# Putting Sustainable Farming into Practice

## *Sustainable Energy Supply for Agricultural Machinery – The SESAM Vision*

Prof. Dr. Peter Pickel

JOHN DEERE

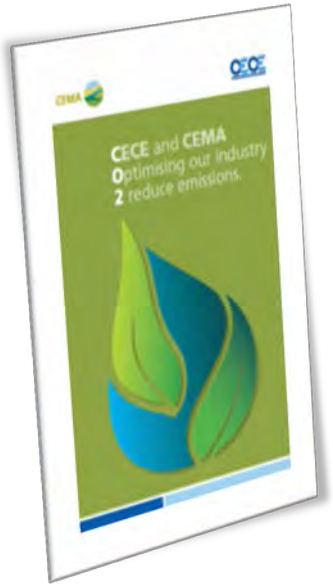
# Political „Threats“ in EU

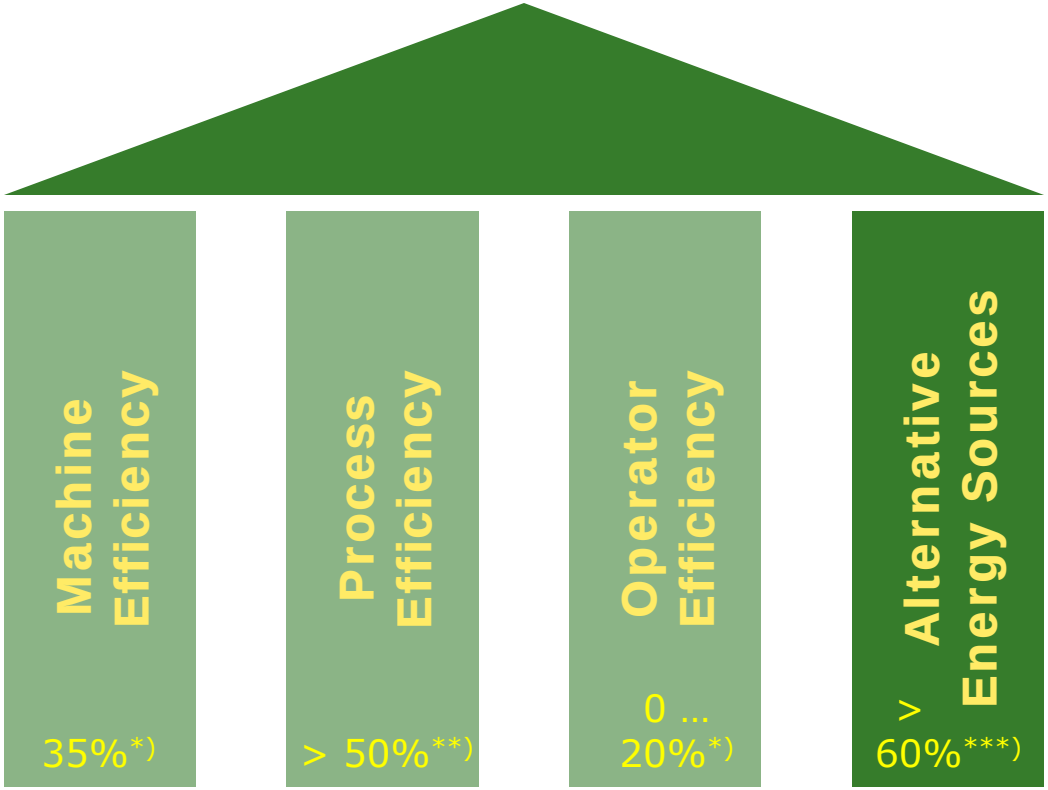
- Mandatory reduction of fleet $CO_2$ emissions
- Reduction of Ag diesel subsidies
- Mandatory environ-mental product cert.
- Renewable Energy Directive 2009/28/EC
- iluc-debate
- Changes in CAP


