A Systems View of Fuel Cell Electric Powertrains for Buses, Trucks and Trains

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Recent Projects

- Leading a consortium of rail businesses on train project
- Whole vehicle responsibility for RCV
- Public-private partnership deployment projects

REFUSE COLLECTION VEHICLE

Vehicle development, engineering and certification for sale

BUS

Powerpack development and integration for product development and demonstration

TRAIN

Contract engineering for market development and demonstration

Systems Engineering and Full Lifecycle Approach

Powertrain as a system – not just a series of components

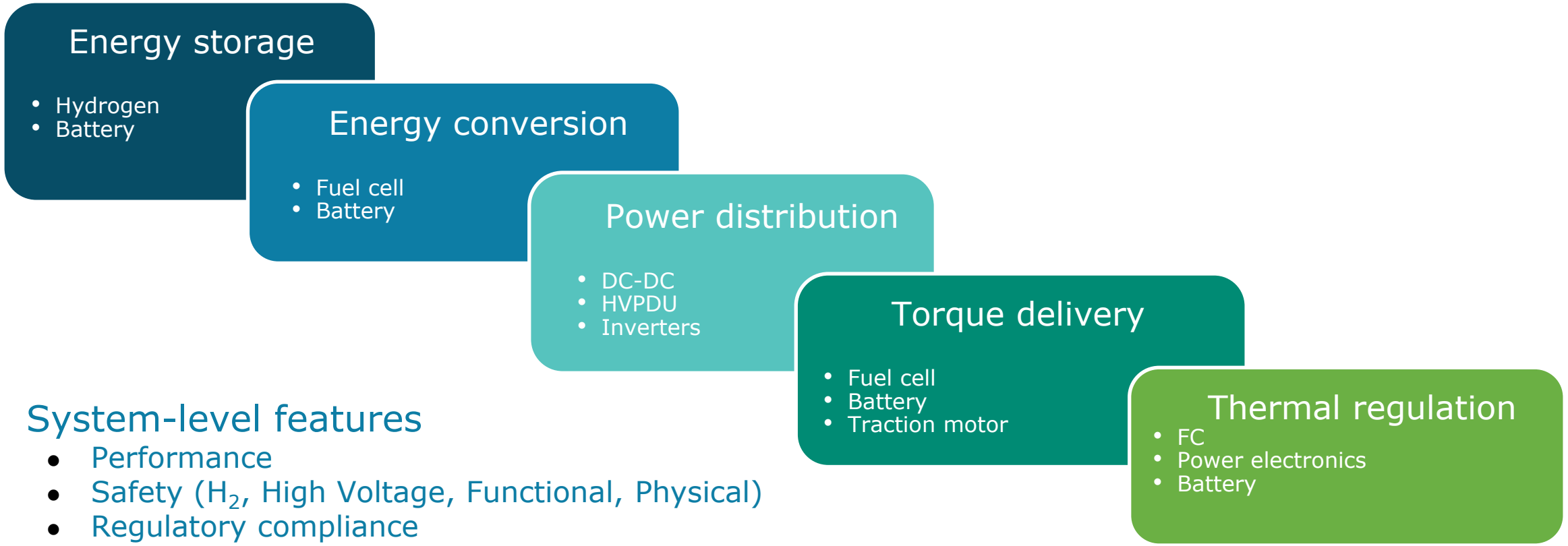
Integrated by A-Drive controller, unique BMS IP development over 12 years

System level optimisation for vehicle performance, efficiency, subsystem lifetime, cost

Powertrain-level testing, field data capture and analysis feedback to system design and optimisation

Simplify and enhance hydrogen powertrain to remove adoption barriers and accelerate our customers' vehicle developments

