Novos Sistemas de Tracção

14-09-2017

CAF

Centenario · Mendeurrena · Centenary

CAF 100 A Century Building Future

1917 - 2017

1/ A bit of history

A bit of history

Animal (Horse) Power

Age of steam

Diesel Power

Electric Power

ESS. Catenary Free.
UCs. Bat. Hydrogen

Magnetic Levitation

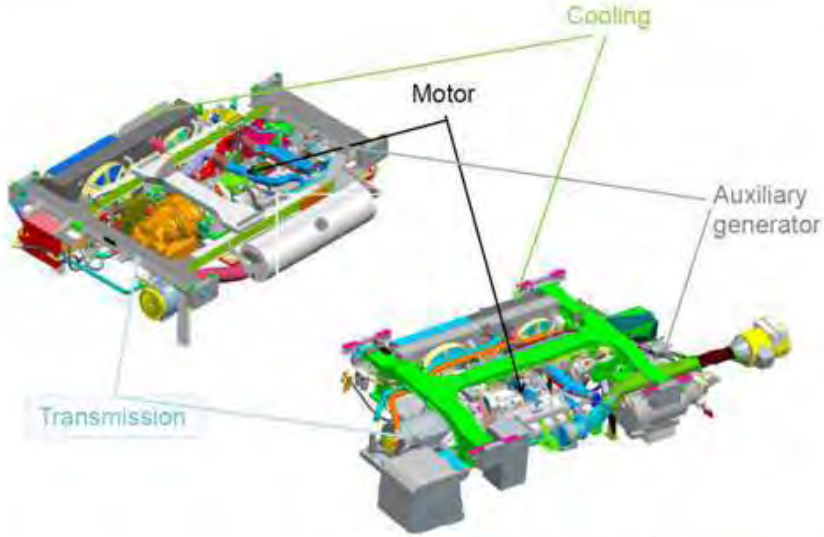
Hyperloop & T-Flight
(flying train)

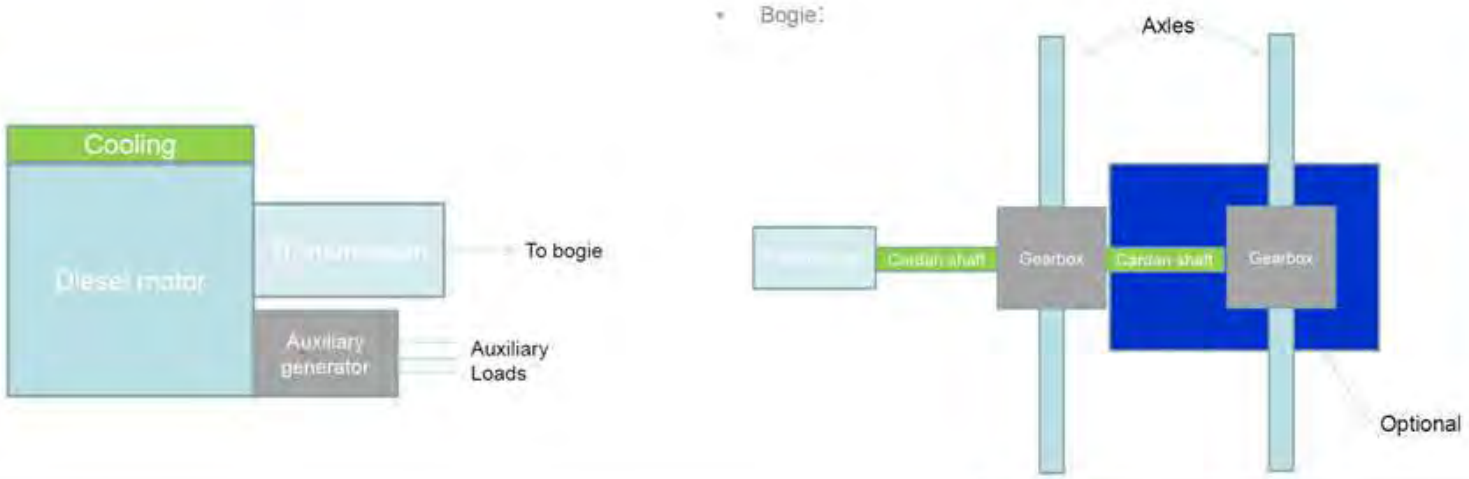
1800 1900 2000

2/ Traction types

DMU

- One or more diesel engines generate the movement to propel the train.
- The engine is connected to a transmission and then to the gear box press-fitted to the bogie axle.
- Same concept as a car.
- The engine is installed in the underframe of a motor car.



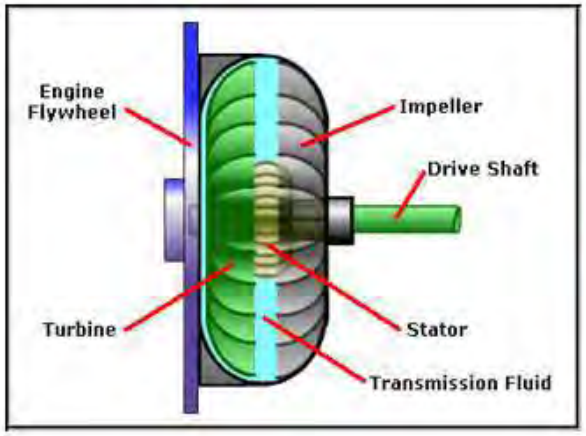


DMU

- Different transmissions available:

Mechanical Transmission, based on gears.

Hydraulic Transmission, based on fluid.



- Hydraulic transmission → Robust solution but lower efficiency.
- Hydromechanical or mechanical transmissions → Include a hydraulic transmission at low speeds (<30 km/h) to perform clutch function.
- Hydraulic transmissions → Include mechanical transmission for high speeds (>80 km/h) to improve efficiency.

DMU mechanic

DMU Cerdeña

- Design, manufacture, test & commissioning of 5 units (3 cars) + 2units (3 cars and 5 cars) + 1 unit (3 cars)
- The unit is designed to run on international track gauge and can reach a maximum speed of **180 km/h.**
- The train is fitted with CAF´s **SIBI System (Active Tilting System)** which provides rail vehicles with a cant effect in addition to that of the track, reducing the effect of the centrifugal force experienced by passengers and allowing the train to travel faster with no loss of comfort when negotiating curves on the route.

DMU hidraulic

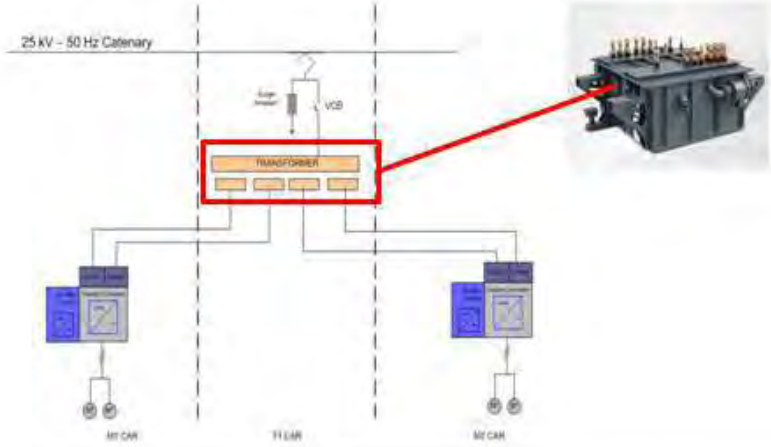
DMU NIR Class 4000

- Design, manufacture, test, commissioning & maintenance of 20 units of 3 cars (60 cars)
- This DMU is designed to run on Northern Ireland Railways, with a maximum speed of 145 km/h.
- This trains is adapted to the new European emissions standards, reducing the consumption and costs of maintenance, all contributing to the procurement of a more ecological train.

