Hybrid Haul Truck

Improve Productivity and Reduce Emissions

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A Rolls-Royce solution

01

Motivation

Defossilization Goals of Mining Industry

Mining Industry Net Zero emission goals

Company	2030 Goal	Net Zero
BHP	-30%	2050
RioTinto	-30%	2050
VALE	-33%	2050
ANGLO AMERICAN	-30%	2040
GLENCORE	-40%*	2050
Newmont	-30%	2050
FM	-15%	tbd
FMG	-100%	2030

* 2035

02

Hybrid Concept

System Overview

Main Components

System Overview
Conventional AC-drive

Propel:

Diesel engine + Alternator provide power.

Rectifier and inverters form an electric, continuously variable transmission.

Wheel motors convert electric into mechanical power.

Retard:

Wheel motors convert mechanical into electrical power.

Retarder grid converts electrical power into waste heat.

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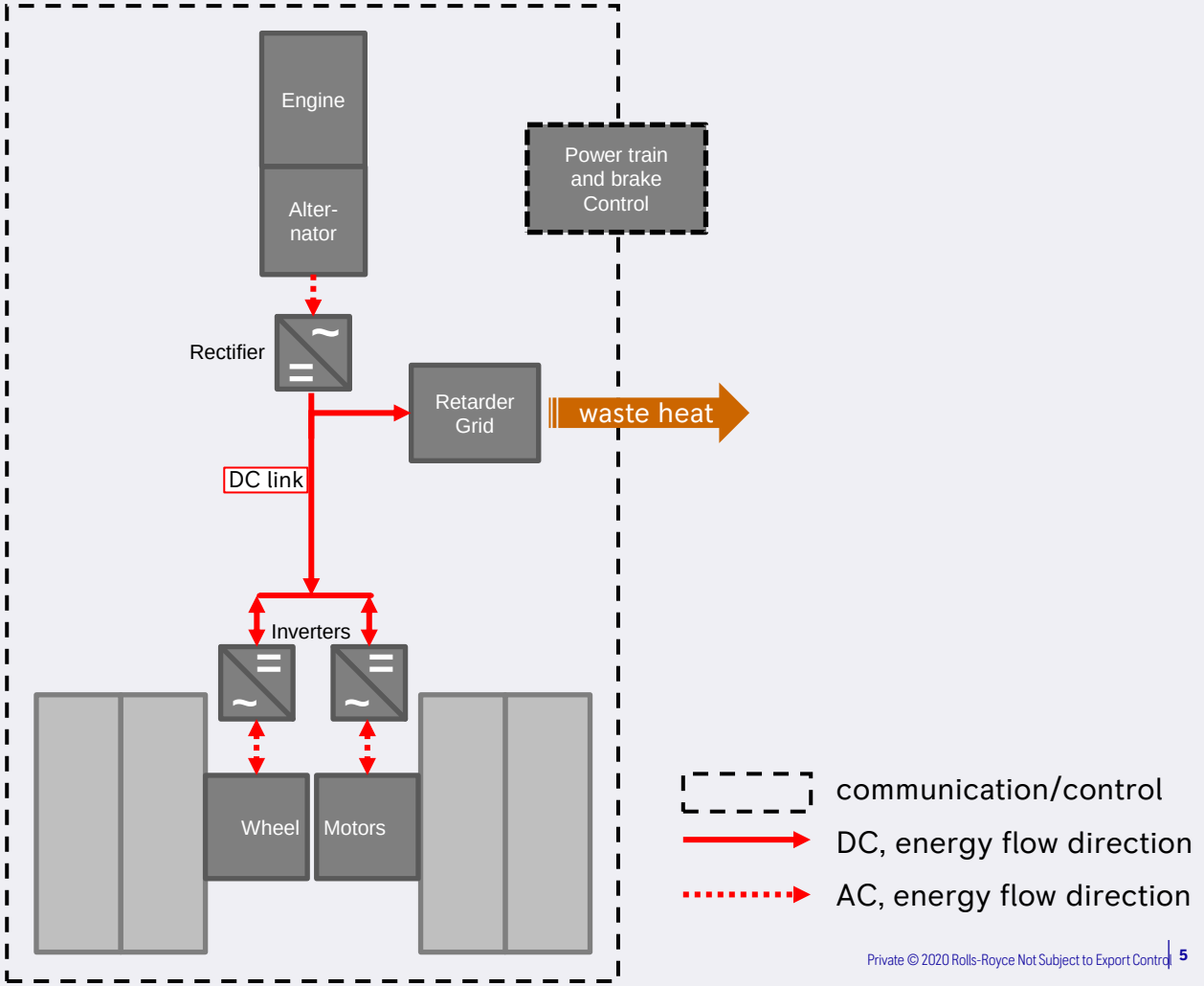