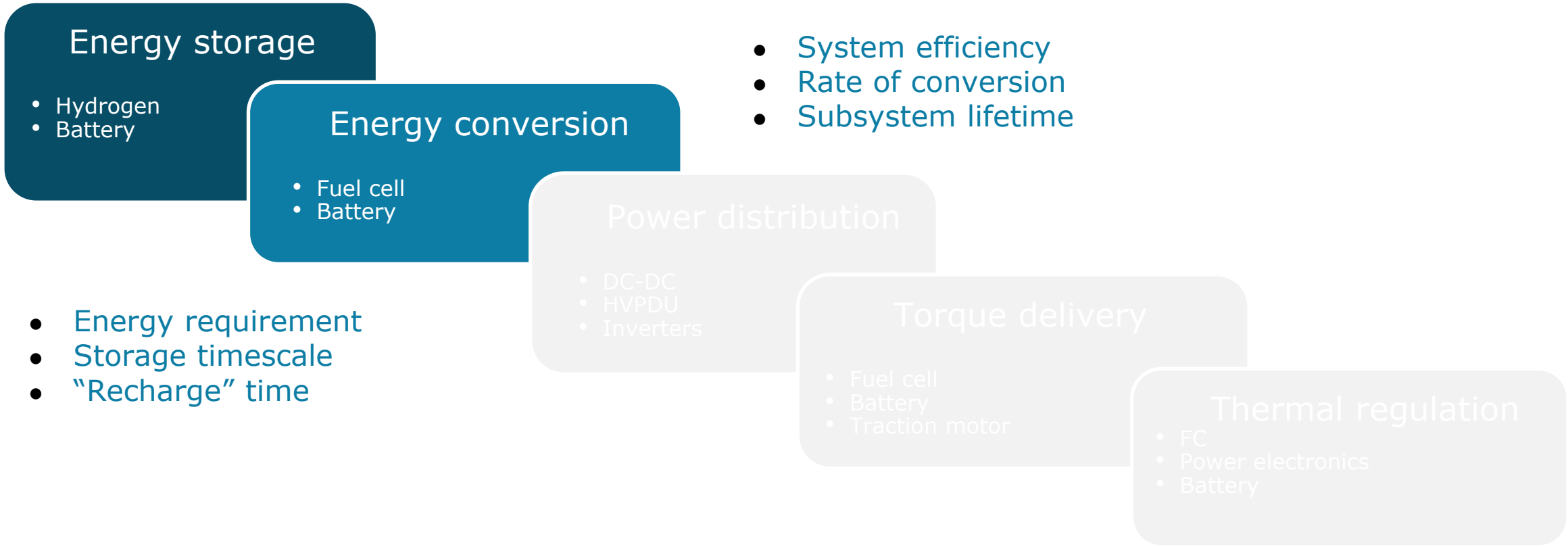
Powertrain as System – Functions and Features



System-level features

- Performance
- Safety (H_2, High Voltage, Functional, Physical)
- Regulatory compliance
- Subsystem lifetime
- Flexibility and modularity