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



JOHN DEERE

# What is sustainable arable farming?

**No doubt – this is**

# What has changed?

**Productivity was increased**

# Productivity was increased

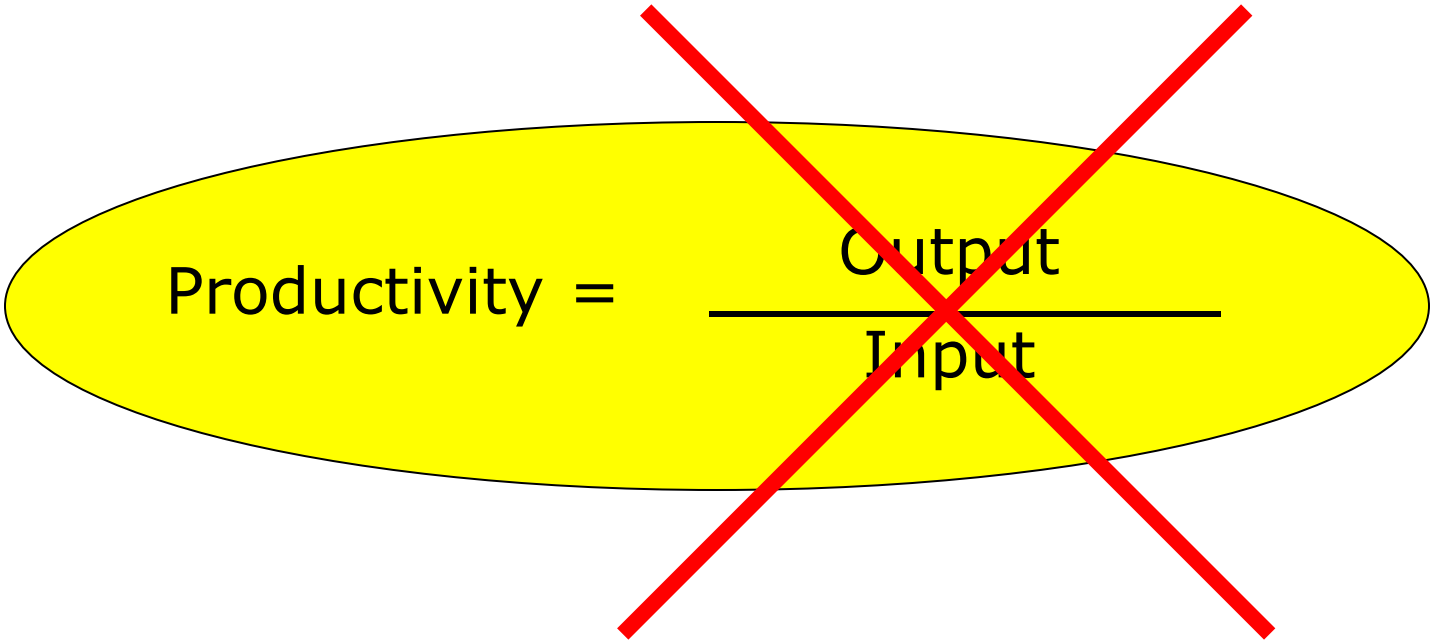



JOHN DEERE

# What has changed?

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

# What has changed?



# What has changed?

"Fossil" fertilizer

"Fossil" PPC

$$\text{Productivity} = \frac{\text{Output}}{\textbf{Human labor}}$$

Fossil energy

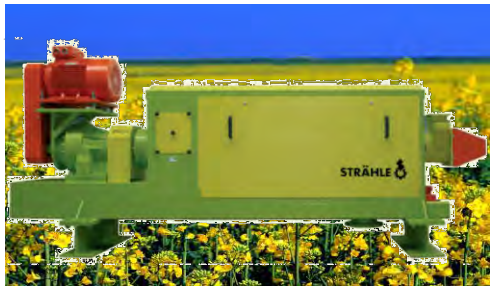
… course there are some more criteria for sustainability beyond $CO_2$-equivalance …

# 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

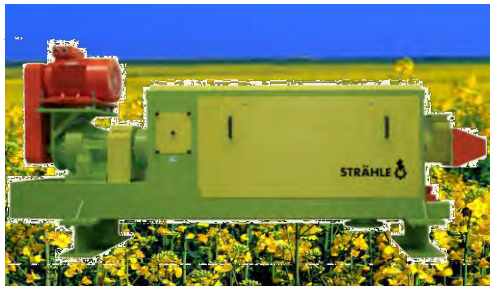
# Question: Agriculture is producer of renewable energy - but how to make renewable energy available to mobility / mobile working machines?






JOHN DEERE

# Fundamental Energy Carriage Paths




chemical energy

electric energy



JOHN DEERE

# 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:

# 6R Multifuel Traktor - Clean multifuel tractor concept




JOHN DEERE

# Basic assumptions

# 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

→ 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

EUROPEAN COMMISSION
Community Research

Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz

FNR
Fachagentur Nachwachsende Rohstoffe e.V.

