



# Electric drives in agricultural machinery

An approach from the tractor side

Dr. Eckhard Buning



**JOHN DEERE**

# Agenda

- Introduction
- Motivation
- History of electric drives in agriculture
- Tractor electrification
- Tractor - Implement electrification
- Summary & Vision

# Motivation – Why higher voltage on agricultural tractors?

- Optimized controllability of power flows across agricultural machines and between machines
- Generate sufficient electrical power
- Reduced parasitic loads caused by engine auxiliaries to improve complete machine efficiency
- Increased flexibility in arrangement of components
- Increase productivity and operator comfort

1937

**News**  
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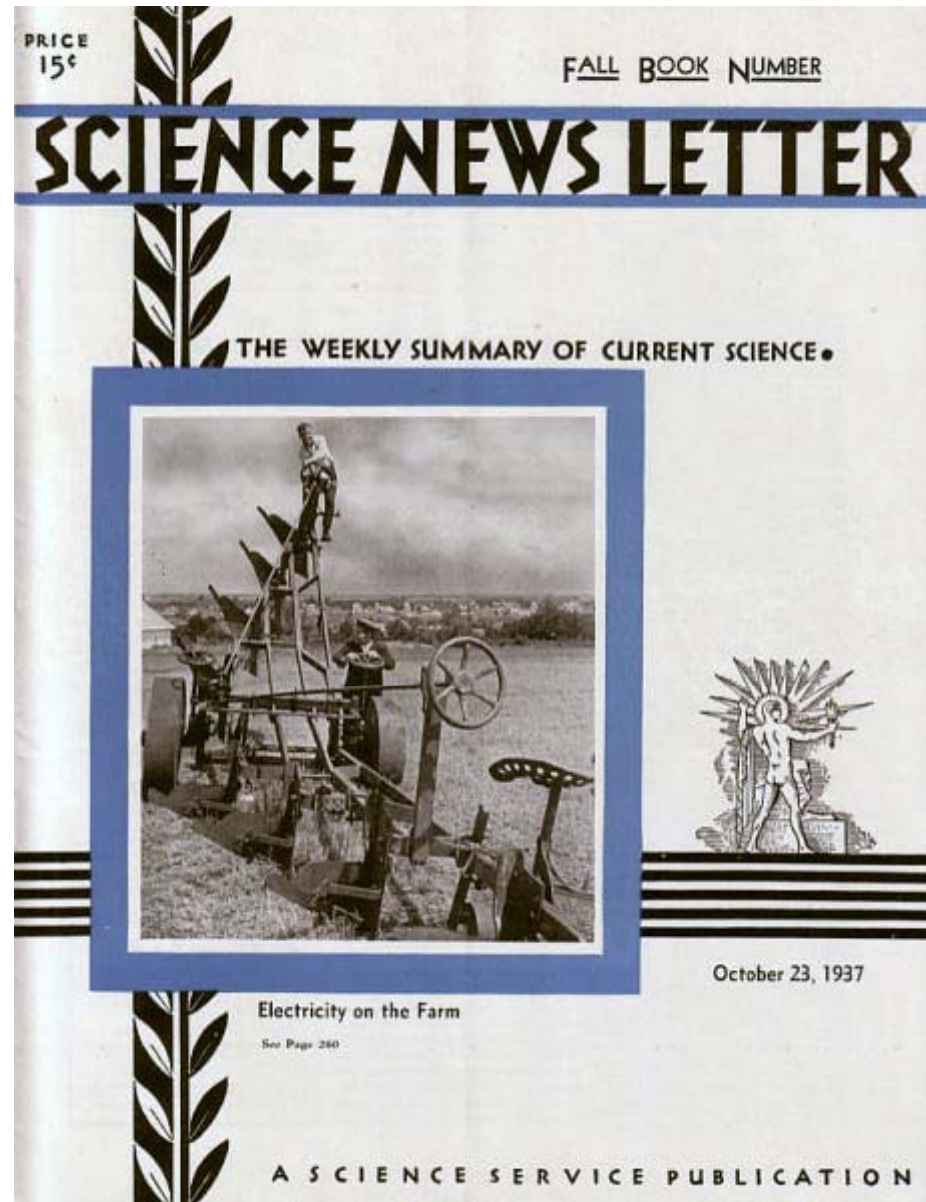
From the October 23, 1937

### TWO-WAY ELECTRIC PLOW IN USE IN SOVIET RUSSIA

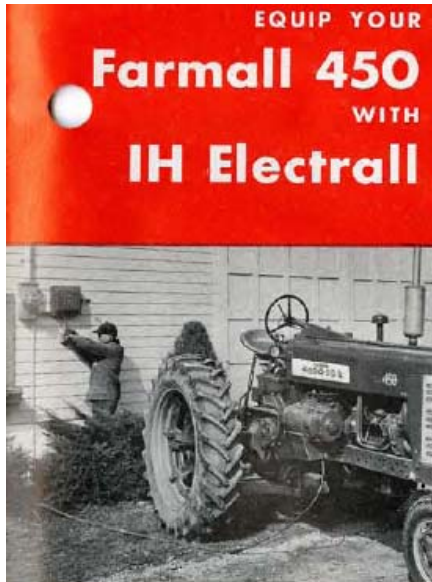
The large hydroelectric plan on the Dneiper River in Russia's Dnepropetrovsk province makes it possible for them to use electric farm equipment like the two-way plow shown on the front cover of this week's *Science News Letter*.

No tractor is attached to the plow, which can reverse and travel in either direction. It is particularly useful on large areas of flat ground without rock like that on which the implement is pictured.

Source: <http://www.sciencenews.org/>



# 1954



(Above) When the power line fails, just plug in Electrall to prevent financial loss and inconvenience. It supplies power to keep the farmstead fully electrified.

### PORTABLE POWER

Gives you "highline" power wherever your tractor will go

### STANDBY POWER

Provides stand-by power in case of highline outage

### MOBILE POWER

Drive balers and other machines with electric power

IH Electrall is a high-capacity electric generator that you can mount on your Farmall 450. It furnishes 115-volt and 208-volt single-phase service and 208-volt three-phase service. Output rating is 12.5 kva. This capacity lets you use your time-saving electric tools, and motors up to 10 hp, wherever your tractor will go; powers your house and barn equipment during highline failures; and drives a McCormick 55 baler, or other machines equipped with Electrall motor.