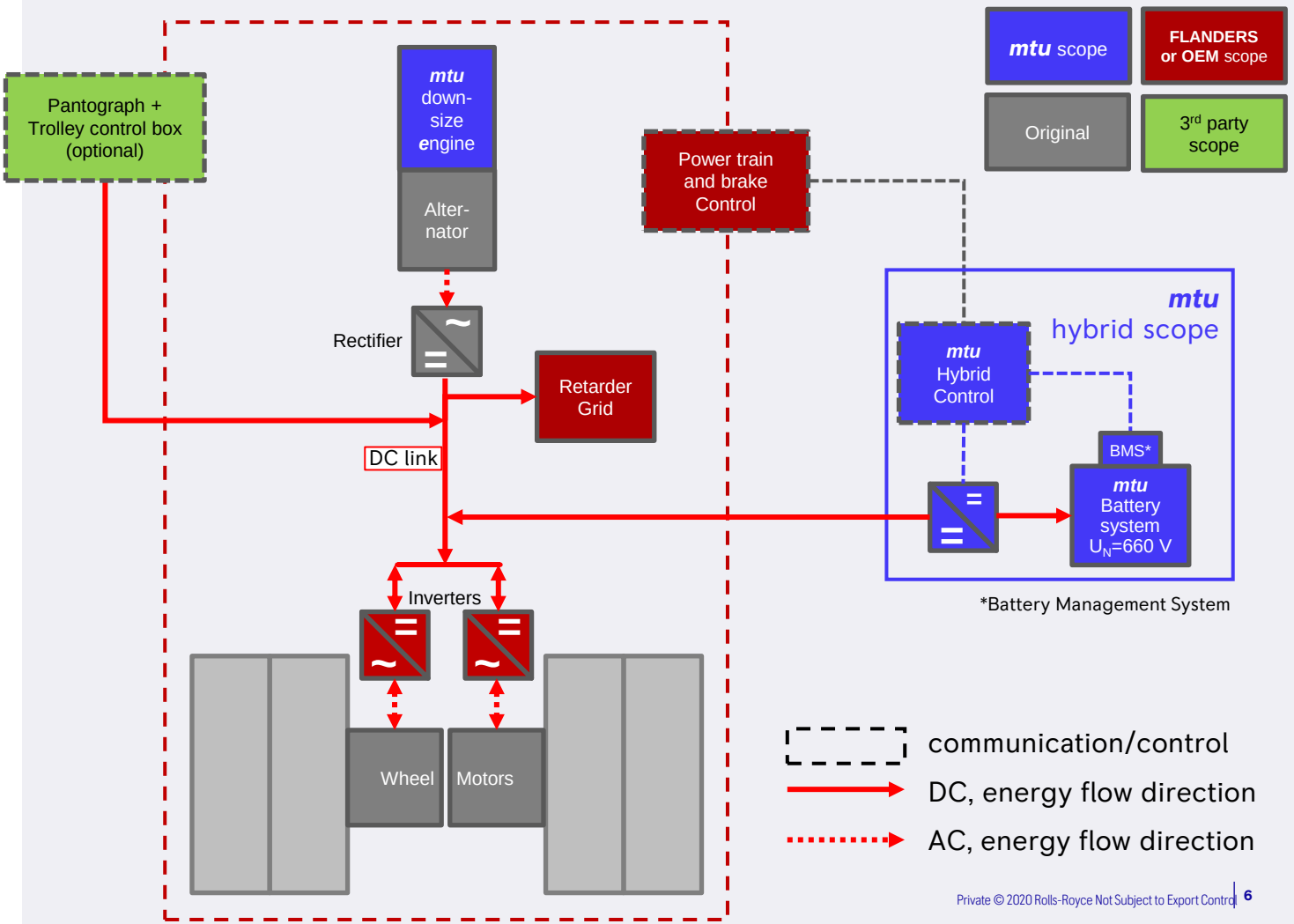
System Overview
Hybrid drive

mtu Hybrid System integrates as a subsystem into truck architecture

FLANDERS Inc.: power electronics and controls for retrofits.

Braking energy is stored and reused.

