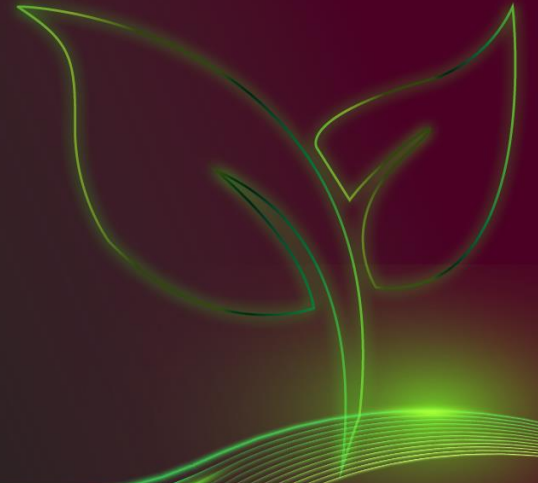


# DEUTZ DAYS 21



## Sustainable Drivetrains for Off-Highway Applications

—  
Dr. Markus Müller, CTO  
November 17, 2021 | Coreum

 moving the world sustainably



# Disclaimer

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Unless stated otherwise, all the figures given in this presentation refer to continuing operations.

The details given in this document are based on the information available at the time it was prepared. This presents the risk that actual figures may differ from forward-looking statements. Such discrepancies may be caused by changes in political, economic, or business conditions, decreases in the technological lead of DEUTZ's products, changes in competition, the effects of movements in interest rates or exchange rates, the pricing of parts supplied, and other risks and uncertainties not identified at the time this document was prepared.

The forward-looking statements made in this document will not be updated.

# DEUTZ technology strategy: open-minded approach to technology



Biodiesel



Multi-fuel



Hydrogen



Synthetic fuels



Sustainable fuels



48V systems



360V systems



Modular battery systems



Fuel cell

Green electricity

DEUTZ is tackling the challenges in off-highway applications by ensuring compatibility with different technologies

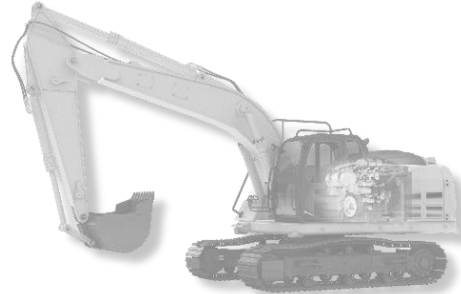
# Possible technology applications of climate-neutral drives



