Electric drive systems

MS-PM, Thomas Adermann
June 2022

Agenda

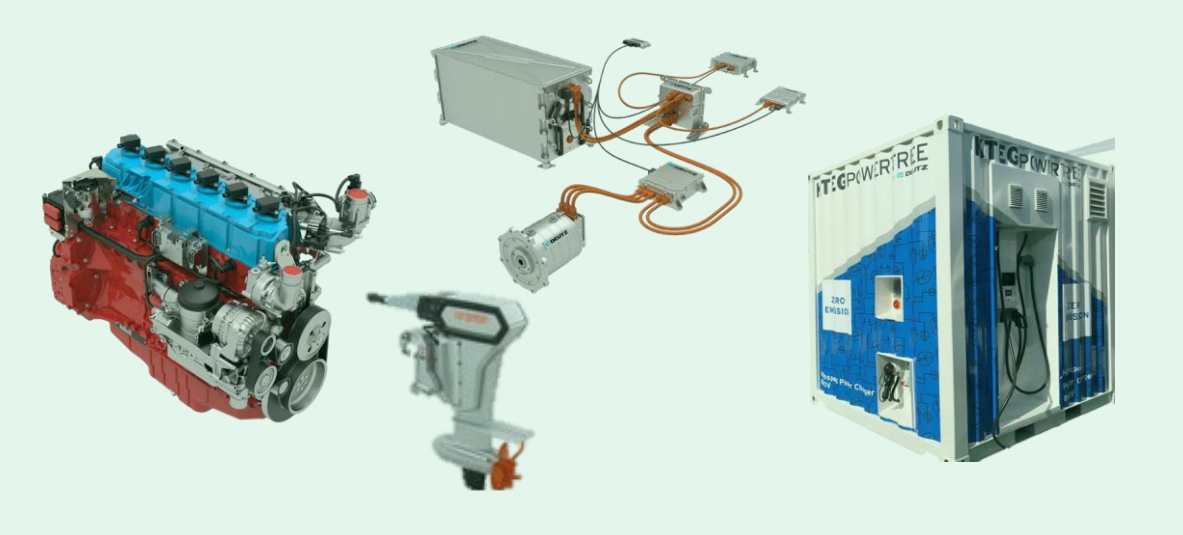
1. Strategy
2. Benefits & References
3. Applications
4. Systems
5. Components
6. Delivery scope
7. Hybrid system
8. E48 drive system
9. PowerTree

Strategy

DEUTZ AG

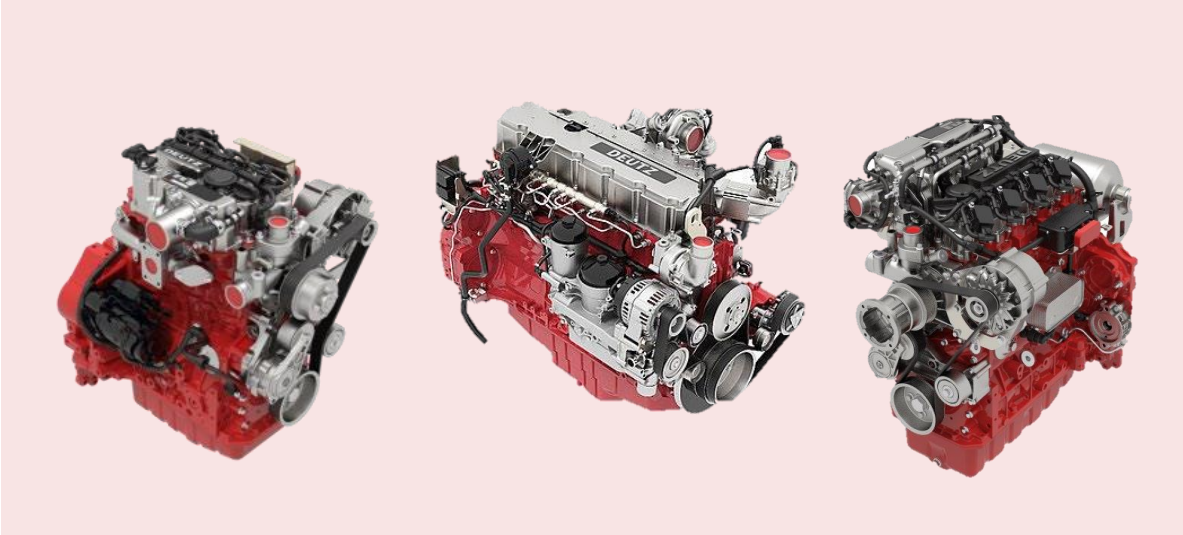
New segment structure from January 2022

GREEN



- Electric drives, Torqeedo and Futavis, hydrogen engine, Blue World Technologies
- Related service business

CLASSIC

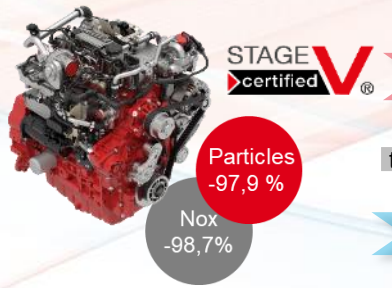


- Diesel, gas (LPG and CNG), and bi-fuel engines
- Related service business

Strong network of established partners support industrialization of safe & reliable electric drive trains for NRMM

DEUTZ Strategy for CO_2-neutral drive systems

Evolution from CLEAN towards CO_2-neutral propulsion systems



State of the art Stage V diesel engines with the latest technology

Gas

Bio-fuels

regenerative/ synthetic fuels

Hydrogen

Clean combustion

today

mid term

Electrification

360V full electric

48V full electric

Fuel cell

Hybrid

DEUTZ enabled CO_2-neutral operation

E-DEUTZ

One stop shop for industrialization of electric drive systems

Customized electric systems

- Electric & hybrid drive systems: 48 V & 360 V
- Modular product kit for fast customer configurations
- Fully industrialized, easy to integrate drive systems for off-highway OEMs

Battery Experts

- Customized Batteries
- Battery Management System & Components
- Engineering solutions
- Testing equipment

Safety and Quality according to ISO26262

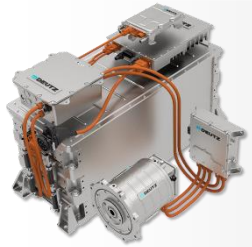
Electric Mobility on Water

- E-propulsion systems for
  - Leisure boats & sailing
  - Water taxis
  - Emergency Rescue
- Power: 1kW-100kW
- Marine battery systems development & manufacturing

DEUTZ has invested >100 Mio. € to expand our off-highway engine capabilities to electrified drive systems & services!

A broad set of products and services for off-highway electrification

Productportfolio & Services



Systems
Electric & hybrid systems
360 V + 48 V

Modular Drive-Systems

Mobile Charging Solutions

Powertree®
Fast charging up to 150 kW / 800 V

Torqeedo
Electric & hybrid marine systems
360 V + 48 V

Marine Solutions

Modular Batteries

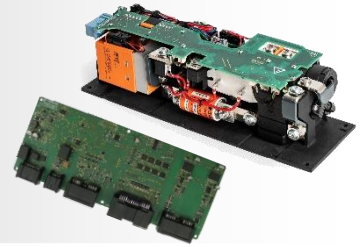
Batteries
Scalable Batteries

DEUTZ AG
Component development
System Integration
Field service & Support

Engineering Solutions

BMS & Battery Components

FUTAVIS
Battery management systems
Battery-components



DEUTZ®

Strong Partner in Off-Highway Electrification

Benefits & References

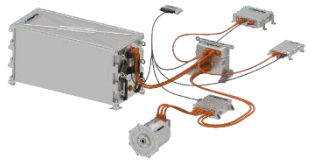
E-DEUTZ Road to success

Electric drive systems for off-highway applications since 2017

2017
Launch of E-DEUTZ

2017
Acquisition of Torqeedo

2018
Presentation of fully functional demonstrators



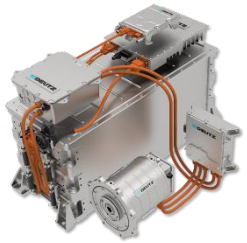
2018
Start of E360 electric drive system project

2019
Acquisition of BMS specialist Futavis

2020
Built up first prototype vehicles

2021
First field testing

2022
Fully functional pre-series systems

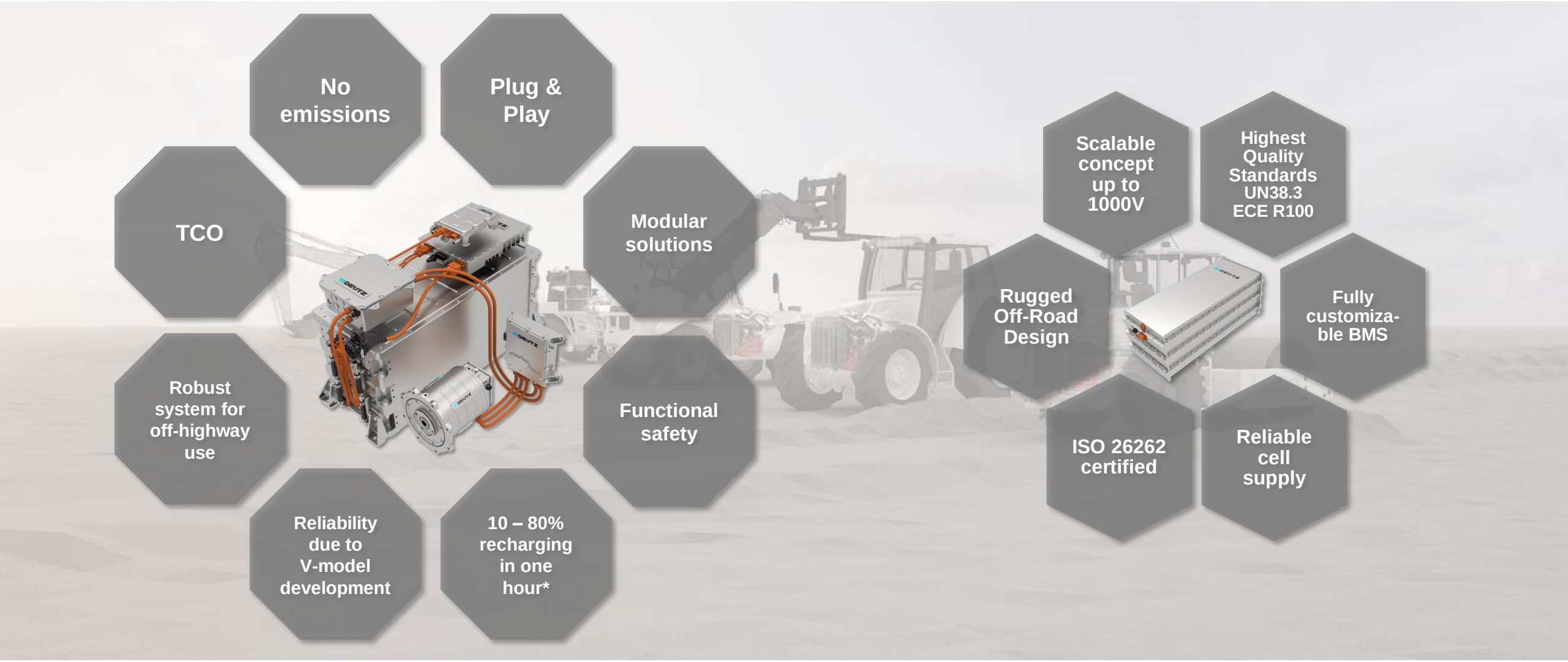


Q1/2023
Start of production & entering European market

2023
Extension of electric product kit

Marketable and individually applicable electric drive systems

Key benefits of our solutions for your applications



Reference - Crawler Crane

Electric drive system for sustainable use

Fully functional pre-series system in 06/22

KEY FEATURES AT A GLANCE

- Up to 3-4 hours operating time
- Charging duration (10% – 80% SoC) : 60 min
- Optimized dynamic behavior & reduced running costs
- No local exhaust emissions & Minimized noise emissions

KEY FACTS AT A GLANCE

- 400 V electric drive system
- 42 kWh Li-Ion Battery
- 40 kW electric powertrain (80 kW peak power)
- 22 kW onboard-charger
- Type 2 charging interface
- High voltage A/C compressor & high voltage cabin heater

Reference - Airport tow truck

Electric drive system for sustainable use

KEY FEATURES AT A GLANCE

- Up to 3-4 hours operating time
- Operating time extension due to recuperation
- Charging duration (10% – 80% SoC) : 60 min
- Optimized dynamic behavior & reduced running costs
- No local exhaust emissions & Minimized noise emissions

KEY FACTS AT A GLANCE

- 400 V electric drive system
- 42 kWh Li-Ion Battery
- 40 kW electric powertrain (80 kW peak power)
- 22 kW onboard-charger & Type 2 charging interface
- Cabin heating, top speed: 30 km/h, drawbar pull: > 26 kN

Fully functional pre-series available in 04/22
Cabin heating available in 09/22

Reference - Telehandler

Electric drive system for sustainable use

Fully functional prototype available in 09/22

KEY FEATURES AT A GLANCE

- Up to 4-5 hours operating time
- Charging duration (10% – 80% SoC) : 60 min
- Optimized dynamic behavior & reduced running costs
- Independent control of driving & working
- No local exhaust emissions & Minimized noise emissions

KEY FACTS AT A GLANCE

- 400 V electric drive system
- 42 kWh Li-Ion Battery
- 2x 40 kW electric powertrain (80 kW peak power)
- 22 kW onboard-charger
- Type 2 charging interface

Reference - Concrete pump

Electric drive system for sustainable use

Functional pre-series in 09/22
Functional use of full capacity in 12/22

KEY FEATURES AT A GLANCE

- Up to 4-5 hours operating time
- Operating time extension due to working while charging
- Charging duration (10% – 80% SoC) : 120 min
- Optimized dynamic behavior & reduced running costs
- No local exhaust emissions & Minimized noise emissions

KEY FACTS AT A GLANCE

- 400 V electric drive system
- 84 kWh Li-Ion Battery
- 40 kW electric powertrain (80 kW peak power)
- 22 kW onboard-charger
- Type 2 charging interface

Reference - PowerTree

Mobile high power charging solution for construction sites

KEY FEATURES AT A GLANCE

- Mobile fast charging up to 150 kW
- Increases vehicle uptime due to fast charging
- Enables independence from the grid infrastructure
- Standard charging interfaces
- Scalable as needed

KEY FACTS AT A GLANCE

- High voltage battery buffer of 126 kWh (272 kWh in development)
- Charging voltage: up to 800 V
- DC Output: CCS Type 2 (1 x 150 kW or 2 x 75 kW)
- AC Output: 32 A / 400 V CEE & 16 A / 230 V CEE
- Compact 10ft Container & total weight < 5.000 kg

Fully functional pre-series available

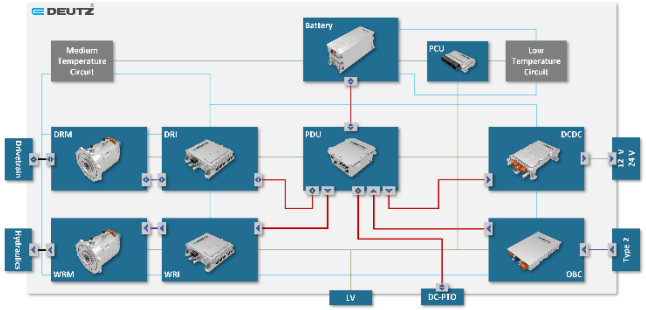
Applications

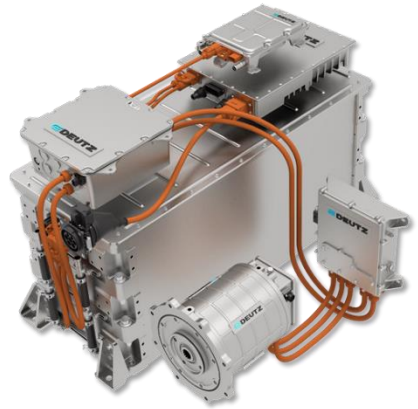
E-DEUTZ

System & component modularity for various applications

NRMM - Applications

E-DEUTZ Modular Systems





E-DEUTZ Components

Variously integratable | **Configurable** | **Single source**

E-DEUTZ electric drive systems for various applications

Examples of DEUTZ customer segments and applications

Mobile Machinery
Construction
Ground Support Equipment - Airport
Agriculture
Special Vehicles

