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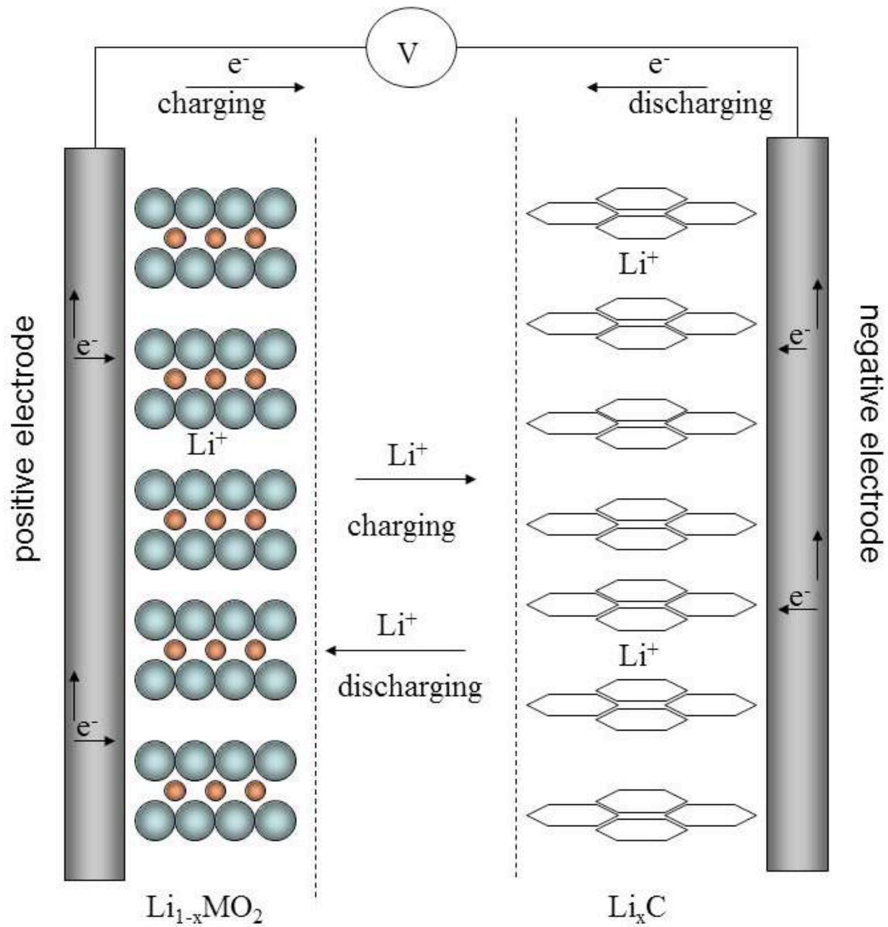
Mobility, Logistics and
Automotive Technology
Research Centre

Next Generation Battery Technologies & Thermal Management for BEVs

Where Technology meets Society,
Where Mobility meets Technology,
Where Logistics meets Sustainability

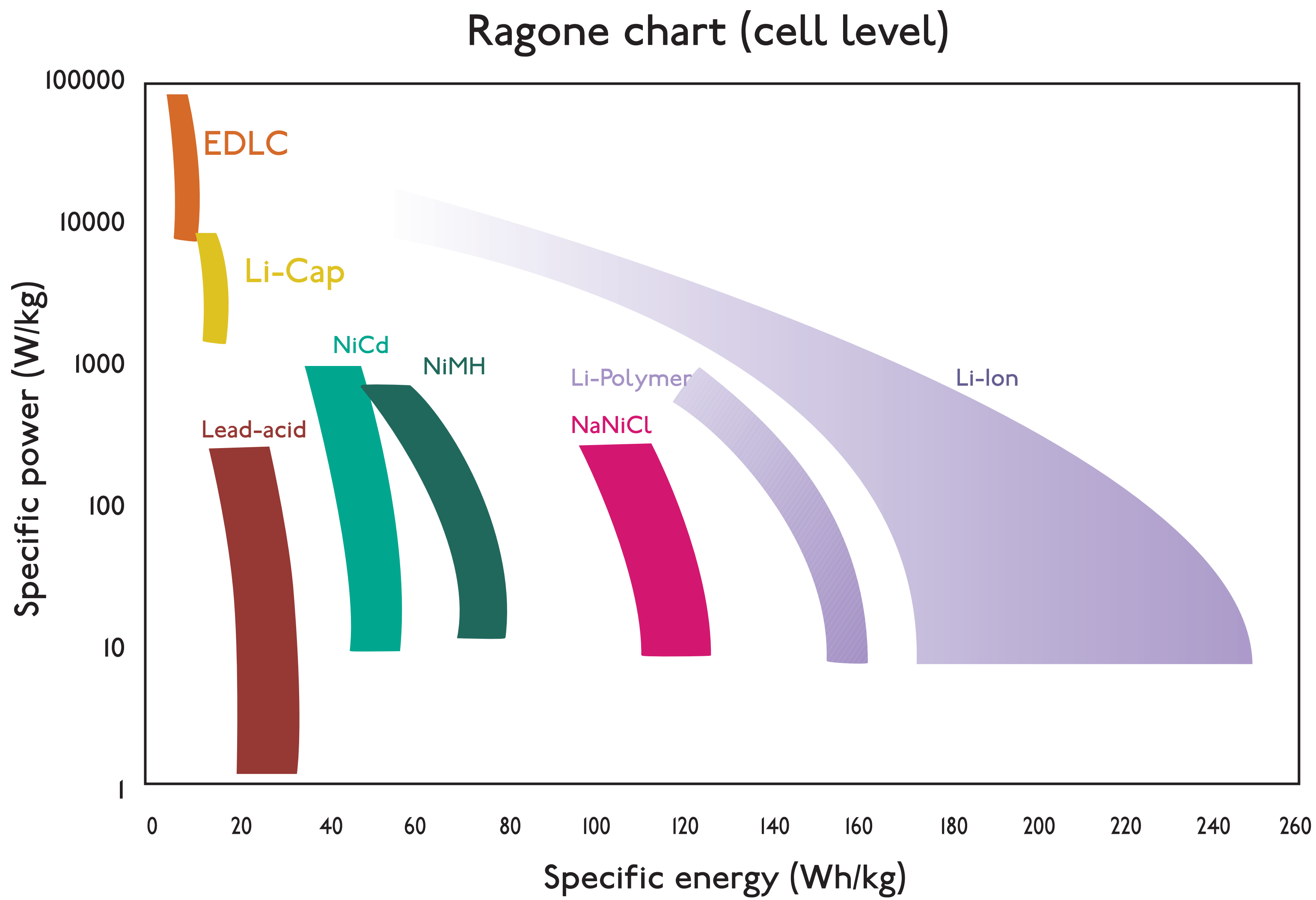
Battery technology



Electrolyte: organic solvents + $LiPF_6$

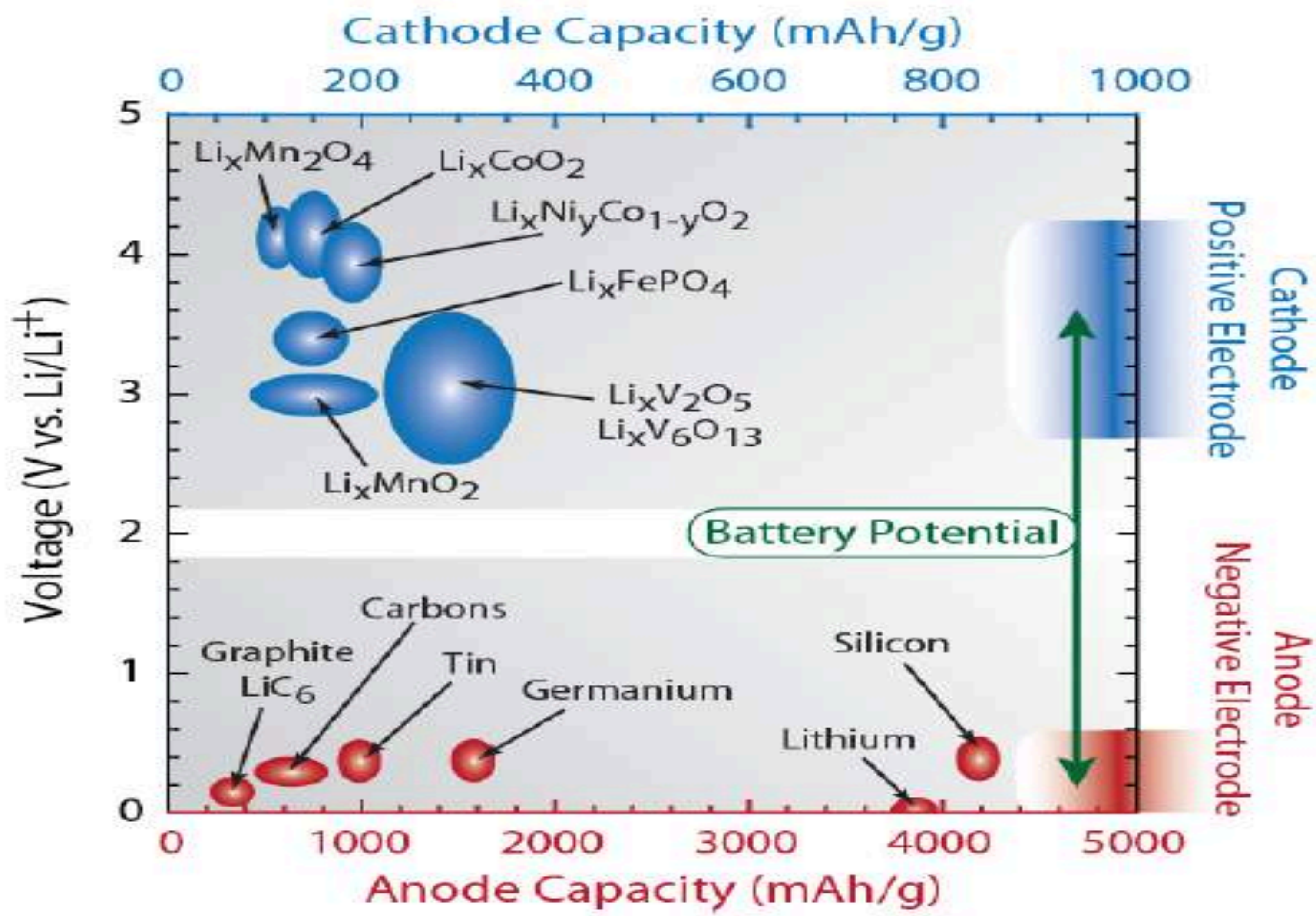
Separator: single or multilayer polymer sheets, typically polyolefin