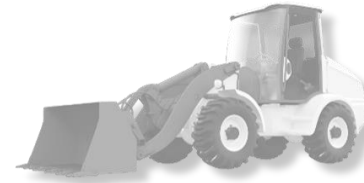
30kW peak  
10kW medium



56 kW peak  
15 kW medium



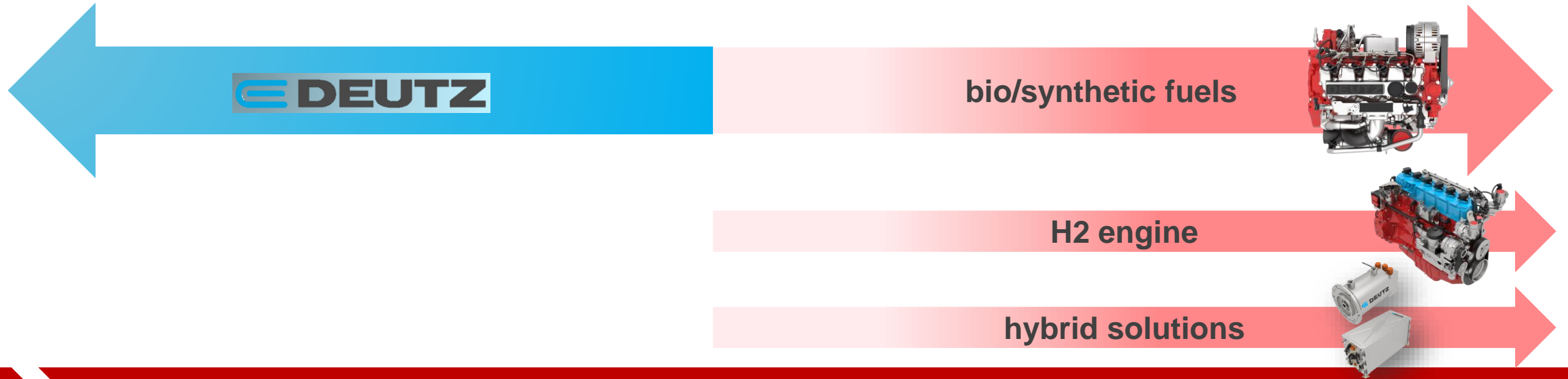
100 kW peak  
45 kW medium



180 kW peak  
70 kW medium



300 kW peak  
115 kW medium



E-DEUTZ focus on drivetrain solutions up to 100 kW

# DEUTZ technology strategy: sustainable fuels



Biodiesel



Multi-fuel



Hydrogen



Synthetic fuels



Sustainable fuels



48V systems



360V systems



Modular battery systems



Fuel cell

Green electricity

**DEUTZ is tackling the challenges in off-highway applications by ensuring compatibility with different technologies**



# Video renewable energy



# The DEUTZ TCG 7.8 H2 engine



DEUTZ TCG 7.8 H2

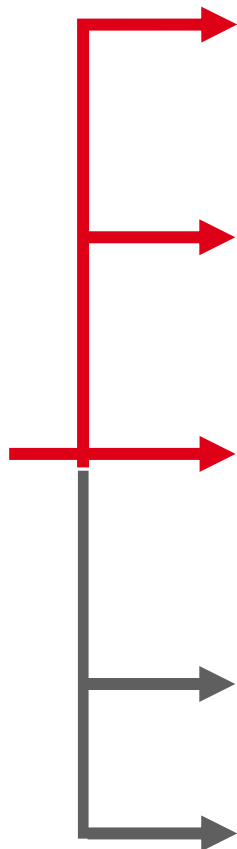
- **CO2-free technology** ( $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ ) fulfills EU “Zero Emission” Standards\*)
- **Economic alternative** to other emission free technologies
  - Attractive total cost of ownership  
(initial investment significantly lower than for a fuel cell)
  - Retrofitting in existing equipment possible  
(Integration H2-tank necessary)
- **High reliability** as based on proven engine technology
- **Fast time to market** with proven supplier infrastructure and existing production facilities
- Works well with **lower H2-gas qualities** (lower cost, less refinement necessary versus fuel cell)
- Growing H2-Infrastructure („bridge technology“), existing **service networks**

\*) < 1 g CO2/kWh

# DEUTZ TCG 7.8 H2



Base engine



## Off-Road

- Excavators
- Tractors & other agricultural machinery



## Stationary energy generation

- Generators (*GenSets*)
- Thermal power stations



## Train

- Regional trains
- Special trains/locomotives



## City and long-distance busses

- Medium range busses, 12m
- Addition to BEV inner city fleets



## Trucks for regional distribution

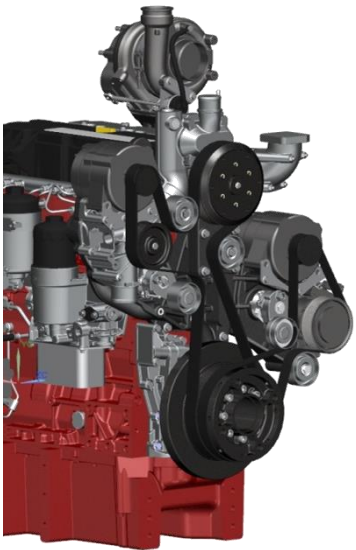
- 16-18t Medium duty trucks / regional delivery business

