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Future Trends, Challenges and Development Issues at the System Level of Lithium-Ion Cells/Battery Packs

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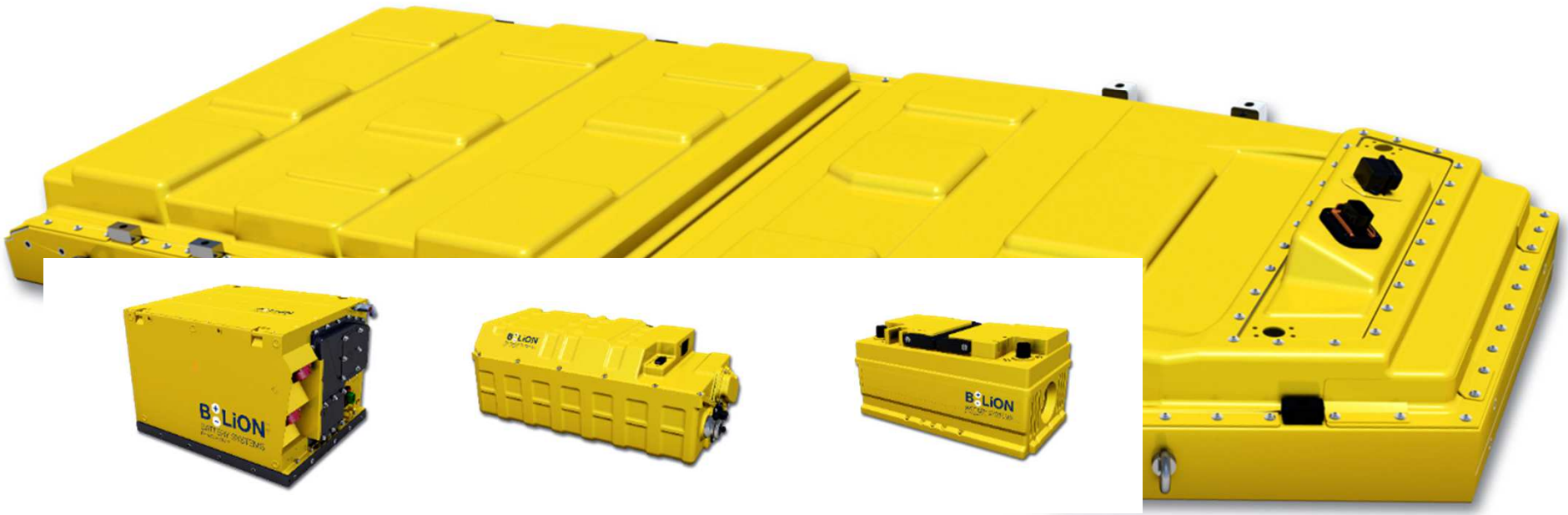
Outline

- **Company Overview**
- **Product portfolio automotive market**
- **Development**
- **Future trends and challenges**
- **Roadmap**

– Excellence in automotive engineering and production
– Deep knowledge of international safety standards
– Integrated thermal and electronic management
– Customizable solutions due to modular design
– Leading Li-ion battery provider for commercial vehicle segment



Battery Systems / Worldwide Presence

410 employees
2 locations in Europe
1 location in North America
3 locations in Asia

- Battery Pack Development
- Battery Pack Testing & Validation
- Battery Pack Production

Battery Systems Zettling (AT)

Zettling (HQ)

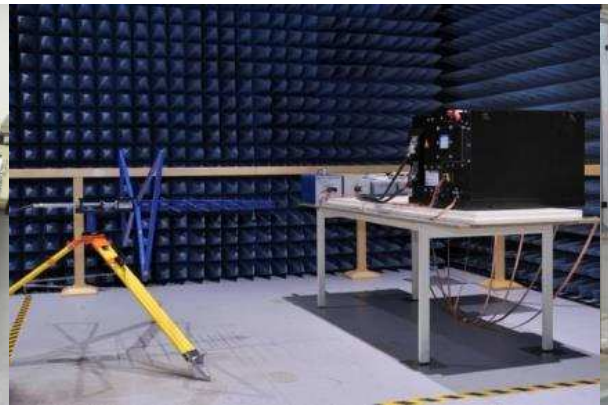
- **Employees: 320** (Effective August 21st 2015)
- **Plant Size:** 14,060 m²
- **Functions**
  Engineering, Testing and Validation
  Prototype Battery Production
  Battery Pack Production

Battery Systems Graz

Graz

- **Employees: 25** (Effective August 21st 2015)
  Plant Size: 1,200 m²
- **Functions**
  Testing and Validation
  Battery Pack Production




