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# JEC Well-to-Tank (WTT) Study: Early Results from Version 4

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# What's New

- WTT data significantly updated and strengthened
  - Input from stakeholders, new studies from JRC
- The time horizon is 2010 to 2020+
- More attention to electricity as BEV and PHEV gain interest.
  - Revised EU electricity mix
- Improved biofuel calculations, for $N_2O$, fertilisers
- This presentation will cover
  - Improved transparency in detailed data presentation
    - Seven Excel results workbooks covering:
      - Oil and gas Biogas Ethanol Biodiesel
      - Synfuels Electricity Heat and Power
- Differences in Version 4 WTT results compared to Version 3c
- Version 4 covers energy and GHG emissions

# Workbook Pathways: Ethanol Example

**JEC WTW study Version** **4.0**

**WTT pathways**

**Ethanol**

| | |
|---|---|
| Summary | Summary results and graphs |
| General notes | General information relevant to all or most pathways in this section |

| *Code* | *Final fuel* | *Description* |
|---|---|---|
| SBET1 | Ethanol | EU sugar beet to ethanol. Pulp to animal feed (a/b). Pulp to fuel (c)<br>Slops not used (a) or used as feed for biogas (b/c). |
| WTET1a/b | | EU wheat to ethanol. Production energy provided by as heat from NG-fired boiler and grid electricity.<br>DDGS to animal feed (a) or to electricity production (b). |
| WTET2a/b | | EU wheat to ethanol. Production energy provided by a NG-fired CHP plant.<br>DDGS to animal feed (a) or to electricity production (b). |
| WTET3a/b | | EU wheat to ethanol. Production energy provided by a lignite-fired CHP plant.<br>DDGS to animal feed (a) or to electricity production (b). |
| WTET4a/b | | EU wheat to ethanol. Production energy provided by a wood-fired CHP plant.<br>DDGS to animal feed (a) or to electricity production (b). |
| WTET5 | | EU wheat to ethanol. DDGS used as internal fuel to produce electricity via biogas. |
| BRET2 | | EU mix barley/rye grain 50/50 ethanol. Production energy provided by a NG-fired CHP plant. DDGS to animal feed. |
| WW/WFET1 | | EU farmed (WF) or waste (WW) wood to ethanol. |
| SCET1a/b | | Brazilian sugar cane to ethanol.<br>Excess bagasse used for heat (a), electricity (b) production |
| STET1 | | EU wheat straw to ethanol. |
| CRET2 | | Corn (maize) (average used in EU) to ethanol. Production energy provided by a NG-fired CHP plant. DDGS to animal feed. |
| CRETus | | Corn (maize) (average used in EU) to ethanol. Production energy provided by a NG-fired CHP plant. DDGS to animal feed. |

| | |
|---|---|
| Agri inputs | Data relative to the production and provision of agricultural inputs such as fertilisers, pesticides etc |
| Process chemicals | Data relative to the production and provision of process chemicals |

# Workbook Pathways: EU Wheat to Ethanol

## JEC WTW study Version 4.0

### WTT pathway

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| | | |
|---|---|---|
| *Code* | **WTET1a/b** | *Description* |
| *Final fuel* | **Ethanol** | EU wheat to ethanol. Production energy provided by as heat from NG-fired boiler and grid electricity.<br>DDGS to animal feed (a) or to electricity production (b). |

### Results

| ***JEC methodology*** | | Energy expended $MJ/MJ_{EtOH}$ | GHG emissions $g\ CO_{2eq}/MJ_{EtOH}$ Total | as $CO_2$ | as $CH_4$ | as $N_2O$ |
|---|---|---|---|---|---|---|
| *Standard steps* | *Actual steps* | **WTET1a** | | | | |
| Production & conditioning at source | Wheat cultivation | 0.29 | 49.6 | 19.72 | 0.78 | 29.08 |
| | Grain drying, storage and handling | 0.03 | 1.5 | 1.40 | 0.08 | 0.02 |
| Transformation at source | *NA* | | | | | |
| Transportation to market | Wheat grain transport | 0.03 | 1.0 | 1.03 | 0.01 | 0.01 |
| Transformation near market | Ethanol production | 1.35 | 15.9 | 25.17 | 2.20 | -11.45 |
| | *Of which credit for DDGS* | *-0.15* | *-22.4* | *-10.33* | *-0.36* | *-11.72* |
| | *Of which credit for surplus electricity from DDGS* | | | | | |
| Conditioning & distribution | Distribution | 0.02 | 1.1 | 1.11 | 0.02 | 0.01 |
| | Dispensing at retail site | 0.01 | 0.5 | 0.48 | 0.03 | 0.01 |
| **Total WTT** | | **1.73** | **69.7** | | | |
| *Min* | | *1.71* | *66.3* | | | |
| *Max* | | *1.76* | *72.0* | | | |
| of which Fossil | | 0.78 | | | | |
| of which Nuclear | | 0.09 | | | | |
| Combustion $CO_2$ emissions | | | 71.4 | | | |
| of which Renewable (shown as negative) | | | -71.4 | | | |
| **Total non-renewable emissions including combustion** | | | **69.7** | | | |
| **% GHG savings relative to gasoline (pathway COG1)** | | | **21%** | | | |

