



Università Degli Studi di Napoli “Parthenope”

***Mobilità Sostenibile: Bio-combustibili e infrastrutture
11 dicembre 2019 - Napoli***



**EUROPEAN
FUEL CELL**
CONFERENCE & EXHIBITION

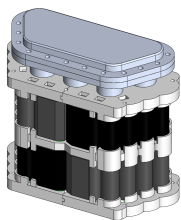


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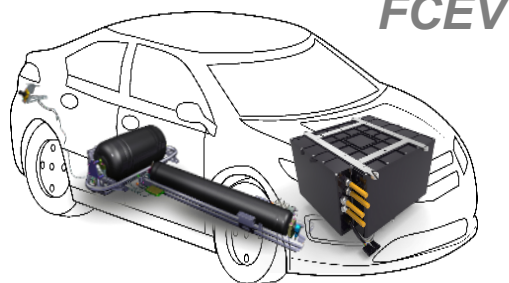


Numerical and experimental activities

On-board energy storage

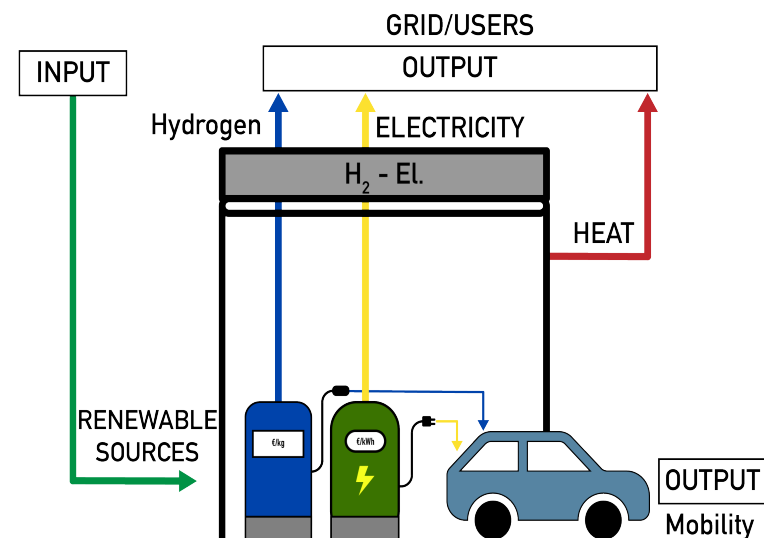


Power units and fuel cell
electric vehicles
development



FCEV

Techno-economic assessment of refueling stations



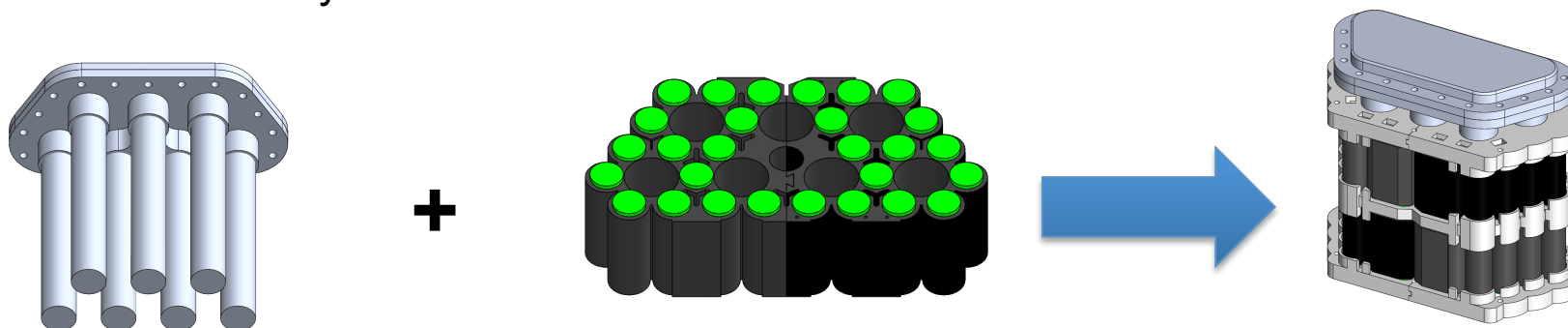
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On-board energy storage

Development of a novel hybrid energy storage system (under patent) for PFCEV

The concept

The novel proposed solution is based on the integration, in a single hybrid component, of a battery pack and a metal hydride tank.

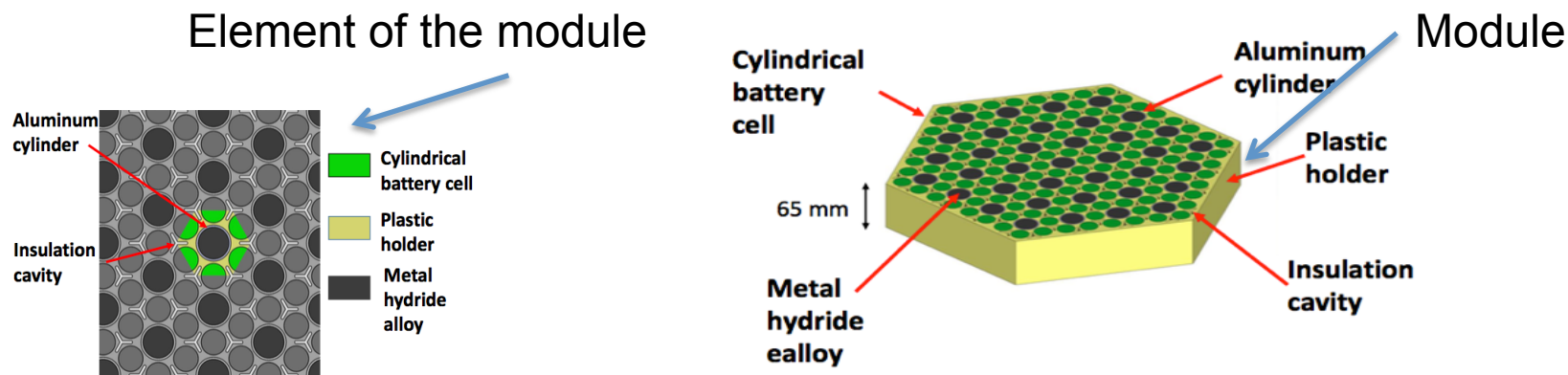


Hybrid energy storage system

The idea of this integration arises considering to simplify and improve the thermal management of the Li-batteries (their warming and cooling) by exploiting the thermal management of the hydrogen adsorption and desorption processes in metal hydrides.

