I RAIL TECHNOLOGICAL FORUM FOR INTERNATIONALIZATION

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FEVE HYDROGEN TRAM

DANIEL SOPEÑA
HYDROGEN TECHNOLOGIES MANAGER
CIDAUT

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Context

Reduction of Energy Consumption

Regenerative braking				Powerplant Efficiency improvement
Substations	Rail track	Other trains	Inside the Vehicle	Non-electrified lines
Grid, Supercaps Flywheel		Braking energy Traction energy	Diesel fueled or Electric Vehicle Supercaps Batteries Hydrogen Fuel Cell	

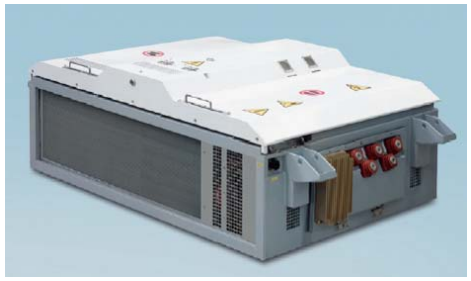


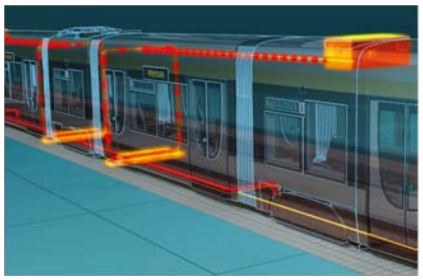




Catenary removal from urban areas

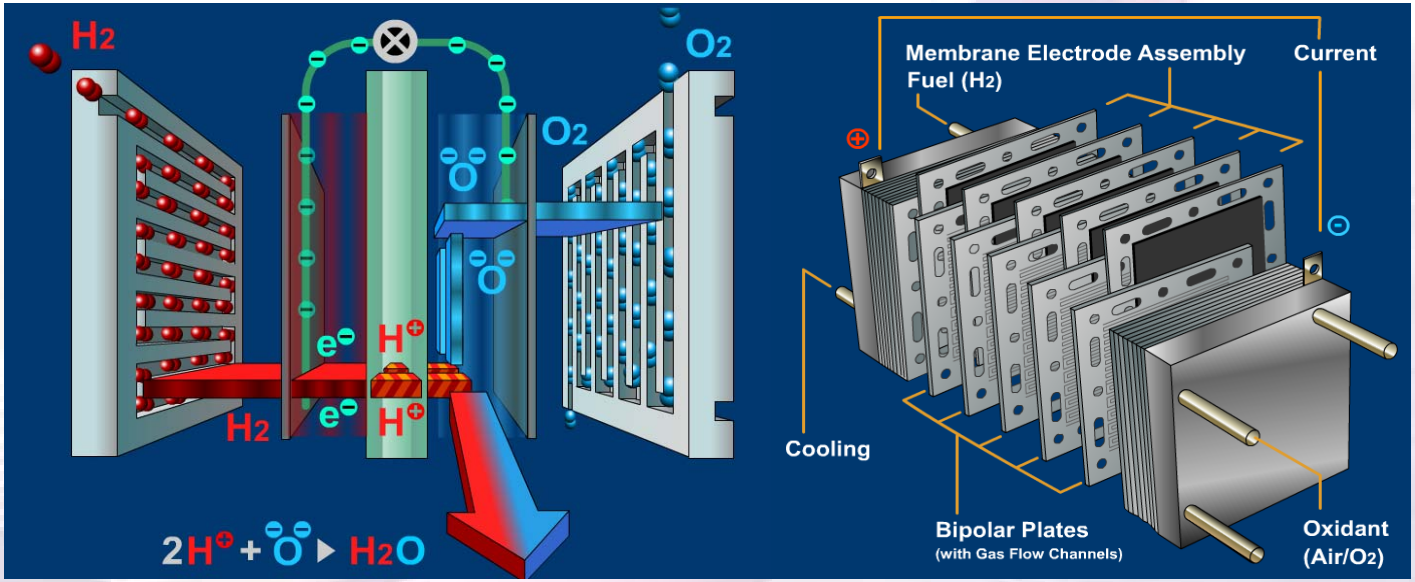
Sitras® HES (SIEMNES)	APS (Alstom)	PRIMOVE (Bombardier)	ACR (CAF)	Hydrogen Trains





What is H_2 and a Fuel Cell?

