Grid-eMotion

Energy & Digital World (EDW) 2024 – Knowledge Session 2.3.2, 13:30-14:30

Alexander McCraw – Sales & Tender Manager eMobility

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Introduction to eMobility

Electrification of Heavy-Duty Trucks and Buses

Why are trucks and buses important?

CO2 emissions from heavy-duty vehicles have been increasing rapidly since 2000. Heavy-duty vehicles accounts for >80% of the growth.

Today road transports accounts for **25%** of the total green house gas emissions in Europe, where **27%** comes from buses and heavy-duty trucks.

Where do we need to go?

Net-zero emissions from the transport sector by 2030.

Countries need to adopt, invest, strengthen and harmonize heavy-duty vehicle fuel economy standards and zero-emission vehicle mandates.

What are the challenges?

Strong and reliable grid connections and additional power supply, and potentially increased power peaks.

Electrification and additional electricity supply may necessitate extensive upgrades to grid infrastructure.

Improved battery technology to cope with the greater weight and range of trucks.

The costs and lead times of the developments mentioned above have the potential to hamper progress.

Destatics (2023): Road transport: EU-wide carbon dioxide emissions since 1990 - German Federal Statistical Office (destatis.de)
EEA (2023): Transport and mobility (europa.eu)

Sustainability and Efficiency

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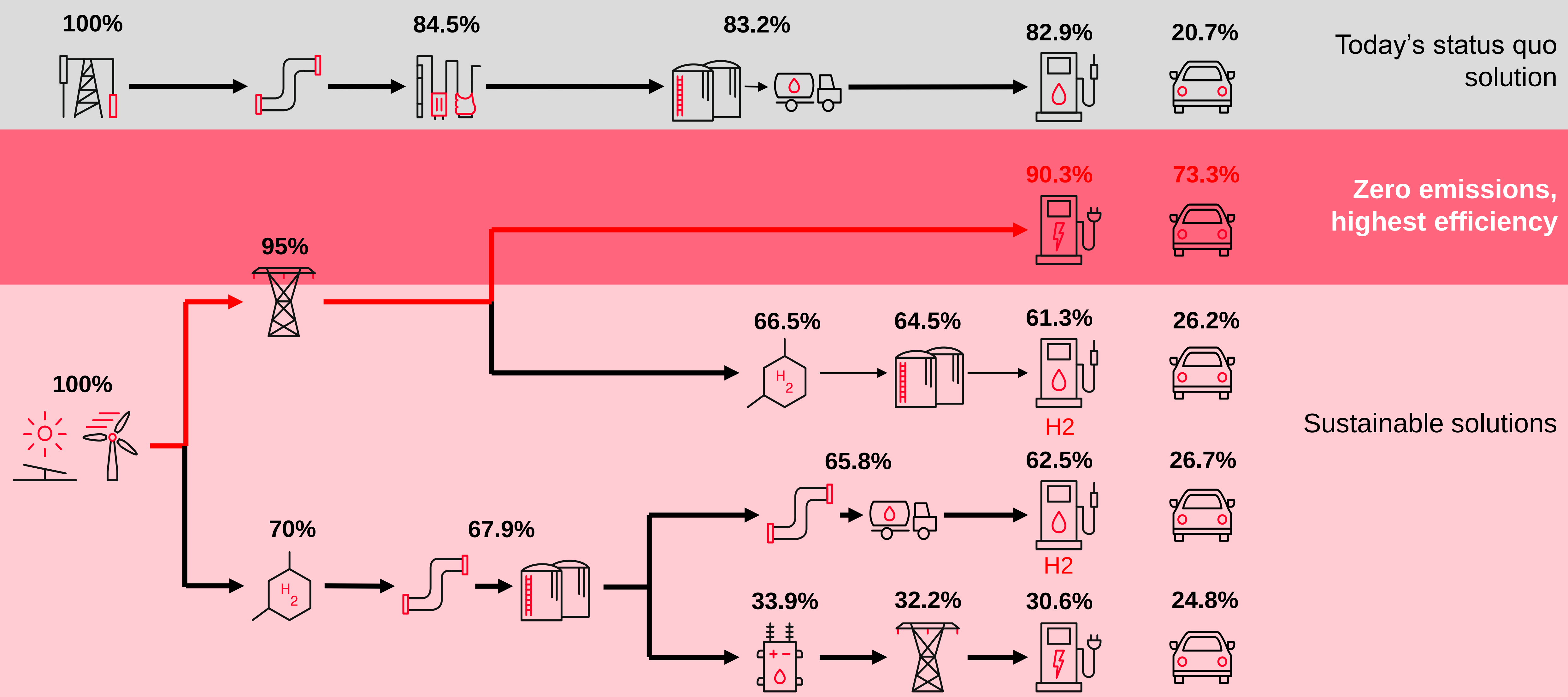