Powertrain controller and ***mtu*** Hybrid Controller continuously communicate dynamic power demand.



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mtu EnergyPack

In series production for ***mtu*** rail hybrid

SIL2 → certified for rail passenger transportation

Lithium-ion technology

Liquid cooled/heated

30,6 kWh capacity

75 kW cont. power

666 V nominal voltage

Approx. 370 kg

Approx. dimensions:
1600mm x 750mm x 220mm

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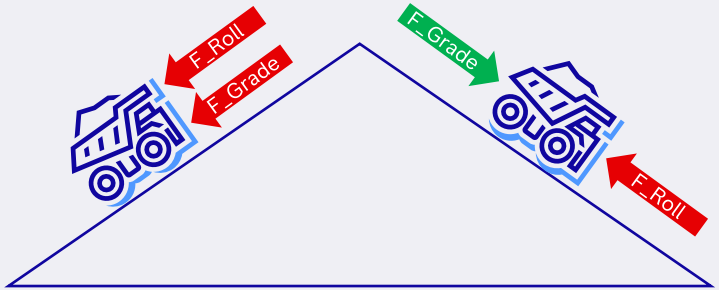
03

CO_2 Saving Potential

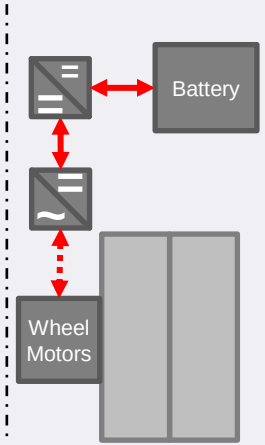
Recuperation Potential

- Downhill force = gross recuperation potential
- Rolling resistance reduces potential
- Energy flow from wheel to storage and back: losses due to component efficiencies

At wheel:
tractive efforts vs. gains



Wheel-to-storage-to-wheel:
component efficiencies



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Performance

Parameters:

Speed limit: 40 km/h

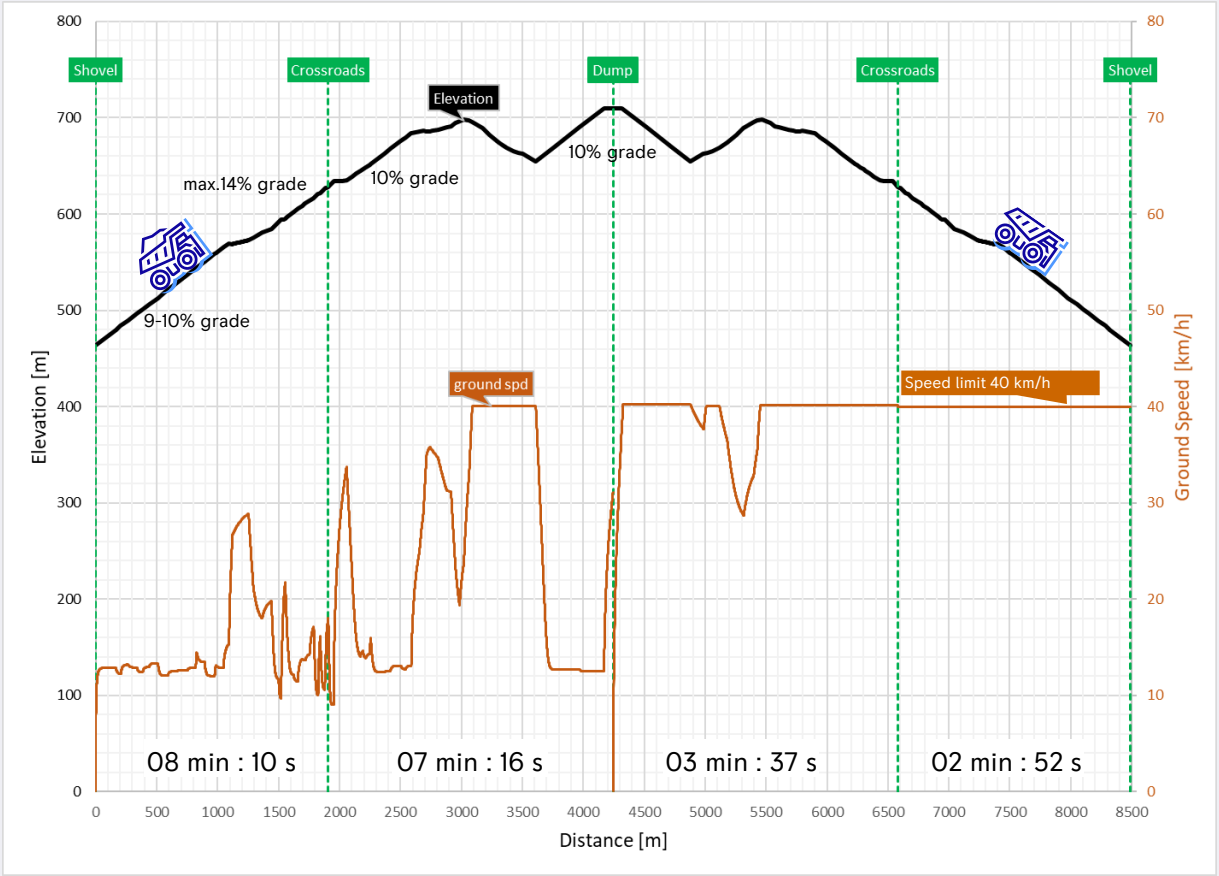
Reference:

