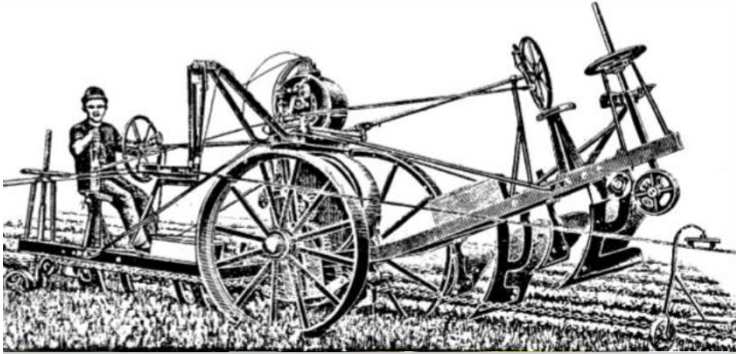


aufgrund eines Beschlusses
des Deutschen Bundestages



Potential of E-mobility in Agriculture

On the pathway to energy neutral
farming

Prof. Dr.-Ing. Peter Pickel
John Deere European Technology Innovation Center
Kaiserslautern



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Electrification - Key Enabling Technology

- Efficiency
- Controllability and dynamic response behaviour



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John Deere ExactEmerge

Electric system characteristics

- 48V PTO generator or high power AEF connector
- 2 servo-motors per row unit

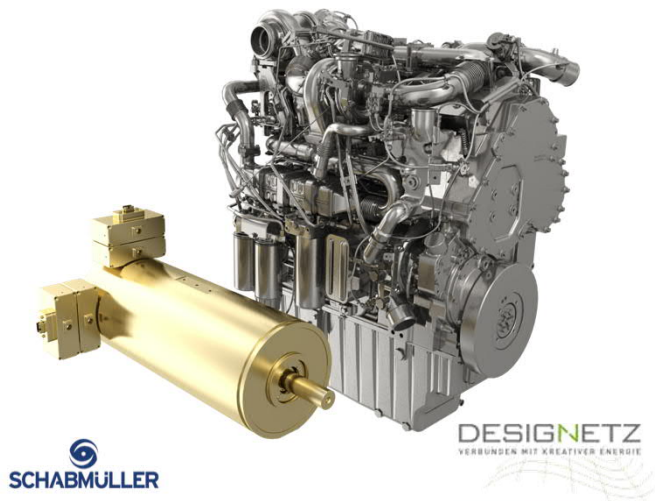


Electrification - Key Enabling Technology

- Efficiency
- Controllability and dynamic response behaviour
- Increased power density



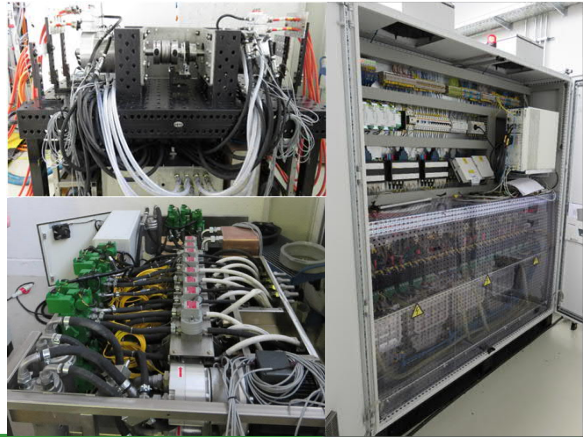
High power density for larger ag machines



SCHABMÜLLER

DESIGNETZ
VERBUNDEN MIT KREATIVER ENERGIE

- Permanent sensing of all machine characteristics (rotor telemetric system)
- Controlled cooling
- 4 double inverters (totally 1200 kVA)



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Electrification - Key Enabling Technology

- Efficiency
- Controllability and dynamic response behaviour
- Increased power density
- Using renewable energy