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Grid-eMotion® Fleet

Grid-eMotion® Fleet – Basic Operating Principle

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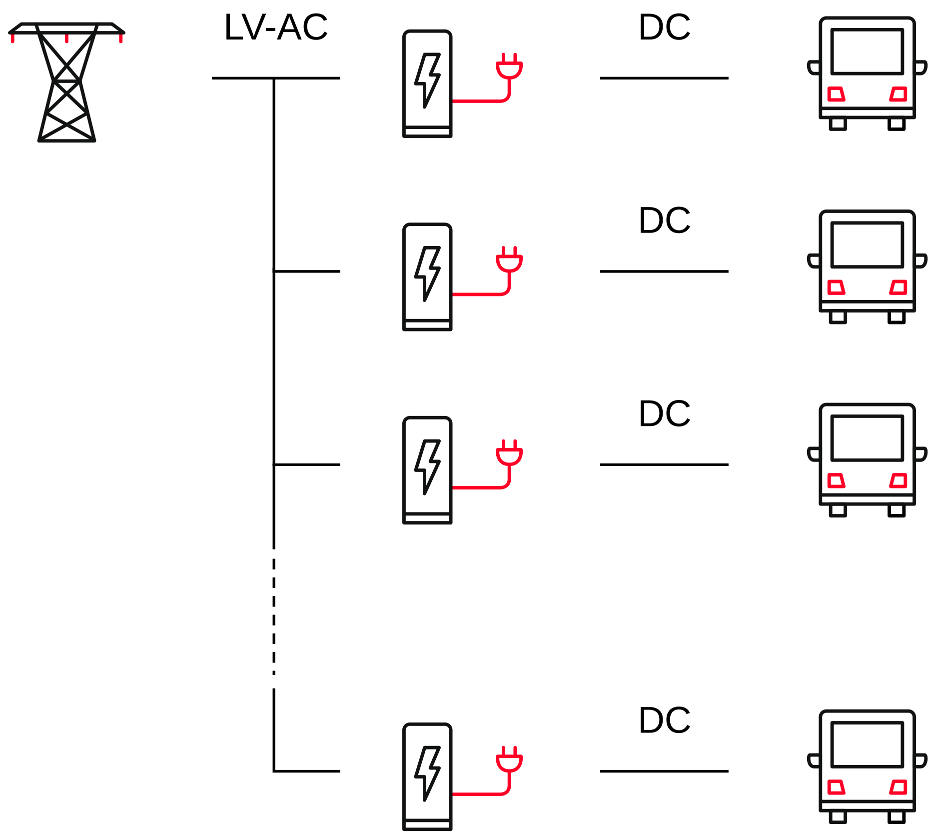
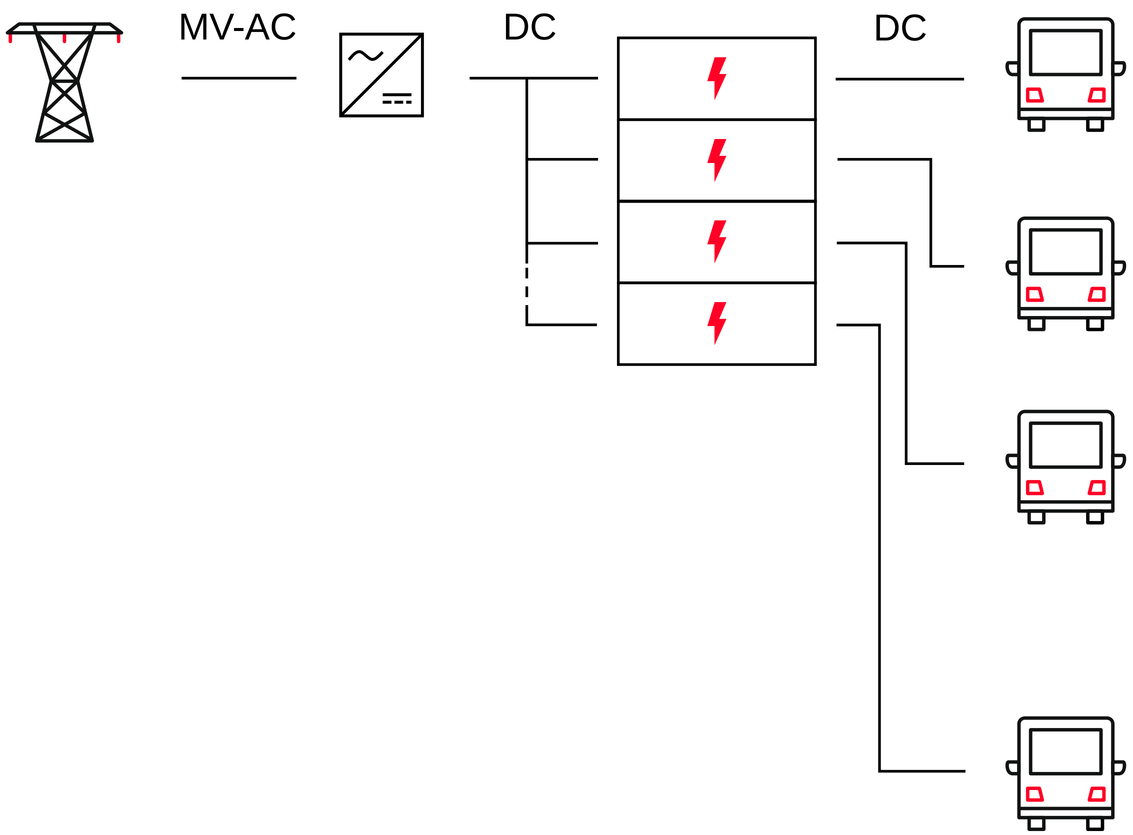
AC