**Other national projects:**

a) 100-Traktorenprogramm (BMELV), 2001 to 2005

b) Motorentwicklung PÖ f. EU-3A (BMELV and FNR), 2006/8

c) ABM/PraxTrak – PÖ f. EU-4 (BMELV and FNR), 20012/14

## Plant oil (PO) powered tractor
# The challenges

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

**Demonstration of 2nd Generation Vegetable Oil Fuels in Advanced Engines**

**2ndVegOIL**

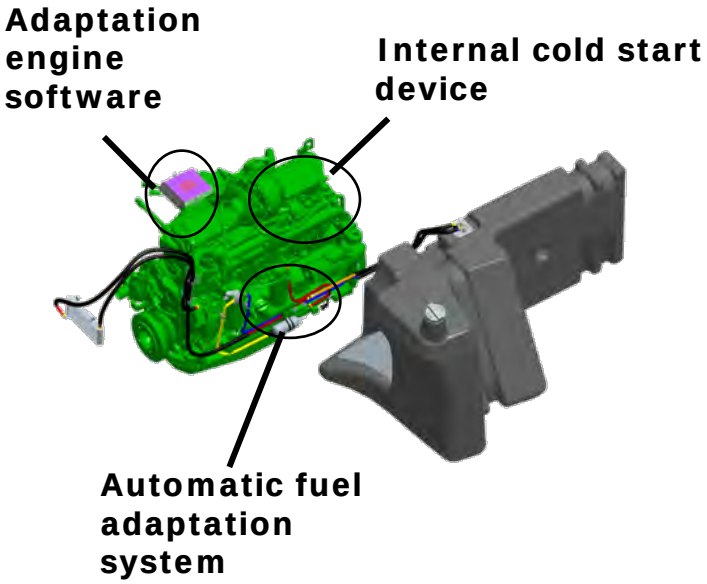
SEVENTH FRAMEWORK PROGRAMME

2nd VegOil EU

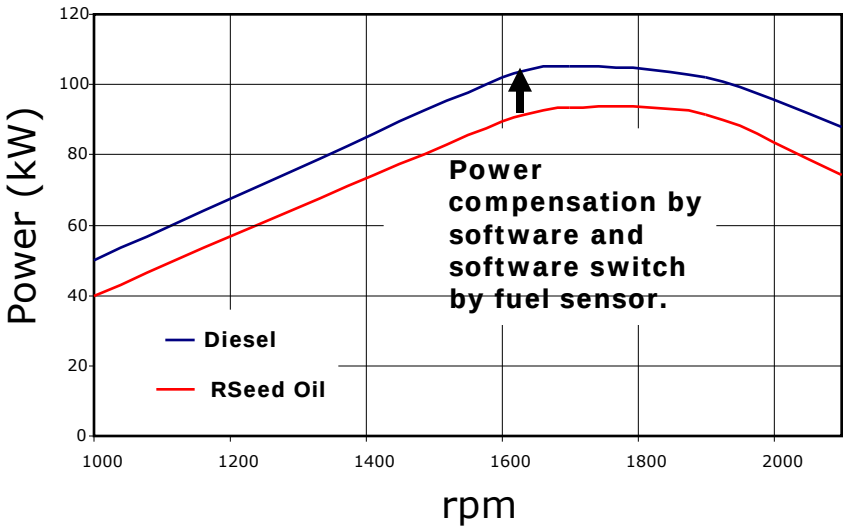


JOHN DEERE

# Multi-Fuel *prepositions*



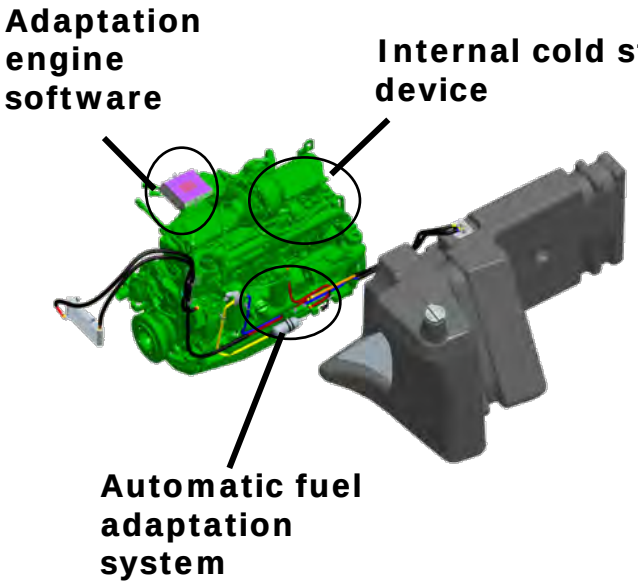

Power decrease with biofuels due to lower heating value






JOHN DEERE

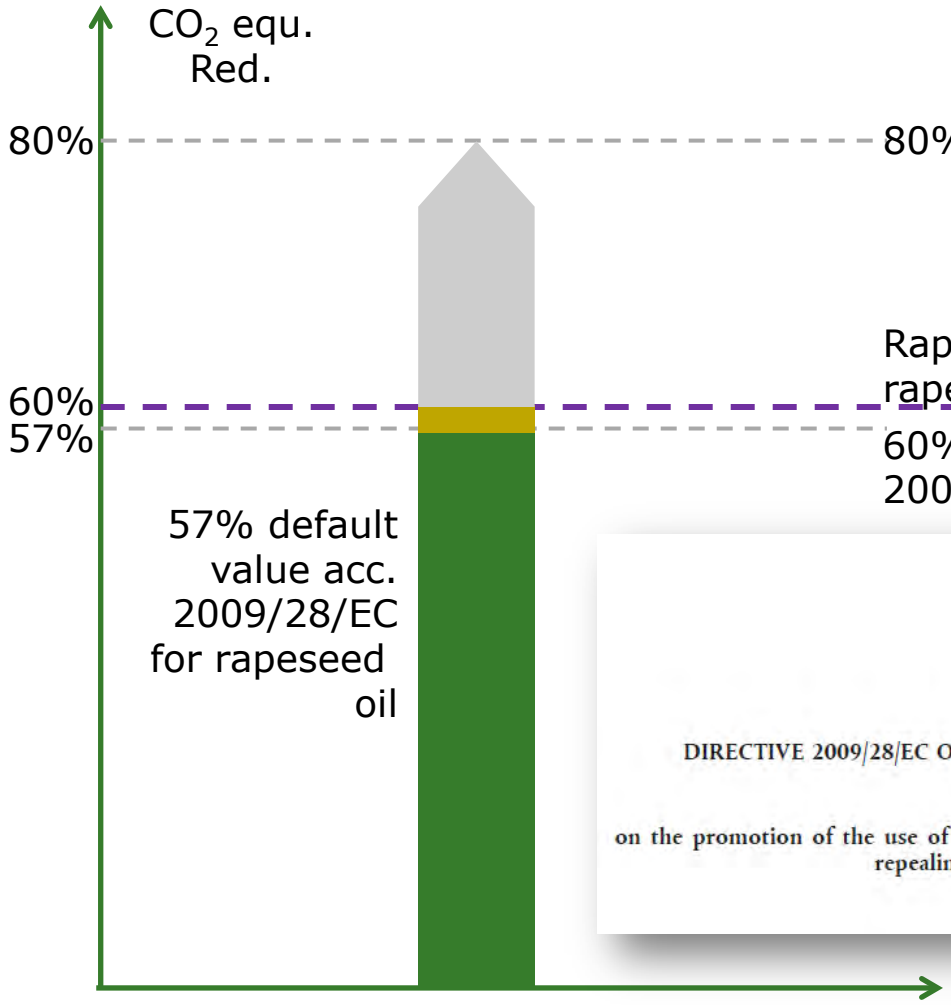
# Multi-Fuel prepositions

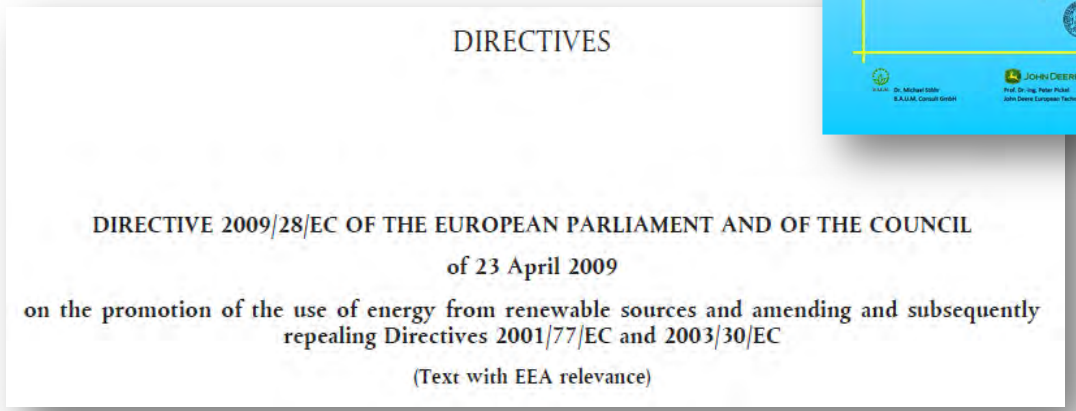



**Current state**

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**

# Climate design of pure vegetable oil as fuel





DIRECTIVES

DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 23 April 2009

on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

(Text with EEA relevance)






JOHN DEERE

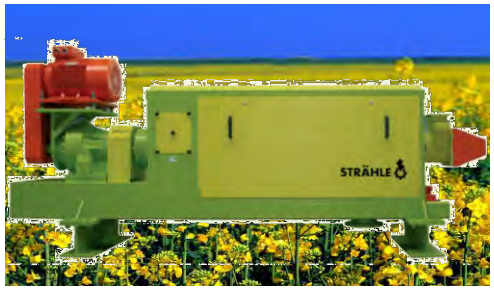
# Summary PPO

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

**www.2ndvegoil.eu**

**www.praxtrak.de**

# Fundamental Energy Carriage Paths




chemical energy

electric energy

# Overview on projects for electrically driven tractors

Gefördert durch:

Bundesministerium für Wirtschaft und Technologie


High voltage battery design

2009 – 2012

(Project agency: TÜV Rheinland)

