"Driving the Future: Unveiling Breakthroughs in Electric Vehicle Technologies - Insights from European Research and Innovation"

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Li-ion and hybrid supercapacitor batteries and DC charging for lightweight electric vehicles

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Multi-Moby: Battery and charging (WP4)

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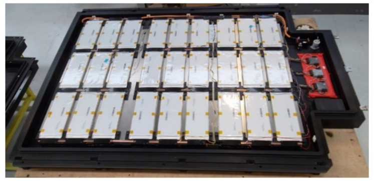


@100V




@48V

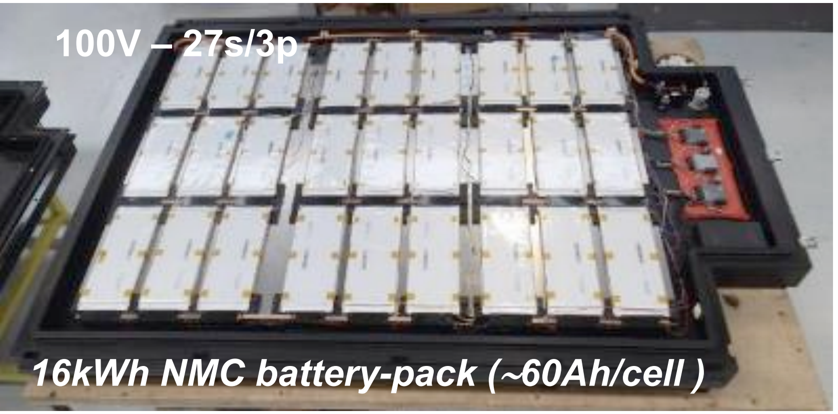
Contribution is in topic area (x):	
x	Powertrain design and assessment
x	Energy efficiency of vehicle sub-systems
	Electric/electronic/sensing architectures enabling autonomy and security of electric vehicles
x	Passive and active safety of electric vehicles
	Simulation tools for the rapid assessment and development of electric vehicles
	Product life cycle assessment, materials combination, eco-design, and other recyclability aspects

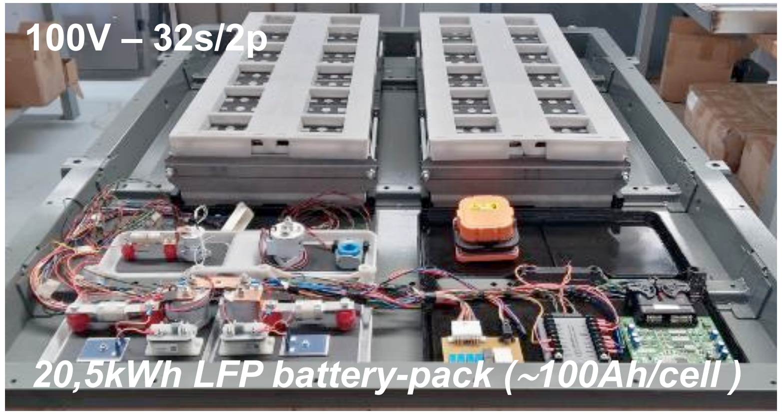
Contribution summary

- The Multi-Moby e-vehicle is a passive and actively safe and lightweight L7/M1 eV aimed for use in urban environments
- Several battery solutions were researched and developed:
  - NMC pouch cells and LFP prismatic cells (high energy)
  - Hybrid supercapacitor (HSC) cylindrical cells (high power)
- DC low voltage charging at 48V and 100 V for efficiency
- Extensive safety focused stress and abuse tests with HSC
- Some conclusions for HSC:
  - 100% fire safety is possible with HSC
    - For example 21700 cells with Current Interrupting Device
  - Newer cells reach > 200 Wh/kg and are on-par with Li-ion