DC



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Modular Solution – High Reliability

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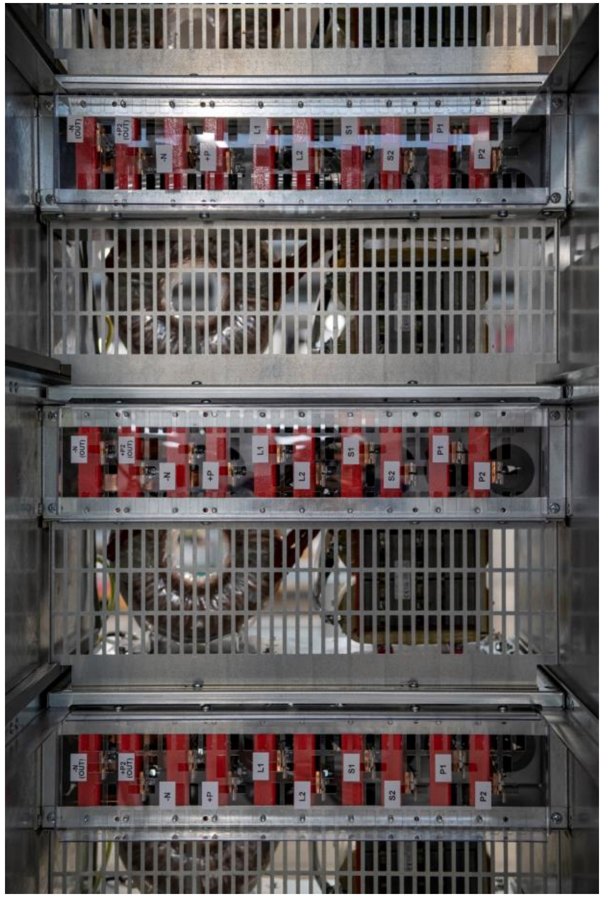
Charging modules can easily be racked in and out