Energy Storage
Home Storage
Industrial Storage
Mobile Charging Solutions - PowerTree

Commercial Vehicles
Truck & Bus
Minibus
Cleaning & Municipality

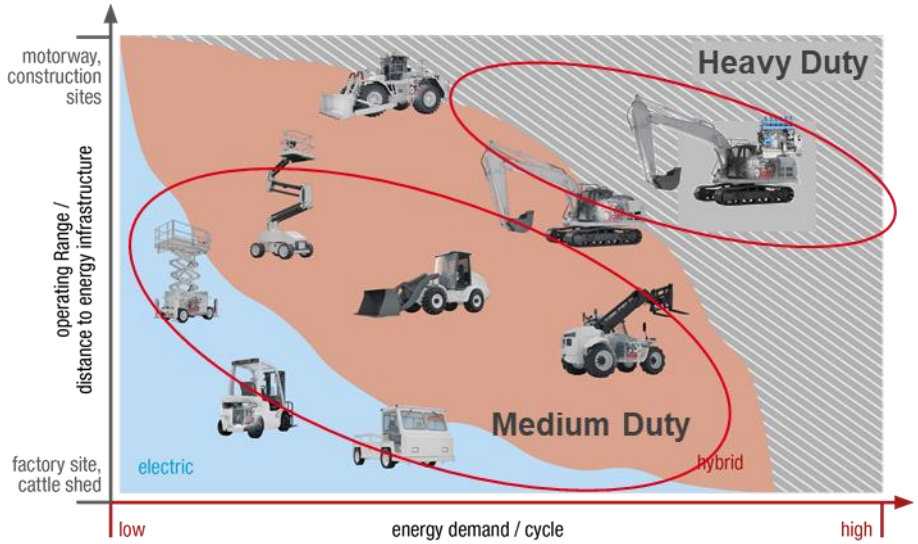
Material Handling
Forklifts
Special Vehicles

Leisure & Sports
Marine
Golf Carts
Fun Cars

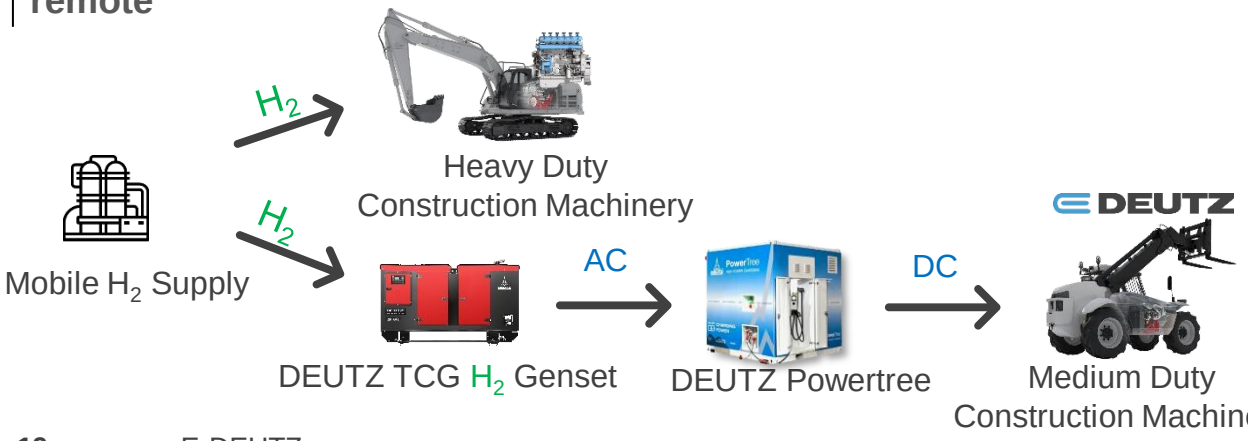
DEUTZ Drive System Solutions

Zero-emission at full performance with DEUTZ on hydrogen & E-drives

urban



remote



- Hydrogen for high load applications
- Electric drives medium & low load applications
- PowerTree for fast charging support
- ➢ Infrastructure independent power solutions by DEUTZ

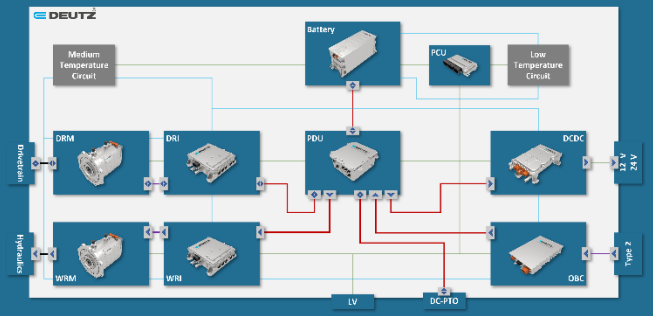
Systems

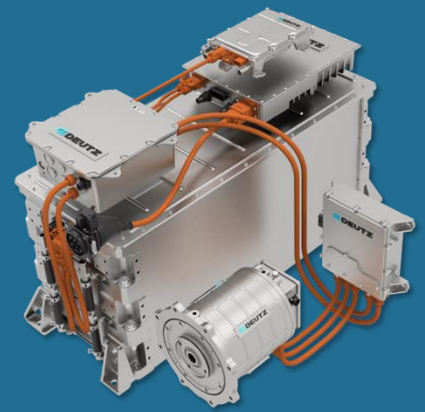
E-DEUTZ

System & component modularity for various applications

NRMM - Applications

E-DEUTZ Modular Systems





E-DEUTZ Components

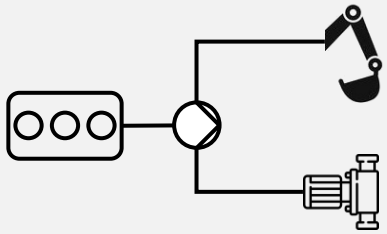
Variously integratable | **Configurable** | **Single source**

E-DEUTZ - Systems

System architectures of different drive system technologies

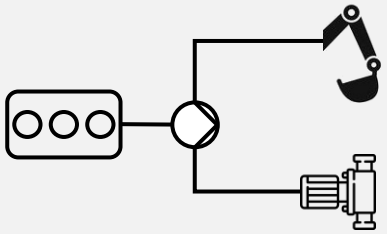
Diesel

Combustion Engine



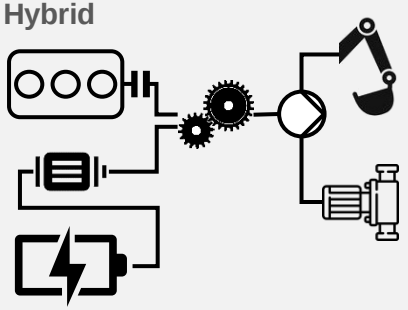
Hydrogen

Hydrogen Engine

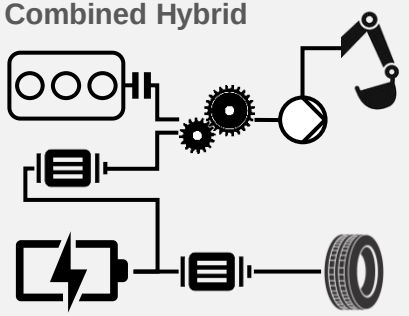


Hybrid

Hybrid

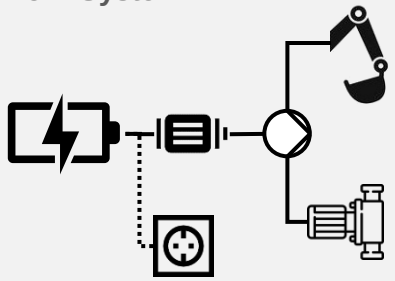


Combined Hybrid

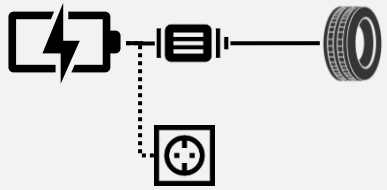


Electric

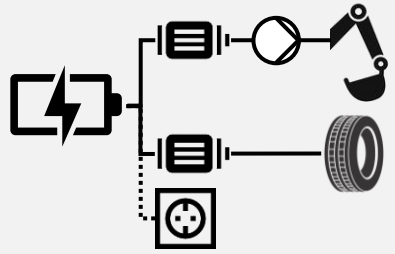
Work System

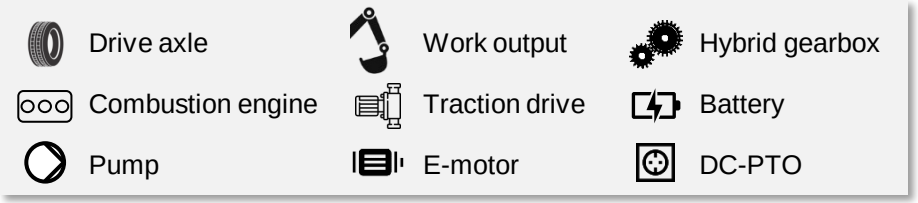


Drive System



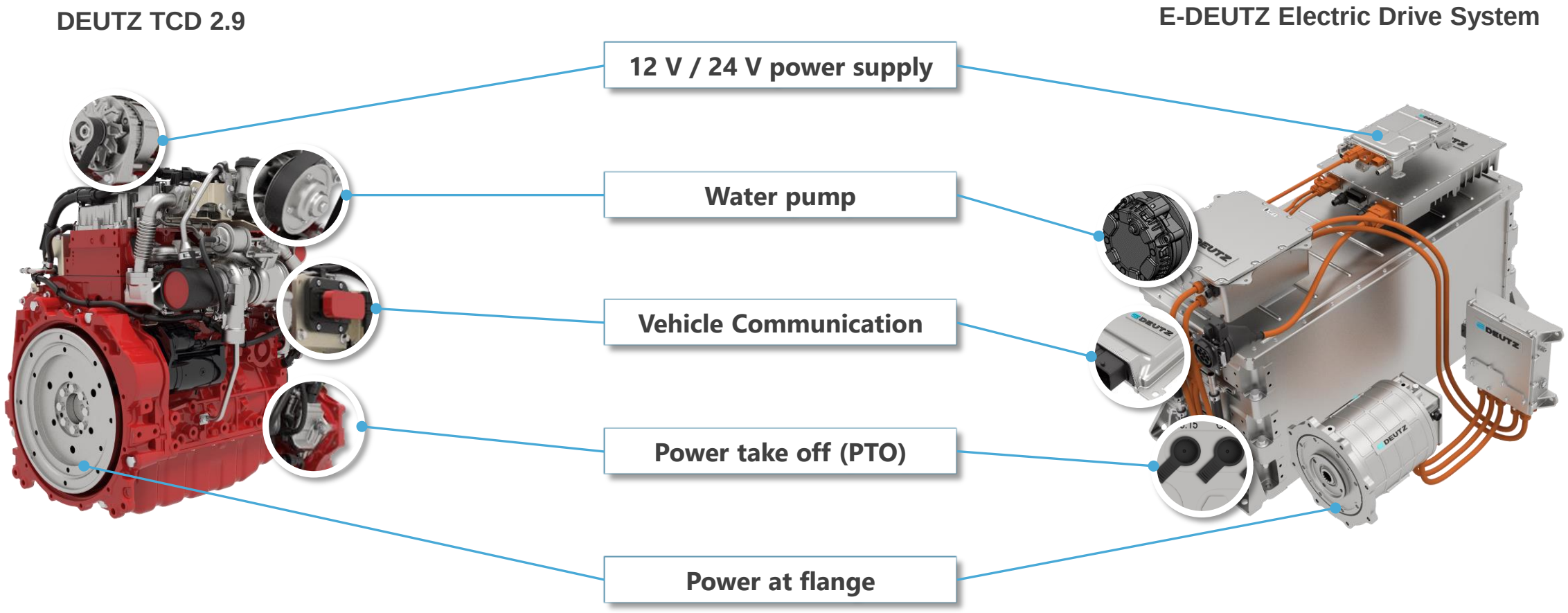
Split System





E-DEUTZ electric drive system operates common interfaces

Drive system interfaces in between the worlds: Diesel vs. Electric



E-DEUTZ electric drive system

Overview of the system‘s component composition

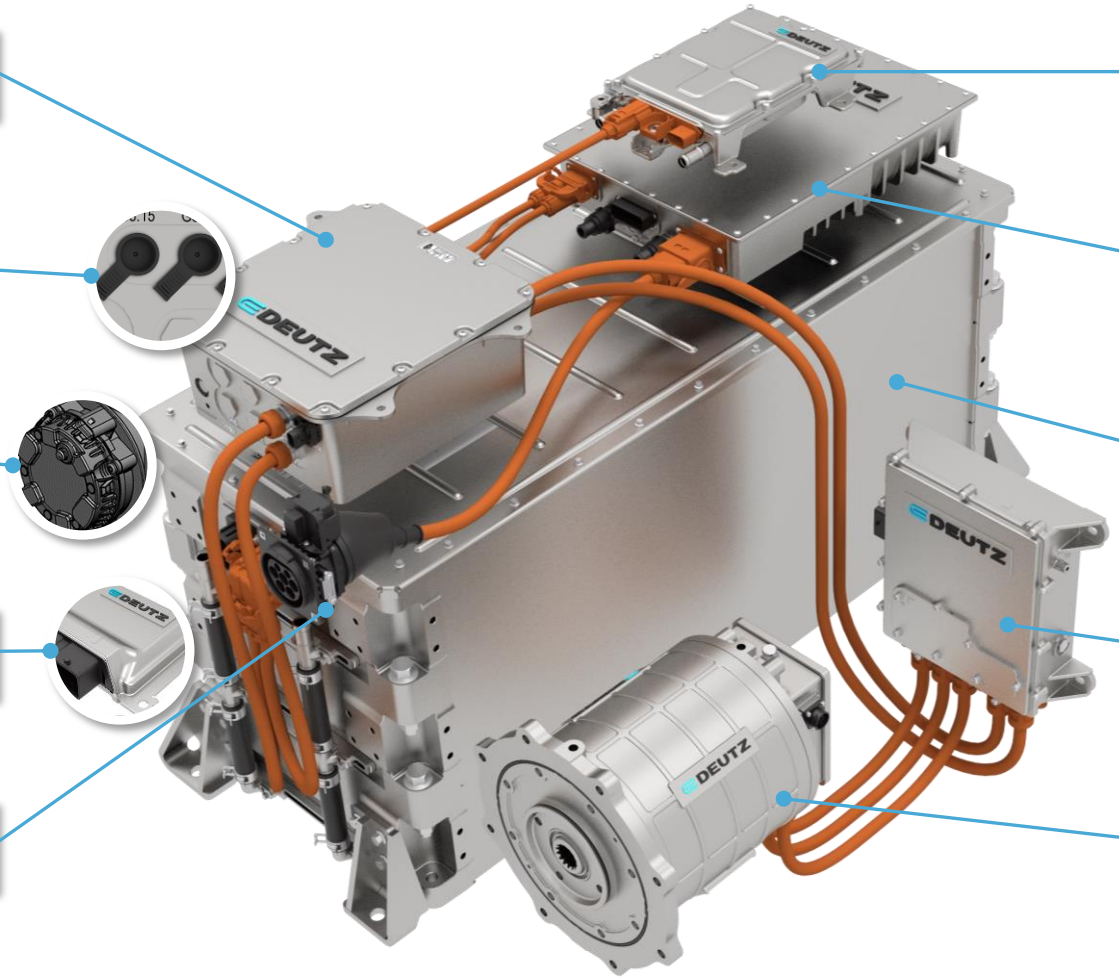
Power distribution unit (PDU)
Connecting HV-components

