap NL (NL Agency)
  Dr. John P.A. Neeft
  e-mail: john.neeft@agentschapnl.nl

- Project partners:
  - ADEME, France (Bruno Gagnepain)
  - BE2020, Austria (Dina Bacovsky)
  - BIO IS, France (Remy Lauranson)
  - CIEMAT, Spain (Yolanda Lechon)
  - EXERGIA, Greece (Konstantinos Georgakopoulos)
  - IFEU, Germany (Horst Fehrenbach)
  - STEM, Sweden (Matti Parika)

- Project website: www.BioGrace.net

Contents

1. Introduction
   - GHG calculations under RED and FQD
2. Why harmonisation of biofuel GHG calculations? “is there a problem?”
3. Project BioGrace
4. Transparency and harmonisation
5. Concluding summary

Transparency & harmonisation

1. List of standard values

- o is publicly available
- o to be used by everyone that makes GHG calculations under RED/FQD based legislation

Transparency and harmonisation by:

- – Including values in all software tools
- – Causing that list is known by all GHG calculation experts
- – Showing that these (and only these) standard values lead to RED defaults
- – Requesting policy makers to make reference from national legislation (implementing RED / FQD)

Transparency & harmonisation

Version 1 - Public

STANDARD VALUES (parameter / unit)	GHG emission coefficient gCO$_2$/kg	gCH$_4$/kg	gN$_2$O/kg	gCO$_{2\text{-eq}}$/kg	gCO$_2$/MJ	gCH$_4$/MJ	gN$_2$O/MJ	gCO$_{2\text{-eq}}$/MJ	Fossil energy input MJ$_{fossil}$/kg	MJ$_{fossil}$/MJ	Density kg/m3	LHV MJ/kg (at 0% water)	Fuel efficiency MJ/t.km	Transport exhaust gas emissions gCH$_4$/t.km	gN$_2$O/t.km
Global Warming Potentials (GWP's)															
CO_2				1											
CH_4				23											
N_2O				296											
Agro inputs															
N-fertiliser	2827,0	8,68	9,6418	5880,6					48,99						
P_2O_5-fertiliser	964,9	1,33	0,0515	1010,7					15,23						
K_2O-fertiliser	536,3	1,57	0,0123	576,1					9,68						
CaO-fertiliser	119,1	0,22	0,0183	129,5					1,97						
Pesticides	9886,5	25,53	1,6814	10971,3					268,40						
Seeds- corn	-	-	-	-					-						
Seeds- rapeseed	412,1	0,91	1,0028	729,9					7,87						
Seeds- soy bean	-	-	-	-					-						
Seeds- sugarbeet	2187,7	4,60	4,2120	3540,3					36,29						
Seeds- sugarcane	1,6	0,00	0,0000	1,6											
Seeds- sunflower	412,1	0,91	1,0028	729,9											
Seeds- wheat	151,1	0,28	0,4003	275,9											
EFB compost (palm oil)	0,0	0,00	0,0000	0,0											
Fuels- gasses															
Natural gas (4000 km, Russian NG quality)															
Natural gas (4000 km, EU Mix qualilty)															
Fuels- liquids															
Diesel										1,16	832	43,1			
Gasoline											745	43,2			
HFO								84,98		1,088	970	40,5			
Ethanol											794	26,81			
Methanol						0,2900	0,0003	99,57		1,6594	793	19,9			
FAME											890	37,2			
Syn diesel (BtL)											780	44,0			
HVO											780	44,0			
Fuels / feedstock / byproducts - solids															
Hard coal					102,38	0,3835	0,0003	111,28		1,0886		26,5			
Lignite					116,76	0,0091	0,0001	116,98		1,0156		9,2			
Corn												18,5			
FFB												24,0			
Rapeseed												26,4			
Soybeans												23,5			
Sugar beet												16,3			
Sugar cane												19,6			
Sunflowerseed												26,4			
Wheat												17,0			
Animal fat												37,1			
BioOil (byproduct FAME from waste oil)												21,8			
Crude vegetable oil												36,0			
DDGS												16,0			
Glycerol												16,0			
Palm kernel meal												17,0			

Available at www.BioGrace.net

Transparency & harmonisation

2. BioGrace GHG calculations

- Excel sheets show how GHG calculations are made:
  - Input data used
  - How to convert input data to GHG emissions
  - Allocation (energy content)
  - How to reproduce RED Annex V default GHG values

- Excel sheets allow for own input
- Excel sheets allow to build own biofuel production pathway

Transparency & harmonisation

BIOGRACE
Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe
www.biograce.net
Intelligent Energy Europe

About | Directory

Production of Ethanol from Wheat (NG steam boiler) Version 1 - Public

Overview Results

All results in g $CO_{2,eq}$ / $MJ_{Ethanol}$	Non- allocated results	Allocation factor	Allocated results	Total	Default values RED Annex V.D
Cultivation e_{ec}				23,3	23
Cultivation of wheat	39,17	59,5%	23,31		23,43
Processing e_p				29,4	30
Ethanol plant	49,40	59,5%	29,40		29,57
Transport e_{td}				1,9	2
Handling & storage of wheat	0,10	59,5%	0,06		
Transport of wheat	0,52	59,5%	0,31		
Transport of ethanol	1,10	100%	1,10		
Filling station	0,44	100%	0,44		
Land use change e_l	0,0	59,5%	[illegible]	[illegible]	[illegible]
$e_{sca} + e_{ccr} + e_{ccs}$	0,0	[illegible]	[illegible]	[illegible]	[illegible]
Totals	**90,7**	[illegible]	[illegible]	[illegible]	[illegible]

Allocation factors	
Ethanol plant	
59,5%	to ethanol
40,5%	to DDGS

Emission reduction
Fossil fuel reference (petrol)
83,8 g $CO_{2,eq}$/MJ
GHG emission reduction
35%

...ns in this Excel sheet......

...follow the methodology as given in ...es 2009/28/EC and 2009/30/EC

~~...C calculations by using GWP ... for CH4 and 298 for N2O~~

...plained in "About" under "Inconsistent use of GWP's"

Available at **www.BioGrace.net**

Calculation per phase

Cultivation of wheat

Yield			
Wheat	[illegible]	kg ha^{-1} $year^{-1}$	
Moisture content	13,5%		
By-product Straw	2.148	kg ha^{-1} $year^{-1}$	
Energy consumption			
Diesel	3.717	MJ ha^{-1} $year^{-1}$	
Agro chemicals			
N-fertiliser	109,3	kg N ha^{-1} $year^{-1}$	
K_2O-fertiliser	16,4	kg K_2O ha^{-1} $year^{-1}$	
P_2O_5-fertiliser	21,6	kg P_2O_5 ha^{-1} $year^{-1}$	
Pesticides	2,3	kg ha^{-1} $year^{-1}$	
Seeding material			

...y of product

Yield	
76.587	MJ_{Wheat} ha^{-1} $year^{-1}$
1,000	MJ / $MJ_{Wheat, input}$
0,128	$kg_{Wheat}/MJ_{ethanol}$

Calculated emissions / **Info**

	Emissions per MJ ethanol				Info: per kg wheat	Info: per ha, year
	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$	kg $CO_{2,eq}$
Diesel	8,01	0,00	0,00	8,01	62,54	325,7
N-fertiliser	7,59	0,02	0,03	15,80	123,42	642,8
K_2O-fertiliser	0,22	0,00	0,00	0,23	1,81	9,4
P_2O_5-fertiliser	0,51	0,00	0,00	0,54	4,20	21,9
Pesticides	0,57	0,00	0,00	0,63	4,92	25,6

Transparency & harmonisation

- Planning for delivery of biofuel production pathways within BioGrace GHG calculation excel sheet:

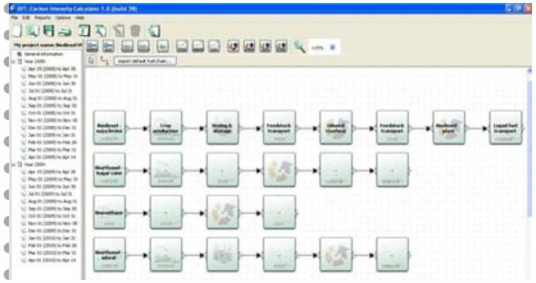
	Version 1 June/July 2010	Version 2 September 2010	Version 3 (& 4) End of 2010
Ethanol	o Sugarbeet o Wheat NG boiler	o Corn o Sugarcane o Wheat NG CHP	o Wheat (process not specified) o Wheat – Lignite fired CHP o Wheat – Straw fired CHP
Biodiesel	o Rapeseed	o Palm oil o Palm oil (methane capture) o Sunflower o Used cooking oil	o Soy
PVO		o Rapeseed	
HVO	o Rapeseed		o Palm oil o Palm oil (methane capture) o Sunflower
Biogas			o Dry manure o Wet manure o MSW

