International Conference on Advanced Material Technology (ICAMT) 2019

Application of Lithium Ion Batteries in a Smart Grid System : Electrical Power Systems and Electric Vehicles

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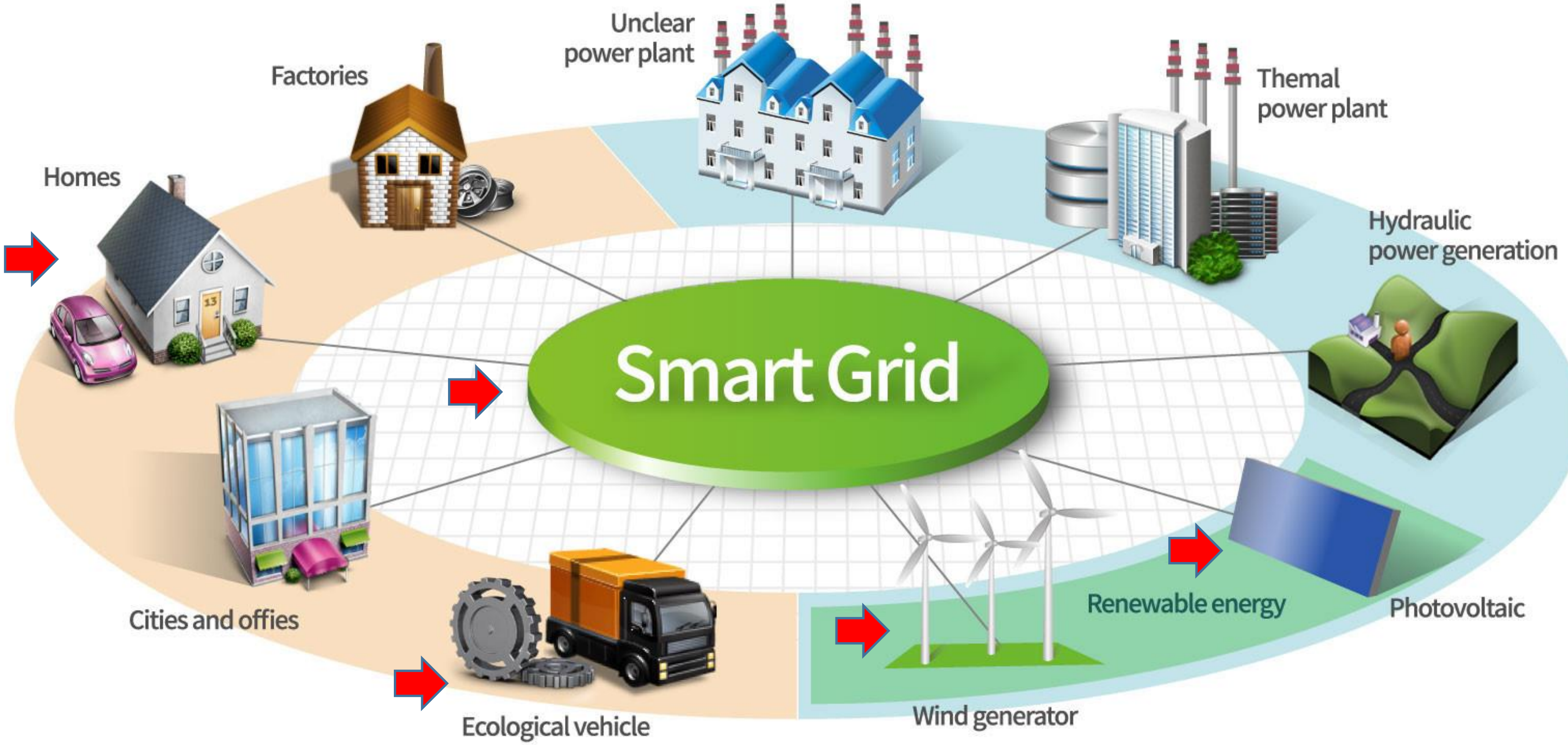
08 October 2019

Smart Grid View



The Smart Grid can be defined as an electric system that uses information, two-way, cyber-secure communication technologies, and computational intelligence in an integrated fashion across the entire spectrum of the energy system from the generation to the end points of consumption of the electricity.

Hamid Gharavi, Reza Ghafurian, Fellow IEEE

Application of LIB in Electrical Power System
Battery Energy Storage Systems (BESS)

The Needs of Energy Storage System

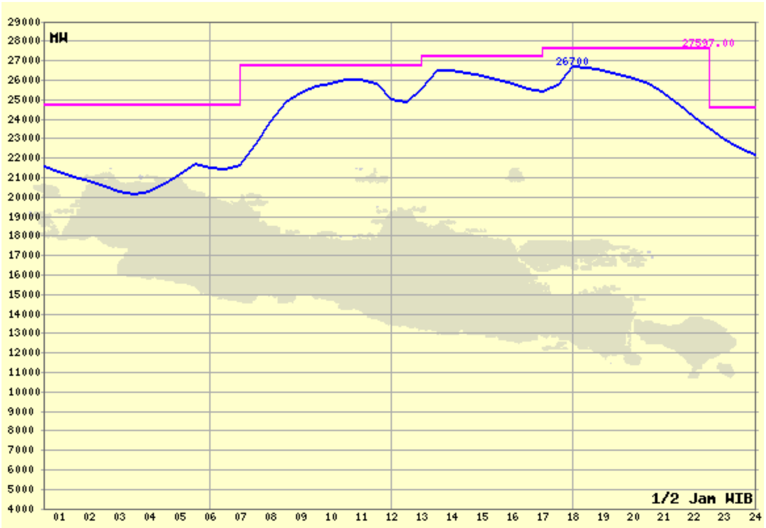
Electricity that can be generated is **fixed** over short period of time but the its demand **fluctuates constantly**. Managing this flow of energy to meet grid demands is **essential** and **very challenging**.

For Utility Scale sized projects (> 5 MW) Advanced Energy Storage technologies play an **integral role** in storing electrical energy so it can be available to meet **consumer demand** at peak times.

Need for storage will **continue to increase** due to:

- Development of large amounts of renewable energy sources
- Management of an antiquated Utility Grid Network
- Higher Energy (Demand) Costs

Daily load curve



Source : http://hdks.pln-jawa-bali.co.id/app4/system.php

Peak load : 26814 MW at 18:00

Reserve : 559 MW

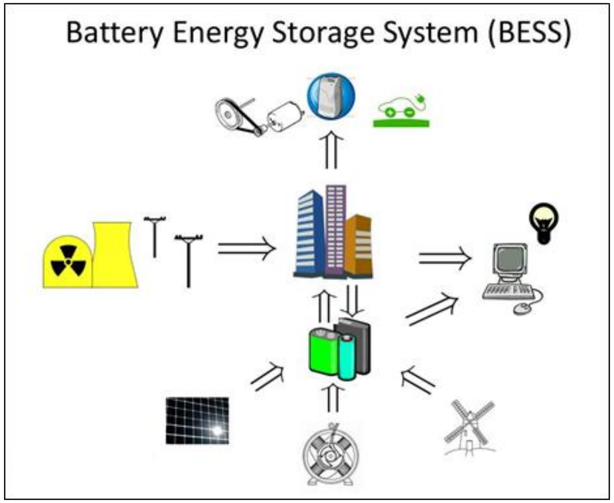
Potential Benefits of Energy Storage System

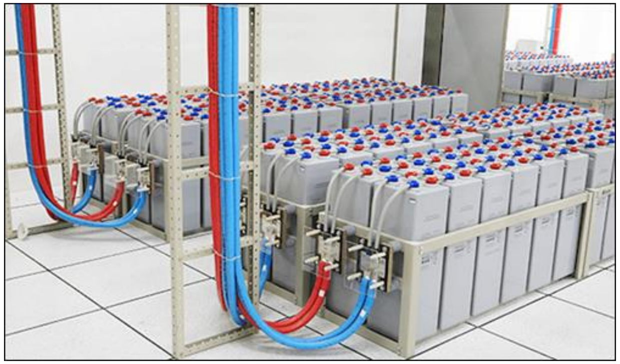
Energy storage system offer possibilities for improved energy generation and access:

- Displace expensive and emissions-intensive diesel-based generation.
- Improve efficiency and profit of existing generating assets
- Reduce overall emissions
- Increase adoption and profitability of renewable energy
- Create local jobs
- Provide environmental benefits

Battery Energy Storage System (BESS)

- Energy Storage System is a general term for the ability of a system to **store energy** using thermal, electro-mechanical or electro-chemical solutions.
- A BESS typically utilizes an **electro-chemical solution.**
- all Energy Storage Systems capture energy and store it for use at a later time or date.
- Examples of these systems: pumped hydro, compressed air storage, mechanical flywheels, and now BESSs.



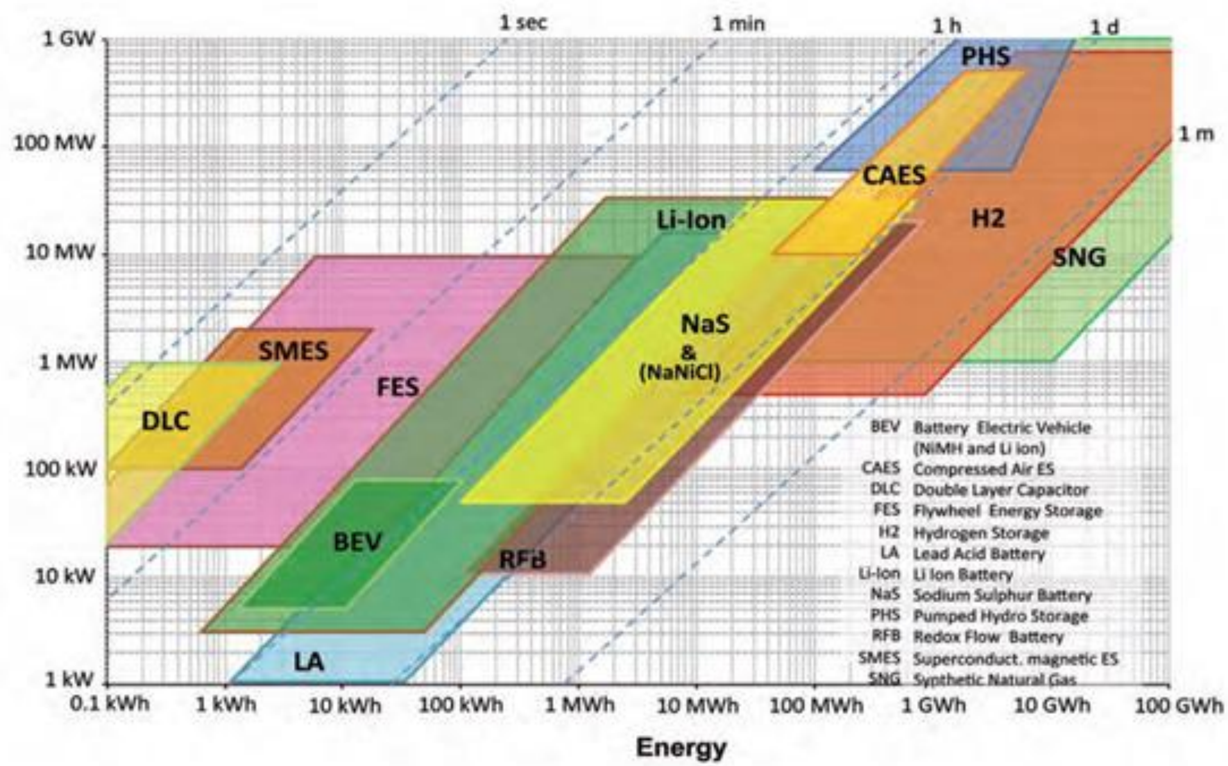


Why is BESS gaining popularity?