# Workbook Pathways: EU Wheat to Ethanol

## Input data

**Physical properties of products and intermediates relevant to this pathway**

| | | Wheat | Ethanol | DDGS |
|---|---|---|---|---|
| Density | kg/m$^3$ | | 794 | |
| Typical moisture content | % m | 16.0% | | 10.0% |
| LHV (dry matter) | MJ/kg | 17.1 | 26.8 | 18.7 |
| Carbon content | % m | | 52.2% | |
| $CO_2$ emission factor | g $CO_2$/MJ | | 71.4 | |
| (assuming total combustion) | kg $CO_2$/kg | | 1.91 | |

*The figures below generally refer to the output of each step rather than to the final product.*
*Energy and emissions terms cannot therefore simply be added up to estimate the overall pathway figures.*

| Process code | Step | Common processes | | Input | Range | | Dist. | Source |
|---|---|---|---|---|---|---|---|---|
| | **Production & conditioning at source** | | | | | | | |
| **WT1a** | **Wheat cultivation** | | | | | | | |
| | Agricultural inputs | | | | | | | |
| | Fertilizers | | g/$MJ_{grain}$ | | | | | |
| | N (as N) | FN | | 1.34 | | | | [Edwards 2012] |
| | P (as $P_2O_5$) | FP | | 0.28 | | | | [EFMA 2005/2006] |
| | K (as $K_2O$) | FP | | 0.21 | | | | [EFMA 2005/2006] |
| | CaO | CA | | 1.44 | | | | [Edwards 2012] |
| | Pesticides | PE | g/$MJ_{grain}$ | 0.07 | | | | [CAPRI 2012] |
| | Seeding material | SWH | g/$MJ_{grain}$ | 1.57 | | | | [EDSU 1996] |
| | Data relative to the provision of agricultural inputs are shown in sheet "Agri inputs" | | | | | | | |
| | Diesel | Z1 | MJ/$MJ_{grain}$ | 0.0390 | | | | [CAPRI 2012] |
| | $CH_4$ emissions | | g/$MJ_{grain}$ | 0.0011 | | | | |
| | $CO_2$ from soil neutralisation | | g/$MJ_{grain}$ | 3.58 | | | | |
| | $N_2O$ field emissions | | g/$MJ_{grain}$ | 0.042 | 0.038 | 0.046 | Normal | [Edwards 2012] |
| **WT2** | **Wheat grain drying, storage and handling** | | | | | | | |
| | Electricity (EU-mix, MV) | Z7c | MJ/$MJ_{grain}$ | 0.0053 | | | | [Kaltschmitt 1997], [CAPRI 2012] |

Draft

## Detailed description of individual processes

**WT1a Wheat cultivation**

Wheat is the highest-yielding cereal crop, but it also takes the highest inputs. This process represents conventional wheat grain farming for 'soft wheat', which accounts for most of EU production, gives the highest yield, and has the highest fermentable content. Straw use is discussed in the main ***WTT report***. Fertiliser inputs are based on [*EFMA 2008*], converted from tonnes/ha to tonnes/MJ of grain using the average EU yield of 5.2 tonnes grain per ha at 13.5% moisture, provided by EFMA. Diesel use per ha was averaged between [*Crop Energies 2008*] and [*ADEME 2002*] (which gave similar numbers) and converted to MJ/MJ grain using the same yield. Pesticides/herbicides data are from [*Crop Energies 2008*], amount of seeding material from [*ETSU 1996*]. The $N_2O$ emissions are calculated by the updated JRC soils emissions model (***WTT report***, *section 3.4*). There is no "reference crop" (see main ***WTT report***).

**WT2 Wheat grain drying, storage and handling**

A small amount of energy is consumed to handle and store grain mainly in the form of electricity. We account for it at this point in the pathway although in practice storage may occur after transportation.

**WT3a Wheat grain transport (road)**

Grain is typically transported by road over a short distance. We assumed a standard truck as described in common process Z2.

**WT41 Ethanol plant (NG-fired boiler and grid electricity)**

Heat is supplied by a conventional natural gas fired boiler and electricity is imported from the grid. This can be considered as representative of a some of the earlier existing installations and is also by far the cheapest solution. The boiler consumes a small amount of electricity and emits small quantities of $CH_4$ and $N_2O$.