Engine with broad application possibilities



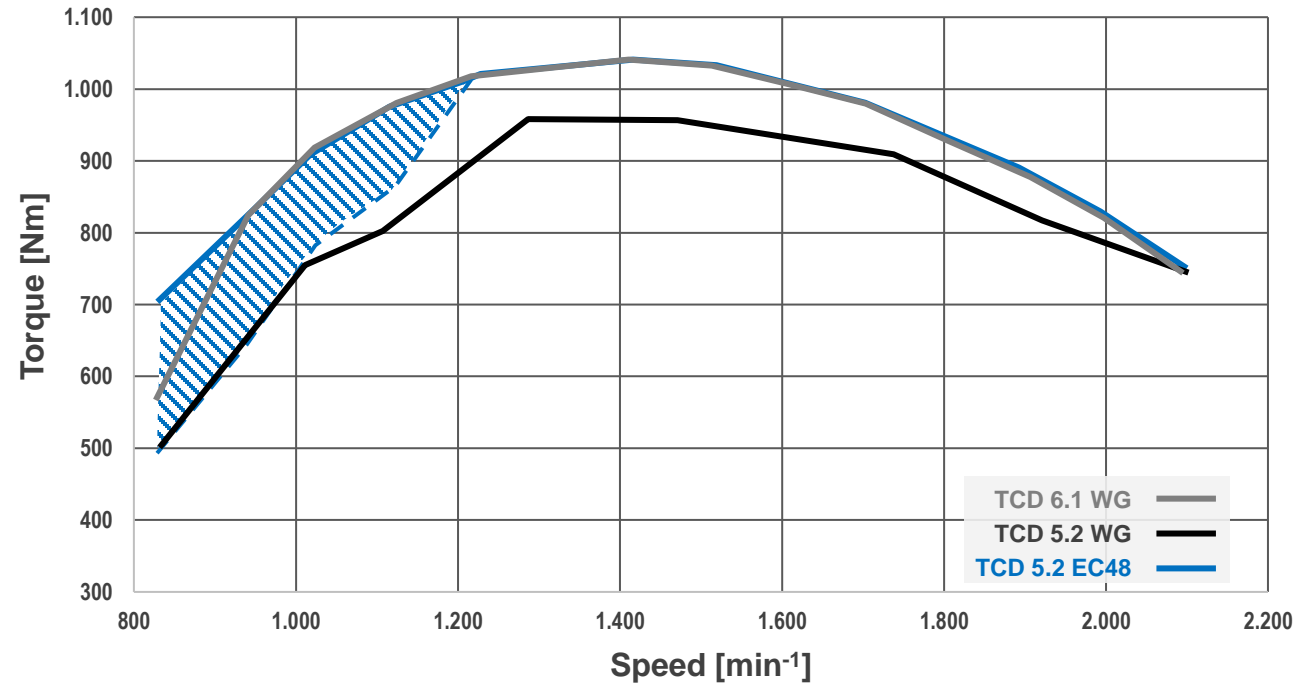
# Enhancement of existing engine portfolio

48V hybridization – Example 4 cylinder TCD 5.2 EC48 



## 4 cylinder engine with electric compressor 48V vs. 6 cylinder engine

- Strong initial torque
- Strong engine dynamic
- No turbo delay
- Fuel efficient