Front side of modules with handle and rails

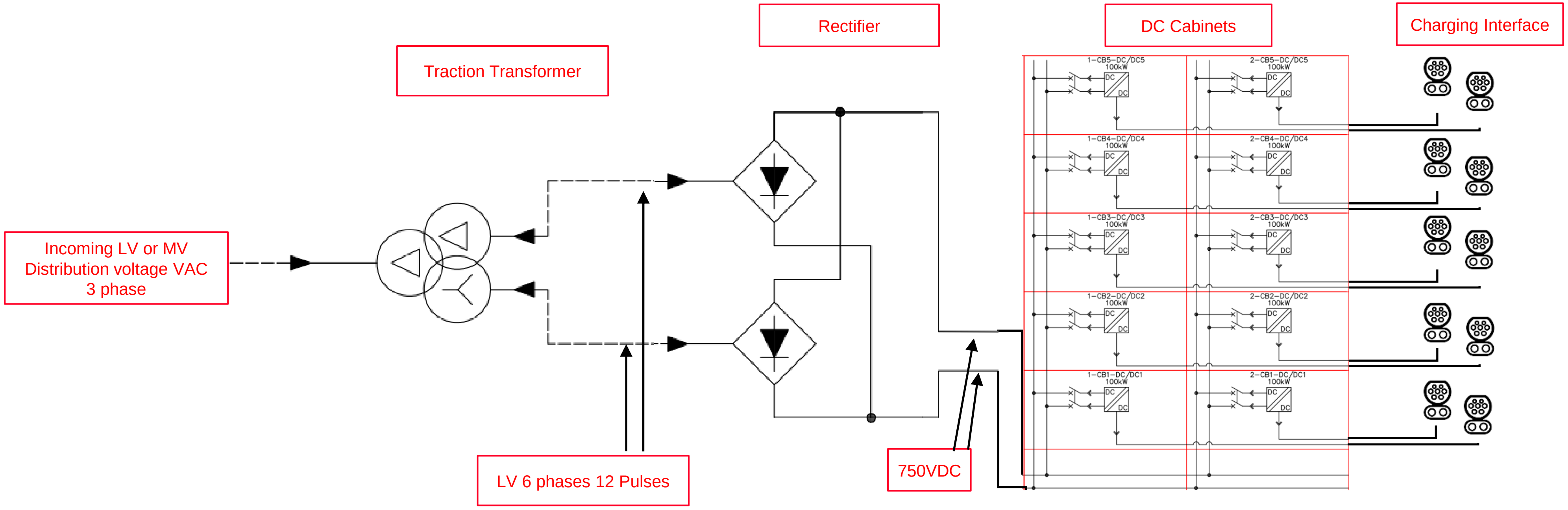


Fixed back panel with contacts

Main power unit of the rectifier is also rackable

Movable rig for easy replacement of diodes

Centralized Rectification



Grid-eMotion® Fleet Indoor Product Line-up

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Converter transformer

Converter transformer

Type	Dry Type
Application	12 pulses
Power	1.2 MVA to 2.3 MVA
Primary voltage	$400V_{AC}$ to 42kV
Primary taps	+/-2 x 2.5%
Secondary voltage	2 x 530 V_{AC}
Frequency	50 +/-1% Hz
Number of phases	3
Vector group	Dy11d0
Cooling	AN
Duty cycle	100% continously
Standards	IEC 60076-11 EN 50329

Rectifier

Rectifier

Type	Diode/Thyristor
Configuration	12 pulse
Power	1 MW to 2 MW
Input	530 V_{AC}
Output	750 V_{DC}
Max Perm Voltage	900 V_{DC}
Insulation Voltage	2500 V_{DC}
Overvoltage Category	OV3
Standards	IEC 60146 EN 50163

DC cabinets

DC Cabinets

Rated Power	10 outputs of 100 kW 5 outputs of 200 kW
Rated Input Voltage	750 V_{DC}
Input Voltage Range	600 ÷ 750 V_{DC}
Rated Output Voltage	650 V_{DC}
Output Voltage Range	150 ÷ 1000 V_{DC}
Cooling	AF
Overvoltage Category	OV3
Standards	IEC 61851-23 IEC 61851-23-1