Power take off (DC-PTO)
PDU Interface for auxiliaries

Water Pump
Pressure for cooling circuit(s)

Powertrain control unit (PCU)
Pressure for cooling circuit(s)

Charging socket
Type 2 charge plug for recharging



High voltage board net converter
DCDC for 360 V to 12 V conversion

Onboard charger (OBC)
Recharging of HV-Battery

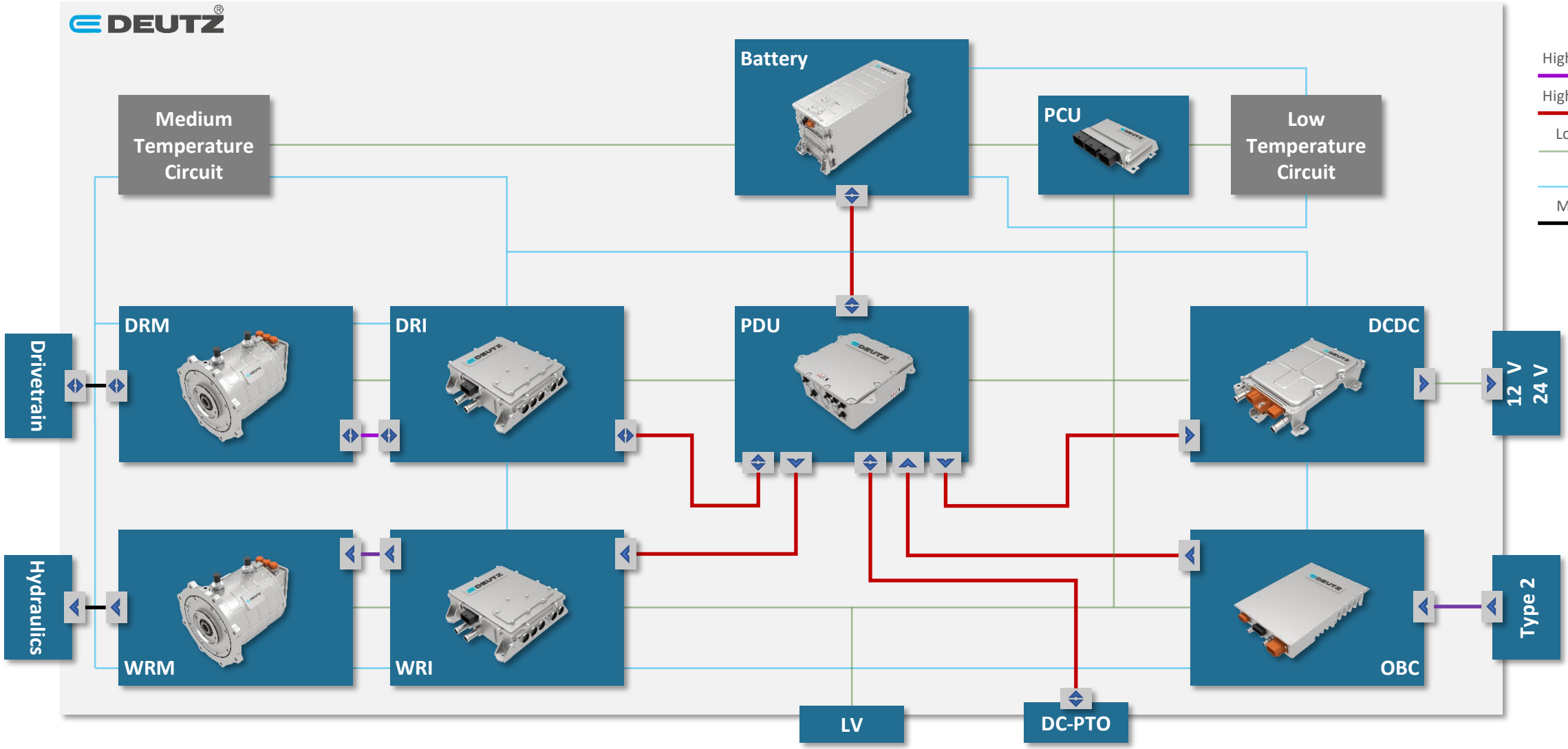
HV-Battery (HVB)
Recharging of HV-Battery (AC)

Work inverter (WRI)
Control and powering of E-Motor

Work motor (WRM)
E-Motor

E-DEUTZ - Systems

Example: System architecture electric system – E360 D40W40-42C



E-DEUTZ - Systems

Modular product kit

E-DEUTZ SYSTEM	VOLTAGE	E-Motors	Battery	PDU + PCU	OBC	DC/DC	ICE	Features
COMBINED HYBRID	48 V	10 kW	13 kWh	48 V	3.3 kW (AC)	500 W	G 2.2	Multiple Motors
FULL HYBRID					6.6 kW (AC)	1000 W	G 2.9	Clutch
E-DRIVE RANGE EXTENDER		15 kW	20 kWh		9.9 kW (AC)			DC - PTO
E-DRIVE	360 V	20 kW	20 kWh	360 V	3.3 kW (AC)	1.5 kW (12V)	D/TD/TCD 2.2	Hybrid gearbox
E-WORK		40 kW	42 kWh		11 kW (AC)	1.1 kW (24V)	D/TD/TCD 2.9	Cabin heating
E-DRIVE + WORK SPLIT		60 kW	… kWh		22 kW (AC)		TD/TCD 3.6	50 kW (DC-charging)
								Multiple Batteries

First availability 2022

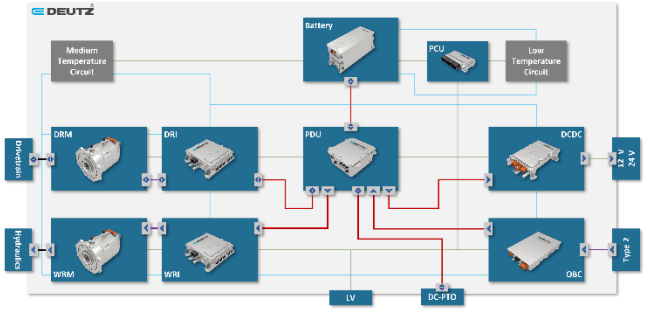
Components

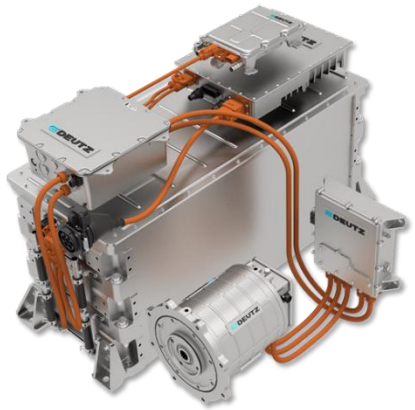
E-DEUTZ

System & component modularity for various applications

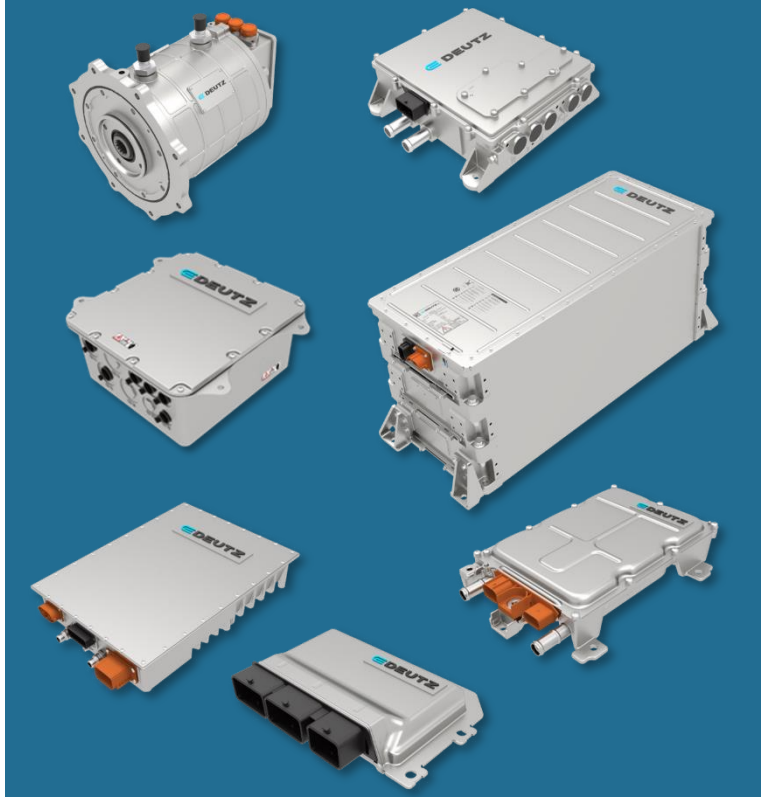
NRMM - Applications

E-DEUTZ Modular Systems





E-DEUTZ Components



Variously integratable | **Configurable** | **Single source**

E-DEUTZ - Components

Component portfolio – E360

E-Motor + Inverter

Cont. power:
40 kW / 136 Nm
Peak power:
80 kW / 273 Nm

Power Unit

PDU

3 HV-Batteries +
2 Power Units +
DCDC + OBC +
DC-PTO

Power Distribution Unit

HBC

High voltage
board net converter
360V / 12V

Converter

HV-Battery

HVB

310 – 400 V range
42 kWh capacity
Up to 135 kW power

Onboard-charger

OBC

Up to 22 kW
Recharge in 2h

Powertrain Control Unit

PCU

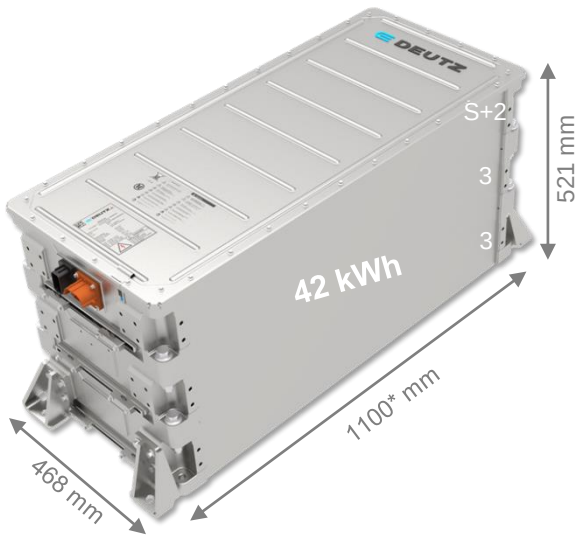
E-DEUTZ system
control and vehicle
communication

E-DEUTZ - Components

Next Generation: Deutz Modular Battery Kit / Gen 2

Today: Generation 1

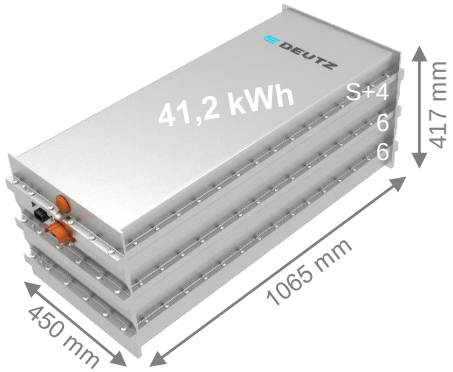
360V Battery

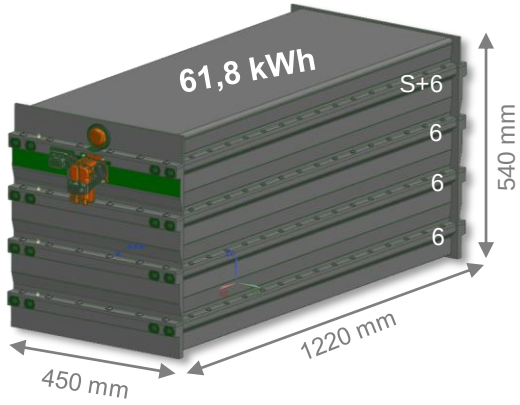


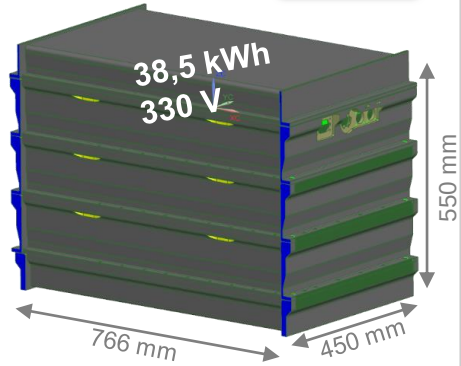
Follow up: Generation 2

360V Variants for high capacity

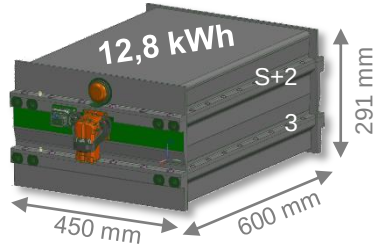
NEW

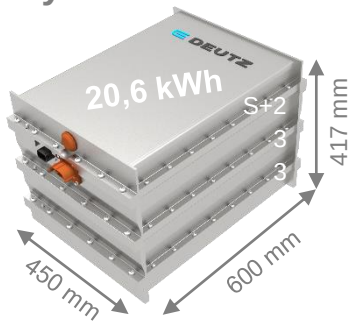


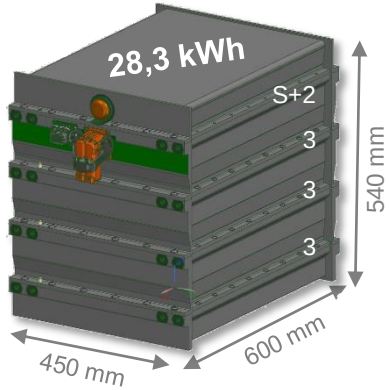




48V Variants for compact systems







Use of standardized & state of the art module technology to ensure future competitiveness

Mid-term capacity increase of up to 30% on cell-level already announced

*w/o mountings

Short Term Solution – E-DEUTZ GEN 1

High voltage Li-Ion Battery pack 360 V / 42 kWh

E-DEUTZ HV-Battery	E360 42 kWh
Battery type	Li-Ion (NMC)
Nominal voltage	352.3 V
Voltage range	300 – 403 V
Nominal capacity	120 Ah / 42.2 kWh
Usable capacity	33.6 kWh
Discharge current (cont. / max.)	190 A / 400 A (10s)
Charge current (cont. / max.)	145 A / 240 A (10s)
Cooling	Water/glycol cooled with water/air heat exchanger
Operating cell temperature	-30°C …+50°C
Storage temperature	-35°C …+35°C
IP protective class	IP67, IP6k9k
Full equivalent cycles during lifetime*	1500 (- 2500)
Dimensions (L x W x H)	1100 x 468 x 521 mm³
Weight	330 kg
Vol. & grav. energy density	157 Wh/l & 128 Wh/kg
Availability	Prototype: as of today Series: Q4/2022