Excerpt of the Product Portfolio for the Automotive Market

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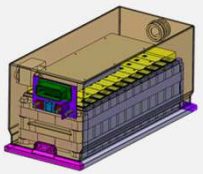
	Energy	Plug-In PHEV	Hybrid (HEV)	48V	12V	Truck PHEV
						
	Serial Production	Serial Production			Serial Production	Serial Production
Energy Content	16 - 36 kWh	6 - 18 kWh	0.2 - 3 kWh	0.25 - 1 kWh	~ 70 Wh	8 - 14 kWh
Power	50 - 120 kW	50 - 120 kW	10 - 50 kW	8 - 11 kW	~ 3 kW	100 - 170 kW
Voltage	400 V	400 V	120 / 400 V	48 V	12 V	400 / 700 V
Weight	180 - 400 kg	80 - 200 kg	10 - 40 kg	~ 15 kg	~ 5 kg	120 - 220 kg
Cooling	liquid (optional)	liquid	air / liquid	AC cooling / liquid	----	liquid
Manuf. Capacity	3,000 / year	> 35,000 / year	50,000 / year	100,000 / year	< 100,000 / year	3,000 / year

Development process

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Mechanical integration

- Weight optimized housing
- Modular concept
- Functional integration

DESIGN

Thermal concept

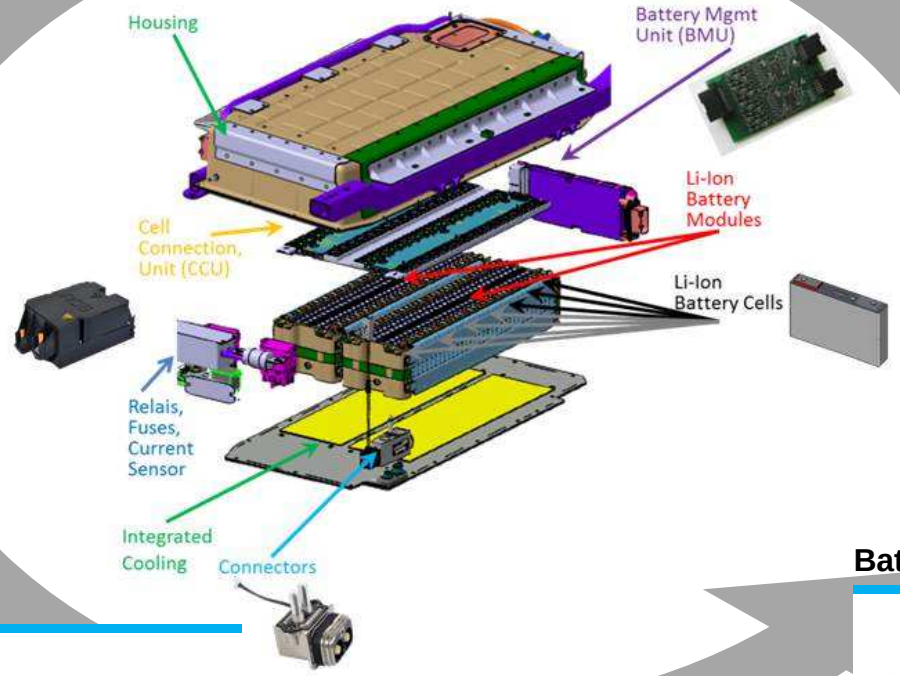
- Thermal simulation
- → Cooling concept for cell thermal management
- → Liquid or air cooled

DESIGN

Electrical integration

- Low cost and high integrated cell to cell connection
- Battery disconnect unit
- Interfaces
- Wiring of measure-ment circuits

DESIGN



Cell Selection

- Tailored cell chemistry
- Different housing types and chemistries feasible

Electronic HW

- 3rd Generation
- Modular Architecture
- Optimized SW and algorithms
- Flexible for all cell technologies
- Battery Management System