Transparency & harmonisation

3. National GHG calculators

Harmonisation of calculators (existing / under development):

- o BioGrace will cause that GHG calculators give the same results
- o GHG calculators are being developed in:
  - – Germany
  - – Spain
  - – UK
  - – Netherlands



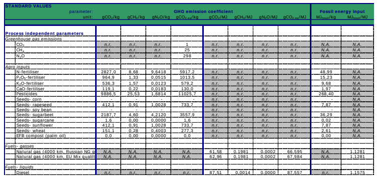
Contents

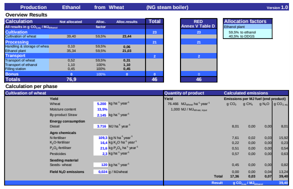
1. Introduction
   - GHG calculations under RED and FQD
2. Why harmonisation of biofuel GHG calculations?
   "is there a problem?"
3. Project BioGrace
4. Transparency and harmonisation
5. Concluding summary

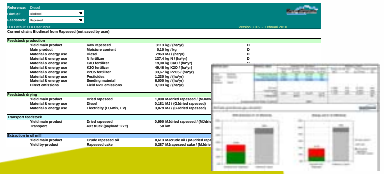
Concluding summary

- One biofuel, different GHG calculations => different results
- IEE funded project BioGrace will:

1. Cause **harmonisation**
   - Excel tool and GHG calculators give same result
   - All GHG calculations are based on one set of standard values
2. Cause **transparency**
   in how RED default values were calculated
3. **Facilitate** stakeholders
   - Tools that allow own input and/or modifications to pathways
4. Broadly **disseminate** results







Thank you for your attention

Intelligent Energy Europe

The sole responsibility for the content of this presentation lies with the authors. It does not necessarily reflect the opinion of the European Union.

The European Commission is not responsible for any use that may be made of the information contained therein.

Project BioGrace – project background

Two approaches (ways of thinking) to perform biofuel GHG calculations on individual batches of biofuels

Poorer — *Applicability (part of legislation)* — *Better*

Complexity: *High* — *Low*

Scientific approach:
- High level of accuracy
- Case-specific numbers
- Variation (*eg* multiple years: crop rotation)
- Focus on correctness of results

Policy approach:
- Compromise between accuracy and applicability
- Average numbers
- Unambiguous and limited amount of variation
- Focus on applicability as part of legislation

CEN TC383 / WG2
Calculation method for GHG emissions under the RED

Jean-François Larivé, convenor

Objective

- Develop an EU standard for a GHG calculation method that complies with the EU Renewable Energy Directive (RED)
- Scope is biofuels and bioliquids (no solid biomass)

Schedule

- Work started late 2008
- Long delay while waiting for EU Commission clarification (Communication released in June 2010)
- Draft standard due to be delivered to CEN in November 2010

Outline (1)

- Common elements
  - Data quality and sources
  - Units and symbols
  - Basis for GHG emission terms
  - Allocation rules
  - Emissions from energy import/export
  - Emissions from transport and machinery use

Outline (2)

- Biofuels and bioliquids production chain
  - Land use
  - Biomass production
  - Biomass preparation
  - Biomass handling (inc. Transport)
  - Biomass conversion
  - Biofuel/bioliquid transport

- Includes processing of wastes and residues

Outline (3)

- Biofuels and bioliquids production chain
  - Land use
  - Biomass production
  - Biomass preparation
  - Biomass handling (inc. Transport)
  - Biomass conversion
  - Biofuel/bioliquid transport
    - Includes processing of wastes and residues
- Chain integration

Main issues

- Land use
  - Accounting for the degraded land bonus
- Basis for GHG emission terms
  - All terms based on output of the product of the particular step in the chain (not the final biofuel/bioliquid)
- Allocation rules
  - Energy allocation for wet products
- Emissions from energy import/export
  - Accounting for heat/electricity exports
- Chain integration
  - Consistency with CoC scheme
  - Combinig actual and default values

What can a standard contain?

- Principles
- Methodology

But not

- Hard data
- Threshold values

This is where CEN and Biograce can be complementary

The Swedish NUTS3-case

Heidelberg 23rd Sept 2010
Serina Ahlgren

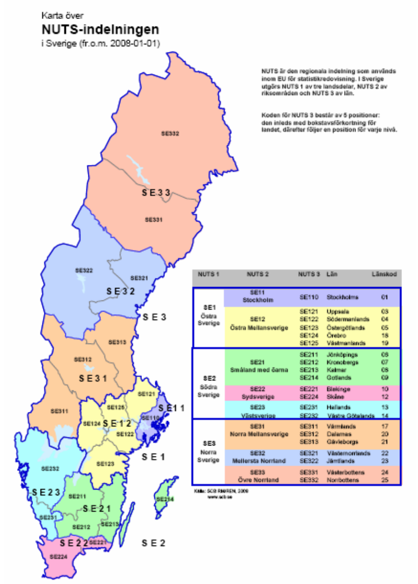
Calculated GHG emissions for

4 crops

- Winter wheat
- Triticale
- Spring barley
- Winter rapeseed

x

24 counties (NUTS 3)



WORKING GROUP

Swedish University of Agricultural Sciences:

Helene Lundkvist, *coordinator*

Serina Ahlgren

Per-Anders Hansson

Olle Andrén

Pär Aronsson

Marie Kimming

University of Gothenburg :