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SESAM-Farm Vision

Decentralized Energy Supply in Rural Areas



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BatteryBoost

Grid plug-in hybrid tractor with a battery change system

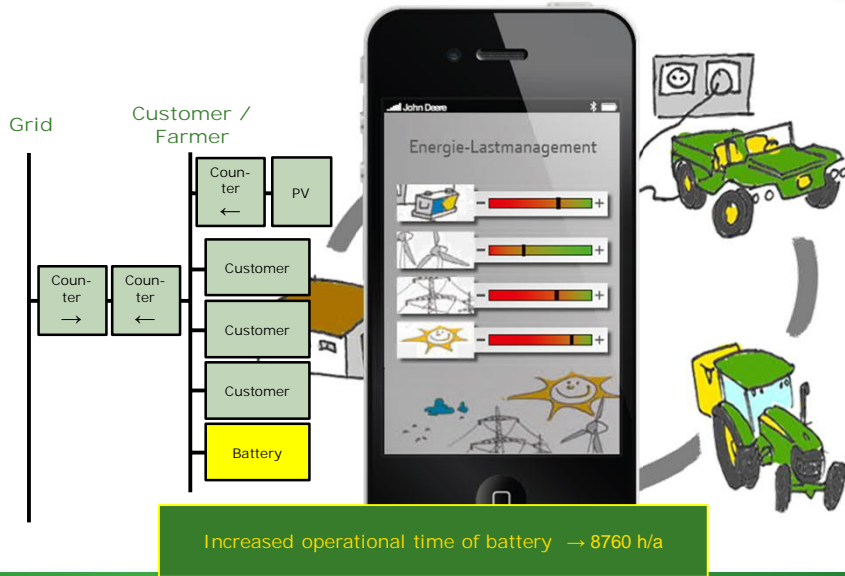


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Intelligent Energy Management



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Infrastructure

N-E-ST Box



Energy manager

DSB

System-cockpit

- Processing (e.g. prediction data)
- Flexibility signaling



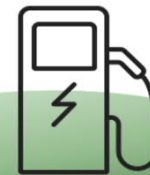
BatteryBoost



SOC
Charging power

Batt. CAN Bus

Charging power req.
Charging cable





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Overview

Engine off


Electrical engine boost




Grid integration


BatteryBoost hybrid tractor features


- Filling processes
- Comfort applications
- Intelligent power supply

- Boost at all speeds
- Range extension
- Smoothing transient engine operation
- Recuperative braking

- Cost effective integration through CCS 2
- Energy / capacity trading
- Emergency power generator
- Battery exchange concept
- Smart power/energy management