*depending on utilization

Long-Term Option for Series Supply – E-DEUTZ GEN2

High voltage Li-Ion Battery pack 360 V / 41 kWh

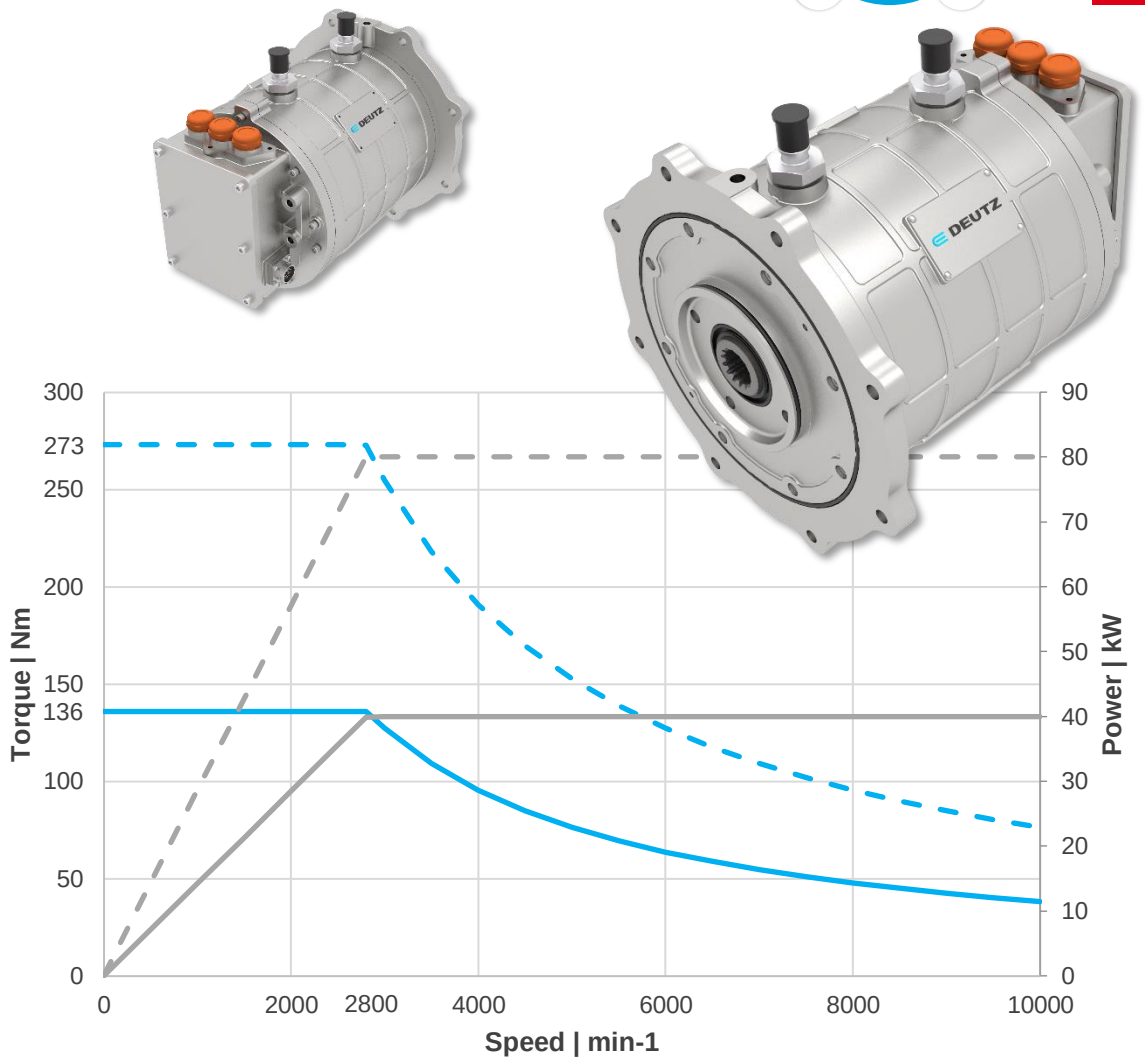
E-DEUTZ HV-Battery	**E360 41 kWh – GEN2** *(prelim.)*
Battery type	Li-Ion (NMC)
Nominal voltage	352 V
Voltage range	300 – 403 V
Nominal capacity	116 Ah / 41 kWh
Usable capacity	32.6 kWh (- 36.7 kWh)
Discharge current (cont. / max.)	220 A / 420 A (10s)
Charge current (cont. / max.)	132 A / 240 A (10s)
Cooling	Water/glycol cooled with water/air heat exchanger
Operating cell temperature	-30°C …+50°C
Storage temperature	-35°C …+35°C
IP protective class	IP67, IP6k9k
Full equivalent cycles during lifetime*	1500 (- 2500)
Dimensions (L x W x H)	1065 x 450 x 417 mm³
Weight	~285 kg
Vol. & grav. energy density	200 Wh/l & ~144 Wh/kg
Availability	Prototype: Q2/2023 Series: 2024

*depending on utilization

E-DEUTZ - Components

E-Motor

E-DEUTZ E-Motor	E360 40 kW
Motor type	PMSM
Speed (rated / max)	2800 / 10.000 rpm
Continuous max. power output	40 kW
Continuous max. torque output	136 Nm
Peak max. power output	80 kW
Peak max. torque output	273 Nm (30 s)
Cooling	Water/glycol cooled with water/air heat exchanger
IP protective class	IP67, IP6k9k
Dimensions (L x W x H)	356 x 298 x 298 mm³
Weight	45,8 kg
Availability	Prototype: as of now Series: Q4/2022

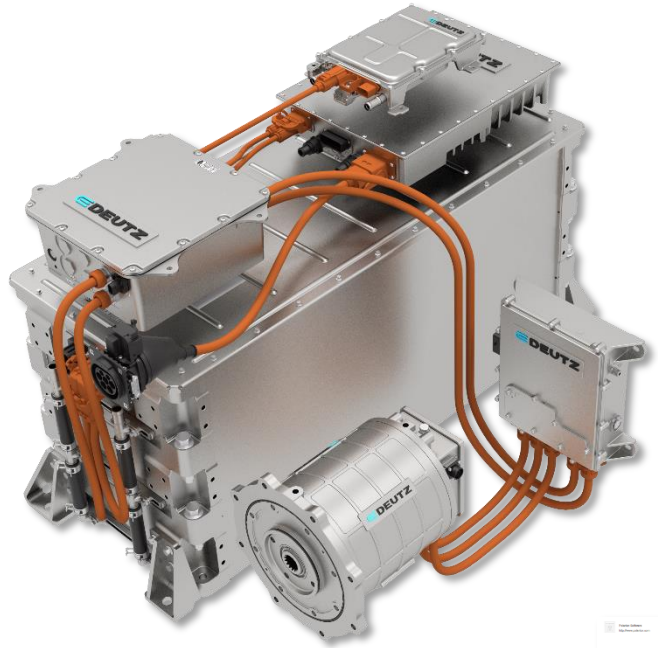


Delivery scope

E-DEUTZ - Systems

Scope of delivery: Basic **E360** system

E-DEUTZ system	**abbr.**	**E360 W40-42**
Work motor	WRM	40 kW / 80 kW
Work inverter	WRI	
High voltage battery	HVB	42 kWh
Onboard charger	OBC	22 kW
High voltage board net converter	HBC	360 V / 12 V: 1.5 kW
Power distribution unit	PDU	DC-PTO (up to 15 kW)
High voltage wiring	HVW	Wiring for all components above
Powertrain control unit	PCU	Incl. software & dataset
Medium temperature circuit	MTC	Incl. radiator, fans, pumps, sensor, surge tank, quick connectors
Optional scope		
Low voltage plug set		Counter plugs for all components
Low voltage board net converter	LBC	12 V / 24 V: 1.1 kW
Low temperature circuit	LTC	Incl. radiator, fans, pump, sensor, surge tank, quick connectors
Low temperature heater	LTH	HVB heating device
High voltage battery	HVB	2nd 42 kWh (parallel connection)
Power unit	-	2nd motor + inverter

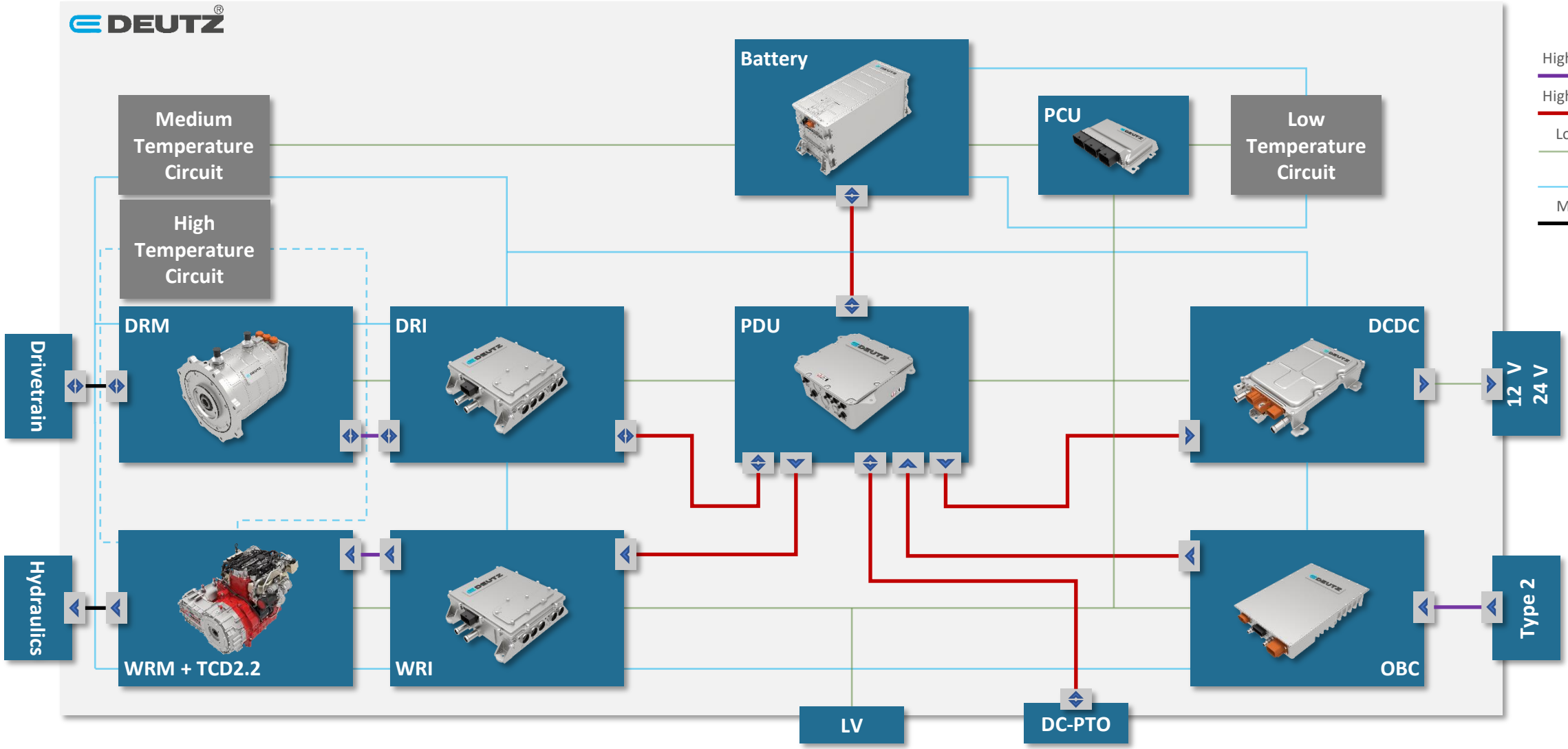


E-DEUTZ documentation
System specification
Installation guideline
Operation manual
CAN specification + system requirements specification
Wiring diagram (LV + HV)
3D models

Hybrid

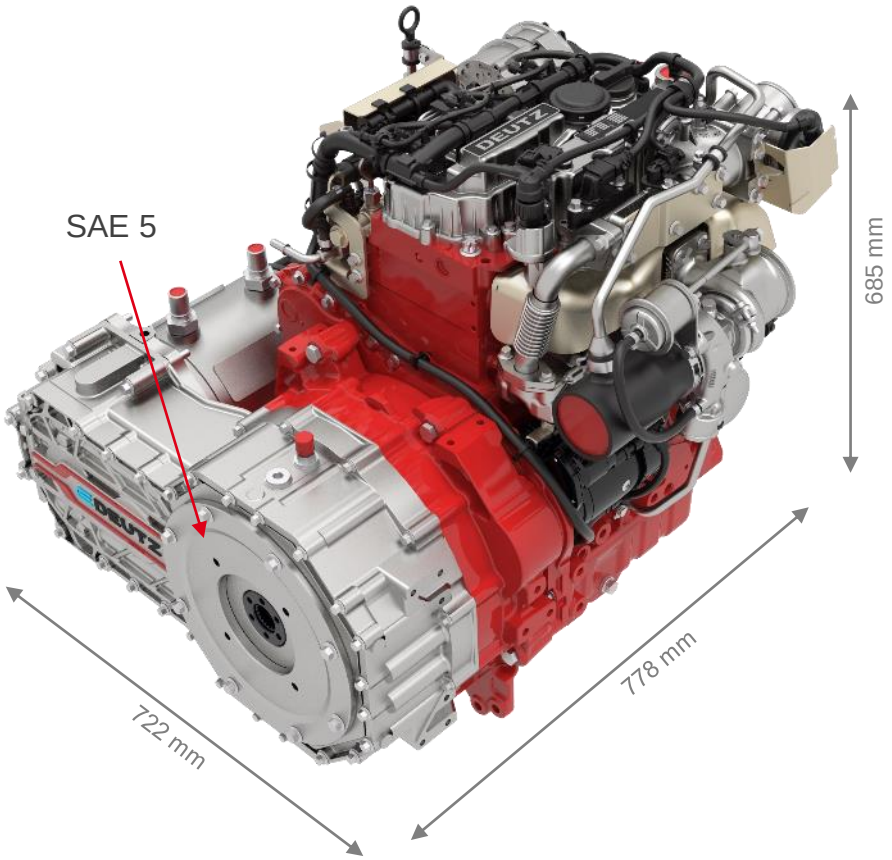
E-DEUTZ - Systems

Example: System architecture combined hybrid system – E360 D40W40-42C PSH



E-DEUTZ - Hybrid solutions

Predevelopment: HV-Hybrid Power pack 360V

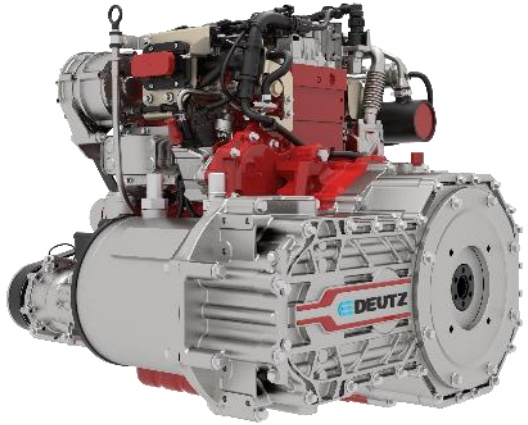


TCD 2.2 L3

- 55,4 kW @ 2600 min^{-1}
- 280 Nm @1600 min^{-1}
- n_{min} = 900 min^{-1}

360 V E-Motor

- 40 kW cont.
- 80 kW peak
- n_{max} = 10.000 min^{-1}



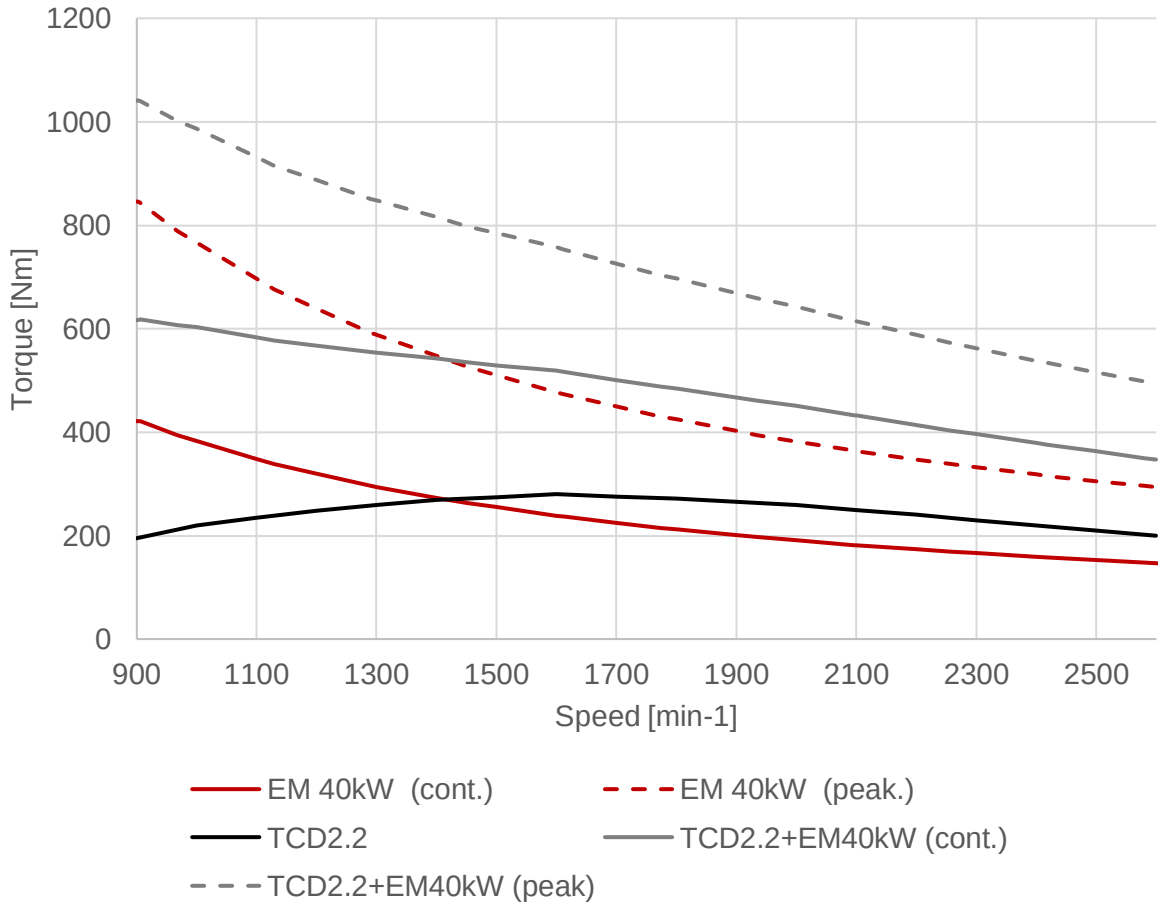
- Flywheel with mass compensation
- Electromagnetically operated clutch (for P2 applications)
- Vibration damper
- Aluminum housing
- Noise-optimized helical gear unit with i = 3.1
- Optional oil cooling module with integrated pump for high performance applications and steep sloping conditions