- All types of BESS offer pros and cons in terms of capacity, discharge duration, energy density, safety, environmental risk, and overall cost.
  - **Decreasing costs -** BESS technology has been a 50% decrease in costs of energy storage over the last two years.
  - **Security of supply -** they improve energy security by optimizing energy supply and demand, reducing the need to import electricity via inter-connectors, and also reducing the need to continuously adjust generation unit output.
  - **Financial incentives -** Many governments and utility regulators are actively encouraging the development of battery storage systems with financial incentives.

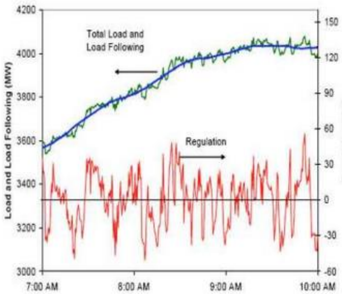
Why BESS over other storage technologies

- Advantages :
  - it has **small footprint** and **no restrictions** on geographical locations.
  - BESS utilizing Lithium Ion technology offer **high energy** and **power densities** that are suitable for utilizing at distribution transformer level.
- Energy and power densities of some technologies:



BESS Utility Applications

Frequency Regulation



- **Purpose**
  - Maintain a constant grid frequency
  - Grid stabilized back-up power (spinning reserve)

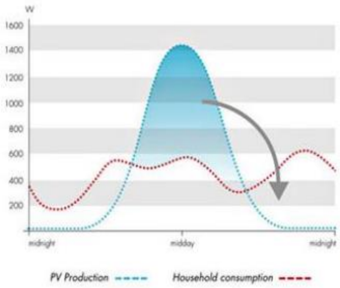
Community Energy Storage

- **Purpose**
  - Neighborhood back-up
  - Local peak shifting
  - Power quality

Residential Energy Storage

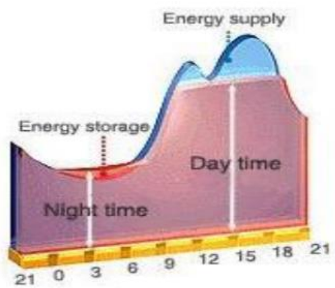
- **Purpose**
  - Residential back-up
  - PV integration

Peak Shifting



- **Purpose**
  - Alternative to peaking gas power plant in urban areas
  - Renewable peak shifting

Load Leveling



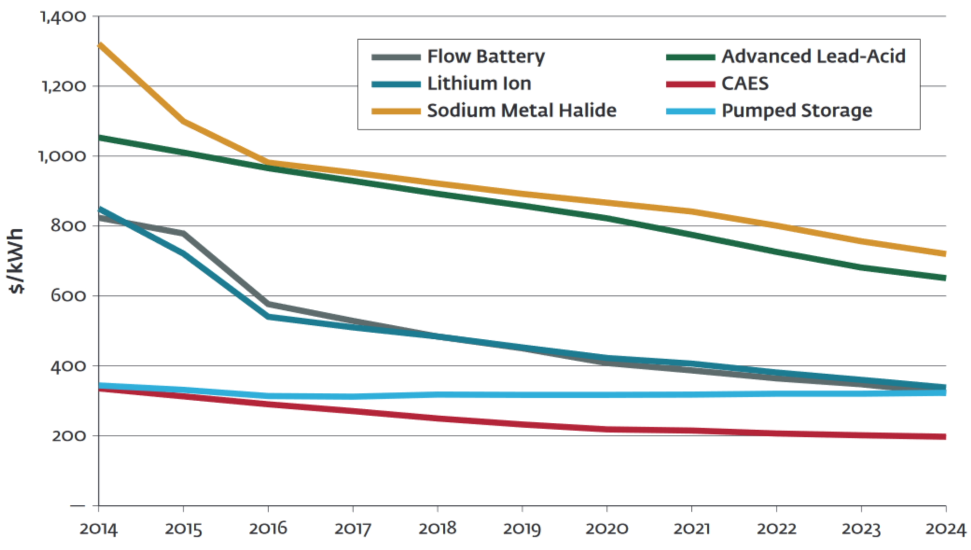
- **Purpose**
  - Energy arbitrage
  - Renewable capacity firming

Source: Clean Energy Ministerial

Energy Storage System Cost Trends

Battery Type	Installed Cost ($/kW)	Est. Annual O&M Cost ($/kW)	Avg. Round-Trip Efficiency	Est. Annual Fuel Savings (L/kW)	Est. Annual Fuel Savings ($/kW)
Flow Battery: Utility-Scale	2,300.2	31.1	70%	1,680	1,831.2
Flow Battery: Distributed	2,874.4	34.5	70%	1,680	1,831.2
Advanced Lead-Acid: Utility-Scale	2,903.5	66.2	80%	1,920	2,092.8
Advanced Lead-Acid: Distributed	3,284.5	66.8	80%	1,920	2,092.8
Lithium Ion: Utility-Scale	2,062.0	47.3	90%	2,040	2,223.6
Lithium Ion: Distributed	2,150.3	50.8	90%	2,040	2,223.6

Estimated Fuel Savings and System Costs of Energy Storage Technologies in Remote Microgrids by Battery Type, World Markets: 3Q 2016

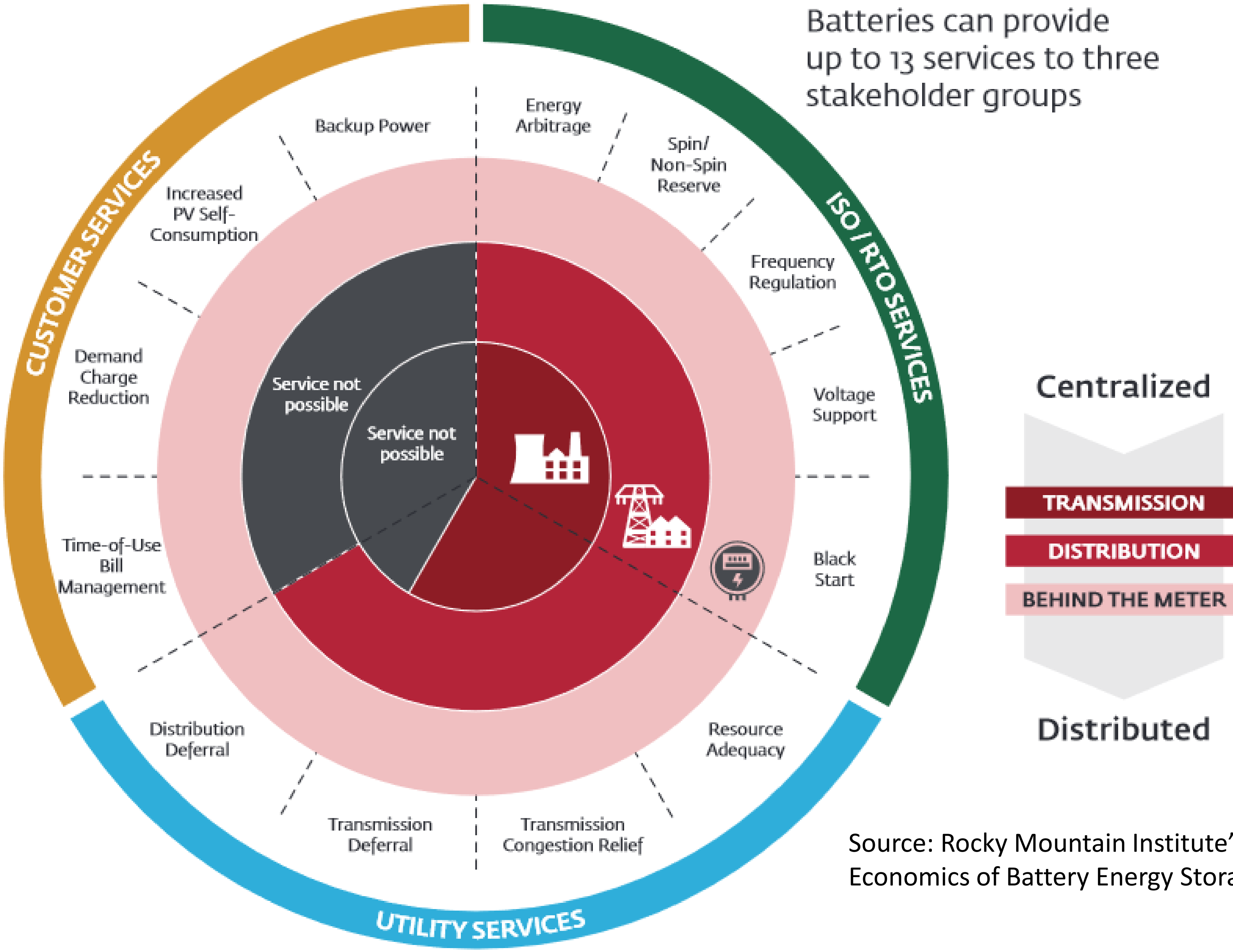


Utility-Scale Energy Storage System Cost Trends by Technology, Global Averages: 2014–2024