Battery technology

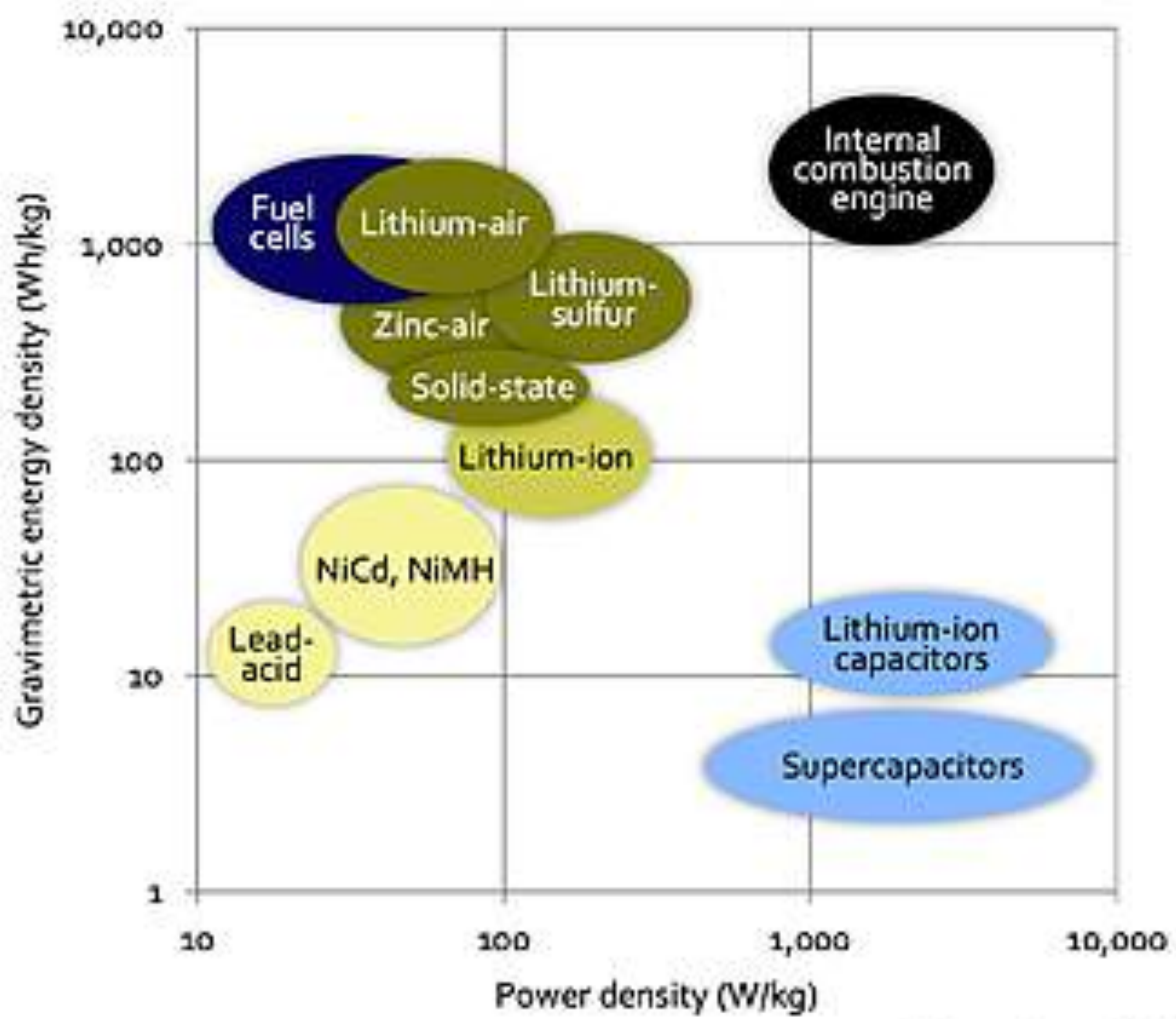


Source: VUB

Battery technology

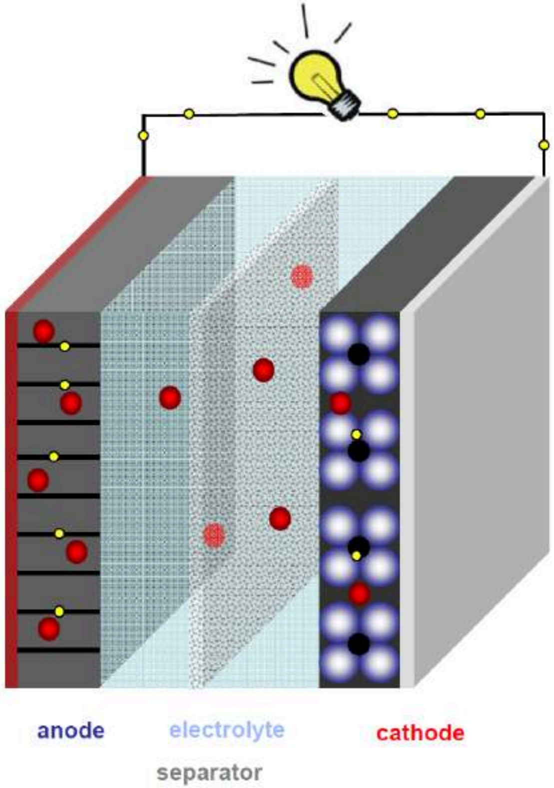


Battery technology



Battery technology

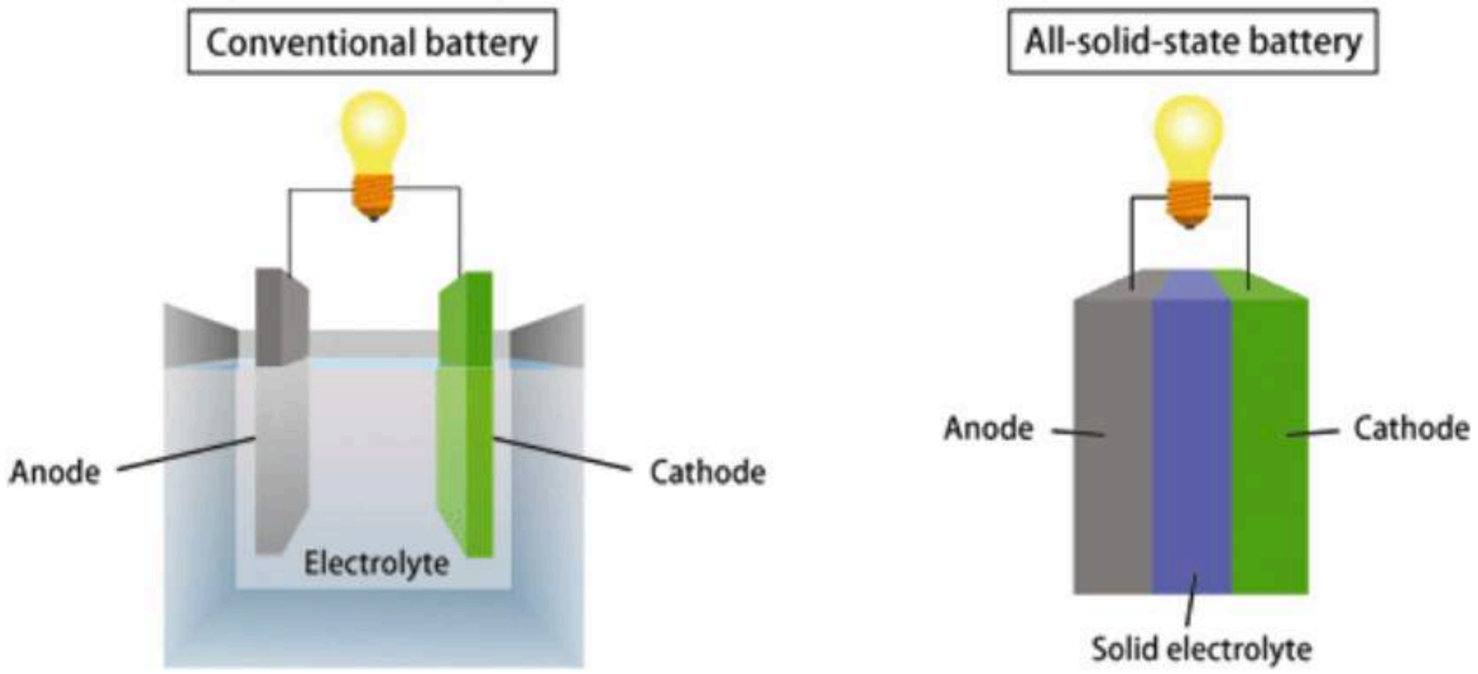
- New approach
- Combination of high voltage spinel & Si-based anode
- High voltage electrolyte is needed: 4.7V
- Energy density >270 Wh/kg
- Technical issues:
  - Electrolyte stability; Si expansion
  - High voltage spinel at higher voltages and temperatures;
  - Lifetime
  - Power performances
- 5 to 10 years



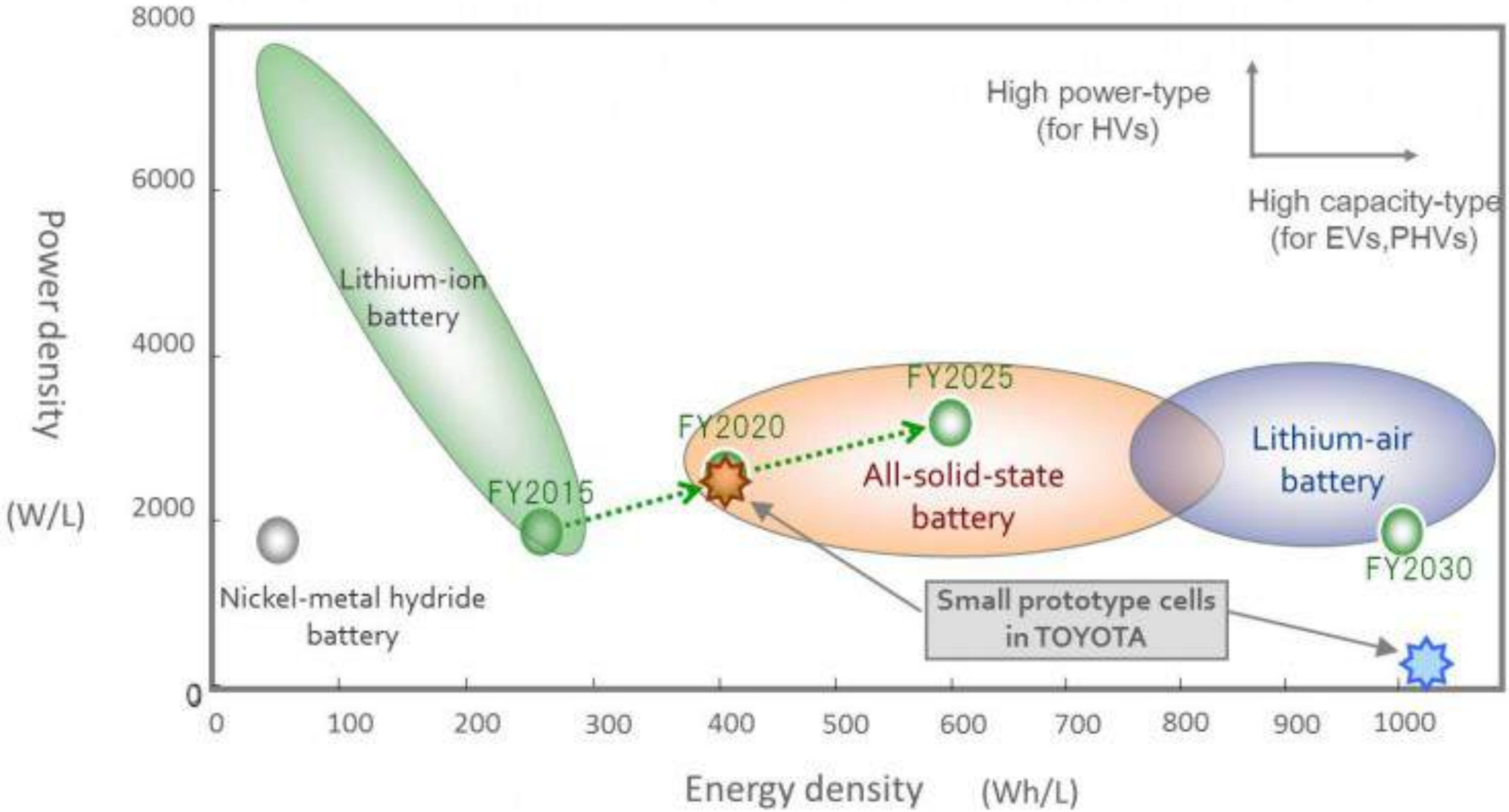
Source: www.fivevb.eu

Battery technology

- Energy density: 280-350 Wh/kg
- Solution for combination with high voltage electrodes
- Safe
- Easy to integrate



Battery technology



Source: Toyota

Roadmap EU

		Current (2014/ 2015)	2020	*2030
Performance targets for automotive applications unless otherwise indicated				
1	Gravimetric energy density [Wh/kg]			
	pack level	85-135	235	> 250
	cell level	90-235	350	> 400
2	Volumetric energy density [Wh/l]			
	pack level	95-220	500	> 500
	cell level	200-630	750	> 750
3	Gravimetric power density [W/kg]			
	pack level	330-400	470	> 470
	cell level		700	> 700
4	Volumetric power density [W/l]			
	pack level	350-550	1.000	> 1.000
	**cell level		1.500	> 1.500
5	Fast recharge time [min] (70-80% ΔSOC)	30	22	12
6	Battery life time (at normal ambient temperature)			
	Cycle life for BEV*** to 80% DOD [cycles]		1.000	2000
	Cycle life for Stationary to 80% DOD [cycles]	1000-3000	3000-5000	10000
	Calendar life [years]	8-10	15	20

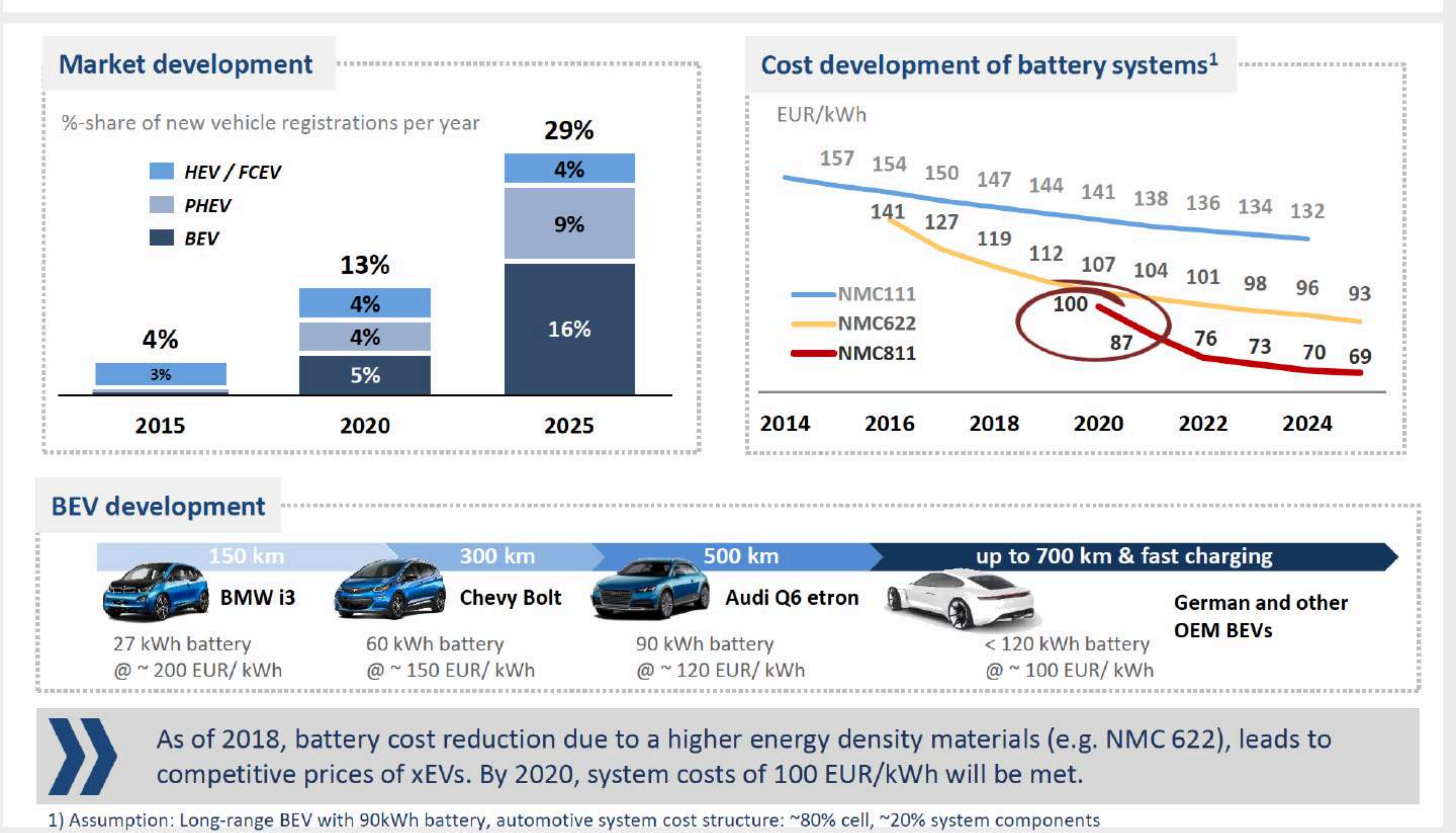
*: Post-Lithium ion technologies are assumed relevant in this time frame