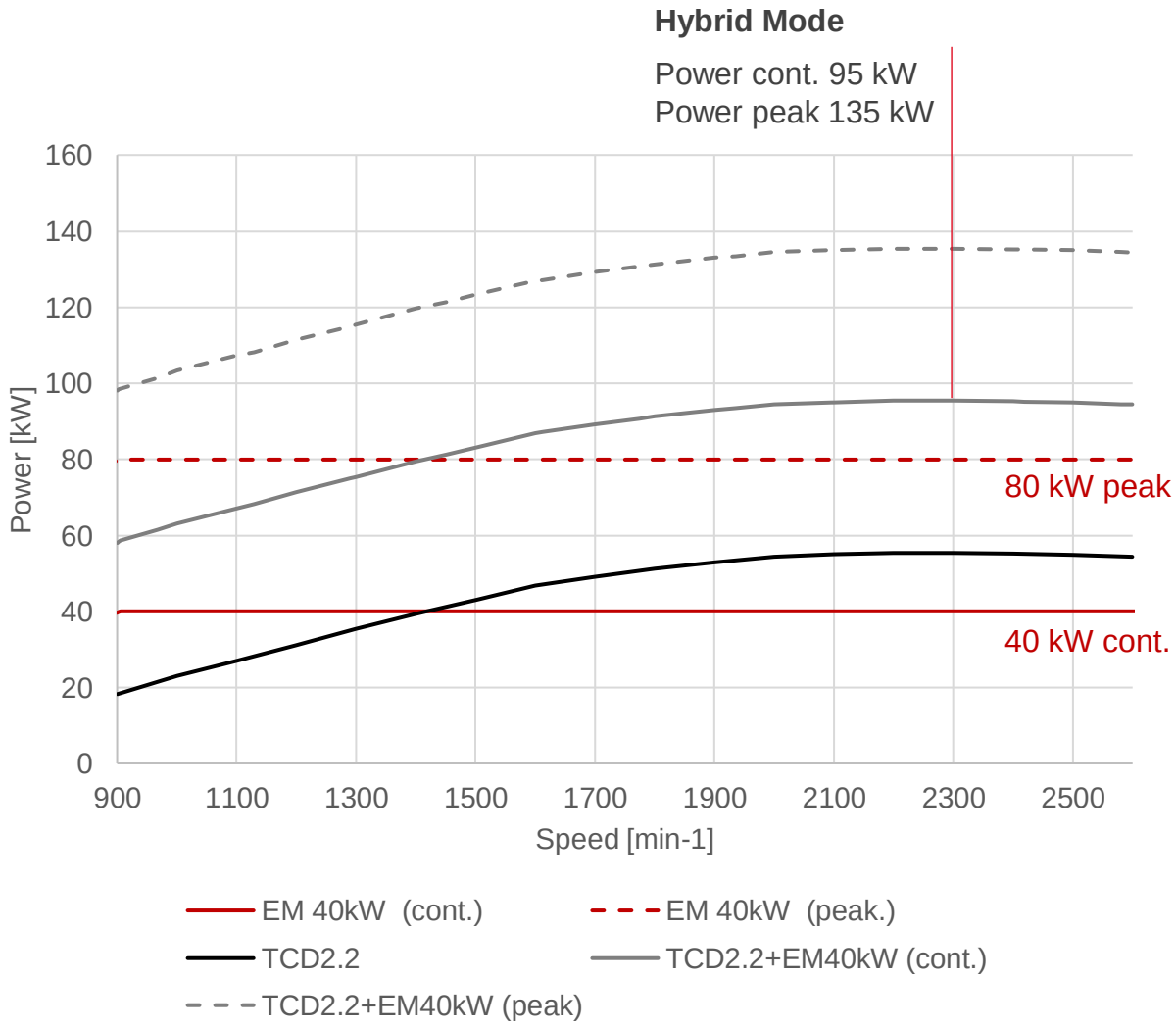
Note

- Predevelopment phase, earliest PT availability tbd
- No industrialisation started yet
- Concept suitable for engines up to 4.0

E-DEUTZ – Hybrid solutions

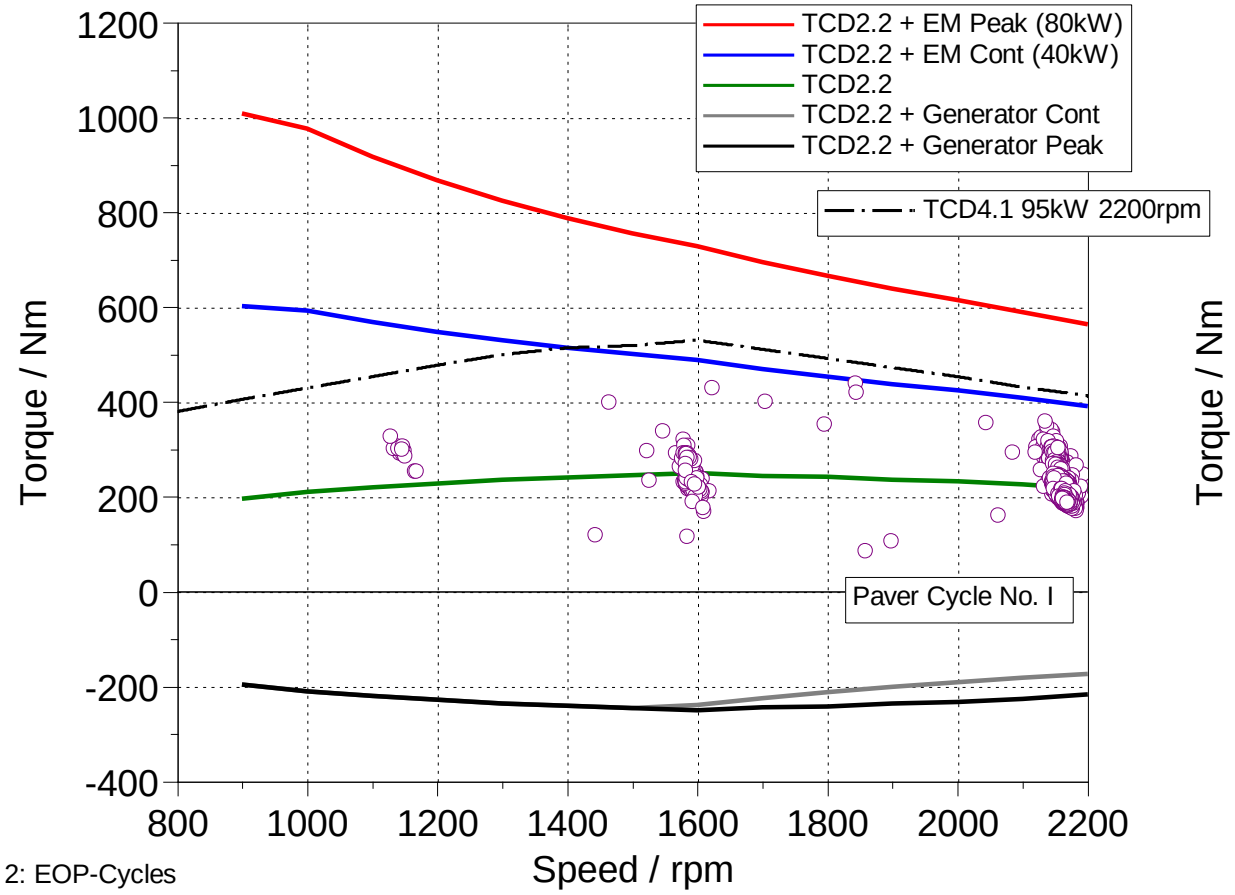
Predevelopment: HV-Hybrid Power pack 360V – performance



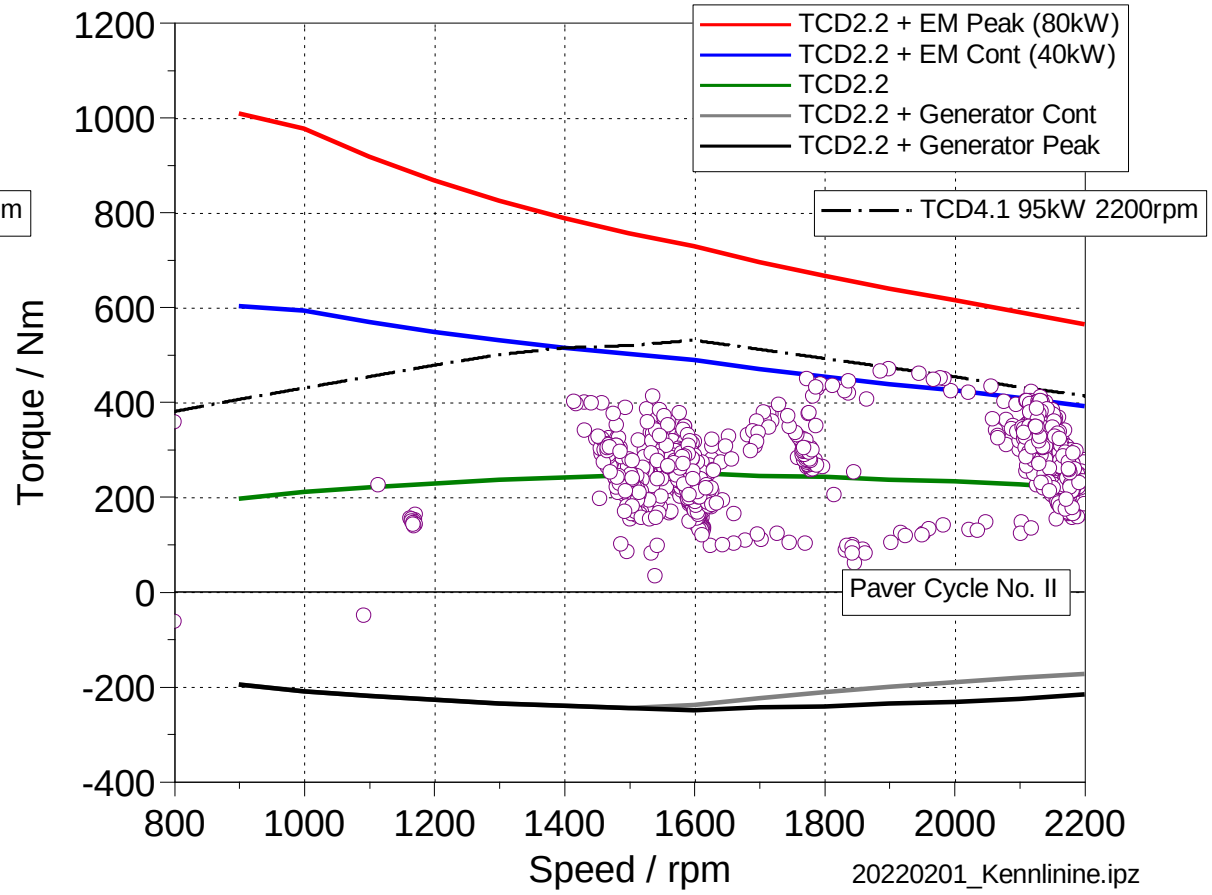


E-DEUTZ - Systems & Components

Paver Cycle – Engine operation vs E360 hybrid fullload curves



2: EOP-Cycles

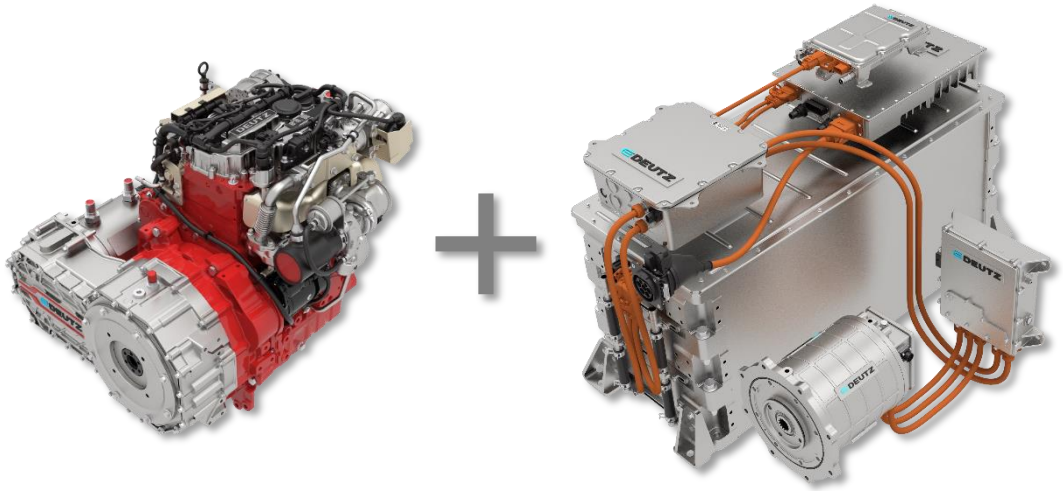


20220201_Kennlinine.ipz

E-DEUTZ - Systems

Scope of delivery: Combined hybrid system

E-DEUTZ system	abbr.	E360 W40D40-42 PSH
Work motor	WRM	40 kW / 80 kW
Work inverter	WRI	
High voltage battery	HVB	42 kWh
Onboard charger	OBC	22 kW
High voltage board net converter	HBC	360 V / 12 V: 1.5 kW
Power distribution unit	PDU	DC-PTO (up to 15 kW)
High voltage wiring	HVW	Wiring for all components above
Powertrain control unit	PCU	Incl. software & dataset
Medium temperature circuit	MTC	Incl. radiator, fans, pumps, sensor, surge tank, quick connectors
Diesel Engine	ICE	TCD2.2 with 55.4 kW
Optional scope		
Low voltage plug set		Counter plugs for all components
Low voltage board net converter	LBC	12 V / 24 V: 1.1 kW
Low temperature circuit	LTC	Incl. radiator, fans, pump, sensor, surge tank, quick connectors
Low temperature heater	LTH	HVB heating device
Power unit	-	2nd motor + inverter

