

Verso una piattaforma italiana per l'idrogeno e le celle a combustibile

**2° WORKSHOP TOSCANO SULL'IDROGENO e TECNOLOGIE COLLEGATE
OPPORTUNITA' e FINANZIAMENTI**

Firenze, 25 Luglio 2014



Advanced Energy Storage and Management in Electric Vehicles

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SCUOLA DI INGEGNERIA



UNIVERSITÀ DI PISA

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H2 “Filiera Idrogeno” project (2006-11)



Regione Toscana



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Regione Toscana

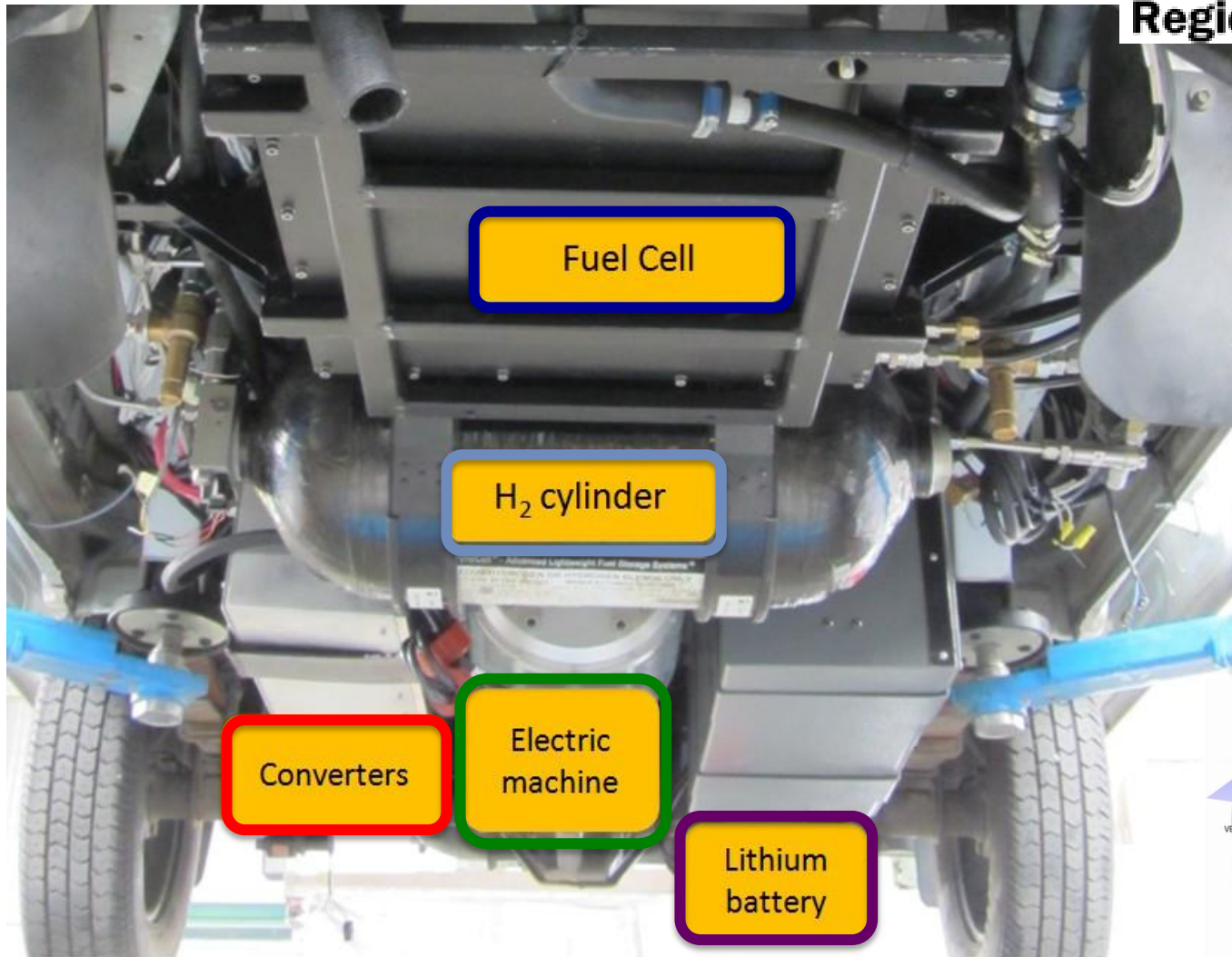
Fuel Cell and Lithium-ion battery hybrid energy storage