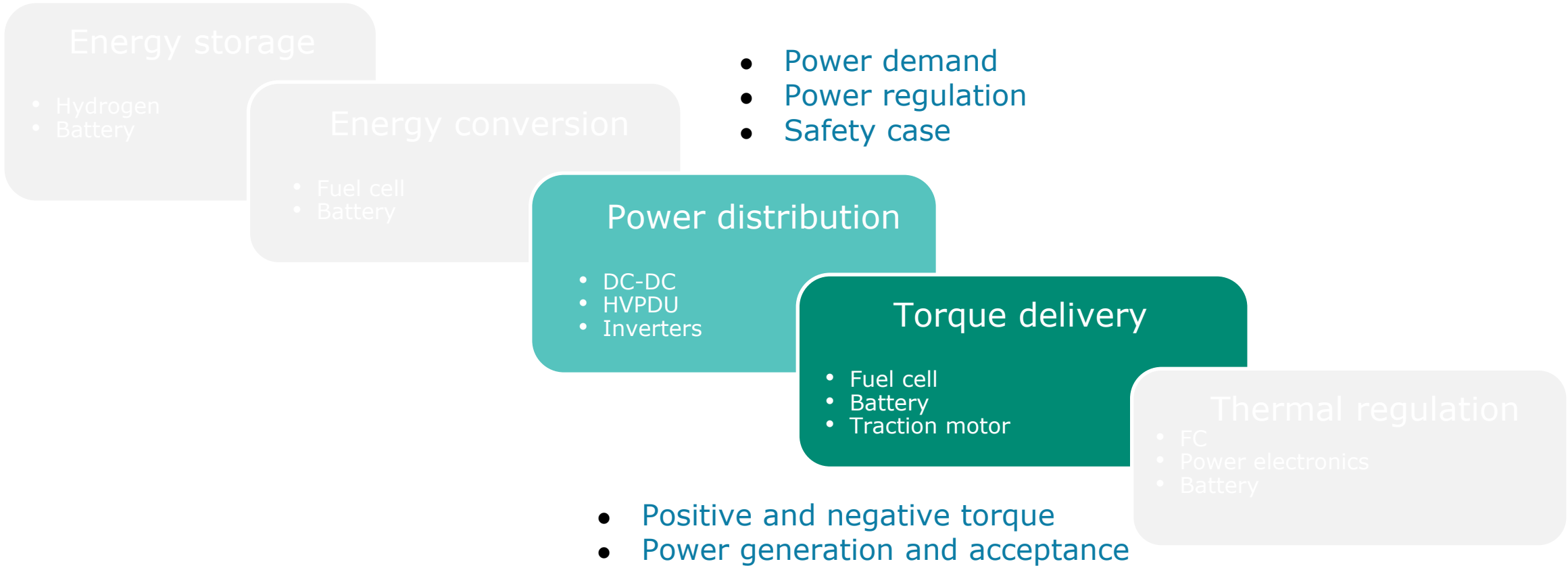
System-Level Energy Management



- Energy requirement
- Storage timescale
- "Recharge" time

- System efficiency
- Rate of conversion
- Subsystem lifetime

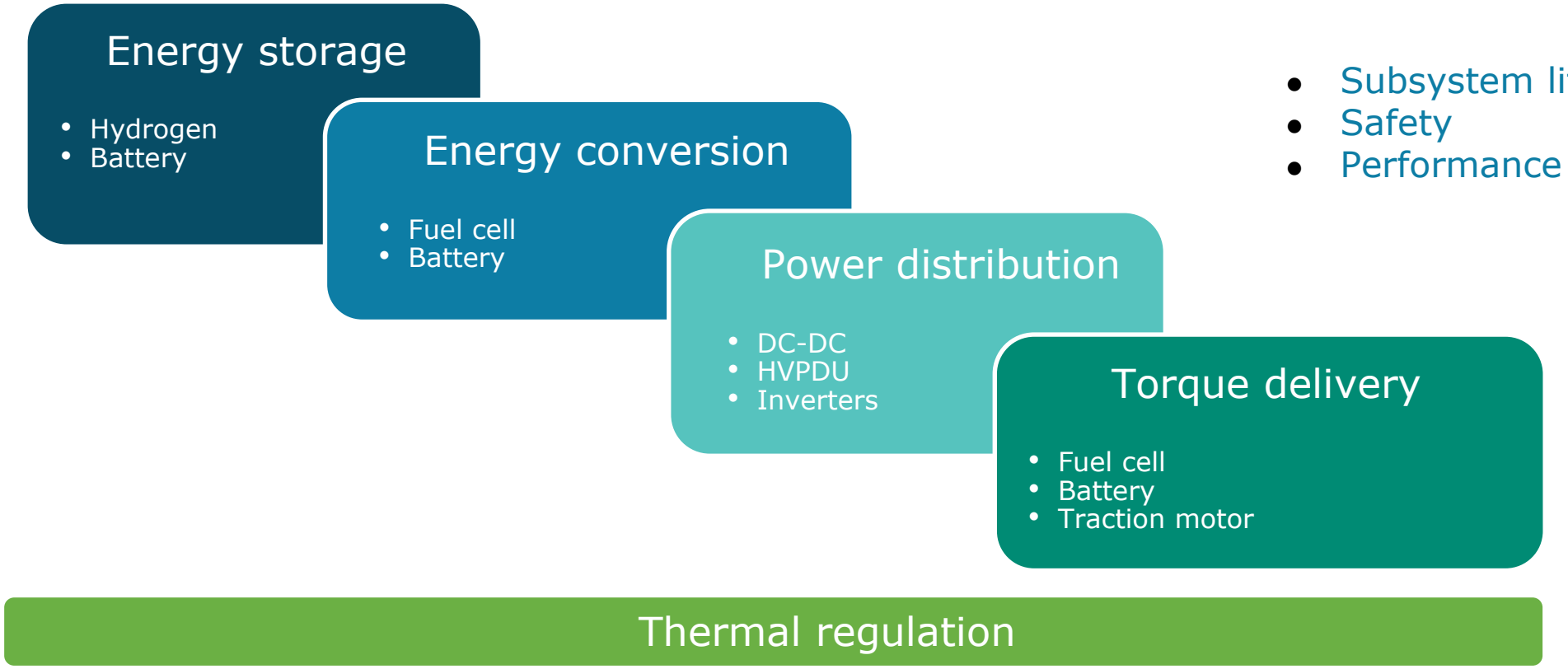
System-Level Power Management



- Power demand
- Power regulation
- Safety case

- Positive and negative torque
- Power generation and acceptance

Thermal Management is everything



- Subsystem lifetime
- Safety
- Performance

Features - Safety

Energy storage

- Hydrogen
- Battery

Energy conversion

- Fuel cell
- Battery

Power distribution

- DC-DC
- HVPDU
- Inverters

Torque delivery

- Fuel cell
- Battery
- Traction motor

Thermal regulation

- FC
- Power electronics
- Battery

- Hydrogen
- Battery
- High voltage
- Functional
- Physical

Features – Subsystem Lifetime

Energy storage
- Hydrogen
- Battery

Energy conversion
- Fuel cell
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Power distribution
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Thermal regulation
- FC
- Power electronics
- Battery

- ”Moving parts” fallacy
- Electrochemical systems
- Fuel cell operating mode
- Battery operating mode

BMS A-Drive Control System at the Heart of Our Technology Platform

- Unique BMS IP development over 12 years
- Provides high-level system functions – safety, energy, power and thermal management
- Validated and tested for regulatory compliance and functional safety

- Fully integrated with Ballard FCMove™ modules for optimised performance and lifetime
- Existing integration with other powertrain components – recommended DC/DCs and HV Batteries, BMS HVPDU and LVPDU
- Extensible to integration of other components as required

Here for life™

Thank you

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