**: May also be relevant to stationary applications

*** Cycle life for PHEV must be bigger

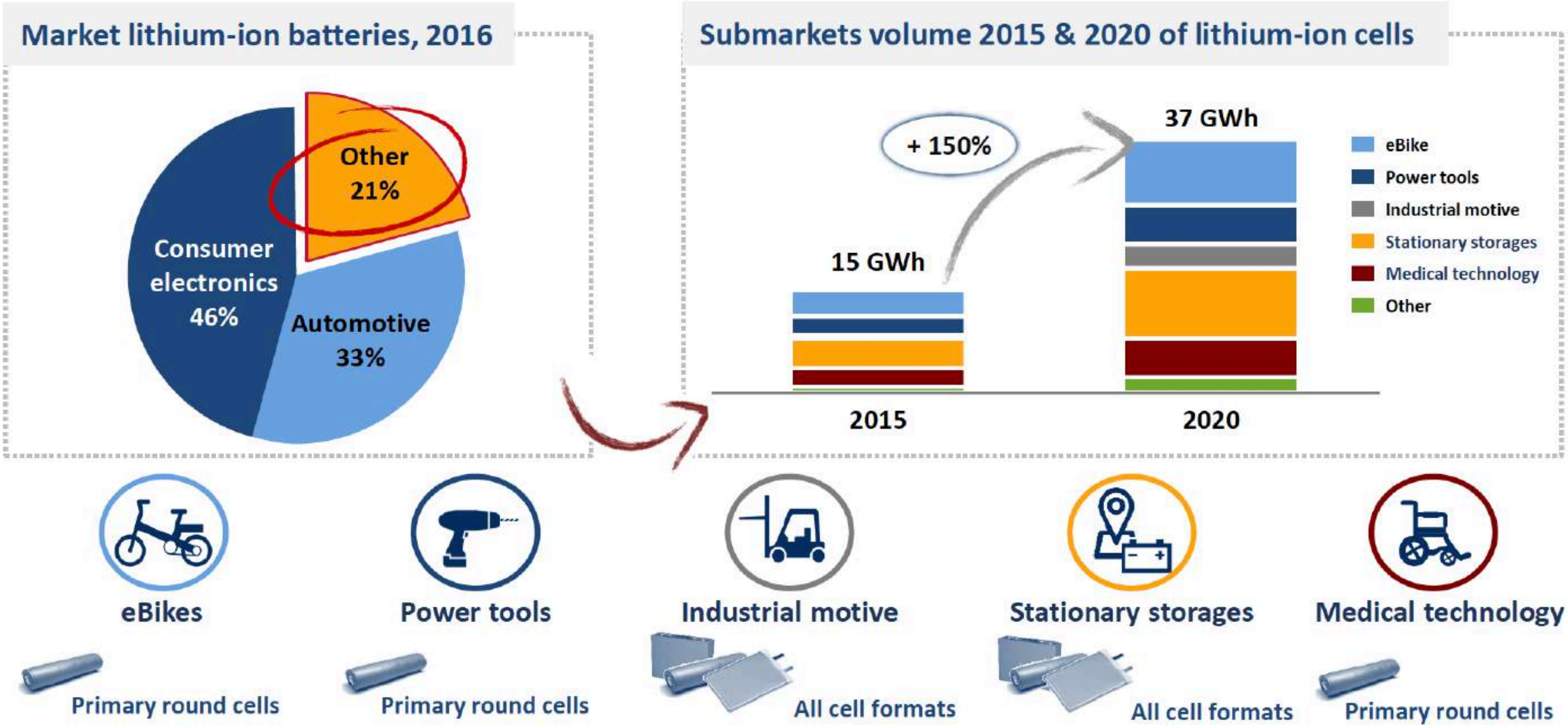
Source: EC, SET PLAN ACTION POINT 7

Battery cost



Source: P3

Battery cost

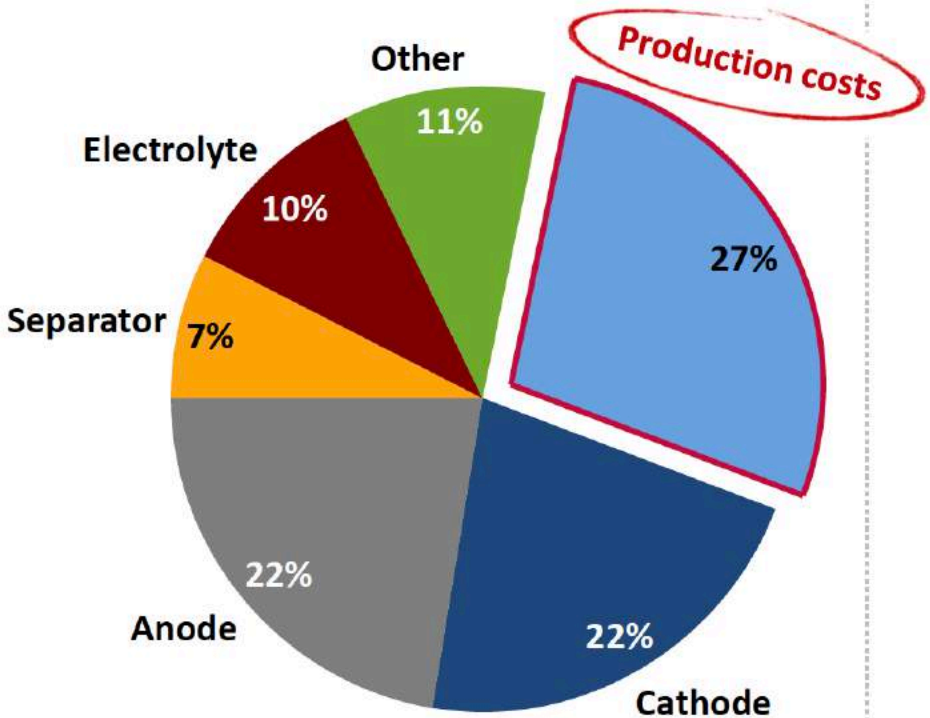


Industrial learning effects also achievable in submarkets by doubling the production volumes.
Particularly powerful and cost-efficient lithium-ion cells open up new niche markets.

Source: P3

Battery cost

Cost structure: BEV Lithium-ion cell, 2016



Cost effect: Relocation of production

For European OEMs and markets, Asian key players transfer their production sites to Eastern Europe.

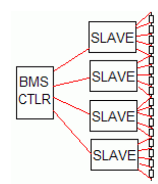
First learning curve effects and constant production improvements will be transferred to new sites in Eastern Europe with ongoing cost reduction. (Labor, energy and space costs, etc.)

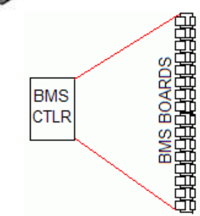
Source: P3

Commercial solutions

Opel Ampera

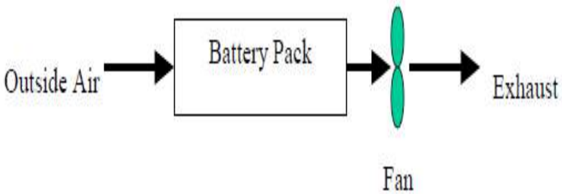
Nissan Leaf



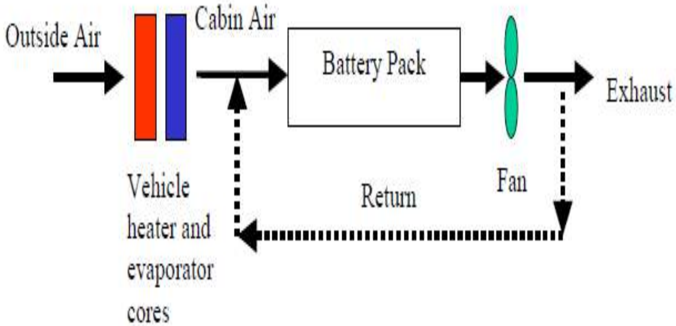


- # mono blocks
- few cells in series per mono block
- several stacks in parallel for having higher capacity
- e.g. Nissan Leaf: 192 cells, 48 mono blocks, 2 stacks in parallel

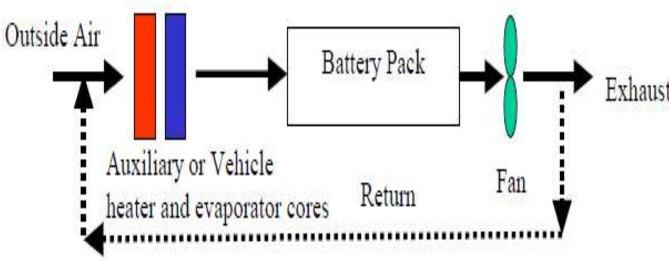
Commercial solutions



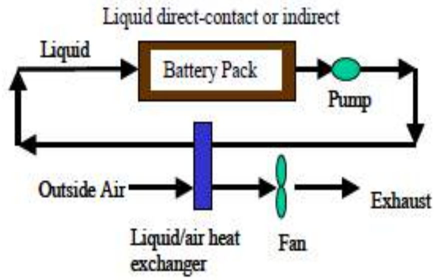
A. Passive Cooling – Outside Air Ventilation



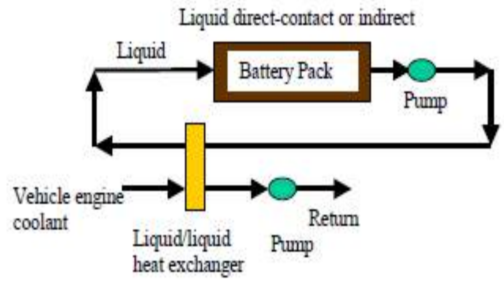
B. Passive Heating and Cooling – Cabin Air Ventilation



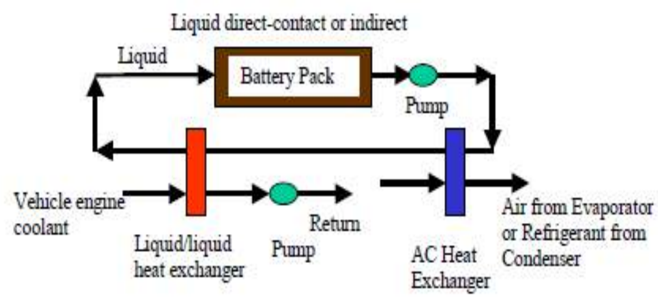
C. Active Heating and Cooling – Outside or Cabin Air



D. Passive Cooling – Liquid Circulation



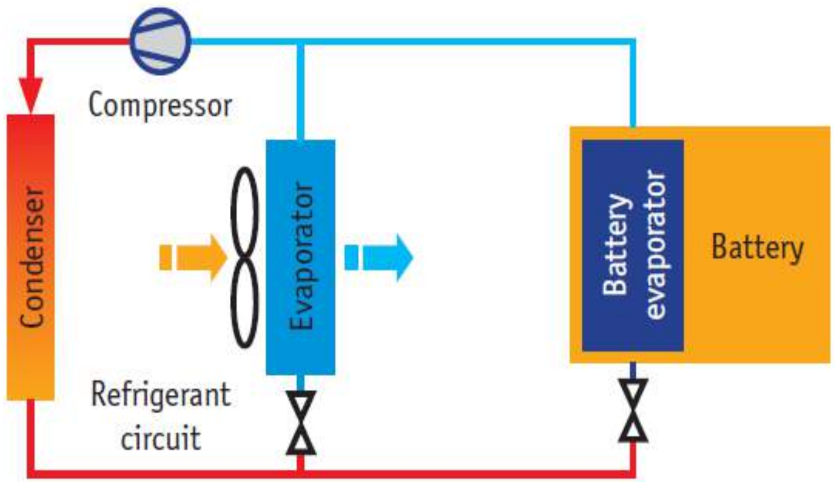
E. Active Moderate Cooling/Heating – Liquid Circulation