Technology scalable to all DEUTZ engines

# DEUTZ technology strategy: electrification



Biodiesel



Multi-fuel



Hydrogen



Synthetic fuels



Sustainable fuels



48V systems



360V systems



Modular battery systems



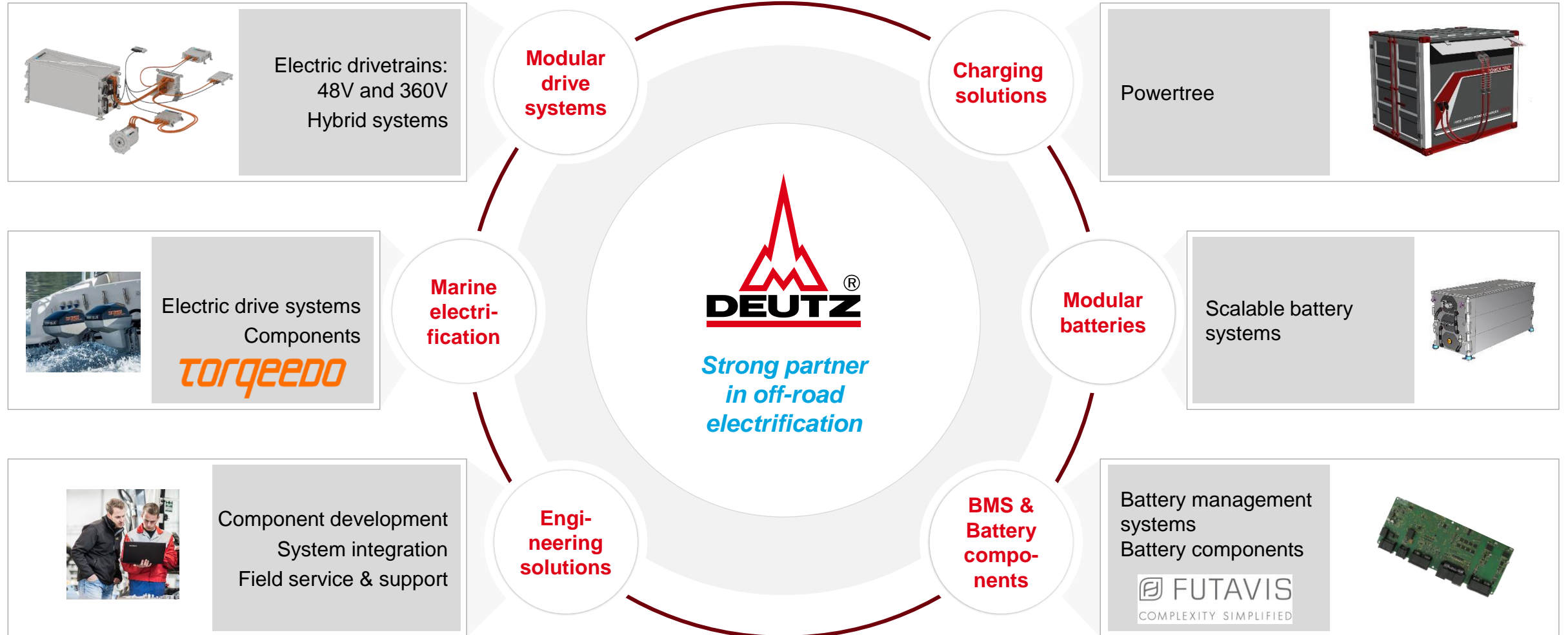
Fuel cell

Green electricity

DEUTZ is tackling the challenges in off-highway applications by ensuring compatibility with different technologies

# Electrification in the DEUTZ Group

Current range of products and services





# Video E-DEUTZ modular product kit



# Examples of E-DEUTZ applications



## MULAG Comet E

- Ground handling tractor already in field test on Amsterdam airport
- SOP planned for 2022



## MAEDA

- Electric crawler crane with 360V system
- Prototype tested by DEUTZ, hand over to customer planned for december



## Hitachi

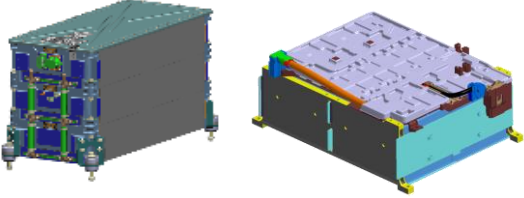
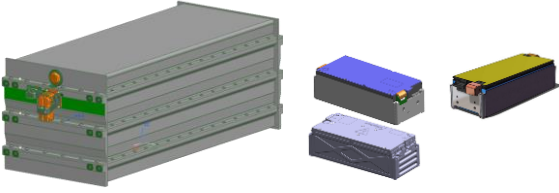
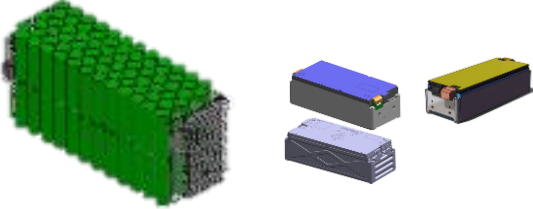
- 2.6t mini excavator with 48V system
- First prototype running November 2021

