Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

Tomorrows battery technology : near- and mid-term outlook

Prof. Dr. Andrea Vezzini

Swiss Mobility Days – April 7th 2016

- BFH-CSEM Energy Storage Research Center

BFH-CSEM
Energy Storage Research Center

BFH-CSEM ESReC

BFH-CSEM Energy Storage Center

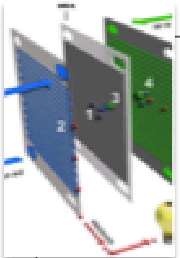
One of the largest independent energy storage research centers for academic R&D activities available to the Swiss industry

Testing and characterization of large capacity cells and modules and development of hard- and software for complete battery and energy systems

Use and test of energy storage systems for mobility applications to substitute non-renewable fuels and reduce CO_2 emission for all mobility carriers (land, air, sea)

Manufacturing technologies for large lithium-Ion cells and modules for a cost effective production of the key components of electrical storage systems

Use and test of PV integrated energy storage systems to enable the integration of new renewable energy sources and their impact on power quality and grid stability



Application, test and development of decentralized and mobile fuel cell systems as a basis for long term storage of electrical energy.

Integrated analysis of Innovation-ecosystems enabling the diffusion of battery storage systems as a means to manage the energy turn-around

Strong Partnerships

CSEM PV-center, Neuenburg
Prof. Dr. Christophe Ballif
(Contract signed)

BKW Technologiezentrum, Nidau
Dr. Daniel Brand
(Prosumer-Lab)

Embedded in three national Research Networks

- FUTURE SWISS ELECTRICAL INFRASTRUCTURE – SCCER-FURIES

SCCER - FURIES
Shaping the FUtuRe SwIss Electrical InfraStructure

- EFFICIENT TECHNOLOGIES AND SYSTEMS FOR MOBILITY – SCCER MOBILITY

sccer mobility

Swiss Competence Center for Energy Research
Efficient Technologies and Systems for Mobility

- HEAT ANND ELECTRICAL STORAGE – SCCER STORAGE

Storage
Swiss Competence Centers
for Energy Research

Automotive Battery Trends

Road transport is responsible for 17.5 % of overall greenhouse gas emissions in Europe and its emissions increased by 23 % between 1990 and 2009.

Mega Trends Create Opportunities and Threats

Mega Trends

- Drive to lower CO_2 emissions
- Urbanisation
- Globalisation

Transportation Trends

- Growth in electric vehicles
- New OEMs emerging
- Smaller, lighter, greener vehicles
- High speed rail
- 50% of automobile sales from BRIC

Impact for Technology and Suplly Chain

Opportunities for:

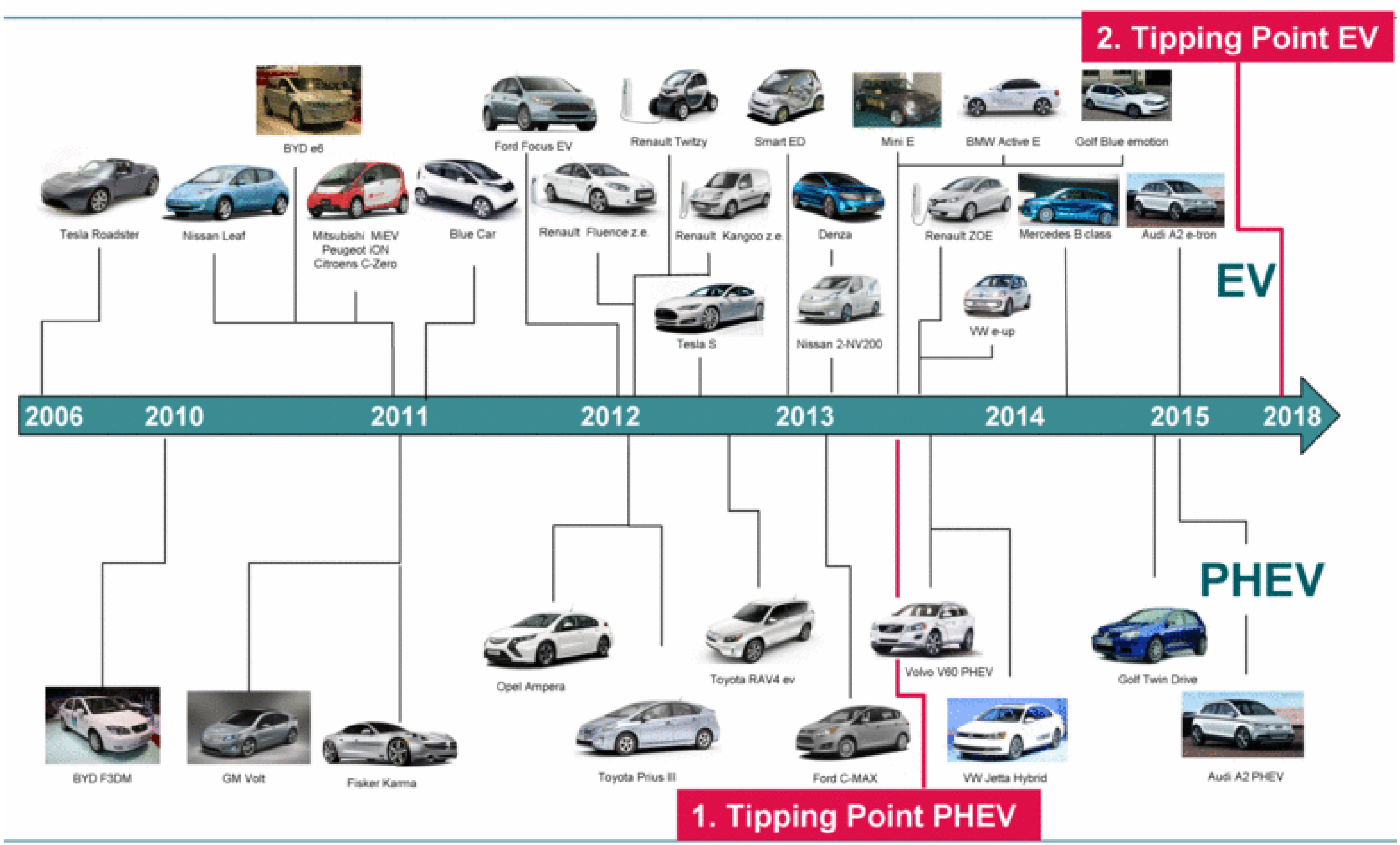
- Battery Systems
- Electric Drivetrains
- Charging Infrastructure
- V2x Technologie
- Software defined Functions