- Engine gross (SAE J1995): 1865 kW
- Flywheel (SAE J1349): 1761 kW
- Wheel power: 1574 kW (powertrain efficiency incl. parasitics: 84%)

→ Hybrid truck performance was set to be identical to original truck

Round trip:

- 2x 4250 m
- 22 min (w/o queuing, loading, dumping)



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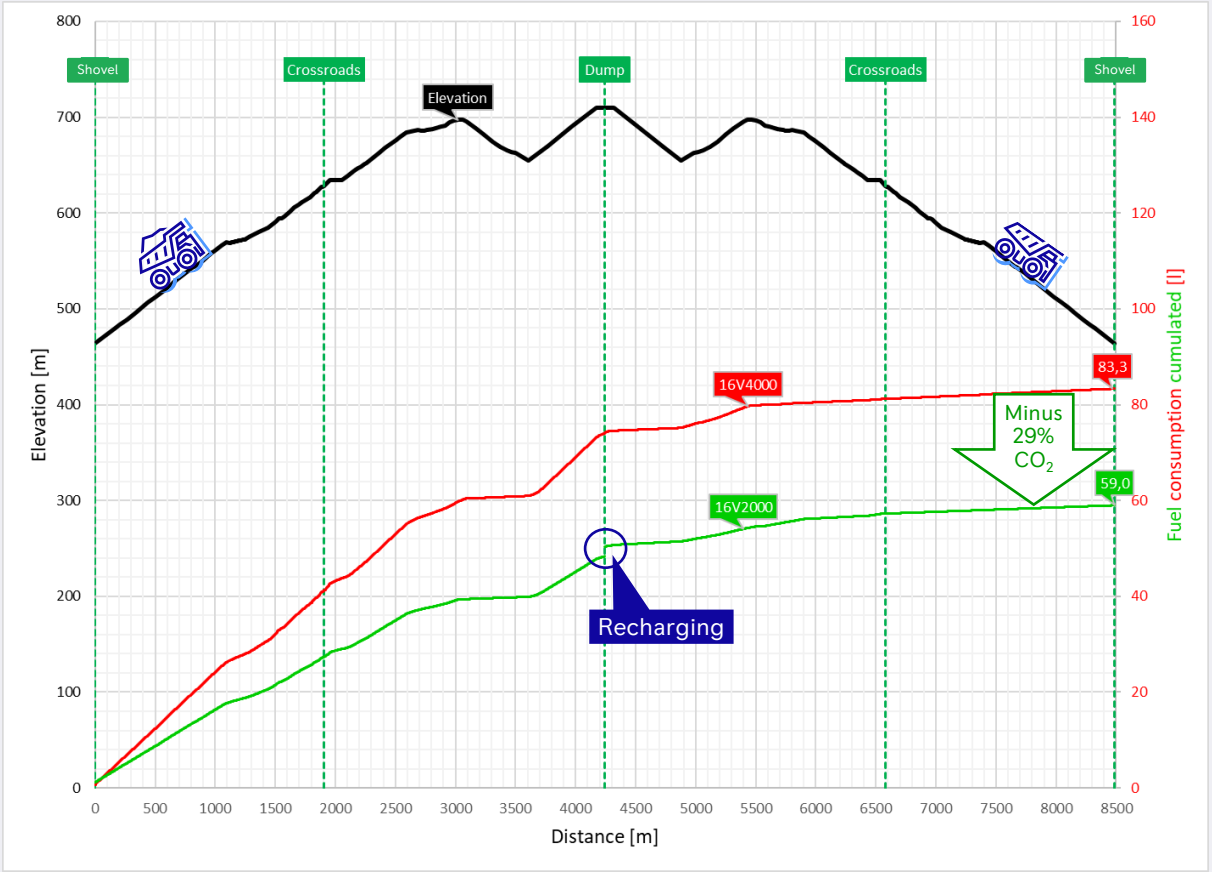
Fuel consumption Haul Cycle