Åsa Kasimir Klemedtsson

REFERENCE GROUP

Anna Lundborg, Swedish Energy Agency

Sven-Olof Ericsson, Ministry of Enterprise, Energy and Communications

Camilla Lagerkvist-Tolke, Swedish Board of Agriculture

Alarik Sandrup, Federation of Swedish Farmers

Methodological choices

Typical values for each NUTS-region

Reference case extensive grassland

Base year for calculations 2010

Data from Statistics Sweden

Yields

Use of artificial fertilisers

Use of pesticides

Other agronomic input data

Moisture content at harvest

Nitrogen leaching

Clay content

Production of artificial fertilisers

Nitrogen 2,9 kg CO_2-eq/kg N

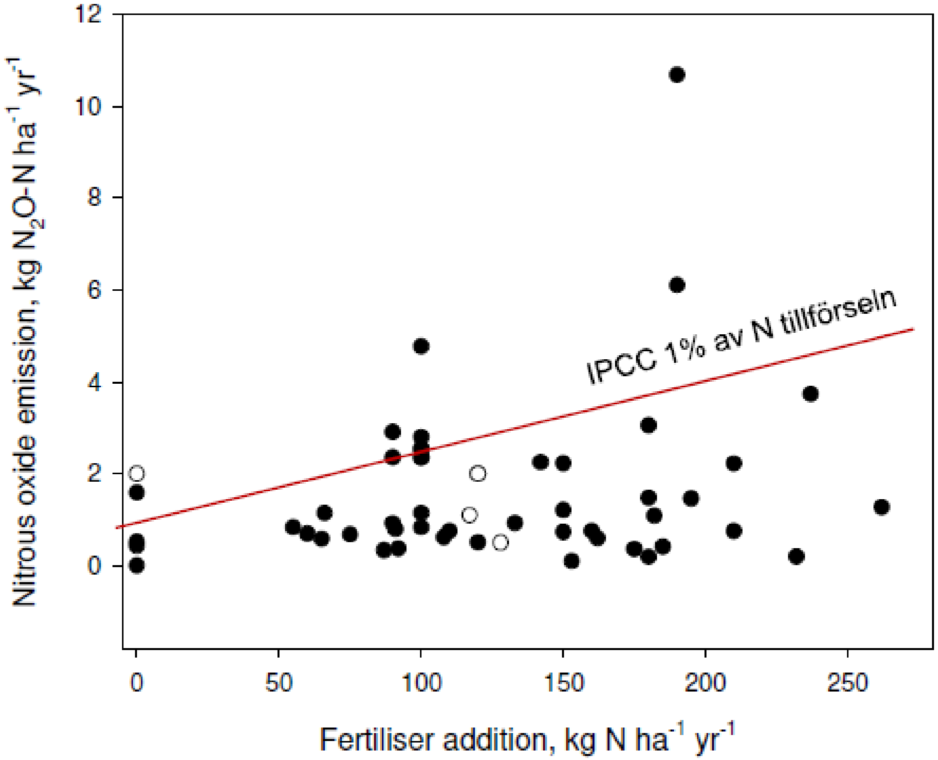
Phosphorus 0,71 kg CO_2-eq/kg P

Potassium 0,46 kg CO_2-eq/kg K

N_2O emissions

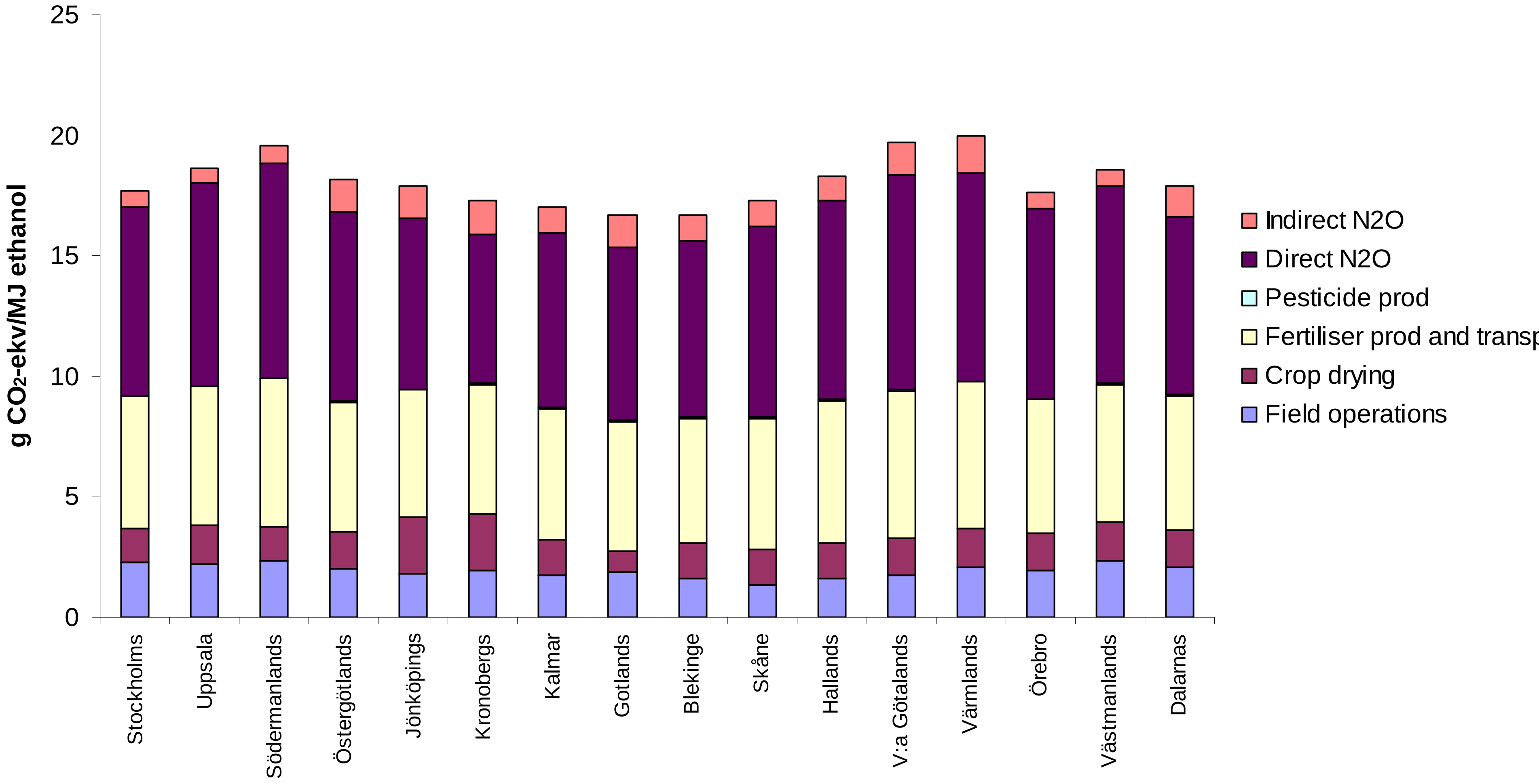
IPCC (2006), direct and indirect emissions

Compared to extensive grassland

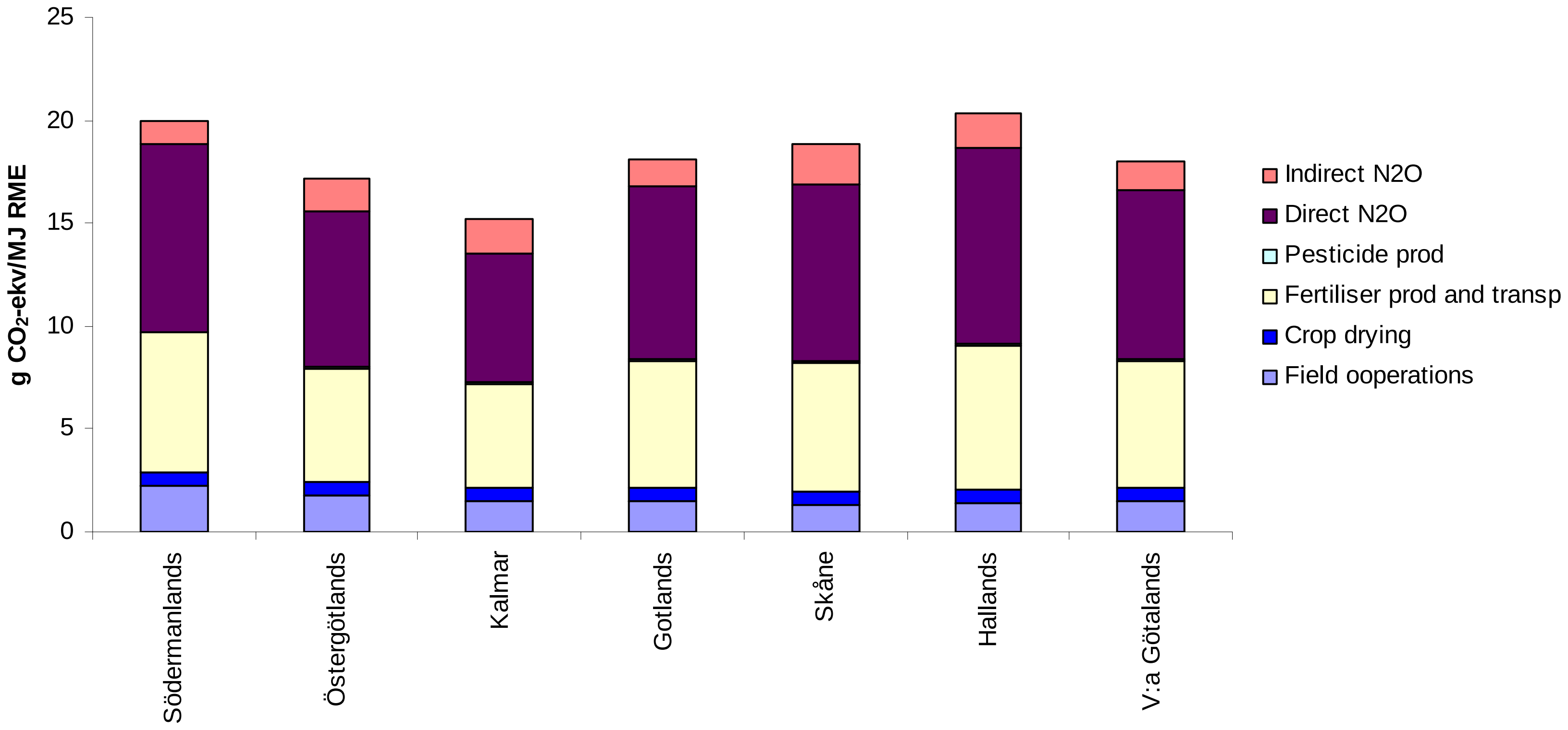


7 Natural N2O emissions on managed land are assumed to be equal to emissions on unmanaged land. These latter emissions are very low. Therefore, nearly all emissions on managed land are considered anthropogenic. Estimates using the IPCC methodology are of the same magnitude as total measured emissions from managed land. The so-called 'background' emissions estimated by Bouwman (1996) (i.e., approx. 1 kg N2O–N/ha/yr under zero fertiliser N addition) are not “natural” emissions but are mostly due to contributions of N from crop residue. These emissions are anthropogenic and accounted for in the IPCC methodology