(Below) Electrall powered baler is started and stopped by an on-off switch. Electrall motor is completely enclosed and water-proof, readily transferred to other jobs.

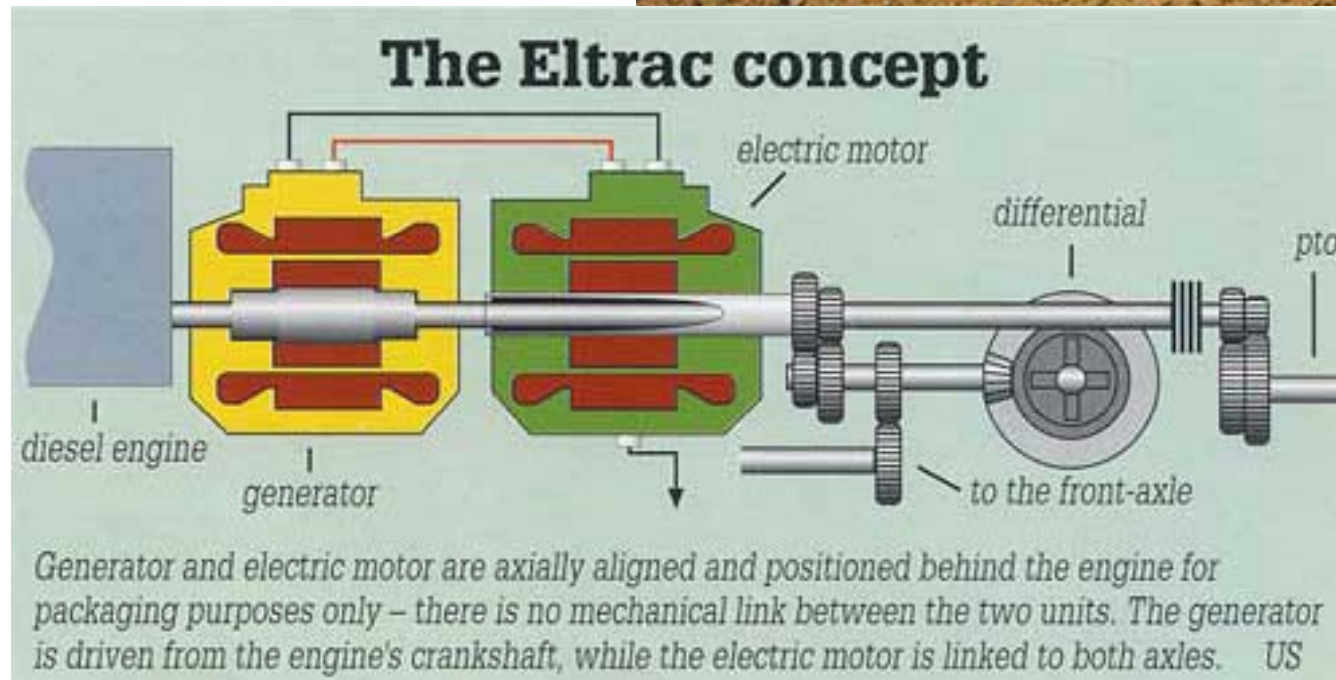




1998

## Eltrac

- E CVT concept
- Control units located on the roof

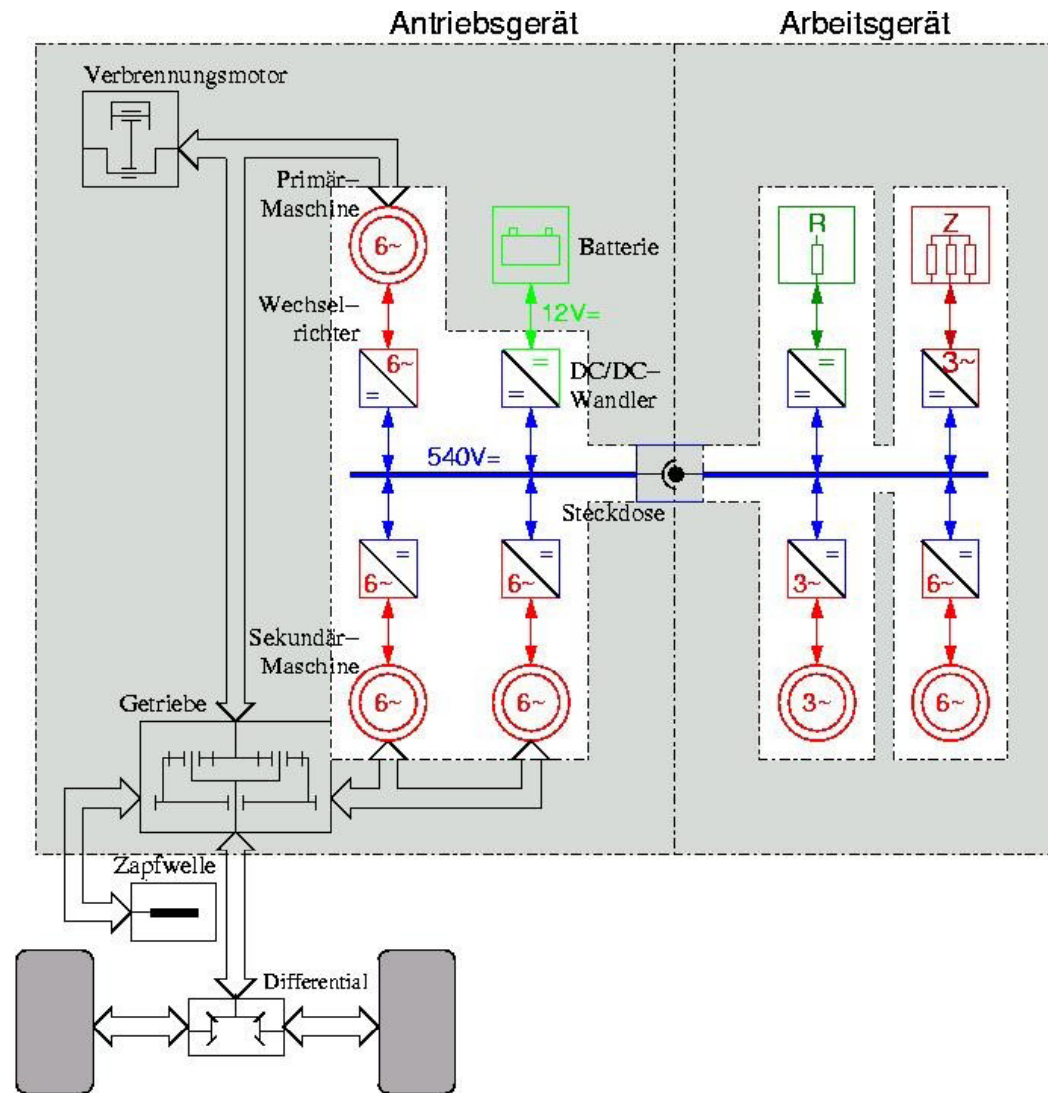


Source: <http://www.eltrac.de/>