EMU AC (15/25 kVac)

Civity EMU Montenegro

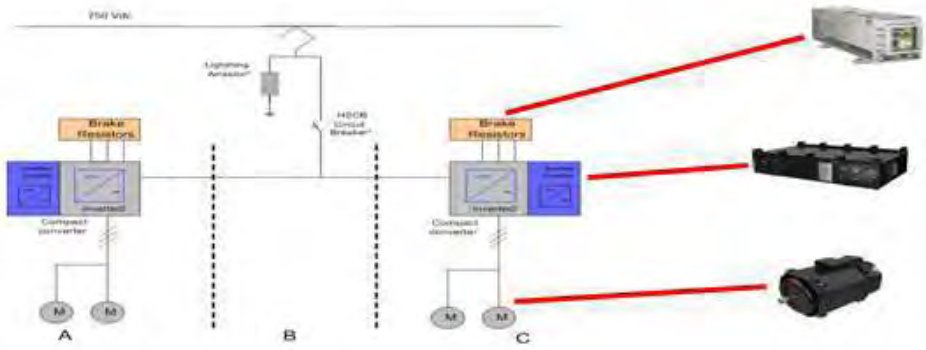
- The train consist is three cars. EMUs can be coupled together by means of automatic couplers.
- The carbody structure is made of aluminium with a crashworthiness system that improves the passive safety of the vehicle.
- The train is designed to run on international track gauge, 25 kV and 50Hz, and can reach a maximum speed of 120 km/h.



EMU DC (overhead catenary)

Renfe's CIVIA

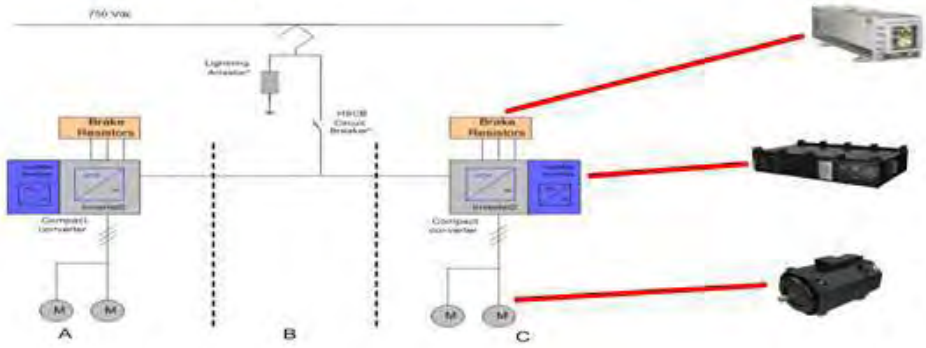
- The Civia Family is composed by 2-, 3-, 4- and 5- car units from a combination of four different car types – two cab end cars (A1 and A2) and two intermediate ones, A3 (half of which, low deck) and A4- with two bogies types – end bogie (BEX) and shared bogie (BC). By means of the automatic end coupler, up to three units can be coupled together.
- Maximum speed: 120km/h
- Total passenger capacity: 517



EMU DC (overhead catenary)

Civity NS

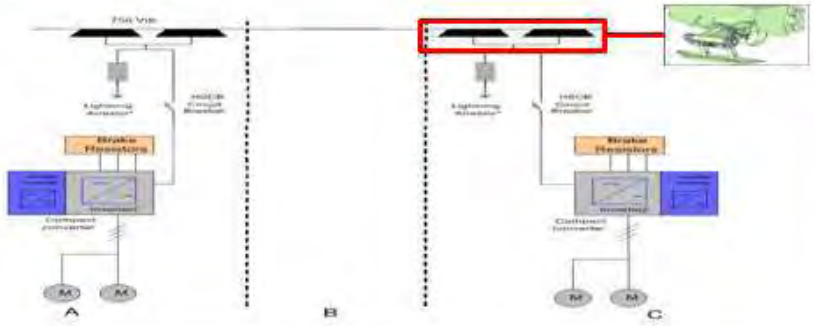
- There are 2 versions of this train:
  - 3-cars unit: A1-B-A2.
  - 4-cars unit: A1-B-C1-A2
- A1 and A2 are the end-cars in all train configurations. They both have the same interior arrangement, but some differences exist in terms of on-board equipment for communications. B is the intermediate car with the pantograph system, multi-functional area with wheelchair spaces and the universal toilet. C1 is also an intermediate car.
- The different EMUs can be coupled between them with a maximum of 3EMUs coupled together.



EMU/Metro DC (third rail)

Metro Bruselas

- 15 Metro Units for the "Société des transports intercommunaux de Bruxelles (STIB)".
- These trains consist of 6 cars connected by unobstructed gangways for optimized passenger distribution across the units.
- Each unit can carry up to 1,200 passengers with two zones designed for persons with reduced mobility.
- In addition, driver cabs are fitted with a central driver desk, designed to be driven by a single driver.