Results winter wheat cultivation NUTS 3



Results rapeseed cultivation NUTS 3

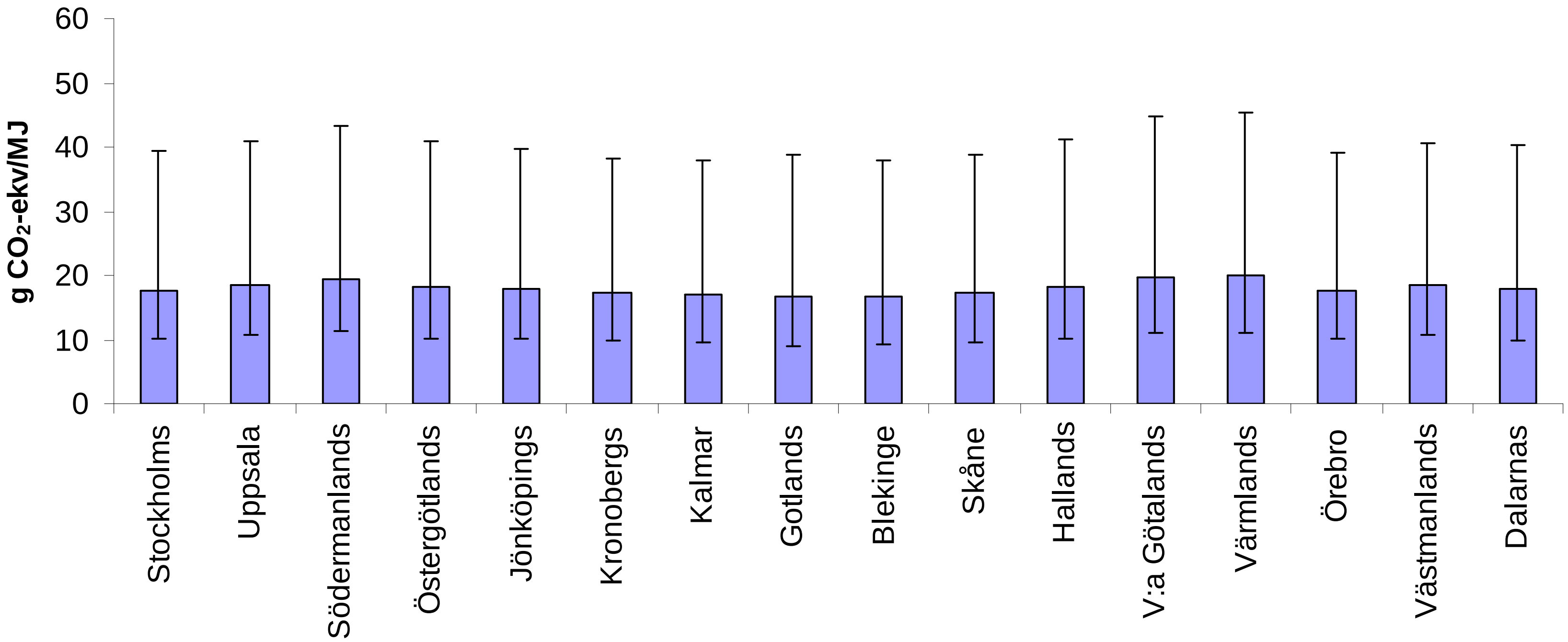


Actual values?

On farm (or field?) level you could collect

- Yields
- Amount of fertilisers
- Type of fertilisers
- Type of soil

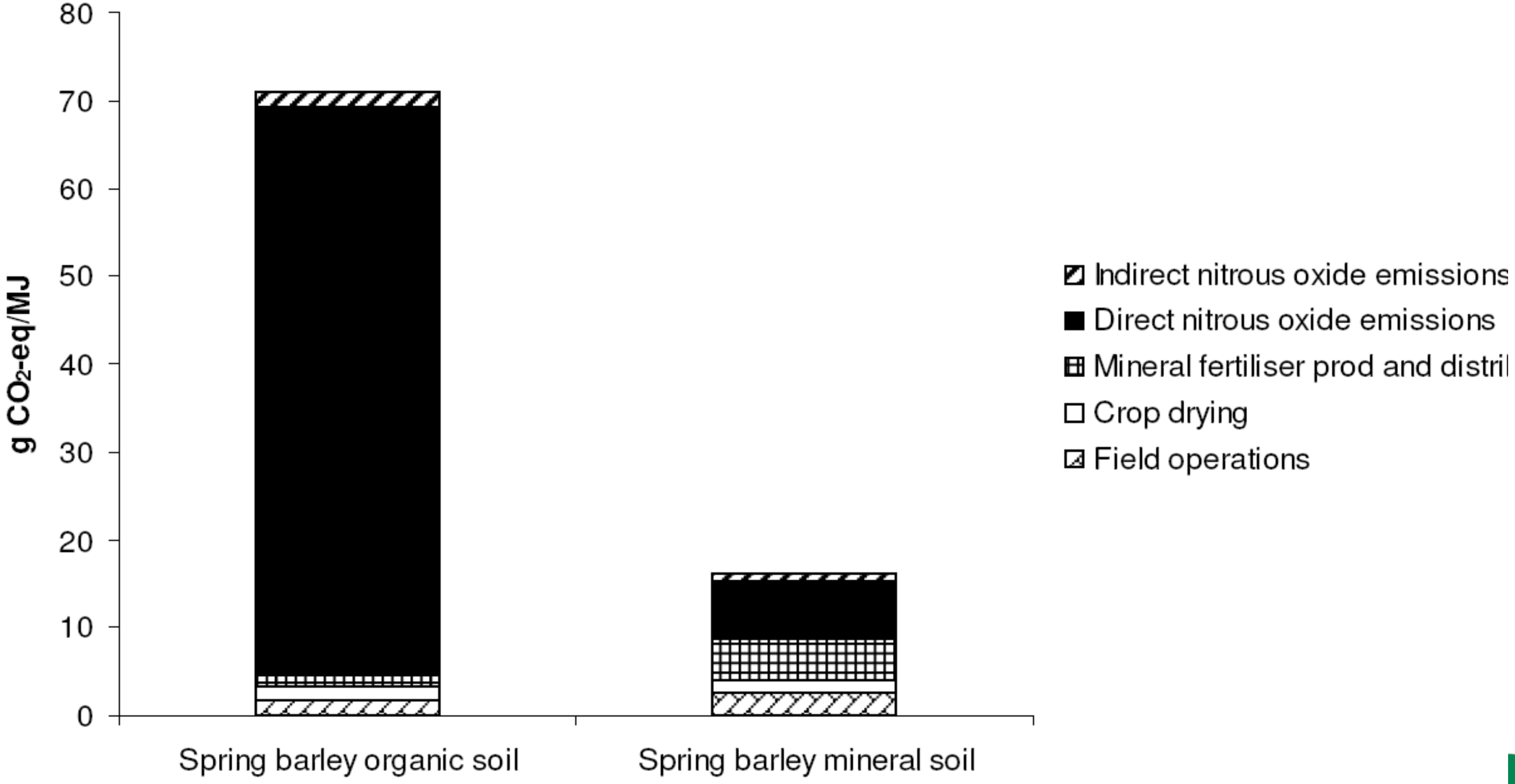
IPCC 2006 uncertainty range



Results for cultivation of winter wheat, including the uncertainty range for emission factors for direct and indirect nitrous oxide emissions

Organic soils

- N-fertilisers 20 kg N/ha year
- N-leaching 31 kg N/ha year
- Lower diesel consumption, light soil
- N_2O emissions +8 kg N_2O-N (IPCC, 2006)



Greenhouse gas emissions (g CO2-eq/MJ ethanol) from cultivation of spring barley on organic soils and mineral soils in Örebro County

serina.ahlgren@miljo.lth.se

Calculation of N_2O soil emissions from cultivation of potential biofuel crops in Europe taking into account natural and crop specific parameters

Presented by Robert Edwards (JRC – IE)
“New” method by Renate Koeble & Adrian Leip (JRC – IES)

Contact: renate.koeble@jrc.ec.europa.eu

BACKGROUND

- "Communication on… practical implementation…" says you can use IPCC tier 1 2 or 3 for actual value calculations.

- That applies at the moment, because no better or more convenient method is available worldwide. But the communication can be changed by the Commission in future.

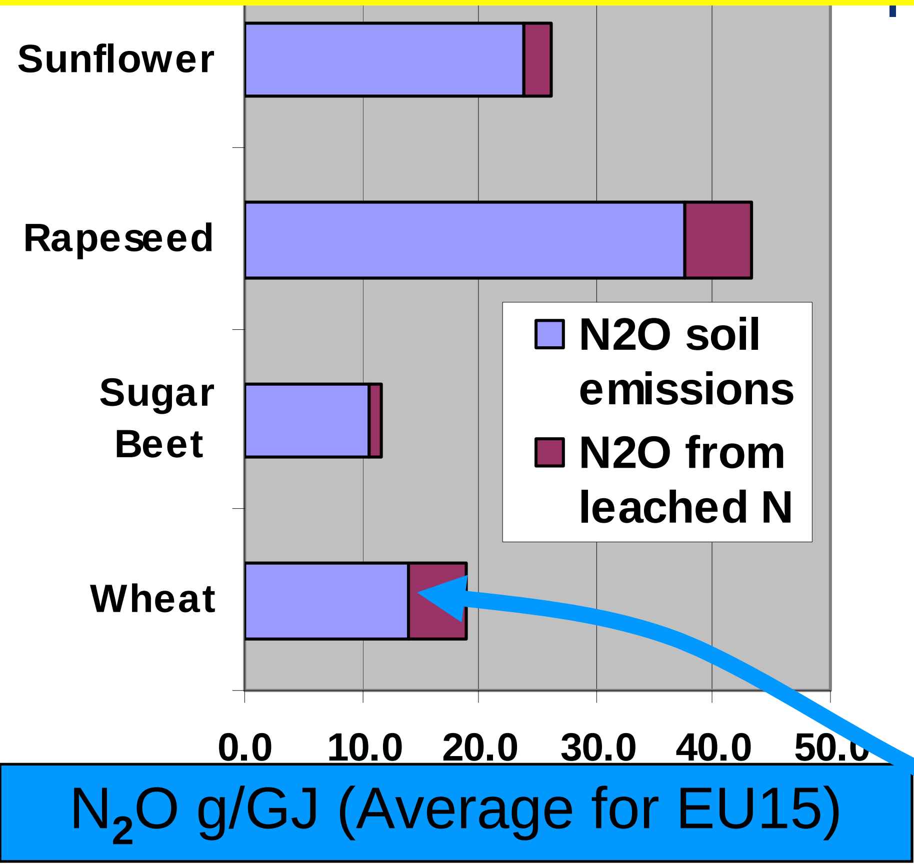
- Default values presently use:
  - FOR EU CROPS: JRC model using DNDC soil chemistry model
  - FOR OTHER CROPS: IPCC(2006)