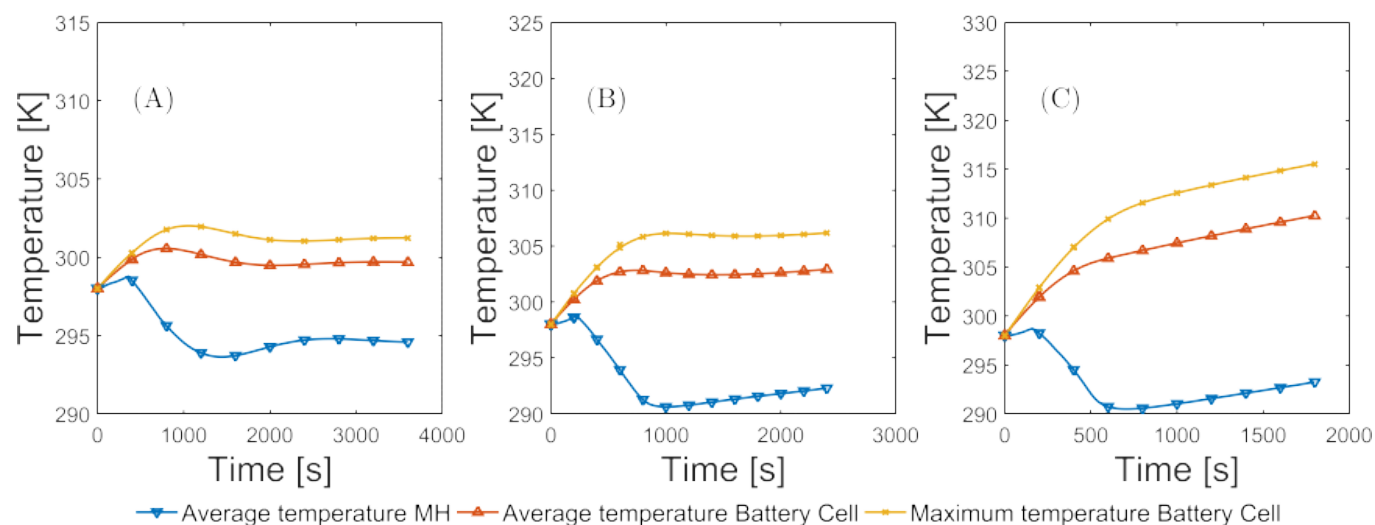
Modeling

a 2D model was implemented in COMSOL 5.2.



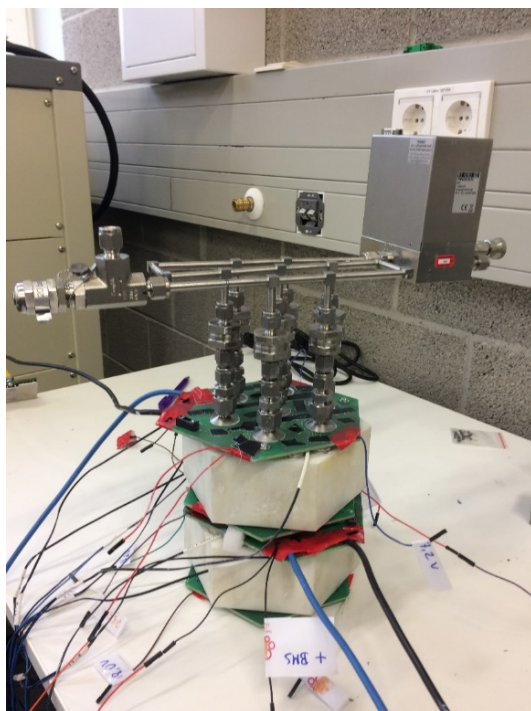
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Modeling Temperature profile

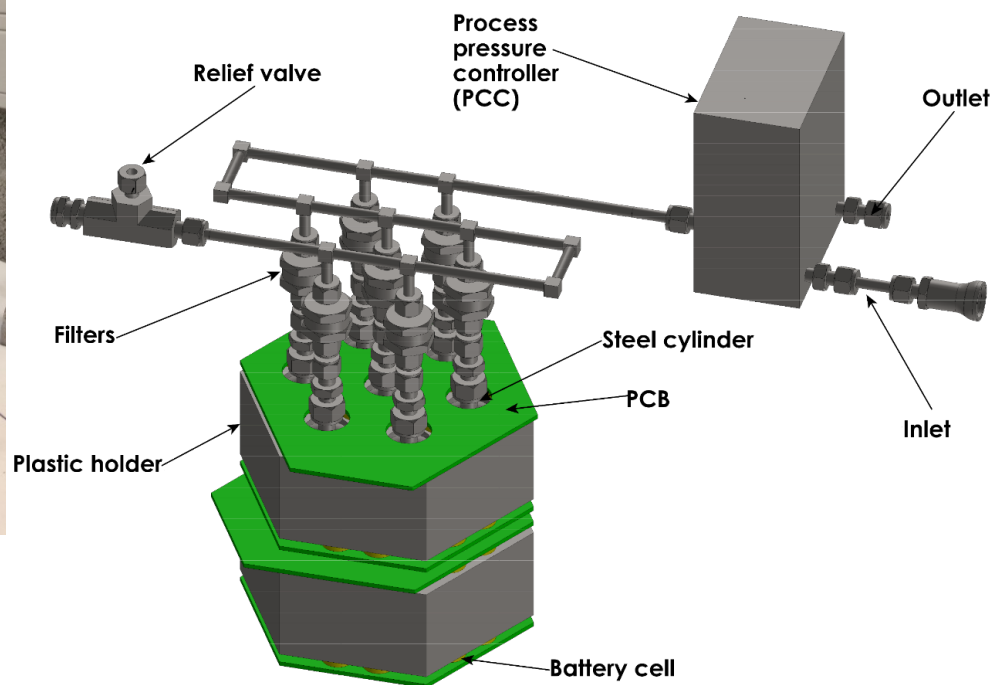


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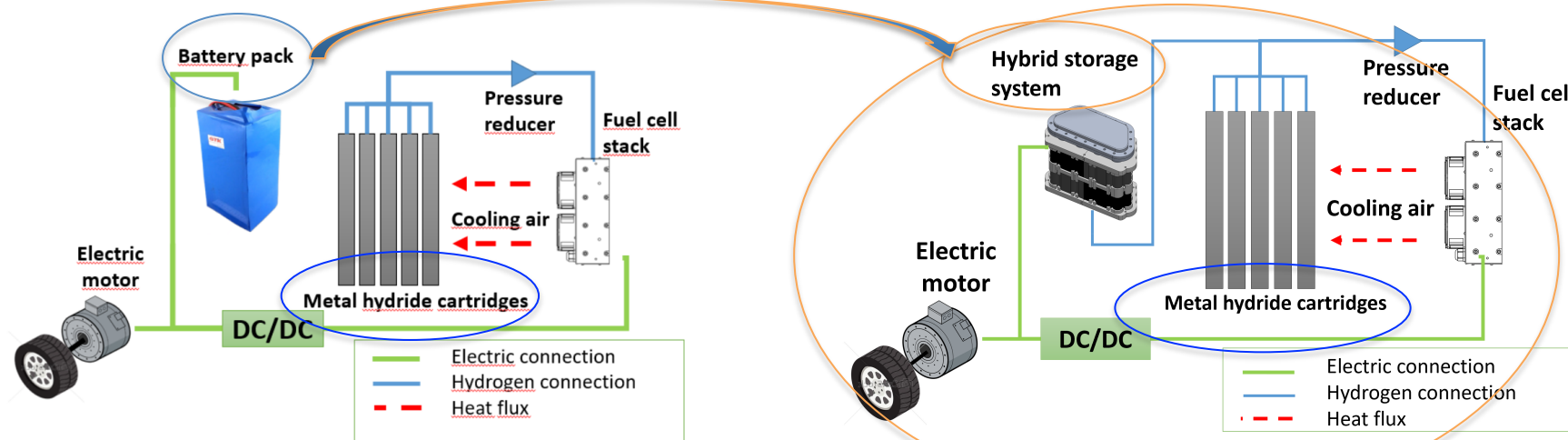
PROTOTYPE DEVELOPMENT AND TESTING