Threats to:

- Large IC Engines
- Metals
- Additives for fossil fuels

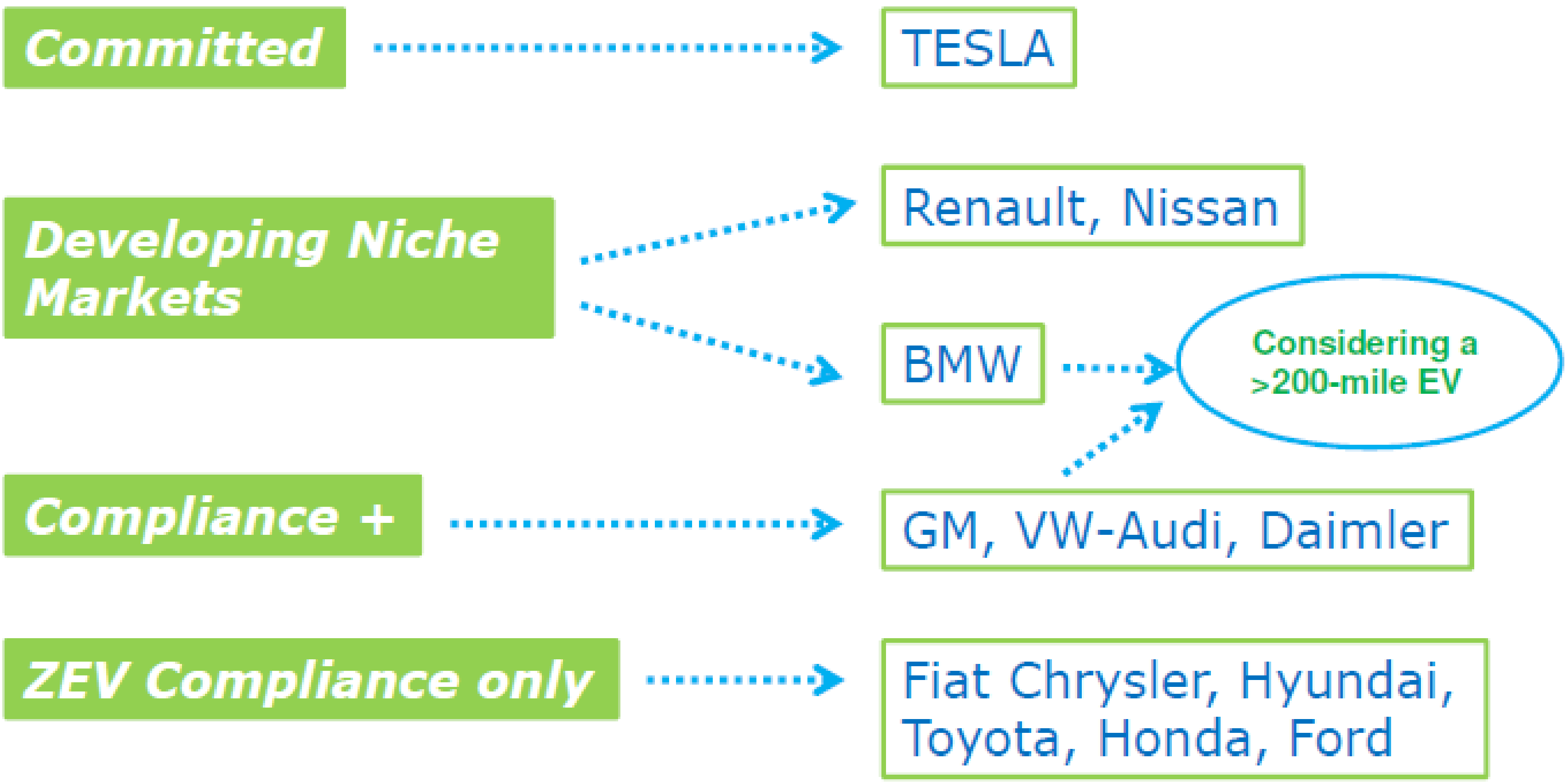
Source: Frost & Sullivan:Automotive Lightweight Materials 360 Degree View, 2011

Market Penetration – Only When?