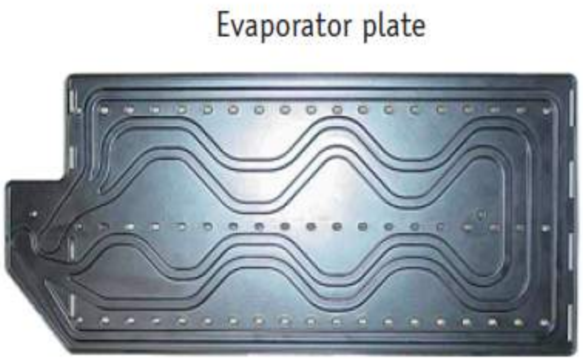


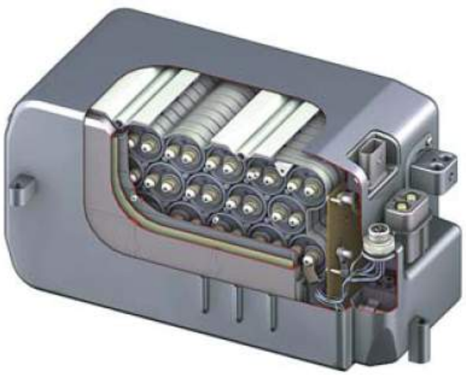
F. Active Cooling and Heating – Liquid Circulation

Commercial solutions

Mercedes-Benz S400 BlueHYBRID





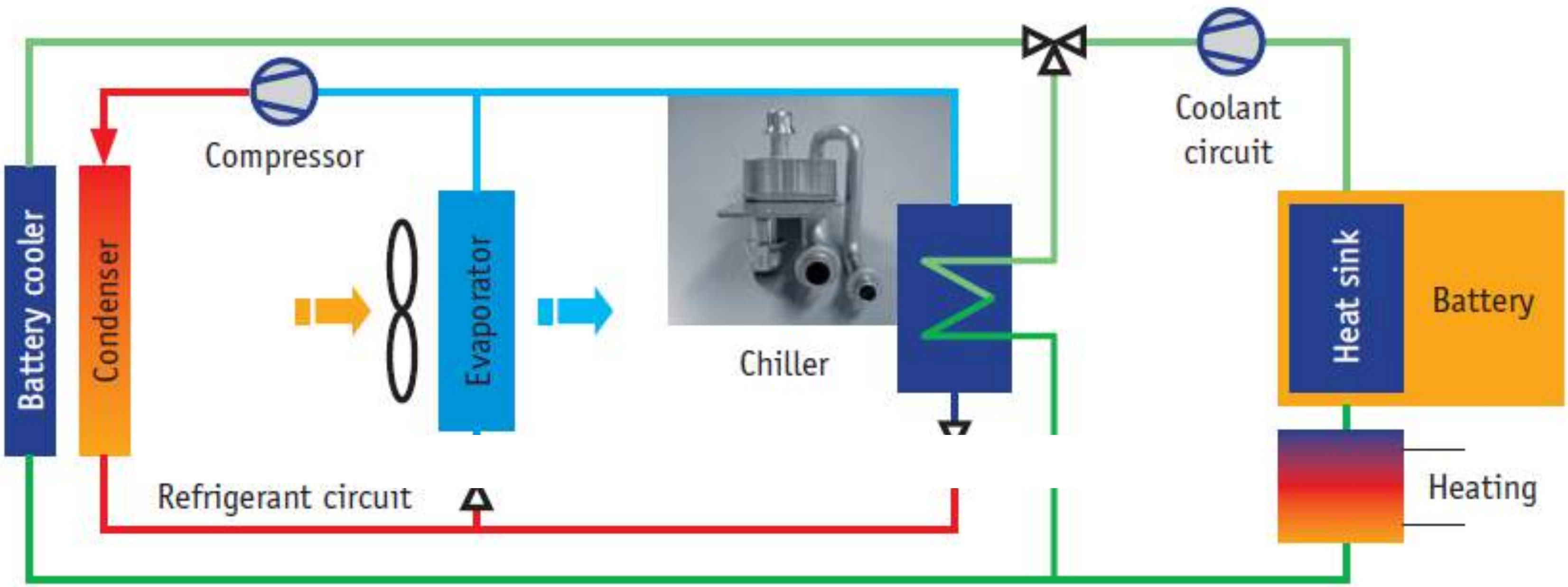


Direct refrigerant-based cooling with cooling plate, Mercedes-Benz S400 BlueHYBRID

Source: Daimler

Commercial solutions

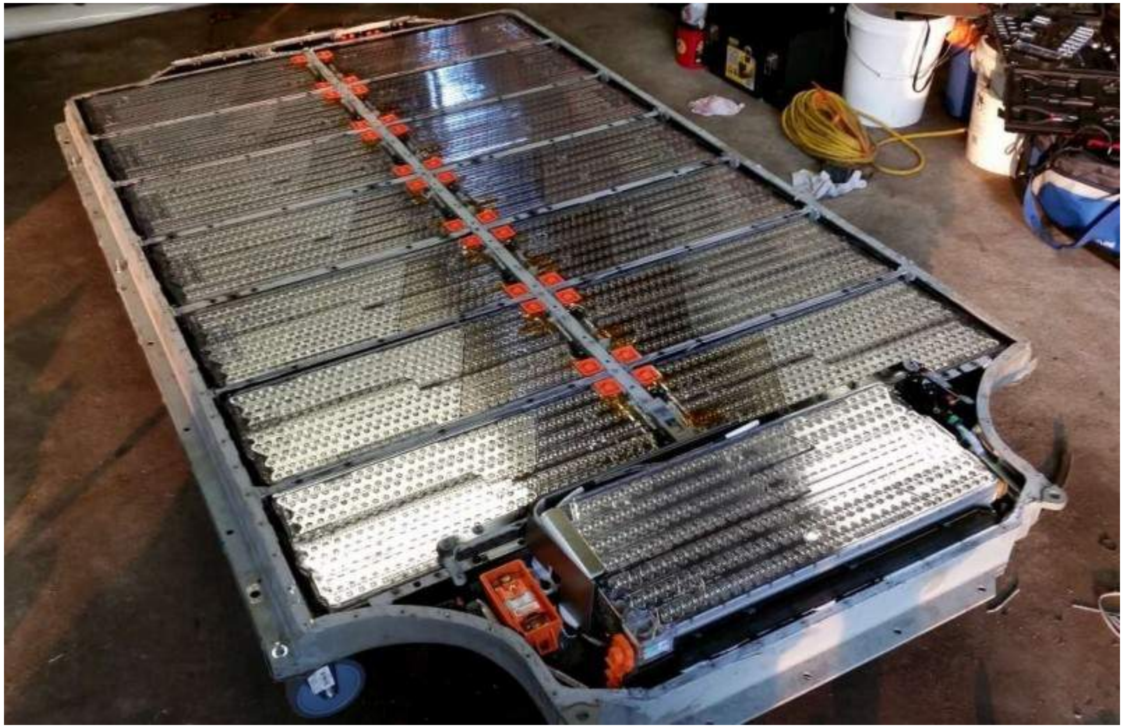
Battery cooling system by Behr using primary and secondary cooling circuit



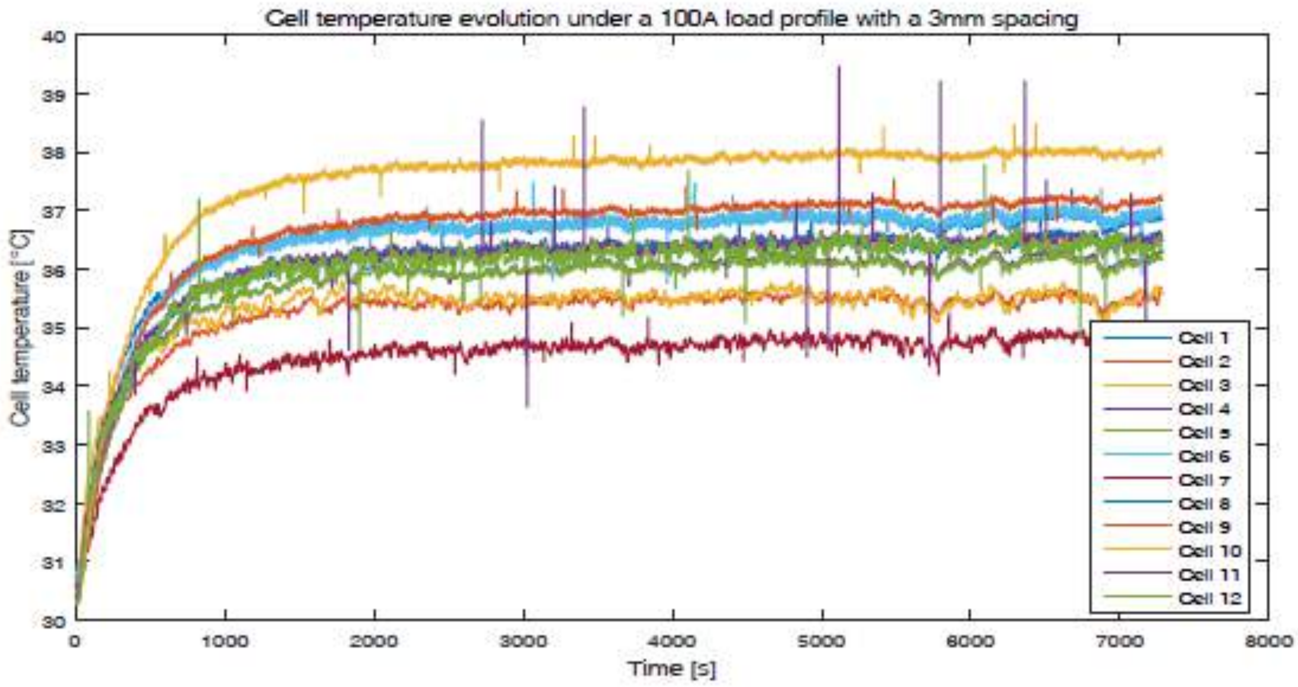
Source: Daimler

Drawback existing solutions

	BMW i3	BMW i8	E-Golf	Tesla Model S
Total weight battery system (kg)	283	98	318	600
Weight (excl. cells) (kg)	58	38	191	270
Potential weight saving of the battery system (%)	10	25	20	25