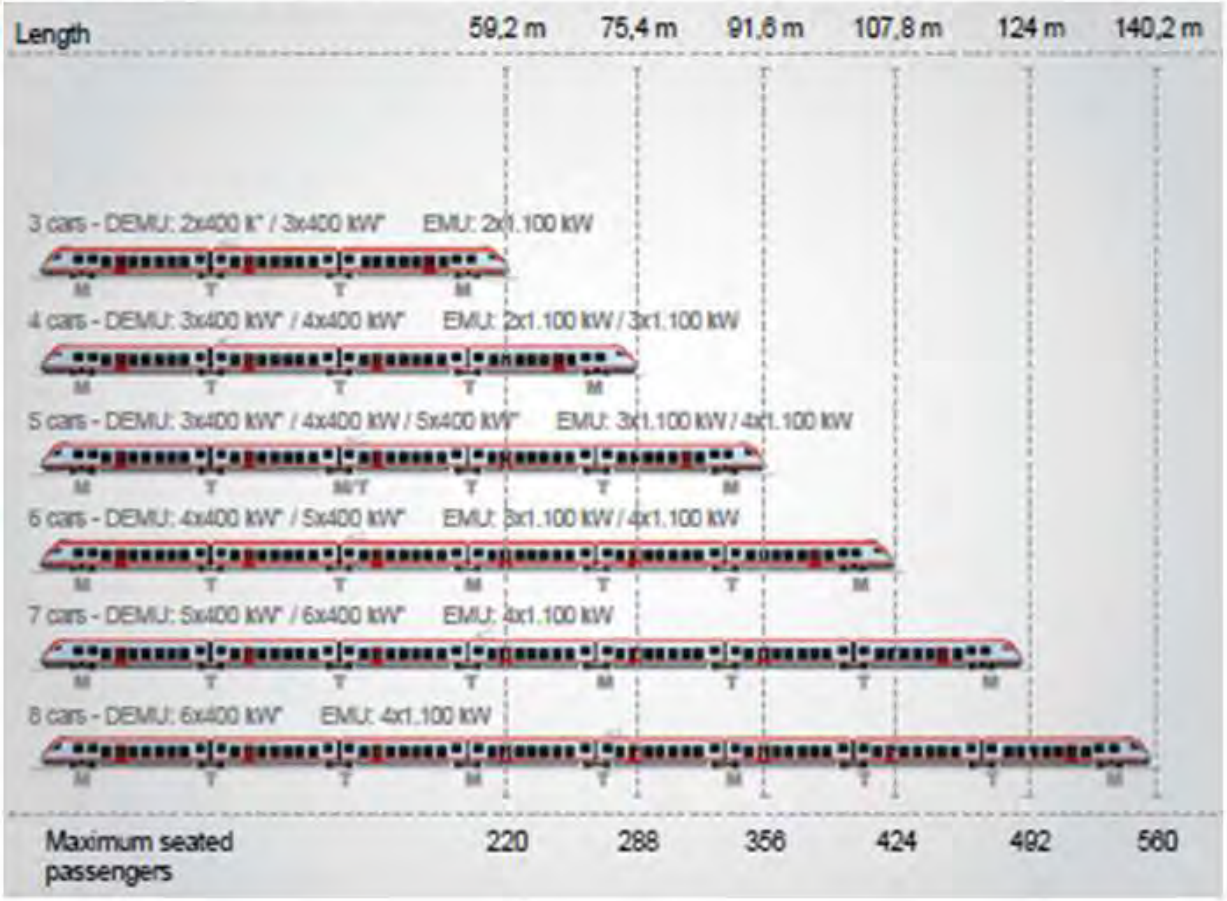


DEMU

CIVITY

HYBRID – DEMU – EMU

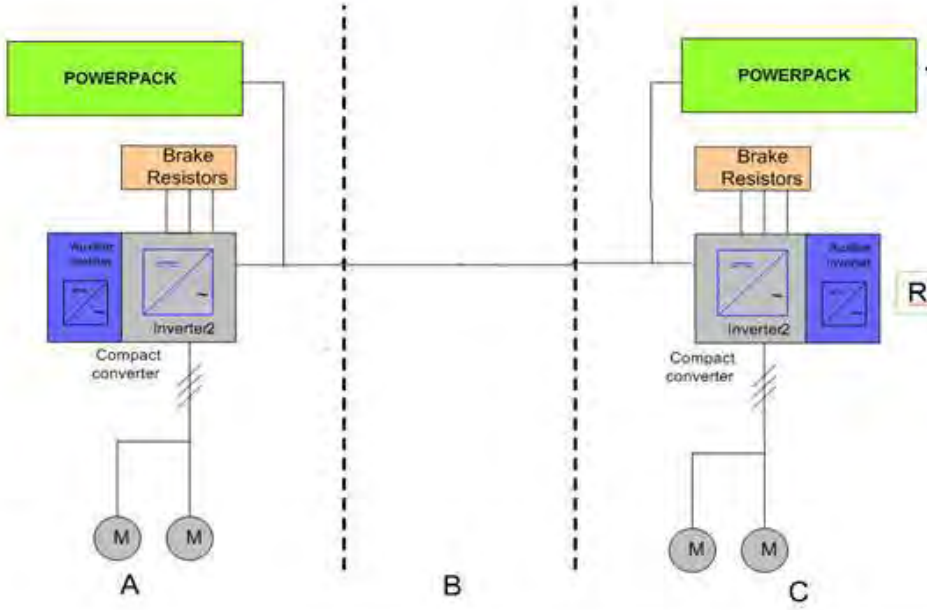
- Within the wide range of regional and commuter trains currently on offer on the market, Civity is a unique solution, as it provides trains with different types of traction based on a single concept of a modular, low-floor vehicle.
- Civity trains are available with the following types of traction:
    - - Electric
    - - Diesel mechanic or diesel hydraulic
    - - Diesel-electric
    - - Hybrid
- Civity is a family of modular low-floor, international gauge trains for regional and commuter services.

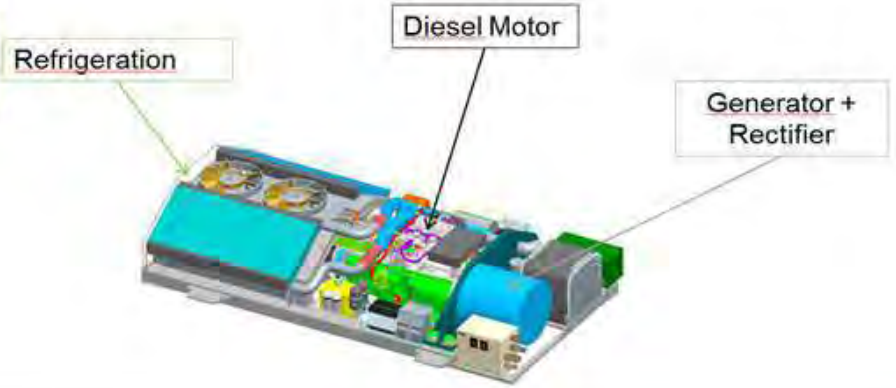


DEMU

CIVITY

- Diesel engines and generators are included. → Replace catenary or 3rd rail.
- Diesel engines + generators provide the neccesary power to the electric traction equipment
- Advantages compared to EMU: Can run in non-electrified routes.
- Advantages compared to DMU:
  - Electrical + mechanical braking
  - Better performaces with TCU
  - Allows hybridization with batteries
- Disadvantages compared to DMU:
  - Heavier solution with higher fuel consumption.
  - More complex and less reliable solution.





DEMU

Bitrac

- One of the major advantages of Bitrac is the use of specific technology for full interoperability between tracks with different gauges, signalling systems and electrical power supply. The integration of the different railway networks makes it necessary to have a fleet of trains capable of running on different networks in the most efficient way possible.
- Bitrac covers electric, diesel-electric and dual-mode (electric/diesel-electric).

Dual Voltage

EMU DC+AC

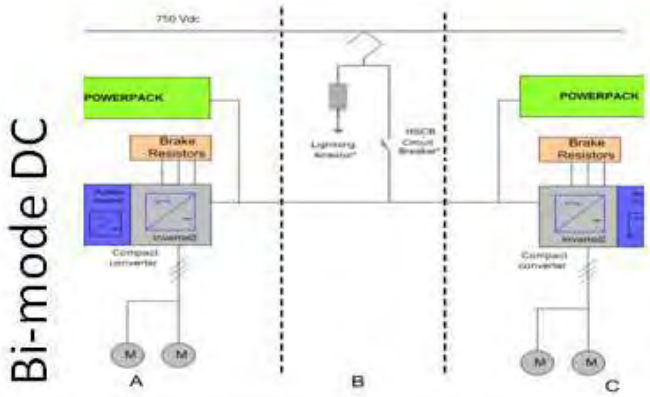
- AVR s/121 & AVGL s/120
- Design, manufacture, test, commissioning & maintenance of 29 units of 4 cars (116 cars in total) & design, manufacture, test, commissioning & maintenance of 27 units of 4 cars (108 cars in total)
- Supply voltage: 3000 Vdc / 25000 Vac
- A 250 km/h self-propelled, dual voltage electric train units with a **variable gauge wheelset system**.