- H_2: Energy vector. It is as green as the energy used for obtaining it
- FC: Electrochemical dispositive that converts chemical energy of hydrogen into electric and thermal energy



- **PEMFC**
  - Is the most common Fuel Cell used for transport
  - Is the Fuel Cell that is nearest to commercialization (2015)

PEMFC for railway sector

- 150kW FC for buses and stationary applications

BALLARD

UTC Power

NUVERA

- From 12000 to 20000h of life time
- Easy integration

H_2 integrations in rail sector

Vehicle Projects and BNSF

Switcher locomotive of 130 Tons

Started up from 2009

Non commercial vehicle

Mean Power: 40 – 100kW; Max. Power: 1MW. Autonomy: 8-10h of intense working

240 kW PEMFC (2 x Ballard P5™) + near to 800kW of lead acid batteries

70kg of H_2 (2 groups of 7 tanks at 350 bar each one)

Railway Technical Research Institute (RTRI)

Intercity train of 70 Tons

Started up from 2008

Non commercial vehicle

120 kW PEMFC (Nuvera Forza) and 360kW of Li-ion Batteries

Maximum speed 100km/h

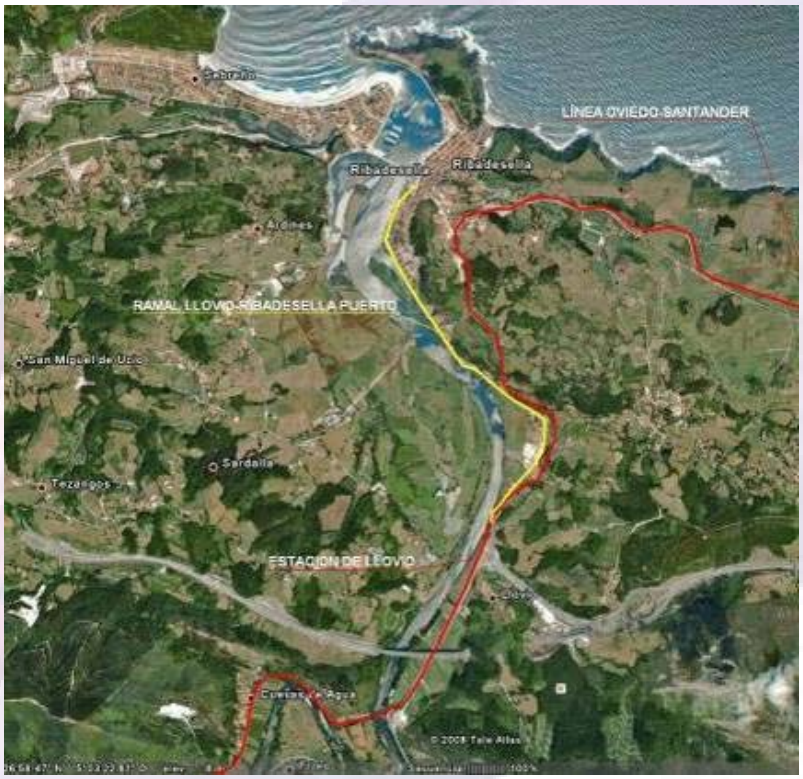
18kg of H_2 at 350bar

Bus voltage 1500VDC

Tram H_2 Project

- **Target:** Integration of a new hybrid power train based on Fuel Cell in a tram that will operate in the LLovio to Ribadesella railway track.