H2 “Filiera Idrogeno” project (2006-11)



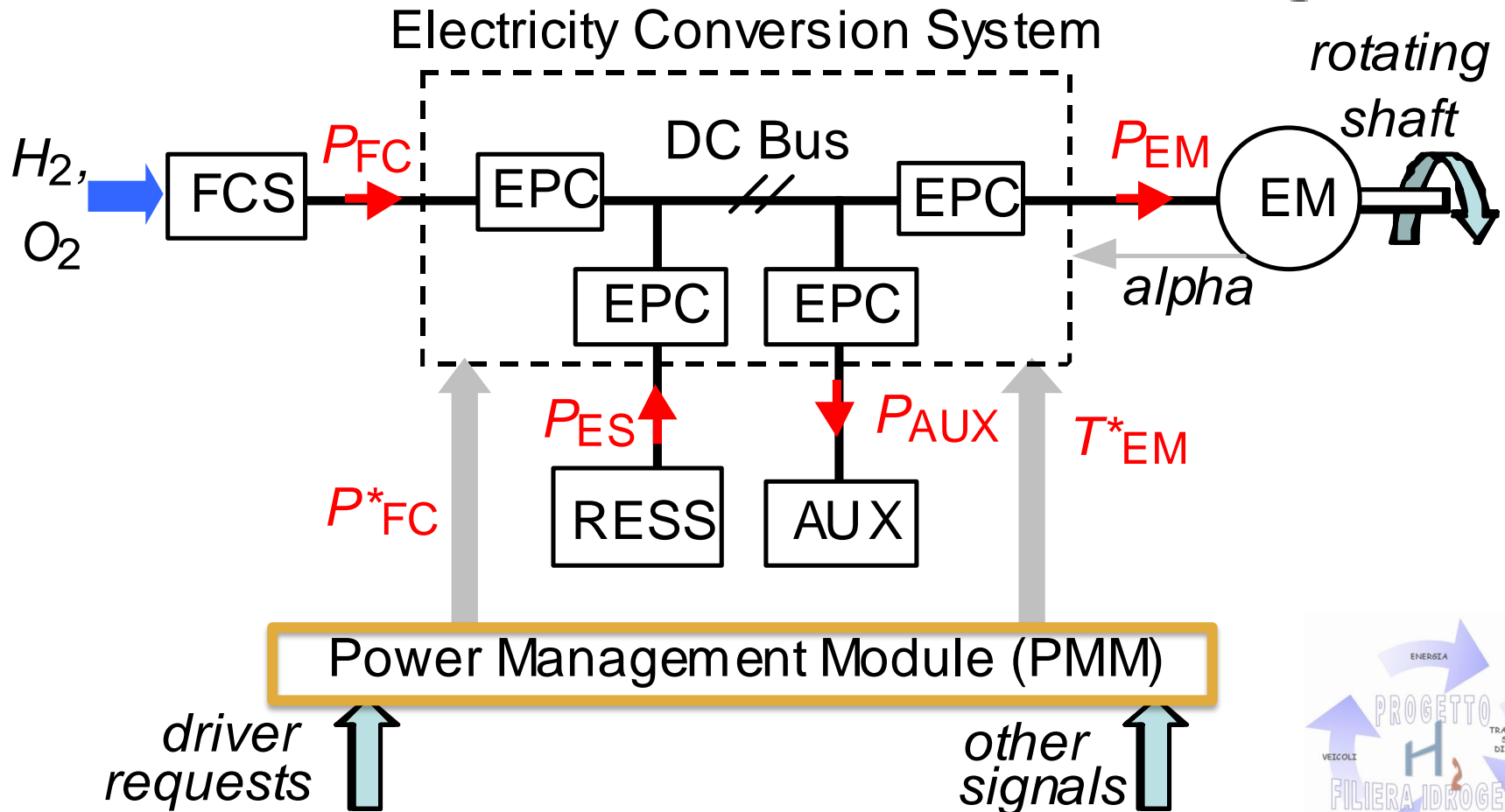
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Series Hybrid Power Train