Source: Rockwood Lithium, 2014

Battery EV Efforts by Major Automakers



The Perspective of Major Automakers

- For the next 10+ years, no viable mass market for EVs due to battery cost and size, and charging time; HEVs and/or PHEVs are a more effective way to reduce the CO_2 footprint
  - Shared by most automakers excluding Renault-Nissan
- In the longer term, fuel-cell (FC) vehicles are more appealing than battery EVs due to the shorter fueling time and longer driving ranges
  - Shared by Toyota, Honda, and Hyundai (less uniformly by Daimler and GM)
- In the short term, we make EVs predominantly to meet California's Zero-Emission Vehicle (ZEV) Mandate
  - Shared by most companies excluding Renault-Nissan, who explore international markets, and excluding Toyota, Honda, and Hyundai, who, even in the short term, favor FC vehicles
- We will offer the lowest-cost EVs we can build and hopefully sell at least in ZEV states
  - Was shared by most automakers prior to Tesla's success
- Our expected losses associated with ZEV-compliance costs for selling larger EVs with longer driving range may be lower than for smaller EVs with shorter range
  - The current position of about half the automakers (GM, Audi, Daimler, Chrysler), who shifted their EV development focus after Tesla's success

Li-Ion Cells Employed in Current EVs

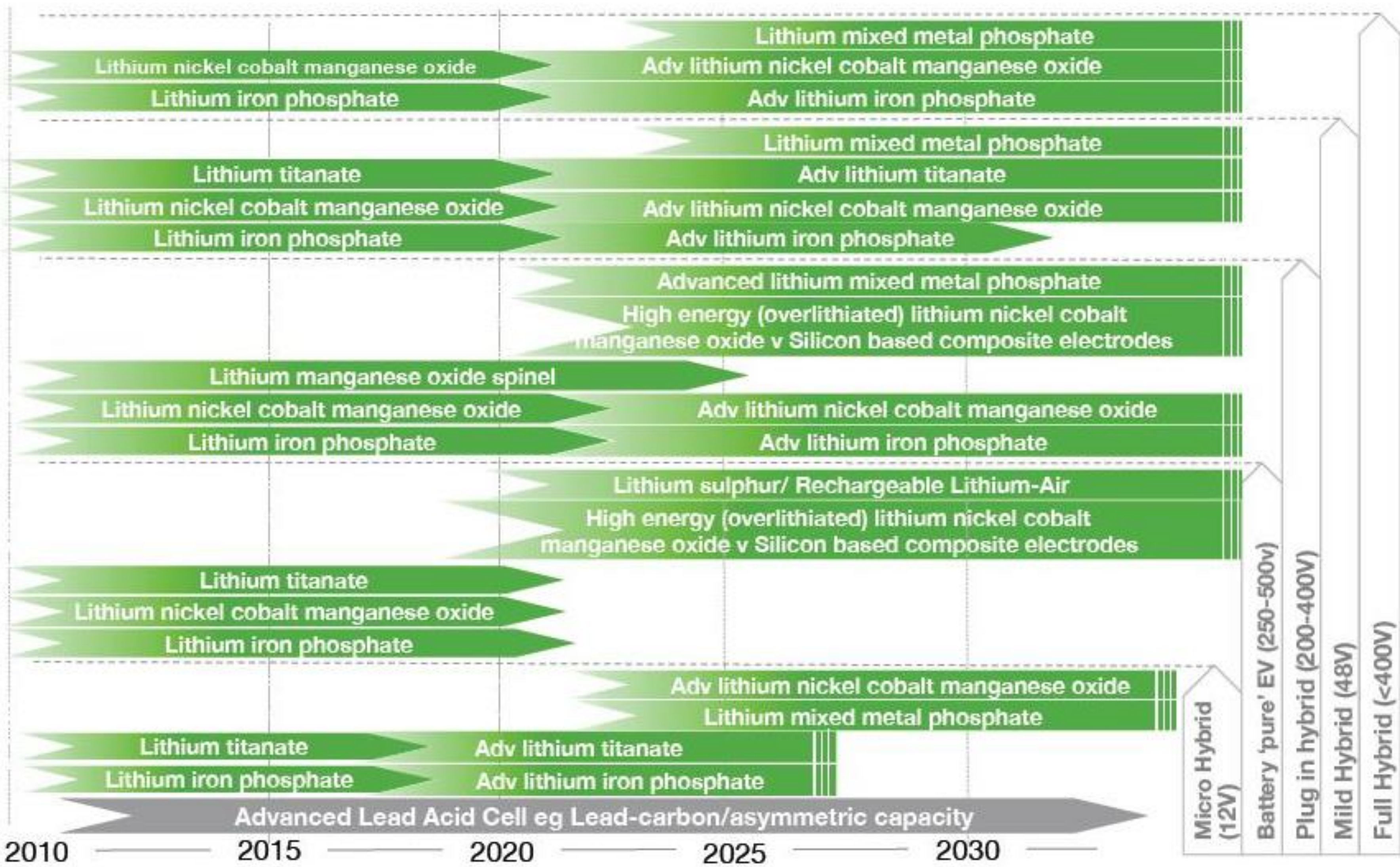
Tesla-Panasonic's current cell offers specific energy 50% higher than the competition. This is primarily due to the use of highly reactive NCA cathodes and high-density electrodes.

