Sustainable Agricultural Energy Supply and Consumption Concepts Based on

Electromobility and Pure Plant Oil

Prof. Dr. P. Pickel & T. Kaiser
Dec. 2014

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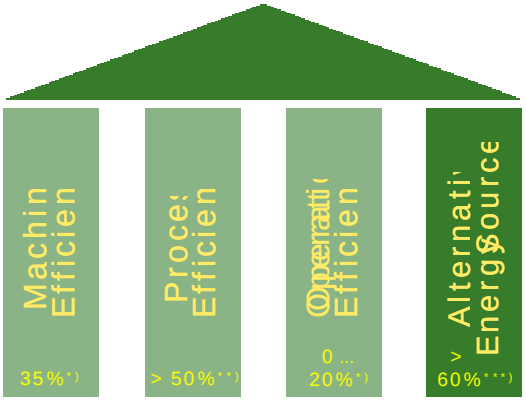
Political frame conditions in EU

- „EU stage V“
- Mandatory reduction of fleet CO_2 emissions
- Reduction of Ag diesel subsidies
- Mandatory environ-mental product cert.
- Renewable Energy Directive 2009/28/EC
- iluc-debate
- Changes in CAP

What else?

1. Ag sector / farms are energy producers and thus support goals of our society
2. In Ag exists high potential for closed-loop short circle energy production and consumption allowing for highest efficiency

CEMA/CECE's Key Pillars of Agricultural Sustainability (modified)



*) "Sophisticated guess"
**) Fuel red. acc. to BLE-calculation in case of a total move to conservative soil tillage in Germany
***) Own results

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What is sustainable arable farming?

No doubt – this is

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What has changed?

Productivity was increased

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Productivity was increased

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What has changed?

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

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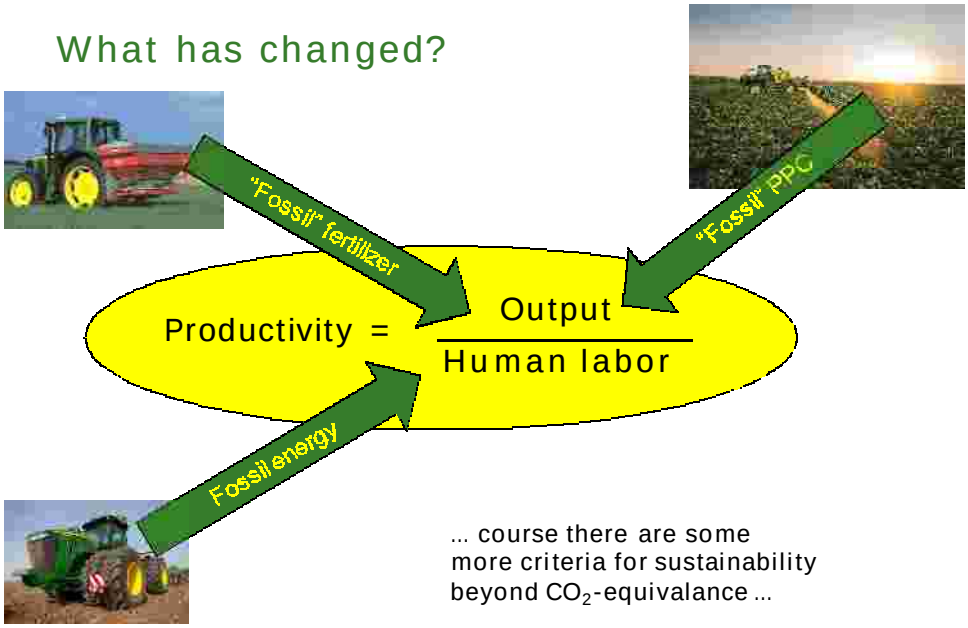

… course there are some more criteria for sustainability beyond CO_2-equivalance …

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Analysis of potential CO_2 reduction

	Energetic inp. (MJ/ha/a) *)	Savings by …	Estimated potential CO_2-reduction
Drive train	3000	Higher efficiency	35 %
		Renewable energy	=60 %
Fertilizer (N, P, K, S)	10000	Automation, Precision, …	20 %
PPC, seeds	400	Automation, Precision, …	50 %

*) Source: S. Dieringer, Master-Thesis, Uni Hohenheim, 2008 and KTBL;
Values rounded for crop rotation Rapeseed, Wheat, Sugar beet and Maize; ploughless

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Question: Agriculture is producer of renewable energy - but how to make renewable energy available to mobility / mobile working machines?

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Fundamental Energy Carriage Paths

chemical energy

electric energy

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Ag diesel subsidies (Germany) Quo vadis?