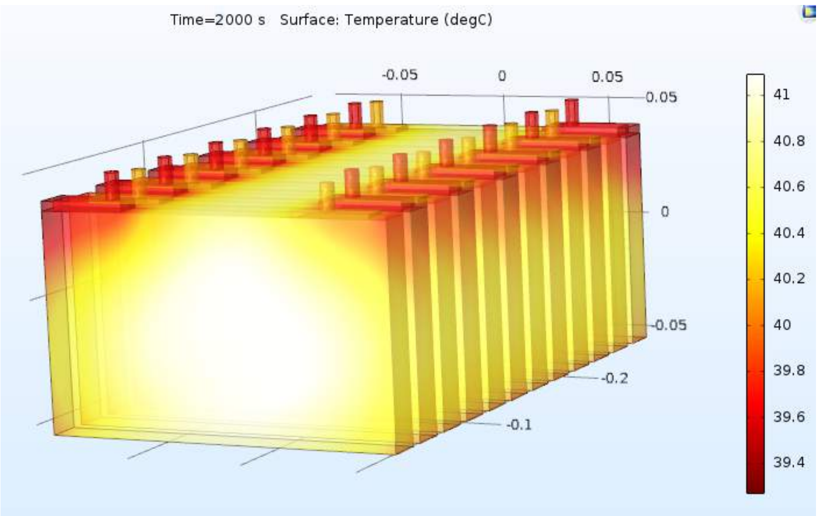


Existing battery thermal management solutions

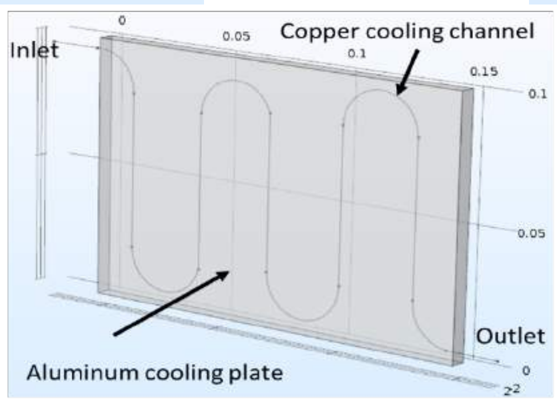


Existing battery thermal management solutions

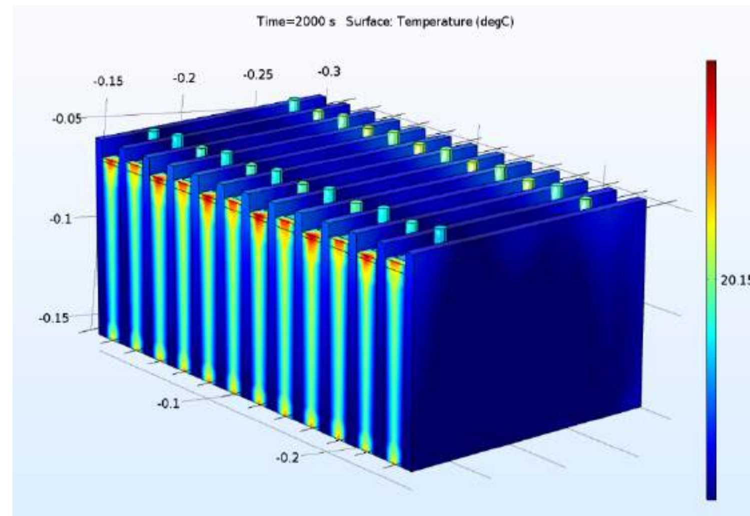
Test at 100A



12 cell module



Al-cooling plate design



With liquid-cooling

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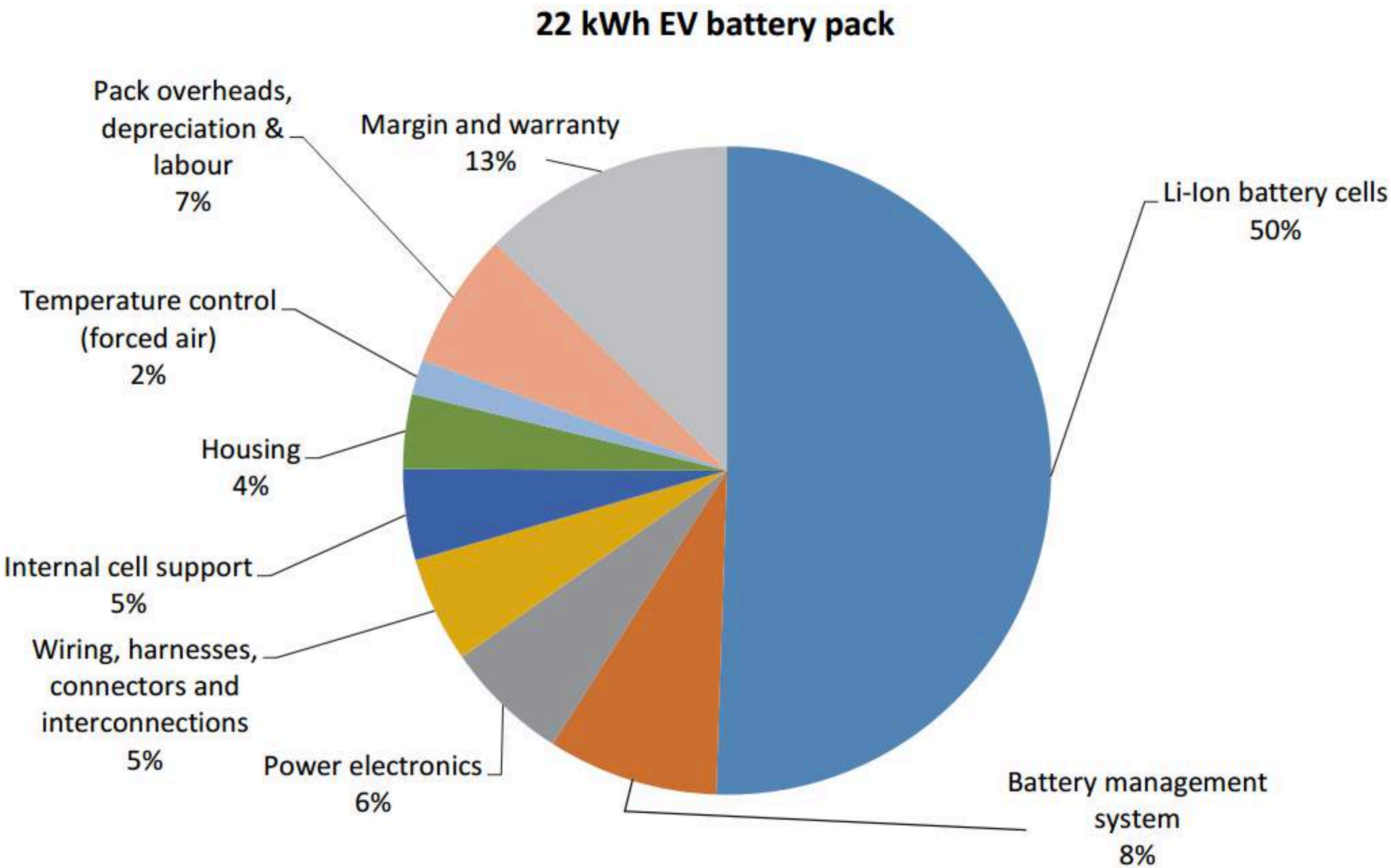
Cost share



22 kWh EV battery pack
Pack overheads, depreciation & labour 7%
Margin and warranty 13%
Li-Ion battery cells 50%
Temperature control (forced air) 2%
Housing 4%
Internal cell support 5%
Wiring, harnesses, connectors and interconnections 5%
Power electronics 6%
Battery management system 8%

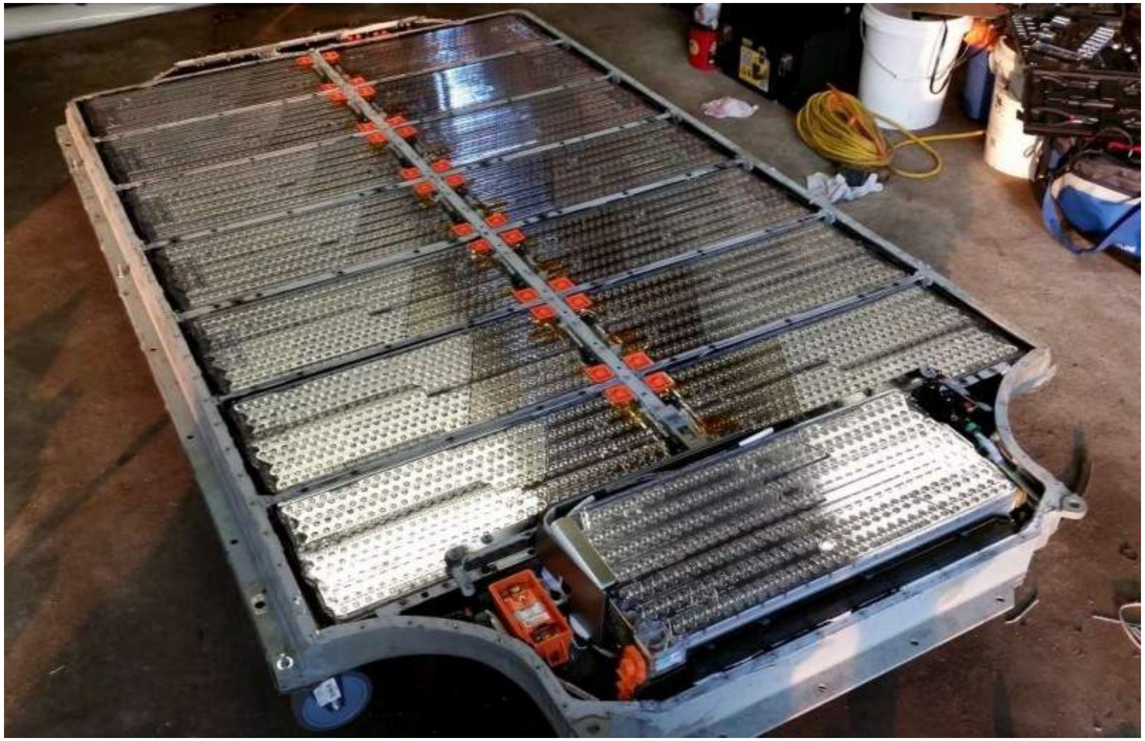
Drawback existing solutions

- Developed for dedicated battery cells and application

- Complex

- Costly

- Heavy



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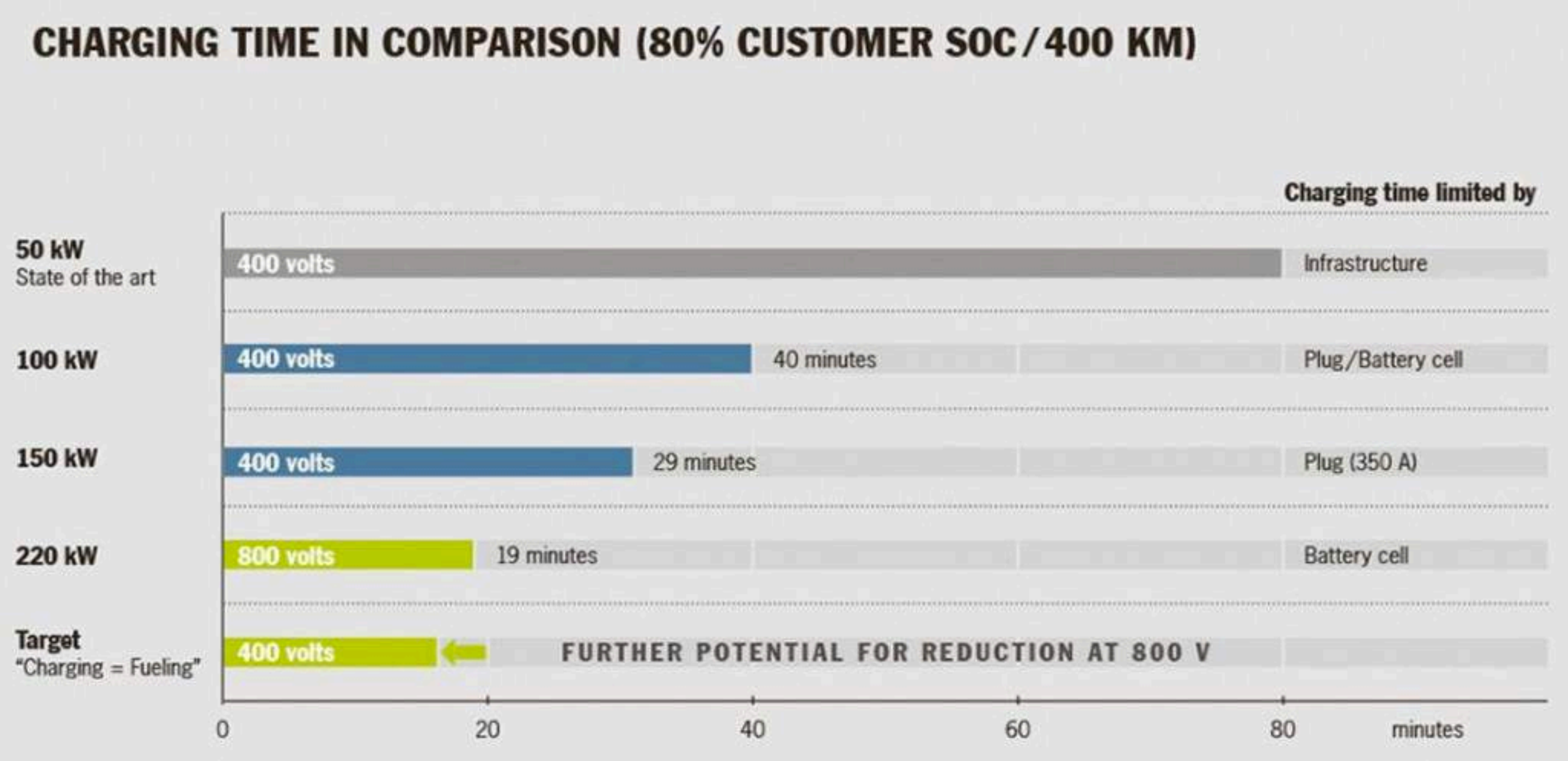
Needs of future thermal management systems