# 2000

## MELA

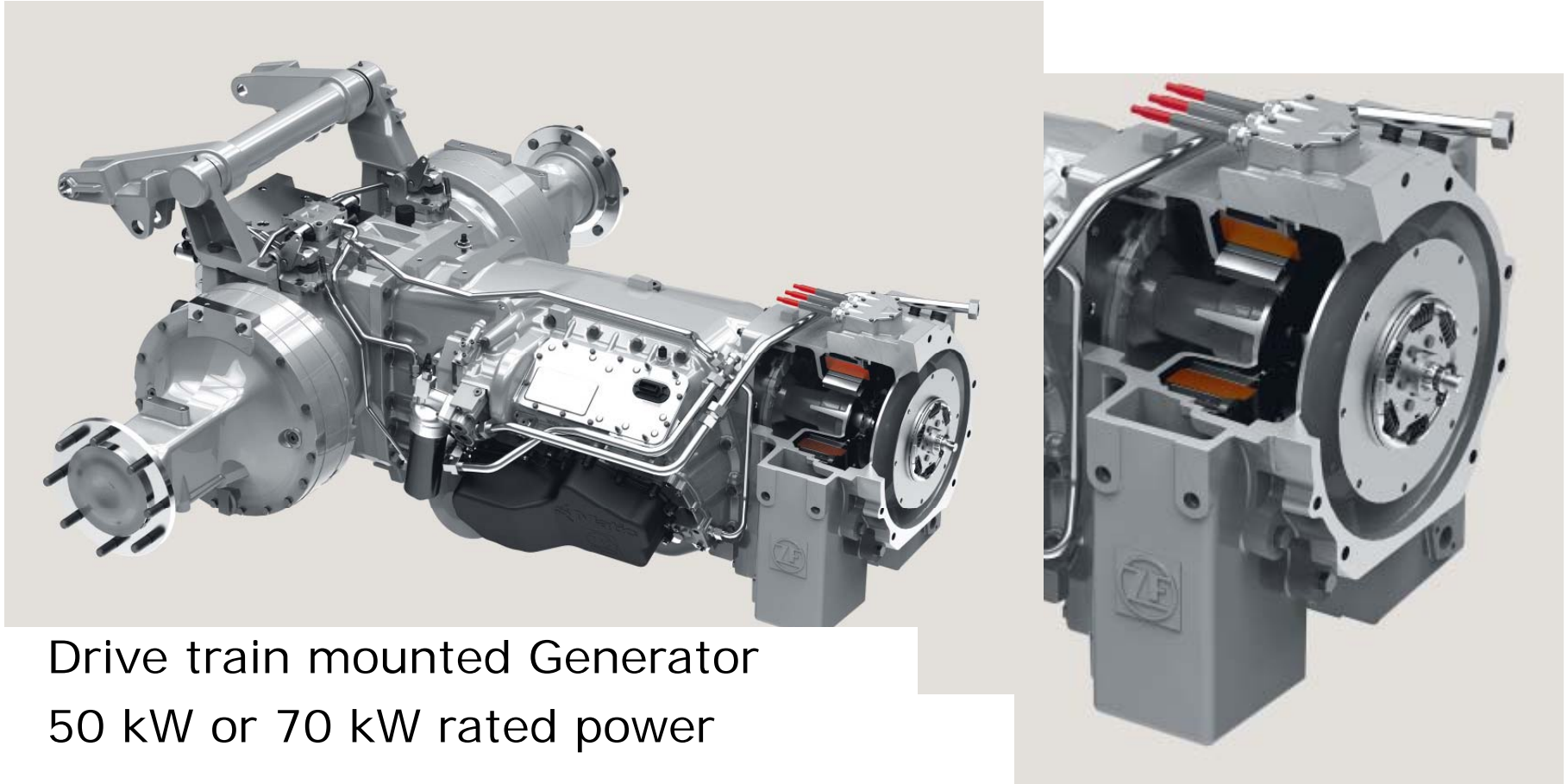
- E-CVT functionality
- Providing DC to the implement
- Electric driven Auxiliaries



Source: A. Szajek, Motivation und Konzepte zum Einsatz elektrischer Antriebstechnik im Ackerschlepper am Beispiel MELA, Tagung Hybridantriebe für mobile Arbeitsmaschinen, Karlsruhe 2007