Deutscher Bundestag Drucksache 17/11552
17. Wahlperiode 19. 11. 2012

Motion from opposition in German Parliament from Nov. 19th 2012:

Increase added value in agricultural and forestry sector by production and application of pure plant oil fuel

Antrag
der Abgeordne
Petra Crone, E
Kelber, Ute Ku
Tack, Dr. Frank-Walter Steinmeier und der Fraktion der SPD

Wertschöpfung im ländlichen Raum absichern - Erzeugung und Einsatz reiner Pflanzenöle in der Land- und Forstwirtschaft ausbauen

Der Bundestag wolle beschließen:

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6R Multifuel Traktor - Clean multifuel tractor concept

SIMA INNOVATION AWARDS
20. November 2012

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Basic assumptions

John Deer-comitt to those who are link ed to the lan

- 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 rapeseed

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Basic Assumptions
Potential (Self-)Supply

Diesel consumption of German agricultural sector

1.6 Mio t = $7 \cdot 10^{10}$ MJ

= 2,5 % of total transport

= 5% of total diesel consumption

à 1.5 – 1.8 Mio. ha

Maximum possible area for rapeseed:

1.8 Mio ha per year.

(UFOP)

~ 8-10% of cultivated area, but subsitutes arable land for feed or imports

Charles Deere demonstrating a walking plow

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Plant oil (PO) powered tractor

The challenges

Other national projects:

a) 100-Traktorenprogramm (BMELV), 2001 to 2005
b) Motorentwicklung PÖ f. EU-Stufe 3A (BMELV and FNR)
c) ABM / PraxTrak – PÖ f. EU-Stufe 4 (BMELV and FNR), 20012/14

Bundesministerium für Ernährung und Landwirtschaft

FNR Fachagentur Nachwachsende Rohstoffe e.V.

Demonstration of 2nd Generation Vegetable Oil Fuels in Advanced Engines

2ndVegOIL

1. **Emissions (NOx)**
2. **Emission after treatment**
3. **Engine lubrification**
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**

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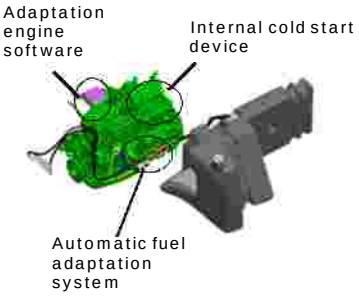
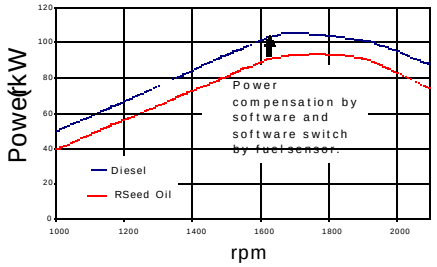
Multi-Fuel *prepositions*



Power decrease with biofuels due to lower heating value



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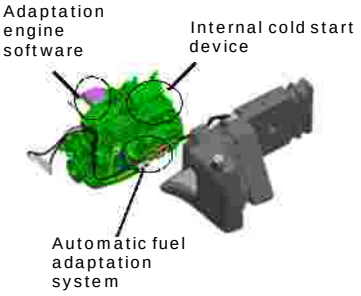
Multi-Fuel prepositions



Current state

1. Emissions acc. TIER 1 – 4i
2. First promising results indicate that we will be able to meet TIER 4 with the integrated approach of 2nd VegOil):
   1. Tractor adaptation
   2. Oil quality management

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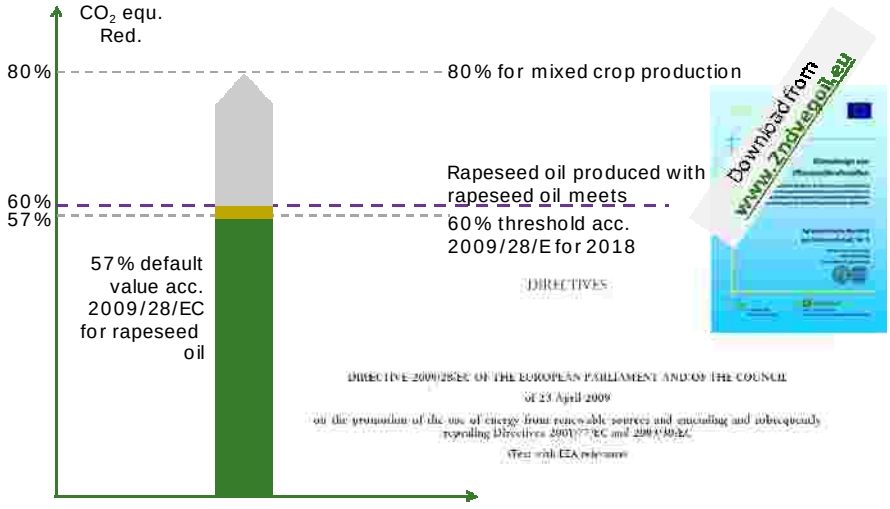
Climate design of pure vegetable oil as fuel



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Summary PPO

- PPO can deliver reduction of GHG by ~60%
- Comparably small development effort
- Cost effective
- Low hanging fruit?