Source: Navigant Research

Battery Energy Storage Value Chain

Batteries can provide up to 13 services to three stakeholder groups



Source: Rocky Mountain Institute's The Economics of Battery Energy Storage

BESS Across the Value Chain

Storage solutions for every step of the value chain

Production

Energy & Power

1 - 10MW

Renewables
Capacity Firming
Smoothing, Shaving

Transmission

High Power

10 – 50 MW

Ancillary Services
Frequency Control

Distribution

Energy & Power

100 Kw – 1MW

Load Management
Peak Shaving
Voltage Control

Consumption

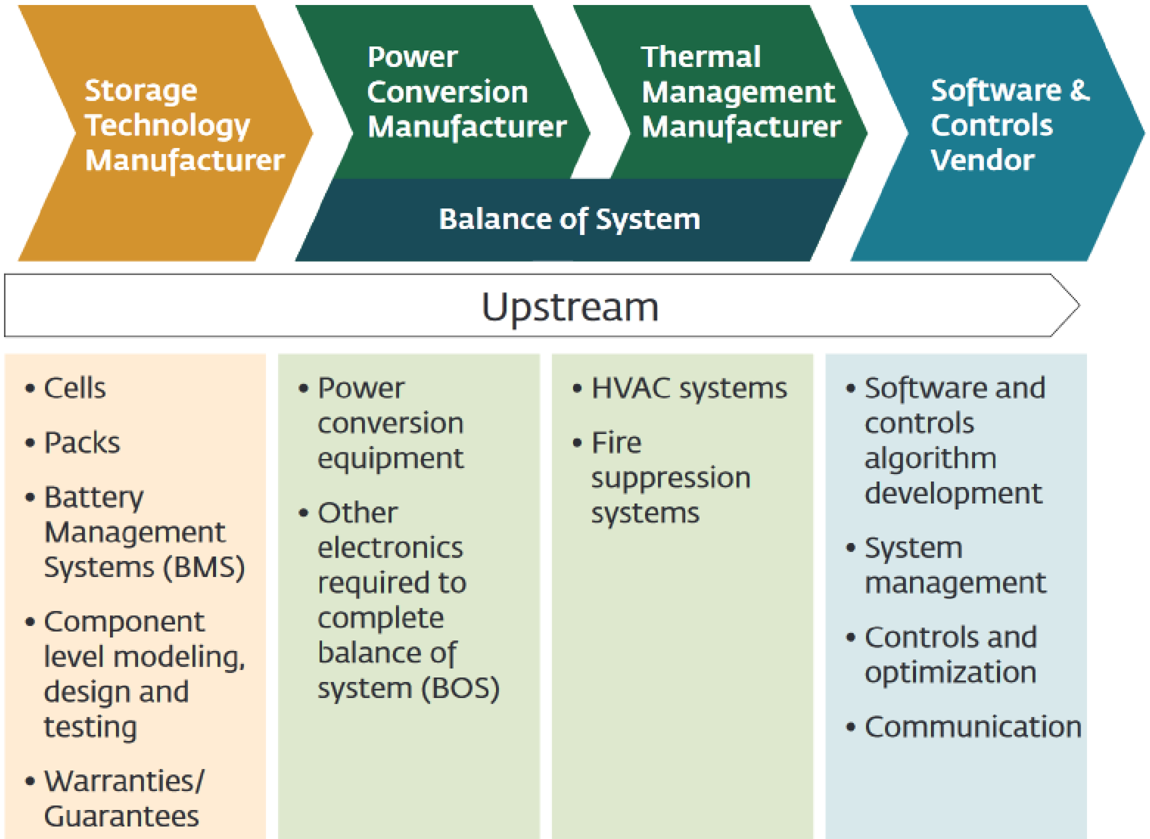
Energy

5 – 50 kW

Time Shifting
Local Energy
Management

Source: Clean Energy Ministerial

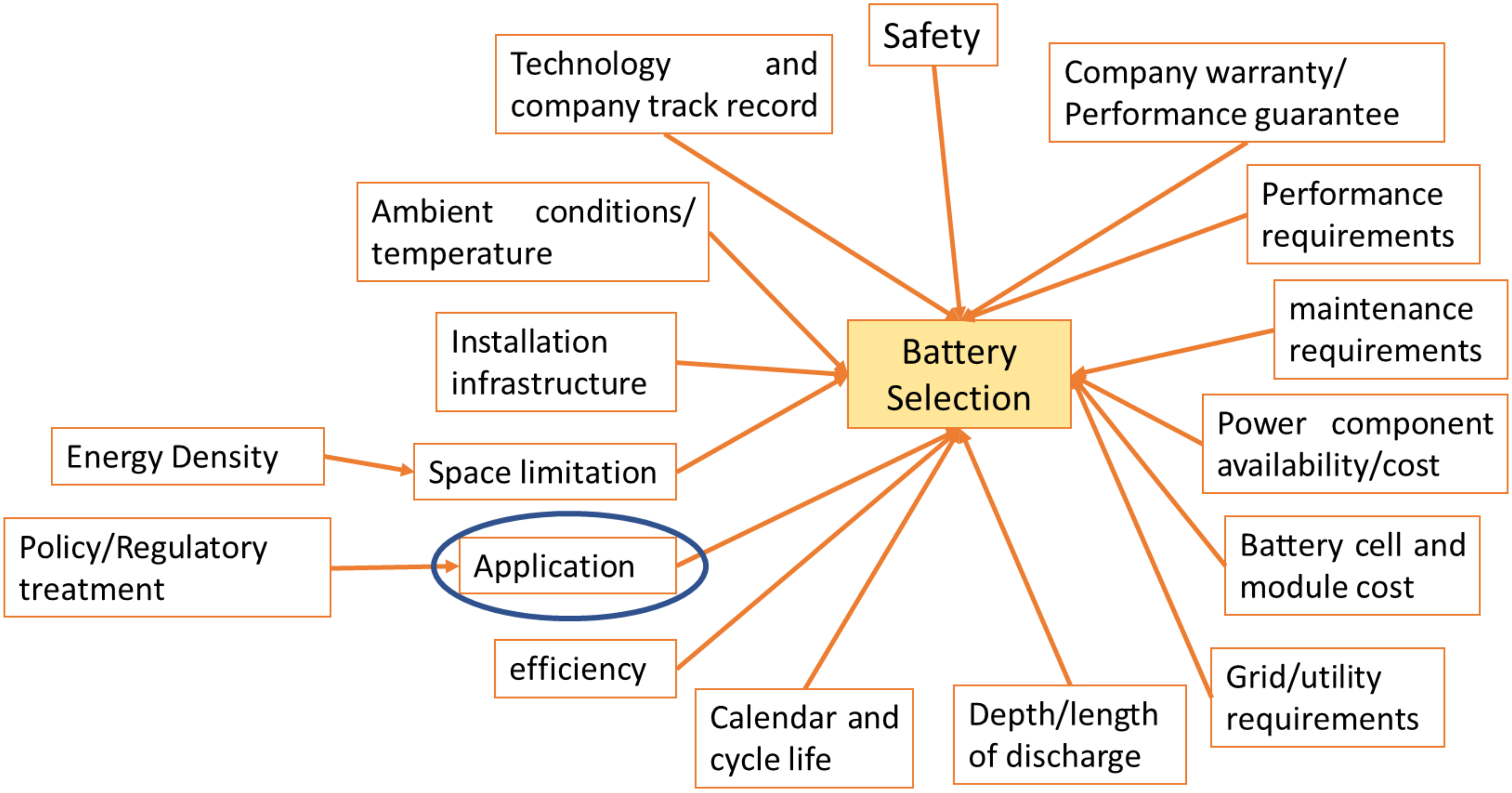
Battery Energy Storage Value Chain



ESSs are **not all created equal**; services, functionalities, and pricing structures can vary from project to project. However, certain components remain consistent for utility-scale and distributed deployments.

Source: Navigant Research

Important Considerations for Battery Selection

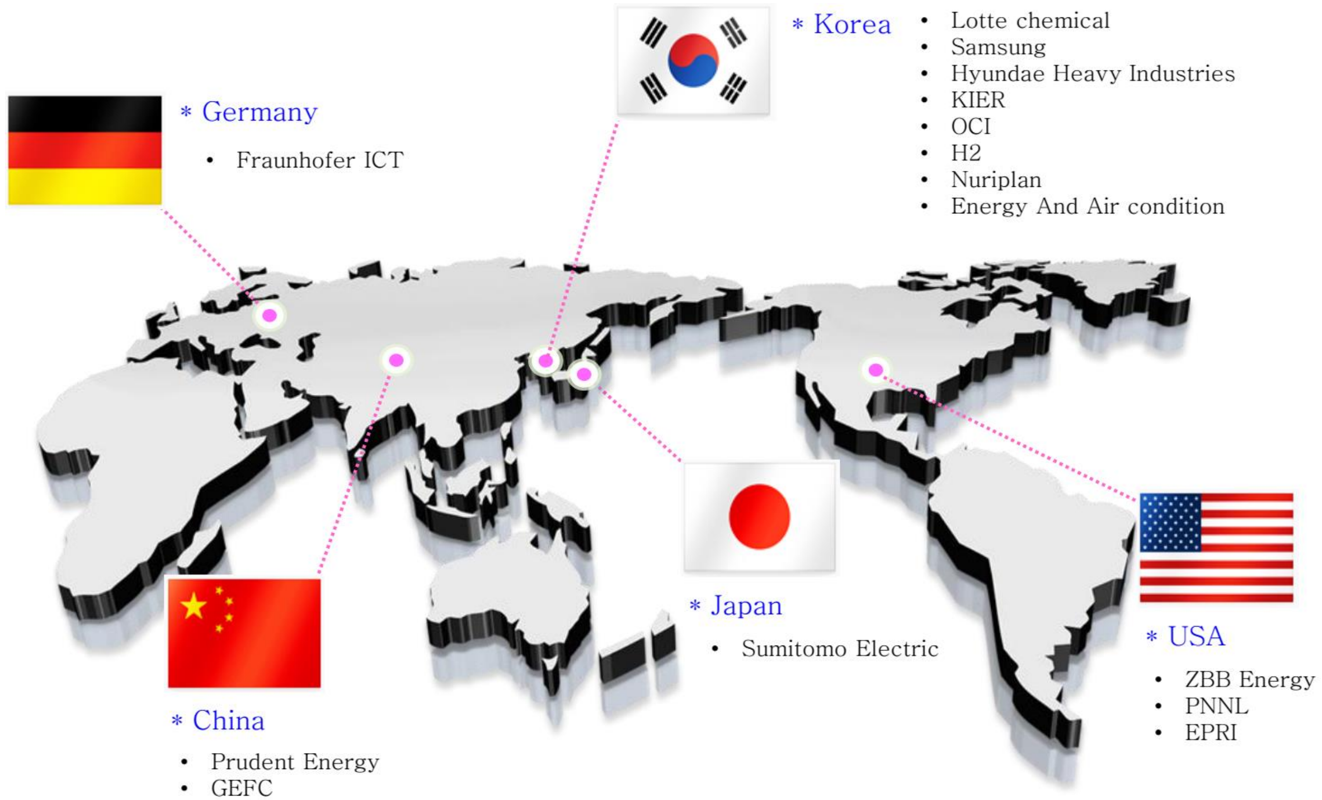


Recent Development of Largest Grid Batteries

Name	Commissioning date	Energy (MWh)	Power (MW)	Duration (hours)	Type	Country
Buzen Substation	3 March 2016	300	50	6	Sodium-sulphur	Japan
Rokkasho, Aomori		245	34	7	Sodium-sulphur	Japan
Hornsdale Power Reserve	1 December 2017	129	100	3	Lithium-ion	Australia
Escondido Substation	24 February 2017	120	30	4	Lithium-ion	USA
Pomona Substation	January 2017	80	20	4	Lithium-ion	USA
Mira Loma Substation	30 Jan. 2017	80	20	4	Lithium-ion	USA
Tesla Solar Plant	8 March 2017	52	13	5	Lithium-ion	USA
Stocking Pelham facility	July 2018	50	50		Lithium-ion	United Kingdom
Jardelund	June 2018	50	48		Lithium-ion	Germany
Minamisōma Substation	February 2016	40	40		Lithium-ion	Japan

https://en.wikipedia.org/wiki/Battery_storage_power_station

Indicative BESS Demonstration Projects*



**This is a indicative list of projects. It is not meant to capture all of the active ESS demonstration projects in any of the countries listed or globally*