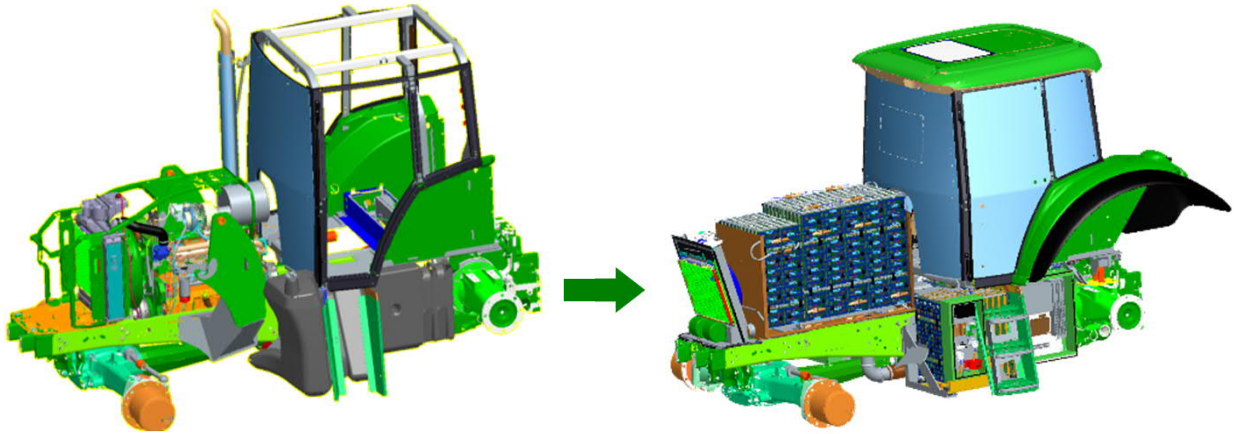



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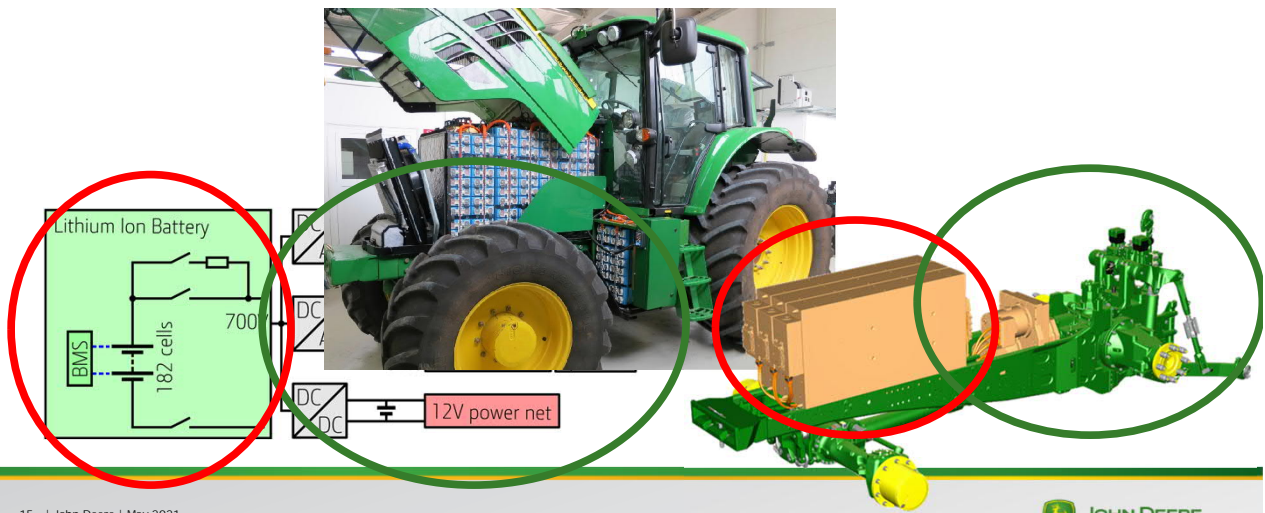


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SESAM fully battery electric tractor



Fully battery electric tractor SESAM tractor concept 2017



The inherent dimension problem of tractor batteries

Rated power	kW	50	180	290	380
Operational time/day	h	4	10	12	12
Req. battery cap. ¹⁾	kWh	100	900	1740	2280