Various customer applications in pre-series stage

# Battery systems: roadmap for modules and battery pack

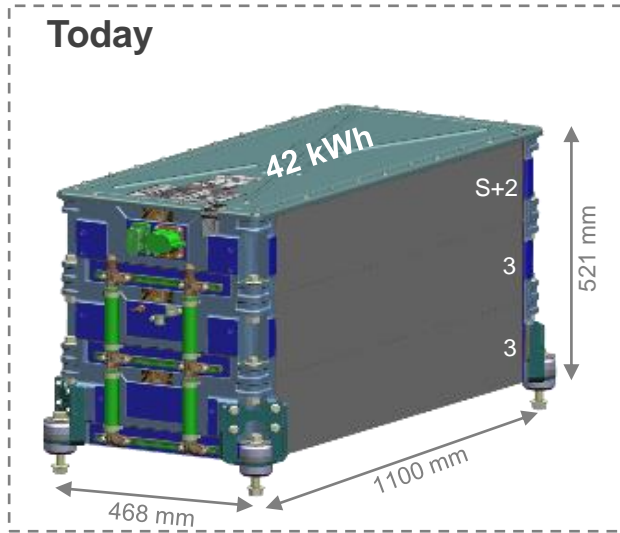
Technical and commercial data points



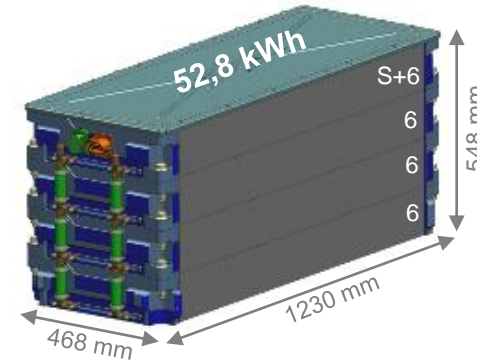
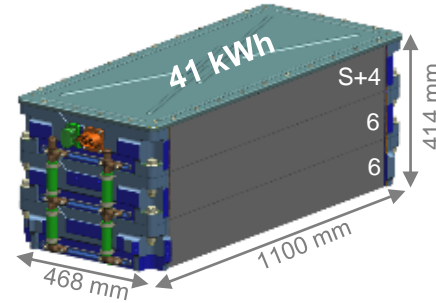
		Status Quo		
		Gen #1	Gen #2	Gen #3
				
Technical details	Celltyp	prismatic	prismatic	cylindrical or prismatic
	Module	5.2 kWh, 48V (BMW i3)	~2.2 kWh	TBD
	Housing	scalable	scalable, different modules, low-cost	scalable, different modules, low-cost
	BMS	Futavis BMS 3.0	Futavis BMS 3.0, later 4.0	Futavis BMS 4.0/5.0
€	Cost Pack	100%	50-70%	30-40%
	SOP	2022 (EOP 2024)	~2023	~2025

Continuous development of modules and battery pack

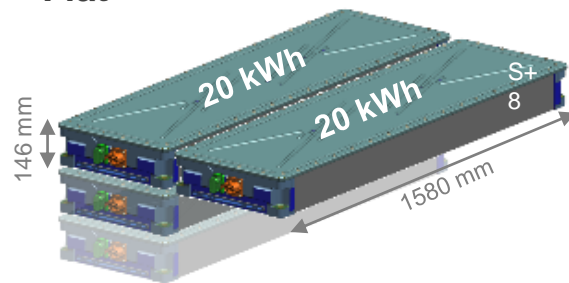
# Battery systems: modular packaging approach



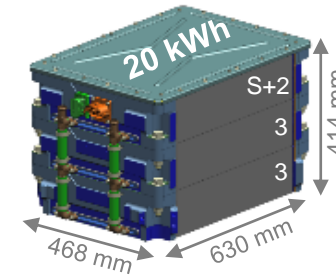
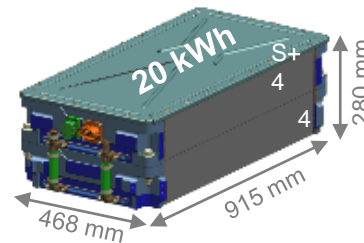
**Follow-up**