Source: Clean Energy Ministerial

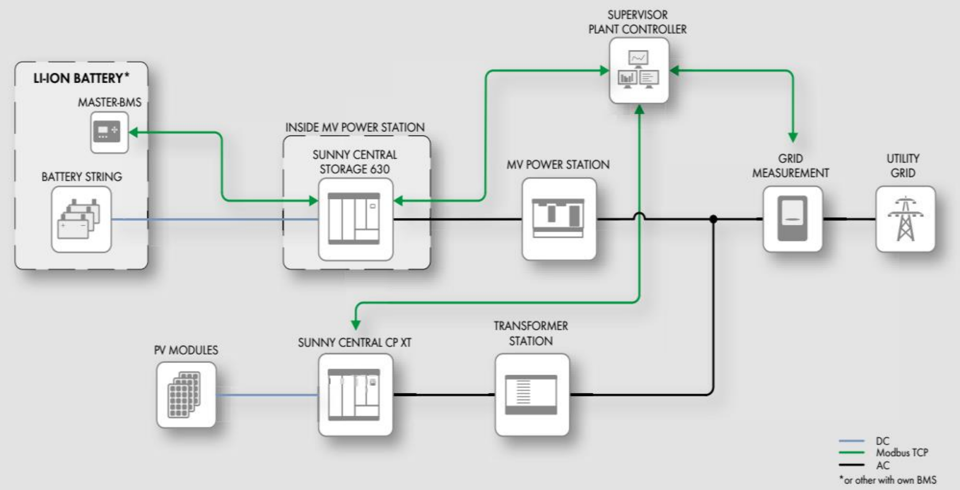
SMAs Sunny Central Storage

- An in-house 2.4-MW test plant is currently being built on-site at SMA in Niestetal, Germany to test new system technologies and certify new products for **megawatt-class hybrid** and **storage systems.**

- At the university of Arizona in Tucson, USA, SMA has developed a **500-kilowatt battery inverter** which, in combination with a 200-kWh lithium ion battery, is capable of **balancing fluctuations** in solar power generation
- The world's first modular, **large-scale battery storage system** with a capacity of 6.25 MW is being built in Aachen, Germany.

The SMA large-scale storage concept consists of the following components:

- Sunny Central Storage battery inverter, with transformer and medium voltage switch gear integrated into a container station.
- Power Plant Controller acts as the smart interface for the PV battery system
- Battery storage system with optimally adjusted power and capacity



Source: SMA's courtesy

30 MW (120 MWh) San Diego Gas & Electric, California

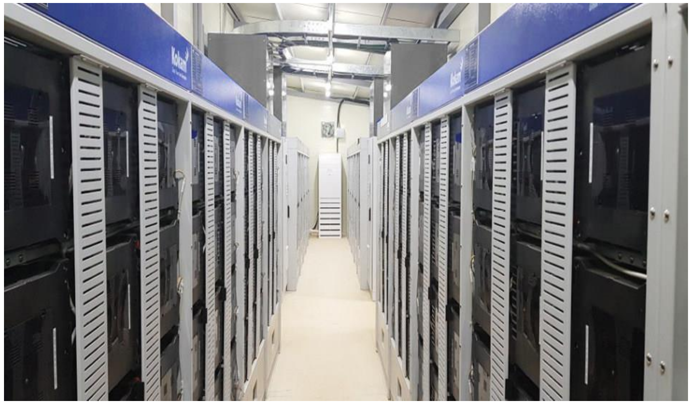
https://www.eseexpo.com/cgi-bin/md_energy/lib/pub/tt.cgi/SDG_E_unveils_30MW_120_MWh_LI_battery_energy_storage_facility.html?oid=6866&lang=2&ticket=g_u_e_s_t

- On February 24th, 2017, San Diego Gas & Electric (SDG&E, San Diego, California) showcased a **30 megawatt (MW) lithium-ion battery energy storage** facility in partnership with AES Energy Storage, which will enhance regional energy reliability while maximizing renewable energy use.
- The energy storage facility is capable of storing up to **120 megawatt hours** of energy, the energy equivalent of serving 20,000 customers for four hours.
- The 400,000 batteries, similar to those in electric vehicles, were installed in nearly 20,000 modules and placed in 24 containers.
- By 2030, the company expects to develop or interconnect more than 330 MWs of energy storage on the system.

Kokam Installs 40 MWh Storage in South Korea

Kokam has announced total 40 megawatt-hours of solar-connected battery capacity in South Korea. Kokam's High Energy **Lithium Nickel Manganese Cobalt Oxide** (NMC) battery technology to deliver the safe, energy dense storage the projects need for **renewable capacity firming** and **energy time shifting**.

The plan foresees **adding 48.7 gigawatts** of renewable energy to the country's electricity mix between 2018 and 2030. Of this, **63 gigawatts will be solar**, which the government fears could destabilize the grid if not **coupled to some form of energy storage system** (ESS).



Kokam ESSs will deliver an estimated annual savings of US$13 million in fuel costs

Source: KOKAM's courtesy

Tesla’s Massive Powerpack Battery

Tesla's facility at Hornsdale Wind Farm

Source: https://electrek.co/2018/09/24/tesla-powerpack-battery-australia-cost-revenue/

Tesla’s massive Powerpack battery project in Australia is quite **financially successful**

The giant battery **cost ~$66 million** and it reportedly already **made up to $17 million** during the first ~6 months of operation

Tesla’s 100MW/129MWh Powerpack project in South Australia provide the same grid services as **peaker plants**, but cheaper, **quicker**, and **with zero-emissions**, through its battery system.

Zhangbei, China, Wind Energy Time Shift and Ancillary Services

Hybrid wind power + Solar PV Generation + Lithium-ion Battery Energy Storage: 216 MW

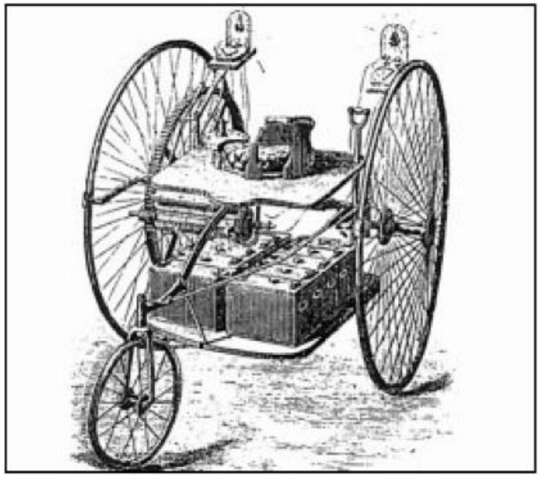
As of completion in 2011, the Zhangbei National Energy Storage and Transmission Demonstration Project is the world’s first and, to date, only utility-scale hybrid renewable energy plant **to integrate utility-scale wind and solar PV generation with large scale lithium-ion battery energy storage**

Location : Zhangbei County, Hebei Province, China
Project Status : Commissioned: 2011
Rated Capacity : Total 216MW (wind 100MW, Solar PV 40MW, Battery storage 20-36MW)
Owner : State Grid Corporation of China (SGCC)
Cost : $1.88 billion (first phase investment: $550 billion)