***SESAM***




Grid integration of EV

Business case for electrification / additional value

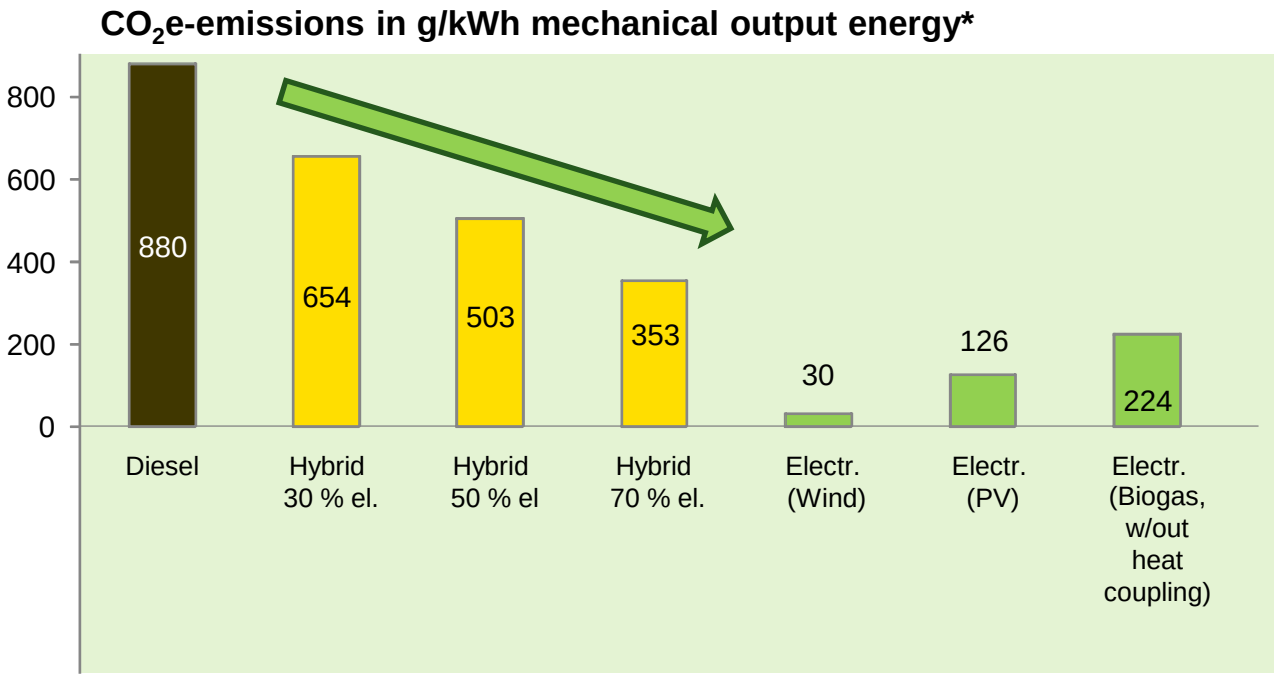
2009 – 2015

(Project agency: DLR)



JOHN DEERE

# Ecological consideration




*) Diesel at 35% efficiency, electric drive at 80% efficiency, Hybrid e.g. 70% conventionell / 30% electric (el. energy mix from Wind, PV and Biogas at each 1/3 )