**Flat**



**Compact variants**

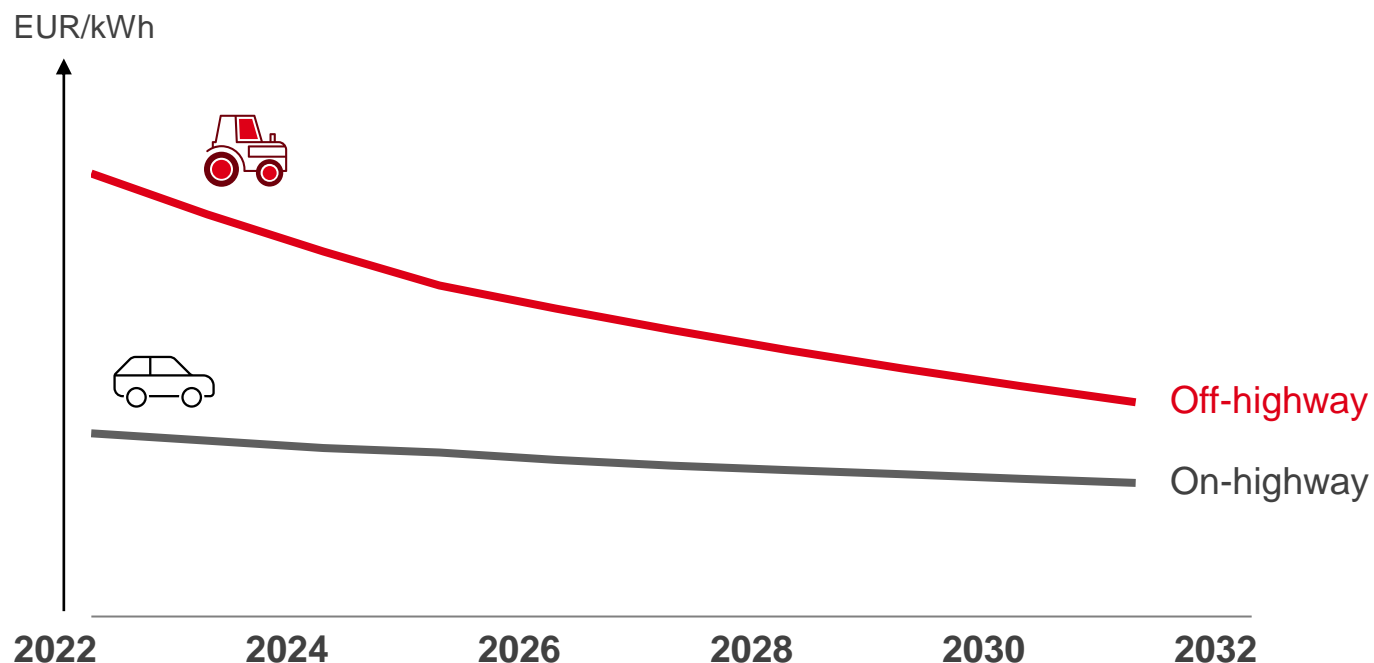


Scalable 360V-battery system at a glance

# Off-highway battery costs decrease slower than on-highway segment



## Battery cost development

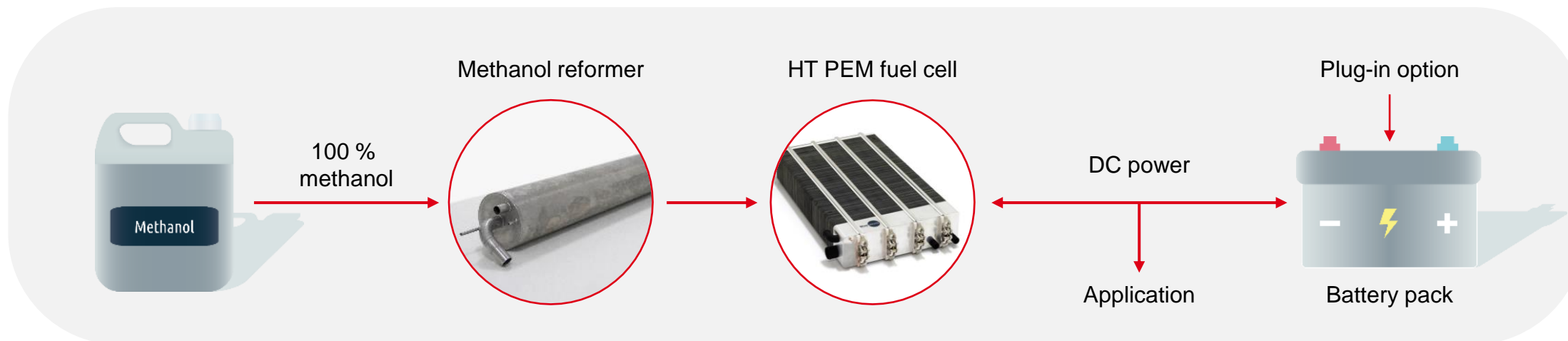


- Off-highway battery pack prices substantially higher than on-highway (factor of ~2-3x to date)
- Due to lacking scale benefits, battery packaging (non-standard and specialized packaging and shapes), and more demanding operational requirements
- Significant pricing declines are forecasted for off-highway market, but with delay and with prices remaining higher than in the on-highway market

**Off-highway packs will always remain significantly more expensive than on-highway**



# Fuel cell technology as electricity source / range extender



Fuel cell based on high temperature PEM-technology combined with methanol reforming (HT-PEM)

- Robust technology for off-highway applications
- Easy methanol storage ensures long-range and fast refueling
- Zero harmful emissions
- Cost savings due to high fuel efficiency and low maintenance