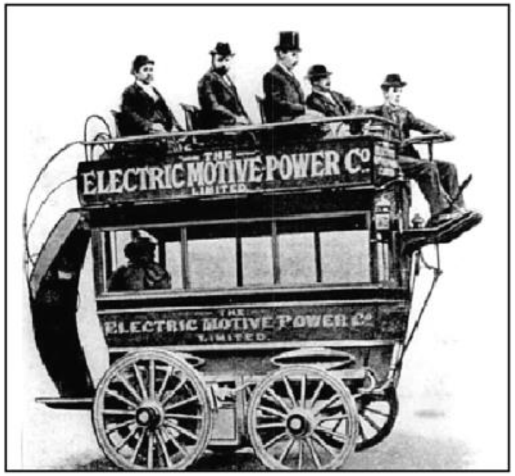
Source: Clean Energy Ministerial

LIB for Electric Vehicles

Early Battery Vehicles



Electric Tricycle, 1881

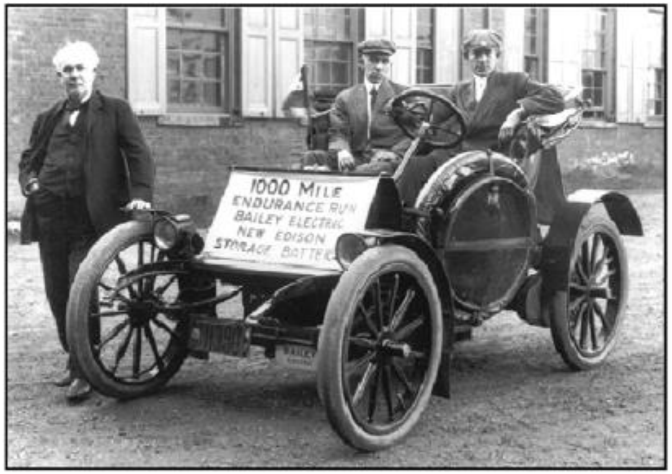


Battery Bus, 1894

La Jamais Contente, 1899

Passenger Wagon, 1891

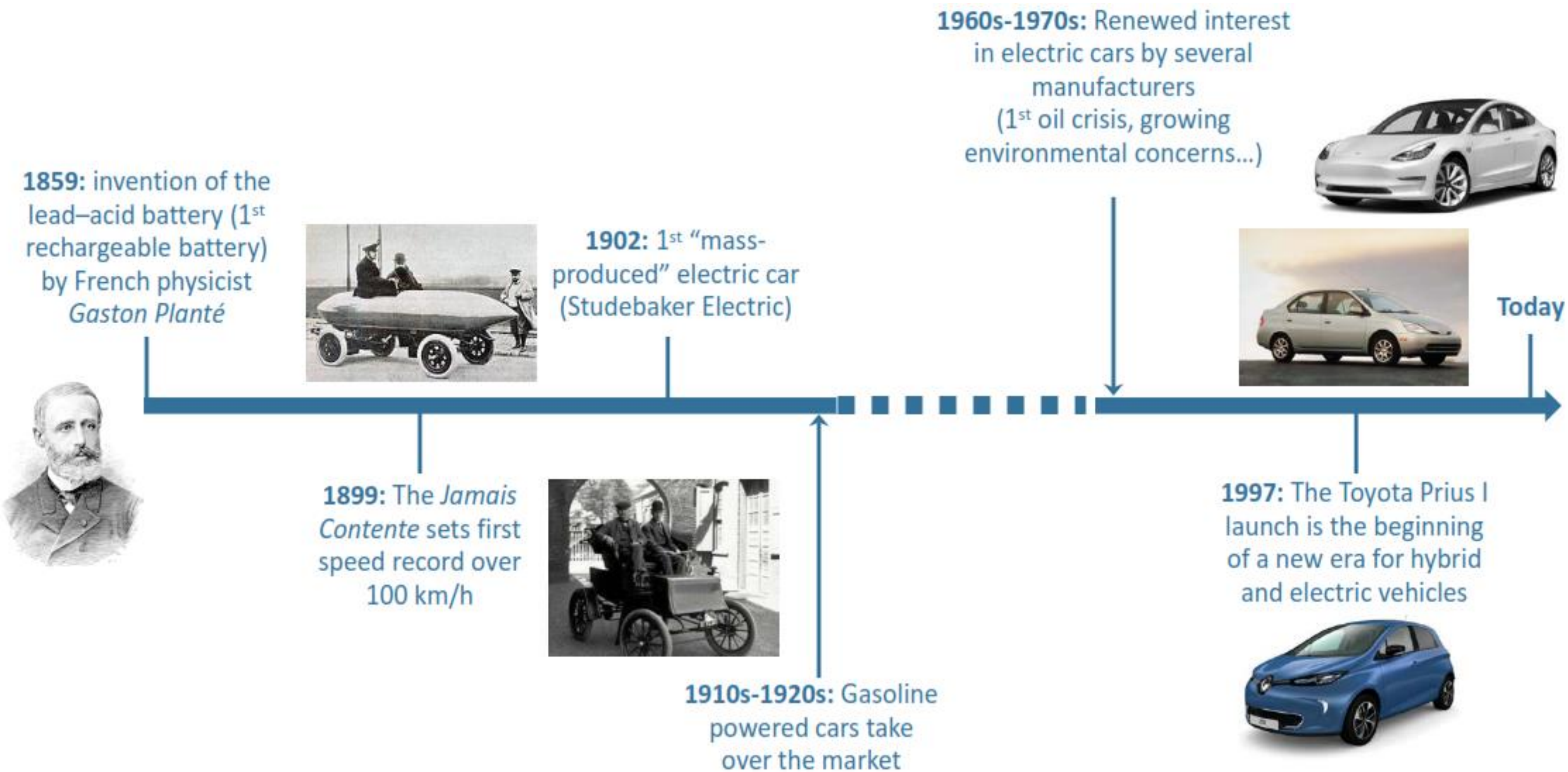
Pope-Waverley
electric runabout, 1905



Thomas Edison (left) with
a Bailey Electric, 1910

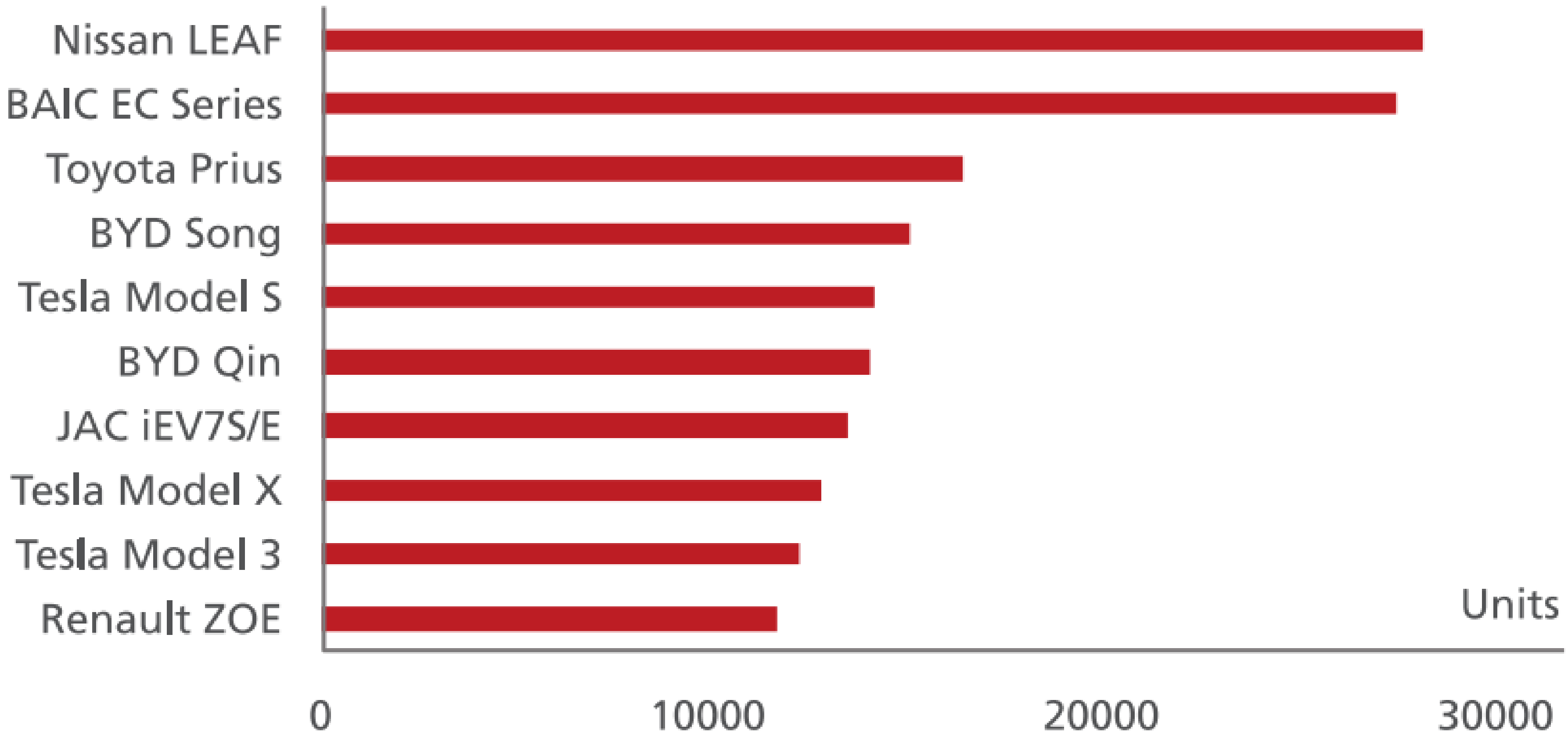
Source : Towards Sustainable Road Transport, Ronald M. Dell et al, 2014

Look Back in History



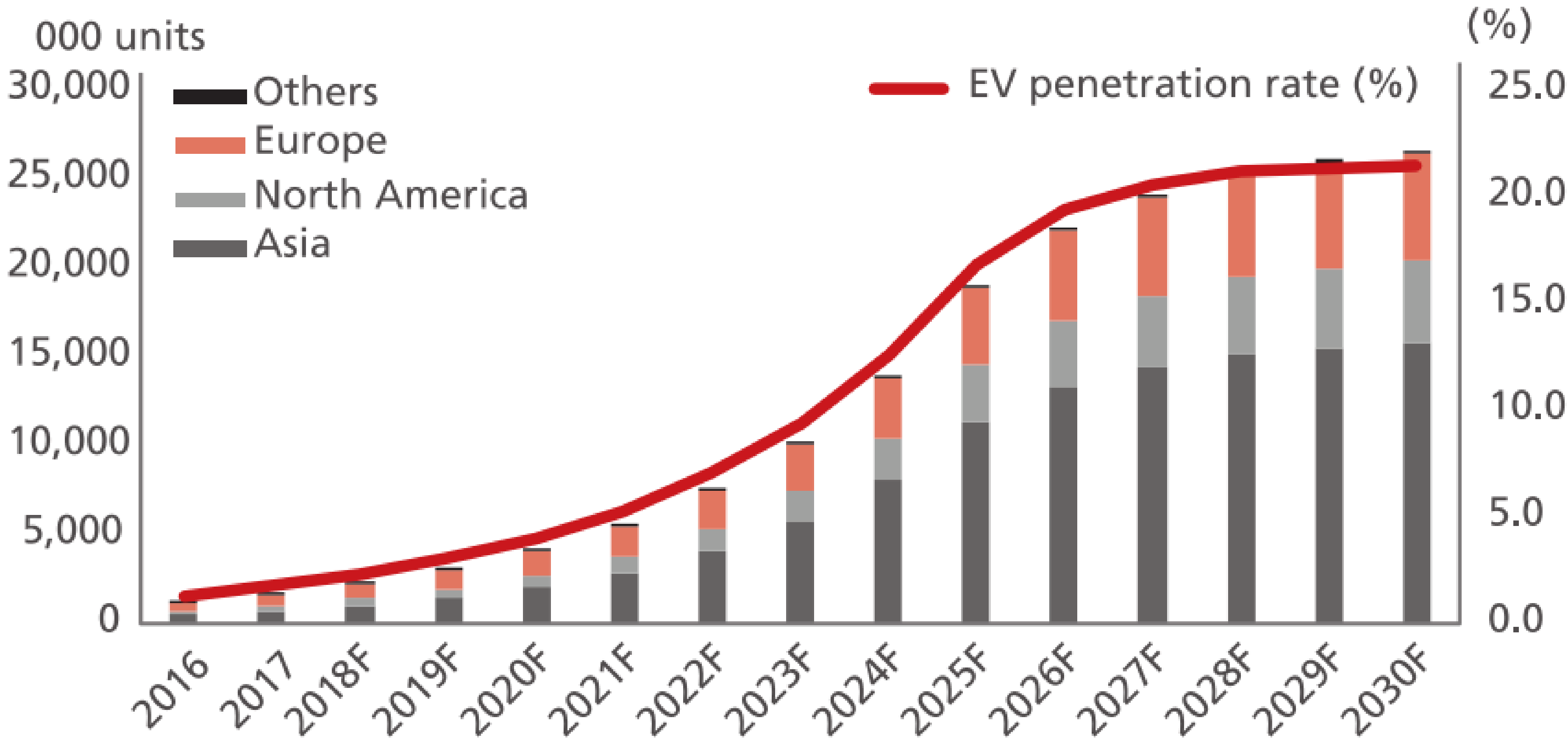
Source : Electric Vehicle Battery Chemistry and Pack Architecture, 2018

World's Top-10 Best-Selling Electric Car (2018)