"FABIOLO" model from SNCV series 3400

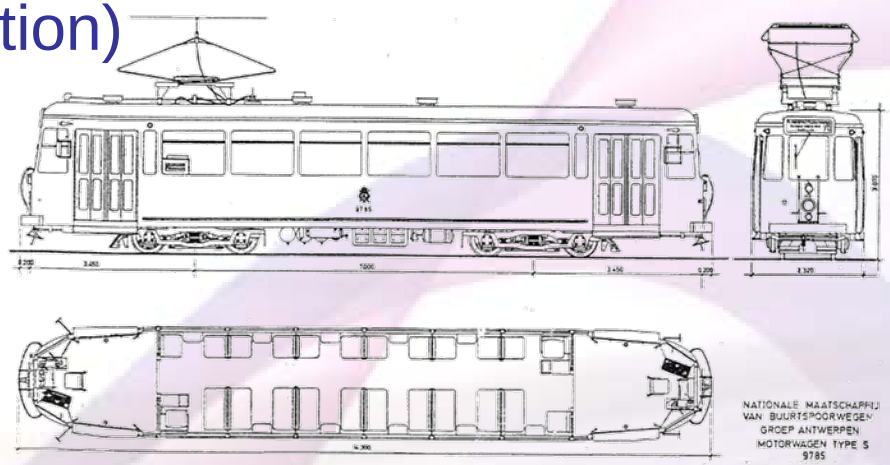


- 1st Prototype ⇒ Design parameters defined by means of end use characteristics.

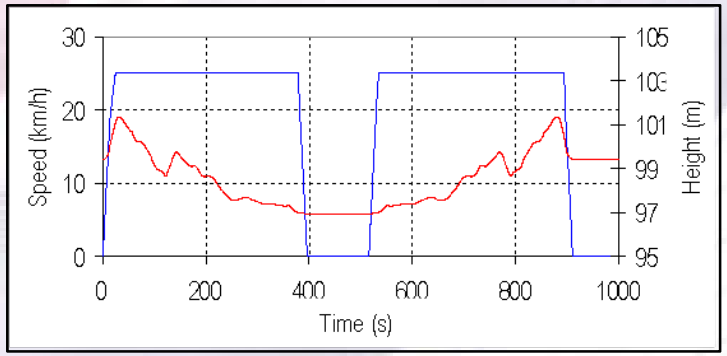
Hybrid description architecture

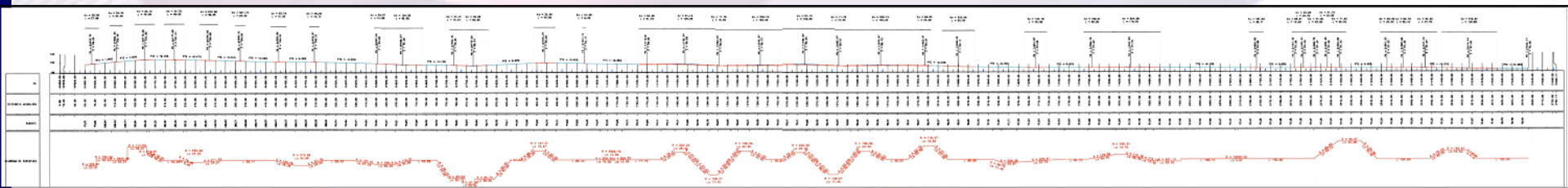
Energy model

Model inputs (Information compilation)



- Vehicle inputs
  - Vehicle performance
    - Mean acceleration: ± 0,4 m/s^2.
    - Maximum acceleration: ±1 m/s^2
    - Maximum speed: 25 – 30 km/h
    - Maximum power: 120 kW
    - Driven motor: 4 asynchronous motors of 30kW
  - Vehicle size, weight, consumption of auxiliaries
  - Maximum passengers: 24 - 40 people
- Track and use inputs
  - Track length and profile.
  - Number of stops and duration
  - Number of daily trips