Conventional:
16 V 4000, 1865 kW

Hybrid:
16 V 2000, 1163 kW
+ battery 1500 kW

Recharging event is visible as offset in fuel consumption (circled)



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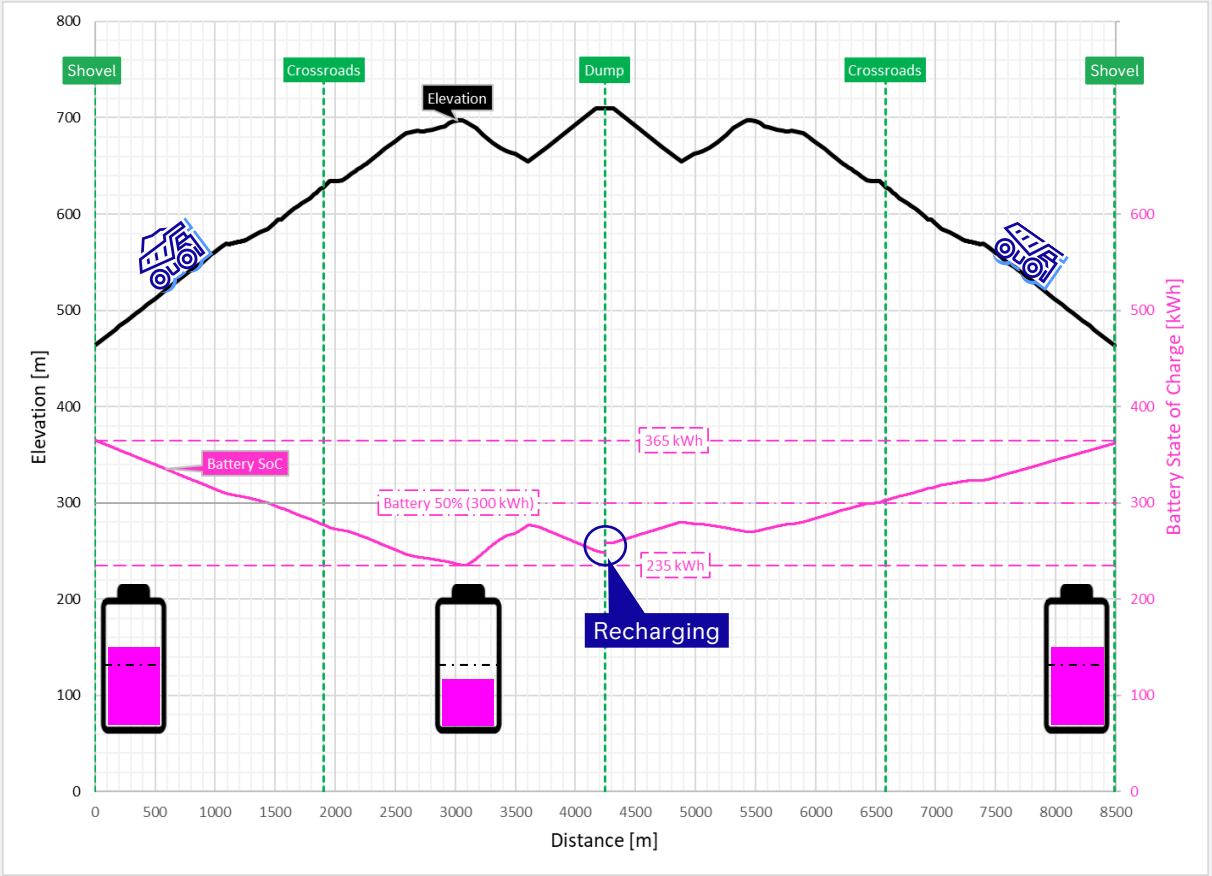
Battery state of charge (SoC)

SoC lift is ca. 130 kWh, i.e. 22% of total capacity → good for battery service life

Symmetric fluctuation around 50% SoC

Recharging event, 11 kWh during dumping is visible as offset (circled)



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04 Packaging, Truck Integration