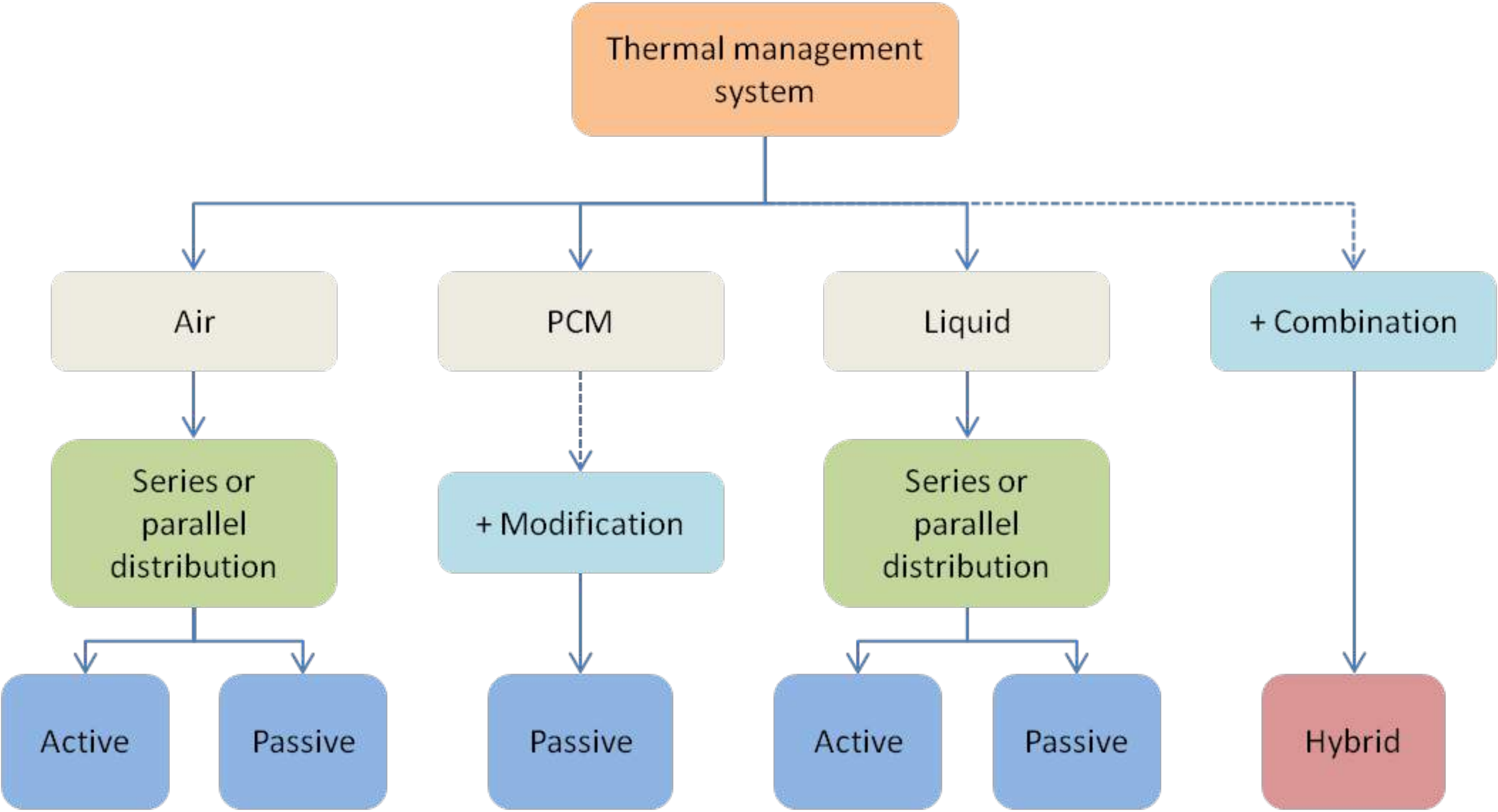


Source: Porsche

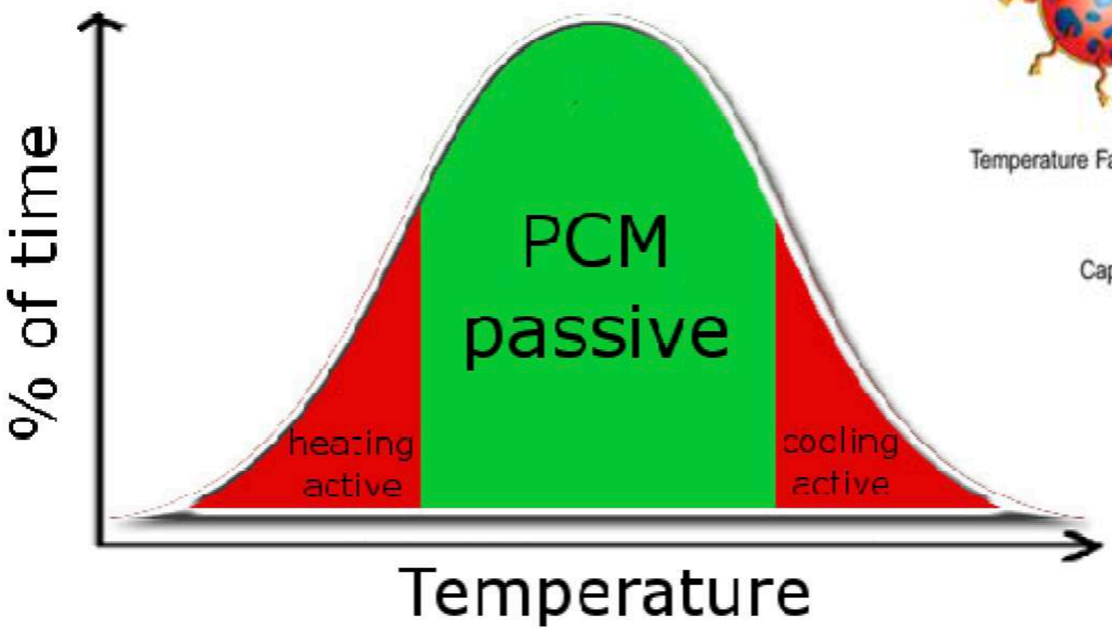
Needs of future thermal management systems

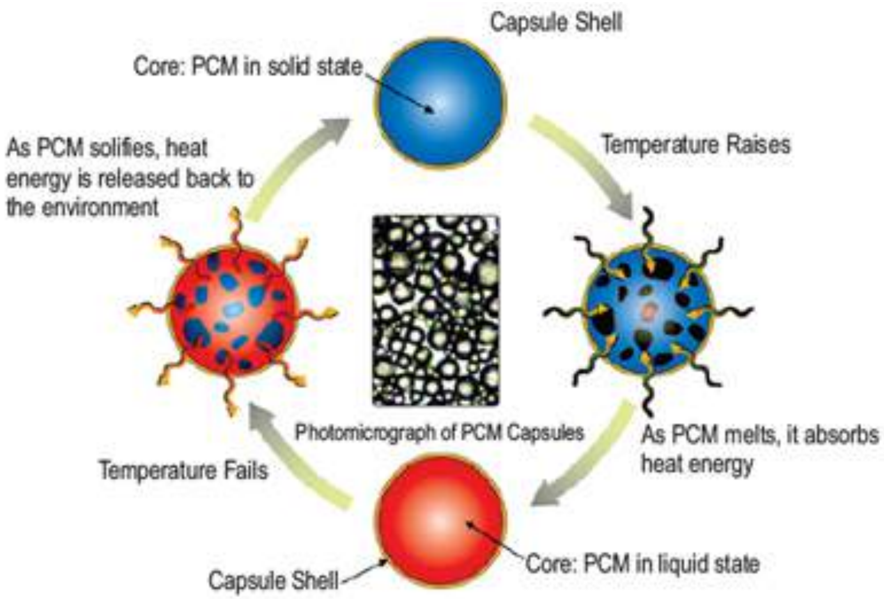
- Modular
- Scalable
- Energy efficient
- Designed for fast charging
- Not heavy