- A prototype of the hybrid storage system was already realized and tested with good results
- The thermal coupling between the metal hydride tank and the battery pack was found able to control the battery cell temperature also in the most stressful conditions



Scooter on-board application



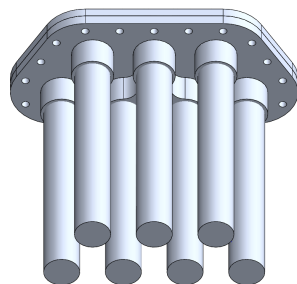
The hybrid storage system replaces the battery pack in the Scooter

- Dimensions: 240x120x200 mm
- Total weight: 10kg
- Total useful energy stored*: 1.4 kWh

Useful energy density*: 140 Wh/kg vs 88.4 Wh/kg
446 Wh/L vs 137 Wh/L

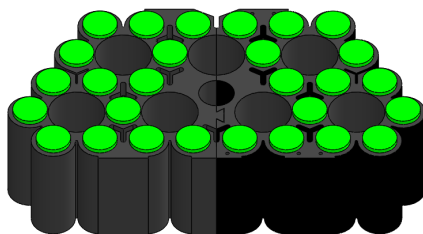
*In the battery pack only 85% DOD has been assumed exploitable. This assumption is usually made to prolong battery life. As for the hydrogen, a Fuel cell efficiency of 55% has been assumed

HYBRID STORAGE SYSTEM FOR PLUG IN FUEL CELL ELECTRIC SCOOTER



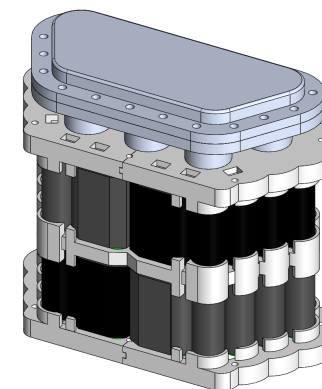
Metal Hydride Tank

- 2 kg of Metal Hydride Alloy
- 34g Hydrogen storable



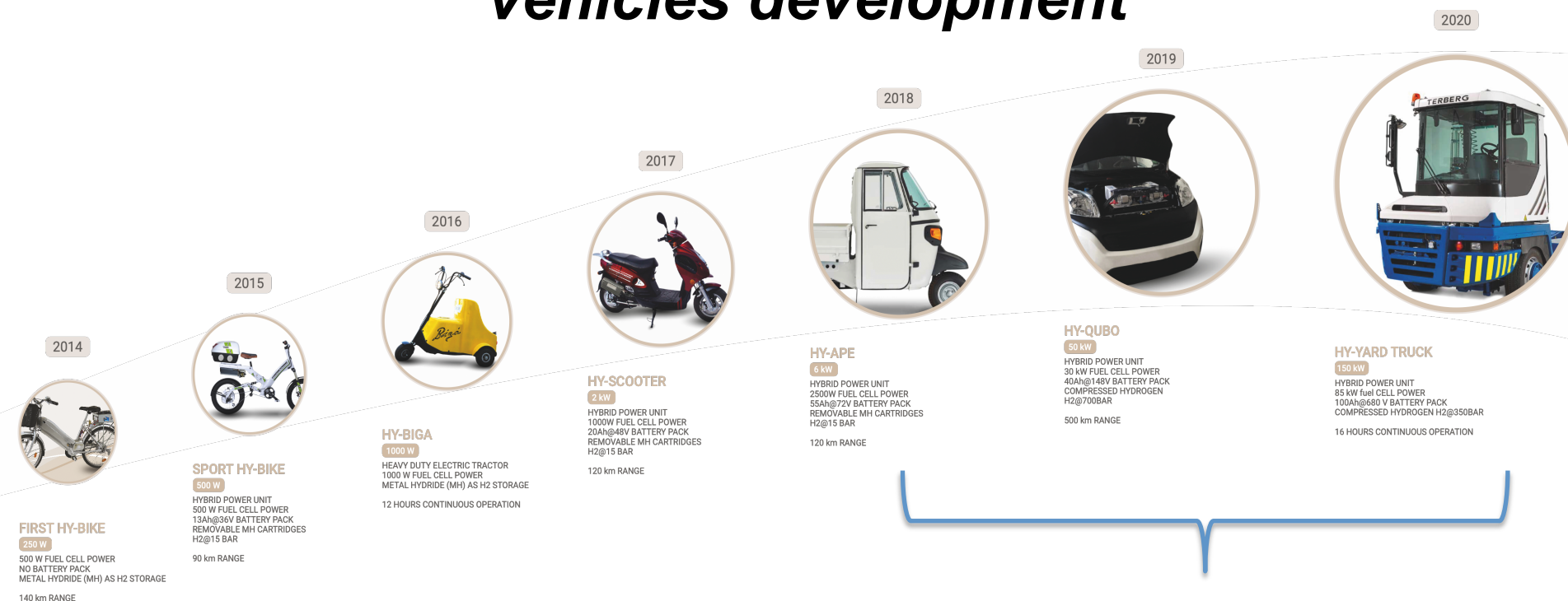
Battery Pack

- 7s 4p battery pack
- 330 Wh nominal capacity
- NCA chemistry



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Power units and fuel cell electric vehicles development



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2018



HY-APE

6 kW

HYBRID POWER UNIT
2500W FUEL CELL POWER
55Ah@72V BATTERY PACK
REMOVABLE MH CARTRIDGES
H2@15 BAR

120 km RANGE



Plug-in fuel cell electric Ape

- 7 kW motor power
- 2.5 kW fuel cell stack
- 500g on-board hydrogen storage capacity
- 72V 40 Ah battery capacity
- New power unit architecture