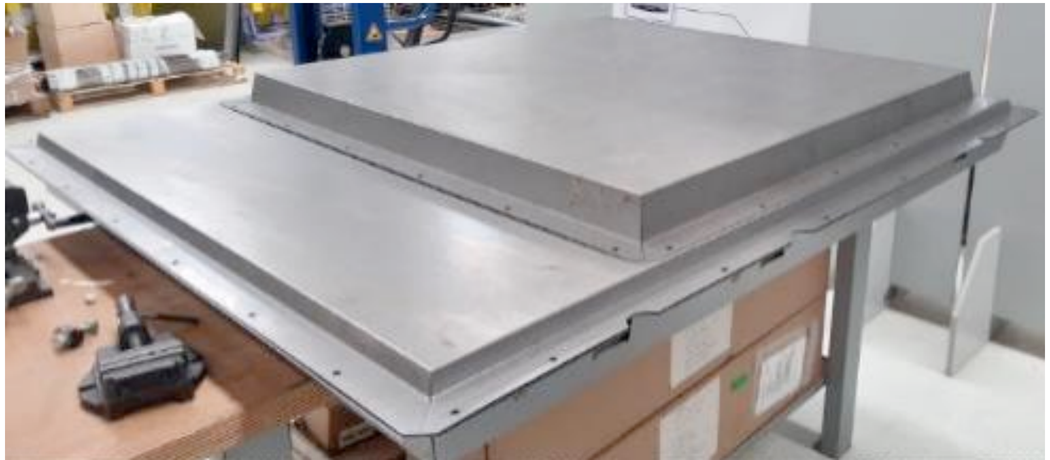
Battery packs developed

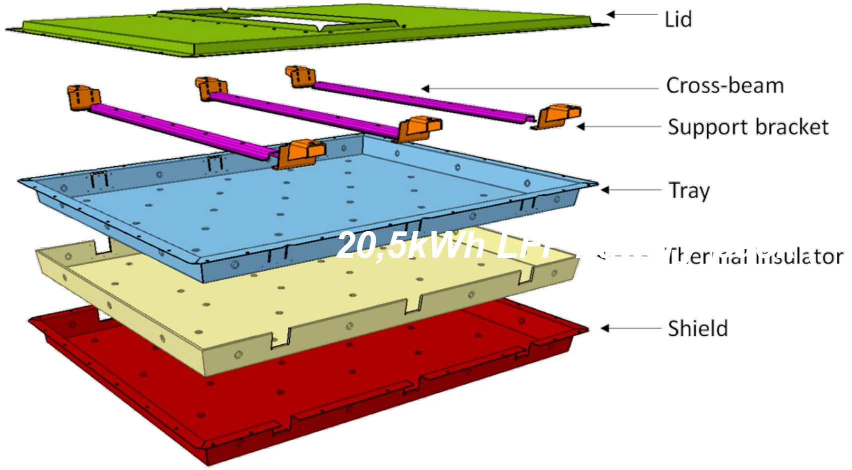
– NMC Pouch cells – LPF prismatic – LTO Hybrid Supercapacitors





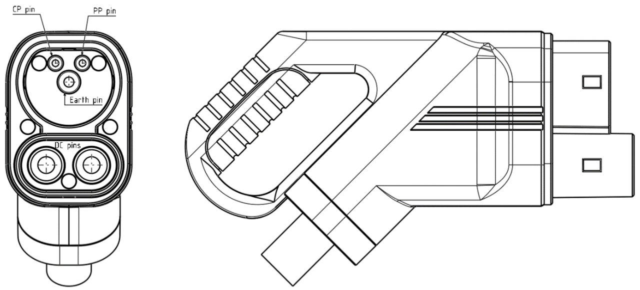
Cost-efficient battery box: thermally insulated – automated laser cutting and folding of light-weight steel metal sheets





Why DC charging?

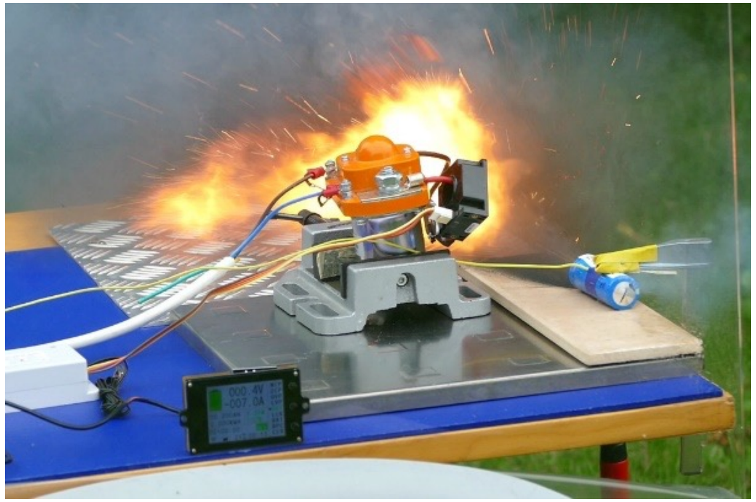
- AC charging:
  - Connected to grid
  - AC/DC in vehicle extra weight and space in vehicle
  - Heat losses in vehicle
- DC charging:
  - Complexity of AC/DC in wall mounted box
  - Less complexity and losses in vehicle
  - Reuse of CCS2 connector, etc.
- Developed by Bitron with IFEVS (3 kW 48V - 7 kW 110V)