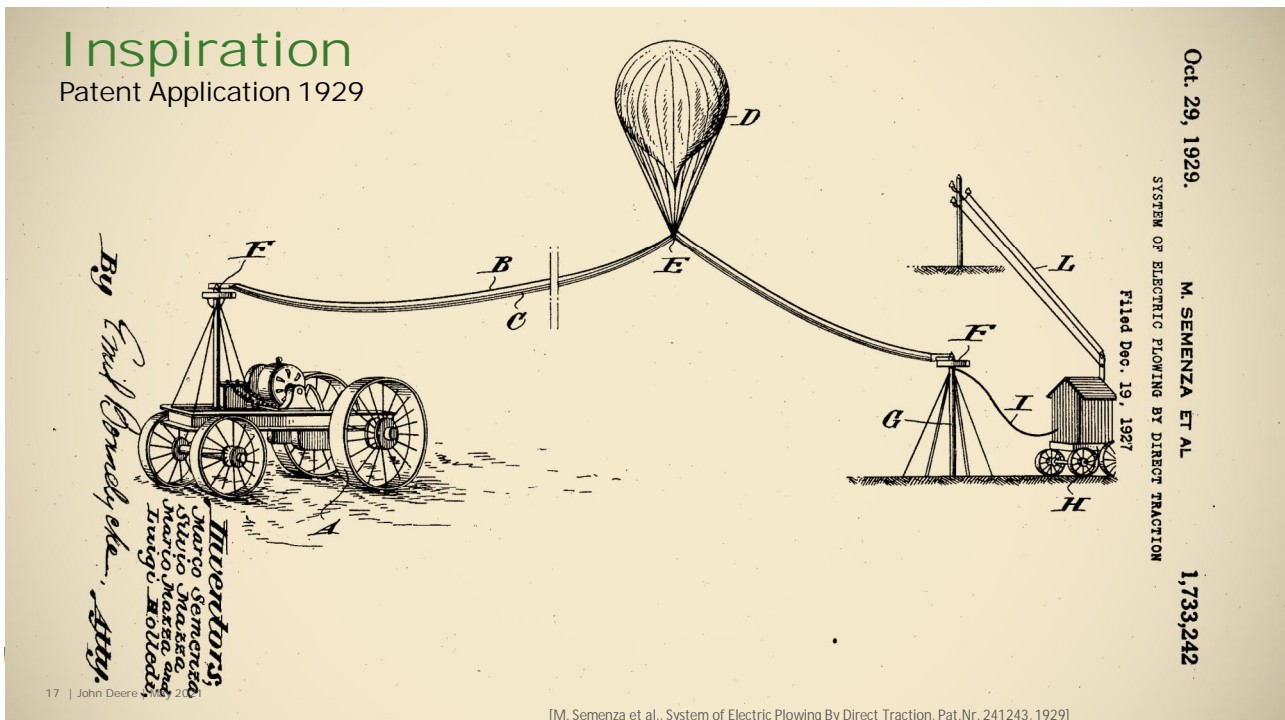
¹⁾ at 50% utilization

Battery dimension



Assumptions:
 ca. 6,6 kg/kWh (for comparison: SESAM bei ~10 kg/kWh)
 ca. 2,2 l/kWh

Source: Fendt / AGCO - modified





Autonomous Electric Tractor

Physical Build

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Overcoming Limits of Onboard Batteries

Corner Stones

Machine Performance	200%
Power Density	200%
Machine Cost	50%
Operating Cost	50%
Applicability of Renewable Power	up to 100%
Supports different stationary power sources	Power grid Battery Generator Fuel cell

Supported by:  Bundesministerium für Wirtschaft und Energie



20 | EIP AGRI | Peter Pickel - John Deere GmbH & Co. KG | February 23rd, 2019

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Energy Transmission

The Concept

Stationary Transformer

Power Grid 400V AC

Stationary

Cable 2,5 kV AC 3,6 kHz

Vehicle

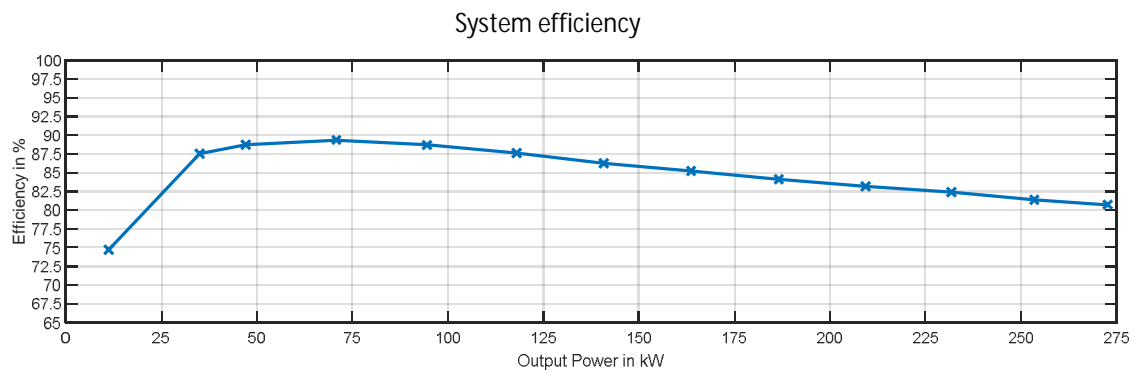
Tractor 700V DC

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Research on High Power Transmission

1 km Cable Power Transmission at a Frequency of 3.6 kHz – Measured at the test bench



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5 Key Theses for Agriculture



1. Electric power trains are the future

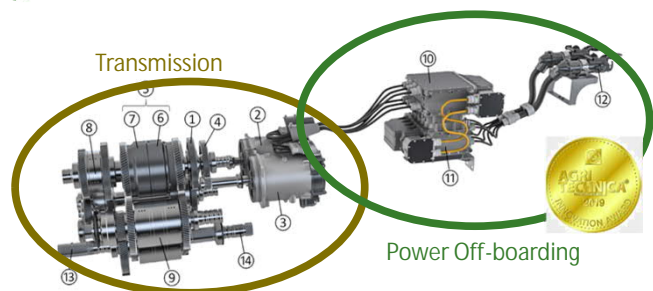
- effectivity
- controllability
- access to renewable energy
- power density

2. Tractor-implement-electrification important driver (hen and egg problem)

3. Hybrid systems depending on need for boost power (not range extenders)

4. Still missing business case and poor energy density for battery electric ag machines

5. Grid services and increase of self-supply with grid-plug-in systems as new (secondary) business cases in agriculture



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