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# Agricultural feedstocks: current status and the path to improvement





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## Background: Literature study

**Title: „Cultivation of Biomass Crops for Biofuels: potential climate impact and other environmental effects“**


**Autors:** F.Eulenstein, W.Merbach, C.von Buttlar, J.Augustin, A.Werner

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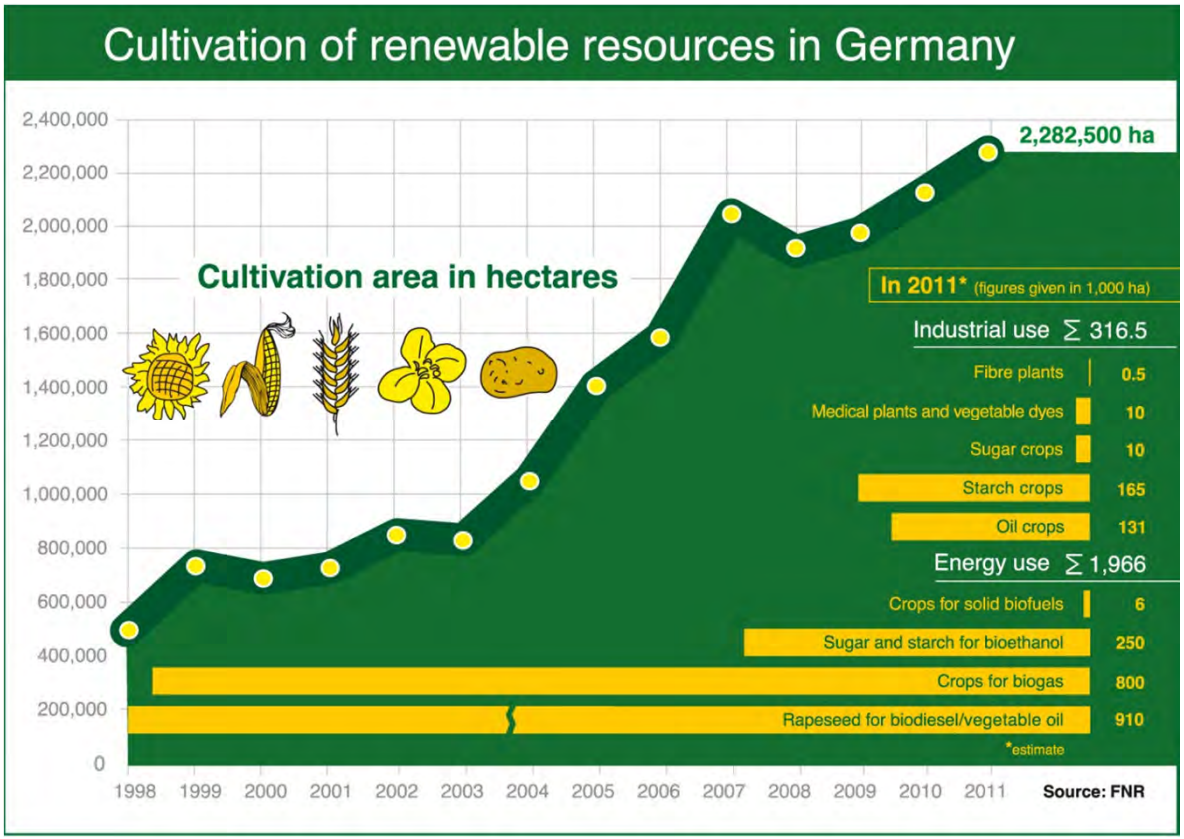
## Topics

- Germanys renewable resources
- Yields and potentials
- Climate balance for biofuels
- Further environmental requirements
- Conclusions

# Cultivation of renewable resources for biofuels in Germany




- 1,96 Mio hectares used for bioenergy-crops (in 2011), of that area:
- 910.000 hectares of rape seed for biodiesel,
- 250.000 hectares of sugar beets &starch for ethanol,
- 800.000 hectares of crops for biogas (mostly for electricity & heat)

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## Germany‘s political targets for the bioful development

- Political target by the year 2020: (percentage of renewable sources of energy)
  - 17% biofuels,
  - 14% of bio-heat
  - 27% of bio-electricity

- Free potential for all bioenergy crops in Germany: 3,5 mio hectares (29% of the arable land)
- For the 17% aim of biofuls we need about 2,4 Mio hectares (~ 70%)

⇒

- Competition between renewables for biofuels, biogas and industrial use
- Only small parts of our fuel-consumption can be supplied by German biomass

# Agricultural feedstocks used

## Wet biomass
(~30% dry mater)

fermentation in biogasplant
(Gas, electricity, head)

## Dry biomass
(~ 85% dry matter)

Biofuel-Ethanol

## Dry biomass
(~ 85% dry matter)

Biofuel-Biodiesel, Oil

## Biomass, straw, wood, biowaste…

Biofuel 2nd generation (BTL)

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# Yields and Oil- equivalents (under German conditions)

| Ethanol |  |  |  |
|---|---|---|---|
| | **maize seed** | **cereal seed** | **sugar beet** |
| yield (dt fm/hectare) | 100 | 80 | 500 |
| equivalent of ethanol (l/hectare) | 2500 | 1900 | 3500 |

| Plant oil/ Biodiesel |  |
|---|---|
| | **rape seed** |
| yield ( dt/hectare) | 35 |
| equivalent of diesel (l/hectare) | 1100 |

| Biogas/ (BTL) |  |
|---|---|
| | **maizeplant** |
| yield (dt/hectare) | 500 |
| equivalent of diesel (l/hectare) | 4300-5000 |

Source: Eulenstein, F. et.a. 2011: Cultivation of biomasscrops for fuels

- New technology BTL promises higher energy-yields per hectare for the future

# Climate balance of biofluels (1th generation)

## Relevant greenhouse gases in agricultural cultivation processes:

- **$N_20$ (nitrous oxide)**
- Source: Soil (90%), cultivation, organic manures, changes in land use
- Importance: high
- ! Risk of leaching: $N0_3$, $NH_4$+, Norg.