www.2ndvegoil.eu

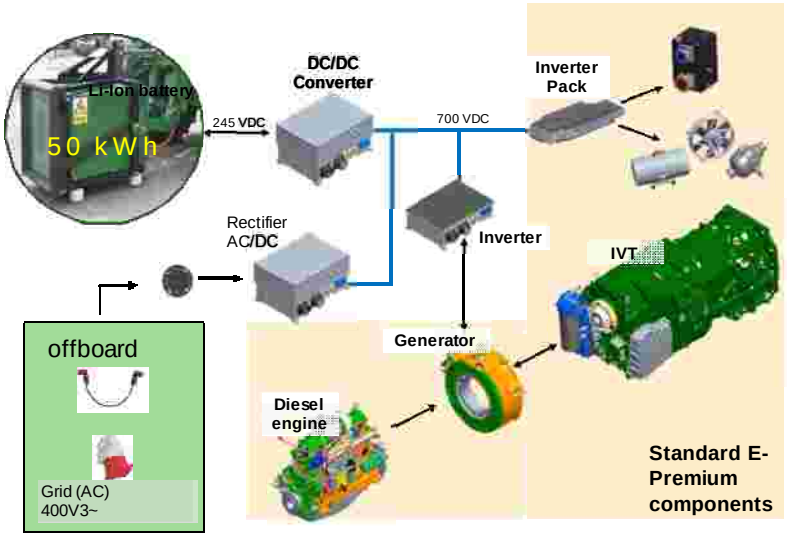
www.praxtrak.de

Overview on projects for electrically driven tractors

Gefördert durch:
Bundesministerium für Wirtschaft und Energie

LIB-OFF-ROAD	High voltage battery design 2009 – 2012 (Project agency: TÜV Rheinland)
SESAM E-Tour ALLGÄU IKT FÜR ELEKTROMOBILITÄT econnect Germany	Grid integration of EV Business case for electrification / additional value 2009 – 2015 (Project agency: DLR)

E Premium modified to a prototype hybrid tractor



IKT FÜR ELEKTROMOBILITÄT econnect Germany JOHN DEERE

Demonstration tractor

IKT FÜR ELEKTROMOBILITÄT econnect Germany E-Tour ALLGÄU

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Features

Engine off applications

- Comfort applications (A/C)
- Filling processes
- Intelligent power supply

Basic hybrid features

- Boost (drive train & implement)
- Range extension
- Emission reduction and fuel savings by reduction of transient engine operation
- Recuperative breaking

Grid integration

- Emergency power generator
- Energy buffer for on-farm power plant (PV, biogas, ...)
- New business model for energy or capacity trading

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The AEF connector (AC/DC) concept history

Level 2 Example – Electric Fertilizer Spreader

Reduced fuel consumption

Improved performance (speed control, torque sensing)

Comfortable coupling

ISO 11783

2007

2013/14

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Basic „SESAM“ vision

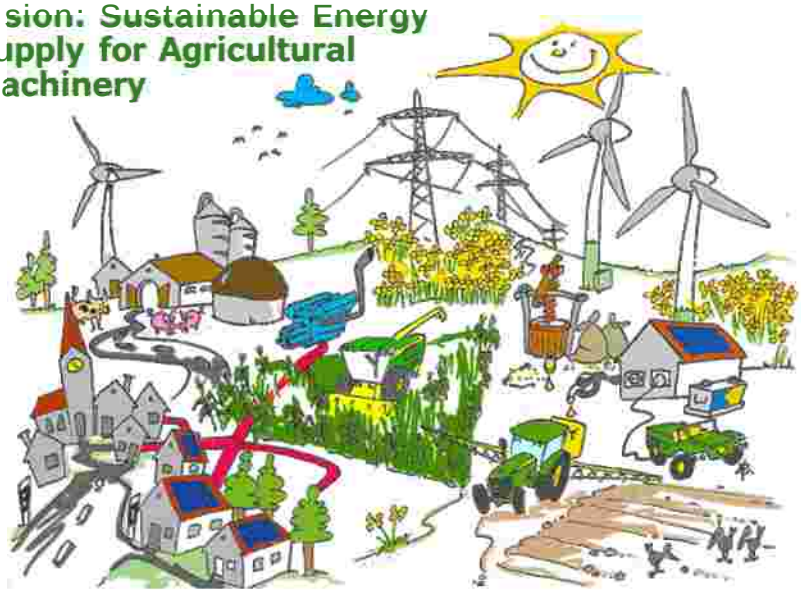
- Hybrid machines are interim solutions only

- Energy autonomous farming
- Mobile application of self-produced electric energy as a new business modell
- Energy storage should have 100% operational time

Electrification summary

- Agriculture can contribute to CO_2 reduction and a smart energy grid
- Hybrid machines are starter for full electric agricultural machines
- Batteries improve utilization of self produced renewable energies
- Energy autonomy will become more attractive due to decreasing reimbursements and increasing energy costs
- Electrification enables automation
- Battery should have a 8760 h/a productive time

Vision: Sustainable Energy Supply for Agricultural Machinery



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