Software / Battery Management

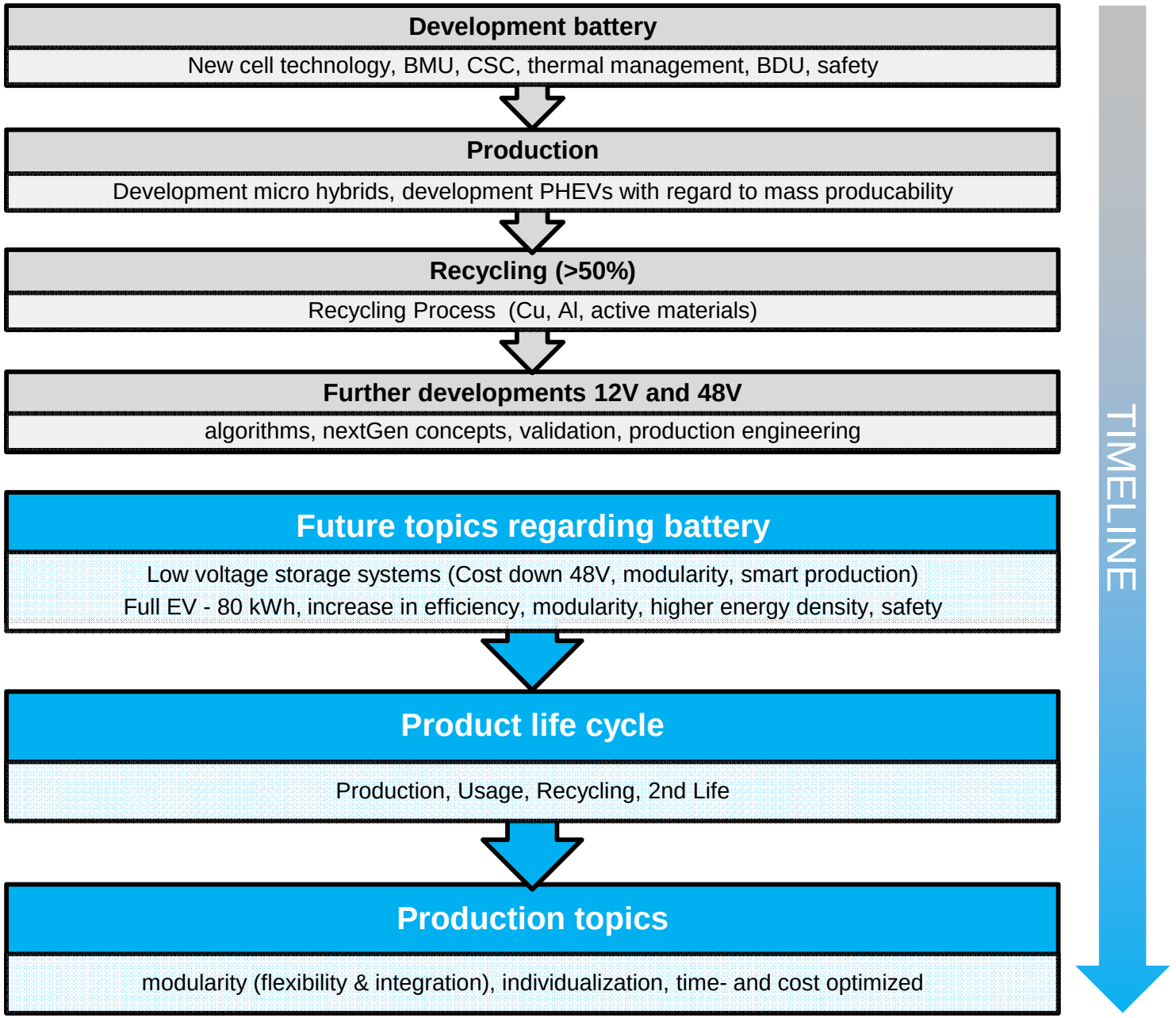
- Functional Safety Concept
- Balancing + CSCs
- State Monitoring (State of Charge, State of Power, State of Health)
- Communication/ CAN
- Usage Logging over life

Battery Pack

Validation

- Performance
- Transportation
- Mechanical
- Thermal and Climatic
- Safety
- Life Cycle
- other

Roadmap for basis development



Challenges and development issues of the system

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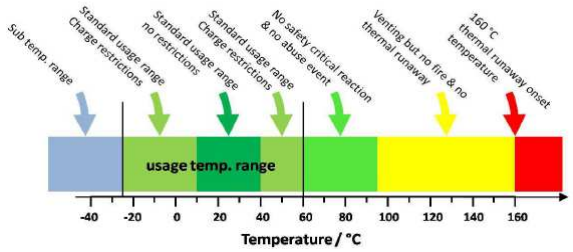
Increase temperature operating range

- Thermal management (cooling + heating)
- Electrolyte issues

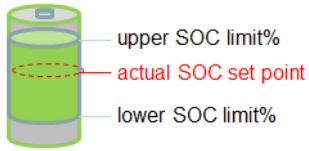


Increase energy density

- Light weight (casing, less components, …)
- New cell technologies
- Improve software
- Higher efficiency of thermal management