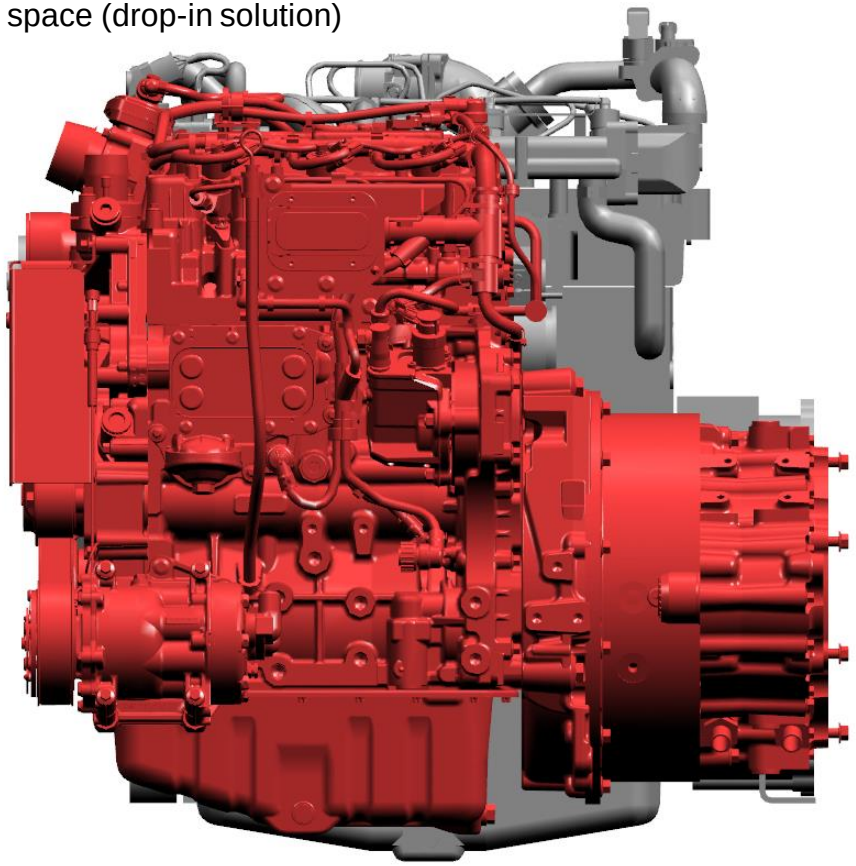


E-DEUTZ documentation
System specification
Installation guideline
Operation manual
CAN specification + system requirements specification
Wiring diagram (LV + HV)
3D models

E-DEUTZ - Hybrid solutions

Platforms details

Downsizing TCD 3.6 (75 kW) to TCD 2.2 (55.4 kW) plus electric motor (20 kW peak) at comparable installation space (drop-in solution)



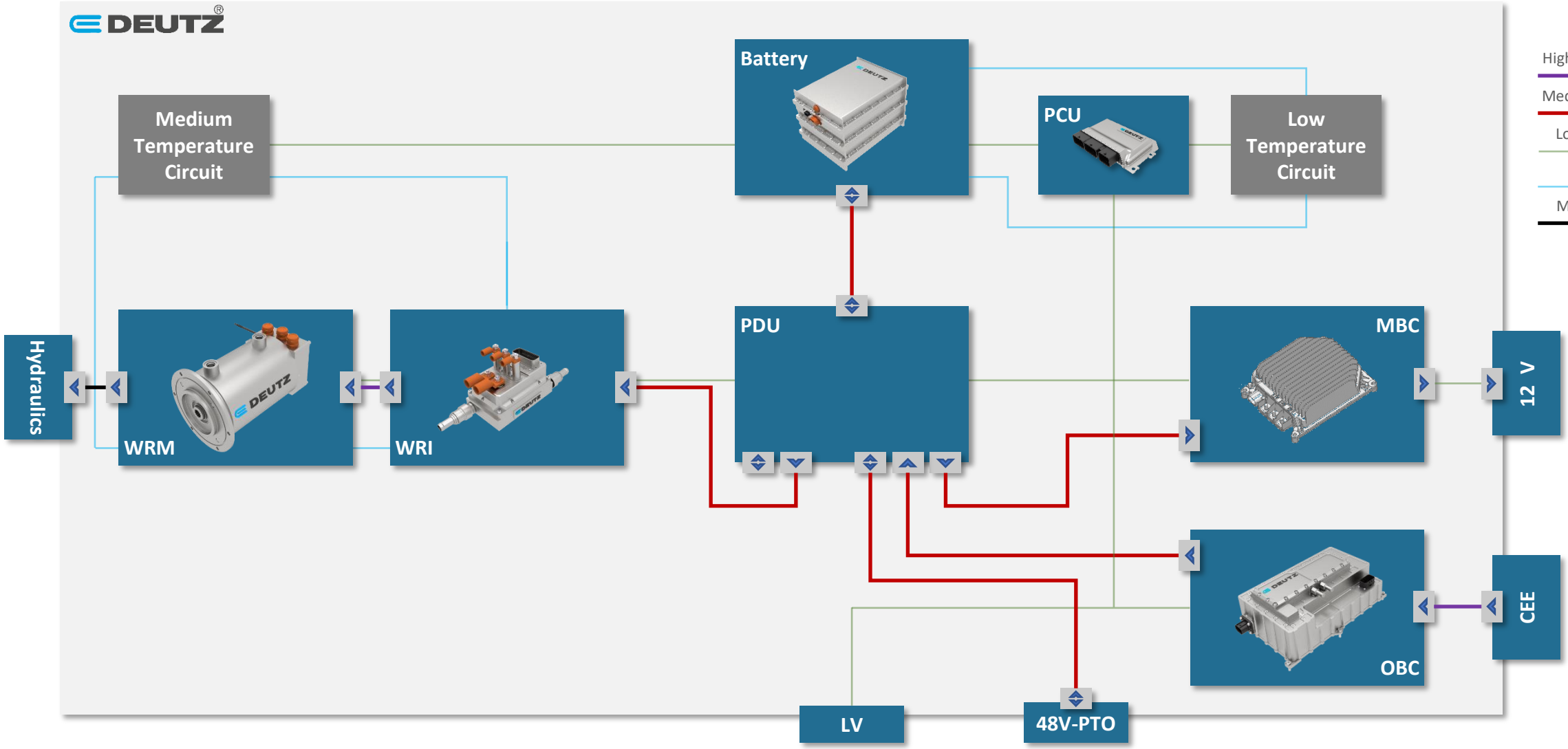
Comparison **TCD 3.6 (grey)** to **TCD 2.2 Hybrid (red)**

DRIVE BOX	360V: 19kW 37kW 56kW (75kW 100kW subsequent) 48V: 9kW 13,6kW
BATTERY BOX	360V: 10kWh 42kWh (scalable) 48V: 5kWh (scalable)
CONVERTER BOX	charger: 110V 230V 360V (up to 1000V optional) output: 12V 24V 48V 110V 230V
DIESEL ENGINES	1.2 2.2 2.9 (3.6 …7.8 subsequent)

E48 system

E-DEUTZ - Systems

Example: System architecture electric system – E48 W10-20



E-DEUTZ - Systems

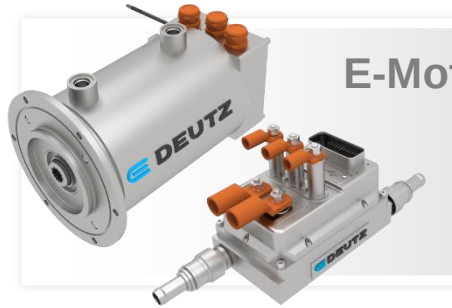
Modular product kit

E-DEUTZ SYSTEM	VOLTAGE	E-Motors	Battery	PDU + PCU	OBC	DC/DC	ICE	Features
COMBINED HYBRID	48 V	10 kW	13 kWh	48 V	3.3 kW (AC)	500 W	G 2.2	Multiple Motors
FULL HYBRID		15 kW	20 kWh		6.6 kW (AC)	1000 W	G 2.9	Clutch
E-DRIVE RANGE EXTENDER					9.9 kW (AC)			DC - PTO
E-DRIVE	360 V	20 kW	20 kWh	360 V	3.3 kW (AC)	1.5 kW (12V)	D/TD/TCD 2.2	Hybrid gearbox
E-WORK		40 kW	42 kWh		11 kW (AC)	1.1 kW (24V)	D/TD/TCD 2.9	Cabin heating
E-DRIVE + WORK SPLIT		60 kW	… kWh		22 kW (AC)		TD/TCD 3.6	50 kW (DC-charging)
								Multiple Batteries

First availability 2022

E-DEUTZ - Components

Component portfolio – E48



E-Motor + Inverter

Cont. power:
10 kW / 50 Nm
Peak power:
14 kW / 70 Nm

Power Unit

HV-Battery

HVB

36 – 51 V range
20,6 kWh capacity

PDU

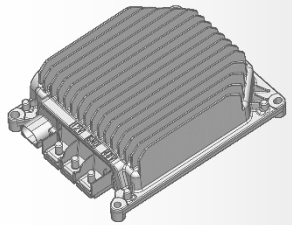
48V-Batterie +
Power Unit +
DCDC + OBC +
DC-PTO

Power Distribution Unit

Onboard-charger

OBC

3.3 kW
Parallel use of
up to three OBCs



MBC

Medium voltage
board net converter
48V / 12V

Converter

Powertrain Control Unit

PCU

E-DEUTZ system
control and vehicle
communication

E-DEUTZ - Components

High voltage Li-Ion Battery pack 48 V / 20.6 kWh (Gen 2)

E-DEUTZ battery	**E48 20,6 kWh**
Battery type	Li-Ion (NMC)
Nominal voltage	44 V
Voltage range	36 – 51 V
Nominal capacity	470 Ah / 20,6 kWh
Usable capacity	18,5 kWh (Target 90 % DoD)
Discharge current (cont. / max.)	250 A / 300 A (7min) / 600A (<1min)
Charge current (cont. / max.)	250 A / 300 A (7min) / 600A (<1min)
Cooling	Water/glycol cooled with water/air heat exchanger
Operating cell temperature	-30°C …+50°C
Storage temperature	-35°C …+35°C
IP protective class	IP67, IP6k9k
Full equivalent cycles during lifetime*	1500 (- 2500)
Dimensions (L x W x H)	610 x 450 x 418 mm³
Weight	~150
Vol. & grav. energy density	180 Wh/l & ~135 Wh/kg

Deutz Group Battery

FUTAVIS BMS and S-Box

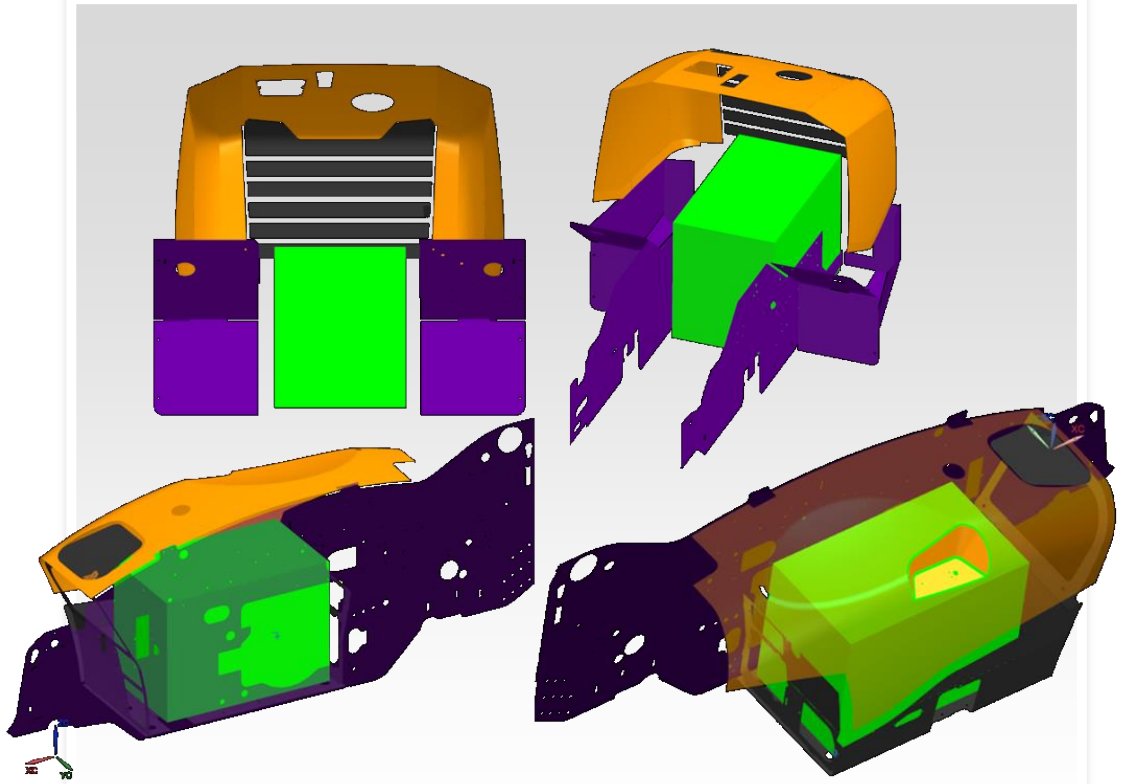
DEUTZ Housing and industrialization

torqeedo Testing and integration

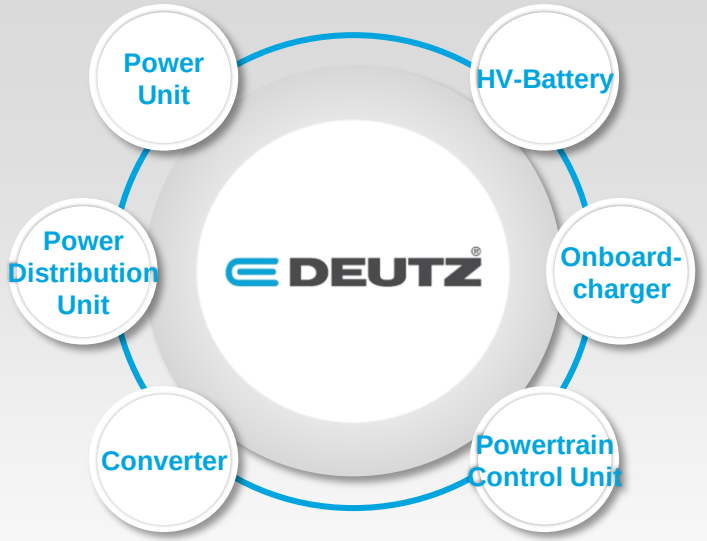
*depending on utilization

E-DEUTZ - Components

High voltage Li-Ion Battery pack 330V / 39kWh (Gen 2)



Customer concept
Volume fitting



Integration analysis based on the project requirements
Different batteries arrangements / volumes