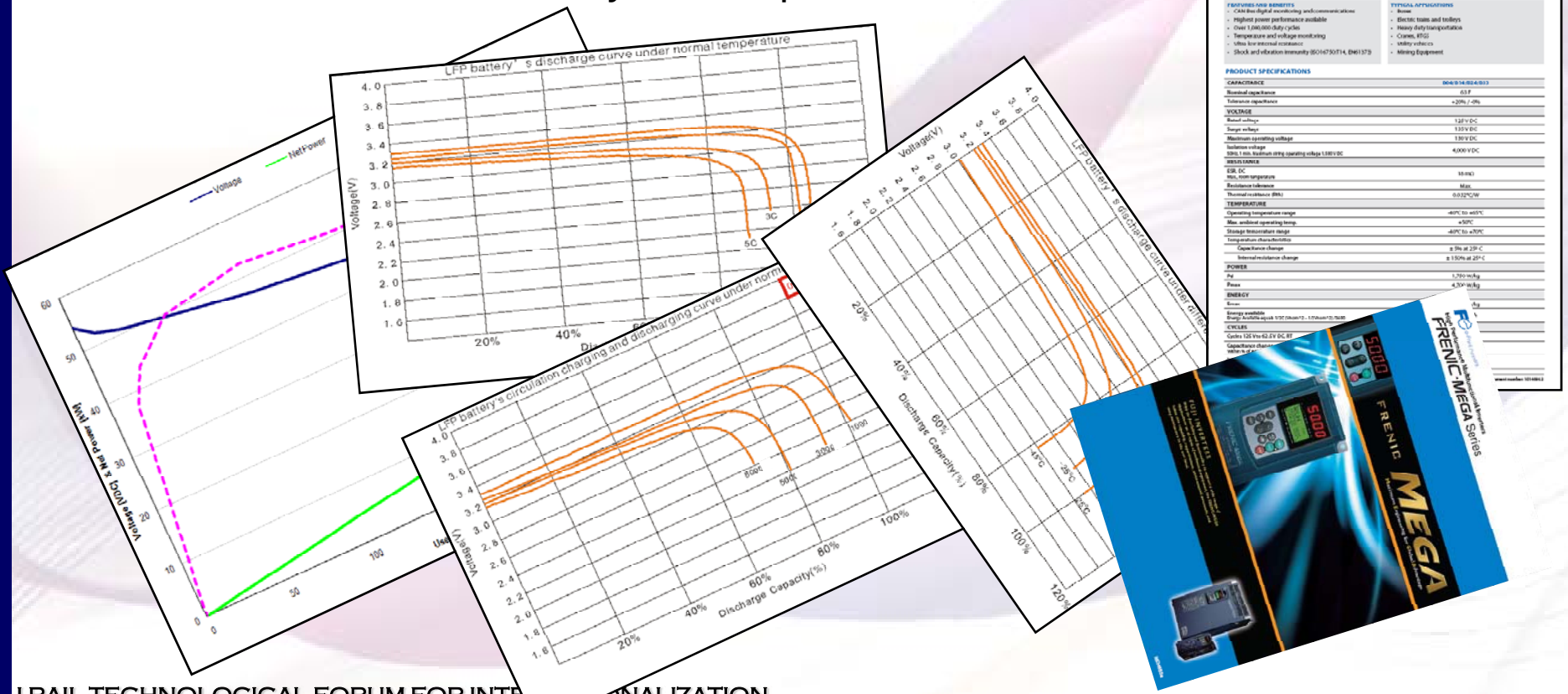




Energy model

Model inputs (Information compilation)