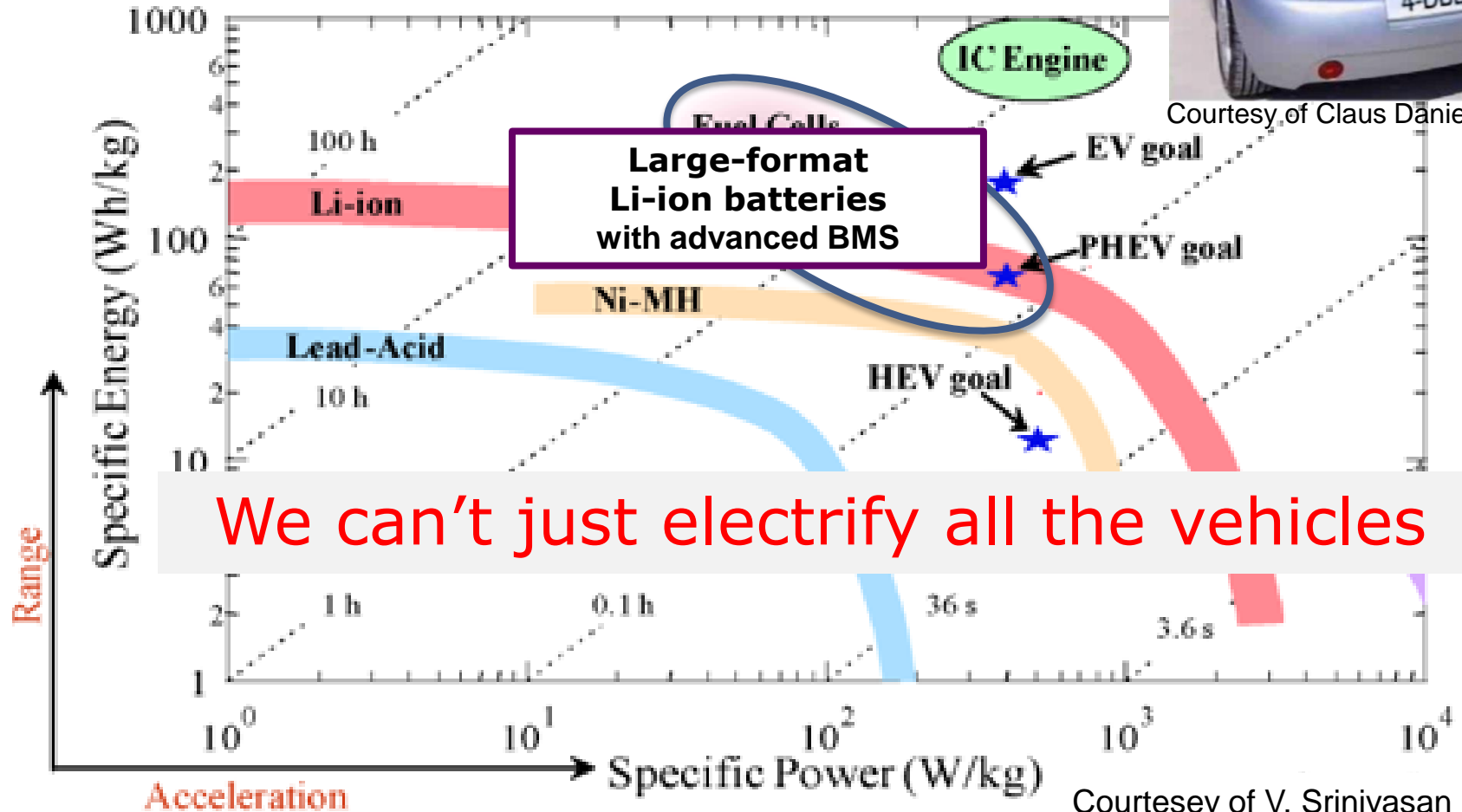
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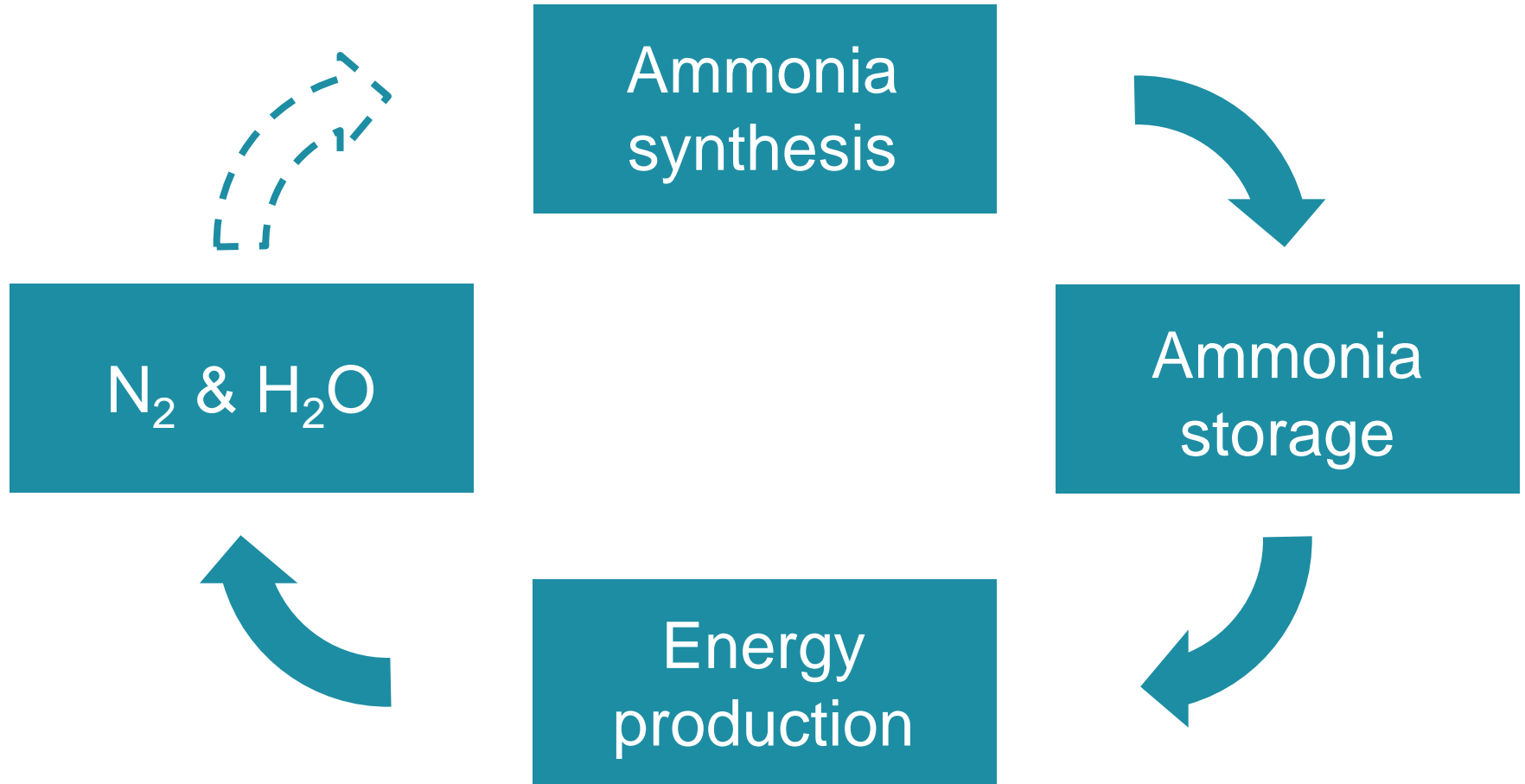
Onboard Energy Storage Systems