Engine
Downsizing

mtu 16V 2000 S96

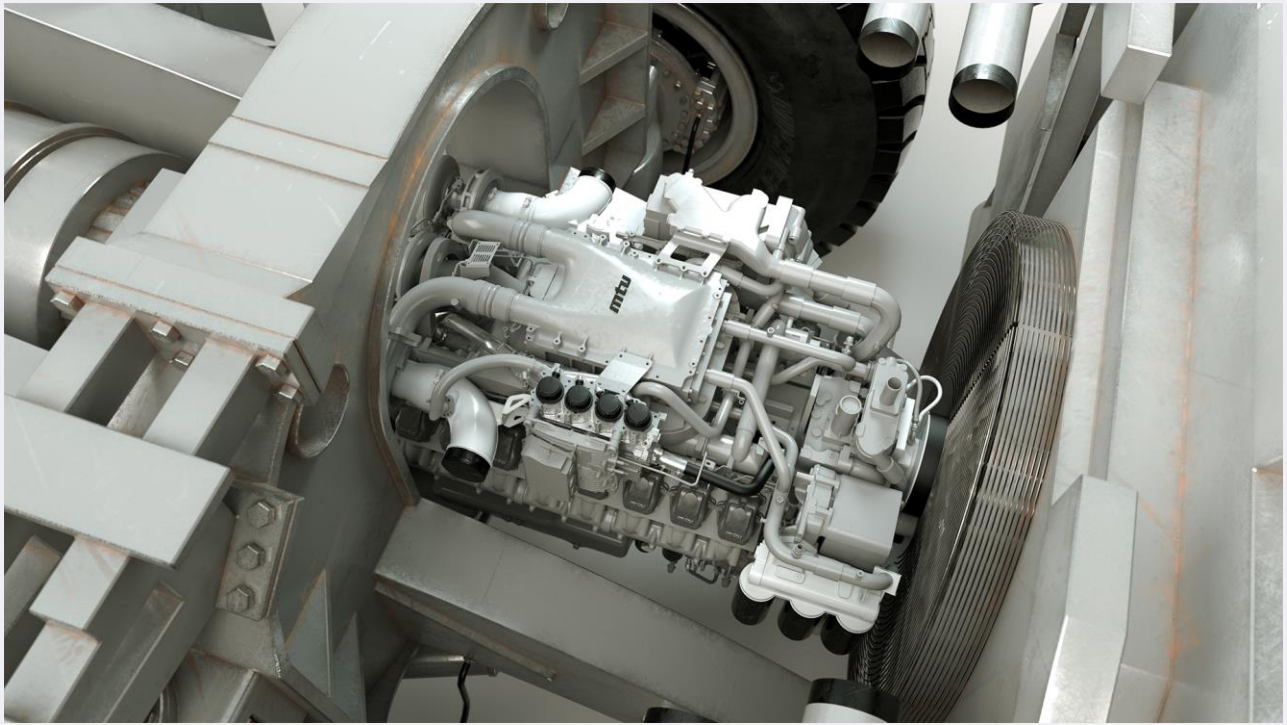
3.600 kg vs. 9.500 kg

36 l vs. 60 l

1163 kW vs. 1865 kW
(1560 hp vs. 2500 hp)

Tier4i vs. Tier2

Fuel efficiency optimized
operation strategy



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Deck platform
Retrofit example

FLANDERS:

Retarder grid

Inverter cabinet

mtu:

DC/DC converters,
Hybrid controller,
Integrated in inverter cabinet

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Weight Estimate*

20x EnergyPacks

10x DC/DC converters

Downsized engine

Reduced tank size

*depending from truck type and individual battery sizing

Tank: -2.000 kg

EnergyPacks: +7.400 kg

Engine: -6.000 kg

DC/DC: +2.000 kg

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Tank*

20x EnergyPacks replace original Diesel tank

*Downsized Diesel tank can be moved to opposite side (one of many options, to be agreed with customer)

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Flexibility

For OEM or retrofit

Modules:

- Battery system
- DC/DC converter
- Hybrid controller

Scalable for any use case:

- Battery power and capacity: adjusted by number of ***mtu*** EnergyPacks
- ***mtu*** engine power range: 567 kW (760 bhp) to 3000 kW (4023 bhp)

Compatible with any power source:

- Diesel engine
- Gas engine
- Hydrogen engine
- Trolley

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Thank you very much for your attention.

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For more information scan this QR Code and send me a LinkedIn message.

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