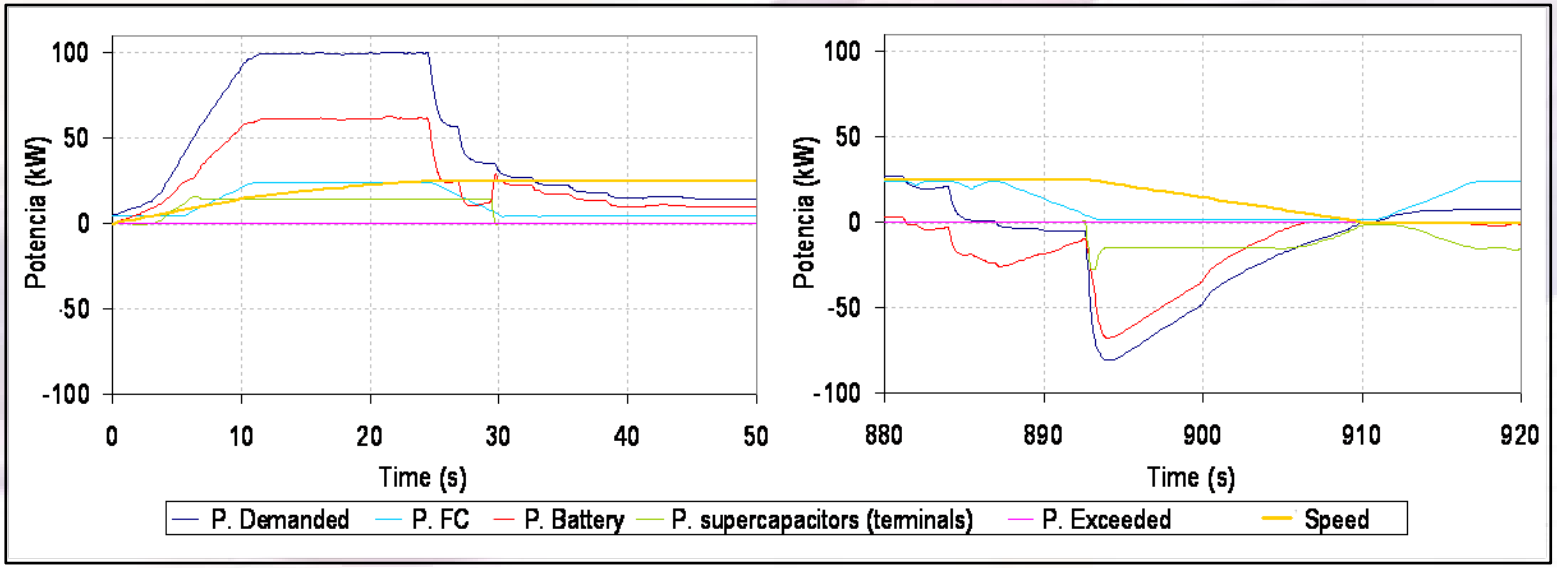
- Power plant inputs:
  - Parameters, characteristic curves and dynamic responses of fuel cells, batteries, supercaps and inverters.
  - Definition of control system loops.