The residual material after fermentation is known as DGS ("Distiller's Grain and solubles") or DDGS after drying. This co-product is assumed to be used in one of two ways:

In alternative ***a*** DDGS is used as animal feed and is assumed to substitute a mixture of wheat grain and soya meal representing a similar level of protein and digestible energy. The level of credit is based on production figures for these alternative materials. For wheat the figures are the same as in process WT1a. The calculation is more complex for soya meal as it is itself a co-product of soya oil production.

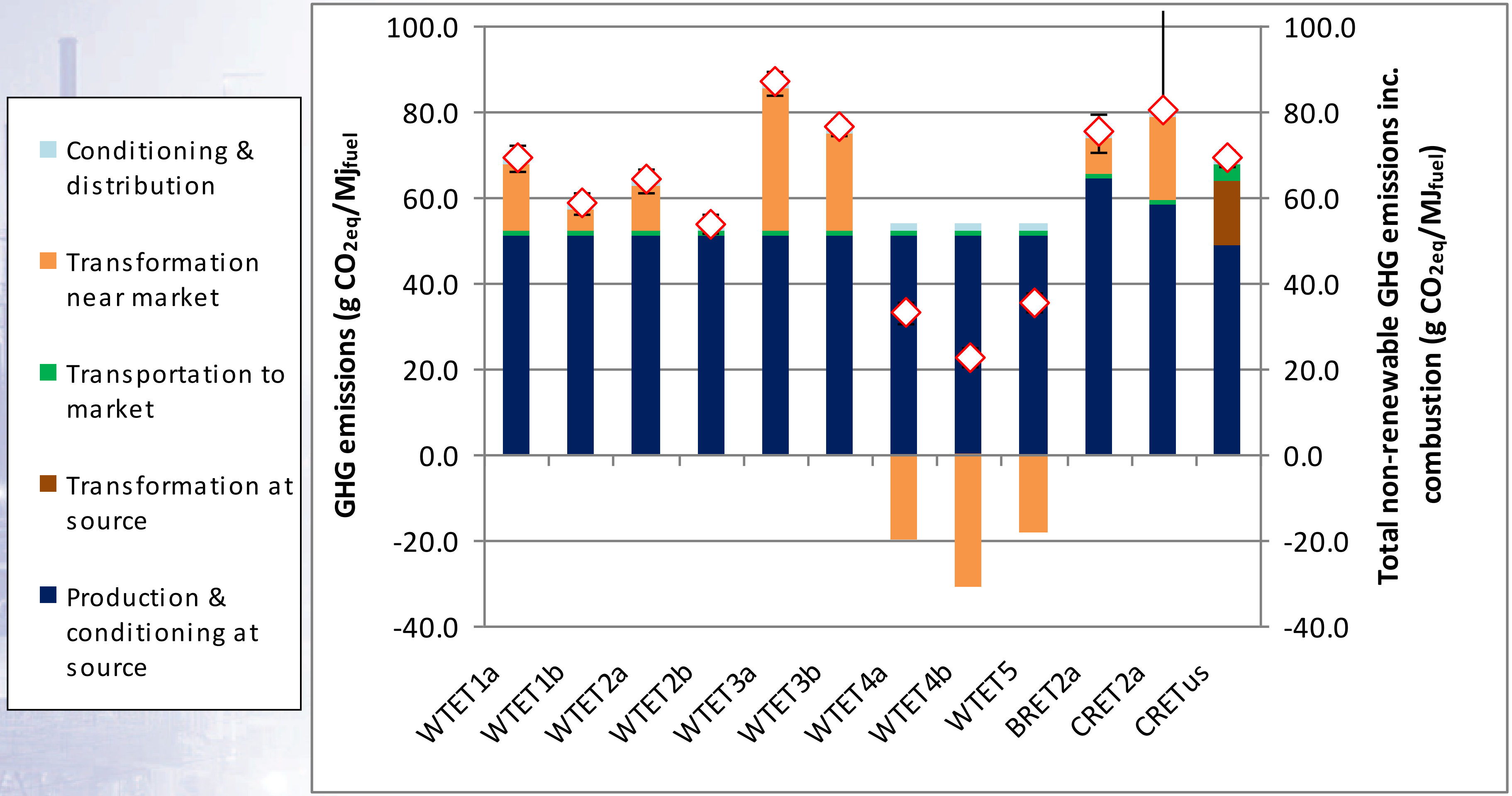
The detailed principles and mechanisms of animal feed credit calculations are discuss in the *main WTT report chapter 3.4.4*.

In alternative ***b*** DDGS is used on site as fuel for the production of electricity. For such a biomass product, efficiency is assume to be fairly low at 30%. This is assumed to be exported to he grid thereby generating a credit corresponding to the EU-mix electricity (MV level).