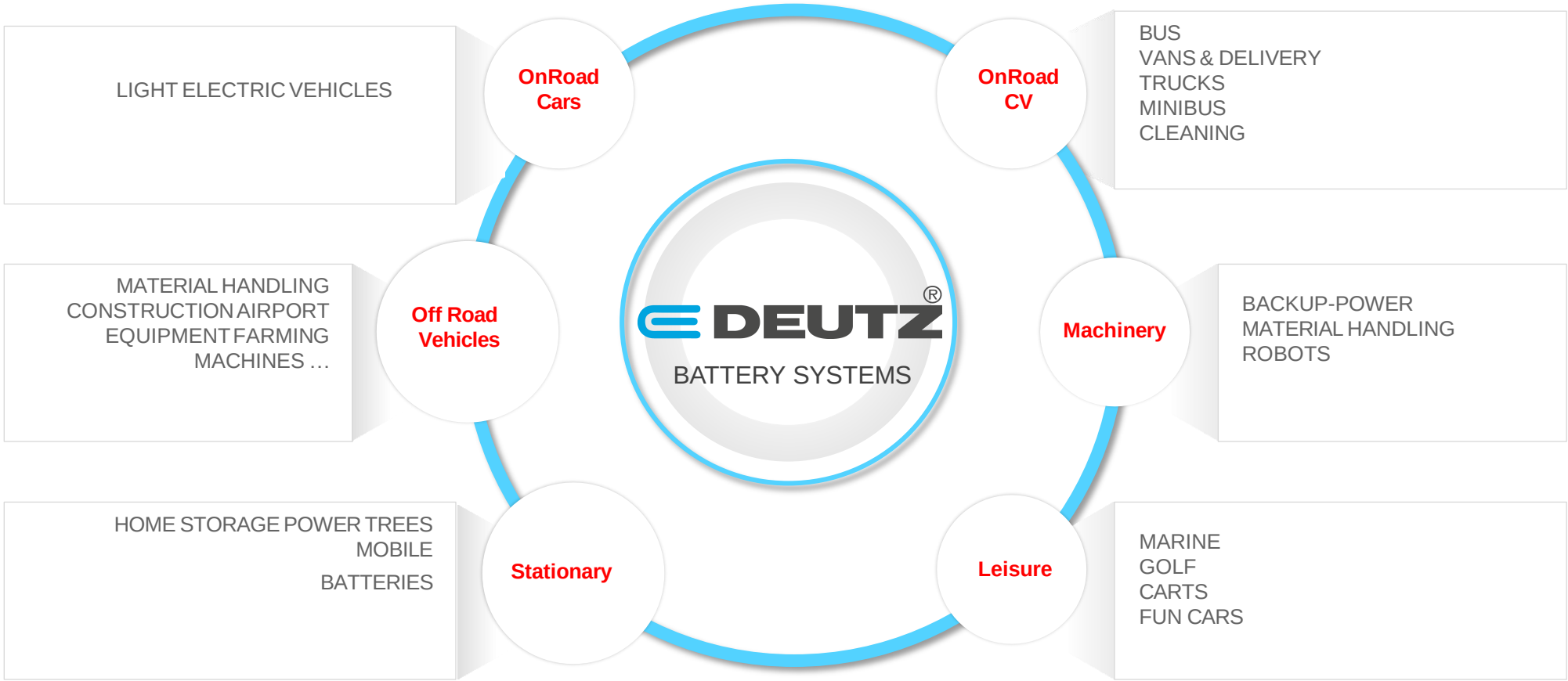
Different reference voltages

preliminary integration analysis: highest power density per available volume

BMS + battery packages

E-DEUTZ - Systems

BMS + batteries applications



E-DEUTZ - Systems

Integration of batteries systems

Customized Modular Drive Trains

- Electric & hybrid drive trains in 48V & 360V
- Modular product kit for fast customer configurations
- Fully industrialized, easy to integrate drive train for Off-Road OEMs

Batteries experts

Tailored Batteries

- Customer-specific batteries from series production
- Configuration from modular set of industrialized components
- 24V to 800V, scalable capacity
- Configurable interfaces
- Certified safety

Battery Components

- Series-ready components
  - Battery-Management System
  - Safety-Box
  - IsoMonitor
  - EOL testing systems & test benches
- Applicable to customer systems
- ISO 26262

Engineering Solutions

- Developments for eMobility
- Component development for series readiness
- Testing & certification
- Functional safety
- Concepts & consulting

E-DEUTZ - Systems

Integration of batteries systems

COMPETENCE

Application level	Battery-level	Module-level	Cell-Level
			
System Integration, Functions, safety	Thermomanagement, Packaging, NVH	Cell chemistry, Batteries characteristics	Cells configuration, Battery management system

E-DEUTZ - Systems

BMS + batteries : DEUTZ group support

Futavis

- Overall project management, main contact
- Lead in battery development, industrialization and homologation
- Construction of prototypes, purchase of pre-series components
- Purchasing of selected components: BMS assemblies, S-box, wiring harnesses if applicable.
- Process engineering assembly, development test facilities

FUTAVIS
COMPLEXITY SIMPLIFIED

DEUTZ

- Support of the mechanics development (esp. housing)
- Sourcing of the battery modules and if necessary further components
- Takeover of field operation

DEUTZ

Torqeedo

- Assembly of the battery packs
- Material control for assembly
- Quality assurance series assembly
- Delivery of the battery packs

torqeedo

Hydrogen engine

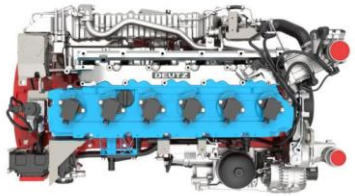
H2-Storyline

Hydrogen engine on genset application

June 2022

The engine company. DEUTZ

RheinEnergie



PRESS RELEASE

Producing energy from hydrogen – DEUTZ and RheinEnergie launch joint pilot project

- Climate-neutral flagship project: electricity from a hydrogen engine fed into Cologne's public grid for first time
- Hydrogen engine combined with a generator provides carbon-neutral electric power
- Huge potential for the local, climate-neutral supply of energy

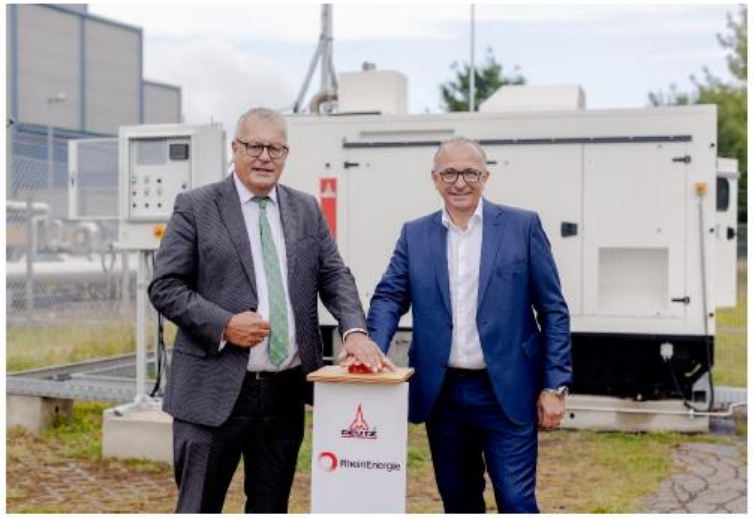
Cologne, June 20, 2022 – Joint pilot project launched: DEUTZ AG and RheinEnergie AG, two Cologne-based companies whose origins date back to the 19th century, are trialing the generation of energy using a stationary DEUTZ hydrogen engine. DEUTZ is a leading global manufacturer of engines and drive technology, while RheinEnergie is a regional energy supplier that has a clear commitment to the green energy transition.

The partners' flagship project got under way on June 20 when the first H_2 genset went into operation at RheinEnergie's cogeneration plant in the Niehl district of Cologne. The combination of a TCG 7.8 H_2 hydrogen engine and a generator will deliver electric power of up to 170 kilovolt-amperes (kVA) during the initial six-month test phase. This electricity will be fed directly into Cologne's power grid. In a second step, the genset's waste heat is to be utilized. The solution being piloted by DEUTZ and RheinEnergie has huge potential for the local, carbon-neutral supply of energy in urban centers.

DEUTZ

The joint pilot project marks an important step on DEUTZ's journey to volume production of the TCG 7.8 H_2, which is scheduled to start in 2024. With an output of around 200 kilowatts, the hydrogen engine is suitable for all off-highway applications. "We are already seeing a lot of interest in our H_2 engines from customers across all application areas," says Dr. Markus Müller, member of the DEUTZ Board of Management with responsibility for research & development. "And we are already planning further pilot applications."

Together, the partners have invested €1.3 million in the pilot project to supply electricity on a climate-neutral basis. A reliable and local energy supply without greenhouse gas emissions necessitates expansion of the H_2 infrastructure and requires sufficient green hydrogen to be made available at affordable market prices. The partners therefore believe that the onus is now on politicians. The European Green Deal will not succeed without regulatory support.



Chairman of the Management Board of RheinEnergie Dr. Dieter Steinkamp and DEUTZ Chief Sales Officer Michael Wellenzohn
Source: RheinEnergie AG

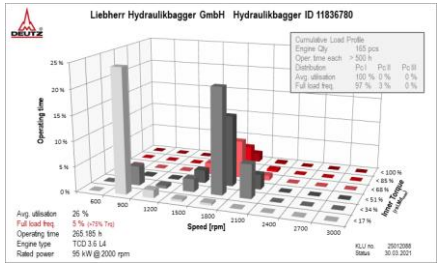
H2-Storyline

How to achieve: CO_2- neutral constuction site

Load profile Diesel engine

Average working time/day

➔ 4,4 working hours



➔ ~60kWh needed for electrification
40 kW E-Motor / ~30% utilization

[40kW x 0,3 x 4,4h = 52,8 kWh]

E-DEUTZ battery

Electrification Battery acc. Load Profile

➔ 100 kWh / 800V

[100 kWh x 0,85 = 85 kWh]

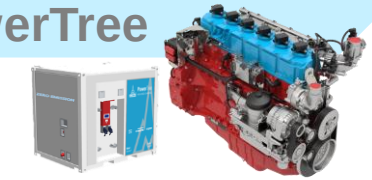
~60kWh needed for electrification in scenario and the use of fast charge application 20%-85%

SAMPLE for Battery 100kWh:

Capacity	~100kWh
Size	~1,720 x 700 x 300 (L x W x H)
Weight	~560 kg

Sample from electrified serial equipment
Compact excavator Loading Time required
➔ 20%-85% ~60 kWh/800V ~35 Min.
➔ 100% 100 kWh/800V ~45 Min.

DEUTZ TCG 7.8 H2 engine in GenSet + PowerTree



off-grid energy supply for construction site

➔ ~11,56 kg/day H2 consumption
[1500 rpm; 44kW; 335Nm]
Scenario: 2x compact excavator loading
~173 kWh ➔ 4 hour load time ➔ ~18 kg/day H2 consumption
➔ ~113 kWh total capacity demand
➔ ~2,6 hours total running time of GenSet
[113 kWh / 44kW = 2,57 h]

Scenario for Construction side:
capacity demand and loading time

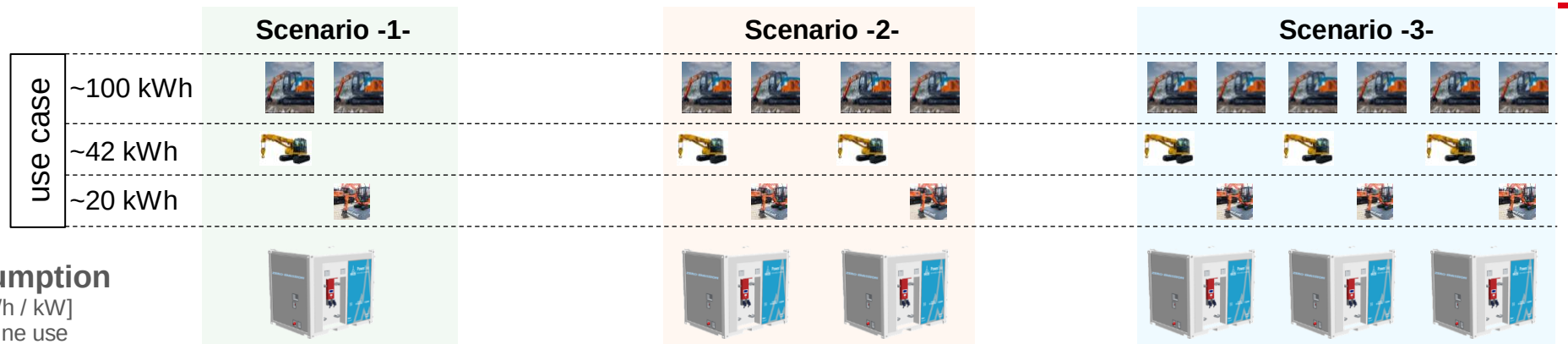
1x  compact excavator (8,5 t)
~60kWh/800V 20%-85% = ~ 35 Min.

1x  medium application
~35kWh/400V 100% = ~ 120 Min.

1x  small application
~18kWh/230V 100% = ~ 180 Min.

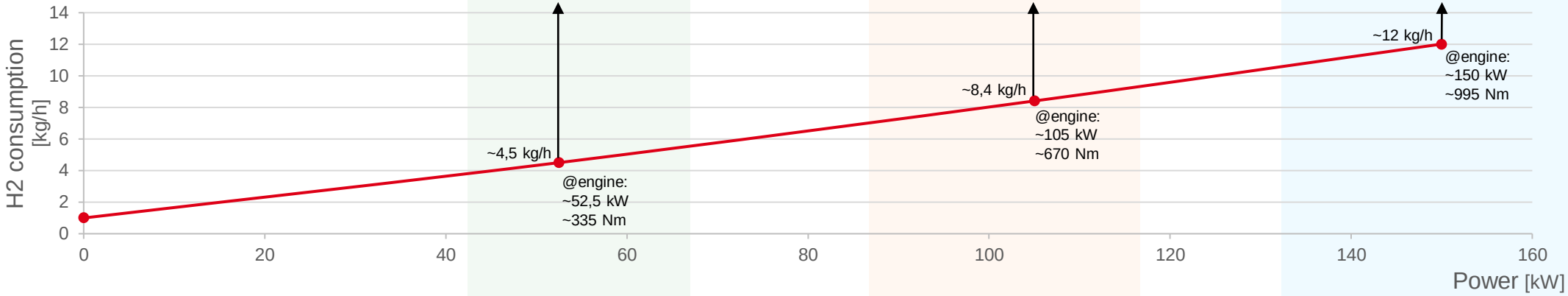
H2-Storyline

Scenario: CO_2-neutral construction site



TCG 7.8 H2 - H2 consumption

in relation to power curve [kg/h / kW]
@1500rpm in stationary engine use



Loading time per day pending on Scenario for off grid construction site - total machine working hours average 4,4 h/day up to 8 h/day - total capacity demand average 113 kWh up to 173 kWh	~11.56 kg/day up to ~18 kg/day ~ 57,78 kg/week up to ~ 90 kg/week	~ 21,57 kg/day up to ~ 33,6 kg/day ~ 107,86 kg/week up to ~ 168 kg/week	~ 30,82 kg/day up to ~ 48 kg/day ~ 154,09 kg/week up to ~ 240 kg/week

PowerTree

DEUTZ PowerTree

Joint Project of Deutz and Torqeedo

High End Industry Components

The First Fast Charger for Construction Sites

Easy Installation and Commissioning

Zero Emission certified

High Flexibility Through Mobile Use

100% Fast Charging without Grid Connection

Balancing of Grid Power fluctuations

DEUTZ PowerTree

Joint Project of Deutz and Torqeedo

- Ensuring power supply for electrically driven off-road applications at the point of use
- Input supply up to 63 A @ 400 V (CEE)
- Output: fast charging up to 150 kW (also without grid connection)
- Mobile use and robustly designed in 10ft sea container, suitable for construction sites
- Buffer storage in form of E-DEUTZ batteries
- Digital services - charging management for multiple vehicles, consumption-analysis and billing
- Suitable for various applications

DEUTZ PowerTree

Joint Project of Deutz and Torqeedo

Technical data	
Dimensions	3.000 mm x 2.500 mm x 2.600 mm
AC Input	63 A @ 400 V (CEE)
Battery Capacity	126 kWh (modular)
Charging Points	2 x CCS + 2 x CEE (400 V + 230 V)
Fast Charging	1x 150 kW Charging Power at 800 V or 2 x 75 kW Charging Power at 800 V
AC Output	32 A @ 400 V + 16 A @ 230 V (CEE)
Operating Modes	On-grid + Off-grid DC- & AC-Charging of Applications
Fire Detection System	Yes
Lifetime	10 years
Total Weight	ca. 4.500 kg
DEUTZ Digital Service	Status of Fast Charger via Mobile Communications