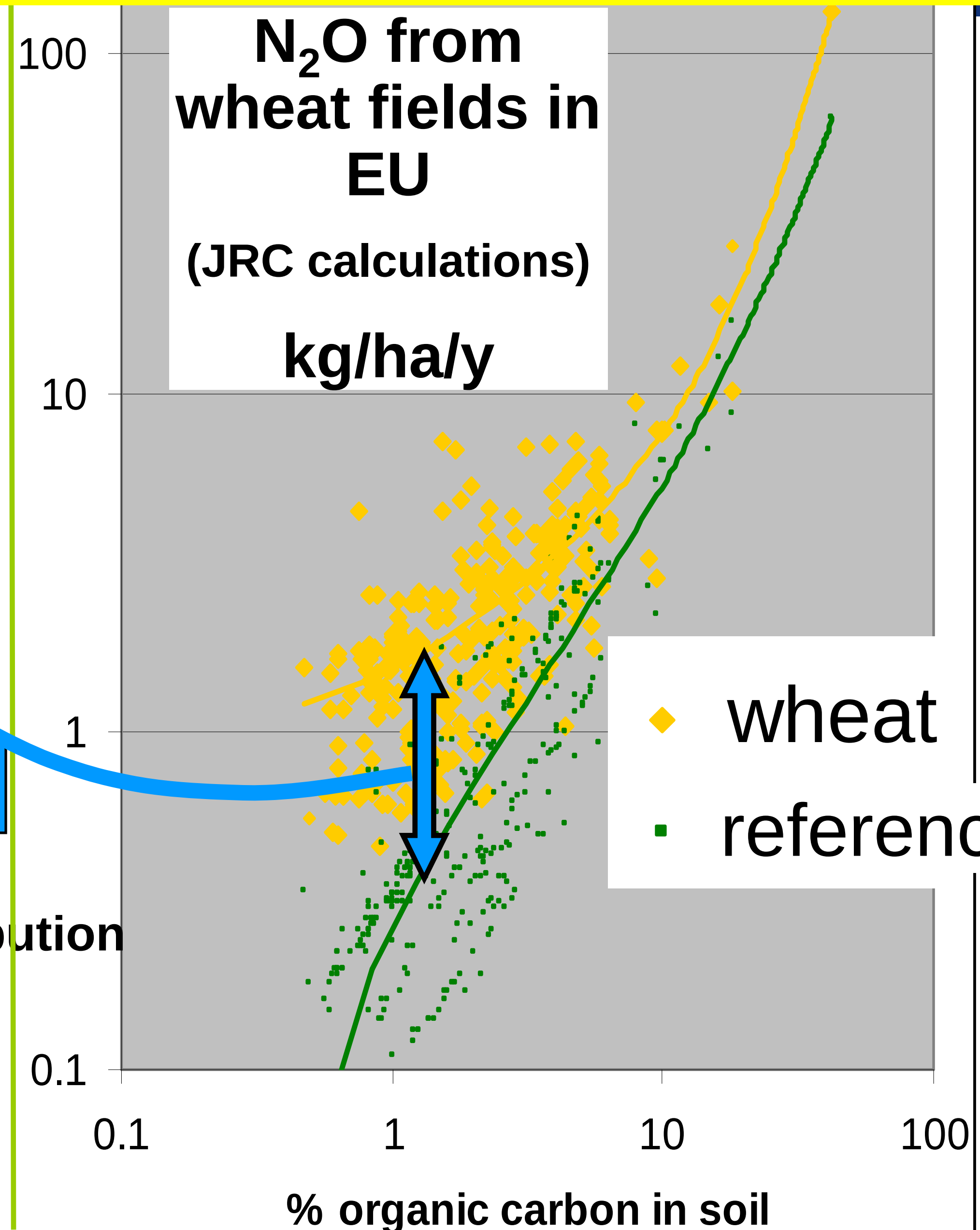
- JRC is working on a worldwide database of N_2O emissions per crop that can be used both for new default values and for calculating actual values.

THE "OLD" (existing) METHOD

- DNDC applied to LUCAS dataset of which crops are on 9000(?) grid-points in EU15
- Using local soil and weather data
- Using NUTS2 fertilizer and manure disaggregated per crop
- Daily N_2O emissions calculated for 2 years
- subtract reference emissions from unfertilized grass
- Caps on maximum emissions from "organic soils"
- Average results on points for each crop
- add IPCC indirect emissions using DNDC run-off %
- **range** dominated by range of indirect emissions
- (after communication of default values, IPCC reduced the range…reflected in WTWv3 only so far.

JRC estimated EU-average N_2O emissions per crop …but it varies by 1000x between fields!





depends on:

1. SOIL
2. Climate

} geographic crop distribution

3. Which reference crop?
4. Yield
5. N fertilizer input

New Method

- **Direct N_2O emissions from agricultural *mineral soils* based on the Stehfest & Bouwman (S&B) model**
- **Direct N_2O emissions from agricultural *organic soils* based on IPCC (2006)**
- **Indirect N_2O emissions via leaching/run-off* based on IPCC (2006)**
- **Reference land use: to be defined (example: managed grassland with animal manure applied)**

*It was assumed that the model of S& B implicitly already includes indirect emissions from volatilization and re-deposition

Direct N_2O emissions from *mineral soils*

The Stehfest & Bouwman model

statistical model based on >1000 N_2O emission measurements for agricultural fields

$$E = \exp\left(c + \sum ev\right)$$

where

E = emission of N_2O (kg N_2O-N ha^{-1} yr^{-1}),

c = constant

ev = effect value for different drivers

Direct N_2O emissions from *mineral soils*

The Stehfest & Bouwman model

statistical model based on >1000 N_2O emission measurements for agricultural fields

$$E = \exp\left(c + \sum ev\right)$$

That means each driver is represented by a *factor* on the emissions

ev is the natural logarithm of each factor

The Stehfest & Bouwman model table of ev = ln(factor)

	Agricultural fields	
Constant value	-1.516	
Parameter	Parameter class or unit	Effect value (ev)
Fertilizer Input (mineral and manure N)		0.0038 * N application rate in kg N ha-1 yr-1
Soil organic C content	<1 %	0
	1-3 %	0.0526
	>3 %	0.6334
pH	<5.5	0
	5.5-7.3	-0.0693

continued on next page

The Stehfest & Bouwman model CONTINUED table of ev = ln(factor)

Soil texture	Coarse	0
	Medium	-0.1583
	Fine	0.4312
Climate	Subtropical climate	0.6117
	Temperate continental climate	0
	Temperate oceanic climate	0.0226
	Tropical climate	-0.3022
Vegetation	Cereals	0
	Grass	-0.3502
	Legume	0.3783
	None	0.5870
	Other	0.4420
	Wetland rice	-0.8850
Length of Experiment	1 yr	1.9910

Direct N_2O emissions from *organic soils*

IPCC (2006)

	Value	Source	N source considered
Direct emissions from Fertilizer Input [kg N_2O-N (kg N)$^{-1}$] EF_1	0.01	IPCC Guidelines (2006), Vol.4, Ch.11, Tab.11.1	Mineral fertilizer and applied animal manure,
Temperate organic crop and grassland soils (kg N_2O-N ha^{-1}) $EF_{2CG,Temp}$	8	IPCC Guidelines (2006). Vol.4, Ch.11, Tab.11.1	

*Factors are combined fractions of NH3/NOx volatilized/leached from the N input (mineral/organic fertilizer, crop residues, mineralization associated with loss of soil organic carbon) and emission factors given in IPCC Guidelines (2006), Vol.4, Ch.11, Tab. 11.3.

