

# TFZ-KOMPAKT 13

## CLIMATE PROTECTION

BY RAPESEED OIL FUEL



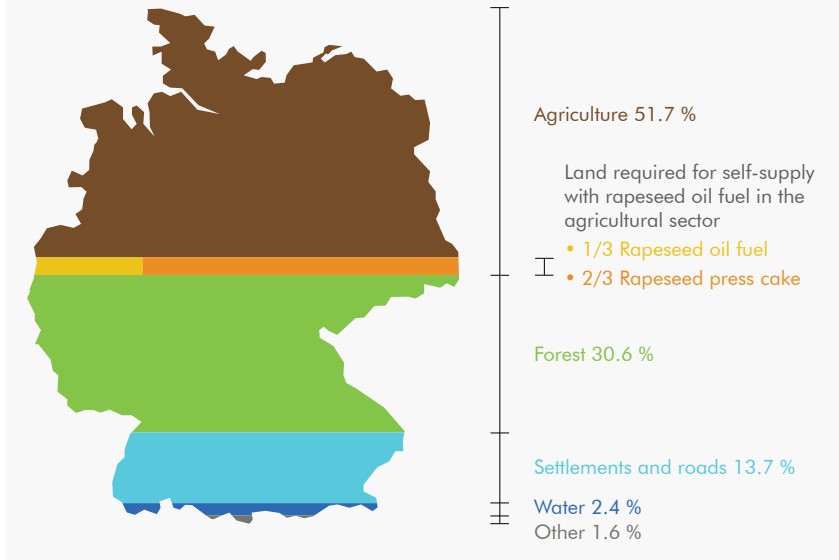
## Why using biofuels in agriculture and forestry ?

Combating climate change is one of society's most important tasks, particularly since the "Paris Agreement" of the UN Climate Change Conference 2015. Agriculture and forestry are, on the one hand, one of the contributors to climate change and, on the other hand, one of the sectors most affected by global warming (e.g. increased occurrence of extreme weather events). Therefore agriculture and forestry should do everything to reduce greenhouse gas emissions and, in doing so, they can set a good example for other sectors. Besides fertilisation and animal husbandry, fuel consumption is one of the most relevant sources of greenhouse gas emissions in the agricultural sector.

Currently, machines used in agriculture and forestry are predominantly run on fossil diesel fuels. Some 2 billion litres, corresponding to 5 % of Germany's overall diesel consumption, can be attributed to the agriculture and forestry sector. Based on a price of € 0.50 per litre, the costs before tax to purchase this amount of fuel equal nearly one billion Euros. Replacing imported fossil fuels with regionally produced rapeseed oil fuel is, from a technical perspective, rather simple, as well as cost-efficient and also economically interesting.



## Land usage in Germany 35.7 million hectares



Land required for self-supply with rapeseed oil fuel in the agricultural sector (own calculations according to the German Federal Statistics Office, 2014)

The annual requirement for fossil fuel of the German agriculture and forestry could be covered by the yield from 1.2 million hectares of rapeseed cultivation. This is equivalent to 6.3 % of Germany's total agricultural land, which amounts 18.9 million hectares. In addition, this area would deliver 2.8 million tons of rapeseed press cake (GM-free protein feed) as co-product, allowing for a reduction in soy imports.

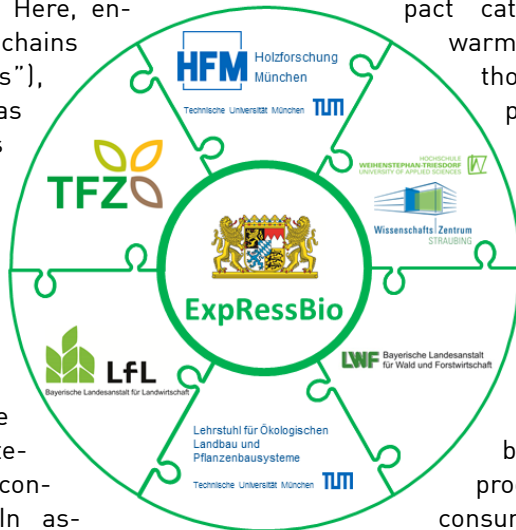
Following questions arise: What

are the actual greenhouse gas emissions of rapeseed oil fuel which is produced in decentralised oil mills? What is the impact of regionally varying soil and climate conditions on rapeseed cultivation? What kinds of optimisation potentials are available?