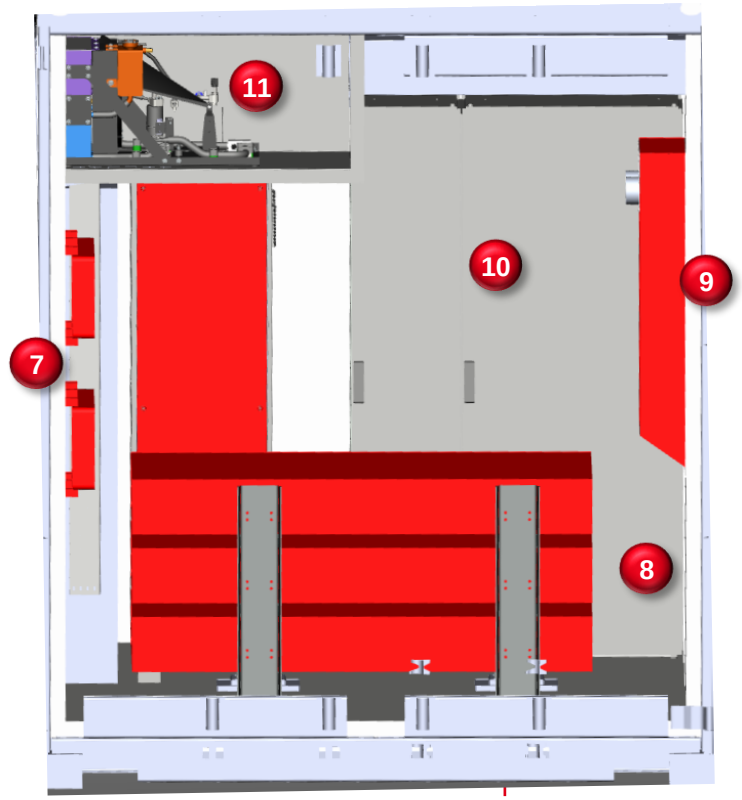
63 A @ 400 V (CEE)
is the same power connection as:

DEUTZ PowerTree

Description of interfaces and internal view – Prototype example

Front- / Site view

1. **10 ft. High-Cube-Seecontainer**
2. **Integrated DC Charger**
3. **Output**
   CCS Typ 2 (800 V: 1 x 150 kW or 2 x 75 kW (opt.))
4. **HMI**
   Start and Control of the System
5. **Output**
   230 V 16A / 400 V 32A
6. **Power Supply**
   63 A / 400 V CEE
7. **2 x 22 kW Charger**
8. **3 x HV-Battery á 42 kWh = 126 kWh**
9. **Containerventilation**
10. **Control Cabinets Installation**
    space for inverter, PT control, telemetry, etc.
11. **Cooling System for HV-Batteries**

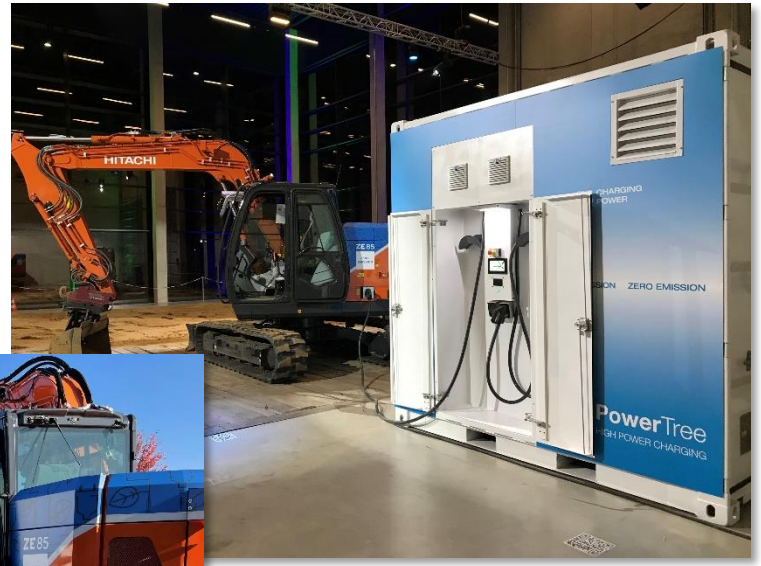


Internal view

DEUTZ PowerTree

Mobile Plug & Play Fast Charger for Off-highway applications

SET UP → PLUG-IN → Charge

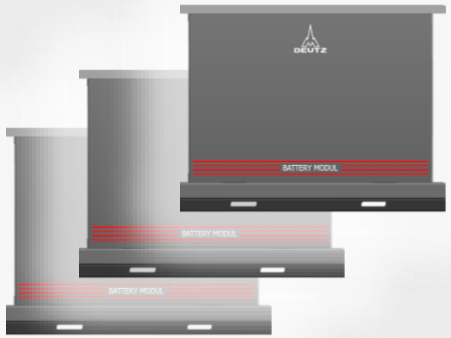


- No trained personnel necessary
- Short commissioning and deinstallation time
- ‘Off-grid’ stand-alone operation through battery storage
- Maximum flexibility through mobile use
- Use despite poorly developed local infrastructure
- Robust container solution for construction site operation
- Enables capacity reduction of the battery and more compact installation dimensions in the construction machine / vehicle

DEUTZ PowerTree

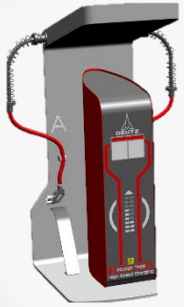
Modular Concept

Extendable battery storage



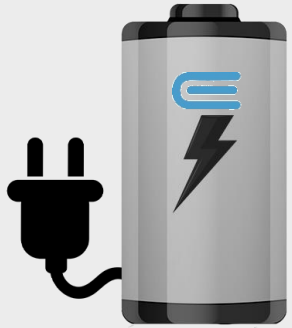
Scalable up to 252 kWh

Charging system with 800 V



Additional charging points possible

Fast-charging technology



Fast charging power up to 150 kW

MOBILE SYSTEM

SCALABLE CONTAINER SOLUTION

DEUTZ PowerTree

DEUTZ Digital Services

We care. We support. We deliver.
DEUTZ SERVICE.

Basic functions

- Operating data of the charging station

Advanced functions

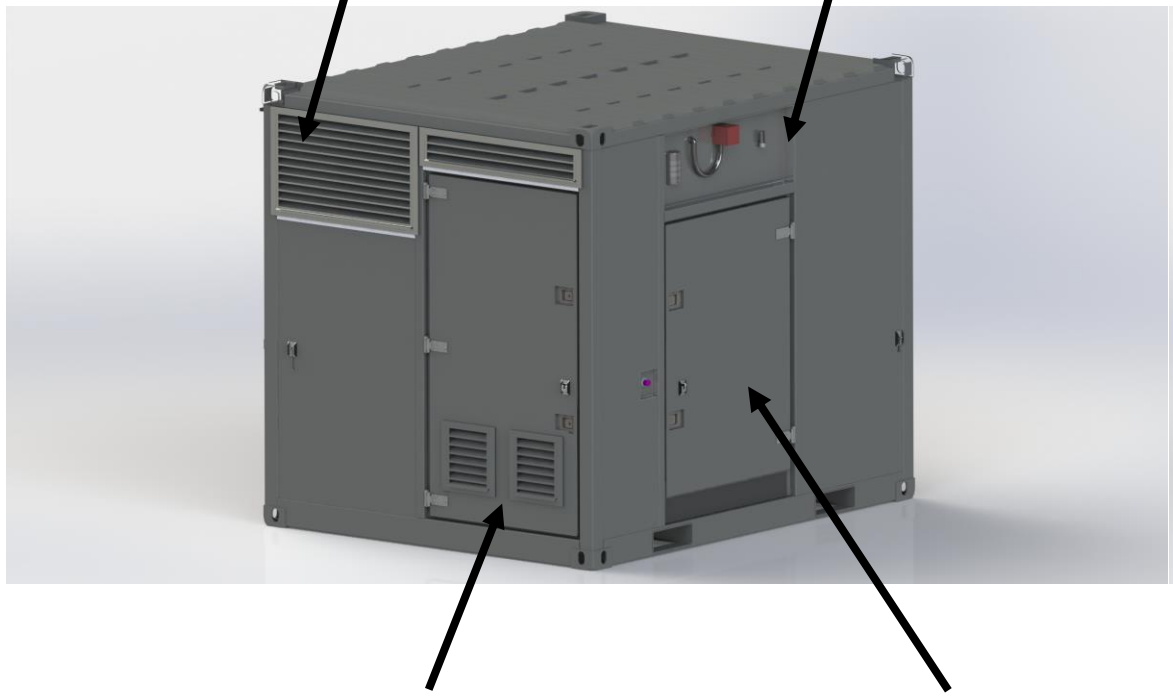
- PowerTree – App
- Operating data from the e-vehicle (based on CCS protocol)
- Billing management
- Geofencing
- Fire alarm
- Fleet management
- Remote maintenance

DEUTZ PowerTree

Development 1.5

Installation and maintenance of the TMS system

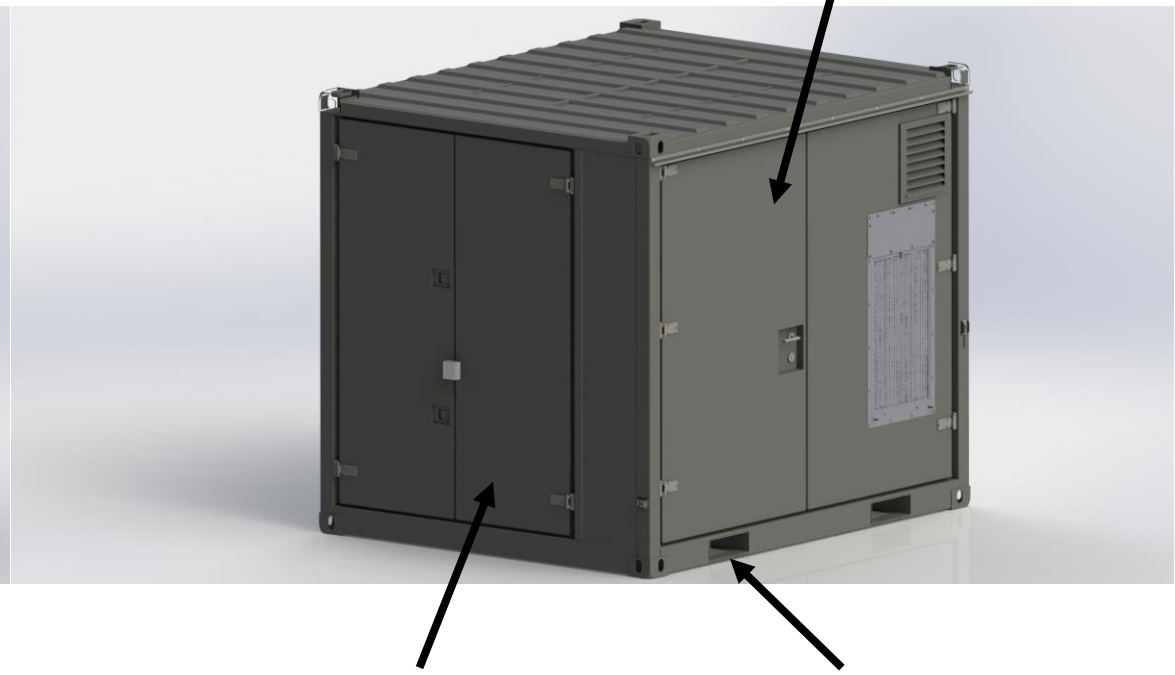
Keine Bauteile außerhalb der Containerkontur



Service door

Charging port

Service door for battery and access to the interior



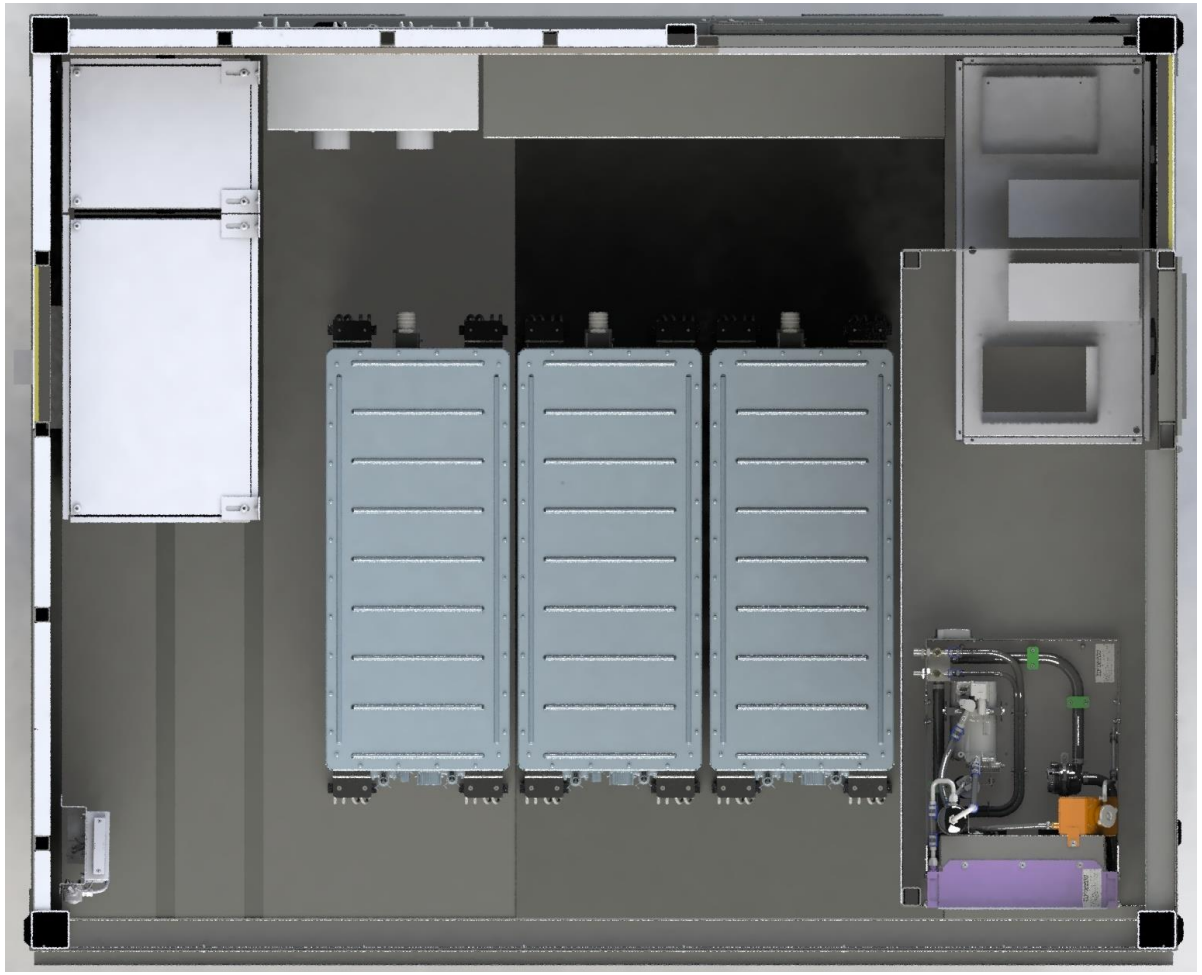
Service door for switch cabinet control

Lifting and transport with forklift and crane possible

DEUTZ PowerTree

Weiterentwicklung 1.5

- Installation space analysis for alternative batteries (DEUTZ batteries)



DEUTZ PowerTree

Concepts control unit

DEUTZ PowerTree

Extended off-road possible applications

DEUTZ PowerTree

DEUTZ Digital Services

We care. We support. We deliver.
DEUTZ SERVICE.

Basic functions

- Operating data of the charging station

Advanced functions

- PowerTree – App
- Operating data from the e-vehicle (based on CCS protocol)
- Billing management
- Geofencing
- Fire alarm
- Fleet management
- Remote maintenance

Disclaimer

This presentation contains forward-looking statements that are subject to various risks and uncertainties. Future results could differ materially from those described in these forward-looking statements due to certain factors, e.g. changes in business, economic and competitive conditions, regulatory reforms, foreign exchange rate fluctuations, uncertainties in litigation or investigative proceedings, and the availability of financing. DEUTZ does not undertake any responsibility to update the forward-looking statements in this presentation.

Thank you!

DEUTZ AG
Ottostr. 1
51149 Köln
Telefon: +49 (0) 221 822-0
Fax: +49 (0) 221 822-3525
E-Mail: info@deutz.com
www.deutz.com