Source: M. Hanselmann, John Deere, modified

# E Premium modified to a prototype hybrid tractor


DC/DC Converter

245 VDC

700 VDC

Inverter Pack

Rectifier AC/DC

Inverter

IVT

Generator

Diesel engine

offboard

Grid (AC) 400V3~

Standard E-Premium components

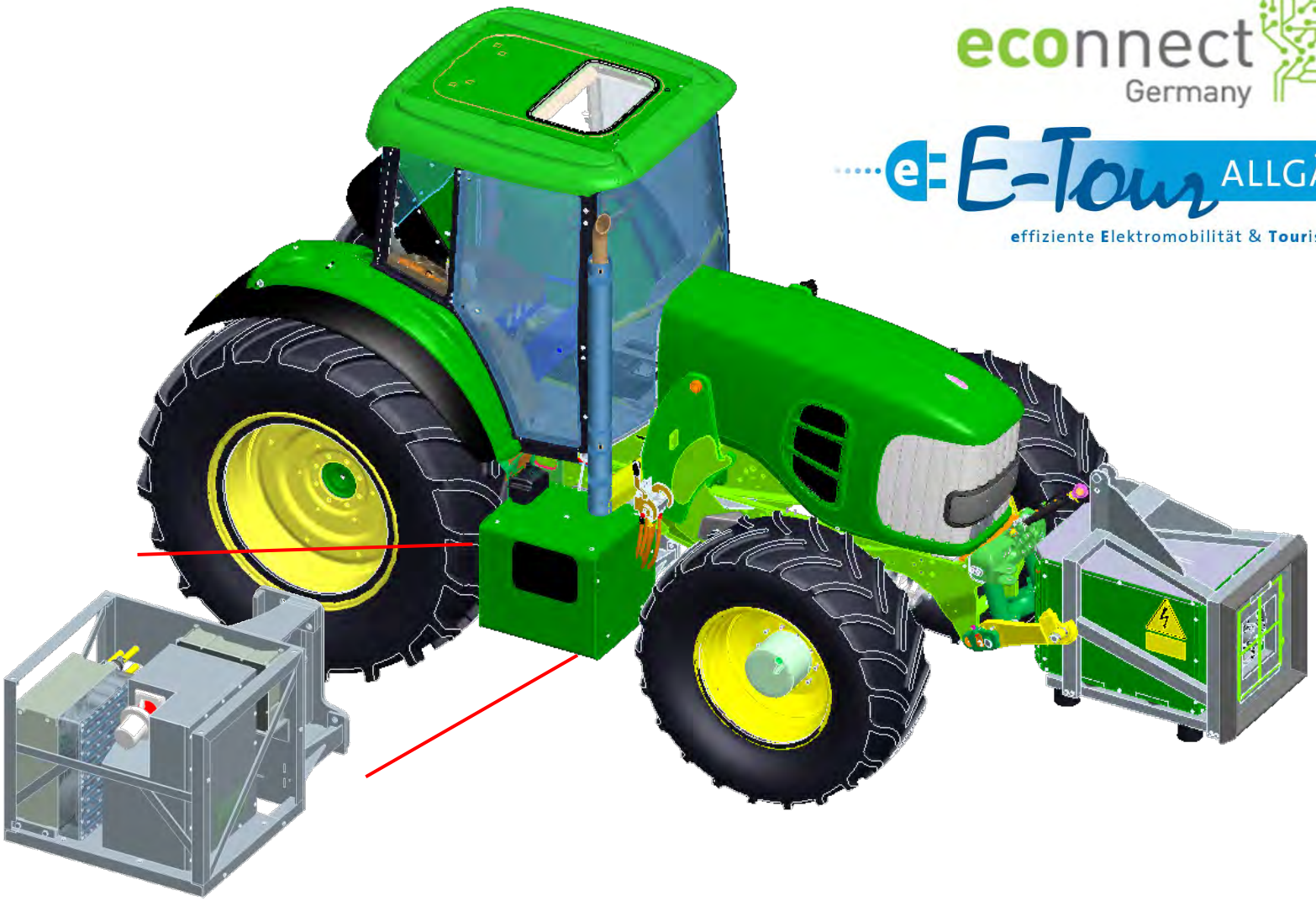
# Demonstration tractor

IKT FÜR ELEKTROMOBILITÄT

econnect Germany

E-Tour ALLGÄU

effiziente Elektromobilität & Tourismus

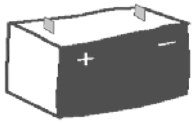




JOHN DEERE

# 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

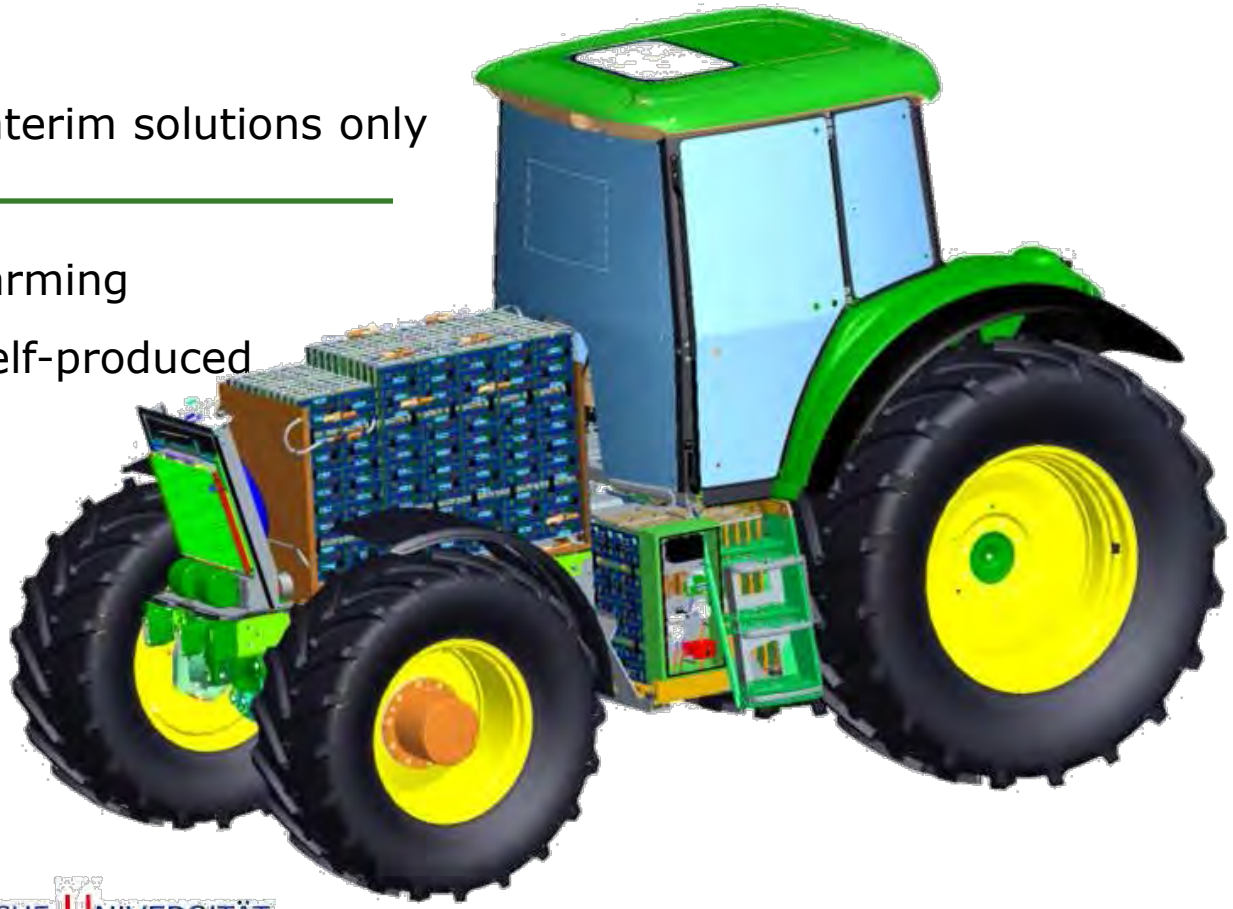
# Basic vision of the SESAM tractor project