Needs of future thermal management systems

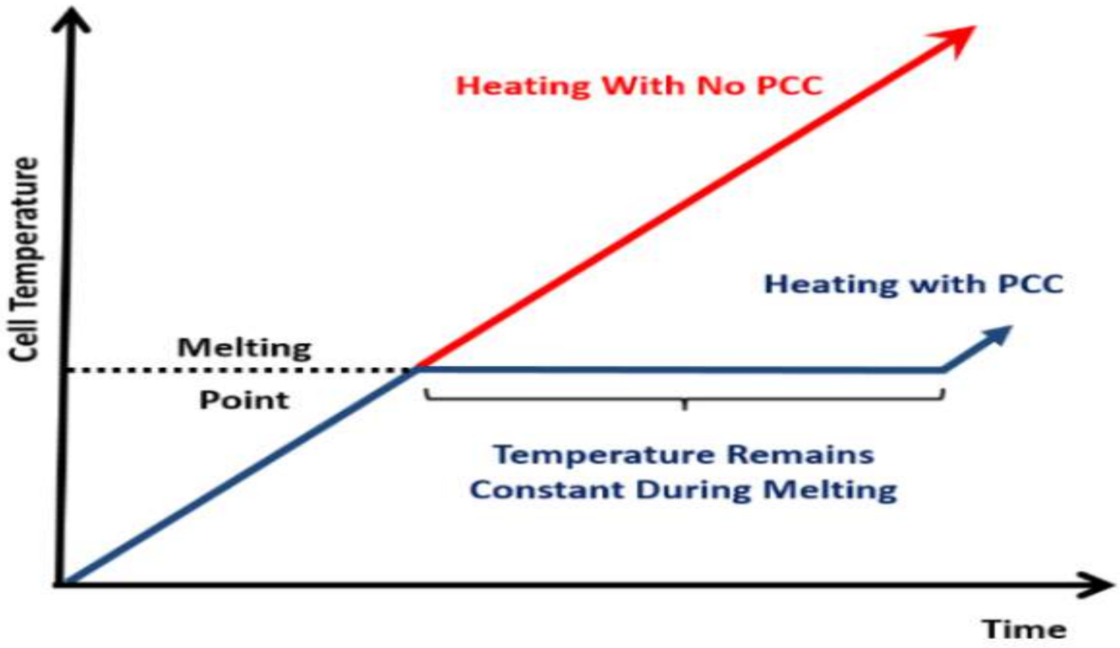


Needs of future thermal management systems

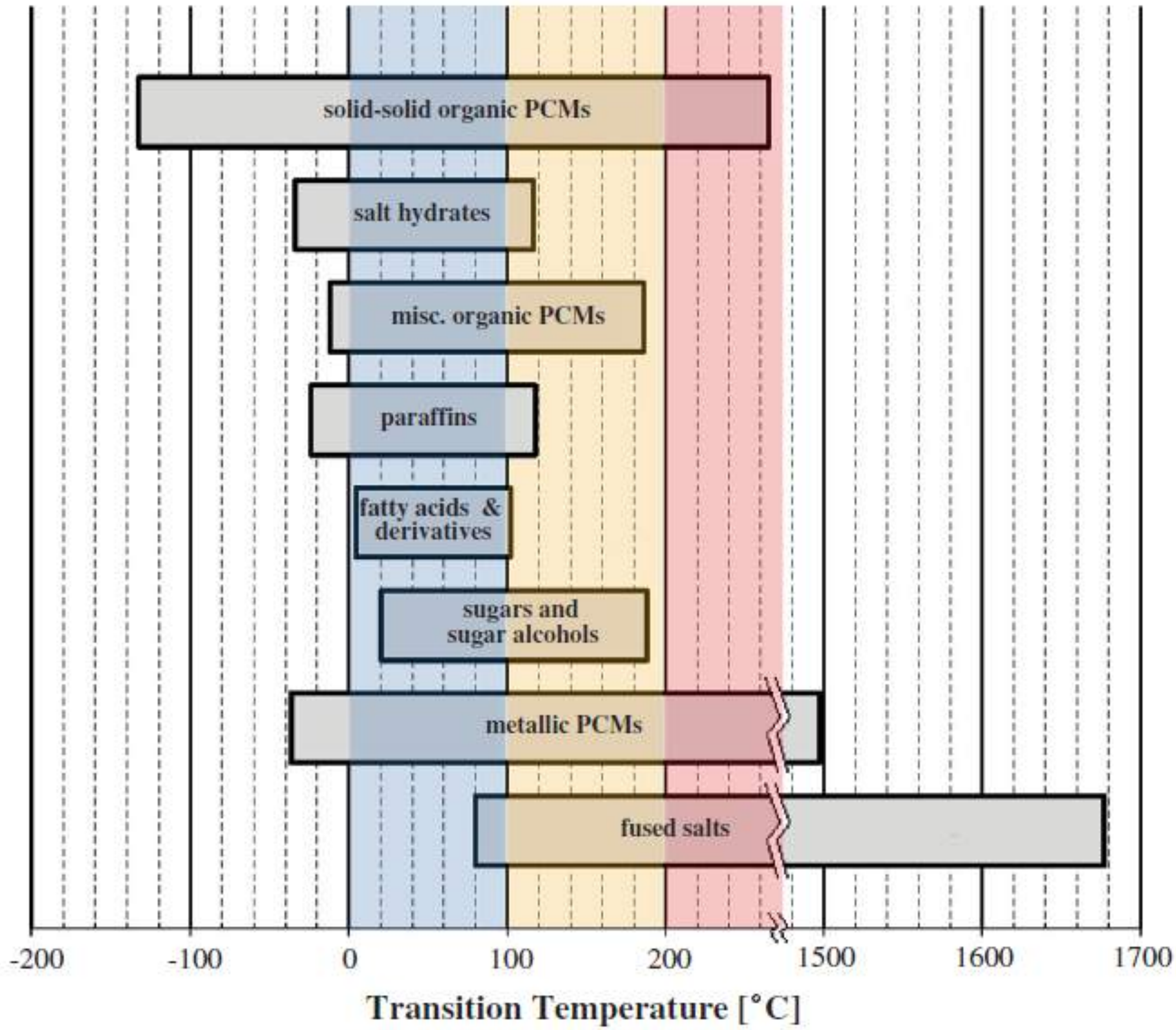




Needs of future thermal management systems

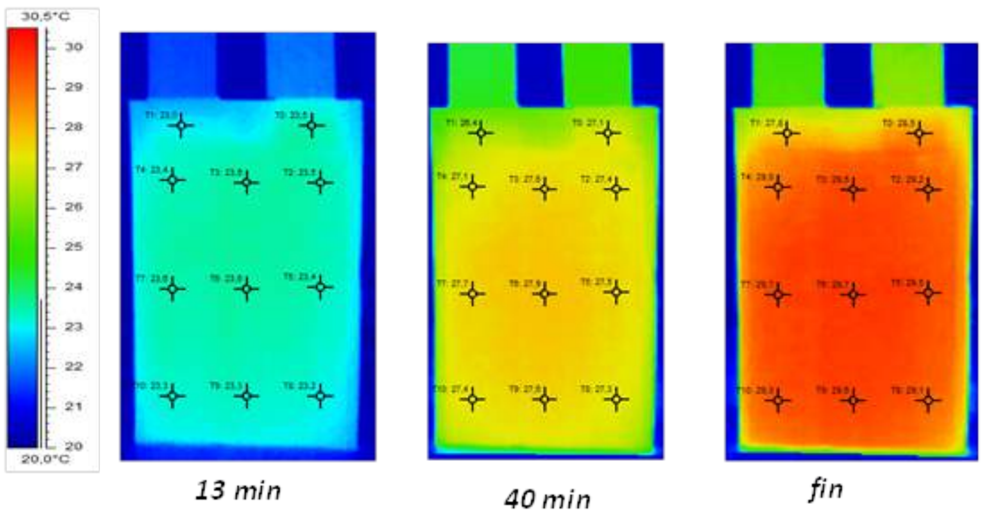


Needs of future thermal management systems

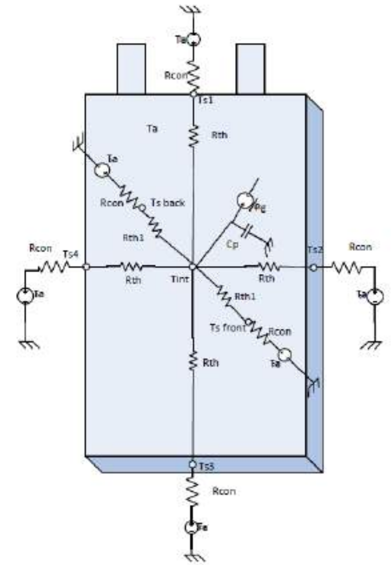


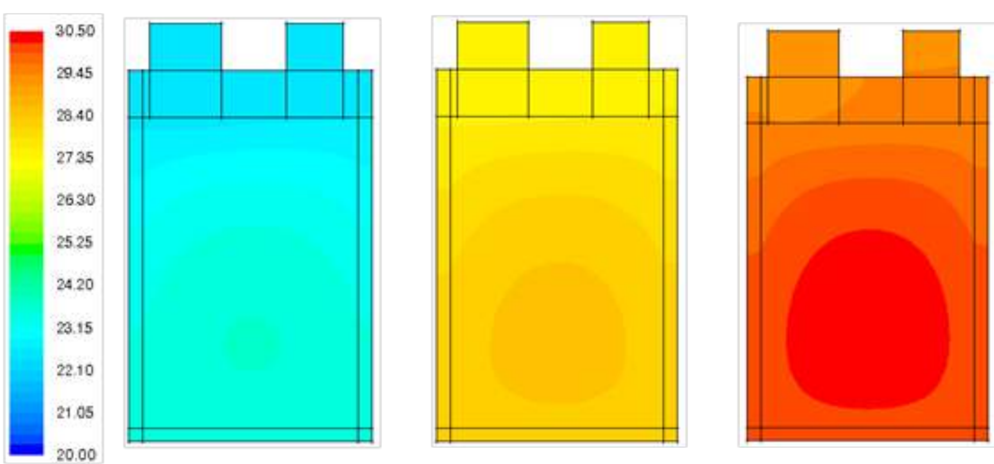
Needs of future thermal management systems

Next generation thermal management systems

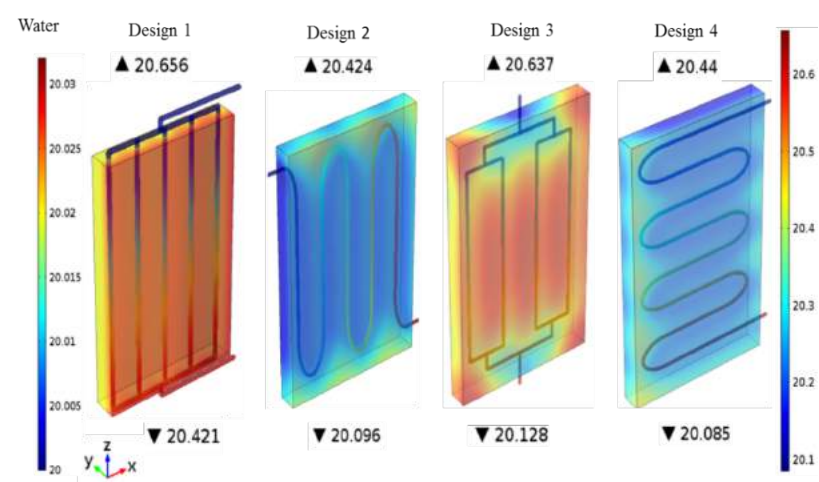


Thermal imager





Simulation



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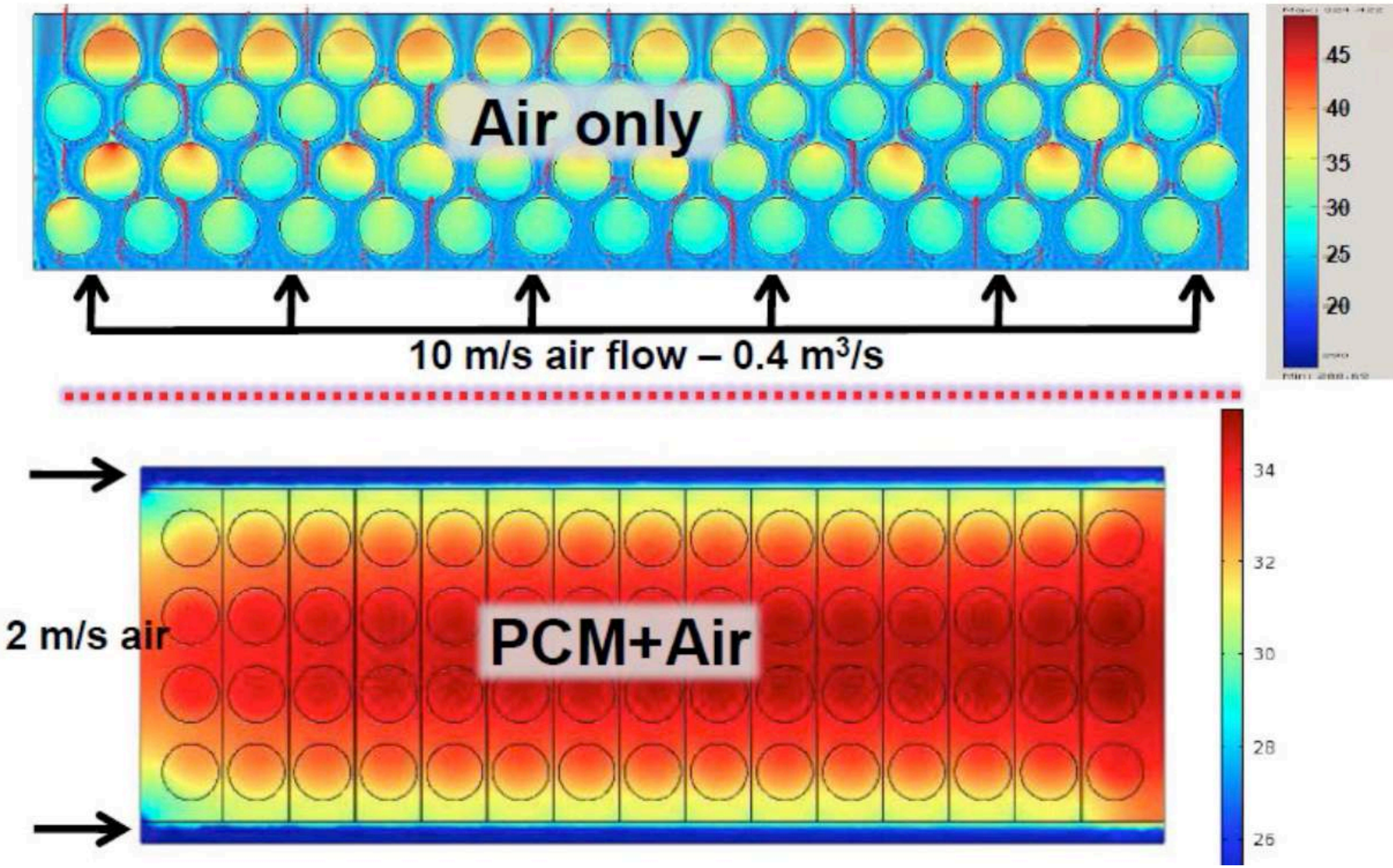
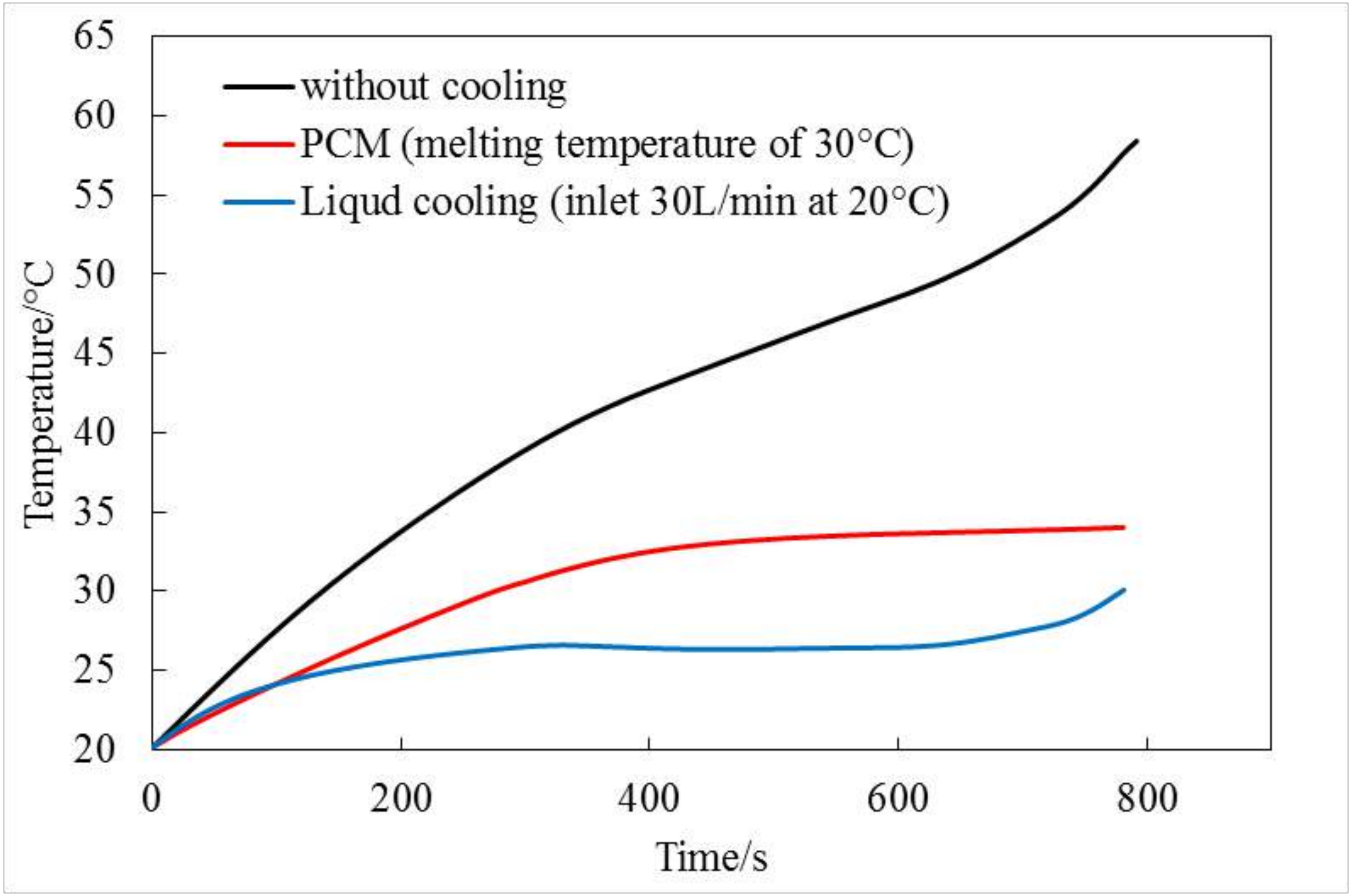
Next generation thermal management systems



