**Life cycle analysis of lubricants from rape seed oil in comparison to conventional lubricants**

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## Introduction and procedure

Comparing with biomass-derived lubricants, in many cases conventional lubricants turn out to have disadvantages for their environmental impact, especially where losses occur during regular operation (e.g. in chainsaws) or where a leakage leads to immediate emissions into the environment as for agricultural machinery. Bio lubricants are supposed to be environmentally friendly, among other things because of their fast biodegradability or the saving of fossil resources. But they can provoke also negative impacts on the environment, caused for example in part by the agricultural production of the raw material. This study gives an overview over the advantages and disadvantages of bio lubricants and offers a valuation of the results.

Like advised by ISO 14040-43, the life cycle of conventional petrochemical is compared with biogeneous lubricant. Pre- and by-products are considered as shown in Fig. 1. The system boundaries and procedures as well as most of the inventory data are documented in [1]. The calculation of the conventional lubricant production was executed by [2]. High quantity of usage was the reason for choosing low-viscous oils for the comparison. We have assumed the same physical properties and durability of the lubricants. Scenario 1 regards the lubrication under complete lubricant loss. The energetic use of completely returned used oil in a heating plant under substitution of light oil and natural gas is investigated in scenario 2a and 2b, respectively.

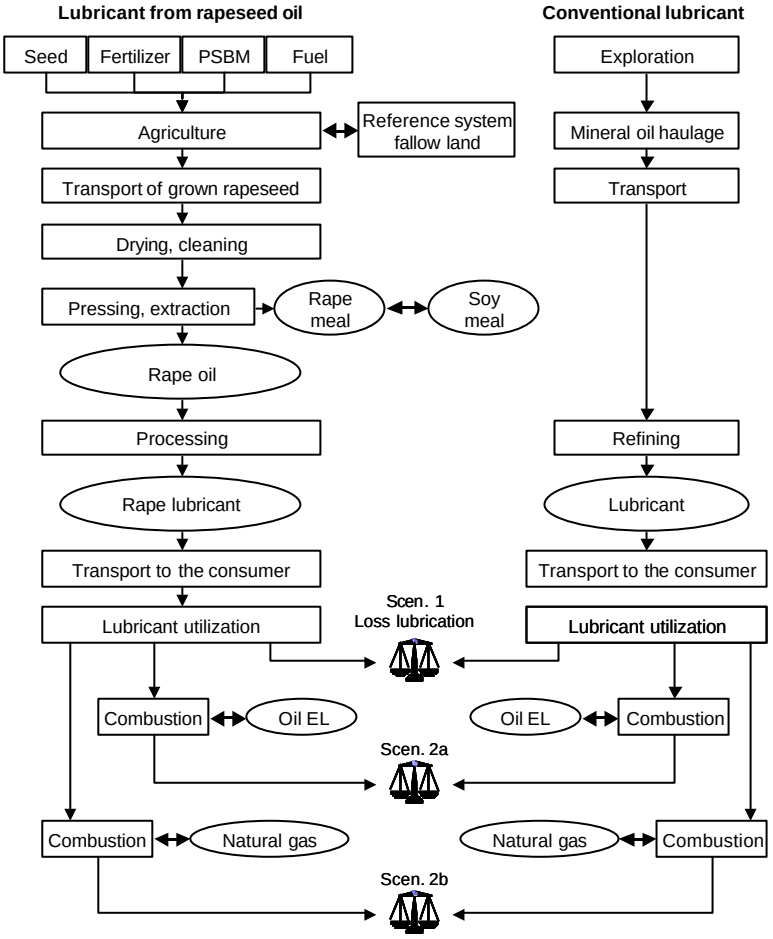


Fig. 1. Life cycle comparison of lubricants with different scenarios of post-use treatment (Oil EL: light oil)

## Results and discussion

Table 1 shows for some of the parameters investigated the quantity of environmental relief (negative values) or further burden (positive values) that occur utilizing one ton of biomass-derived instead of conventional lubricant. In addition, aggregated quantities for different impact categories have been set in italics, calculated as equivalents of the main substance ($CO_2$ equivalents for the greenhouse effect etc.).

For example, rapeseed-derived lubricants contribute to the saving of exhaustible energy resources. In loss lubrications the bio lubricants show even better results than in combustion after use. The type of fossil fuel substituted by the old lubricants has little impact on the results. The same conditions are revealed for the greenhouse effect. Acidification, eutrophication, and $N_2O$ as the main parameter of stratospheric ozone depletion give a negative influence on the results for rapeseed-derived lubricants. The differences between the scenaria are negligible because of the dominance of agricultural production in the results.

Table 1. Total results of selected impact categories and single substances. Reference: 1 ton of bio lubricant

| **Parameter** | **Unit** | **Scen. 1: loss lubrication** | **Scen. 2: combustion 2a: extra light oil** | **2b: natural gas** |
|---|---|---|---|---|
| *Energetic resource demand* | *GJ* | *- 48,10* | *- 37,93* | *- 38,36* |
| *$CO_2$ equivalents* | *t* | *- 2,09* | *- 1,33* | *- 1,54* |
| *$SO_2$ equivalents* | *kg* | *9,25* | *8,94* | *8,46* |
| *$PO_4$ equivalents* | *kg* | *1,96* | *1,98* | *1,98* |
| $N_2O$ | kg | 4,22 | 4,23 | 4,23 |
| CO | kg | - 0,12 | - 0,04 | - 0,01 |
| NMHC | kg | - 0,90 | - 0,76 | - 0,88 |
| Particulate (diesel) | kg | - 0,11 | - 0,10 | - 0,11 |
| Dust | kg | 0,30 | 0,32 | 0,30 |
| Formaldehyde | g | - 7,54 | - 6,72 | 1,96 |
| Benzene | g | - 12,04 | - 11,32 | - 11,14 |
| Benzo(a)pyrene | mg | - 0,41 | - 0,33 | - 0,61 |
| Nitropyrene | mg | - 1,73 | - 1,68 | - 1,73 |
| TCDD equivalents | ng | 12,16 | 38,74 | 51,44 |

Hence, the comparison of bio lubricants with conventional lubricants shows advantages and disadvantages. Objectively weighing these results is not possible as this would require subjective judgements of the value. However, a final valuation is possible, e.g. if considering the so-called ecologic significance of the analysed parameters under reference to the specific contributions (see e.g. [3]). Estimating the saving of exhaustible energy resources and the greenhouse effect to be much higher in their ecologic significance than the other impact categories, for instance, can lead to a valuation in favor of bio lubricant.

**Summary**
The substitution of conventional by biomass-derived lubricants causes environmental advantages as well as disadvantages. Advantages are to be seen in saving exhaustible energies and diminishing the greenhouse effect. Disadvantageous are the potentials of acidification, eutrophication, and ozone depletion. A final objective valuation on the basis of these aspects is not possible. However, it can be carried out in a verbal way, e.g. arguing on the ecologic significance of the different environmental impacts.

The substitution of conventional by biomass-derived lubricants has more advantages in loss lubrication than for subsequent thermal utilization. For thermal utilization there are no significant differences whether light oil or natural gas are substituted.

**References**
[1] Borken J, Patyk A, Reinhardt G A: Base data for ecological assessments: Transportation, agriculture and mining. Vieweg-Verlag, Braunschweig/Wiesbaden 1999, ISBN 3-528-03118-2, in German
[2] Calculations by A Patyk. IFEU Heidelberg 2001
[3] Reinhardt G A, Zemanek G: Life cycle analysis of biofuels: Base data, results, valuations. Erich Schmidt-Verlag, Berlin 2000, ISBN 3-503-05814-1, in German