IKT FÜR ELEKTROMOBILITÄT

SESAM

- Hybrid machines are interim solutions only

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



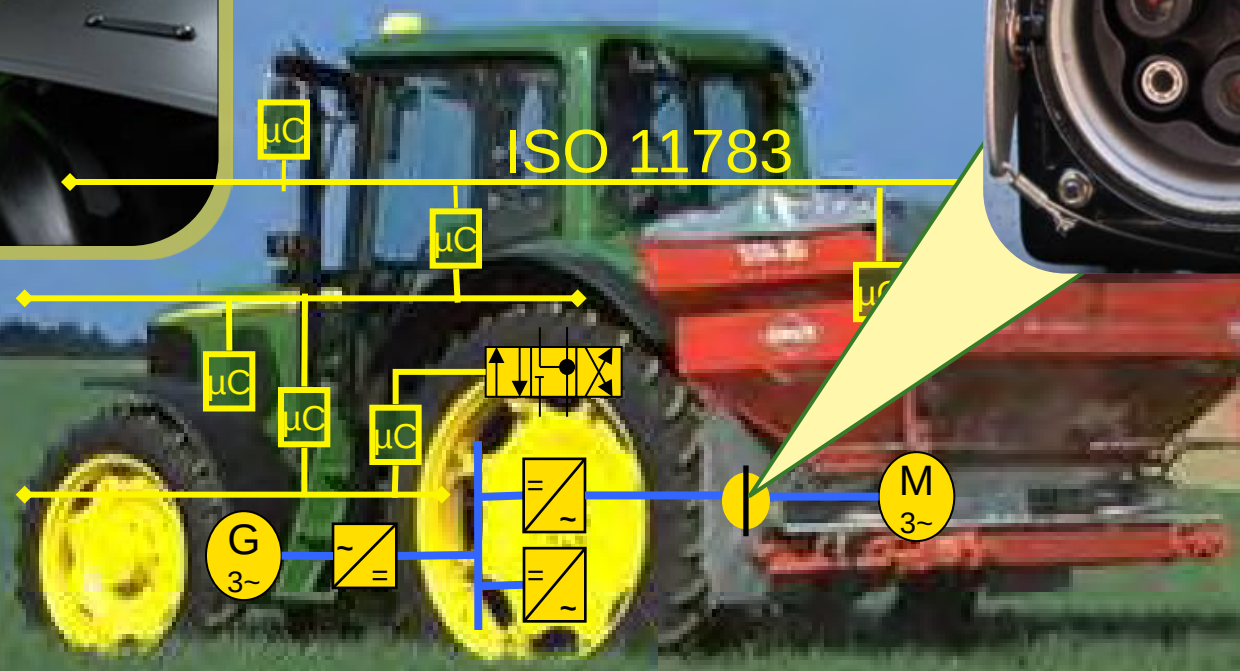
B.A.U.M.