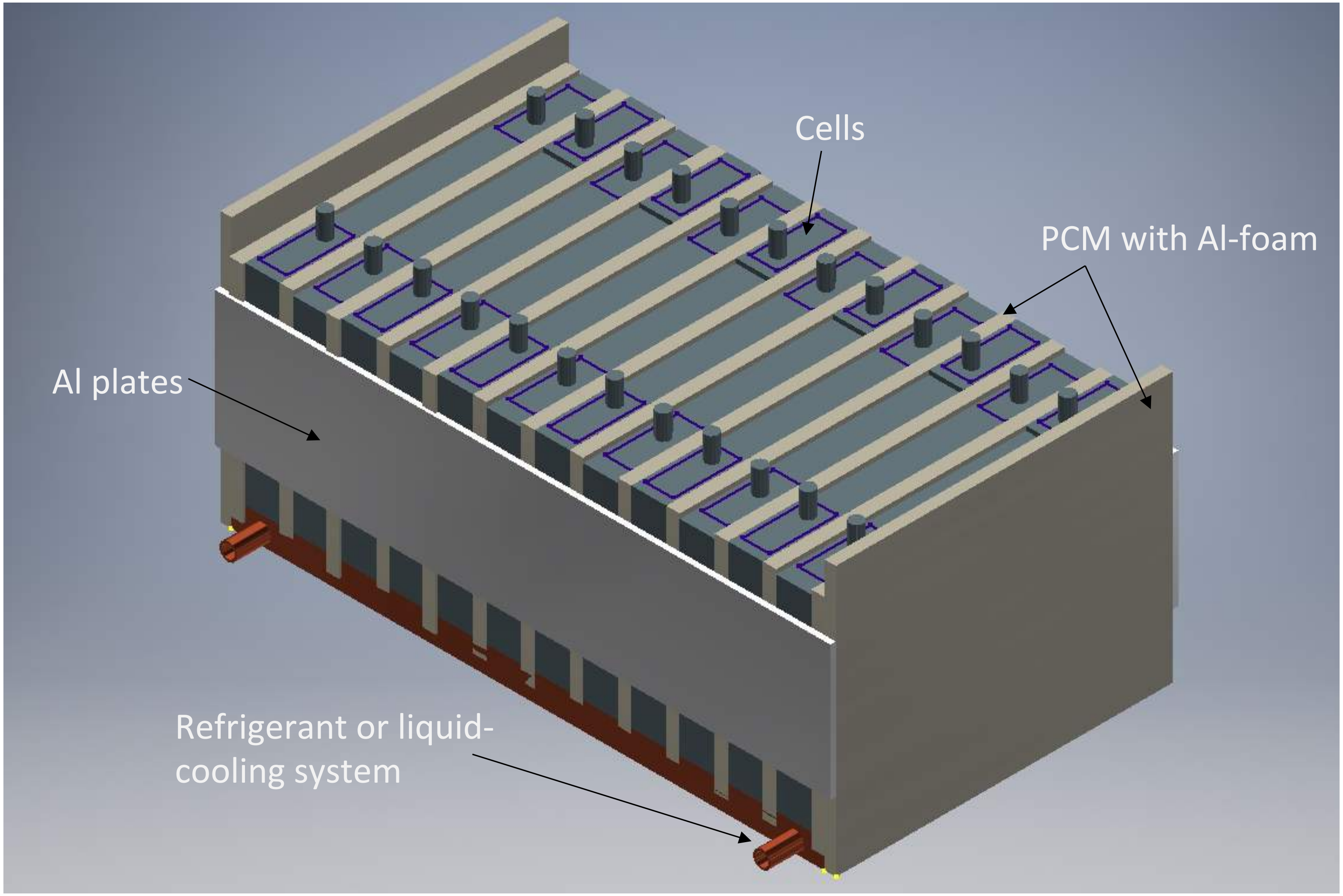
Source: Allcell Technology

Next generation thermal management systems



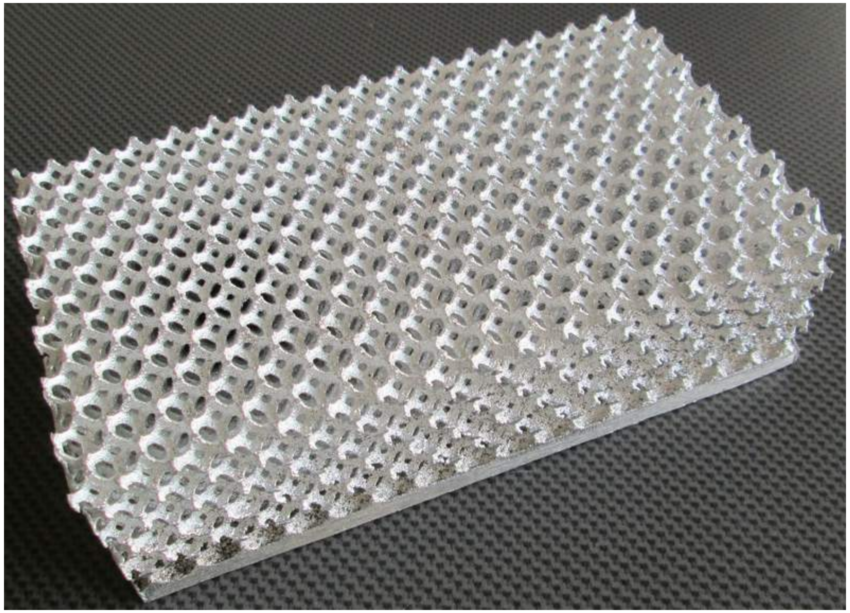
Source: VUB

Next generation thermal management systems



Next generation thermal management systems

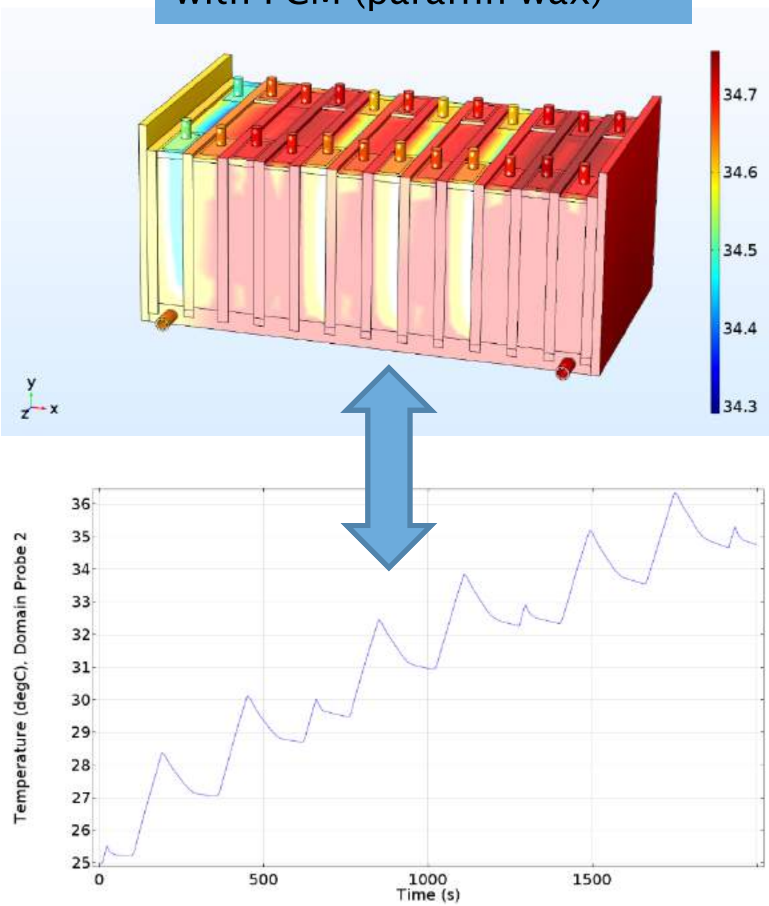
- High thermal performance, due to its large interstitial surface area up to $2500m^2/m^3$
- High porosity makes it a very lightweight material
- Mechanical robustness
- Up to 15% lighter battery system compared to SoA systems



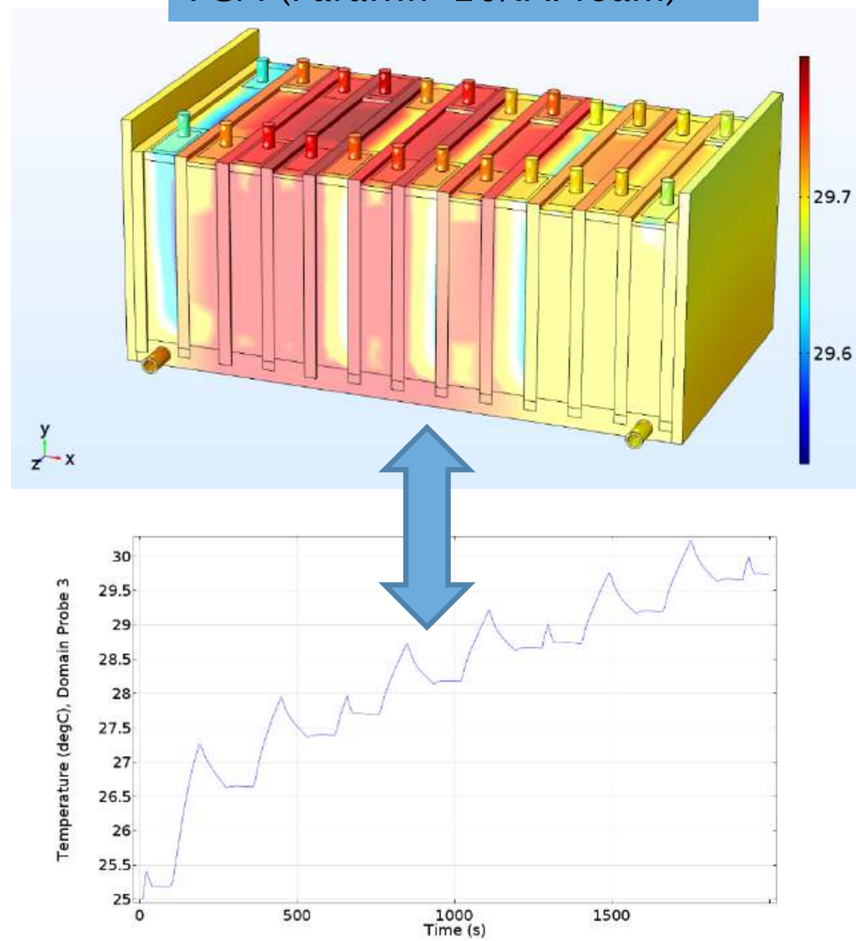
Next generation thermal management systems

➢ Test at 100A

12 cells module design with PCM (paraffin wax)



12 cells module design with PCM (Paraffin+20%Al-foam)



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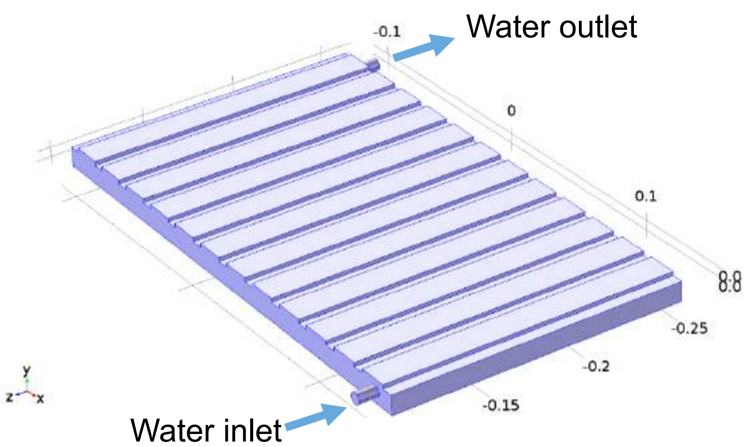
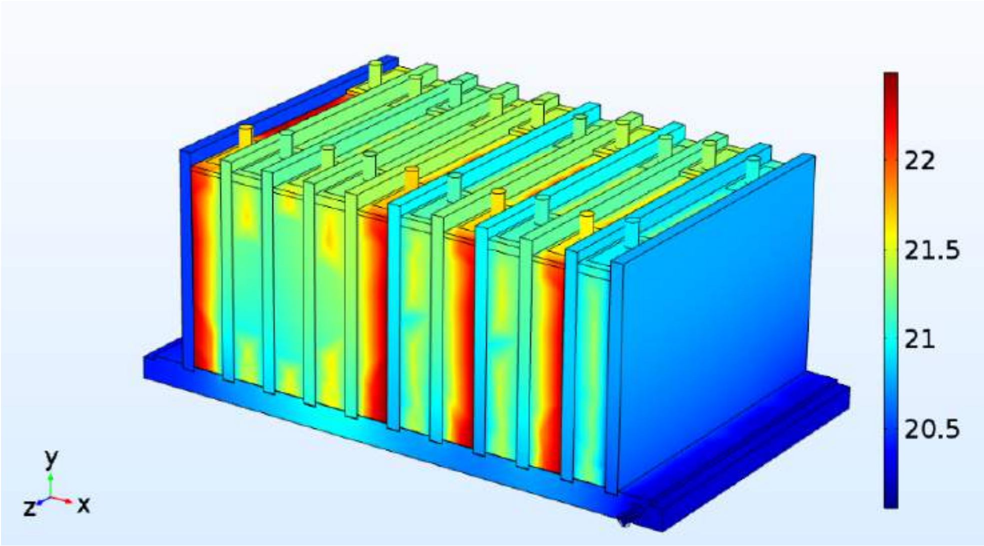
Next generation thermal management systems

- Test at 100A





Liquid-cooling plate.

12 cells module design with PCM (Paraffin + Al-foam) and liquid cooling.

Possible collaboration topics

- Next generation battery systems (incl. thermal management) for BEVs
  - For existing battery technologies
  - Next generation battery technologies
  - Modular & scalable
- Tailored made solutions
- Reduction of cost, weight and volume
- Thermal management at complete vehicle level
- Thermal management solutions for inverters, e-motors, ...

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THANK YOU FOR YOUR ATTENTION

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