2009

## ZF Terra+



- Drive train mounted Generator
- 50 kW or 70 kW rated power

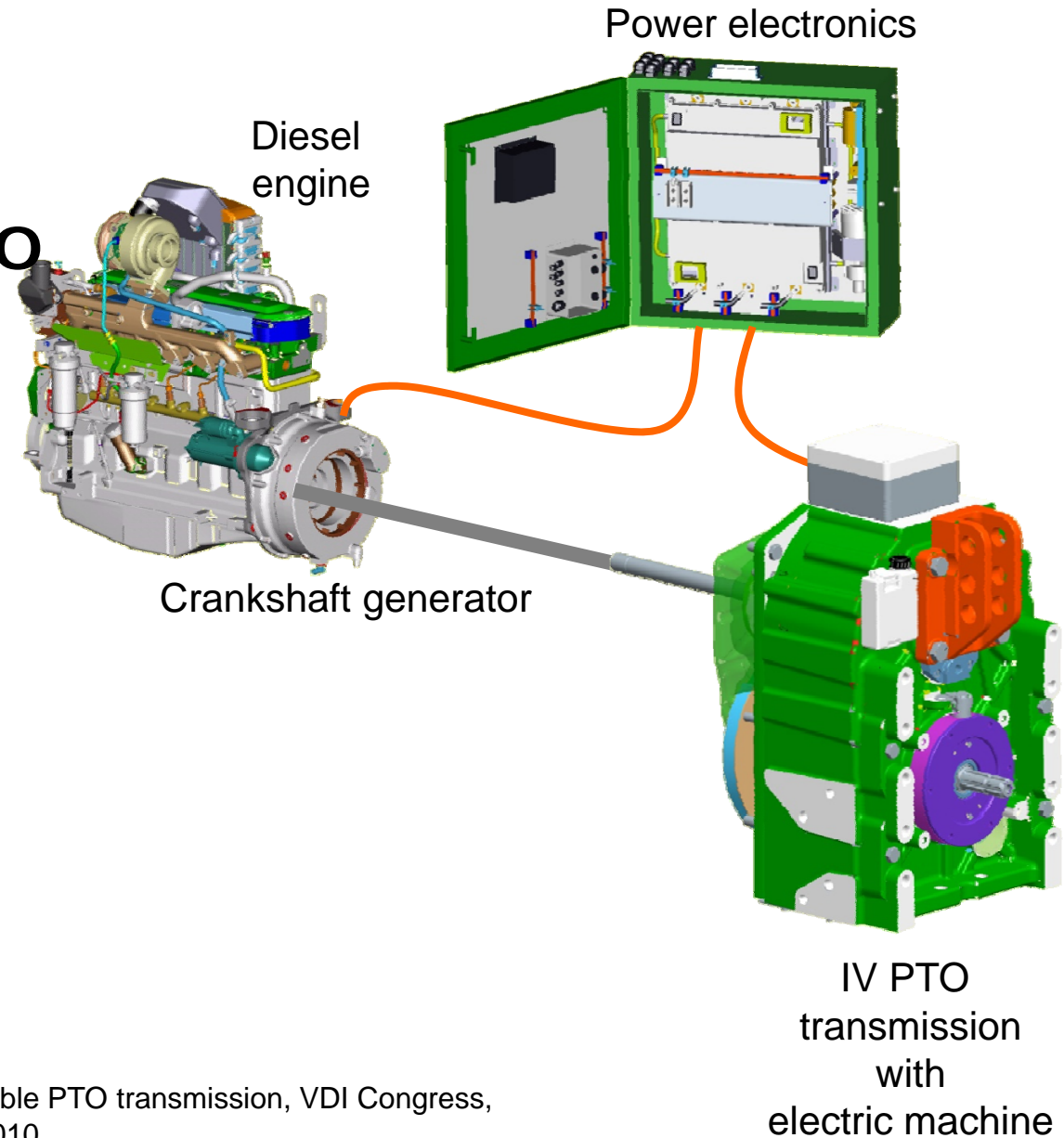
Source: ZF Press Kit Agritechnica 2009



2009

## John Deere Infinite Variable PTO

- Diesel engine speed independent PTO speed
- Change of PTO rotation direction
- Generating electric power for further consumers



Source: Gugel R., John Deere, Infinitely variable PTO transmission, VDI Congress, Transmissions in Vehicles, Friedrichshafen 2010



JOHN DEERE

2009

## Belarus Tractor 3023



- Prototype at Agritechnica 2009
- 220 kW diesel engine
- 172 kW generator
- diesel-electric drive train
- electrically driven front PTO

Source: [www.landwirt.com](http://www.landwirt.com); [www.farmphoto.com](http://www.farmphoto.com); [www.fwi.co.uk](http://www.fwi.co.uk)