	Cell Maker	Chemistry	Capacity	Configuration	Voltage	Weight	Volume	Ener dens	Spec Ener	Used in:	
		Anode/Cathode	Ah		V	Kg	liter	Wh/liter	Wh/kg	Company	Model
1	AESC	G/LMO-NCA	33	Pouch	3.75	0.80	0.40	309	155	Nissan	Leaf
2	LG Chem	G/NMC-LMO	36	Pouch	3.75	0.86	0.49	275	157	Renault	Zoe
3	Li-Tec	G/NMC	52	Pouch	3.65	1.25	0.60	316	152	Daimler	Smart
4	Li Energy Japan	G/LMO-NMC	50	Prismatic	3.7	1.70	0.85	218	109	Mitsubishi	i-MiEV
5	Samsung	G/NMC-LMO	64	Prismatic	3.7	1.80	0.97	243	132	Fiat	500
6	Lishen Tianjin	G-LFP	16	Prismatic	3.25	0.45	0.23	226	116	Coda	EV
7	Toshiba	LTO-NMC	20	Prismatic	2.3	0.52	0.23	200	89	Honda	Fit
8	Panasonic	G/NCA	3.1	Cylindrical	3.6	0.048	0.018	630	233	Tesla	Model S

The gap will shrink to 20-25% in the next 3 years, but it is not enough to override concerns with the 18650 approach relative to:

- Reliability, too many components and processes
- Limited cycle life and anticipated reduction in power over life
- Battery power at low state of charge is only slightly above motor power, and with anticipated battery power fade over life, the battery can, over time, limit vehicle power at low state of charge

Electrochemical Energy Storage Roadmap(s)



Source: UK automotive council, 2014

TESLA's 50GWh Battery Factory (Gigafactory)

Gigafactory 1.0

- $4-5 Billion investment
- Under construction in Reno, NV
- 6,500 full-time jobs
- First battery packs mid-2016

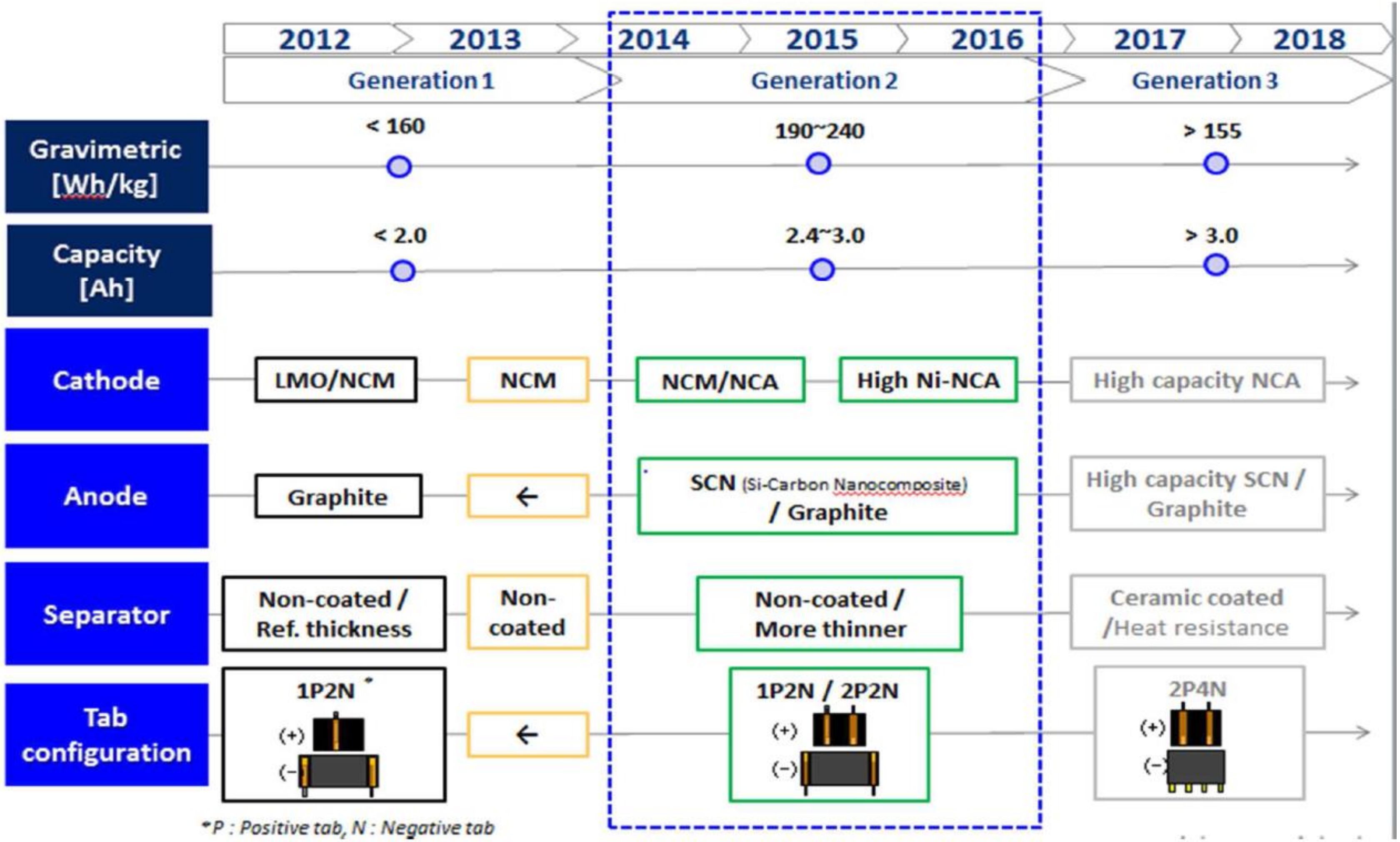
- By 2020 it plans to ramp up production to build as many as 500,000 vehicles per year
- Currently only approximately 20 percent of its 1-million-square-foot facility is already up and running.
- The company is already building Powerwall home-storage batteries, and production will only speed up as more square footage becomes usable