Courtesy of Claus Daniel, ORNL



Ammonia Opportunity



Progetto SAVIA



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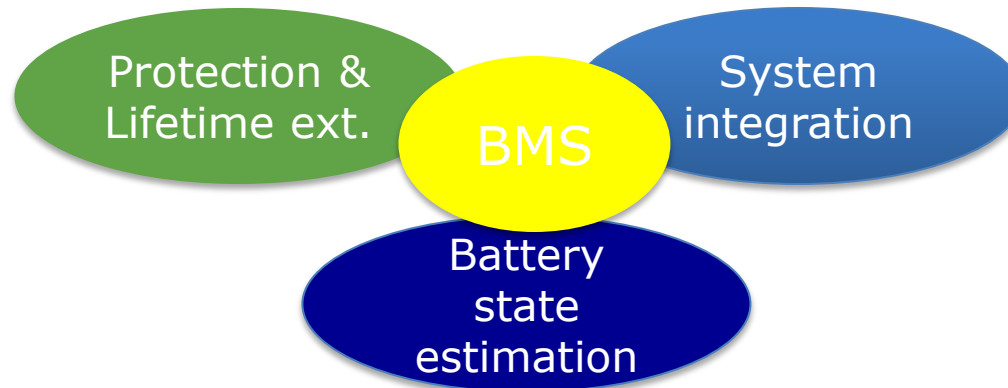


- Series hybrid power train
- ICE powered with NH_3 and a tiny quantity of H_2 used to recharge the battery (**range extender**)
- H_2 is produced onboard by NH_3 cracking