# John Deere E Premium 7530





# Crankshaft Generator



## Technical Data

480V 3~

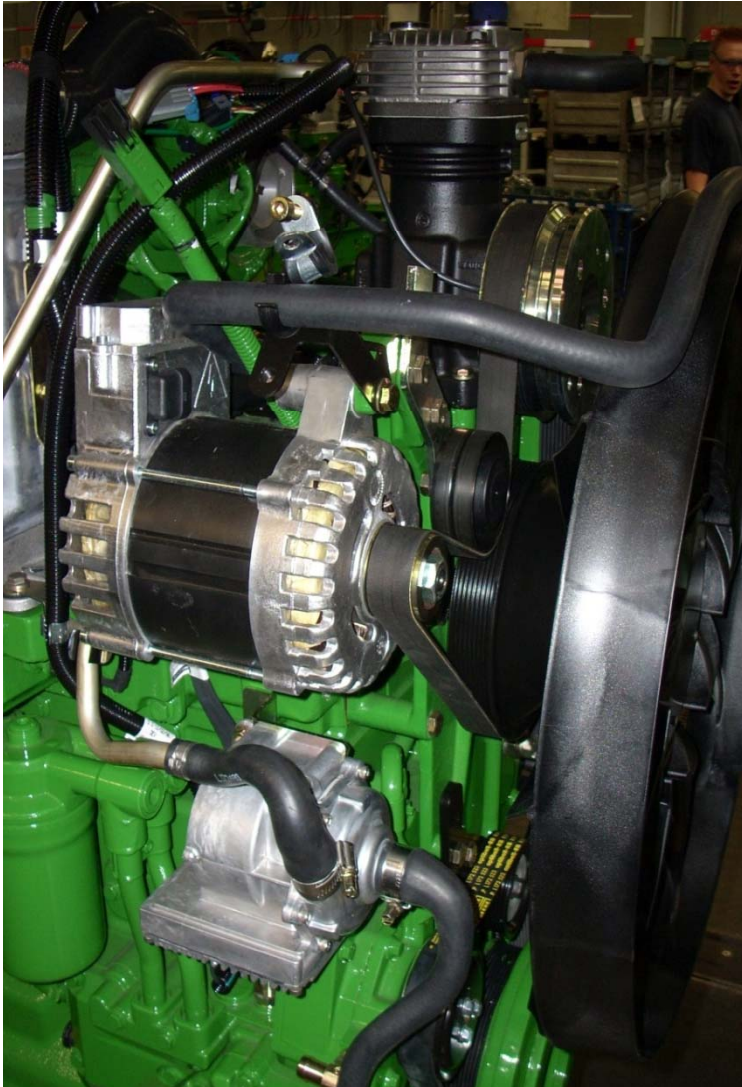
Power: 20kW

Water cooled

AC Induction machine



## Fan Drive



### Technical Data

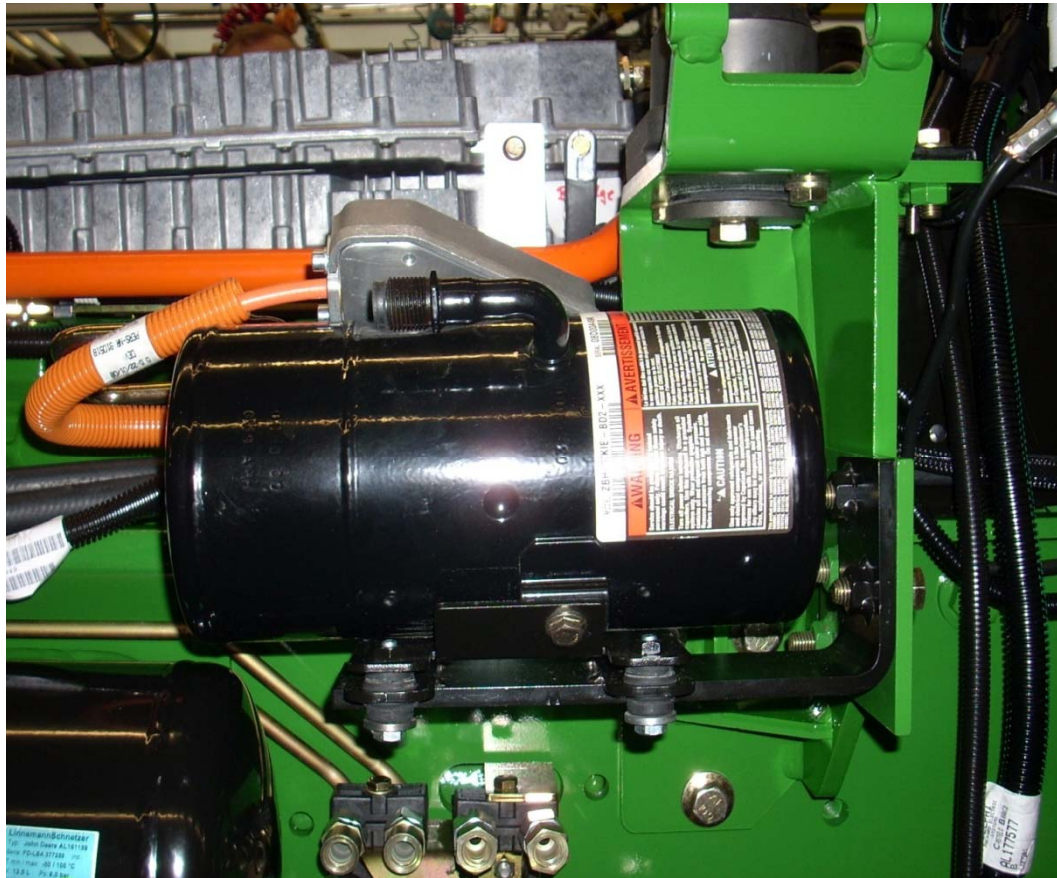
#### Fan motor

- Reversible
- 480 V 3~
- Power: 10 kW
- Air cooled

#### Air compressor

- electro-magnetic clutch (12V)