Double-plug CCS2 boxes

CCS2 wall boxes

Type	CCS2
Plugs	Two
Rated Current	125 A, 250 A
Voltage Range	150 ÷ 1000 V_{DC}
Base dimensions	300x300 mm
Height	1620 mm
Standards	IEC 61851-23
Accessories	Status indicators Push buttons Hook for cable management
Optional	RFID for user authentication

Dublin, Ireland

Grid-eMotion® Flash

Operating Your eBus Fleet with Flash Charging

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Range is not the constraint but time

Buses present a particular challenge as operators want the vehicles on the road transporting passengers, rather than transporting batteries or waiting at charging stations.

The energy will have to be taken on somewhere, the question is where is the most economically efficient place to do so?

Timetable

High-power in-route charging at selected bus stops and short layover time at terminal provide same driving hours and commercial speed as a diesel fleet

High-passenger capacity (up to 4,000 passengers/h)

Smaller battery and having all technology mounted on the roof means more space and weight available free to carry passengers.

Long-life battery

Due to in-route charging principle, the high-power/low-energy battery pack is used in its optimal operating range

Grid compatible

Connection fee and energy cost minimized through embedded peak shaving functionality

Light infrastructure at depot

Either free parking after fast (4-5 min) high-power charging upon arrival or low-power (50 kW) mutualized charging

Grid-eMotion® Flash: A New Electric Bus

Intelligent energy management

The design of electric buses must be carried out according to operation and not according to technology

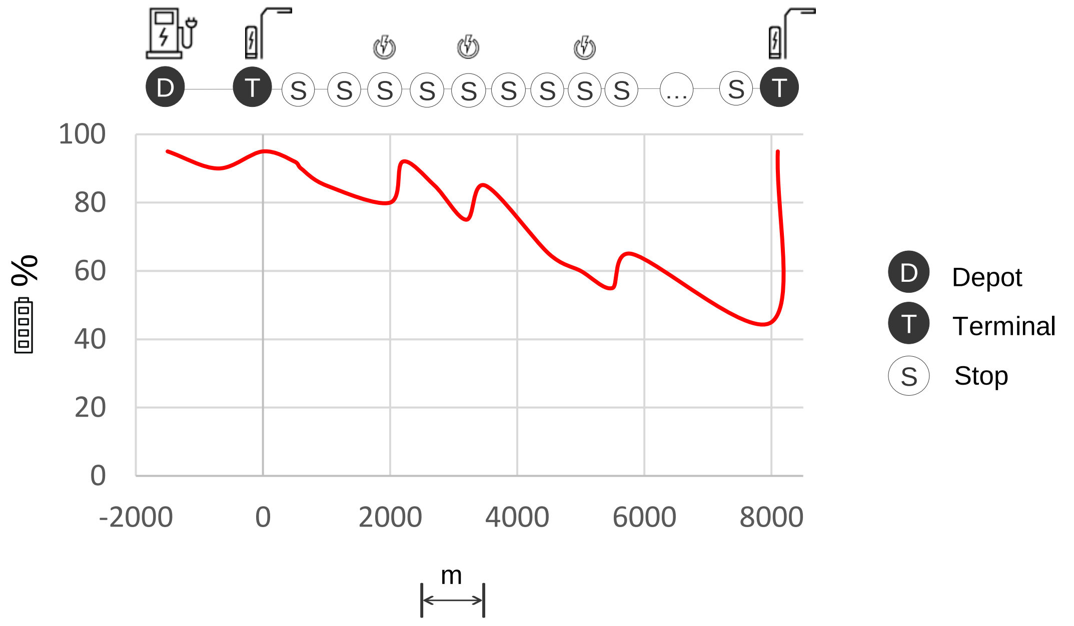
01 Flash charge to reduce charging time at terminals (compliance with the timetable) and not for reasons of autonomy

02 Flash charge while passengers embark/disembark (quick connection/disconnect < 1s)

03 Flash Charge to save Buses (TCO) and parking spaces at terminals/depots

04 Longevity of the on-board battery

High energy efficiency and competitive TCO



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Flash Charging Using the Drivetrain to Charge the eBus

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How the system works ?