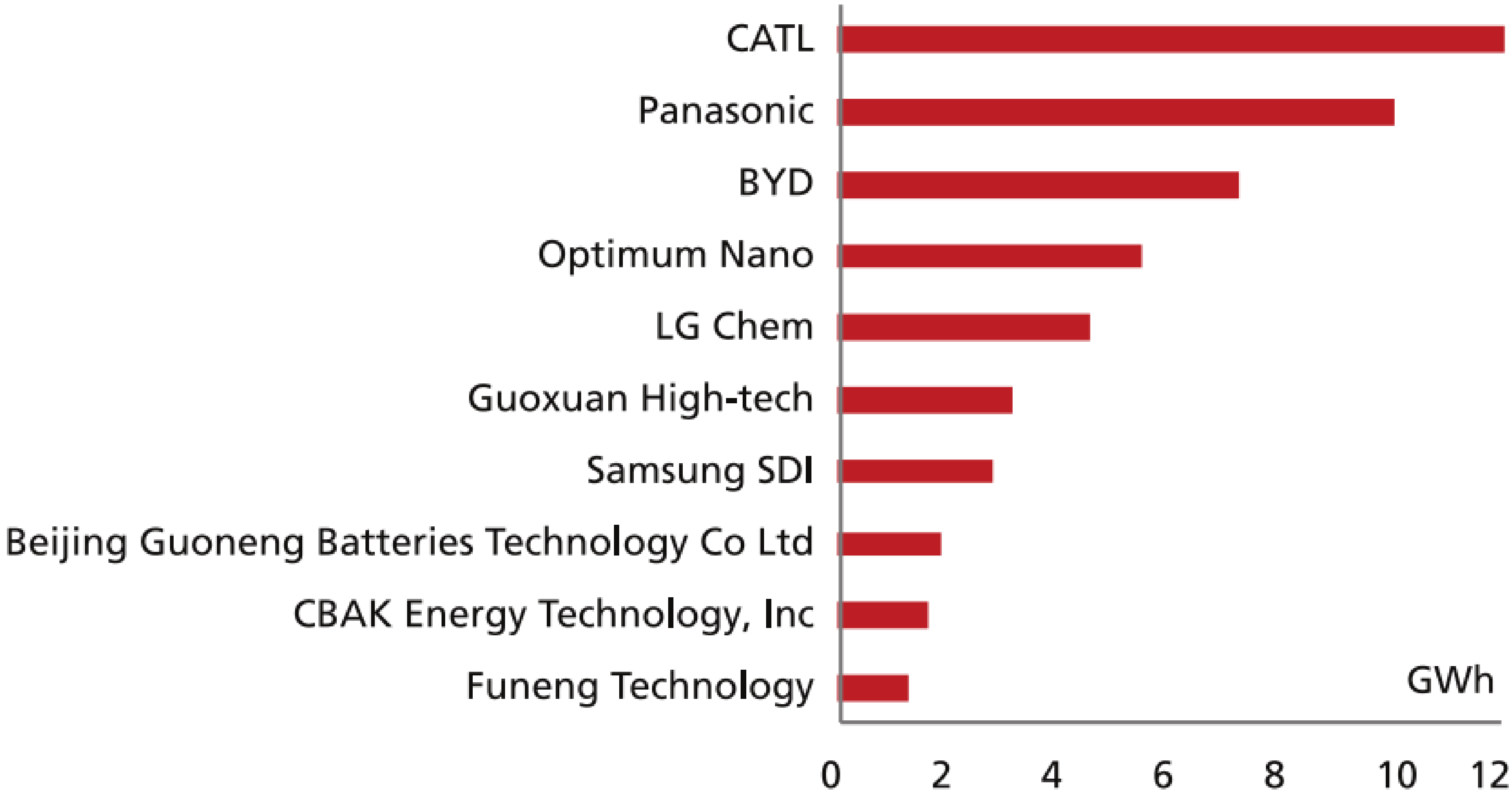
Source: Inside EVs

Global EV Sales & Penetration Rate



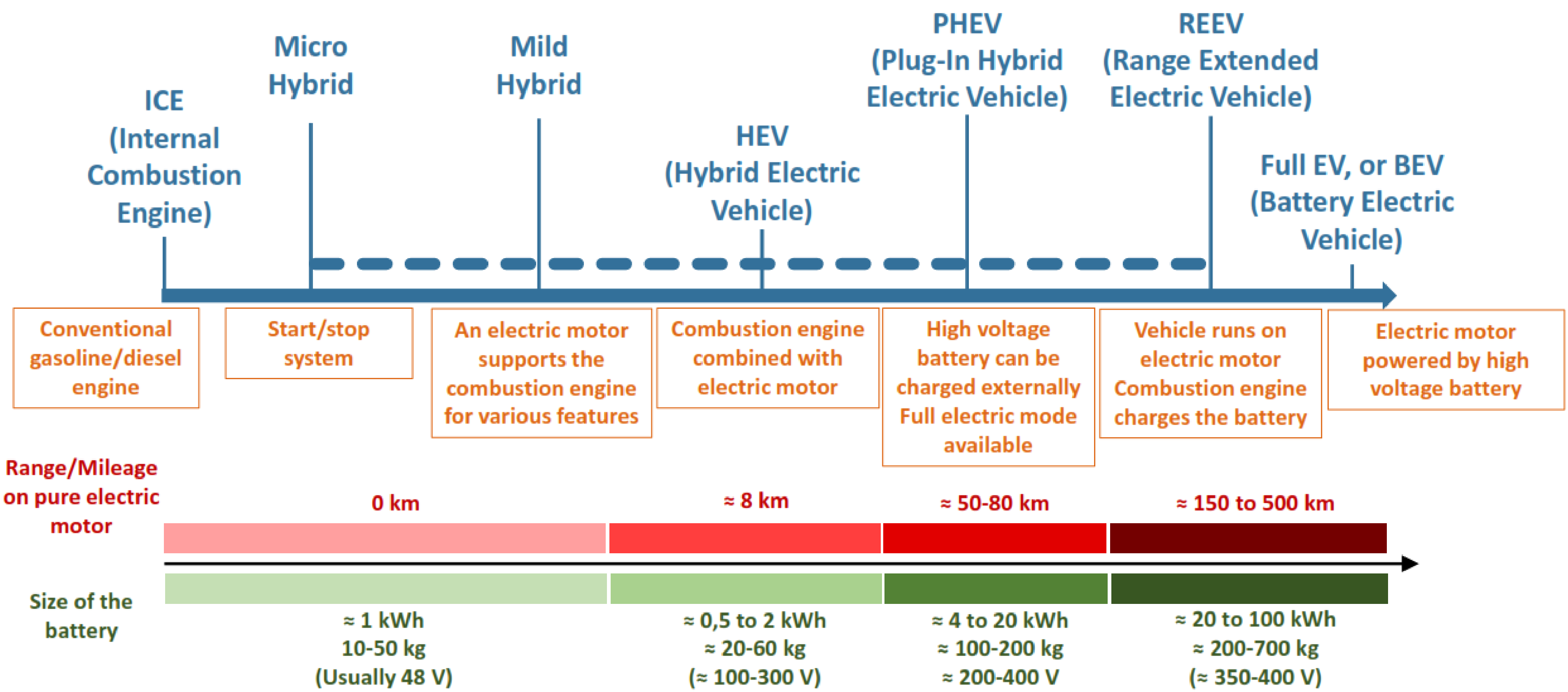
Source: CAAM, Global EV Outlook 2017

Top-10 EV-Battery Manufacturer



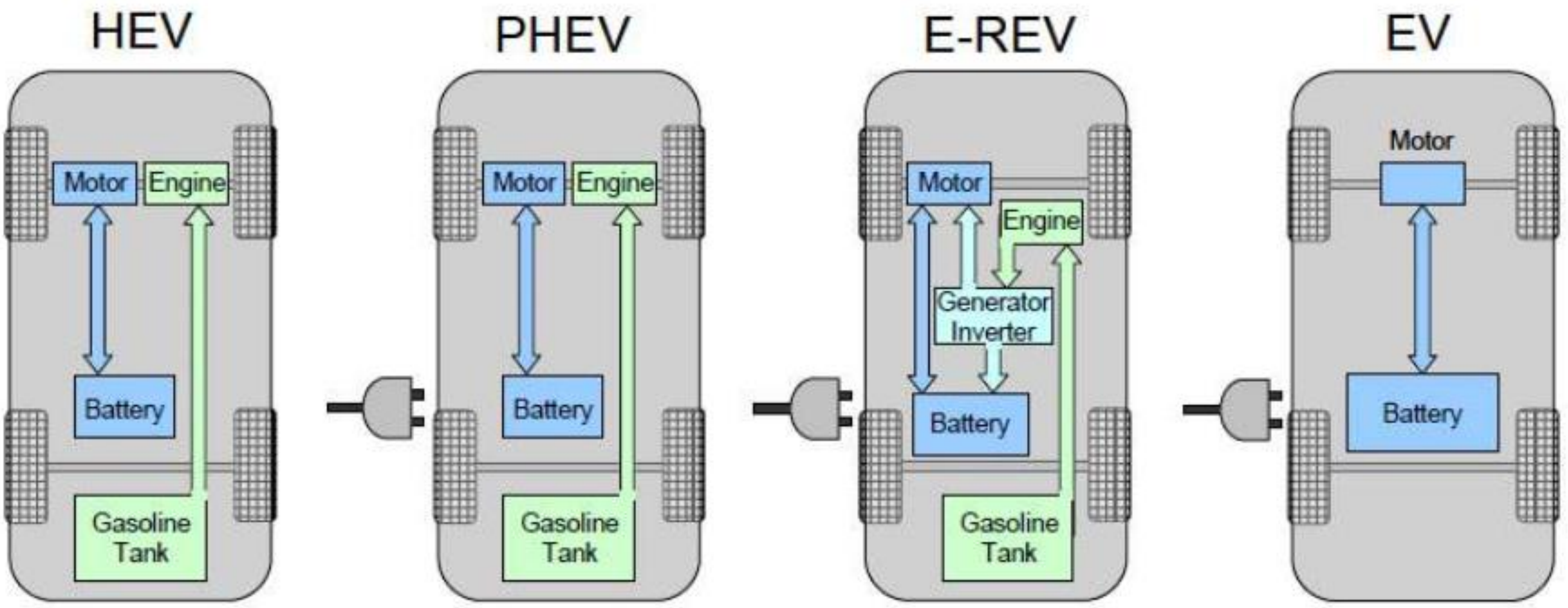
Source: GGII

Types of Electric Vehicles



Source : Electric Vehicle Battery Chemistry and Pack Architecture, 2018

Different Structures of Electric Vehicles



Source: Citi Research

Battery Pack Architecture in Electric Vehicle

Tesla Model 3

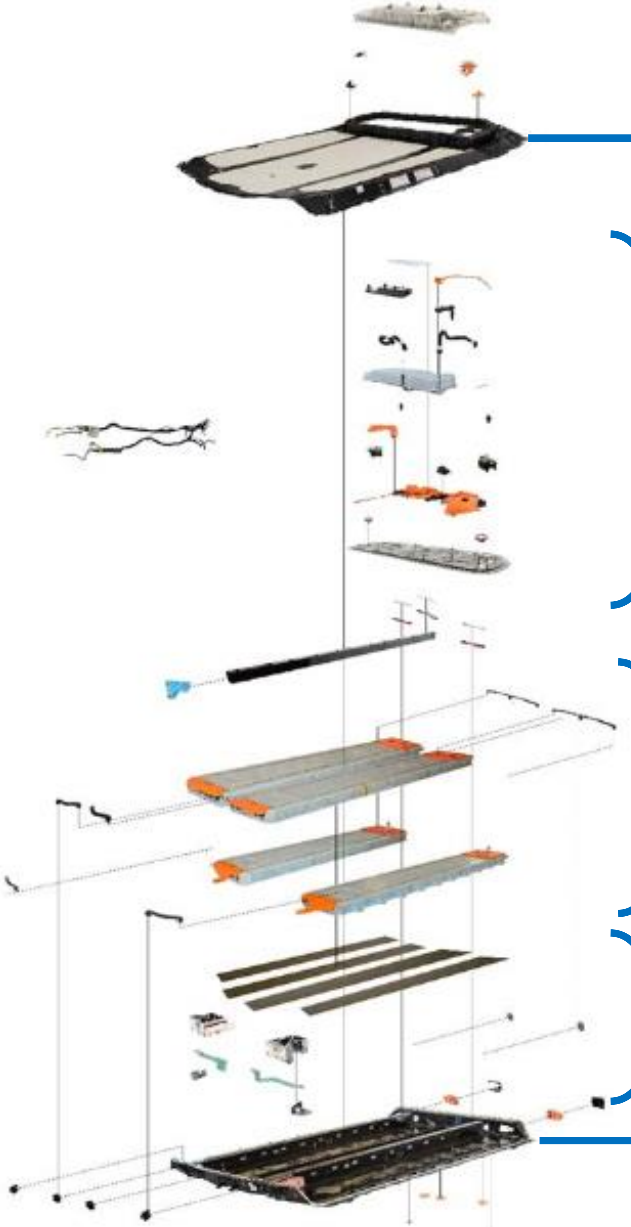
Weight = 460 kg (26 % of 1766 kg)