TECHNISCHE UNIVERSITÄT KAISERSLAUTERN



JOHN DEERE

# The connector



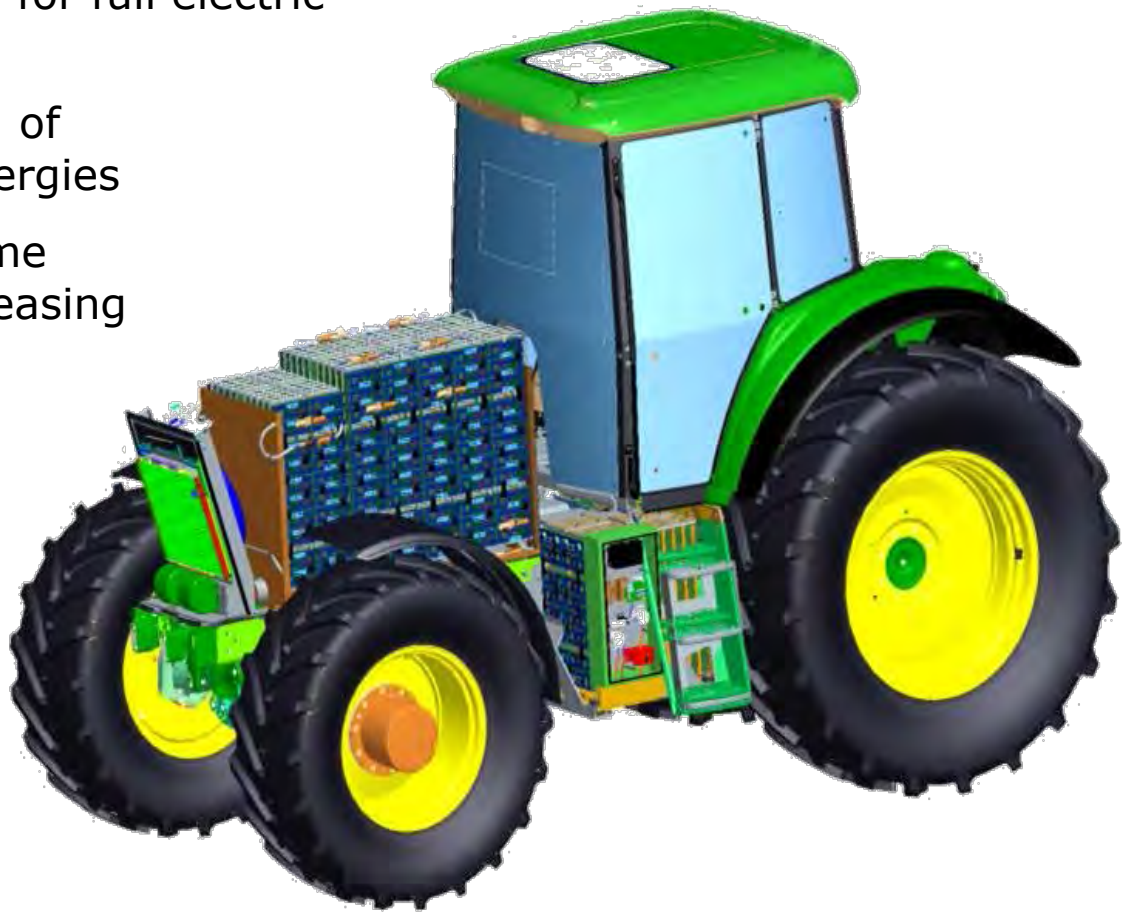

JOHN DEERE

# Vision: Process controls machinery

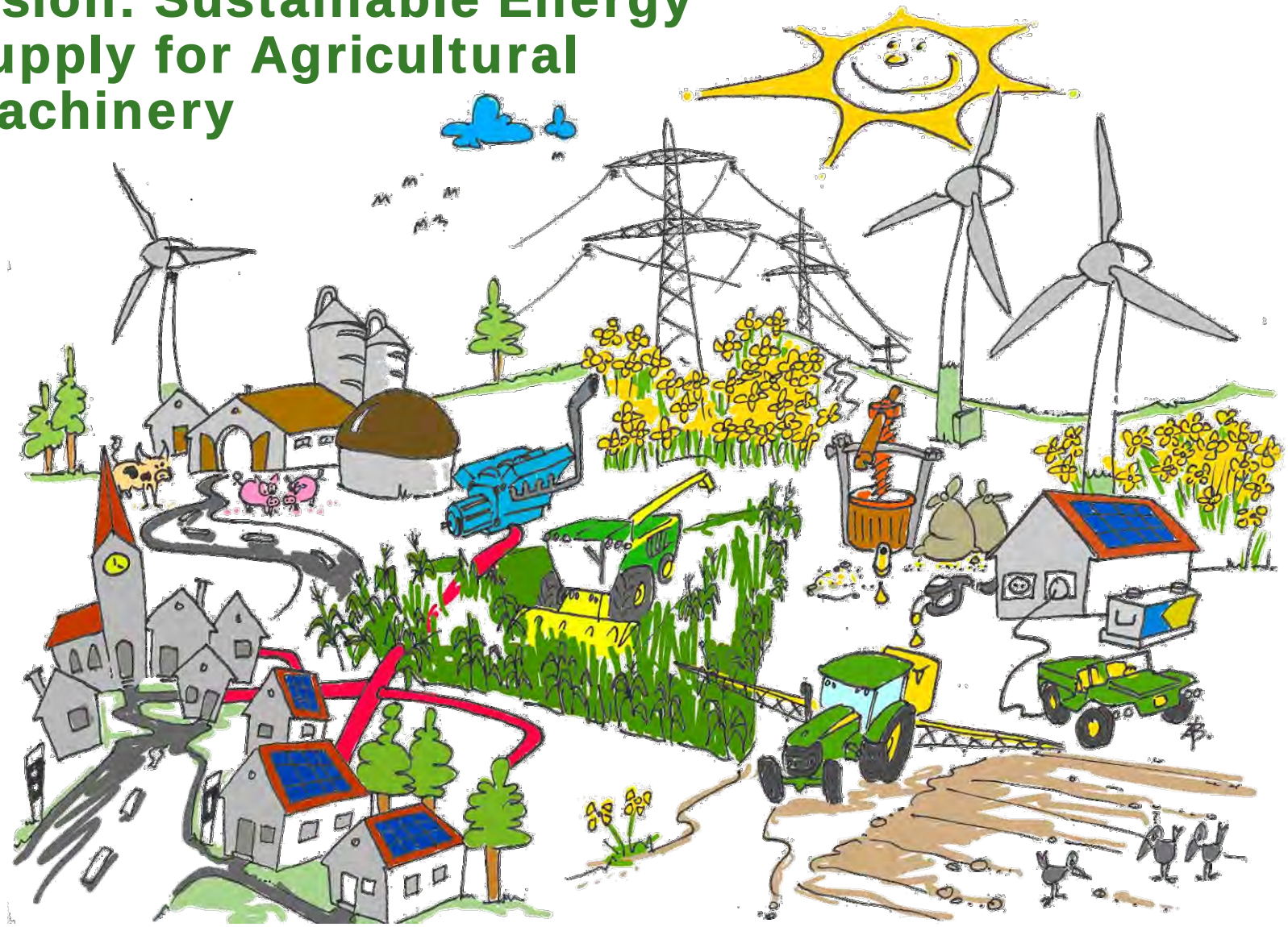

Source: Klaus Hahn (modified)

# 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




JOHN DEERE
6930
Premium
GREEN POWER
Feeds Your Engine