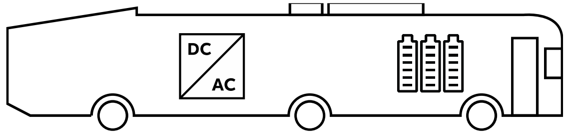
The flash-charging concept uses a stabilised voltage source to provide a simpler interface to the vehicle

The drivetrain automatically switches from delivering power to the wheels (DC/AC) to charging the batteries (DC/DC).

There is no need to wait while communication is established, the charging process starts right away.

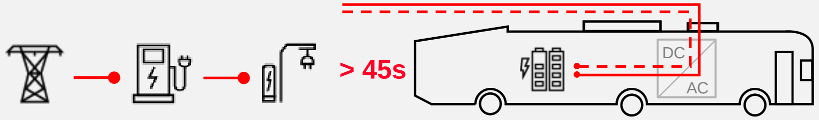
Concept for reducing the startup time

In motion



Grid-eMotion™ Fleet

With OppCharge



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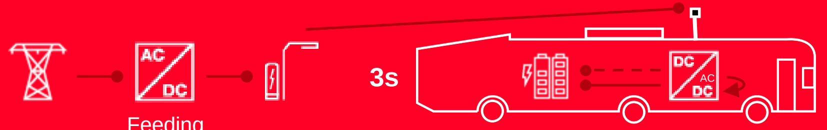
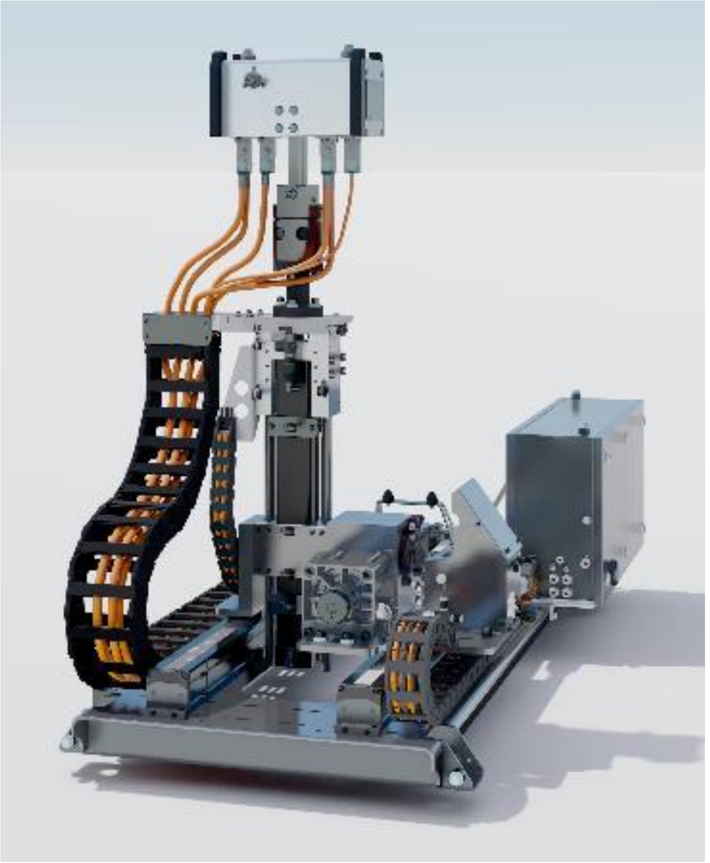
Traction inverters used as charger



Automated transfer system



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600 kW Infrastructure at depot

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No infrastructure in parking area

Charging on arrival or at departure only (600 kW)

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What did bus electrification teach us? How can we apply that for trucks?

