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# Use of on-farm produced biofuels on organic farms – Evaluation of energy balances and environmental loads for three possible fuels

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**Abstract**

The aim of this work was to evaluate systems making organic farms self-sufficient in farm-produced bio-based fuels. The energy balance and environmental load for systems based on rape methyl ester (RME), ethanol and biogas were evaluated using a life cycle perspective. Complete LCAs were not performed. Important constraints when implementing the systems in practice were also identified.

The RME scenario showed favourable energy balance and produced valuable by-products but was less positive in some other aspects. The use of land was high and thereby also the emissions associated with cultivation. Emissions, with the exception of $CO_2$, during utilisation of the fuel were high compared to those of the other fuels in the study. The technology for production and use of RME is well known and easy to implement at farm scale.

The production of ethanol was energy consuming and the by-products were relatively low value. However, the area needed for cultivation of raw material was low compared to the RME scenario. The production and utilisation of ignition improver and denaturants were

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associated with considerable emissions. Suitable ethanol production technology is available but is more optimal for large scale systems.

The biogas scenario had a low relative need for arable land, which also resulted in smaller soil emissions to air and water. Another advantage was the potential to recycle plant nutrients. On the other hand, the potential emissions of methane from storage of digestate, upgrading of biogas and methane losses during utilisation of fuel produced a negative impact, mainly on global warming. Small scale technology for biogas cleaning and storage is not fully developed and extensive tractor modifications are necessary.

The global warming effects of all three systems studied were reduced by 58–72% in comparison to a similar farming system based on diesel fuel. However, the fuel costs were higher for all scenarios studied compared to current diesel prices. In particular, the large costs for seasonal storage of gas meant that the biogas scenario described is currently not financially viable.



*Keywords:* Organic farming; RME; Ethanol; Biogas; Biofuel; Life cycle perspective

## 1. Introduction

Before the mechanization of agriculture, all energy supplied to the farming system was of renewable origin. Today the situation is totally different, since the major source of traction power on the farm, the tractor, is almost always fuelled by diesel from fossil oil. Fossil oil is a limited resource and its use contributes to increased amounts of $CO_2$ in the atmosphere.

In organic farming, there is an effort to use only bio-based energy and renewable raw materials, with the aim of achieving sustainable production systems (SJV, 2001). However, estimations show that the organic farms in Sweden annually consume approx. 36,000 $m^3$ diesel oil (Baky et al., 2002), which can hardly be considered to be sustainable in the long term. Furthermore, this consumption will gradually increase as the scale of organic farming increases. A change to bio-based fuels is supported by the Swedish authorities (SJV, 2001) and will be a logical step towards a sustainable food production system. There is also major work going on in the EU to increase the use of bio-based fuels. The goal of the Commission is for 5.75% of the total volume of fuels in the transport sector to be of renewable origin by the year 2010 (EC, 2003).

In a study by Baky et al. (2002), rape methyl ester (RME), ethanol and biogas were identified as possible fuels for self-sufficiency of motor fuel on organic farms in the short and medium term. These three fuels are also identified as having the potential to meet the goal of the Commission on the Swedish market, with respect to systems of production, distribution and utilisation (SOU, 2004).

RME is produced by transesterification of rapeseed oil. Transesterification is performed by exchanging the trivalent alcohol glycerol with a univalent alcohol, for example methanol (Norén, 1990). In the transesterification process, potassium hydroxide (KOH) is added as a catalyst. After reaction, surplus methanol,