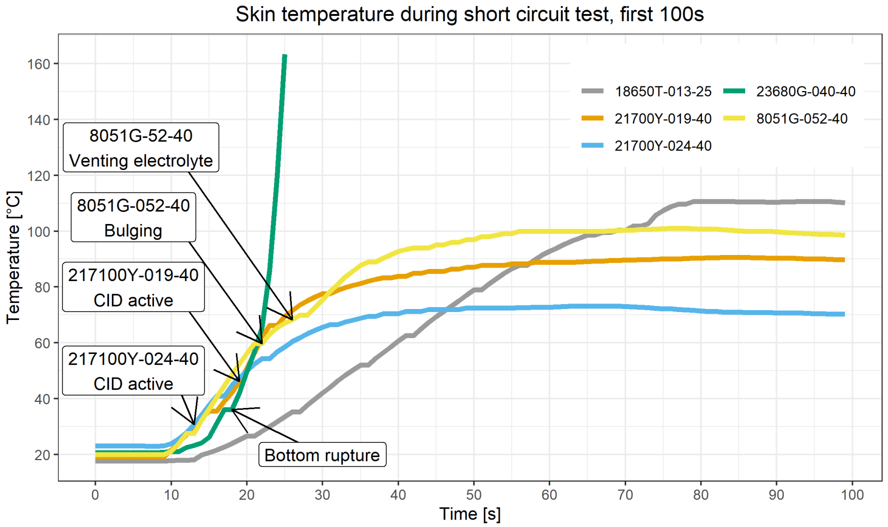


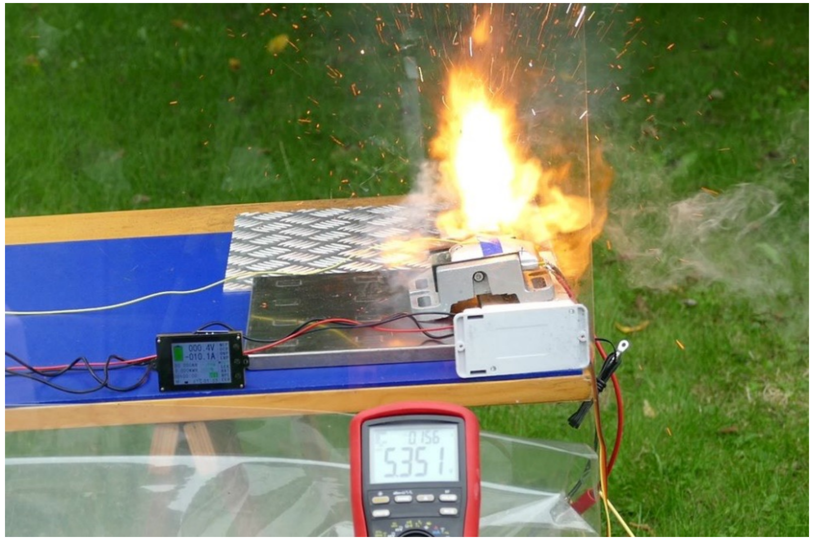
Pro & cons of Li-ion vs HSC

	Li-ion	HSC
Energy density	160 Wh/kg (LFP) – 230 Wh/kg (NMC)	80 Wh/kg, 130 Wh/kg upto 200 Wh/kg
Power	< 1C, peaks to 3C, 4C	10C, < 4C (power vs. energy cell type)
DoD	60 to 80%	96%
Cycle life	typ. 3000	typ. 10000 - 20000
Thermal range	-10 to 45°C typ.	- 30 to +70°C typ.
Safety	Dendrites! Short-circuit fault mode	No dendrites.
Short circuit / overcharging risk	Low probability but catastrophic	Low probability and open-circuit fault mode (not for all cells)
Charging	30 minutes to hours	Can be very fast (10C = 6 minutes)

Stress and abuse tests on HSC







Hard short-circuit tests and overcharging tests:

- Can go very fast: 10 to 20 seconds
- Electrolyte evaporates and ignites

- Greatest risk induced externally by faulty BMS or charger
- Most BMS identified are not fault-tolerant!

Can HSC make batteries ultra-safe?

- CID device was shown to be crucially important
  - Current is interrupted) and heat generation stops
  - But not generally used (also in Li-ion battery cells)
- Not sufficient to have overpressure valve
- Only possible with cylindrical cells
- Use of silicon gel can contain avalanche effect

Overcharging tests	18650T-013-25 cylindrical alu. 2 pins)	21700Y-022-40 cylindrical steel top/bottom	21700Y-024-40 cylindrical steel top/bottom	8051G-053-40 pouch
Current [A]	5	10	10	10
Voltage @ failure [V]	4.81	5.26	5.40	7.20
Result	Explosion fire	CID triggered Cell open circuit	CID triggered Cell open circuit	Explosion fire
Max temp. incr. [°C]	55.2 (silicone)	56.0	21.2 (silicone)	75.8
Safety	**No**	**Yes**	**Yes**	**No**

Some conclusions

- Low Multi-Moby vehicle weight reduces battery size
- 4.9 kWh/100 km (WLTP) 8.4 kWh/100 km (Artemis)
- 15 kWh battery sufficient for up to 300 km (urban type driving)
- LFP batteries today best option for Li-Ion (=> Na-ion ?)
- Newest HSC reach same energy density with safety and operational benefits (temperature, power, …)
- Today's drawback: currently more expensive (volume issue)
  - But: sustainability is also long life and less maintenance costs
- Battery cells, BMS and charger design need to designed for faults to increase fire safety

Q & A

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