Dual Voltage

EMU DC+DC

METRO MADRID S/8400

- Design, manufacture, test, commissioning & maintenance of 30 units of 6 cars (180 cars in total)
- Supply voltage: 600 Vcc / 1500 Vcc
- CAF has supplied over 1,500 cars to Metro Madrid. These highly reliable units incorporate advanced technology and offer ultimate comfort to their users.



Hydrogen

EMU Hydrogen

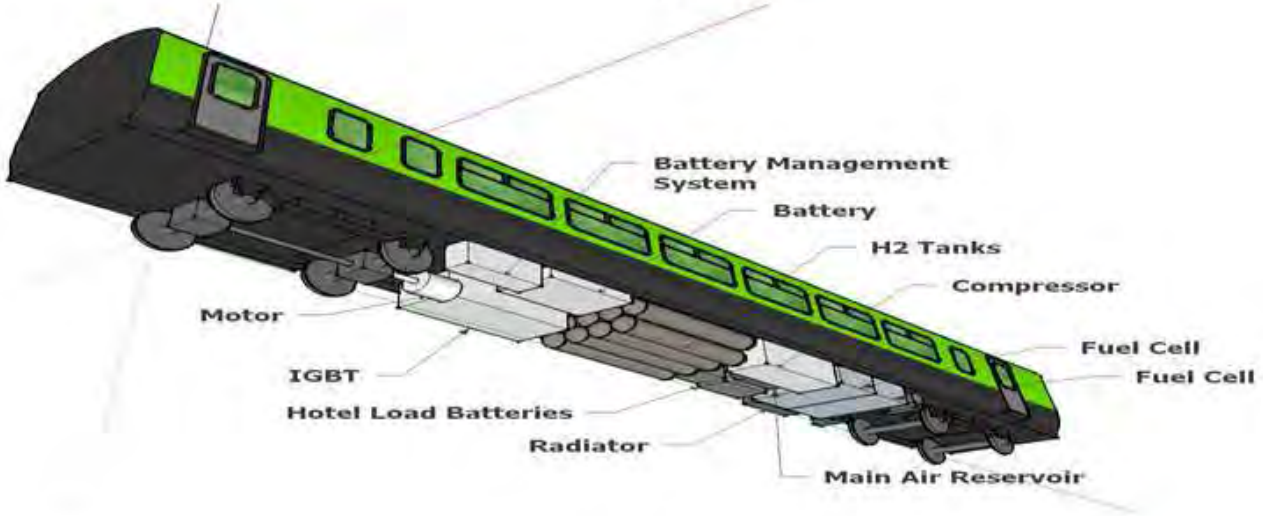
- Full emission-free
- Enables sustainable train operation while its performance matches that of regular regional trains.
- It could allow a 600 to 800 km autonomy.
- Combined with batteries to boost acceleration when neccesary and store the braking energy

Advantages:

- Improve journey times
- Eco friendly: drastically cut emissions
- Improve ride quality

Disadvantages:

- Technology in development → Few solutions available and very expensive.