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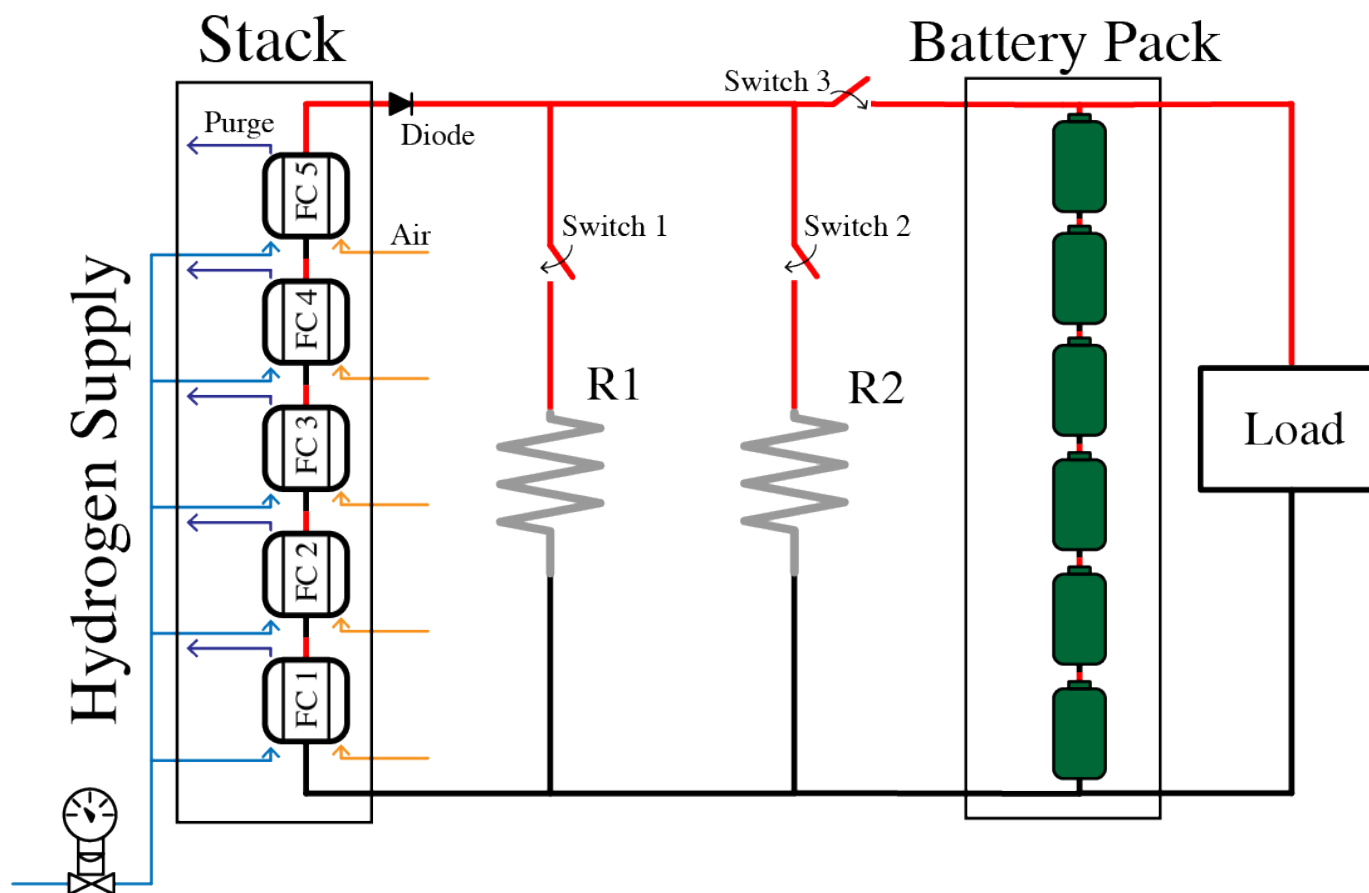


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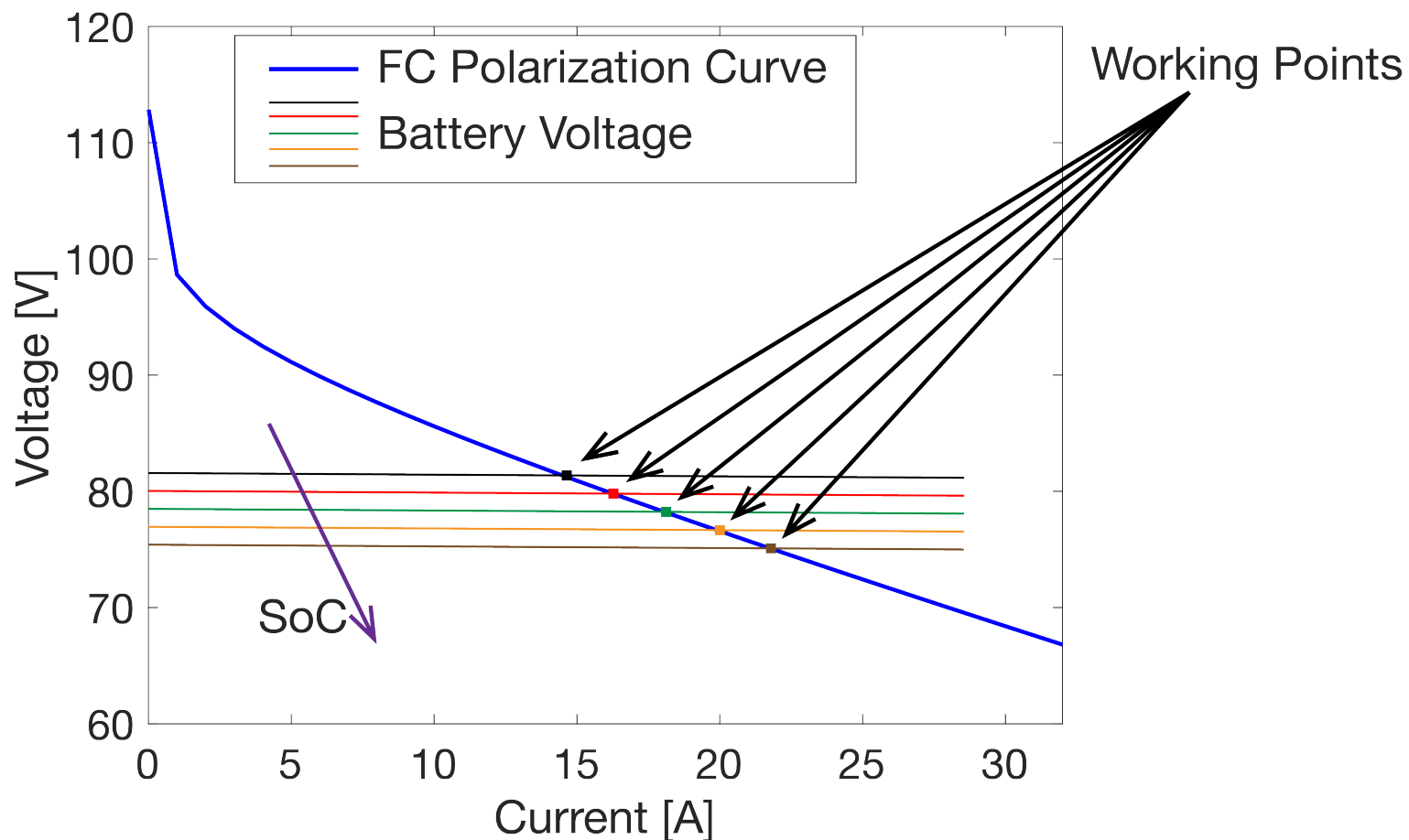