Length = 2.15 m
Width = 1.47 m

4 modules, 4416 battery cells
Nominal Voltage = 355 V
Capacity = 217 Ah
Energy = 75 kWh

Source : Electric Vehicle Battery Chemistry and Pack Architecture, 2018

Battery Pack Architecture in Electric Vehicle



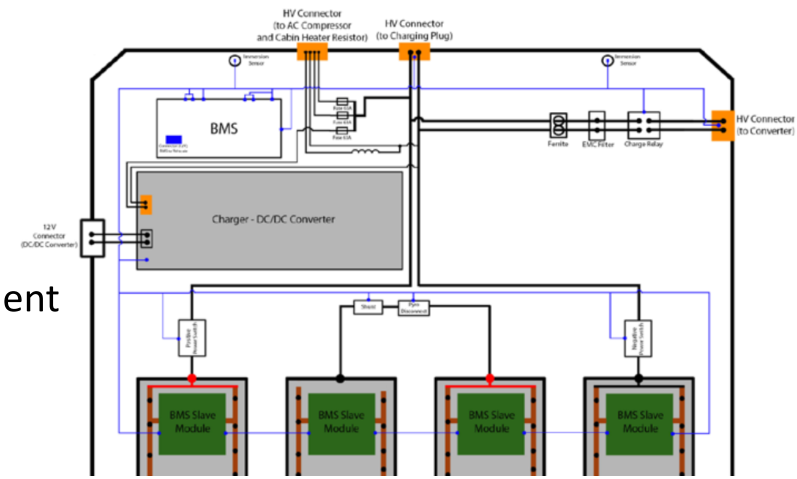
Top Enclosure

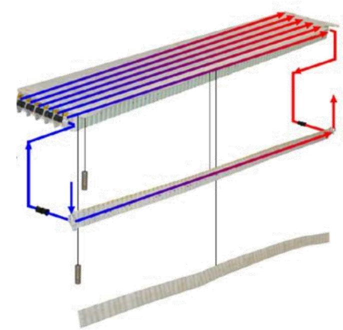
Electronic Management System

Battery Module

Thermal Management System

Bottom Enclosure

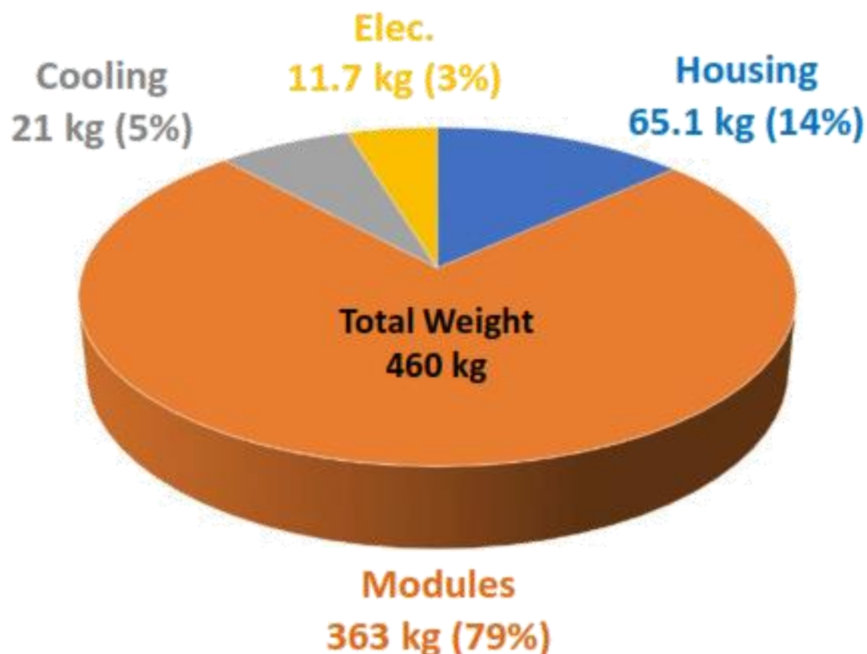




Source : Charles Hatchett Seminar, England 2018

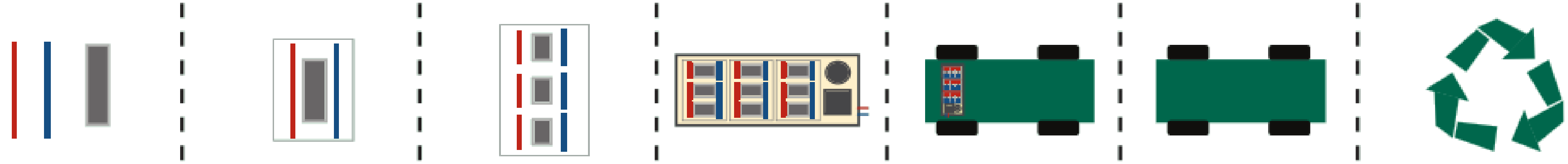
Weight Distributions

Tesla Model 3 (EV)



Source : Cedric Weiss, PhD 2018

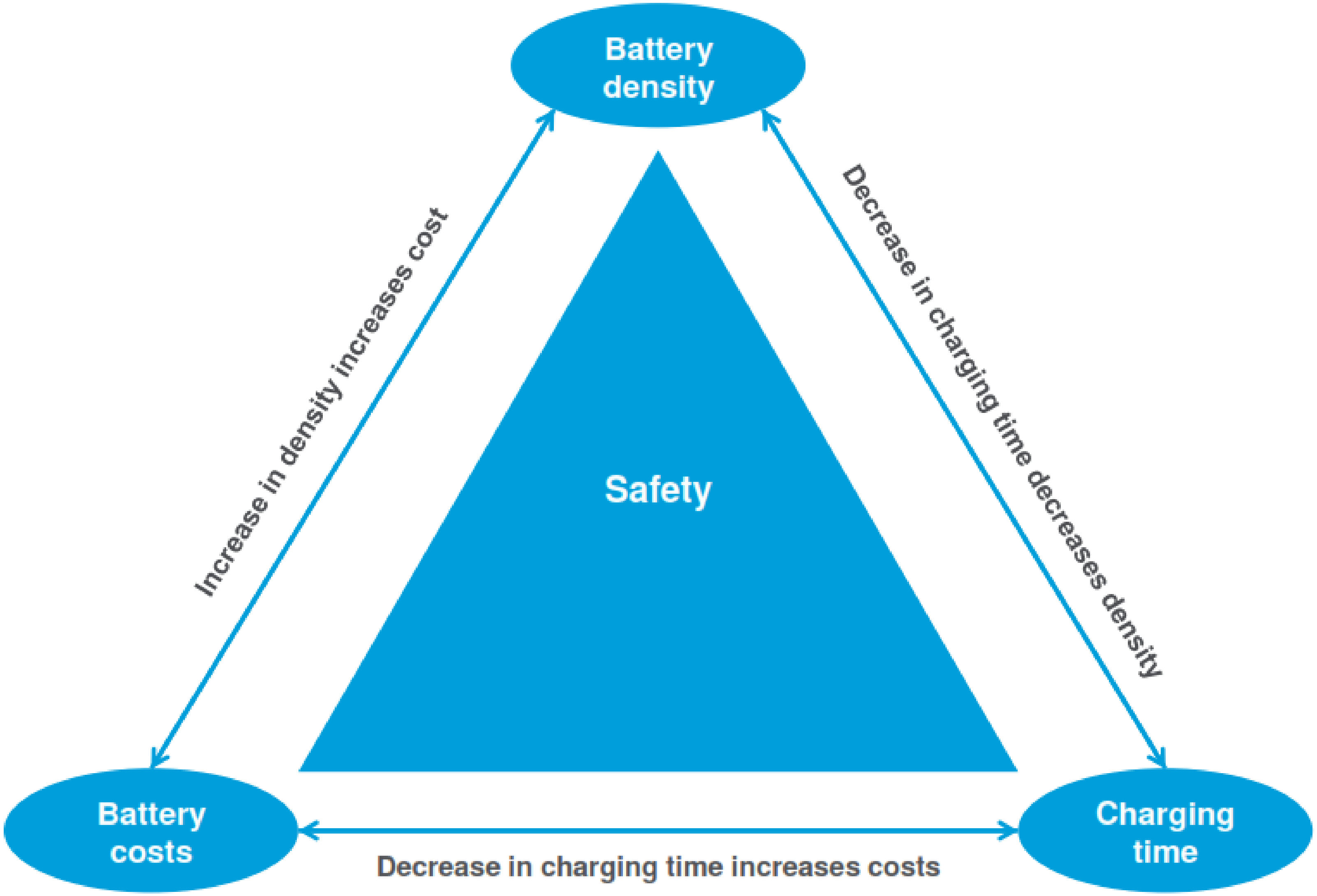
The Value Chain for Electric-Car Batteries



Component production	Cell production	Module production	Pack assembly	Vehicle integration	Use	Reuse and recycling
Manufacture of anode and cathode active materials, binder, electrolyte, and separator	Production and assembly of single cells	Configuration of cells into larger modules that include some electronic management	Installation of modules together with systems that manage power, charging, and temperature	Integration of the battery pack into the vehicle structure, including the battery-car interface (connectors, plugs, mounts)	Use during specified in-vehicle battery lifetime	Battery reuse; deconstruction and cleaning preparatory to recycling of materials and components

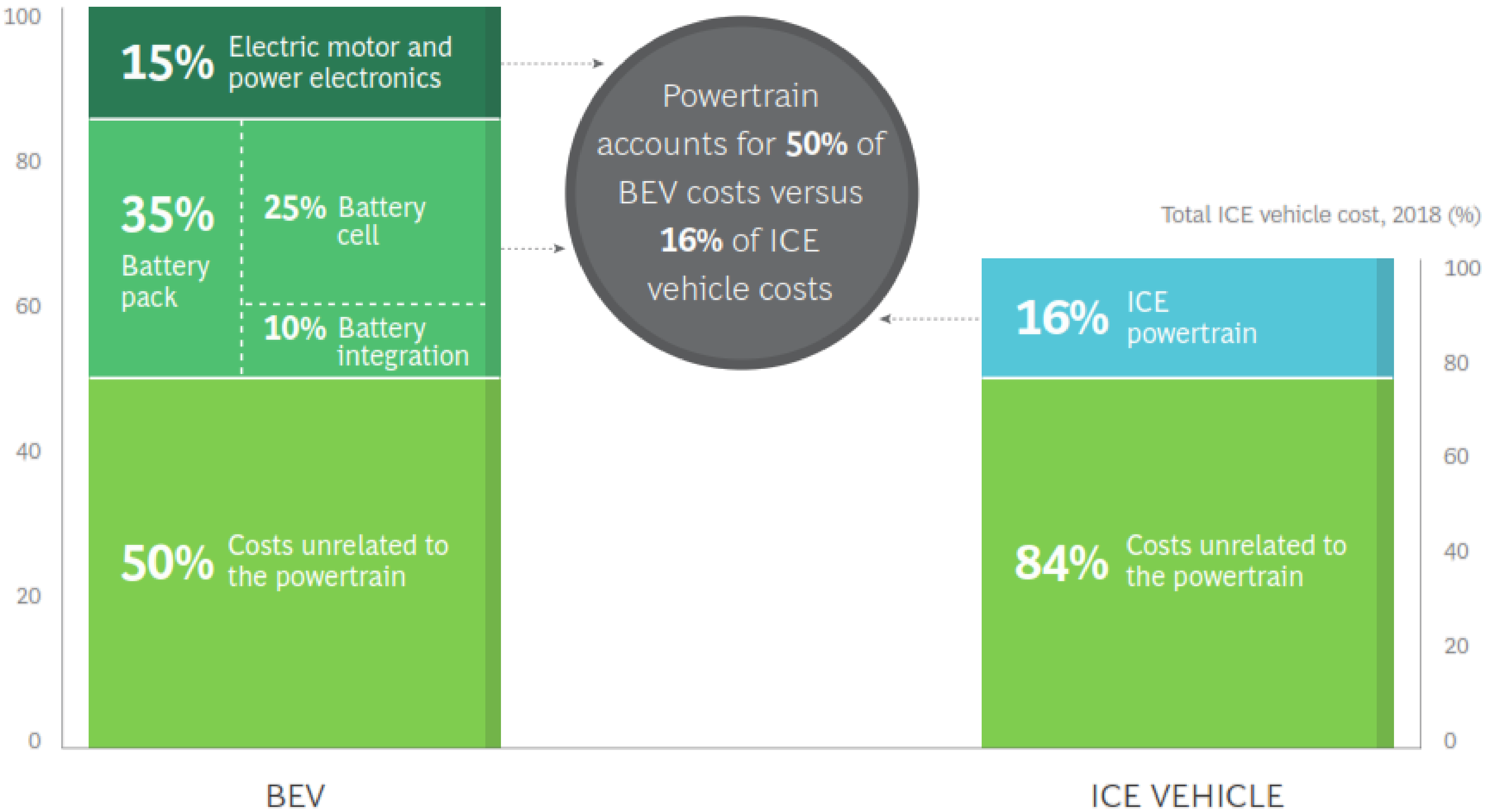
Source: BCG analysis.