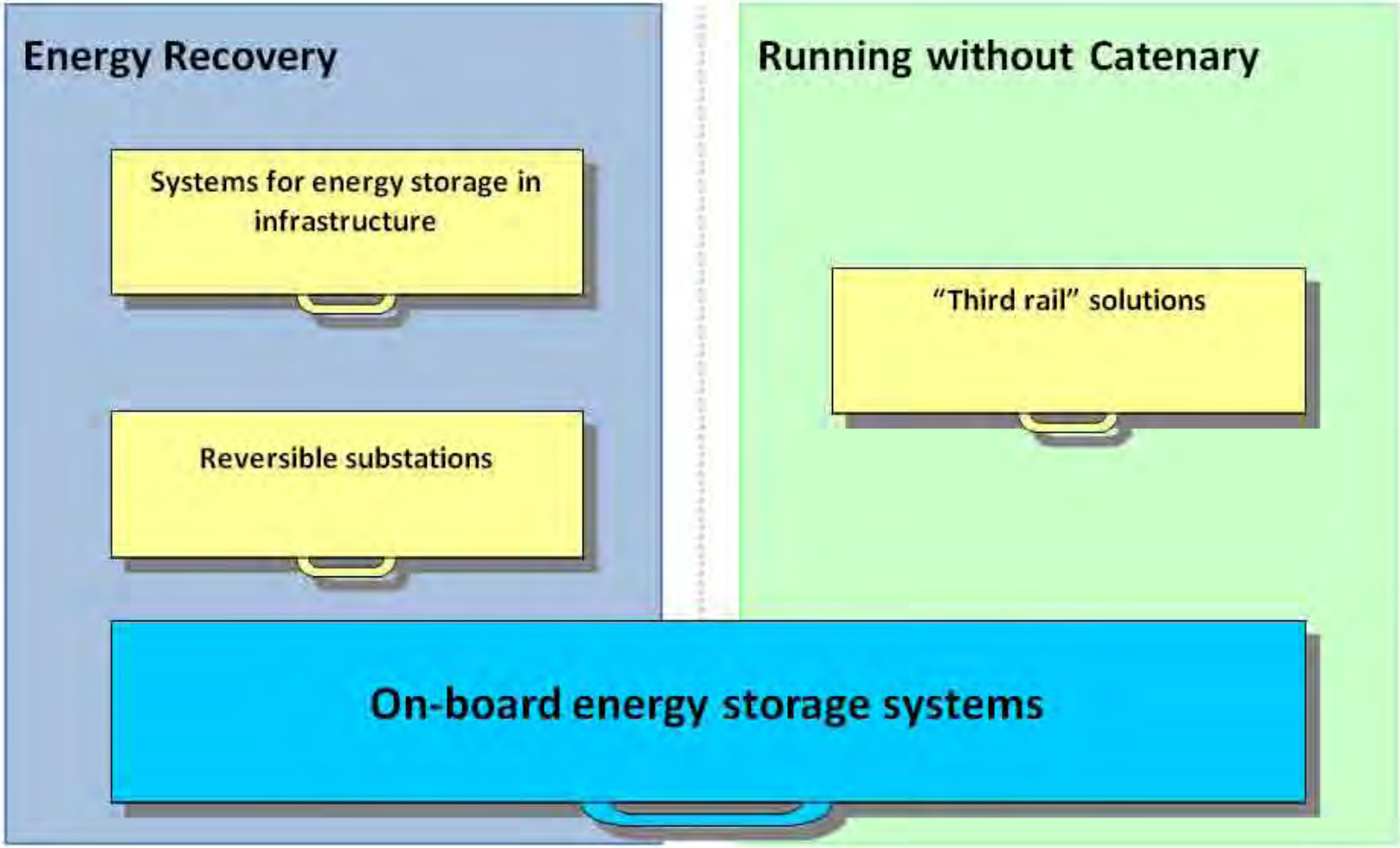
2/ Energy Storage Systems

Context and Problems

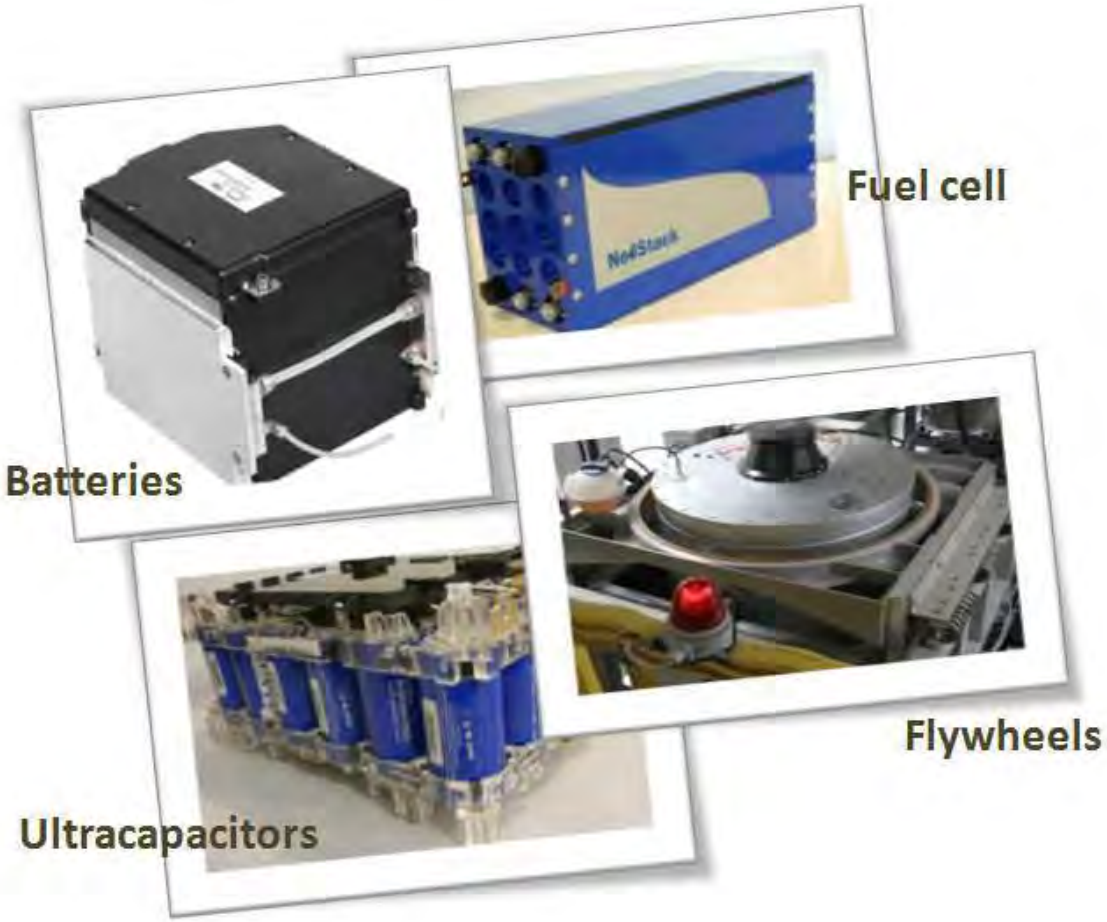
- Demand for increasingly clean and more efficient systems from an energy point of view.

- Growing concern about the visual impact of catenary in historical areas.

Alternatives



On board Storage Technologies



More than 9 years of research to analyze, study, integrate and test different energy storage systems

On board Storage Technologies

Integrate both technologies in the ESS

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

On board Storage Technologies

	Ultracapacitors	Li-Ion Batteries
Specific Energy	Medium [6Wh/kg]	High [140Wh/kg]
Specific Power	High [1000 W/kg]	Medium [500W/kg]
Format	Cilindric (standard format)	Pouch – Prismatic – Cilindric (No standard format)
		

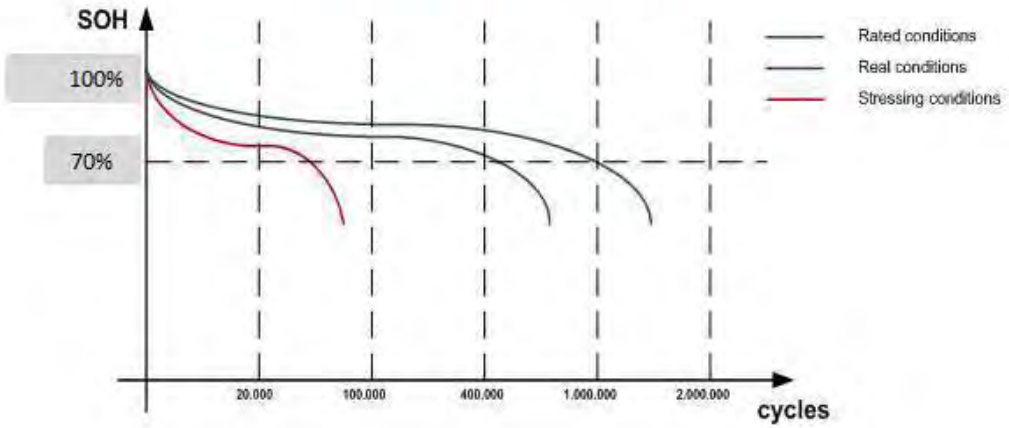
On board Storage Technologies

Influencing factors of the ageing:

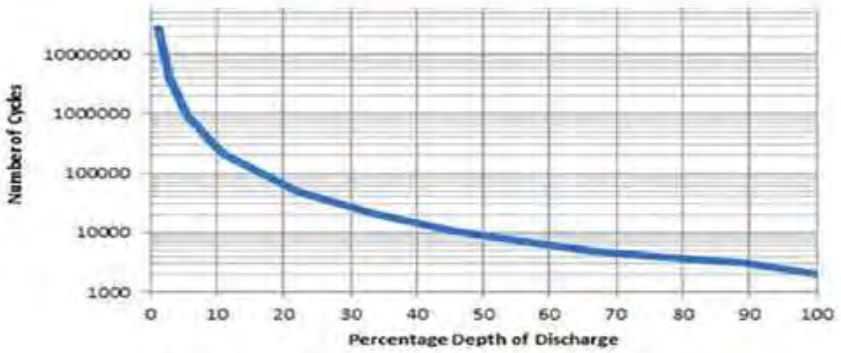
- Temperature
- Voltage
- Current
- Qty of cycles
- DoD (Deep of Dischage)
- Calendar life

Continuous characterization of the cells in the laboratory

Ultracapacitors



Li-Ion Batteries



Greentech Technology

The **Greentech** is an on-board energy storage system based on the use of supercapacitors whose high-speed recharge obviates the need for catenary between stops and **saves energy**.