APE POWERTRAIN CONCEPT

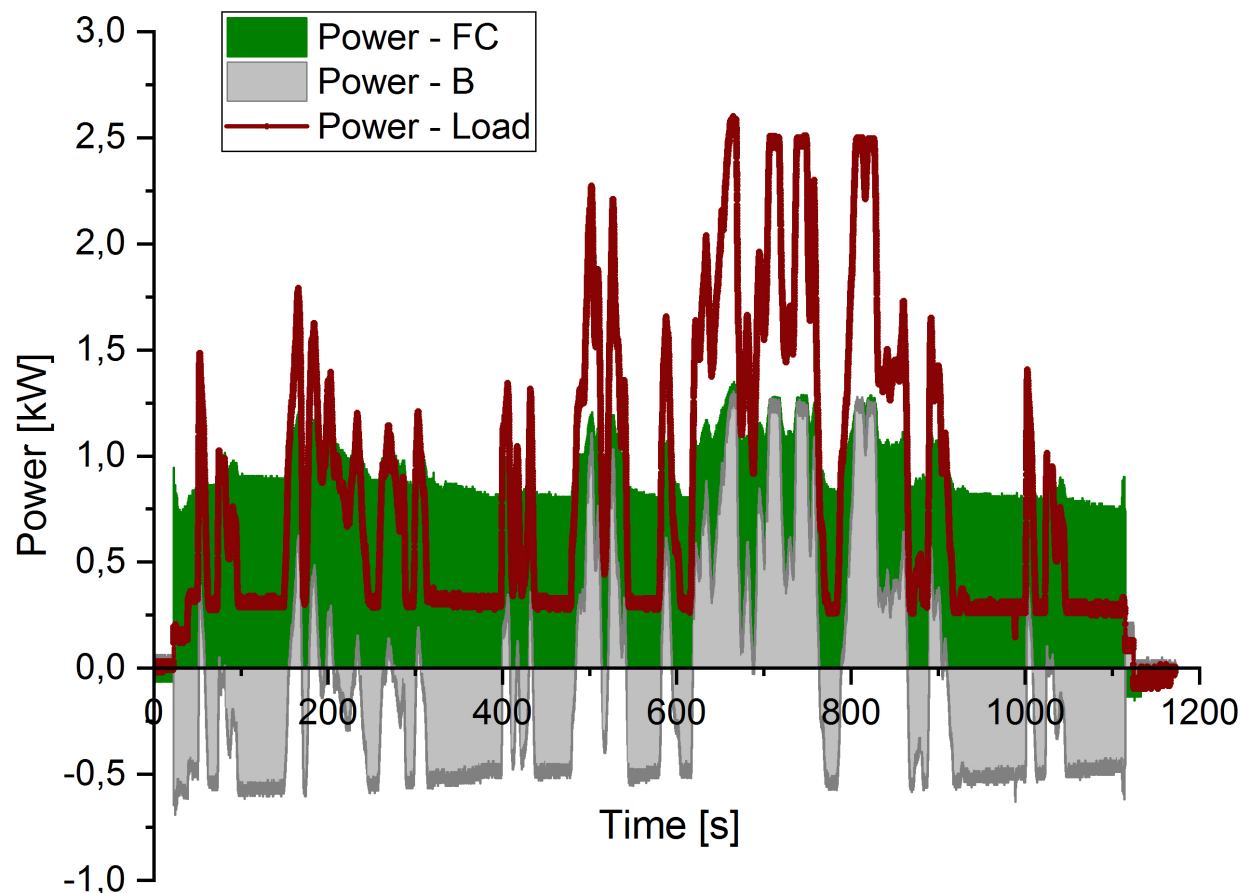
- ❑ Five fuel cells connected in series, Horizon 500W LT-PEM
- ❑ Two resistors (9 Ω each)
- ❑ 72V battery pack, LiFePO₄