Source: Tesla Motors JB Straubel – CTO, co-founder 2015 EIA Conference June 15, 2015 Washington, D.C.

Tesla’s 35GWh Gigafactory – Synopsis

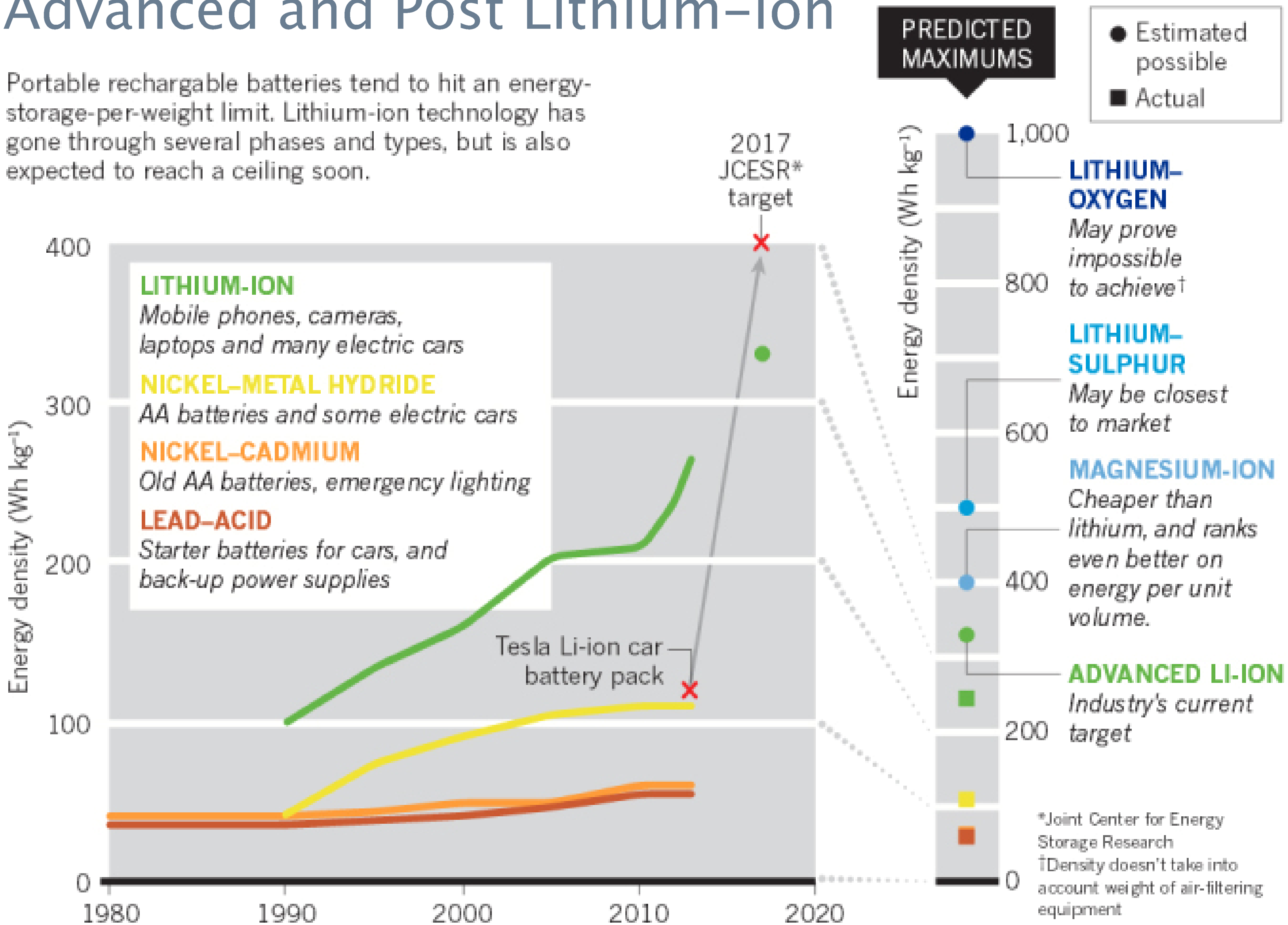
- Tesla suggests that it will put up half of the $5 billion investment, with Panasonic investing on the order of $1–1.5 billion, but unconfirmed reports from Japan suggest that Panasonic only committed to about $200M next year
- Pack cost much below $200/kWh is unlikely before 2020, which brings the cost of the proposed 70-kWh pack for a 240-mile D class EV to $14,000 (or higher).
- If 35 GWh are indeed installed and utilized, initial assessments shows that pack pricing for the 2025 time scale could be as low as $167/kWh, $8,400 for a 50-kWh battery and $11,700 for a 70-kWh pack
- Other automotive and utility customers for the factory are possible but far from assured
- The chosen site outside Reno, Nevada offer lower labor and utility cost than Japan sites and short supply lines to the Fremont Tesla car factory