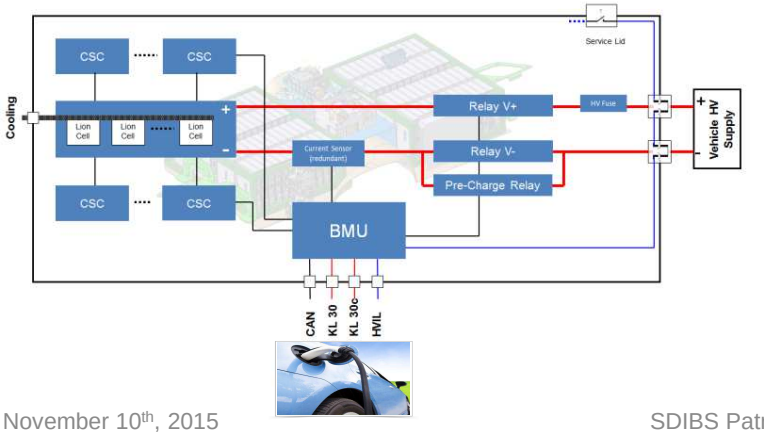
Simplify / improve algorithms

- State of Health (SoH)
- State of Power (SoP)
- State of Charge (SoC)



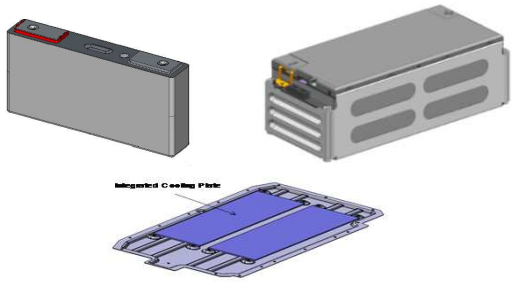
Electronics development

- BMU, CSC, CAN, BDU



Increase modularity

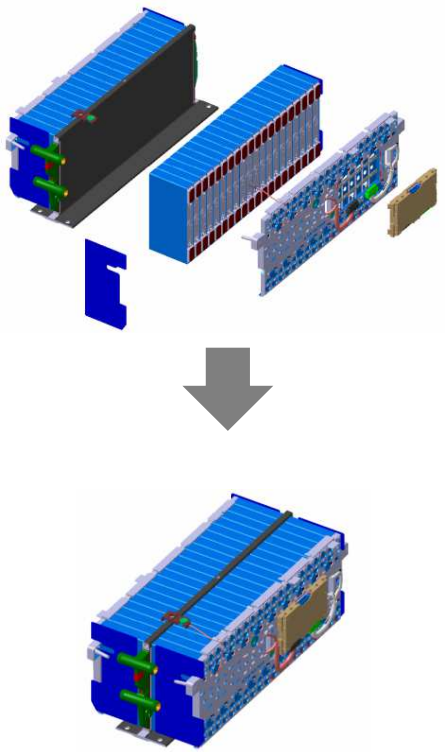
- From cell to module to whole system



High volume mass production

- Automation
- Design layout
- Cost-down

Standardization as key for mass producability



	Component	HEV Mild	HEV Full	PHEV PHEV REX	PHEV City	EV Full range	Standard possible?
Electronics	CSC						YES
Electronics	BMU						YES
Electronics	Sensors						YES
Electronics	Communication						YES
Electronics	Safety						YES
Electrics	Cells						YES
Electrics	HV/LV connectors						YES
Electrics	Fuse						YES
Electrics	BDU						PARTLY
Electrics	Cooling	liquid		Air/Liquid			PARTLY
Electrics	Validation						PARTLY
Electrics	Housing	Extra housing				Housing part of vehicle	NO

high

low

Standardization potential

Battery Systems Product Roadmap

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From 12V systems up to high energy BEV applications
Product diversification driven by matching market needs

Current Products

HEV Truck Gen I

BEV Battery Pack

HEV Truck Gen II

12V Light Weight Li-Ion Battery

HEV Truck Gen III

PHEV Battery Pack

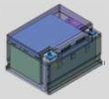
New Products

PHEV / HEV Truck Gen IV

PHEV Battery Pack Gen II

12V Light Weight Li-Ion Battery Gen II

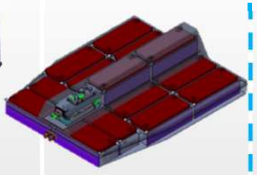
48 V System Gen I



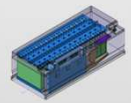
High Power HEV Battery

Innovation Fields

PHEV/EV Systems based on:
- Improved Battery management
- Integrated sub components
- Next generation cell technologies



48 V System Gen II (specific cells)



Diversification of product portfolio beyond vehicle industry

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2020

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Dieses Projekt wird aus Mitteln des Klima- und Energiefonds gefördert und im Rahmen des Programms „Leuchttürme der E-mobilität “ durchgeführt.

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