- **$C0_2$ (carbon dioxide)**
- Source: fossil fuels for engineering
- Importance: high

- **$CH_4$ (methane)**
- Sources: application of manures, organic soils
  - others: Animals (75%), storage of.organic manure
- Importance: low

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# Greenhouse gases and climate balance

| Fuels | | Results<br>kg $CO_2$- equivalents/ GJ fuel<br>(from $N_20$, $CO_2$, $CH_4$) | Default- value for cultivation<br>(BioNachVer 2007),<br>VOGT u. FEHRENBACH, 2010 |
|---|---|---|---|
| fossil diesel | brutto (bevor production) | 73,61 | |
| | netto (after production) | **91,7** | |
| biomass | brutto (after cultivation) | **15 - 35** | **11-35** (dependent on the crop) |
| difference fossil - renewable | free for conversion from biomass to fuel | **55-75** | |

Source: Eulenstein, F. et.a. 2011: Cultivation of biomasscrops for fuels

- Biomass values: **without** change of land use from extensive to intensive
- The difference between $CO_2$-equivalent of the biomass production and fossil fuels is 55 – 75 kg $CO_2$/ GJ fuel.
- A reduction of greenhouse gases is possible, if the conversion from biomass to biofuel consumes less than this range!

# Climate balance of biomassproduction für biofuels

„Under condition of cultivation WITHOUT change from extensiv to intensive landuse systems and belong official fertilizing recommendations“

| culture | results (kg $C0_2$-equ./GJ fuel) | | | | Default- Value for cultivation (BioNachVer 2007), VOGT u. FEHRENBACH, 2010 |
|---|---|---|---|---|---|
| | $CO_2$ | $N_2O$ | $CH_4$ | total ($CO_2$, $N_2O$,$CH_4$) | |
| rape | 20,5 | W 4,68 | -0,63 | **24,55** | **35,6/ 29,1** |
| | 20,5 | FK 6,76 | -0,63 | **26,36** | |
| weat | 13,3 | W 17,1 | -0,77 | **29,63** | **22,3** |
| | 13,3 | FK 49,5 | -0,77 | **62,03** | |
| rye | 13,3 | W 8,9 | -2,26 | **19,94** | **22,3** |
| | 13,3 | FK 18,3 | -2,26 | **29,34** | |
| maize-corn | 13,3 | W 7,2 | -0,8 | **19,7** | **17,8** |
| | 13,3 | FK 22,7 | -0,8 | **35,2** | |
| maize-biomass | 5,4 | W 3,8 | -0,52 | **8,68** | **23,3** |
| | 5,4 | FK 11,9 | -0,52 | **16,78** | |
| maize-biomass on organic soils | 23,6 | 14,5 | -0,52 | **34,98** | **23,3** |
| sugar beat | 10,4 | 14,5 | -0,51 | **24,39** | **11,3** |

w = warm- dry; FK = humid- cold

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## Climate balance of biomassproduction für biofuels

**Results:**

- In comparison to fossil fuels, greenhouse gases can be reduced!
- The main sources are nitrogen oxide ($N_20$) and carbon dioxide ($CO_2$).
- Lower values in North-Germany (warm) as in Southern Germany (weat and cold ).
- Current guideline values can be kept for rape, rye and maize-biomass.
- Necessary adjustments for wheat, sugar beets and organic soils .
- Change from grasland to arable land should be avoided.
- Crop Growing with reduced nitrogen surplus is recommended.

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# Further environmental requirements to biomass production

## Biodiversity

- Crop-rotation
- High diversity of species
- Low pesticides
- Ecological balance

## Water protection

- ***EU WFD – Water Framework Directive, EU-nitrate-guidelines***
- ***Critical value 50 mg nitrate/ liter***
- ***Nitrate-balance***

## Soil protection

- ***Federal Soil Protection Act***
- ***Erosion prevention***
- ***Stable humus-balance***

## Land use

- ***No change extensive – intensive***
- ***No losses of gasslands***
- ***No losses of forests***

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# Conclusions

**Results:**

- Germany will supply **17% of biofuels** by 2020. Therefore ~ 70% of the free area for bioenergy crops is needed.
- The biomass- yield potential is high. Future **raises** are expected **moderately**.
- **Default values** for greenhouse gases are **approved** under certain conditions (no change of land use, moderate cultivation intensity).

**Research is required in following areas:**

- Adaption of **default values** for wheat and sugar beets.
- Other factors like **soil** und **climate** conditions have to be considered.
- Production of agricultural feedstocks should respect principles of **sustainability** for climate, water, soil and biodiversity.

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**Thank you for the attention!**