Li-Ion Technology Roadmap FPR 18650



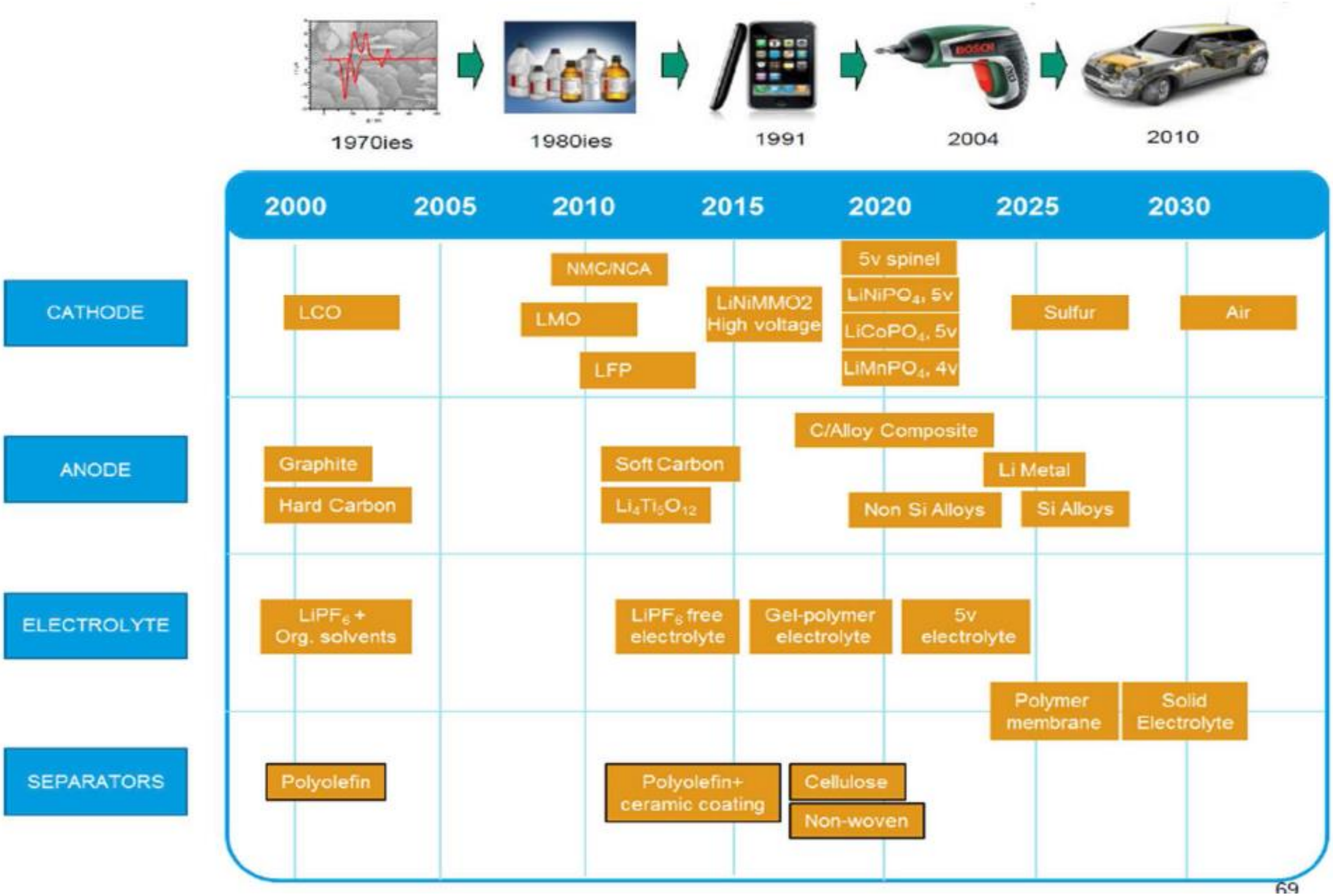
Source: BMZ, 2016

Advanced and Post Lithium-ion



Source: IDTechEX, Advanced and Post Lithium-ion Batteries 2016-2026: Technologies, Markets, Forecasts , 2015

What Li-Ion will be next?