Greentech Technology

Within this line of CAF Power & Automation products, there are 2 different technologies, both applicable to any articulated vehicle platform: **Greentech Evodrive** and **Freedrive**.

CAF Power & Automation GREENTECH FREEDRIVE

CATENARY FREE

+

ENERGY RECOVERY

+

BACKUP

ENERGY RECOVERY

+

BACKUP

CAF Power & Automation GREENTECH EVODRIVE

Greentech Technology

Within CAF's order book there are **9 tram projects** that incorporate the Greentech technology. Starting with Seville, which is **in operation since 2010**, all together sum up **159 trams** in **7 countries** (Spain, United Kingdom, Australia, Taiwan, Luxembourg, Brazil and Estonia) and **9 cities** (Seville, Zaragoza, Granada, Birmingham, Newcastle, Kaohsiung, Luxembourg, Tallinn and Cuiaba).

Greentech Technology

ZARAGOZA TRAMWAY (PPP)

Construction of the first tramline in the city of Zaragoza, Spain. CAF is a member of the SPV which financed, delivered and is currently mantaining and operating the tramway line. On the EPC part, CAF was responsible for system electrification, supplying the trams (21) and workshop equipment.

On Line 1, a **3.2 km** section of the 12.8 km operates **without catenary.**

Greentech Technology

KAOHSIUNG TRAMWAY (Turn-key)

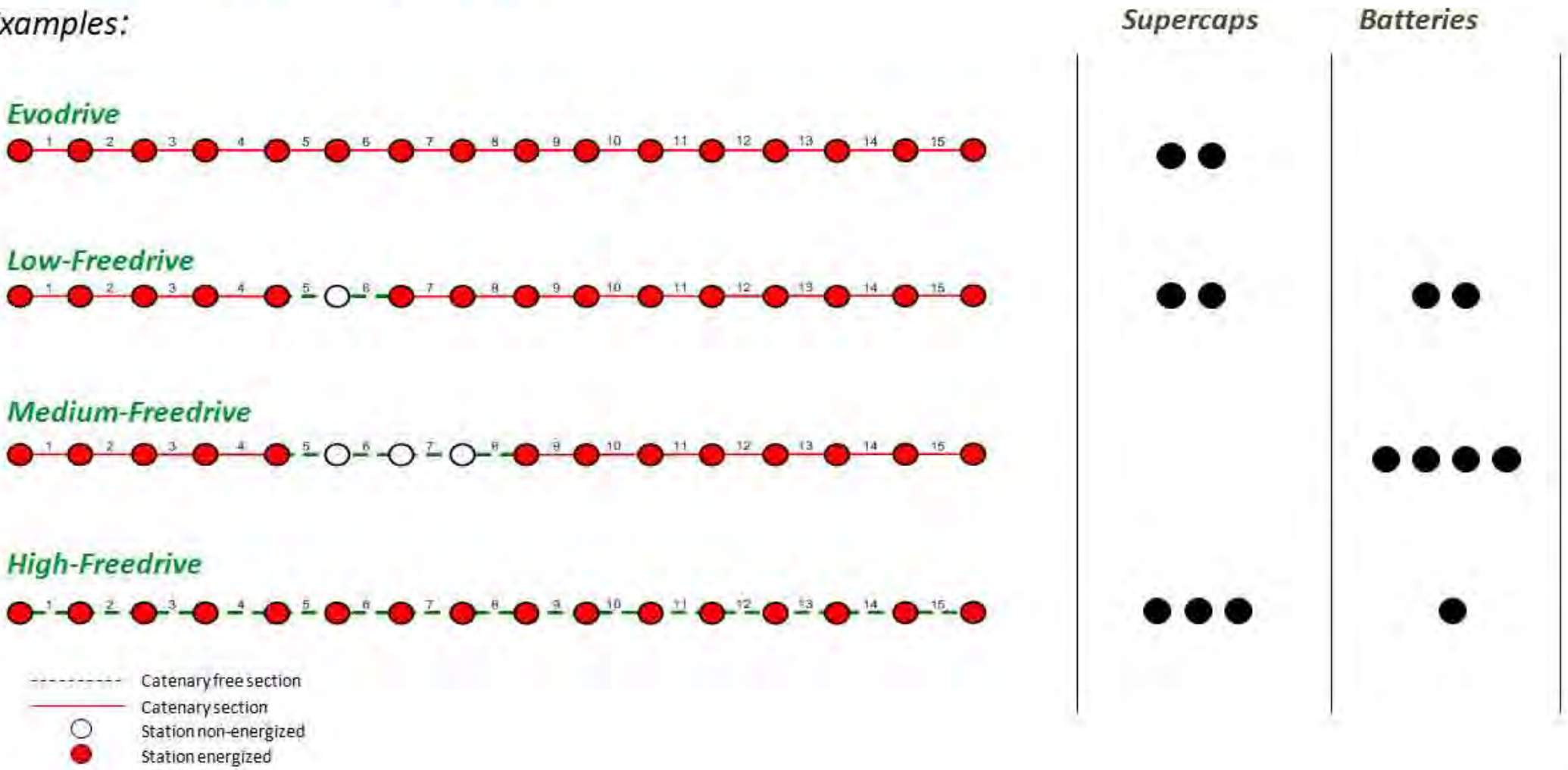
Construction of the first phase of the LRV circular line in Kaohsiung city in Taiwan. This is a turn-key project in which CAF supplies the rolling stock (9), signalling system, electrification, ticketing system and the integration of all subsystems in addition to Project Management.

First LRV system in the world on a fully catenary-free route (8,8 km).

Greentech Technology

MODULAR and CONFIGURABLE

Examples:



Freedrive

Greentech Freedrive is an **on-board energy storage system** that allows **catenary free movement + energy recovery + backup**.

CAF has the **ability to adapt to different operational scenarios** with catenary-free tram operations, through the hybrid **combination of lithium-ion supercapacitors and batteries**. In this way, parameters such as performance, autonomy, cost and traffic type are optimised.

Advantages

- It allows vehicles to operate in catenary-free sections.
- Variable autonomy: from a typical distance of hundreds of metres to many kilometres thanks to lithium batteries
- Fast charging process (<20 seconds)
- Reduction in the level of visual intrusion
- Reduction in investment in infrastructure
- Elimination of the catenary in some sections, in order to reduce the visual impact in urban centres
- Non-proprietary system, applicable to any new or existing manufacturer and infrastructure.

Freedrive - Functionality

CONVENTIONAL TRAM

Traction phase: Between stations the energy is supplied by the catenary

Braking phase: Some kinetic energy is returned to the catenary. The rest of the energy is dissipated in the braking resistors.

CATENARY-FREE TRAM

Traction stage: When running between stations the energy is supplied by the ESS.

Braking phase: The kinetick energy is recovered in the ESS.

Charge in station: The ESS system is fully charged during the stops.