Expansion of system know-how with BLUE WORLD TECHNOLOGIES partnership

# Solutions for CO2-free powertrains for mobile machinery



Urban



Mobile H2 supply



Power supply

AC



DEUTZ Powertree

DC

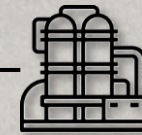


Construction machinery with **high** load factor



Construction machinery with **low** load factor

Rural / No Infrastructure



Mobile H2 supply

H2



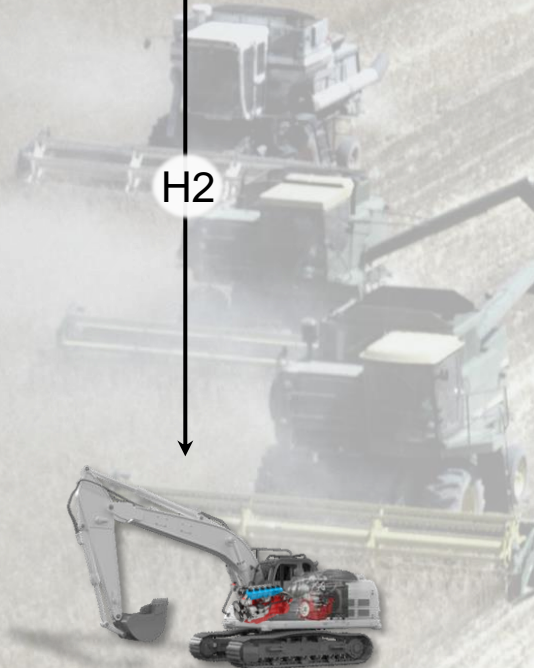
H2 GenSet

AC



DEUTZ Powertree

DC



Construction machinery with **high** load factor



Construction machinery with **low** load factor

**DEUTZ provides a tailored solution – no matter what infrastructure is available**

# The path to a climate-friendly future



Construction machinery



Material handling



Agricultural machinery



Stationary systems



Other



Diesel



Alternative fuels



Gas



Fully electric



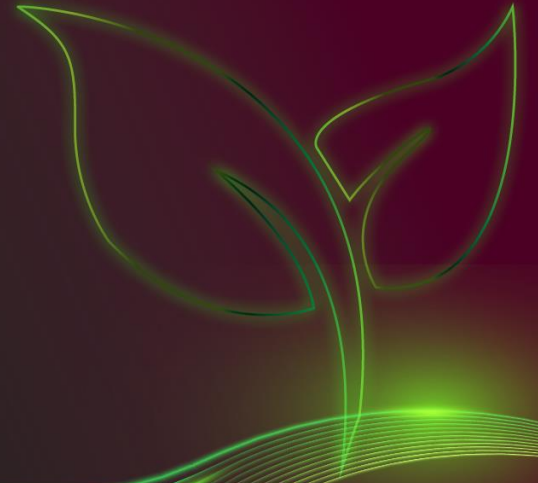
Hybrid electric



Hydrogen

Diverse drive solutions required for different performance requirements

# DEUTZ DAYS 21



# Thank you!

 moving the world sustainably

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