

13th UIC Sustainability Conference



Onboard Traction Storage System for Rolling Stock



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CAF Power & Automation



CAF Power & Automation is
a company of the **CAF** group

CAF Power & Automation is a leading company in
the design and manufacture of solutions for the
Railway and eBus Market

We develop traction, control & communication and
Energy Storage Systems - ESS

By combining the **latest technology and the
highest reliability**, CAF Power & Automation has
become a world class reference within the railway
industry

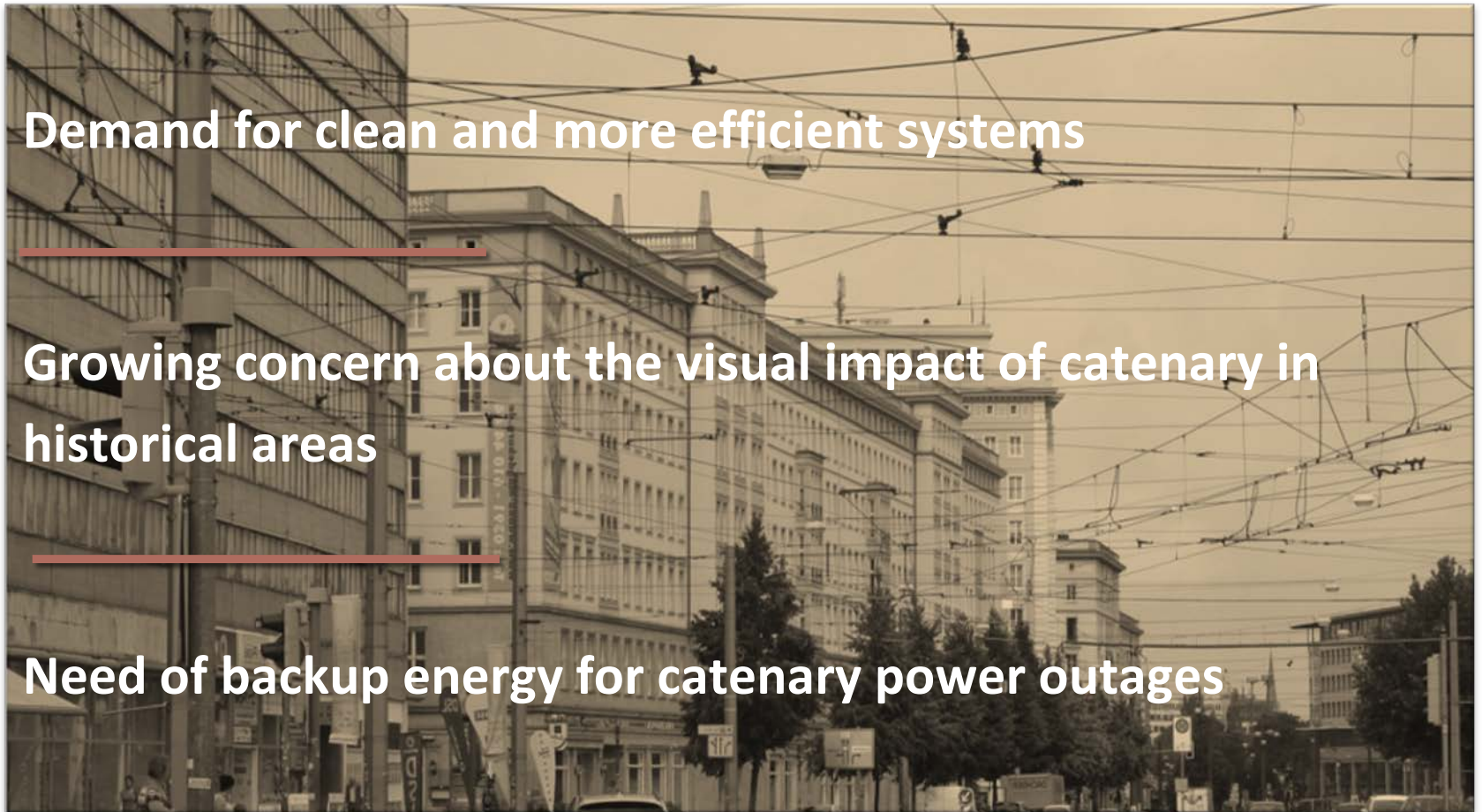


Context and main drivers

Demand for clean and more efficient systems

Growing concern about the visual impact of catenary in historical areas

Need of backup energy for catenary power outages



Technology Overview

More than 7 years of research to analyze, study, integrate and test different Energy Storage Systems