Battery Management System

- Cell voltage, temperature and current measurement
- Main switch control
- Charge equalization
- Thermal management
- Data/Event logging
- Communication w/ other sub-systems
- Diagnostics

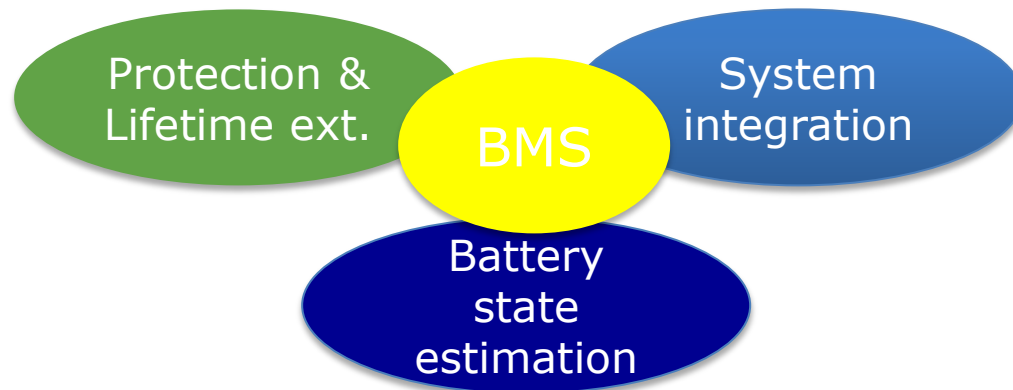


- State-of-Charge estimation (SoC)
- State-of-Health estimation (SoH)
- Residual useful life (RUL)

BMS Functions Partitioning and Mapping

- Cell voltage, temperature and current measurement
- Main switch control
- Charge equalization
- Thermal management

- Data/Event logging
- Communication w/ other sub-systems
- Diagnostics

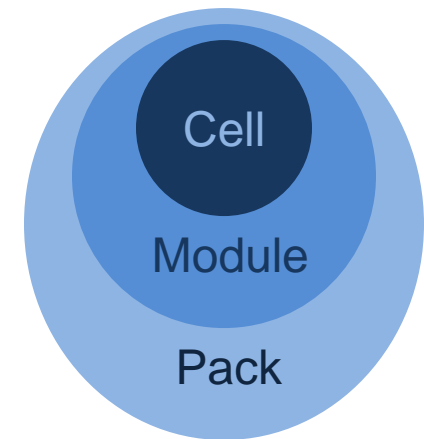


- State-of-Charge estimation (SoC)
- State-of-Health estimation (SoH)
- Residual useful life (RUL)