Indirect N_2O emissions from *mineral and organic soils*

IPCC (2006)

	Value	Source
N2O from N leaching/runoff from managed soils in regions where leaching/runoff occurs [kg N_2O-N (kg N)$^{-1}$] $Frac_{LEACH-(H)}$ and EF_5	0.00225*	IPCC Guidelines (2006), Vol.4, Ch.11, Tab.11.3;

*Factors are combined fractions of NH3/NOx volatilized/leached from the N input (mineral/organic fertilizer, crop residues, mineralization associated with loss of soil organic carbon) and emission factors given in IPCC Guidelines (2006), Vol.4, Ch.11, Tab. 11.3.

Input Data (10 by 10 km grid)

Crop distribution and yield:
Data for single crops is available on a 5 by 5minutes grid for year 2000 from Monfreda et al. (2008).

Mineral Fertilizer input:
based on country fertilizer consumption for the year 2000 from the International Fertilizer Association (IFA, 2009) and crop and country specific fertilizer application given in IFA/IFDC/FAO (1999)

Organic fertilizer input:
Total N input from manure on agricultural land per country was available on a country level from the EDGAR database (JRC/PBL, 2009) for the year 2000. The N input from manure was distributed homogeneously over crop and grassland areas within the countries.

continued…

Input Data (continued) (10 by 10 km grid)

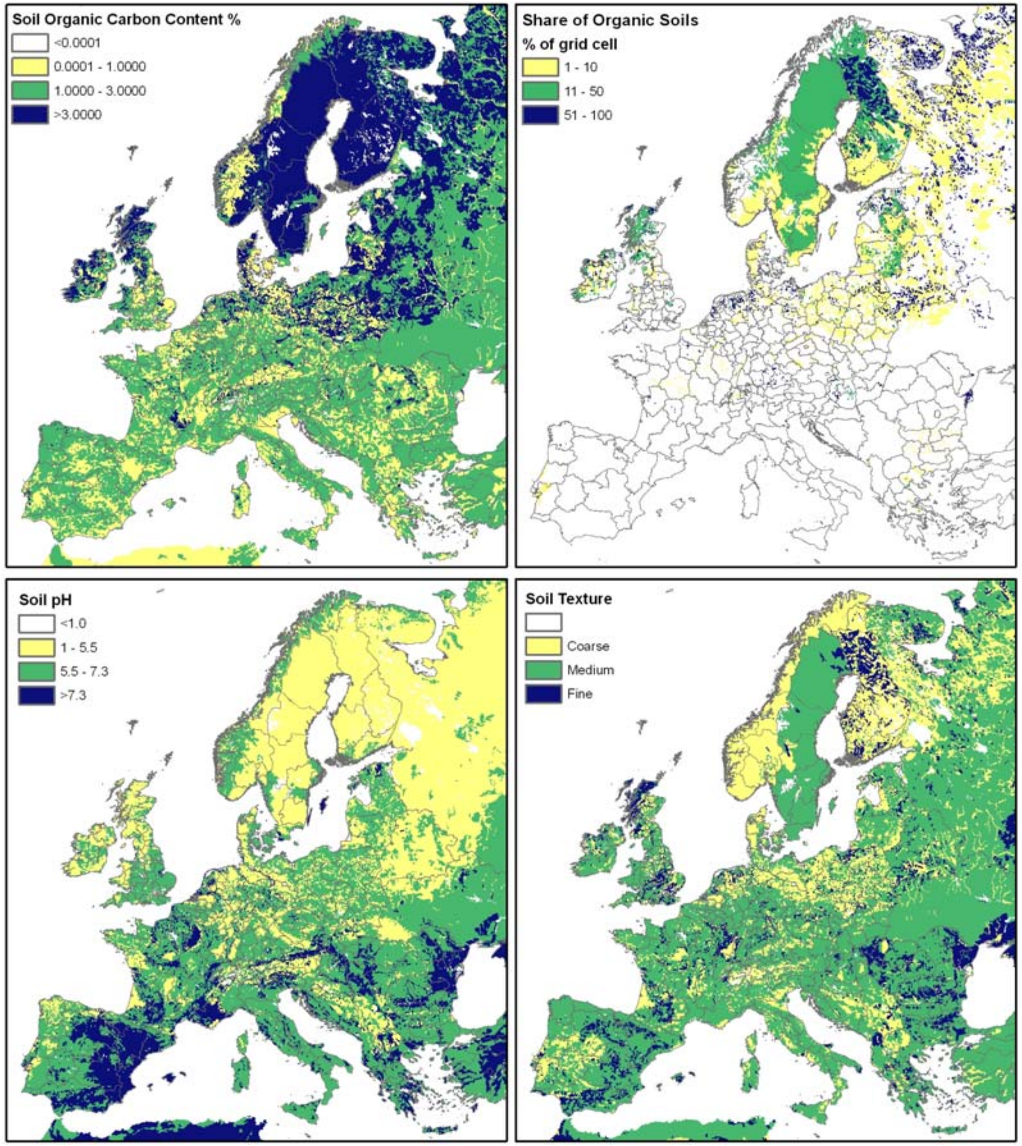
Soil properties:

Soil properties required were calculated based on the Harmonized World Soil Database Version 1.1, March 2009 (FAO/IIASA/ISRIC/ISS-CAS/JRC, 2009) by Hiederer (2009).

Climate zones:

A ecological/climate zones map as defined in IPCC (2006) volume 4 chapter 3 and 4 for the calculation of carbon stock changes has been compiled by Hiederer (2010).

Example of Input Data: Soil properties

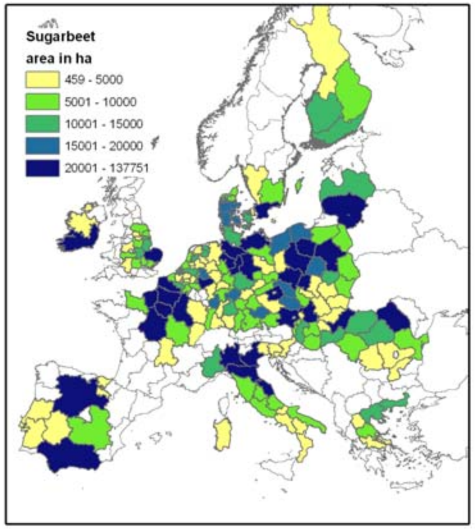


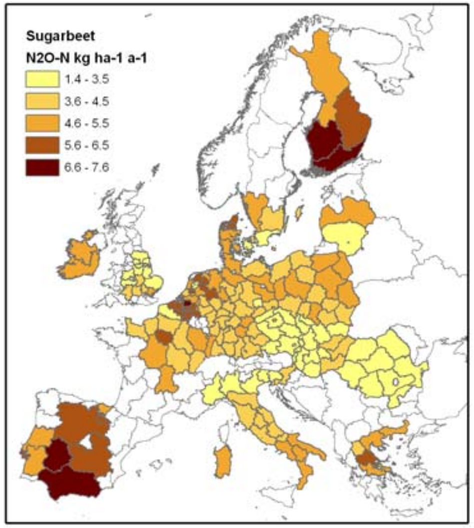
Example of Results on NUTS2 level: Sugar beet and Rapeseed

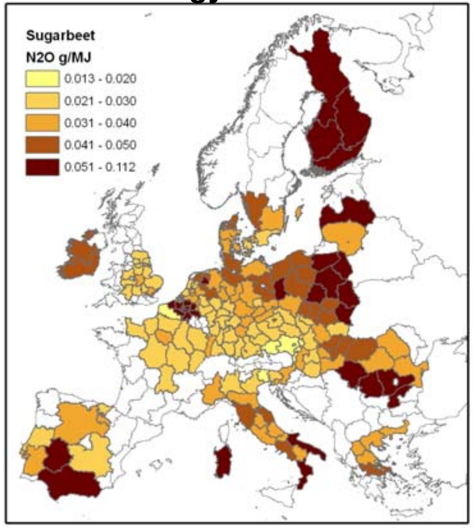
Crop area in ha

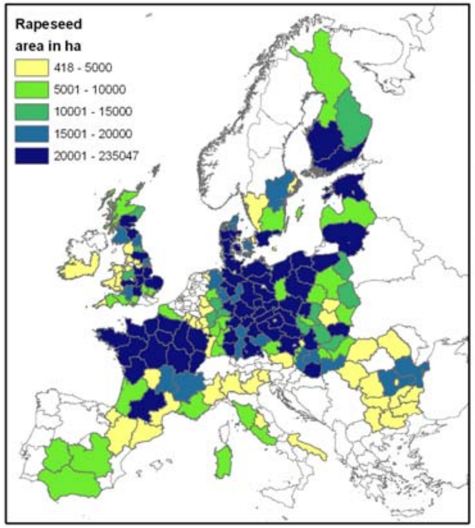
N_2O Emissions per ha

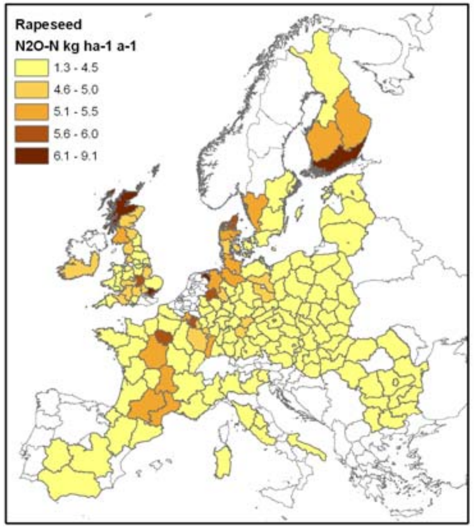
N_2O Emissions per MJ of biofuel energy content