Integrate both technologies in the ESS **to cover different profiles:**
Li-Ion batteries and Ultracapacitors

	Energy density	Power	Life expectancy (approx. number of cycles)
Li-Ion Batteries	High	Medium	Medium
Ultracapacitors	Medium	High	High

Energy density

- Ultracapacitor: directly related to running range
- Li-Ion battery: very high energy density

Power

- Ultracapacitor: allows to charge at very high current. Ultra-rapid charging process: 20 sec.
- Li-Ion battery: medium charging power, needs few minutes

Lifetime

- Ultracapacitor: very high cyclability
- Li-Ion battery: high cyclability



Product family



CATENARY- FREE
+
ENERGY RECOVERY
+
BACKUP



ENERGY RECOVERY
+
BACKUP



Energy Storage System

MODULAR and CONFIGURABLE on-board Energy Storage System

- ✓ **Allows vehicles to operate in catenary-free operation mode + energy recovery + backup**
- ✓ **Up to 10km catenary-free range with batteries**
- ✓ **Ultra-fast charging process (<20 seconds)**
- ✓ **It reduces visual pollution and investment in infrastructures.**
- ✓ **Modular configuration to optimize TCO (Total Cost of Ownership)**
- ✓ **Non-captive product, open solution for other vehicles**
- ✓ **Plug-in equipment, independent from traction converter and easy to extend**



HYBRID ESS

Ultracapacitors and Lithium-Ion batteries

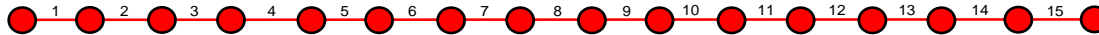


Energy Storage System

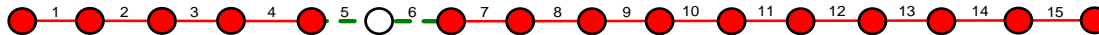
MODULAR and CONFIGURABLE

Examples:

Evodrive



Low-Freedrive



Medium-Freedrive



High-Freedrive



----- Catenary free section
 ----- Catenary section
 ○ Station non-energized
 ● Station energized

Ultracaps

Batteries



ESS integration – inside view

PRODUCT INTEGRATION

ESS (Energy Storage System): DC-DC and ESU integrated

- Full control of the integration chain
- Hybrid solutions allowed thanks to dual DC-DC converter
- Advanced energy management

ESU (Energy Storage Unit)

- Optimize power/energy density
- Modular concept
- Air cooled and water cooled

Power and Energy storage module

- Avoid single supplier and standardization
- Obsolescence control and overhaul supported

Control and protection boards

- UCMB (UltraCapacitor Management Board)
- BMS (Battery Management System)

All the cells are monitored continuously

Energy storage cells

- Continuous liability and cycling tests of cells in our laboratories and in the field for component homologation and life cycle validation
- Only reputed and solid providers homologated



ESS standards

Complies the state of the art of the standards:

CELL LEVEL

Safety Standard for Lithium batteries

Safety of primary and secondary lithium cells and batteries during transport

Onboard Lithium Ion traction batteries

Standard for Capacitors

Capacitors for power electronics, Electric Double-Layer capacitors.

UL1652

IEC 62281

IEC 62928

UL810

IEC 61881-3

Standard not published yet

ESS LEVEL

Fire and Smoke

Shock and vibration

IP protection

Power Supply with Onboard Energy Storage Systems, Series hybrid systems

Acoustic noise test

Electromagnetic Compatibility

Railway applications- electronic used on rolling stock

Combined testing of inverter-fed alternating current motors and their control system