Energy model

Algorithms

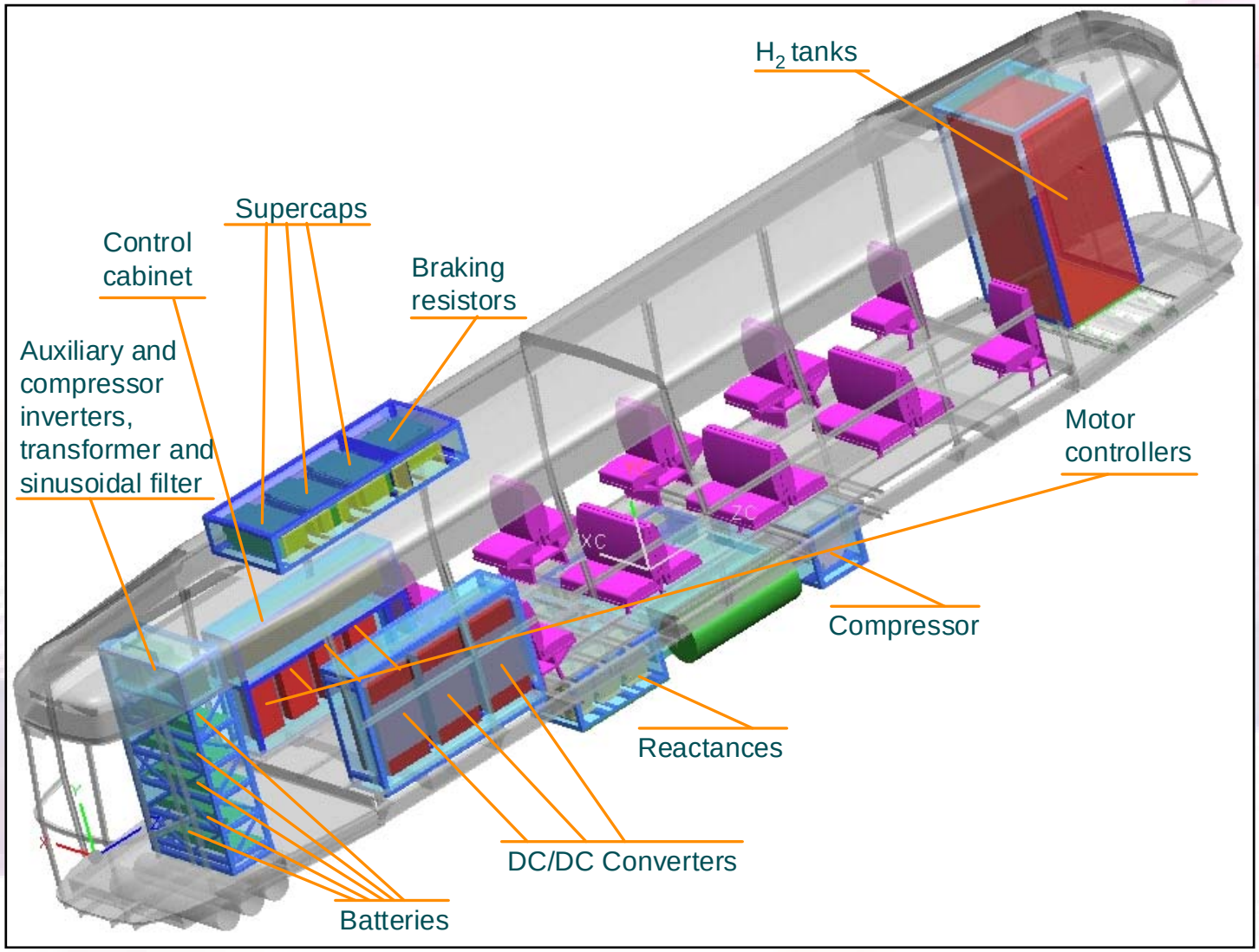
- Bus voltage should be constant.
- Supercaps maintain bus voltage and “smooth transitory states”. They help batteries during traction peaks and braking.
- Batteries should maintain the charge of supercaps.
- Fuel cells supply all the energy throughout the railway track. They always try to work in steady-state conditions.



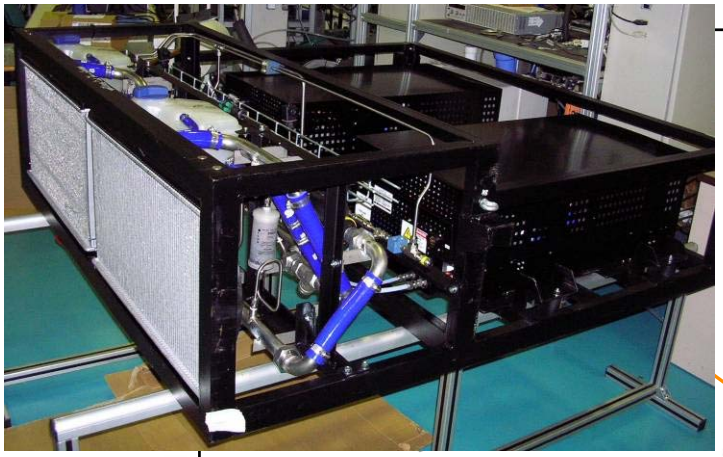
Powerplant sizing

- **Fuel Cells**
  - 2 Fuel cells HyPM HD 12 from HYDROGENICS
- **Li-ion batteries**
  - 156 cells of 90Ah each one in series.
- **Supercaps**
  - 3 units of BMOD0063 P125 from MAXWELL
- **DC/DC power converters and inverters** from FUJI Electric.
- **Hydrogen storage:** 12 bottles of 50 l of compressed H_2 at 200 bar
- **Bus voltage:** 670 – 700 VDC

Powerplant Distribution



Powerplant Distribution



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Conclusions

- 1st hydrogen railway vehicle in Europe
- Integration of the new power plant has been finished
- The train will be first view in August. Starting up will be completed in the next months

- Hydrogen would be the “renewable fuel” of the future
- Possible applications of Hydrogen in railway sector: LRVs (Trams, Train-Tram,…) or shuntings