BMS functions

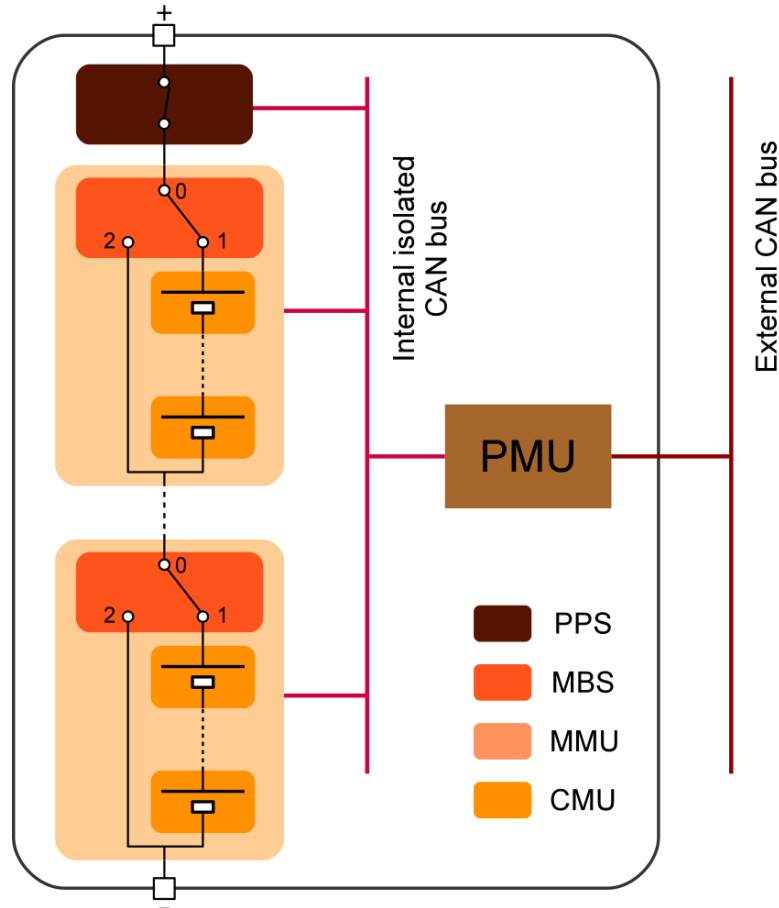
Mapping

Physical battery partitioning

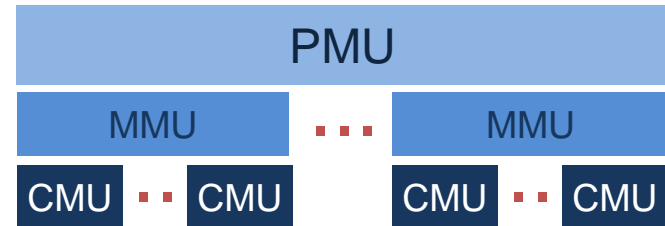


Hierarchical platform

BMS Hierarchical Platform



Vehicle Management System



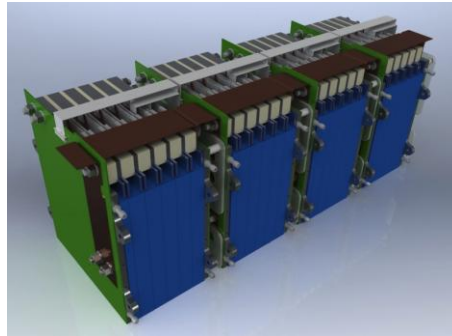
- PMU (Pack Management Unit)
- MMU (Module Management Unit)
- CMU (Cell Monitoring Unit)
- PPS (Pack Protection Switch)
- MBS (Module Bypass Switch)

H₂ BMS

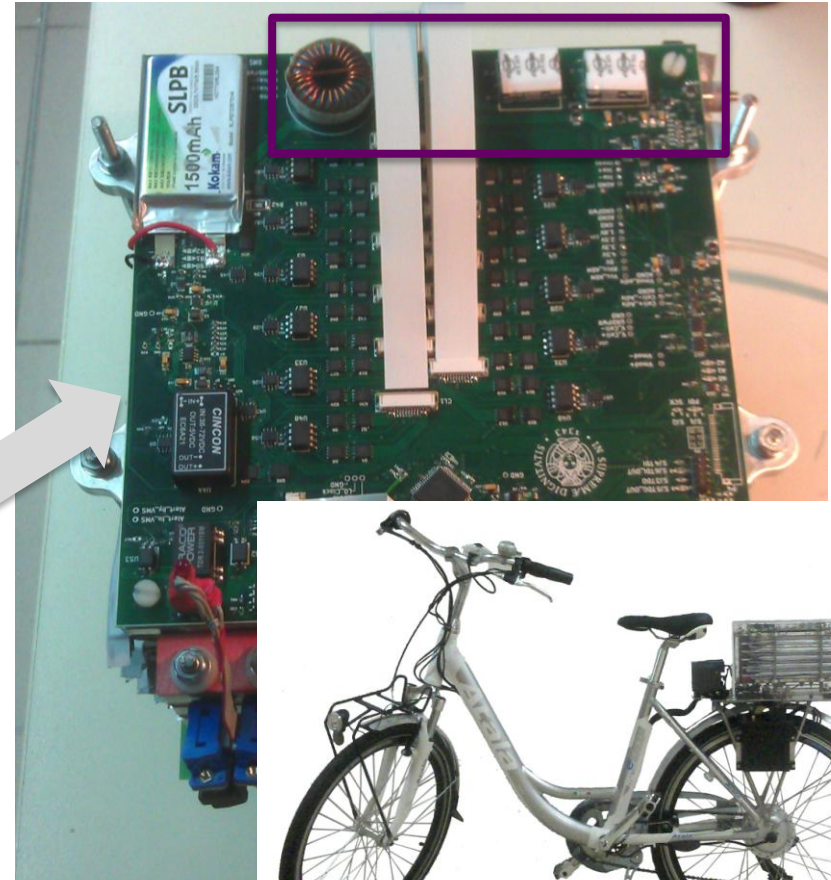
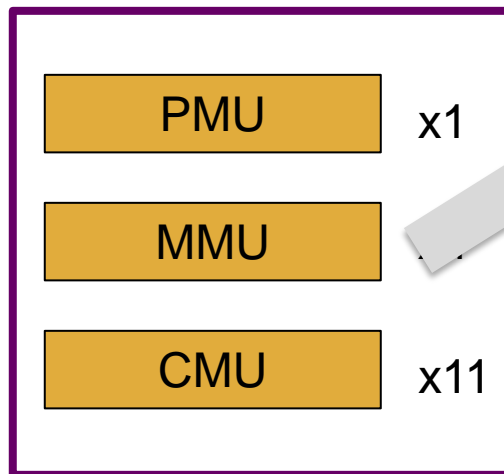