# ExpResBio methods for greenhouse gas calculation

For conducting life cycle analyses (LCA) of products or processes, a transparent evaluation of the overall environmental impact is essential. Here, entire process chains ("life-cycles"), as well as co-products and waste products, must be taken into account. A life cycle analysis takes diverse impact categories into consideration. In assessing raw materials used in agriculture and forestry, it is common to include the impact categories primary energy demand, global warming, eutrophication, acidification and particle emissions. As part of the "ExpResBio" project (funded by the Bavarian State Ministry of Food, Agriculture

and Forestry), an expert team has developed a harmonised method with a focus on analysing greenhouse gases for Bavaria (impact category: global warming). The method allows comparing various bioenergy sources with fossil energy sources. From this analysis, recommendations for action can be derived for producers and consumers of bioenergy sources as well as for decision-makers. As a result, production processes can be optimised with regard to their sustainability. The "ExpResBio methods" have been published in a series of reports by the TFZ (Berichte aus dem TFZ Nr. 45) and can be downloaded at [www.tfz.bayern.de](http://www.tfz.bayern.de).



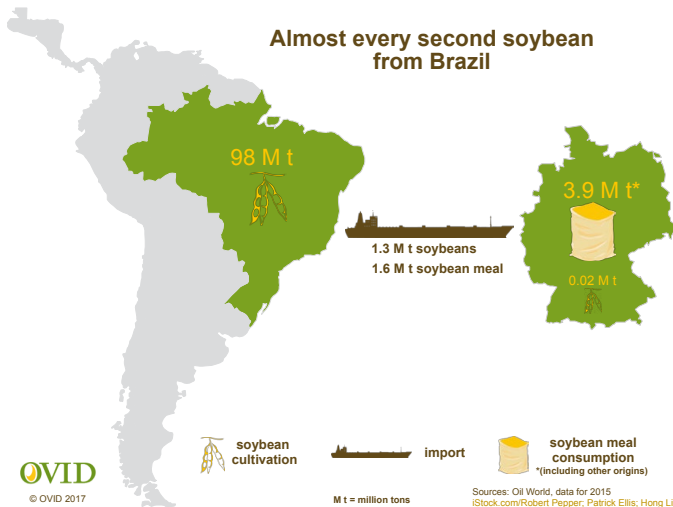
## Evaluation of co-products

If co-products are produced alongside the primary production path, the emitted greenhouse gas emissions must be addressed to the primary products and co-products as realistically as possible. This may require allocation by economical aspects (proceeds) or physical aspects (mass or energy content). Alternatively, credits can be given for the replaced product (substitution).

By using the **allocation method**, which is required for biofuels by the Renewable Energy Directive 2009/28/EC (RED), greenhouse gas emissions are proportionately allocated to the primary product

and the co-product by the calorific value and the respective production quantities (energy allocation).

In contrast, no allocation of greenhouse gases takes place by applying the **substitution method**. Rather, it is assumed that rapeseed press cake will replace soy meal imported from overseas. Hence, rapeseed oil is awarded an emission credit for the substituted soybean meal. This credit can be given with or without considering direct land use change (e.g. clearing rain forest). In addition, the previous crop value from rapeseed cultivation may also be credited.