0D MODEL



OPERATION



2019

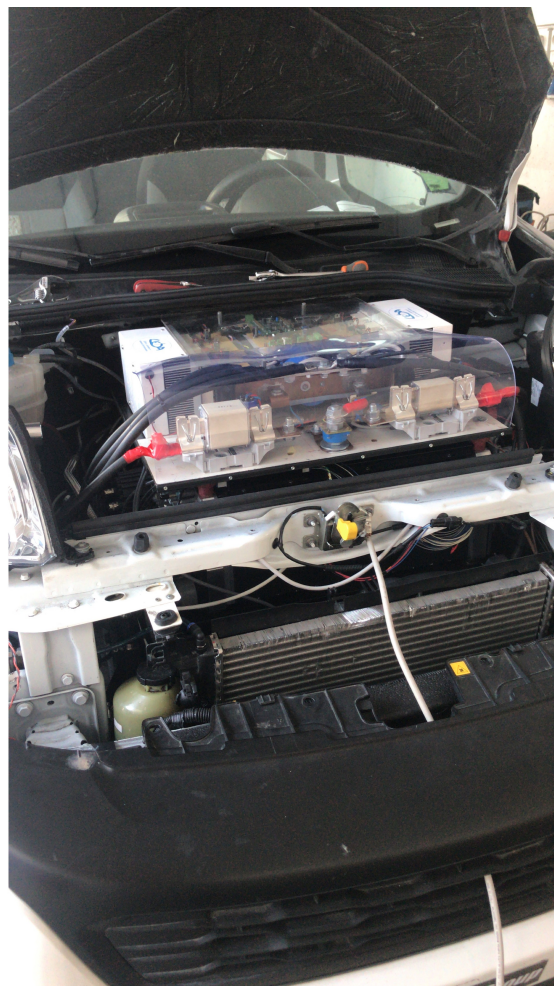


HY-QUBO

50 kW

HYBRID POWER UNIT
30 kW FUEL CELL POWER
40Ah@148V BATTERY PACK
COMPRESSED HYDROGEN
H₂@700BAR

500 km RANGE



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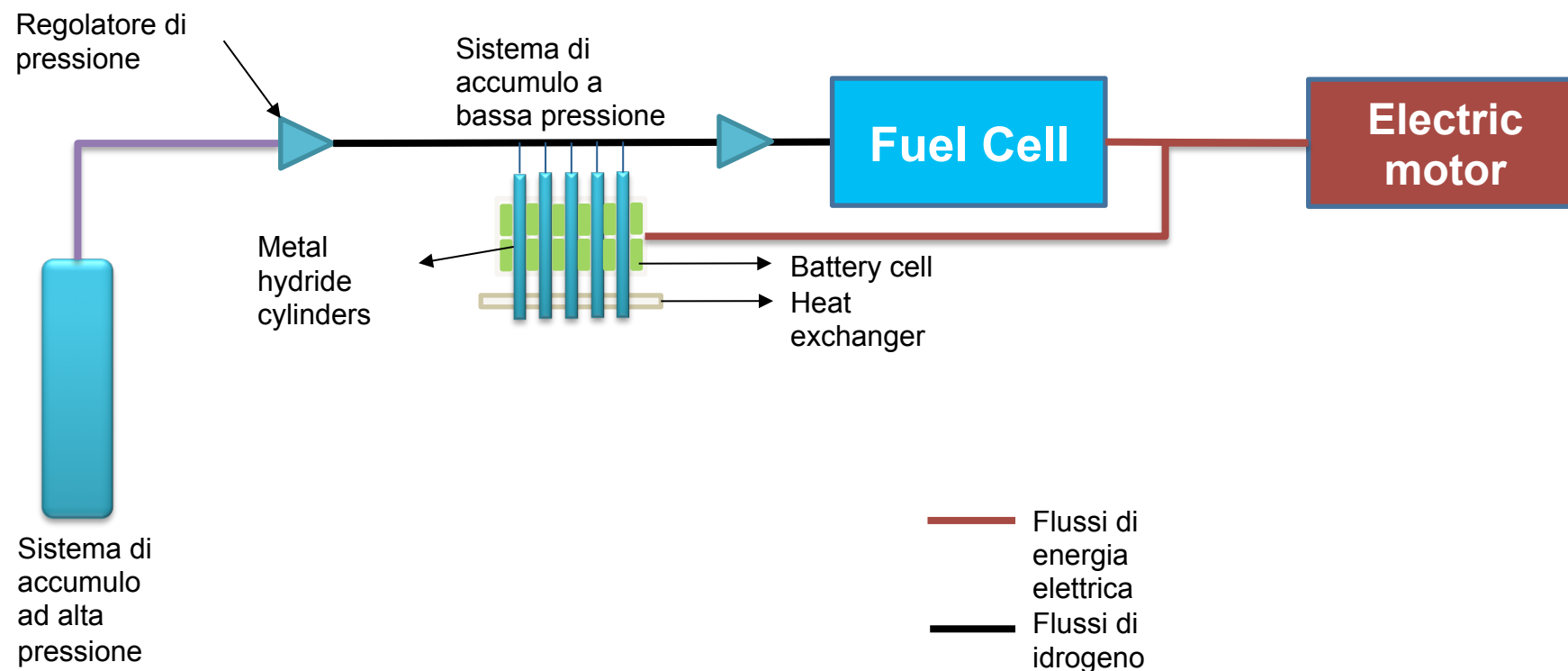
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Qubo: the novel configuration with the hybrid energy storage system



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FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING



This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 826339. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.

2020



H2Ports

Implementing Fuel Cells and Hydrogen Technologies in Ports

HY-YARD TRUCK

150 kW

HYBRID POWER UNIT
85 kW fuel CELL POWER
100Ah@680 V BATTERY PACK
COMPRESSED HYDROGEN H₂@350BAR

16 HOURS CONTINUOUS OPERATION

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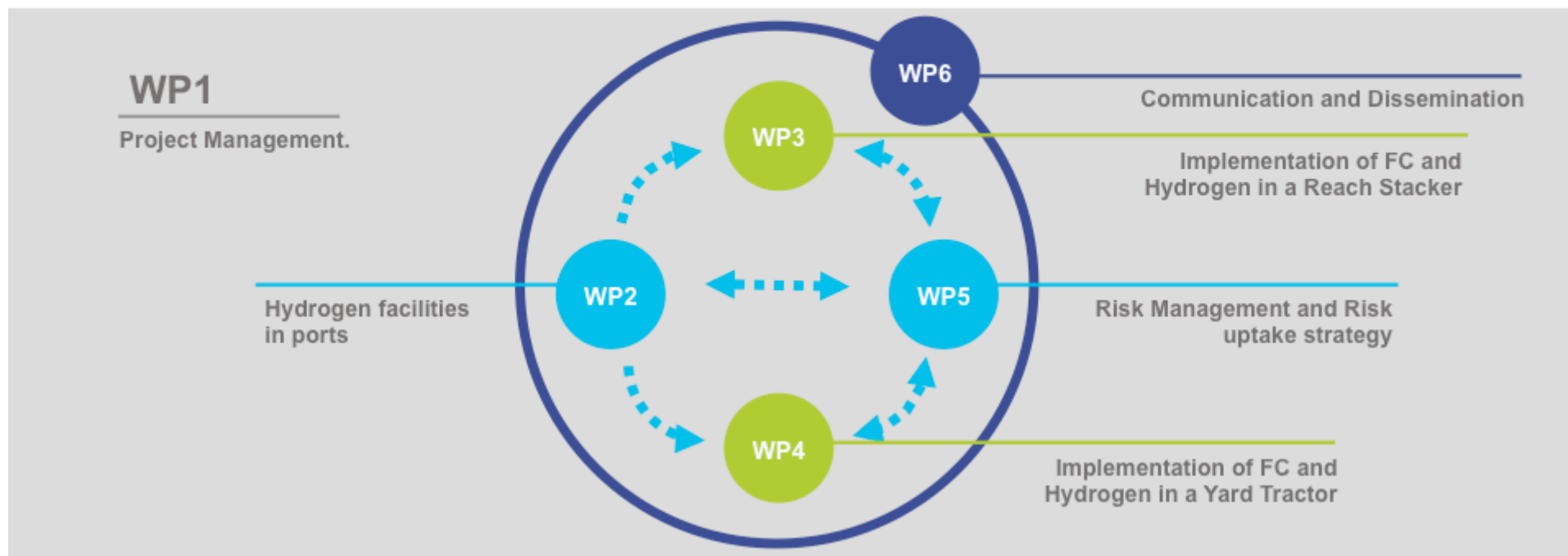
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Project Structure



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WP4 4x4 FC Yard Truck @ Grimaldi Terminal



FCHJU funding € 1,100,000 approx.



ATENA, Grimaldi Group, Ballard,
National Hydrogen Centre,
Fundacion Valenciaport



Development and deployment a
4x4 Yard Tractor equipped with a
Fuel Cells and test it in Valencia
Terminal Europa (Grimaldi Group).
It involves three tasks:

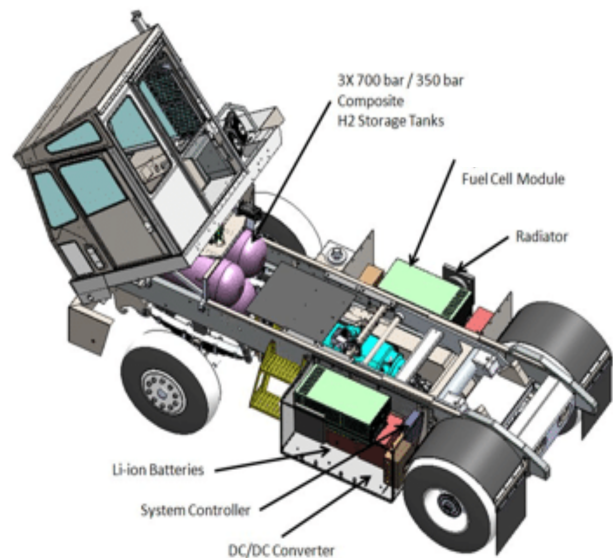
- Design of the new FCEV YT
- Assembling of new components
in the YT
- Testing and Piloting of the
FCEV YT in Valencia, Spain