**ET1 Ethanol transport**

Ethanol has to be transported from the production plant to a conventional fuel depot. Road transport is assumed by a standard road truck according to process Z2.

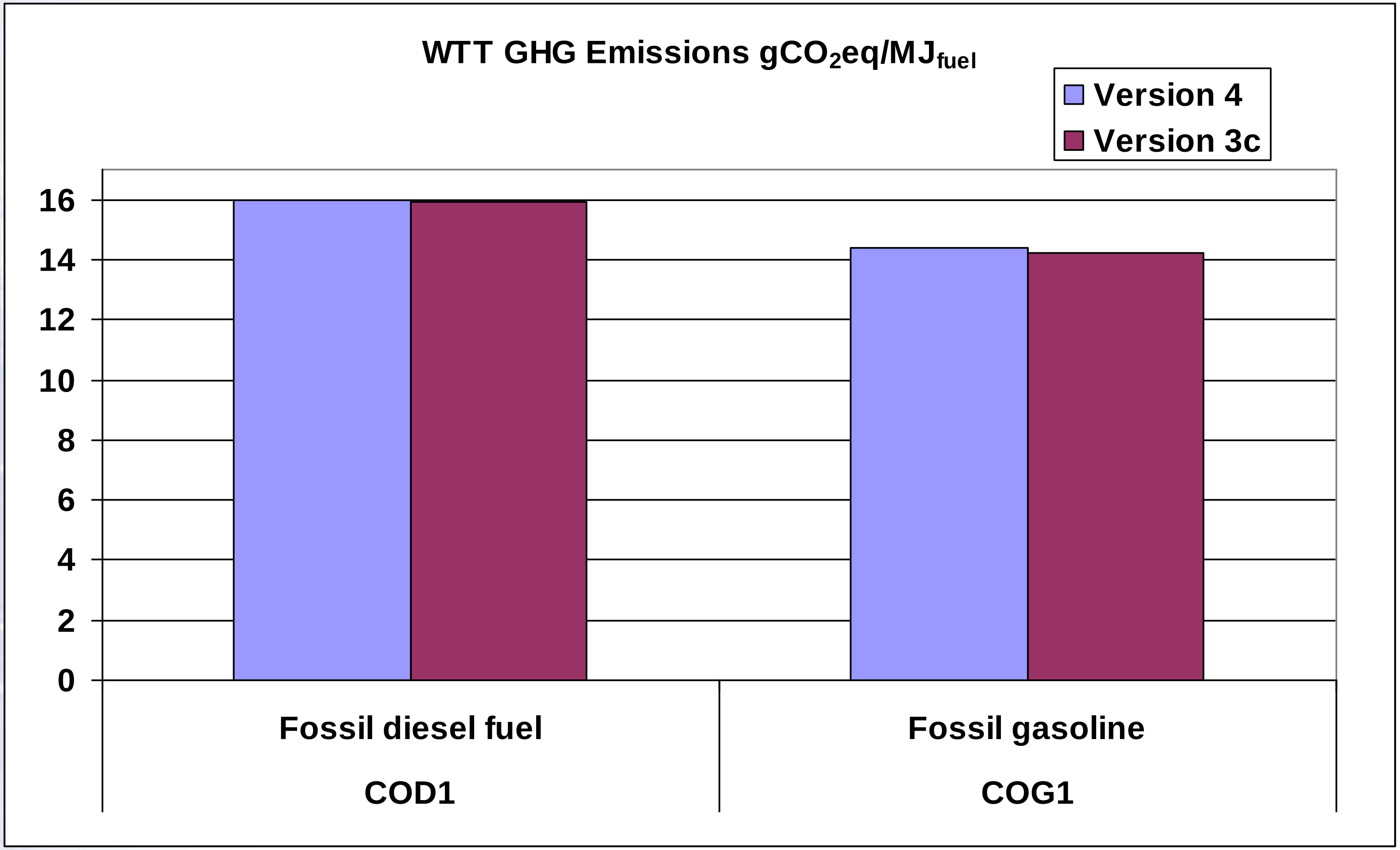
# Workbook Pathways: Common Charts



# How have the pathways changed?

- Some pathways have been deleted or will not be carried forward from the WTT to the WTW report
  - Some pathways are unlikely: e.g. a GTL plant in Europe
  - Alternatives are already described in other pathways
    - e.g. options explained for rapeseed not repeated
- And some new pathways have been added
  - Biodiesel from waste cooking oil and tallow
  - European shale gas pathway (preliminary data)
  - Ethanol pathway from mixed cereals (barley/rye) and maize
  - Methane/diesel from renewable electricity (speculative)
- Some pathways are still being reviewed and will appear later:
  - Hydrogen pathways,
  - More speculative pathways where it is difficult to find data
    - For example, 'sugar to diesel', algae products, biobutanol