Freedrive

A Energy Storage System optimized to meet the specific operational needs:

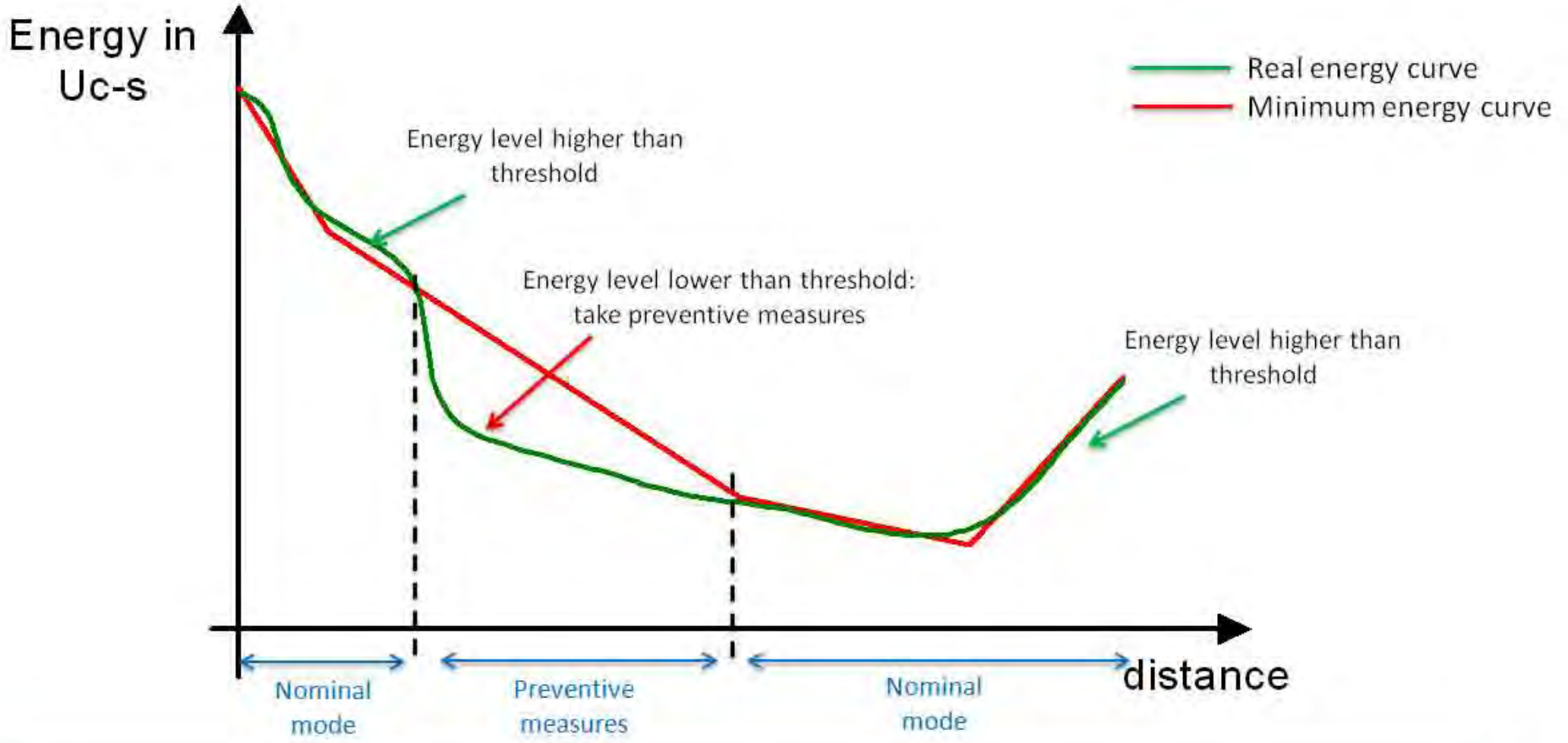
✓It is not possible to cover all specific operational needs and requirements with a single technology/solution. This is the reason for using a modular and configurable system, combining different ESS technologies, such us supercapacitors and batteries, allowing the highest level of **customization.**

✓**CAF's experience optimizing the system:**

- **Simulations and calculations** are done in order to predict the energy and power requirements, to determine the **number of Greentech boxes** and number of modules of UC and BAT.
- **Infrastructure and operational conditions** also play an important role, as they have a strong influence on the needs the ESS system has to cover.
- **Advanced energy management** system in the vehicle:
  - Adequate hybridization between UC and BAT
  - Auxiliary load management
  - Traction performance adjustment per section

Freedrive

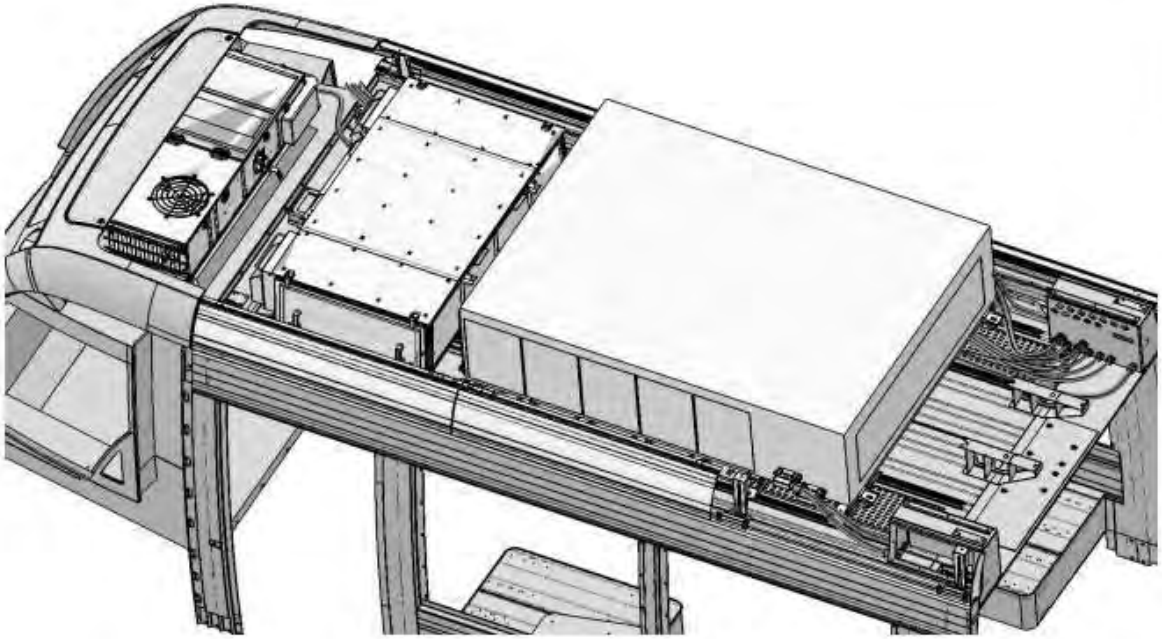
During operation real energy curve is compared to the minimum energy threshold:



Freedrive

Installation of the Greentech system

- The system is mounted on the roof to the end modules of the tramway.
- Maintenance similar to any conventional electrical equipment.