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Conversion to an Electric Vehicle

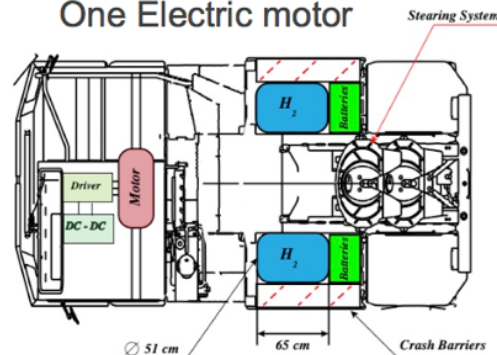
Hybrid Hydrogen Yard Tractor

Complete Projects

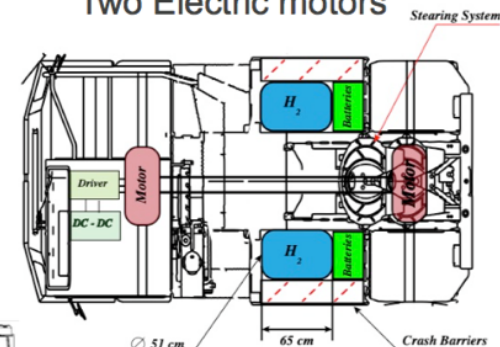


Powershift trasmission

One Electric motor

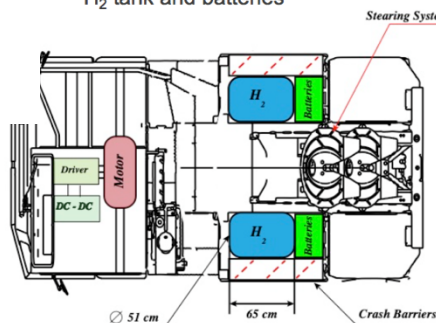


Two Electric motors

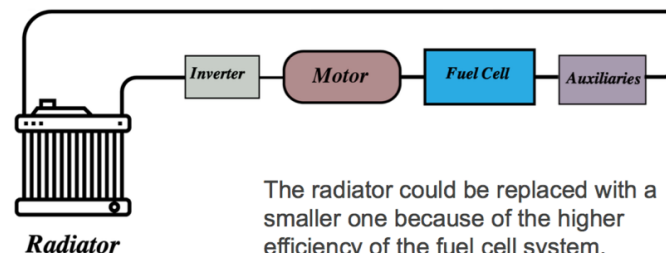


FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

H₂ tank and batteries



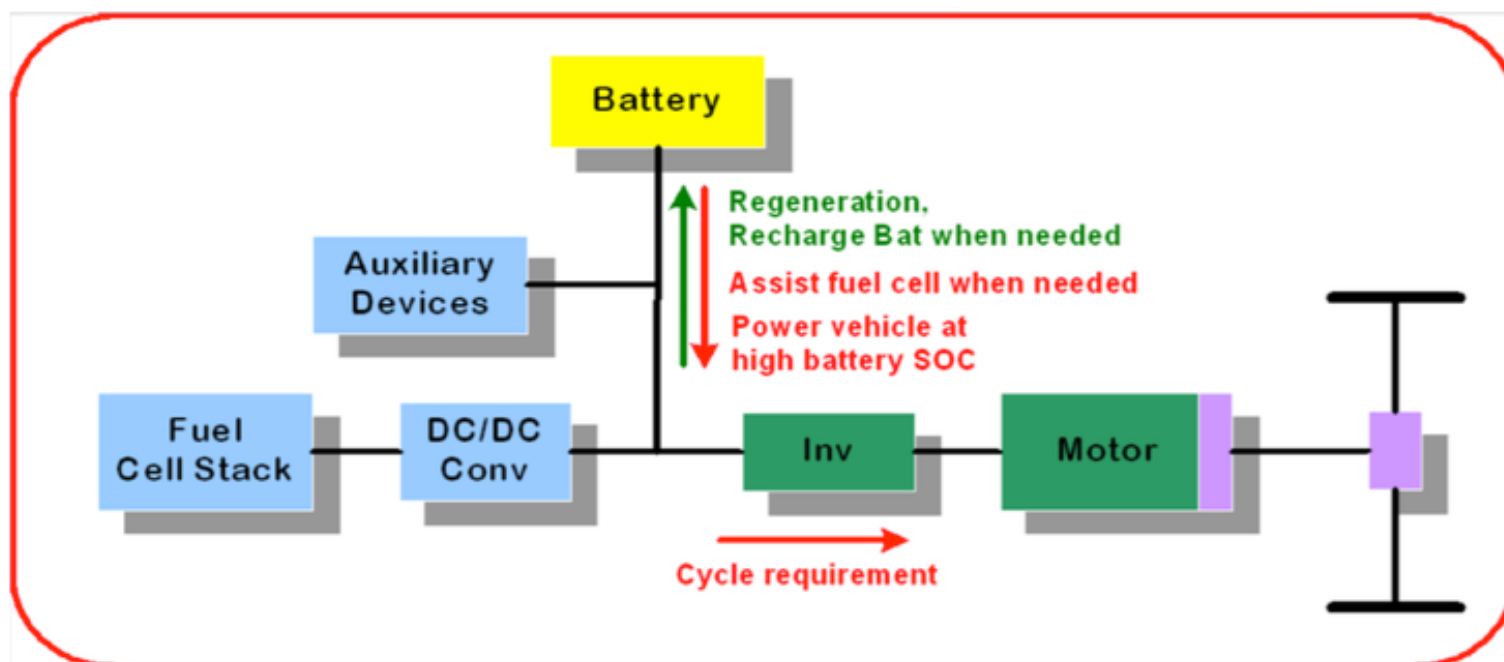
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JOINT UNDERTAKING



The radiator could be replaced with a smaller one because of the higher efficiency of the fuel cell system.