# A/C Compressor



## Technical Data

Power: 5 kW

Liquid Coolant cooled

IP67



# External Power Supply



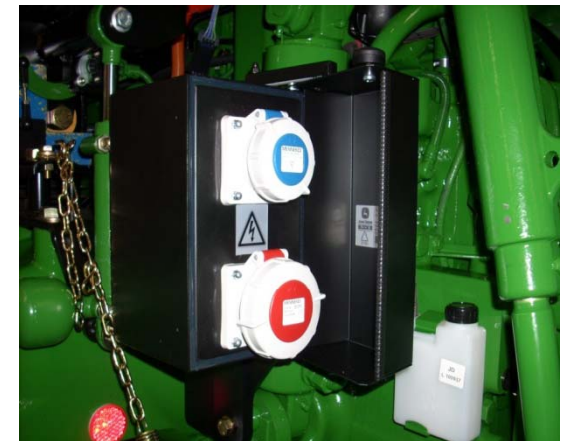
## Technical Data

400 V 3~

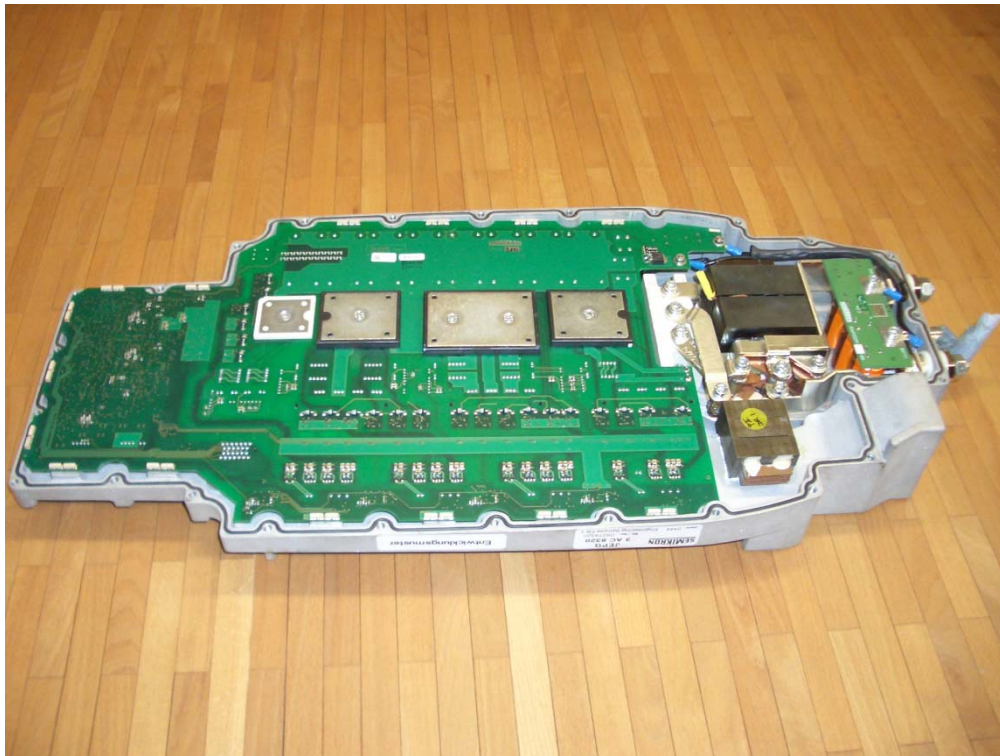
230 V 1~

CEECON Connector

Max. Power 5 kW



# Power Electronic Devices



## Technical Data

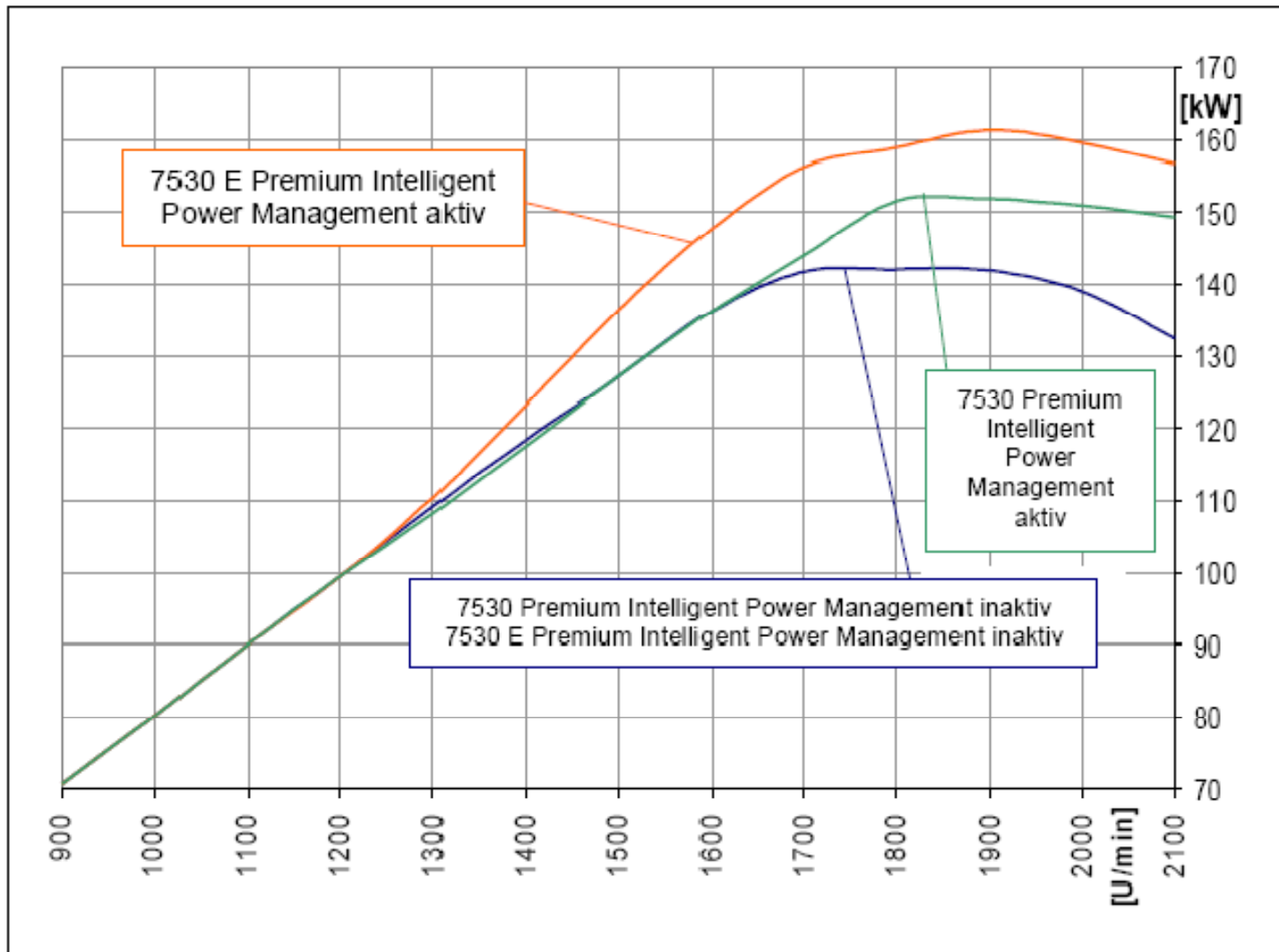
700 V DC Link Voltage

DC/DC Converter 4.2 kW

Water Cooled



# Power Characteristic Comparison E Premium – Premium Tractor



## E Premium tractor - Benefits for the operator

- Electrical power supply 230/400 V
- Reversible fan to clean front grille
- 7,5 kW additional intelligent power
- Additional power available at lower engine speed
- Improved AC system functionality
- Improved air brake system functionality
- Increased alternator power
- Reduced fuel consumption

# Design Criteria

## Voltage level

- power level to be considered
- technology from industrial automation
- components from automotive applications