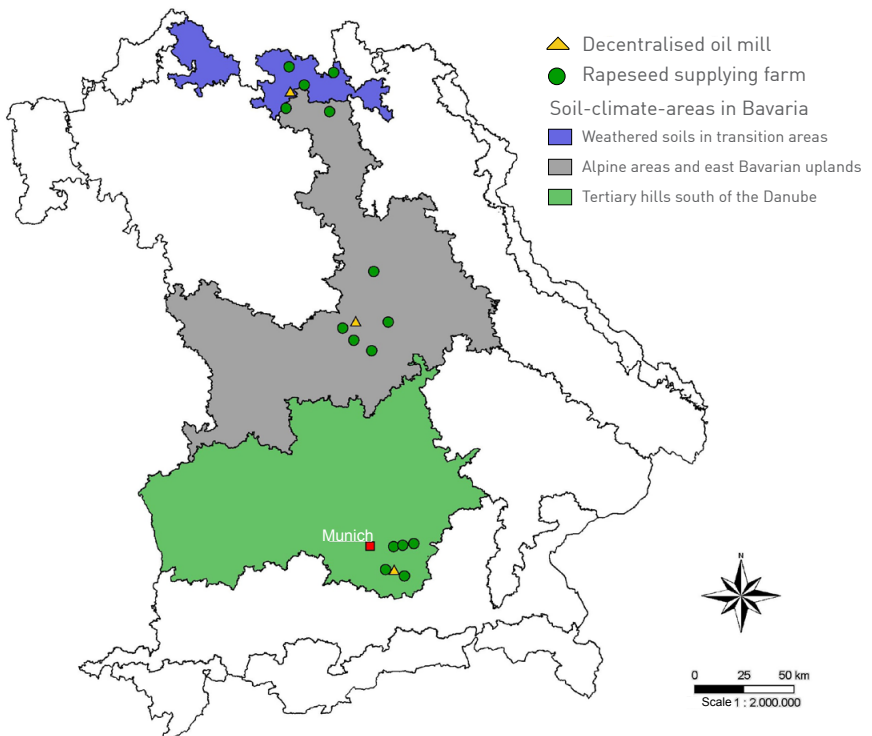


Soy imports from overseas [Source: obs/OVID, German Association of the Oil Crushing Industry e.V.]

## Actual greenhouse gas savings by rapeseed oil fuel

In order to analyse greenhouse gas emissions from rapeseed oil fuel production in Bavaria, region specific operating data from three decentralised oil mills for the years 2013 to 2015 were collected. Each of these oil mills was supplied with rapeseed by five farms. These farms are located in three soil and climate regions:

“Weathered soils in transition areas”, “Alpine areas and east Bavarian uplands” and “Tertiary hills south of the Danube”. The data cover the entire process chain including rapeseed cultivation, transportation, storage, oil pressing, filtration etc.



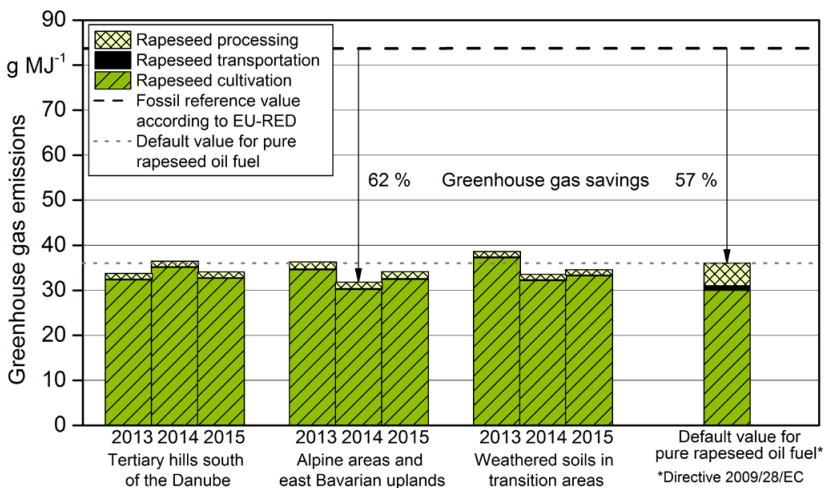
Location of the decentralised oil mills and the rapeseed supplying farms

The greenhouse gas emissions from rapeseed oil fuel are primarily attributed to rapeseed cultivation. Depending on the natural local conditions (e.g. yield potential) and the farm specific production methods (e.g. fertilisation management), greenhouse gas emissions from rapeseed oil fuel can vary by region and farm. Minimal variation was observed in the transportation and processing of rapeseed in the three Bavarian oil mills examined. Decentralised rapeseed processing causes lower greenhouse gas emissions compared with industrial oil extraction due to the short

transportation distances and an oil extraction technique with low energy input (cold pressing without solvent extraction and refining).

### Results by energy allocation

If greenhouse gas emissions are calculated under consideration of the co-products by using the energy allocation method, then rapeseed oil fuel from Bavaria shows, on average, savings of 58 % compared with fossil diesel (average value from 15 farms and three oil mills over three years). This value is slightly better than the RED standard value for pure rapeseed oil (57 %).



Greenhouse gas emissions from rapeseed oil fuel from three Bavarian oil mills in various soil and climate regions compared to the RED standard value for pure rapeseed oil (energy allocation method)



The highest greenhouse gas savings of 62 % compared with fossil diesel fuel was achieved in the soil and climate region “Alpine areas and east Bavarian uplands” with rapeseed processing in the corresponding decentralised oil mill in the year 2014 (see figure on page 7). In a comparison of oil extraction methods, the greenhouse gas

emissions from decentralised rapeseed processing amount to around 1 g per MJ, and from industrial processing it amounts to 5 g per MJ (RED disaggregated default value). Hence, greenhouse gas emissions from decentralised rapeseed processing are 80 % lower than from industrial processing.