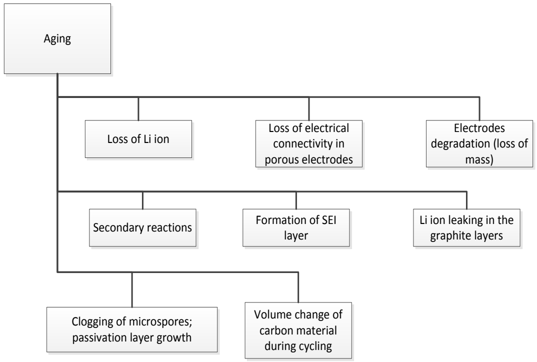


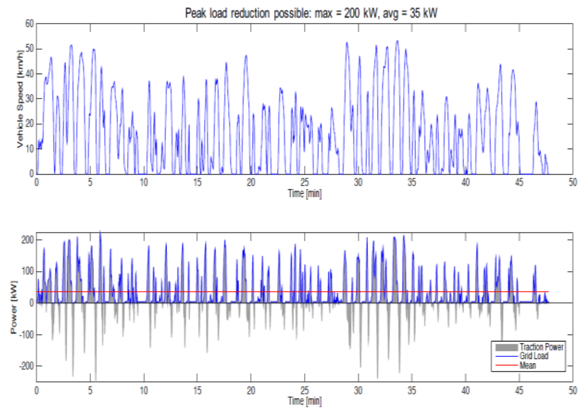
Source: BMZ, 2016

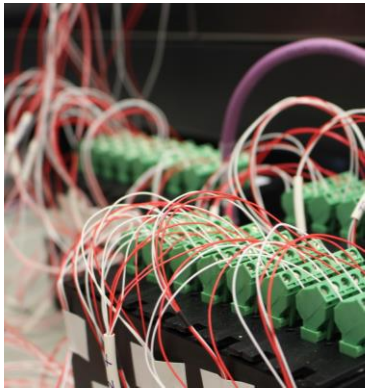
Our Research

BFH-CSEM Energy Storage Research Center

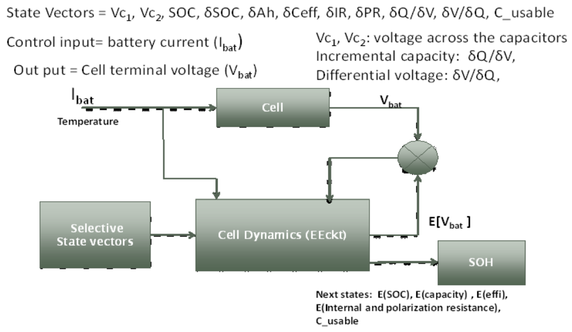
Battery Research at the BFH-CSEM ESReC

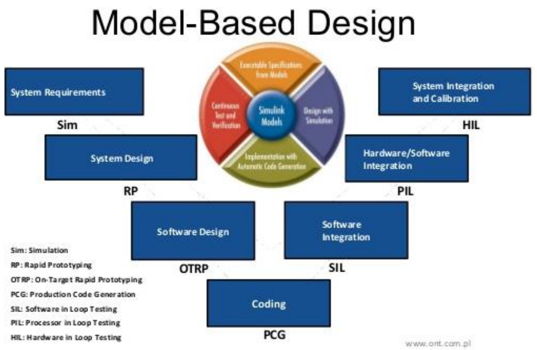






- Aging Mechanism
- Application Specific
- Battery testing
- Life Cycle Testing





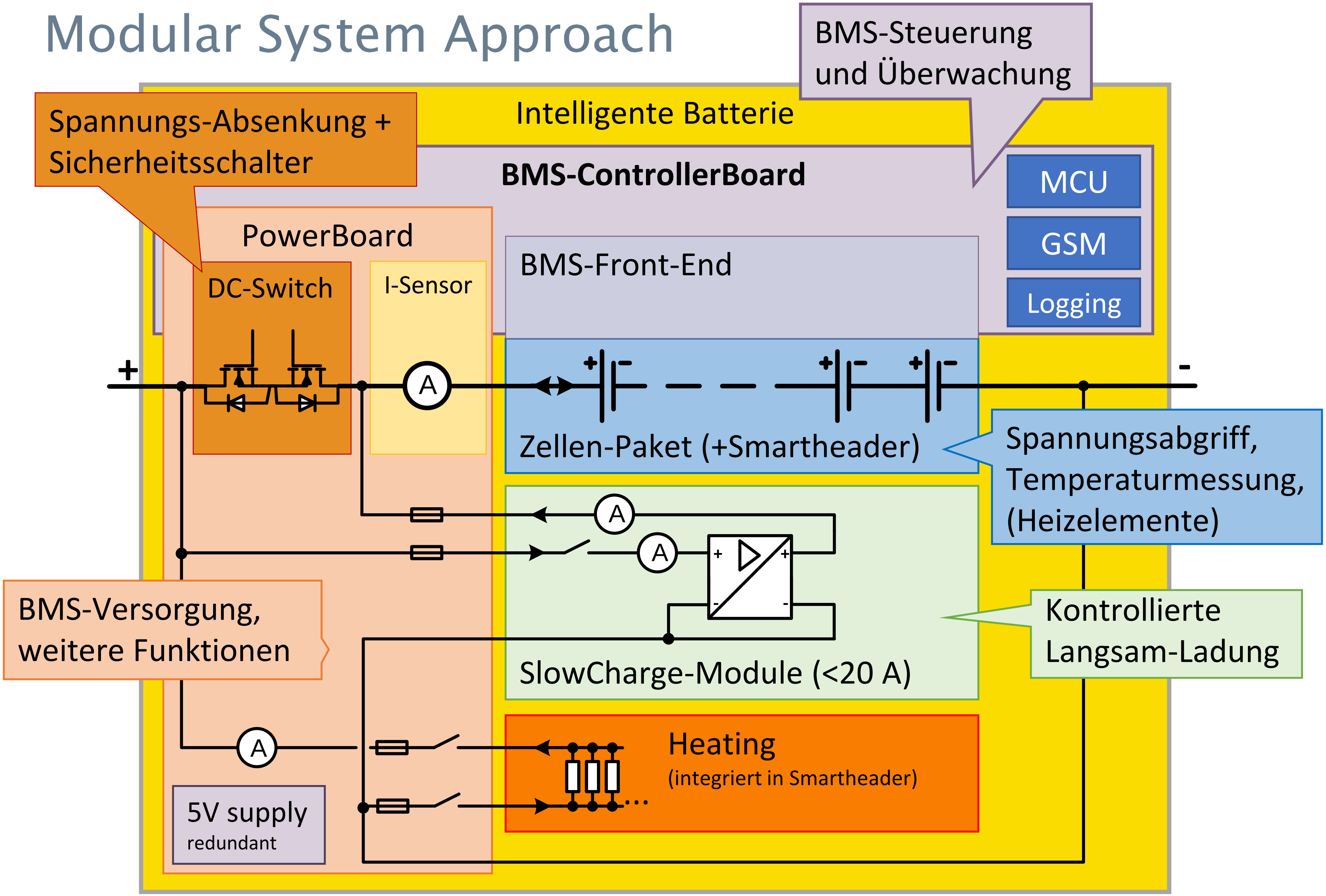
- SOC/SOC/SOH-Models
- Life Cycle Models
- Battery-Management-System Software Development
- Battery-Management-System Hardware Development