Power converters installed on board rolling stock

EN 45545

IEC 61373

IEC 60529

IEC 62864-1

IEC 60076-10

EN 50121-2

EN 50155

IEC 61377-1

IEC 61287-1

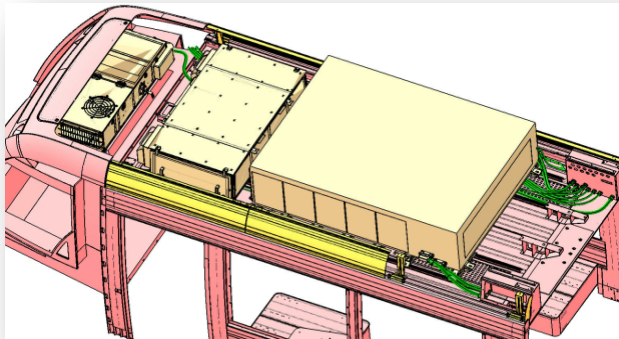
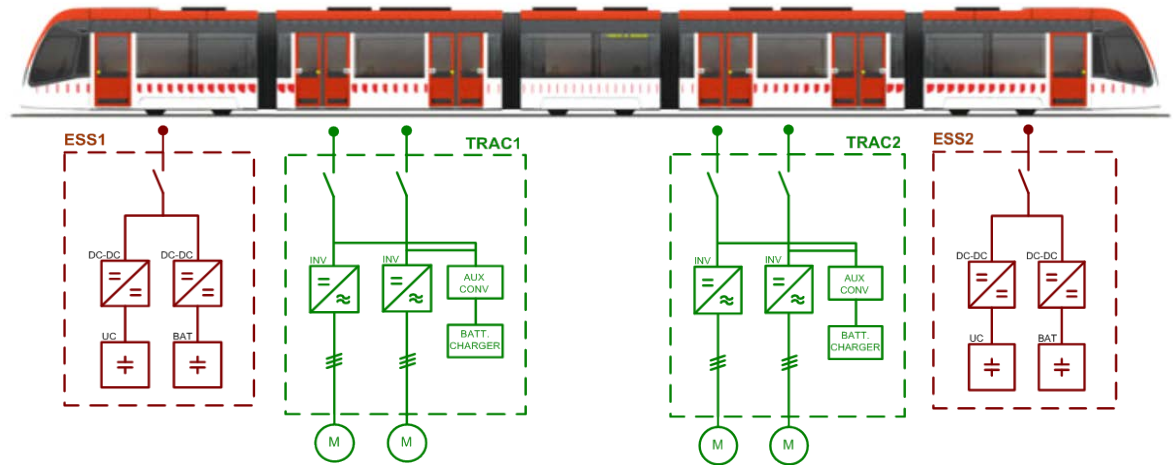
Standard not published yet



ESS integration- vehicle

The vehicle is designed for conventional service and the **ESS system can be installed later as “plug-in”**.

A vehicle equipped with an ESS system **operates as a conventional tramway** if the ESS system is cut off.



ESS integration- charging point

- ✓ Power supply:
 - Third rail and shoes located in the bogies
 - Short rigid catenary installed at the stops
- ✓ Minimum visual impact and safe solution.
 - Third rail is powered only when the vehicle is over the rail
 - The rigid catenary can be permanently energised or only when the tram is in the station
 - Automatic charging sequence, no operation by the driver
- ✓ Simple and low cost solution
- ✓ Easy installation and maintenance



Service proven from 2010!



European projects - OSIRIS/MERLIN



FP7 Project coordinated by UNIFE



Merlin: Sustainable and intelligent
Management of Energy for smarter Railway
systems in Europe: an Integrated optimisation
approach



Market leaders in Rolling Stock ESSs



750 VDC – SEVILLA

- 5 tramways
- Number of ESS: 10
- In service since : 2010



750 VDC – ZARAGOZA

- 21 tramways
- Number of ESS: 26
- In service since 2010



750 VDC – GRANADA

- 1 tramways
- Number of ESS: 26
- Service in 2016



750 VDC – TALLINN

- 21 tramways
- Number of ESS: 21
- Service in 2015



750 VDC – CUIABA

- 42 tramways
- Number of ESS: 42
- Service in 2016



750 VDC – KAOHSIUNG

- 9 tramways
- Number of ESS: 18
- Service in 2015



750 VDC – LUXEMBOURG

- 21 tramways
- Number of ESS: 63
- Service in 2017



750 VDC – BIRMINGHAM

- 21 tramways
- Number of ESS: 42
- Service in 2018

8 PROJECTS
153 VEHICLES
264 ESS



Conclusions

- ✓ Complete solution to real market demand: catenary-free operation, energy saving, backup
- ✓ TCO optimized: minimization of the infrastructure costs, energy recovery savings
- ✓ Open solution for the operator: optional, easy to extend, non-captive equipment
- ✓ Customized to the requirements of each project: power, energy, charging infrastructure
- ✓ Technology of the future: energy storage technologies has increasing and improving prospects boosted by other sectors (e.g. automotive).
- ✓ Safe and reliable: proven in revenue service since 2010.

***MARKET LEADER
IN ON-BOARD ENERGY STORAGE SYSTEMS***



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