Cooling systems

Hybrid power train architecture



FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING



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ENEA

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Techno-economic assessment of refueling stations

On site hydrogen production

- Hydrogen production from biogas
- Hydrogen production from ammonia
- Hydrogen production from PV/electrolysis

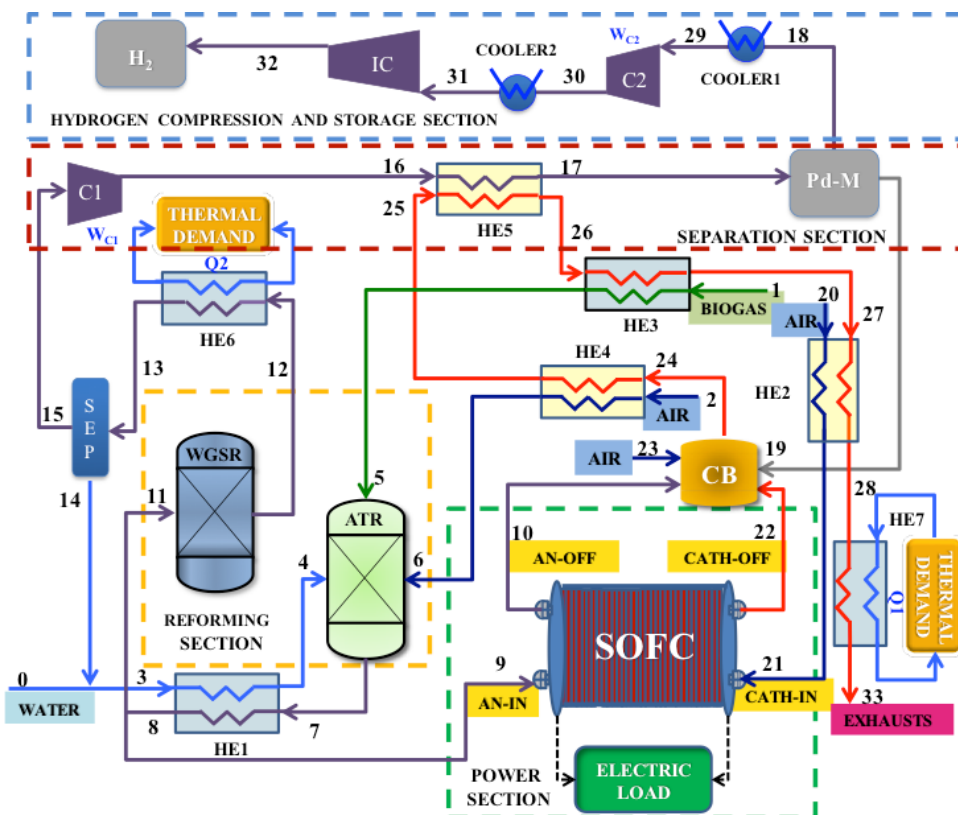
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• **Hydrogen production from biogas**



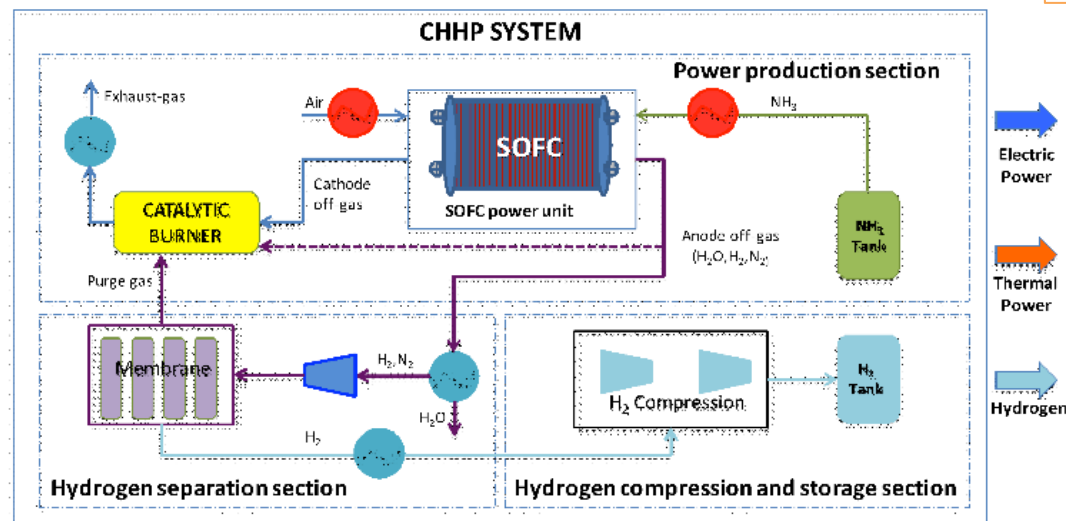
ATR (or SR) process
70 kg/h biogas (LHV 17.7kJ/kg)
SOFC: 38 kW (DC gross power)
Heat: 110 kW
H₂: 100 kg/day, 820 bar

Hydrogen production efficiency (%)	42.6
Thermal production efficiency (%)	35.6
Overall efficiency (%)	78.2
LCOH (€/kg)	6.6

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- Hydrogen production from ammonia**

SOFC 21 kW (DC)
NH₃: 37 kg/h
H₂: 100 kg/day, 820 bar



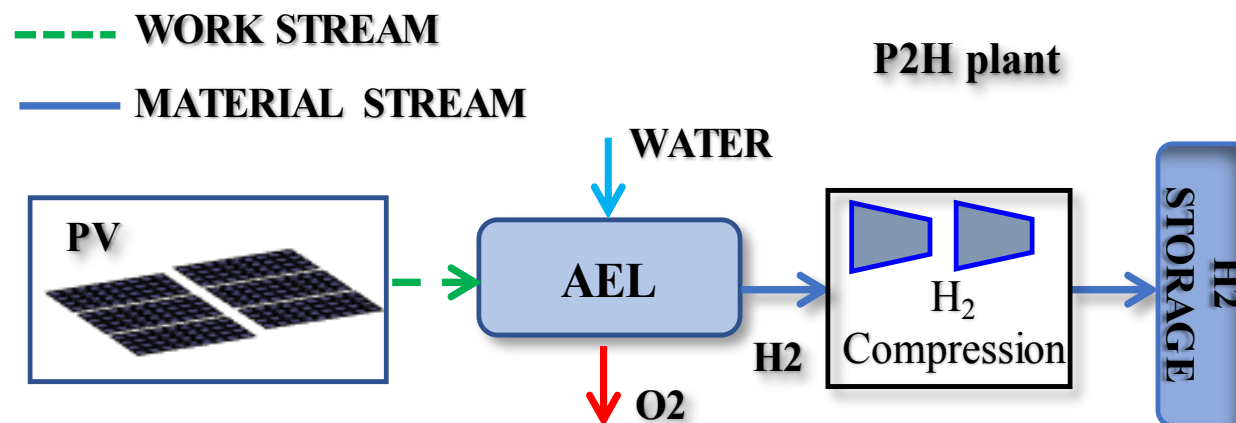
	H ₂	H ₂ + EV Charging
Electric efficiency (%)	-	14
Thermal efficiency (%)	11	15
Hydrogen production efficiency (%)	70	42
Overall efficiency (%)	81	71
LCOH (€/kg)	9.6	10.4

SOFCs: 35/40 kW (DC)
NH₃: 62 kg/h
H₂: 100 kg/day, 820 bar
50 kW DC fast charging

Research activities conducted with the collaboration with KIST

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- **Hydrogen production from PV/electrolysis**



PV plant size: 94 kWp
Grid connected
AEL, 4.9 kWh/Nm³ (10 bar)
H₂: 22 kg/day (10 Nm³/h), 350 bar

LCOH 19.1 (€/kg)

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