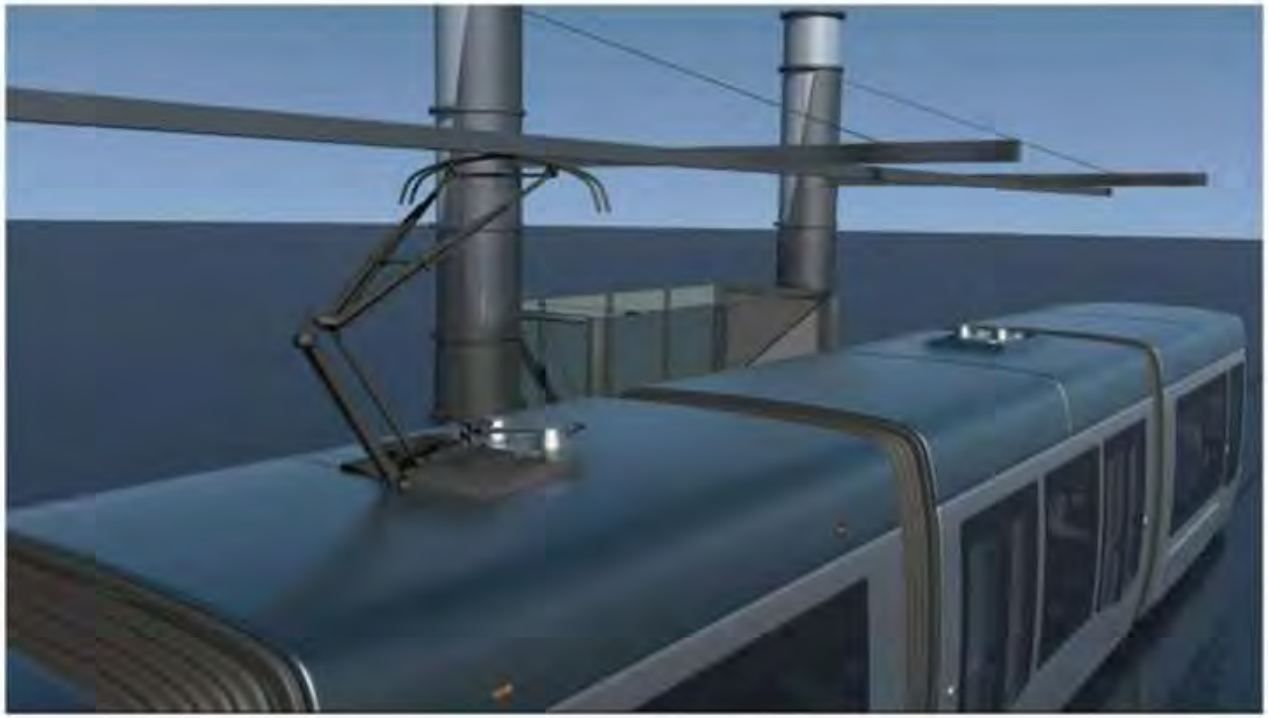
Freedrive

Charging system

- Ultra-fast charging process. Recharge is performed in 20 seconds
- Charging process can be performed either from overhead catenary system of from ground system.
- The catenary is only necessary in the stations (integrated in the station's design).

Freedrive

- Short catenary installed at the stops
- Rigid catenary
- Safe solution. Permanently energised or only when the tram is in the station
- Simple and low cost solution
- Easy installation
- Easy maintenance



Freedrive

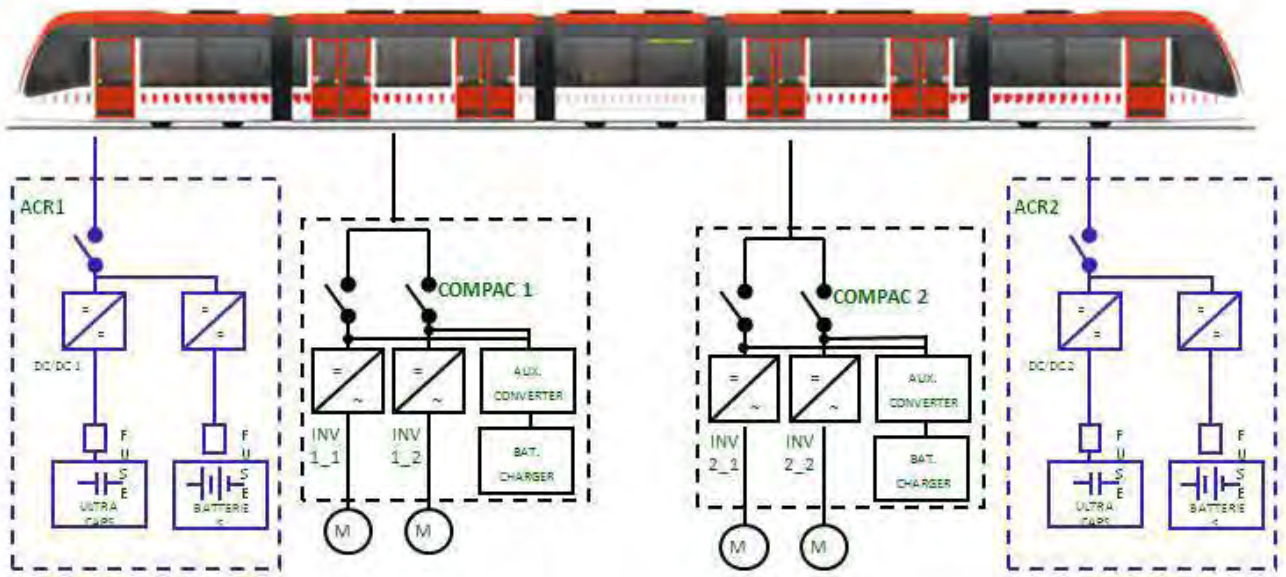
- Third rail and shoes located in the bogies
- Minimum visual impact
- Safe solution. Third rail is powered only when the vehicle is over the rail
- Easy installation
- Easy maintenance

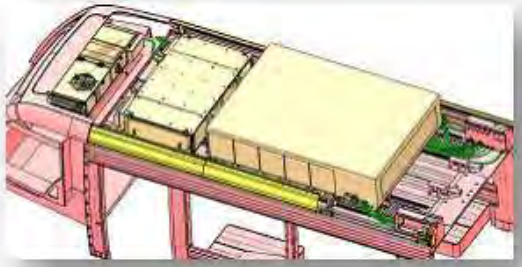
The URBOS platform

Flexible platform that allows different configurations.

- The URBOS trams designed for conventional service can later allow the installation of the ESS system as a "plug-in", i.e., Birmingham tram.

- A URBOS tram equipped with ESS system operates as a conventional tramway if the ESS system is cut off.





Integration in other rolling stock and vehicles

Integration in other vehicles is possible:

On board Energy Storage Systems

Tramways
URBOS

EMUs
CIVITY

Locomotives
BITRAC

e-bus

vectia

IPEMUs

IPEMUs for Auckland
(Independently Powered EMUs)

- Supply of 14 new IPEMUs of 3 cars each
- The design is based in the currently operating 3-car EMUs supplied by CAF with a main modification: update it so that an OESS is mounted, which allows the IPEMUs to provide suburban commuter service on the non-electrified track section between Papakura and Pukekohe.

- Commercial service: 120 km/h
- Passenger capacity: 585
- Distance: 18 km.

ROLLING STOCK
SIGNALLING
SERVICES
EQUIPMENT & COMPONENTS
TRANSPORT SYSTEMS

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