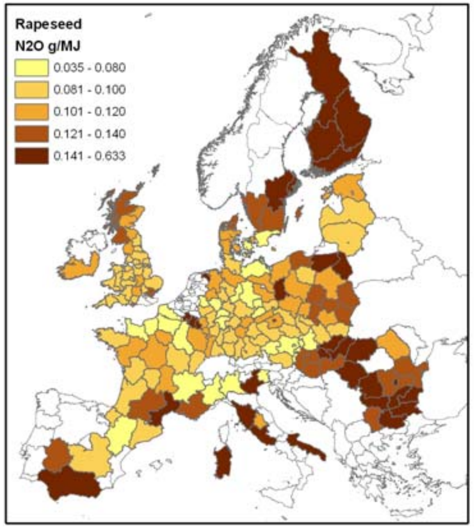












Note: reference land use "managed grassland" considered, energy content values refer to the crop yield not the bio-ethanol/diesel produced

Example of Results on NUTS2 level

			Data based on harmonized Data Sets for EU27								
NUTS2 Code	NUTS2 Name	Crop Name	Crop area where leaching occurs (in %)	Crop area on organic soils (%)	Crop area (ha)	Crop Yield (kg ha-1)	Manure Input (kg N ha-1 a-1)	Mineral Fertilizer Input (kg N ha-1 a-1)	Direct and Indirect Emissions from Crop Cultivation (kg N20-N / ha)	Direct and Indirect Emissions from Grassland fertilized with Manure (kg N20-N / ha)	Direct and Indirect Emissions from Crop Cultivation with Reference Land Use "Grassland fertilized with Manure" subtracted (kg N20-N / ha)
AT11	Burgenland (A)	rapeseed	26	5	8069	2364	36	103	4.15	1.26	2.88
AT12	Niederosterreich	rapeseed	31	0	35546	2400	36	103	3.17	0.96	2.21
AT22	Steiermark	rapeseed	100	0	710	2324	36	103	4.00	1.21	2.79
AT31	Oberosterreich	rapeseed	100	0	7458	2778	36	103	3.74	1.13	2.61
BE34	Prov. Luxembourg (B)	rapeseed	100	0	497	2466	174	83	7.05	2.53	4.52
BE35	Prov. Namur	rapeseed	100	0	1723	2056	174	83	6.21	2.25	3.95
BG31	Severozapaden	rapeseed	1	1	2158	1051	9	11	3.94	1.71	2.23

Example of Results on NUTS2 level

Country ID	Country Name	NUTS2 Code	NUTS2 Name	Crop Name	Crop area wher
13	AUSTRIA	AT11	Burgenland (A)	rapeseed	
13	AUSTRIA	AT12	Niederosterreich	rapeseed	
13	AUSTRIA	AT22	Steiermark	rapeseed	1
13	AUSTRIA	AT31	Oberosterreich	rapeseed	1
16	BELGIUM	BE34	Prov. Luxembourg (B)	rapeseed	1
16	BELGIUM	BE35	Prov. Namur	rapeseed	1
20	BULGARIA	BG31	Severozapaden	rapeseed	

Data based on harmonized Data Sets for EU27

Crop area where leaching occurs (in %)	1	100	100	100	100	31	26
Crop area on organic soils (%)	1	0	0	0	0	0	5
Crop area (ha)	2158	1723	497	7458	710	35546	8069
Crop Yield (kg ha-1)	1051	2056	2466	2778	2324	2400	2364
Manure Input (kg N ha-1 a-1)	9	174	174	36	36	36	36
Mineral Fertilizer Input (kg N ha-1 a-1)	11	83	83	103	103	103	103
Direct and Indirect Emissions from Crop Cultivation (kg N20-N / ha)	3.94	6.21	7.05	3.74	4.00	3.17	4.15
Direct and Indirect Emissions from Grassland fertilized with Manure (kg N20-N / ha)	1.71	2.25	2.53	1.13	1.21	0.96	1.26
Direct and Indirect Emissions from Crop Cultivation with Reference Land Use "Grassland fertilized with Manure" subtracted (kg N20-N / ha)	2.23	3.95	4.52	2.61	2.79	2.21	2.88

More Information and Data are Available on Request to

renate.koeble@jrc.ec.europa.eu

EUROPEAN COMMISSION JRC

Documents you will need:

Institute for Environment and Sustainability

1. ***Basis:*** **RE Directive 2009/28/EC, especially annex V**

2. ***Further guidance:***

   "Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels"

   Google: (2010/C 160/02)

   http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2010:160:0008:0016:EN:PDF

3. ***Most input data:***

   "Input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology"

   http://re.jrc.ec.europa.eu/biof/html/input_data_ghg.htm

4. ***Data we forgot (fertilizer manufacture etc.):***

   JEC WTW report version 2C, **WTT App. 1**, section 10, p. 40

   http://ies.jrc.ec.europa.eu/jec-research-collaboration/downloads-jec.html menu on sheet 1

RESULTS AND INPUT DATA FOR BIOFUELS PATHWAYS

Methdology according to rules laid out in the Renewables Directive proposal

Data as per 14/11/2008

Results

Ethanol
FAME/HVO
Biogas

Input data

Code	*Final fuel*	*Feedstock*
SBET	Ethanol	Sugar beet
WTET	Ethanol	Wheat
CET	Ethanol	Corn
ROFA	FAME	Rape seed
SOFA	FAME	Sunflower seed
SYFA	FAME	Soy beans
Waste oil	FAME	Animal fat
		Waste cooking oil
HVO	Hydrotreated veg. oil	Vegetable oil
OWCG	Biogas (compressed)	Municipal waste
		Wet manure
		Dry manure

menu on sheet 1

RESULTS AND INPUT DATA FOR BIOFUELS PATHWAYS

Methdology according to rules laid out in the Renewables Directive proposal

Data as per 14/11/2008

Results

Ethanol
FAME/HVO
Biogas

Input data

Code	*Final fuel*	*Feedstock*
SBET	Ethanol	Sugar beet
WTET	Ethanol	Wheat
CET	Ethanol	Corn
ROFA	FAME	Rape seed
SOFA	FAME	Sunflower seed
SYFA	FAME	Soy beans
Waste oil	FAME	Animal fat
		Waste cooking oil
HVO	Hydrotreated veg. oil	Vegetable oil
OWCG	Biogas (compressed)	Municipal waste
		Wet manure
		Dry manure

3. "Input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology" ETHANOL RESULTS SHEET

Ethanol

Back to menu

		Standard step	Energy consumed (MJx/MJf) Total primary Best est.	Total primary min	Total primary Max	Fossil	Net GHG emitted ($g\ CO_2eq/MJf$) Best est.	min	Max	CO_2 g/MJ	CH_4 g/MJ	N_2O g/MJ
SBET1a	**Ethanol from sugar beet, sugar beet pulp taken into account via allocation by energy (w/o biogas from slop)**											
	Cultivation	1	0.08				11.54			5.1	0.01	0.021
	Road transport, 30 km	3	0.01				0.84			0.8	0.00	0.000
	Ethanol plant	4	0.64				18.87			17.4	0.05	0.000
	Ethanol road transport [1)]	5	0.02				1.10			1.1	0.00	0.000
	Refuelling station	5	0.01				0.44			0.4	0.00	0.000
	Total WTT GHG emitted						**32.8**	31.0	36.9	24.9	0.06	0.021
	Credit for renewable combustion CO_2						-71.3			-71.3		
	Total pathway		**0.76**	0.68	0.83	**0.44**	**-38.5**	-40.2	-34.4			
SBET1b	**Ethanol from sugar beet, sugar beet pulp taken into account via allocation by energy (w biogas from slop)**											
	Cultivation	1	0.08				11.54			5.1	0.01	0.021
	Road transport, 30 km	3	0.01				0.84			0.8	0.00	0.000
	Ethanol plant	4	0.49				9.47			8.8	0.03	0.000
	Ethanol road transport [1)]	5	0.02				1.10			1.1	0.00	0.000
	Refuelling station	5	0.01				0.44			0.4	0.00	0.000
	Total WTT GHG emitted						**23.4**	21.4	27.5	16.2	0.03	0.021
	Credit for renewable combustion CO_2						-71.3			-71.3		
	Total pathway		**0.60**	0.53	0.67	**0.29**	**-47.9**	-49.8	-43.7			
WTET1	**Ethanol from Wheat, NG boiler, DDGS taken into account via allocation by energy**											
	Cultivation	1	0.16				23.43			10.3	0.02	0.043
	Road transport, 50 km	3	0.02				0.38			0.4	0.00	0.000
	Ethanol plant	4	0.48				21.12			19.5	0.06	0.000
	Ethanol road transport [1)]	5	0.02				1.10			1.1	0.00	0.000
	Refuelling station	5	0.01				0.44			0.4	0.00	0.000
	Total WTT GHG emitted						**46.5**	43.0	52.1	31.7	0.08	0.043
	Credit for renewable combustion CO_2						-71.3			-71.3		
	Total pathway		**0.69**	0.67	0.70	**0.56**	**-24.8**	-28.3	-19.1			

etc.