Regione Toscana

- 11x NMC cell per module
- 4x modules

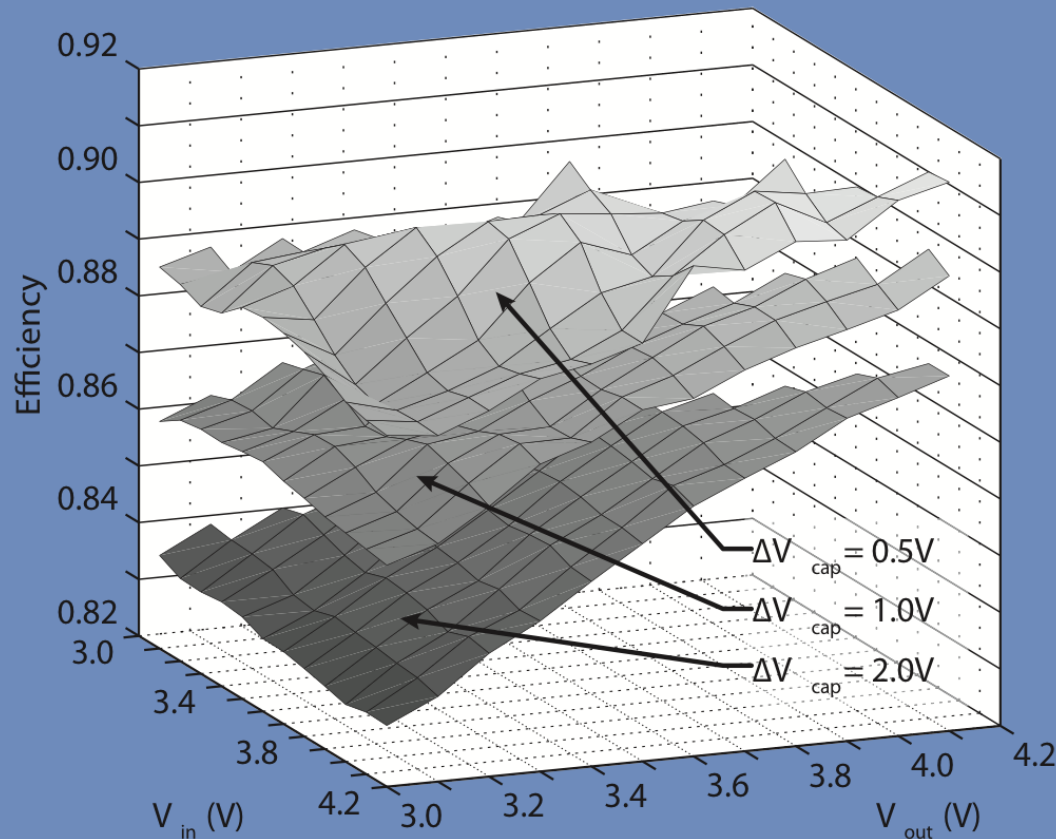


H₂ BMS architecture





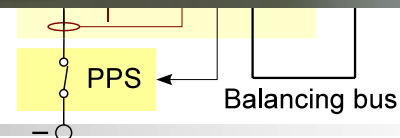
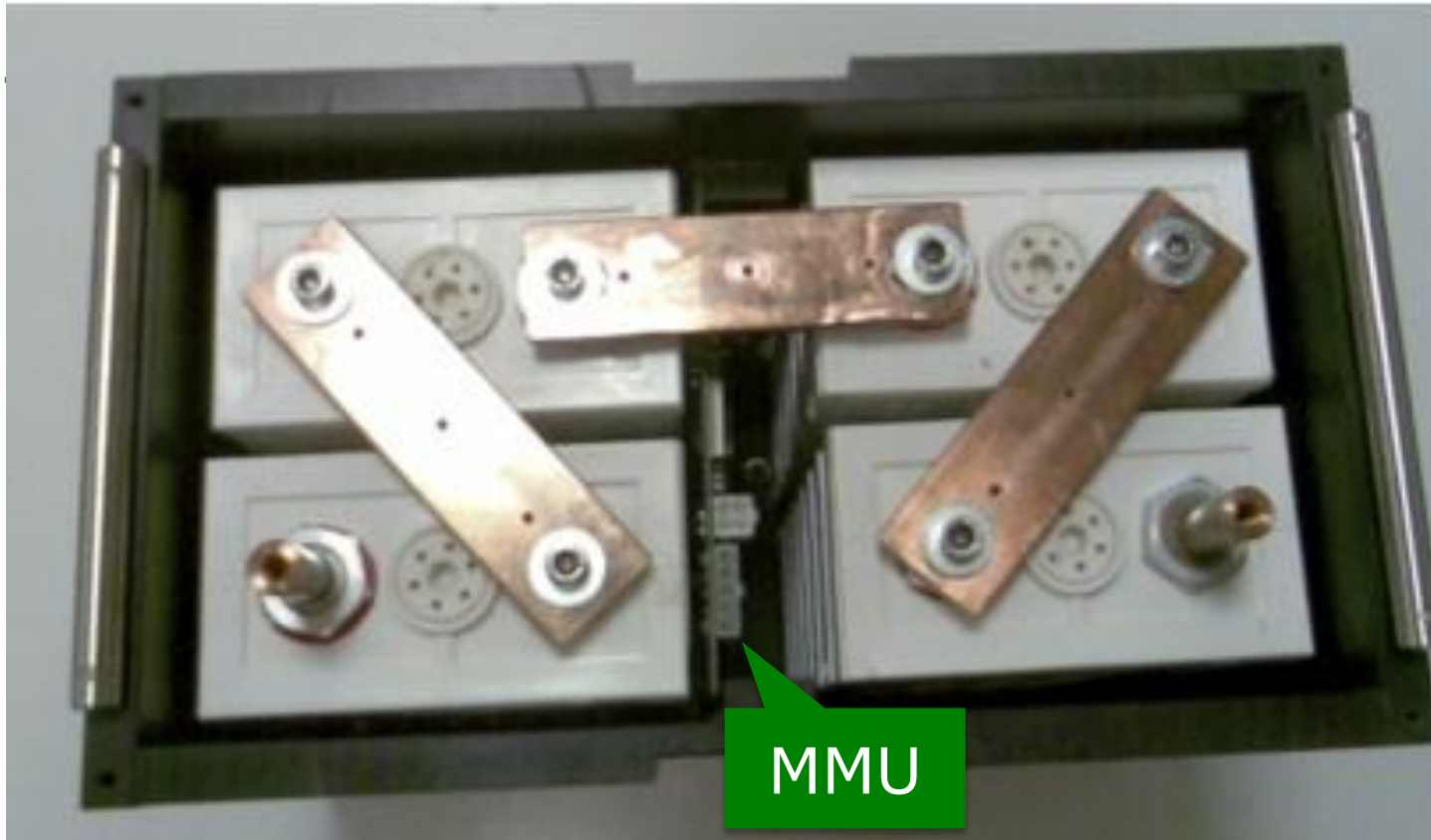
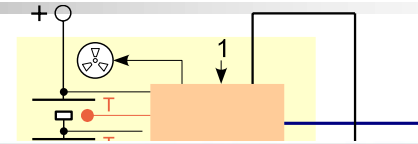
Active charge equalizer based on a highly efficient Buck-Boost DC/DC converter with a supercapacitor as energy tank



F. Baronti et al. "High-Efficiency Digitally-Controlled Charge Equalizer for Series-Connected Cells based on Switching Converter and Super-Capacitor" in *IEEE Trans. on Ind. Informat.*, 2013

12V BMS

4x LiFePO₄ cell per module



Conclusions

- Experiences and expertise in H₂ Fuel Cell related technologies:
 - Power management in hybrid power train
 - Battery Management Systems
 - System integration and testing
- Willing to share our know-how and to contribute to new projects

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Mission: The ES-TC aims at providing an open, multi-disciplinary and dynamic environment to foster the aggregation and collaboration among experts from academy and industry interested in testing, modeling, managing, and deploying energy storage systems. The main focus is on rechargeable batteries and super-capacitors, but attention is also drawn to other innovative energy storage technologies. An

Thanks for your attention!

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