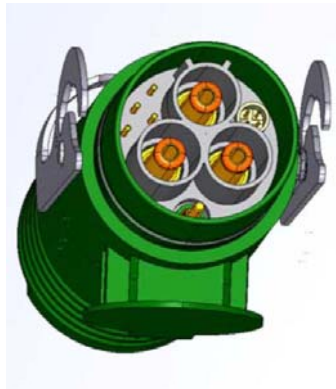
## Safety

- to be ensured during design, manufacturing, operation & service
- safety by system design
- system design has to avoid need for educated personal in service

# Tractor – Implement electrification

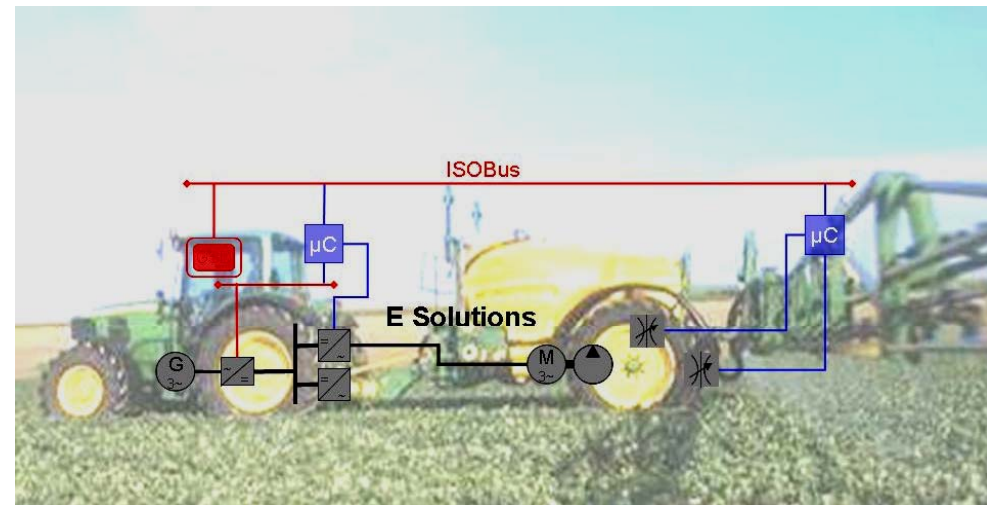
## The next level of electrification

### Electric power for Implements



Targets:

- Enhanced plug-n-play
- Controlled power distribution
- Reduced input costs
- Optimized implements, better output quality



**Electrification: Control and Distribution of Power**



# Implement example – Sprayer



Source: K. Hahn: High Voltage Tractor-Implement Interface, SAE Commercial Vehicle Engineering Congress , 2008

# Electric power interfaces: A complement



Electric Power  
(e.g. 2x 150kW),  
integr. communication  
and 14V supply for controller  
on implement

Hydraulic Power  
(e.g. 40kW)

ISOBUS

Mech. Pow  
(e.g. 150kW)



- Modes:**
- **Implement sends demands**
    - Tractor sets voltage / frequency
  - **Tractor provides constant U/f**
    - Implement integrated power electronics
  - ...

## Summary & Vision

### Electric drives have entered the arena of Ag machinery

#### ➤ Tractor

- Provide just the required power to auxiliary drives independent from the combustion engine speed
- Intelligent control of auxiliary drives helps to reduce fuel consumption
- Power available for electrical driven tools / implements

#### ➤ Implement (tractor related items)

- Optimized attachment, plug & play
- Enhancement to ISOBUS and automation

## Summary & Vision

### ➤ **Tractor/implement system electrification**

- Technology transfer from automation industry possible
- Agricultural System Engineering apply technology to optimize processes and reduce input costs
- Standardized interface is one key element for success
- Mitigation scenarios to be provided for existing equipment





This technology has the potential to become a new milestone in the history of agricultural equipment