# Comparing V3c and V4: Gasoline and Diesel

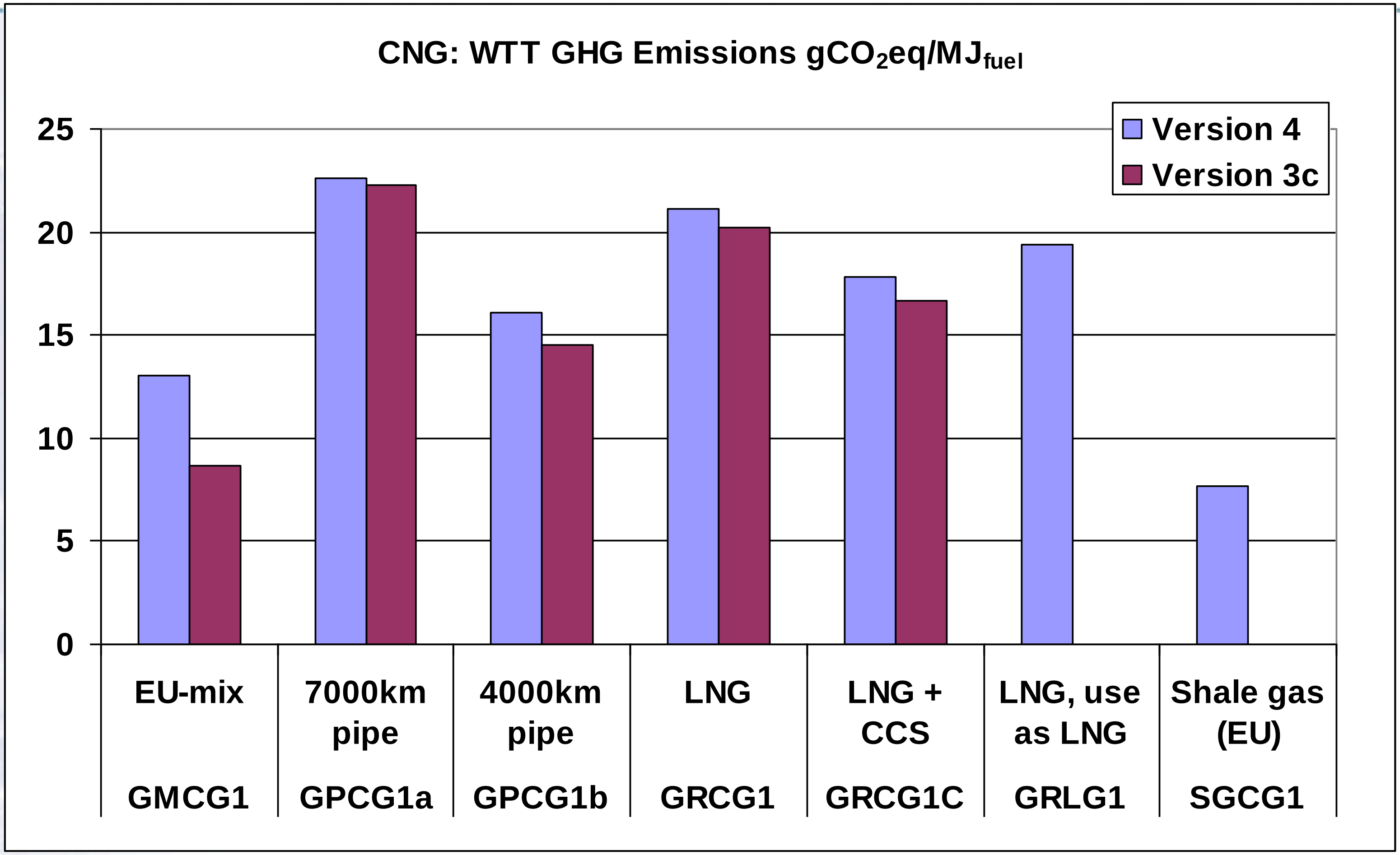



Combustion GHG, 73.2$gCO_2$eq/MJ

Combustion GHG, 73.4$gCO_2$eq/MJ

- No significant change from v3c; minor impact of revised EU-mix electricity
- Flaring and ventilation figures are being updated from 2005 to 2011