Potential of Lithium-Ion Batteries for energy saving

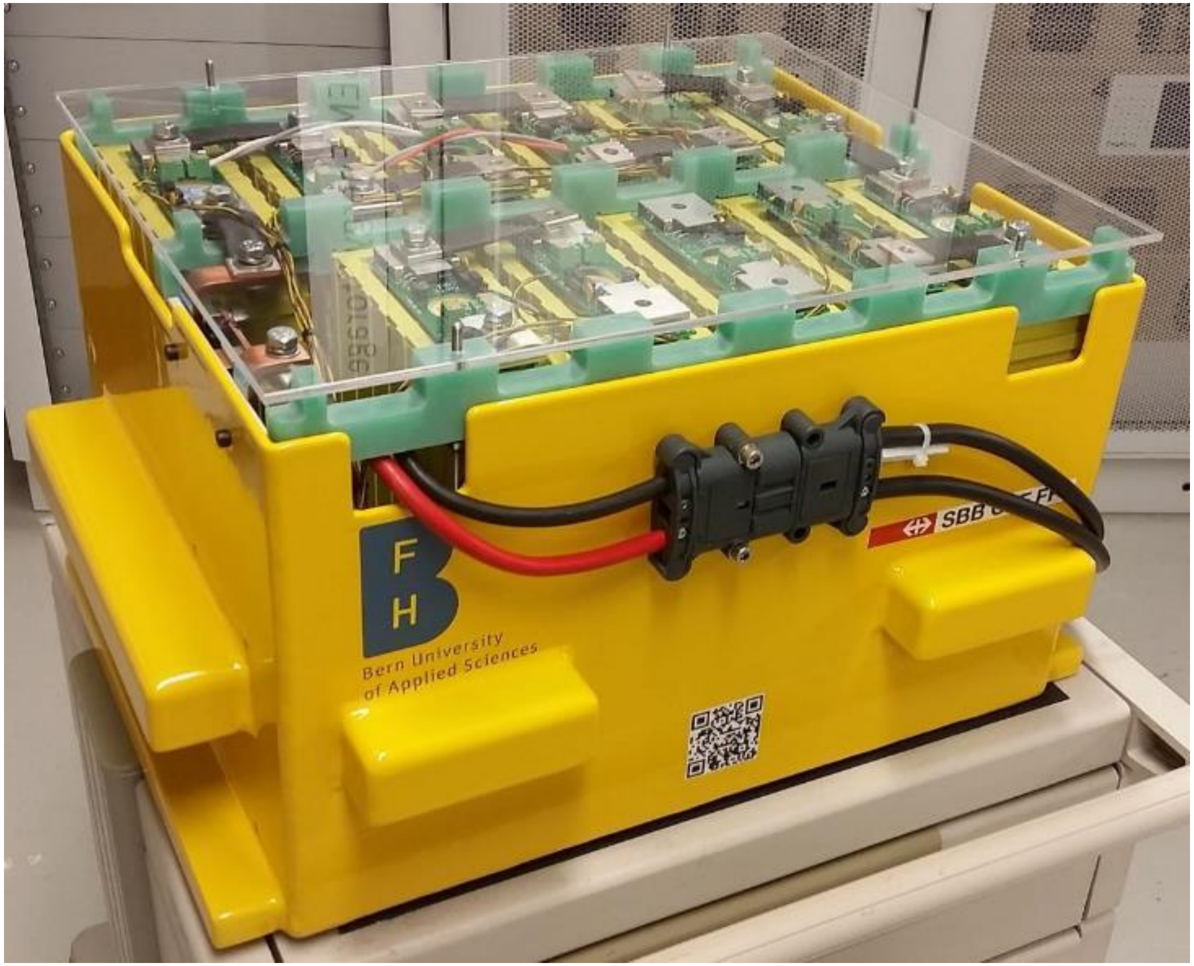
SBB CFF FFS

- Quantify energy saving potential of Lithium-Ion Batteries for the use in train wagons (passenger coach)
- Cooperation with SBB started September 2015 and has now resulted in a BFE funded pilot project for 2016/17
- Designing a Lithium-Ion battery including Battery Management System adapted for the use in passenger coaches

Modular System Approach



36V/180 on board storage battery for SBB



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Questions?

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