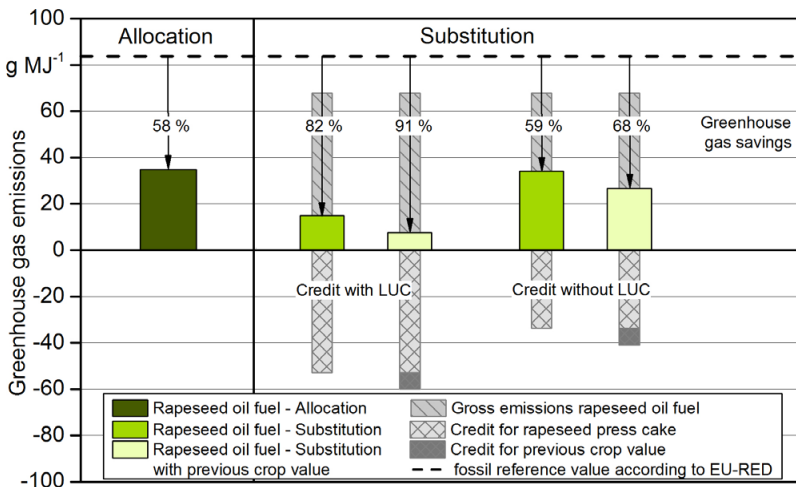
## Results by substitution method

Using the substitution method, the co-product rapeseed press cake is evaluated in accordance with its actual use as a high-quality protein feed for livestock production. The substituted product is soybean meal. The use of domestic protein feed is being also pushed by the "Bavarian Protein Initiative" of the bavarian ministry of agriculture.



Rapeseed cultivation has a positive impact on the yield of the following crop (previous crop value), for which it can be given an additional credit.

Following this calculation method, without considering land use change from soy cultivation and without crediting the previous crop value, rapeseed oil fuel from Bavaria achieves greenhouse savings of 59 % (see figure below).



Greenhouse gas savings from rapeseed oil fuel from Bavaria according to the allocation and substitution methods [with and without considering land use change (LUC)]

When land use change for soy cultivation is taken into account, the greenhouse gas savings rise up to 82 % (assumption: 8.4 % of soy originates from areas with land use change<sup>1</sup>, e. g. through the clearing of rain forests and ploughing up of scrubland). If greenhouse gas emissions of 7.3 g per MJ are also credited to rapeseed oil fuel as previous crop value<sup>2</sup>, the greenhouse gas savings amount up to 91 % compared with fossil diesel fuel. Up to now, the substitution method including credits for co-products and the previous crop value has not been accepted to be applied for quota counting according to the Directive 2009/28/EC. However, as stated in the directive: "For the purposes of policy analysis the Commission should also, in its reporting, present results using the substitution method."

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- 1 Sutter, J. (2007): Soybean. In: Jungbluth, N. (ed.) Life Cycle Inventories of Bioenergy. Ecoinvent Report No. 17. Dübendorf: Swiss Centre for Life Cycle Inventories, p. 125–140.
- 2 Kage, H.; Pahlmann, I. (2013): Potenziale zur Minderung der Treibhausgasemissionen im Rapsanbau. In: Fachagentur Nachwachsende Rohstoffe e. V. (FNR) (ed.): Gülzower Fachgespräche, No. 45, p. 235–259.



# Parameters for climate-friendly rapeseed cultivation

Around 95 % of the greenhouse gases from rapeseed oil fuel are attributed to the rapeseed cultivation phase. Just fewer than 90 % arise in the context of rapeseed fertilisation. High nitrogen requirement of rapeseed and the resulting nitrous oxide emissions from soil are a heavy burden on the greenhouse gas balance<sup>3</sup>.

A considerable field for the improvement of rapeseed oil fuel's greenhouse gas balance is to increase nitrogen efficiency in rapeseed cultivation. As part of this, the crop cultivation aspects and the type nitrogen fertilisers used have to be considered.

## Fertiliser production

Organic nitrogen fertilisers from livestock or biogas production are often regarded as "residual waste" and are not burdened with a so-called "greenhouse gas footprint". Mineral nitrogen fertiliser production is highly energy-intensive and thus, causing a big greenhouse gas footprint. Mineral fertilisers containing nitrates leave the production plants with the biggest greenhouse gas footprint, followed by urea and ammonia fertilisers (see table).

Forms of nitrogen	Greenhouse gas footprint from production	Reactivity time of the nitrogen
Nitrate	very large	very fast
Ammonia	large	fast
Urea	large	slow
Manure	none	very slow

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3 The global warming potential of nitrous oxide is around 300 times higher than that of carbon dioxide.