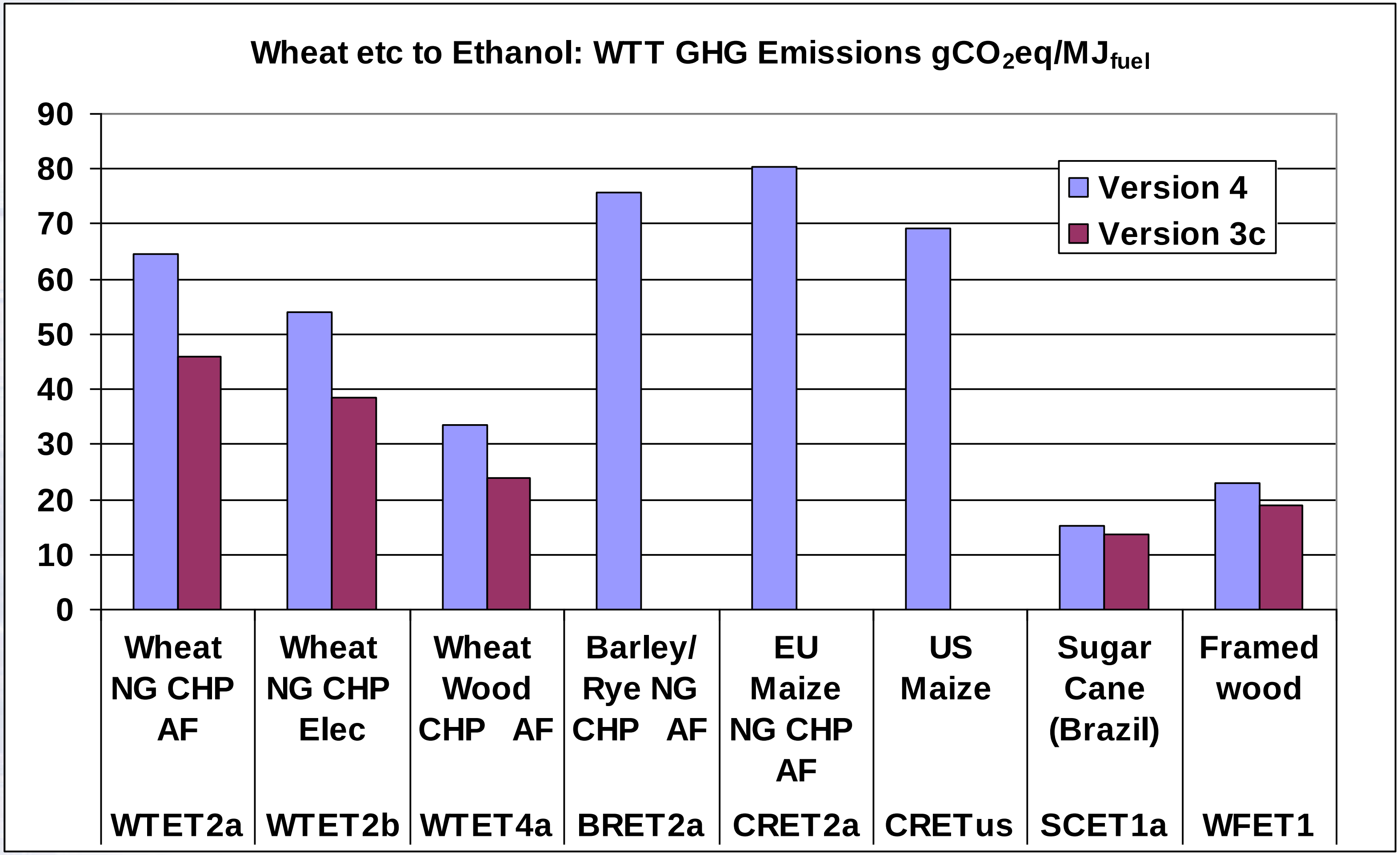
# Comparing V3c and V4: CNG




Combustion GHG, 56.2g$CO_2$eq/MJ

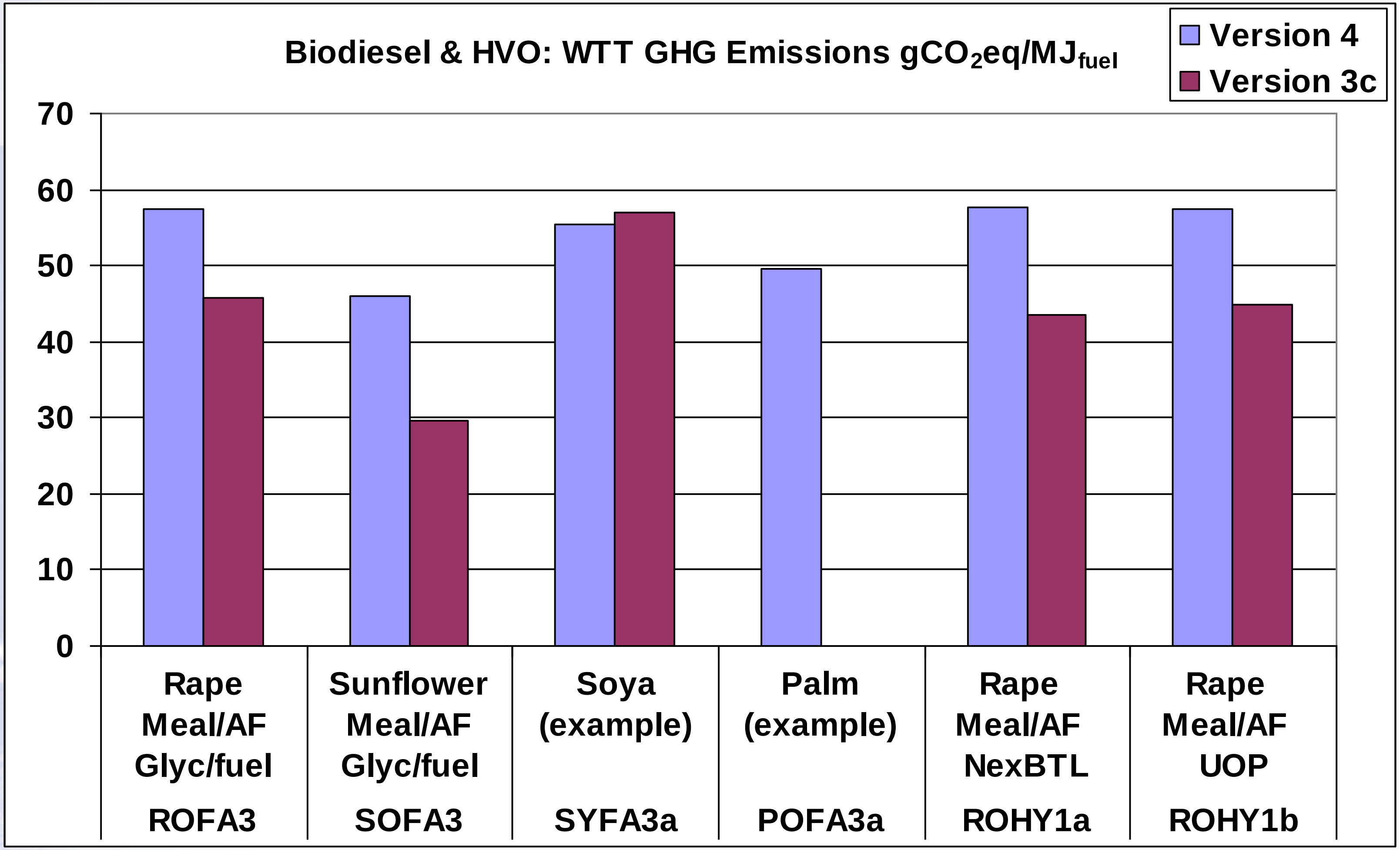
- Higher GHG emissions from NG extraction and processing ($CO_2$ venting)
- Better pipeline transport estimates

