Advanced vegetable oil fuels in advanced engines

The 2nd VegOil project

UN Framework Convention on Climate Change
Durban, South Africa
EU Pavilion – Dec 7th 2011

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A JIG SAW PUZZLE STORY

We must not look for the one solution!

If we want to strive for real sustainable energy supply we have to look for multiple, multi-scale, and thus also for decentralised solutions

– A piece of the puzzle –
LET'S START WITH A QUESTION

WHAT HAS BEEN THE GREATEST INNOVATION OF MANKIND?
John Deere Tractors?

NO!
Fossil fuel powered agricultural machines rank on no. 5

So what?

Innovation No. 1

Arable crop farming

- After more than 1 Mio years …
- … mankind changed nutrition style completely from protein based to carbohydrate (energy) based …
- … enabling unbelievable welfare and population growth up to 7,000,000,000 recently….
- … creating the need for world climate summits
- … and mankind started to settle down
Innovation No. 2

Live stock farming

- Animal proteins as the first luxury „mass product”…
  - … bringing back protein based nutrition and …
  - … the 7,000,000,000 population will grow and with this people will develop a growing demand for better life conditions and thus for proteins
Innovation No. 3

Agricultural machinery
Agricultural production technology

- Improved welfare
- Partially a combination with live stock farming
- Needs drive train energy (fuel)

Invention No. 4?

You already know No. 5 ...
Basic assumptions

- Diesel engines will stay basic drive technology for mobile agricultural machines at least for a mid term prospective
- As a fuel vegetable oil can support global sustainability (but usage is strongly limited)
- The highest energy density produced by photosynthesis is found in natural vegetable oil
- We find optimal agricultural conditions for production of rapeseed oil in Central Europe
- JOHN DEERE’s colours are colours of the rapeseed flower

Energetic equivalent volume of fuels

Source: TFZ Straubing (Bavaria, Germany) Modified
Central European biofuel alternatives
Energy balance different renewable fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Agricultural input</th>
<th>Conversion</th>
<th>Sum input</th>
<th>Sum output</th>
<th>Balance</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MJ/ha</td>
<td>MJ/ha</td>
<td>MJ/ha</td>
<td>MJ/ha</td>
<td>MJ/ha</td>
<td></td>
</tr>
<tr>
<td>Rapeseed oil</td>
<td>14812</td>
<td>529</td>
<td>15342</td>
<td>36450</td>
<td>21108</td>
<td>2.38</td>
</tr>
<tr>
<td>RME</td>
<td>14812</td>
<td>4474</td>
<td>19287</td>
<td>36360</td>
<td>17073</td>
<td>1.89</td>
</tr>
<tr>
<td>Ethanol from wheat</td>
<td>12025</td>
<td>41689</td>
<td>53714</td>
<td>62726</td>
<td>9012</td>
<td>1.17</td>
</tr>
<tr>
<td>Ethanol from sugarbeet</td>
<td>14880</td>
<td>63315</td>
<td>77995</td>
<td>127020</td>
<td>49025</td>
<td>1.63</td>
</tr>
<tr>
<td>Methane from corn</td>
<td>15158</td>
<td>72395</td>
<td>87553</td>
<td>192456</td>
<td>104903</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Energy Balance Results

- Rapeseed oil: 2.38
- RME: 1.89
- Ethanol from wheat: 1.17
- Ethanol from sugarbeet: 1.63
- Methane from corn: 2.20
Basic Assumptions
Potential (Self-)Supply

Diesel consumption of German agricultural sector

\[ 1.55 \text{ Mio t} = 6.65 \cdot 10^{10} \text{ MJ} \]

\[ \Rightarrow 1.82 \text{ Mio. ha} \]

Maximum possible area for rapeseed:

1.8 Mio ha per year.

= 2.2 % of total transport
= 5% of total diesel consumption

= 10% of cultivated area, but substitutes arable land for feed or imports

Pure Vegetable Oil (PVO)
powered tractors
Mandatory side conditions

Currently about 100 ha
but decreasing with time
and with increasing diesel price

No doubt!
Connection to live stock farming needed!
Calculatory income is needed

1. Minimum farm size
2. or farming societies
3. or increasing diesel price
4. Tax regulations must fit
5. Rapeseed cake usage
6. Decentralized/self supply
7. Manufacturer supply
Today’s alternative two ways of thinking\(^{1}\) have to merge to meet future demands

\(^{1}\) Either change the fuel (biodiesel; BtL) or the engine (pure plant oil)

Both sides have to move

1. **DIN 51605**
   Fuels for vegetable oil compatible combustion engines – Fuel from rapeseed oil

2. **DIN SPEC 51623**
   Fuels for vegetable oil compatible combustion engines – Fuel from vegetable oil

3. **CEN/TC WS 56**
   Fuels and biofuels – Pure plant oil fuel for diesel engine concepts

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Plant oil (PO) powered tractor

The challenges

Demonstration of 2nd Generation Vegetable Oil Fuels in Advanced Engines

2ndVegOIL

1. Emissions (NOx)
2. Emission after treatment
3. Engine lubrication
4. Fuel viscosity
5. Thermal characteristics
6. Cold start behaviour
7. Transient behaviour
8. Motor power characteristic
9. Storage of fuel
10. Quality of fuel and blends
EU Project Proposal 2ndVegOil: Multifuel-Tractor

Preceeding projects:
1. 100-Traktorenprogramm (BMELV), 2001 to 2005
2. Motorentwicklung PÖ f. EU-3A (BMELV and FNR), 2006 to 2008

The 2ndVegOil Partners
1. John Deere (D)
2. Vereinigte Werkstaetten für Pflanzenöltechnologie (D)
3. Technical University Munich, Internal Combustion Engines (D)
4. Lubrizol Ltd. (UR)
5. Waldland Vermarktungs-ges. m.b.H. (AU)
6. RhônaLnergie Environnement (F)
7. Fédération Régionale des CUMA Rhône-Alpes (F)
8. Institute of Technology and Life Sciences ITP (PL)
9. Nederlands Normalisatie-instituut NEN (NL)
10. engineering (D)

Other scientific partners

Multi-Fuel prepositions

Power decrease with biofuels due to lower heating value

Power compensation by software and software switch by fuel sensor.
### Field test fleet

<table>
<thead>
<tr>
<th>Model</th>
<th>Lubricant</th>
<th>Basic fuel</th>
<th>Fuel additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>6830 Premium</td>
<td>ACEA E7</td>
<td>Rapeseed</td>
<td>JD Biodiesel Protect 100</td>
</tr>
<tr>
<td>6930 Premium</td>
<td>ACEA E7</td>
<td>Sunflower</td>
<td></td>
</tr>
<tr>
<td>7430 Premium</td>
<td>ACEA E9</td>
<td>Camelina Sativa</td>
<td>Lubrizol</td>
</tr>
<tr>
<td>7530 Premium</td>
<td>Jatropha</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EU Stufe 3A / TIER 3

EU stage 3B / int. TIER 4 and pre-investigations for EU stage 4 / TIER 4

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### 2nd VegOil seen in the French TV

EU Rendez Vous Your Results
Innovation No. 4?

Summary

Pure cold pressed vegetable oil as an agricultural fuel is an integrated technological approach
… combing the three grand innovations and …
contributing to …
… sustainability and …
… agricultural economy and …
… to our future business
Let's go for it!

Vision: Sustainable Energy Supply for Agricultural Machinery