3. "Input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology" ETHANOL RESULTS SHEET

Ethanol

transport and distribution emissions for all steps are added together in RED		Net GHG e (g CO_2eq/ Best est.	m
SBET1a	**Ethanol from sugar beet, sugar beet p ergy (w/o biog**		
	Cultivation	11.54	
	Road transport, 30 km	0.84	
	Ethanol plant	18.87	
	Ethanol road transport [1)]	1.10	
	Refuelling station	0.44	
	Total WTT GHG emitted	**32.8**	31
	Credit for renewable combustion CO_2	-71.3	
	Total pathway	**-38.5**	-40
SBET1b	**Ethanol from sugar beet, sugar beet p ergy (w biogas**		

3. “Input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology” ETHANOL RESULTS SHEET

Ethanol

		Standard step	Energy consumed (MJx/MJf)				Net GH (g CO
			Total primary			Fossil	
			Best est.	min	Max		Best est.
SBET1a	**Ethanol from sugar beet, sugar beet pulp taken into account via allocation by energy (w/o b**						
	Cultivation	1	0.08				11.54
	Road transport, 30 km	3	0.01				0.84
	Ethanol plant	4	0.64				18.87
	Ethanol road transport [1)]	5	0.02				1.10
	Refuelling station	5	0.01				0.44
	Total WTT GHG emitted						**32.8**
	Credit for renewable combustion CO_2						-71.3
	Total pathway		**0.76**	0.68	0.83	**0.44**	**-38.5**
SBET1b	**Ethanol from sugar beet, sugar beet pulp taken into account via allocation by energy (w bio**						
	Cultivation	1	0.08				11.54
	Road transport, 30 km	3	0.01				0.84
	Ethanol plant	4	0.49				9.47
	Ethanol road transport [1)]	5	0.02				1.10
	Refuelling station	5	0.01				0.44
	Total WTT GHG emitted						**23.4**
	Credit for renewable combustion CO_2						-71.3
	Total pathway		**0.60**	0.53	0.67	**0.29**	**-47.9**
WTET1	**Ethanol from Wheat, NG boiler, DDGS taken into account via allocation by energy**						
	Cultivation	1	0.16				23.43

etc.

Sugar beet cultivation

	I/O	Unit	Amount
Diesel	Input	$MJ/MJ_{sugar\ beet}$	0.0226
N fertilizer	Input	$kg/MJ_{sugar\ beet}$	0.00042
CaO fertilizer	Input	$kg/MJ_{sugar\ beet}$	0.00143
K_2O fertilizer	Input	$kg/MJ_{sugar\ beet}$	0.00048
P_2O_5 fertilizer	Input	$kg/MJ_{sugar\ beet}$	0.00021
Pesticides	Input	$kg/MJ_{sugar\ beet}$	0.0000046
Seeding material	Input	$kg/MJ_{sugar\ beet}$	0.000021
Sugar beet	Output	MJ	1.0000
Field N_2O emissions	-	$g/MJ_{sugar\ beet}$	0.012

Source:

Dreier, T.; Geiger, B.; Lehrstuhl für Energiewirtschaft und Kraftwerkstechni

10 Production of agro-chemicals

All data on fertilizer and fuel inputs for agro-chemicals provision come from [*Kaltschmitt 1997*]. These data include the transport of the processes, the "MJ primary energy per MJ input" of fuel inputs includes the LHV and fossil carbon (as CO2) content of the fuel itself, as we energy/emissions to make it. However, [*Kaltschmitt 1997*] do not include upstream energies and emissions, so our figures are moderatel where a lot of electricity is used. Our primary energies are similar to those in the new [*ADEME 2003*] report.

Code	Process	Assoc. processes	Input	Expended energy			GHG emissions			
			kg/ kg prod.	As used MJ/ kg prod.	MJx/ MJ	Primary MJx/ kg prod.	g CO_2/ kg prod.	g CH_4/ kg prod.	g N_2O/ kg prod.	g CO_2eq/ kg prod.
AC1	**Nitrogen Fertilizer Provision**									
	Electricity (EU-mix, MV)	Z7a		0.6	2.83	1.78	74.8	0.18	0.0034	80.0
	Hard coal	KO1		3.9	1.09	4.32	405.8	1.51	0.0011	440.8
	Diesel	Z1		0.9	1.16	1.00	75.3	0.00	0.0000	75.3
	Heavy fuel oil	Z3		4.4	1.09	4.77	384.1	0.00	0.0000	384.1
	NG	Z6		33.0	1.13	37.31	2083.0	6.58	0.0008	2234.7
	N2O from process								9.6300	
	Primary energy and emissions/kg					***49.17***	*3022.9*	*8.27*	*9.6353*	***6065.3***
AC2	**P fertilizer provision**									
	Electricity (EU-mix, MV)	Z7a		1.6	2.83	4.54	191.2	0.47	0.0086	204.5
	Hard coal	KO1		0.6	1.09	0.62	58.6	0.22	0.0002	63.6
	Diesel	Z1		1.1	1.16	1.30	98.1	0.00	0.0000	98.1
	Heavy fuel oil	Z3		5.0	1.09	5.44	438.3	0.00	0.0000	438.3
	NG	Z6		3.2	1.13	3.56	198.8	0.63	0.0001	213.3
	Primary energy and emissions/kg					***15.47***	*985.0*	*1.31*	*0.0089*	***1017.8***
AC3	**K fertilizer provision**									
	Electricity (EU-mix, MV)	Z7a		0.2	2.83	0.62	26.2	0.06	0.0012	28.0
	Diesel	Z1		0.5	1.16	0.63	47.3	0.00	0.0000	47.3
	NG	Z6		7.5	1.13	8.48	473.4	1.50	0.0002	507.8
	Primary energy and emissions/kg					***9.73***	*546.9*	*1.56*	*0.0014*	***583.2***
AC4	**CaO fertilizer provision (85%CaCO3+15%CaO,Ca(OH)2)**									
	Electricity (EU-mix, MV)	Z7a		0.4	2.83	1.13	47.7	0.12	0.0022	51.0
	Coal	KO1		0.3	1.09	0.35	33.3	0.12	0.0001	36.2
	Diesel	Z1		0.2	1.16	0.21	16.2	0.00	0.0000	16.2
	NG	Z6		0.3	1.13	0.34	18.9	0.06	0.0000	20.3
	Primary energy and emissions/kg					***2.04***	*116.1*	*0.30*	*0.0023*	***123.7***
AC5	**Pesticides (etc) provision**									
	Electricity (EU-mix, MV)	Z7a		28.5	2.83	80.72	3398.9	8.29	0.1535	3635.0
	Hard coal	KO1		7.6	1.09	8.35	784.2	2.91	0.0021	851.9
	Diesel	Z1		58.1	1.16	67.40	5086.9	0.00	0.0000	5086.9
	Heavy fuel oil	Z3		32.5	1.09	35.37	2849.9	0.00	0.0000	2849.9
	NG	Z6		71.4	1.13	80.71	4505.9	14.24	0.0018	4834.0
	Primary energy and emissions/kg					***272.55***	*16625.8*	*25.45*	*0.1573*	***17257.6***

JEC-WTW vs. RE Directive data:

- Existing default/typical values use the same **database** as JEC-WTWv2c

…but a different methodology!

- All of JEC-WTW v2c is on-line: http://ies.jrc.ec.europa.eu/jec-research-collaboration/downloads-jec.html
- Also there you will also see *WTT results and input data* for JEC-WTW**v3**....see WTT App1 and 2. This is not relevant.
- New default values are in preparation which use a LATER version of JEC input data database than v3: the database and new defaults will be published together

Procedure to work out actual values:

- Default values calculated by the Commission are typical values + (40% of the emissions from the processing).
- Typical values (for a given type of biofuel) are supposed to represent the mix of that sort of biofuel likely to be used in EU.