# Comparing V3c and V4: Ethanol



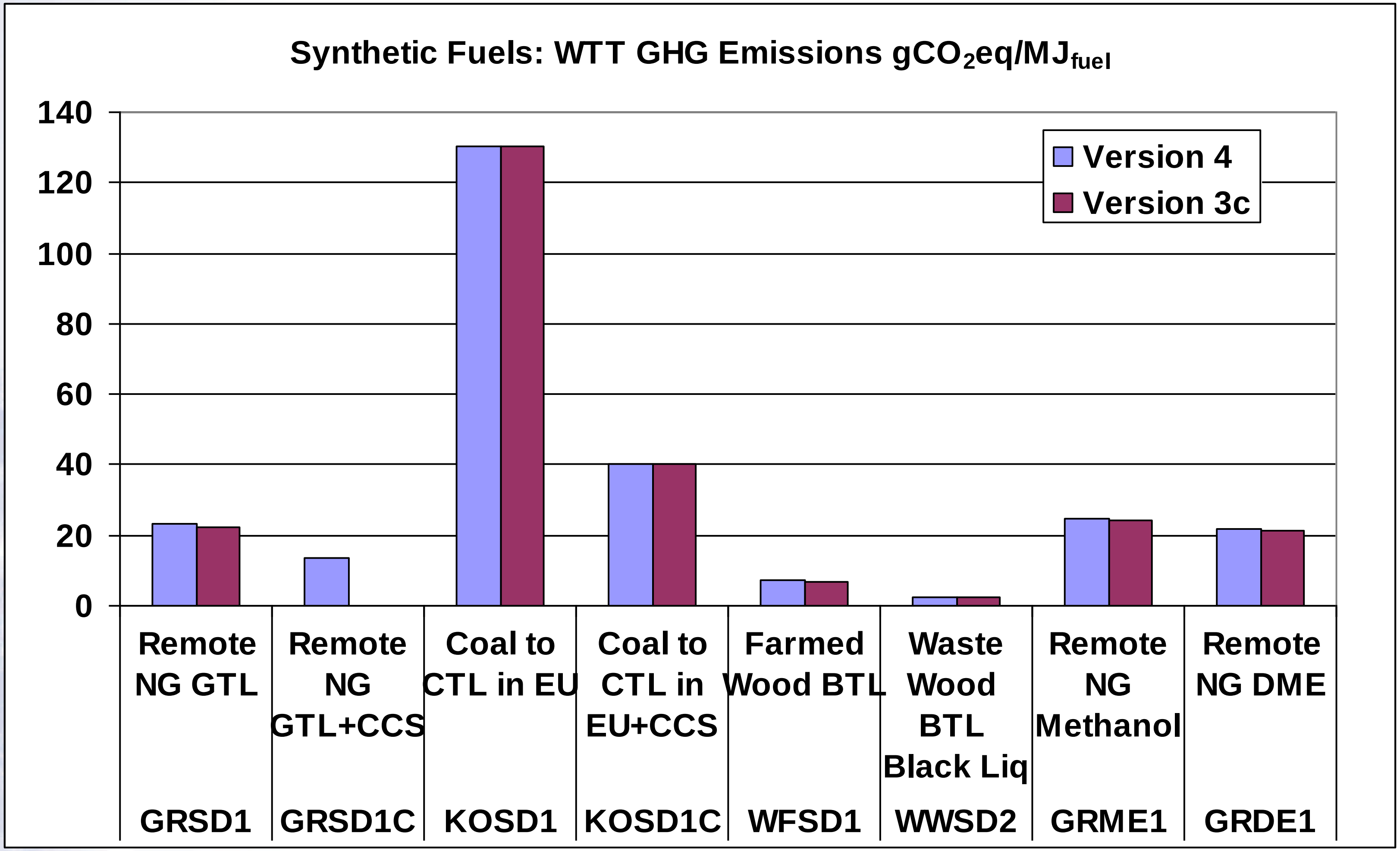

- Significant changes in agriculture (N fertiliser, $N_2O$ emissions)
- Improved ethanol plant modelling

# Comparing V3c and V4: Biodiesel & HVO




- Significant changes in agriculture (N fertiliser, $N_2O$ emissions)
- Crop transportation distances harmonised, minor changes to processing

# Comparing V3c and V4: Synthetic Fuels

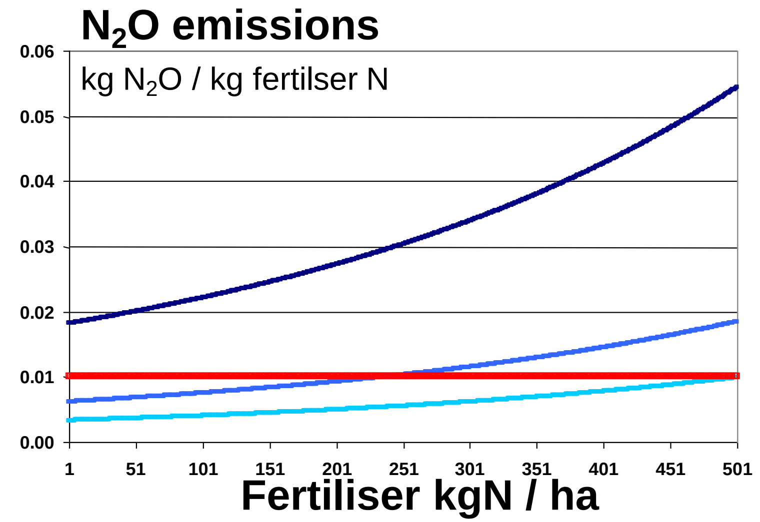



- Virtually unchanged

# Accounting for $N_2O$ Emissions

- Growing plants need nitrogen from the soil and from fertilisers
- Some of this nitrogen escapes directly to the atmosphere as $N_2O$
  - The amounts are small, but $N_2O$ is a potent Greenhouse Gas
- $N_2O$ emissions depend of soil, climate, cultivation techniques, fertiliser rates and crop, so estimating them is difficult
  - And there is a large uncertainty
- New work by JRC has produced a method that can be applied globally and is easily replicable

- Red line shows IPCC figure
- Blue lines show min, average, max from JRC model
- The variability is because of soil organic carbon and pH variations



# Next Steps

- Target for WTT (and TTW) publication is June, 2013
  - Updated Version 4 report based on Version 3c structure
    - Work in progress will be added in the autumn
  - Seven workbooks in XLS format
  - Report will include information on:
    - European crude oil appetite, including flaring & venting
    - More information on WTT refining contributions
    - Accounting for $N_2O$ emissions
    - Description of land use change effects
  - Graphing tool to visualise data – hopefully!

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# Backup Slides

# Comparing V3c and V4: Biogas