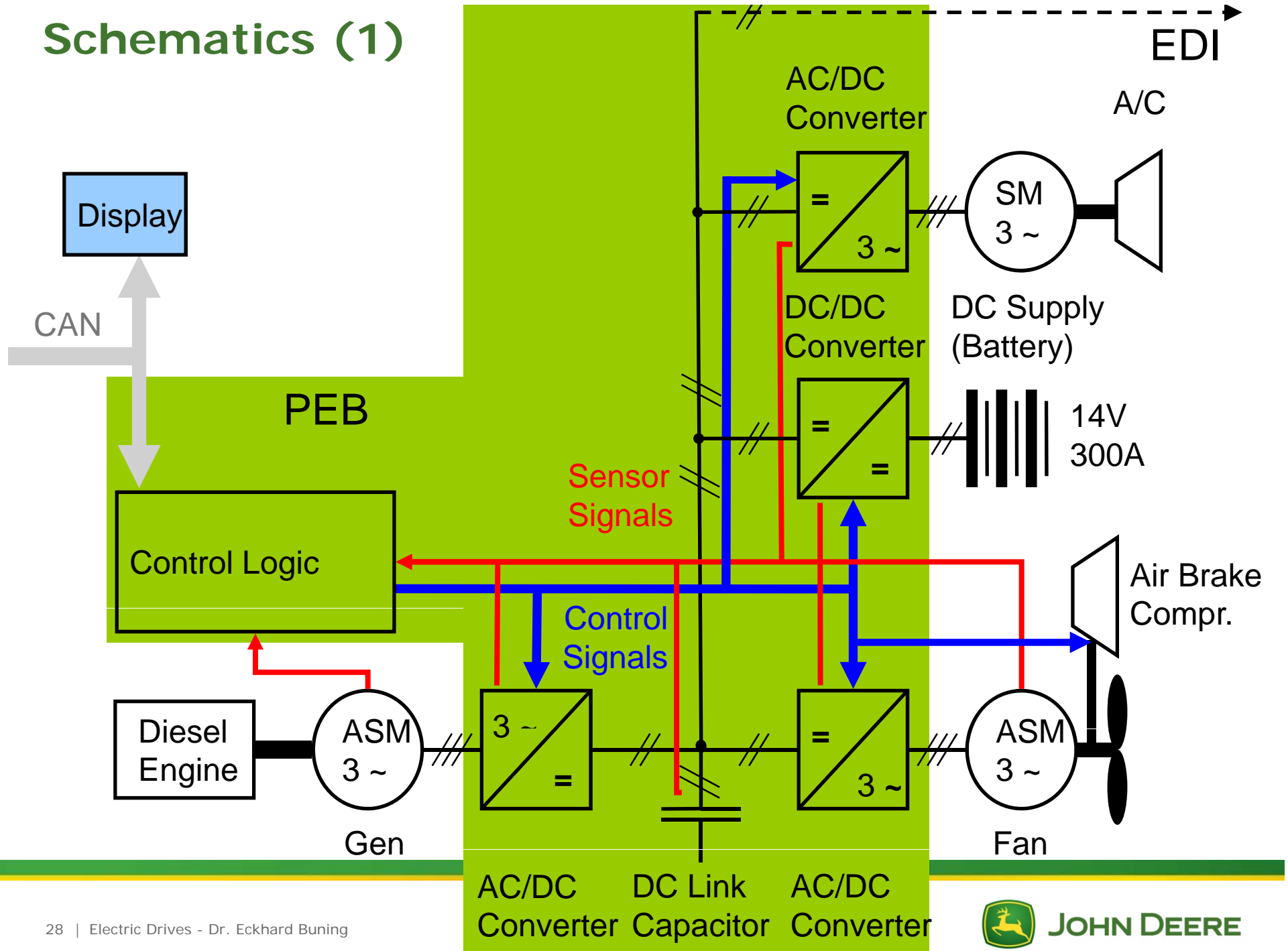
# Backup

# E Premium – Tractor line

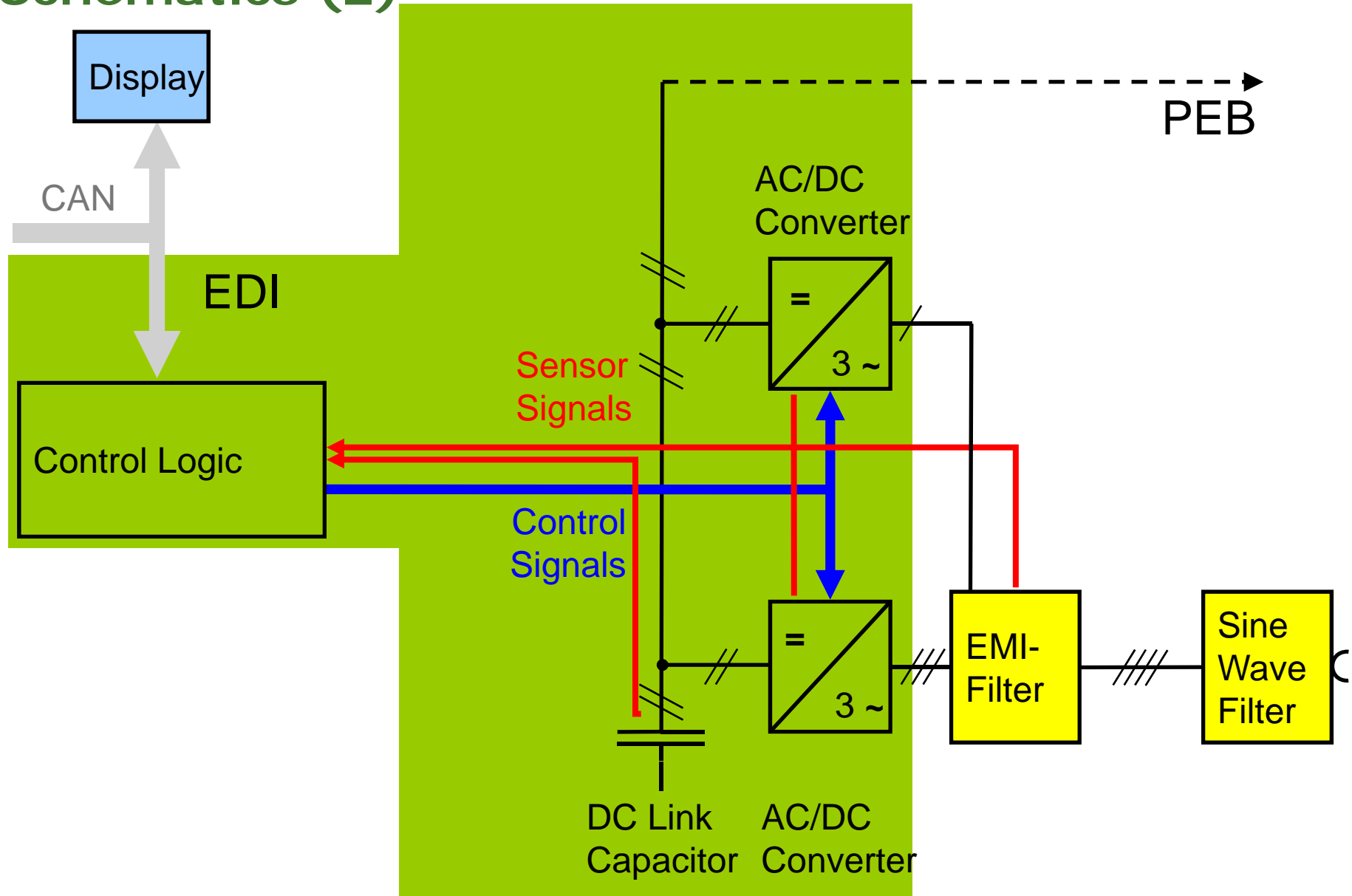
- Models available: 7430; 7530
- Rated Engine Power\*: 121 kW; 132 kW
- Engine Emission Level: TIER III
- Transmission: Infinite Variable Transmission
- A/C System in Base Configuration
- Max. Speed: 40 K or 50 K (optional)

\* acc. 97/68 EC

# Schematics (1)



# Schematics (2)





# Introduction - Scope of this presentation

## In scope:

- Generating the power
  - Generator
- Managing the power
  - System/Controller
- Using the power
  - Engine Auxiliaries
  - Provide electrical power to implements/attachments

## Out of scope:

- Traction Drives
- Implements
- Storage of electrical power– Fuel Cells