Buses and trucks

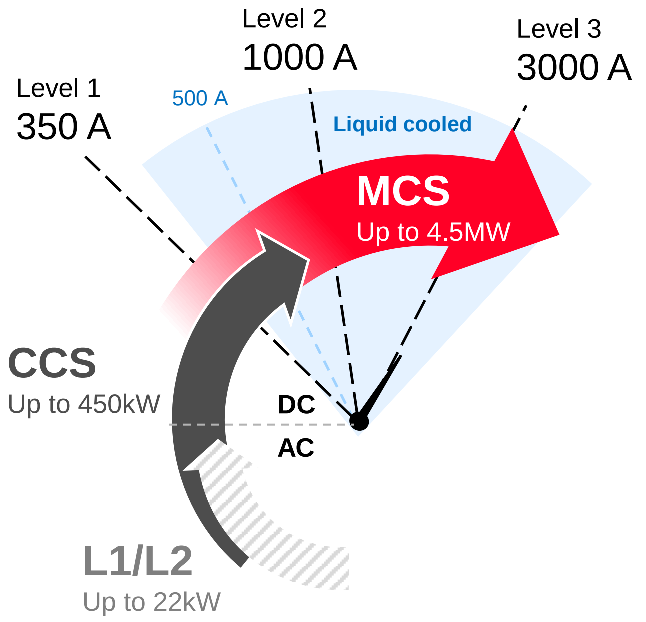
Buses	Trucks
Mostly follow the same use case, independent of operator and region.	Extreme variety in the use of trucks, e.g. drayage, logistics (first mile, middle mile, last mile), public services, construction, mining.
Typically the owner of the vehicles is the operator.	The owner is rarely the operator of the vehicle.
Vehicle typically rests at depot, route terminals and bus stops.	No typical rest location, many possibilities depending on use case.
Overnight (“slow”) charging usually around 75 kW	CCS plug is currently the only option in the market, with charging power limited to 500 A (~450 kW) with current standards.
Opportunity (“fast”) charging (~300-600kW), sometimes possible on route via pantograph.	No high-power charging solution yet available. Pantographs are not viable for this market as there is insufficient roof space on truck cabs.

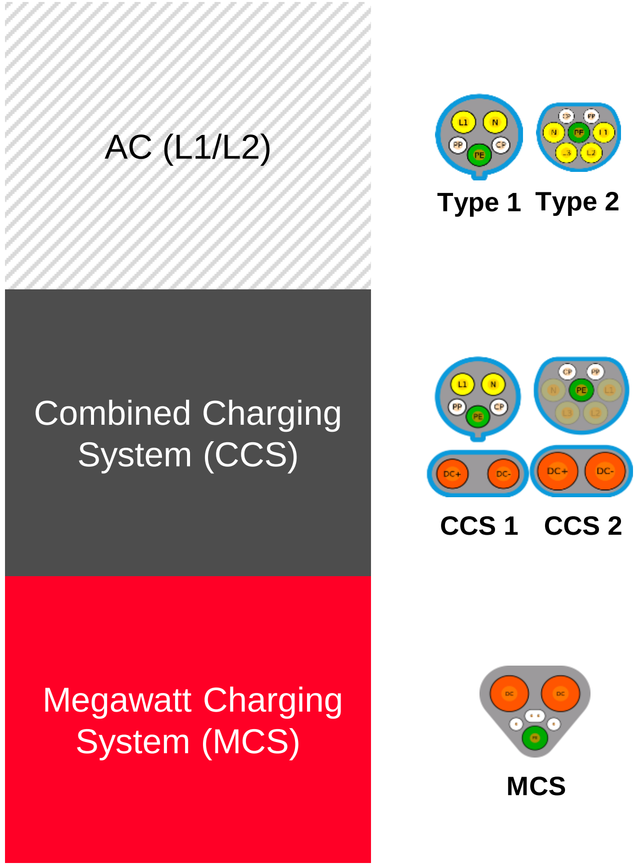
Established market —— New market

The missing link for trucks is still high-power charging

MCS promises to solve the missing link problem

- It will enable 45 min break charging which is the current window common between most long-haul operators
- Until then, electric truck operation will focus around areas where shorter range or longer charge periods are possible





Expected development path

1. MCS technology is still in the prototyping phase, with pilots expected around 2026-2029.
2. MCS will coexist with CCS until at least 2028
3. MCS adoption at scale is not expected until 2028,
4. Dedicated MCS-only charging parks are unlikely in the near term. The simultaneous use of 40 MCS chargers at peak power (a factor of 40) is improbable. Thus, significant CAPEX investments in a 40 MVA grid connection today are progressing slowly. Smart charging will absolutely play a role to manage charging peaks.

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