Image: Lorentz Heigt/LfL

Ground-level application of manure

### Fertilising effect

In comparison with mineral fertilisers, the nitrogen efficiency of organic fertilisers such as liquid manure or digestate is lower. This is because organically-bound nitrogen must first be microbially broken down and gaseous nitrogen losses occur in the form of ammonia during their application. However, mineral nitrogen fertilisers also differ in terms of reactivity time of the nitrogen at which they take effect depending on the mineral forms they contain (see table on page 11). Nitrate-containing mineral fertilisers (e. g. calcium ammonium nitrate) are comparably fast whereas ammonium-containing mineral fertilisers (e. g. ammonium sulphate) have a slower effect on plants. Urea can only be absorbed by plant roots through conversion processes in the soil, which can lead to gaseous nitrogen losses at the same time. Apart from few exceptions (urea, ammonium sulphate), the nitrogen fertilisers

used in agricultural practice are mixtures of the mentioned forms of nitrogen.

### Basically an efficient nitrogen fertilisation must feature:

- ▶ adapted to location (in consideration of the natural yield potential: climate and soil),
- ▶ needs-based (in consideration of nitrogen availability in soil and crops),
- ▶ low-loss (in consideration of weather conditions and use of ground-level application techniques, see image).

In addition, the use of nitrification inhibitors in organic nitrogen fertilisers or the use of stabilised mineral fertilisers is recommended.

## Recommendations for action

### **Tuning factors for a climate-friendly, optimised production of rapeseed oil fuel:**

- ▶ fertilisation management adapted to the location and farm type (reduction of greenhouse gases and costs),
  - ▶ needs-based nitrogen fertilisation adapted to plant growth,
  - ▶ avoidance of soil compaction and water logging,
  - ▶ low-loss application of organic fertilisers,
  - ▶ short transport routes and decentralised processing,
  - ▶ approach full capacity of oil mills, machines and equipment,
  - ▶ optimal harvesting time to reduce energy-intensive drying processes (7 % water content of rapeseed is optimal for decentralised processing),
  - ▶ higher oil yield through increase of the oil content in the rapeseed (variety selection) as well as through an increase in the mechanical extraction rate,
- ▶ use of renewable energies to provide electricity for pressing, for example a vegetable oil operated combined heat and power unit with a high level of heat utilisation.

### **Advantages of the use of regionally-produced rapeseed oil fuel in agricultural machines:**

- ▶ contribution to climate protection by reduction of greenhouse gases (up to 91 % compared with fossil diesel fuel),
- ▶ increase of added value through on-farm processing of rapeseed,
- ▶ resource conservation,
- ▶ independence from mineral oil imports,
- ▶ soil and water protection,
- ▶ increase in regional added value,
- ▶ security of the supply of food, animal feed and fuels.

**Rapeseed oil fuel is the preferred energy carrier in agricultural and forestry machinery.**

## Literature:

- [1] Remmele, E. (2009): Handbuch. Herstellung von Rapsölkraftstoff in dezentralen Ölgewinnungsanlagen, 2., neu bearb. und erw. Aufl., Gülzow: Fachagentur Nachwachsende Rohstoffe e. V., 88 Seiten
- [2] Wolf, C.; Dressler, D.; Engelmann, K. et al. (2016): ExpResBio – Methoden. Berichte aus dem TFZ Nr. 45. Straubing: Technologie- und Förderzentrum, 166 Seiten
- [3] Dressler, D.; Engelmann, K. et al. (2016): Rapsölkraftstoffproduktion in Bayern – Analyse und Bewertung ökologischer und ökonomischer Wirkungen nach der ExpResBio-Methode. Berichte aus dem TFZ Nr. 50. Straubing: Technologie- und Förderzentrum, 162 Seiten

## Note



The detailed research report in German language is available online in the series Berichte aus dem TFZ, Nr. 50, at [www.tfz.bayern.de](http://www.tfz.bayern.de).

The ExpResBio methods presented on page 4 are published in German in the series Berichte aus dem TFZ, Nr. 45.

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A wide-angle photograph of a rural landscape. In the foreground, a vibrant yellow rapeseed field stretches across a gentle slope. A dirt road winds through the field, leading to a red tractor. The background shows rolling green hills, scattered trees, and a distant horizon under a clear sky.

The Technologie- und Förderzentrum (TFZ) is an institution of the Bavarian Ministry of Food, Agriculture and Forestry (Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten). The main goals of the TFZ and its more than 90 staff members are the support of the agricultural production, the processing and utilization of renewable resources by applied research, the development and testing of products and methods and the transfer of technology by demonstration and education. In addition the TFZ is responsible for financial support of projects in Bavaria. Applied research, development, testing and process evaluation at the TFZ is done in three different divisions:

- Renewable Resources Crops and Material Cycles
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