EV vs ICE Estimated Industry Cost



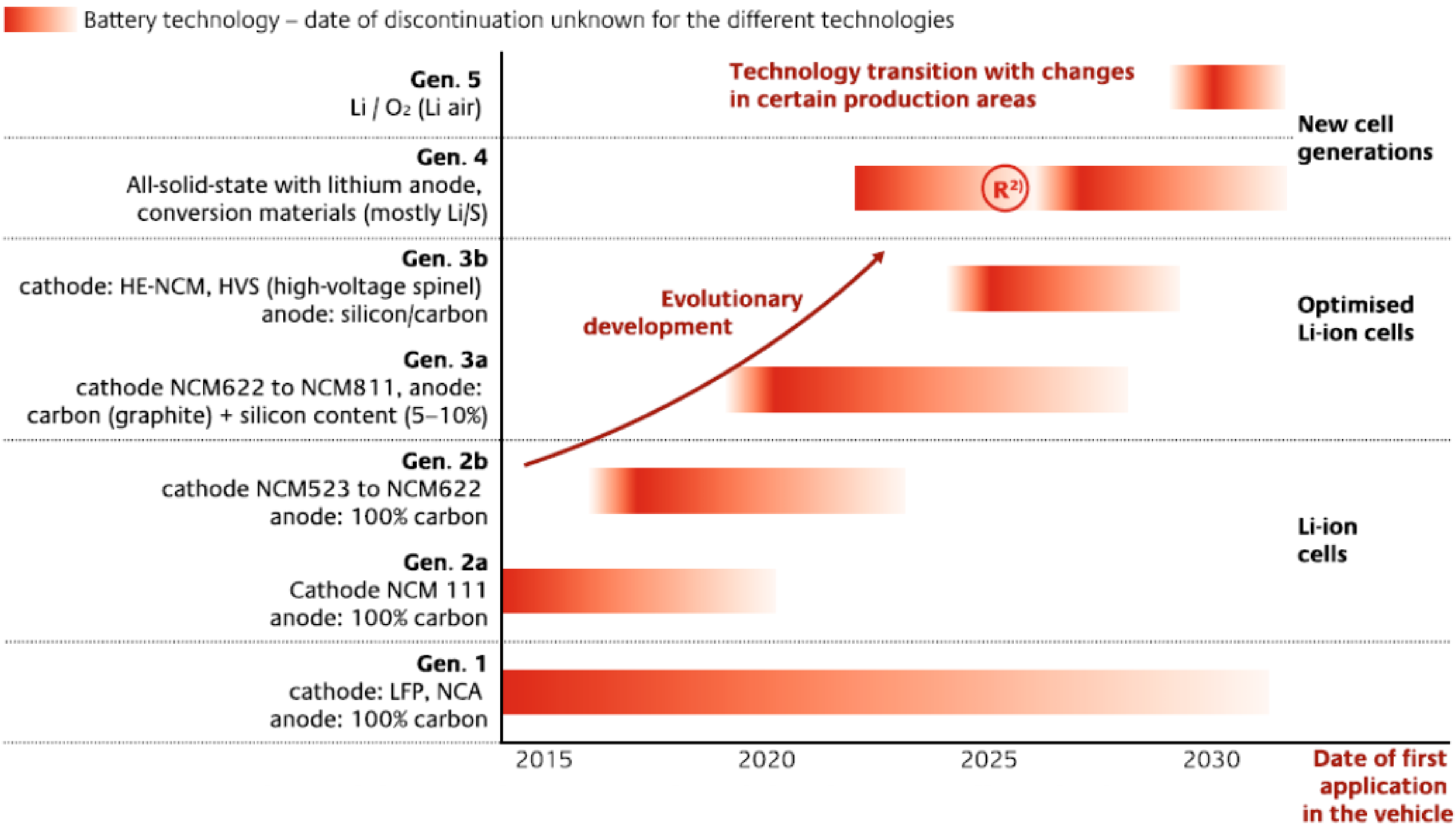
Source: Citi Research

BEVs are 35% More Expensive than ICE Vehicles



Sources: JPMorgan Chase; BCG analysis.
Note: BEV = battery electric vehicle; ICE = internal combustion engine. The electric powertrain consists of the electric motor, power electronics, and battery pack.

Classification of Li-ion Batteries



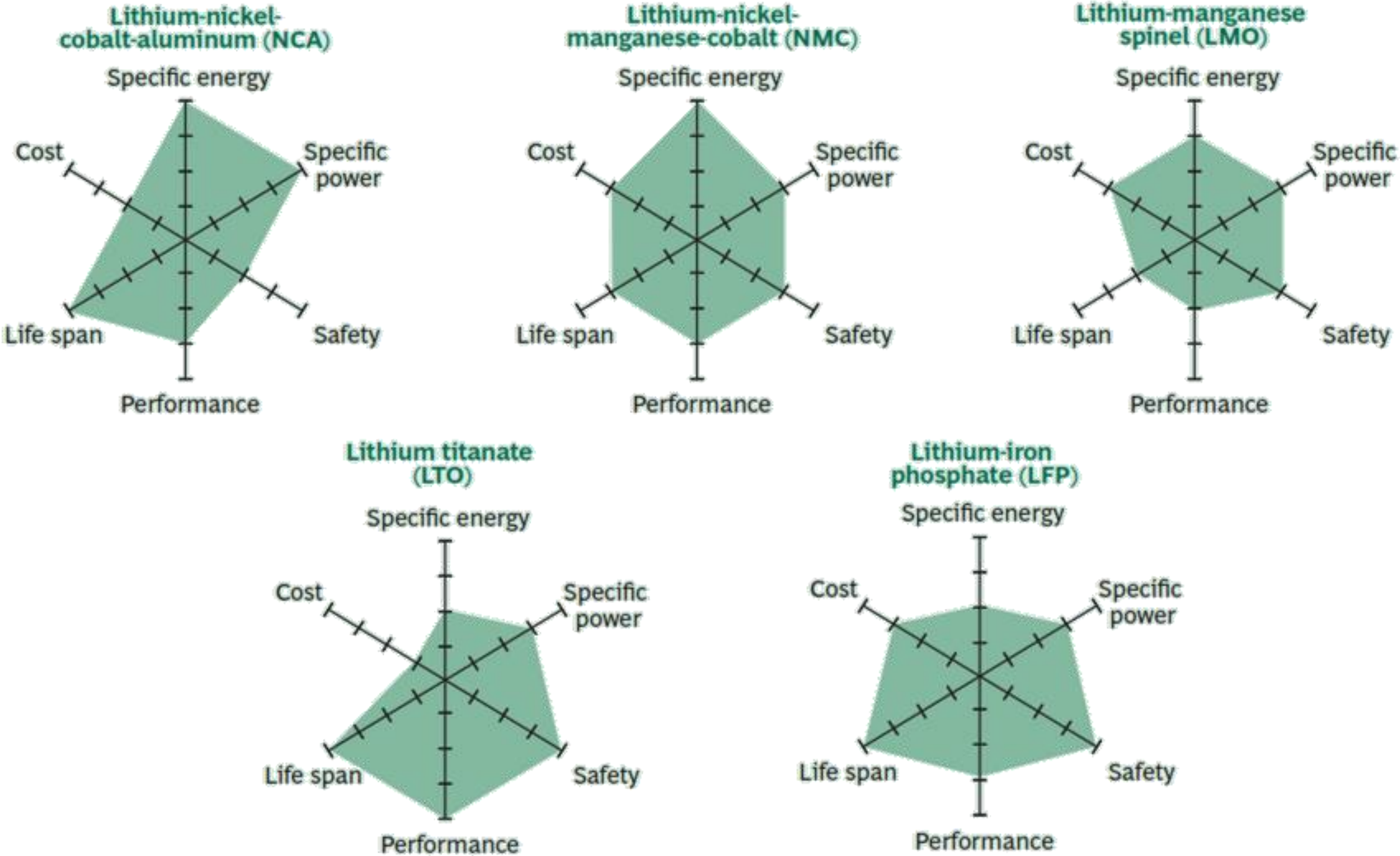
Source : Roadmap integrierte Zell- und Batterieproduktion Deutschland, 2016.

Performance Requirements of Battery Application

	Applications	Capital cost	Safety	Cycle lifetime	Energy density	Power density	Charging time	Reliability[1]
SLI	1 Start-stop	●	○	◐	○	●	○	●
EV	2 HEV/PHEV	◐	◐	●	○	●	●	◐
EV	3 BEV[2]	●	●	◐	●	◐	◐	●
EV	4 Commercial vehicles[3] (E-Bus)	●	●	●	◐	●	●	●
ED	5 Electronic devices	○	●	○	●	○	◐	○
BES[4]	6 Low frequency	●	●	○	◐	◐	○	○
BES[4]	7 High frequency, short discharge	●	●	●	◐	●	●	○
BES[4]	8 High frequency, long discharge	●	●	●	◐	◐	◐	○

1 Measured as low-temperature performance;
2 Battery Electric Vehicles include 100% battery powertrain and long-range PHEV;
3 Exclusively e-buses due to their dominance in the electric commercial vehicle segment;
4 BES low frequency includes back-up/uninterrupted power supply, high frequency short discharge is mainly frequency regulation & renewables stabilization, high frequency short discharge is mainly residential and grid peak shaving and load shifting;
Source: Arthur D. Little analysis

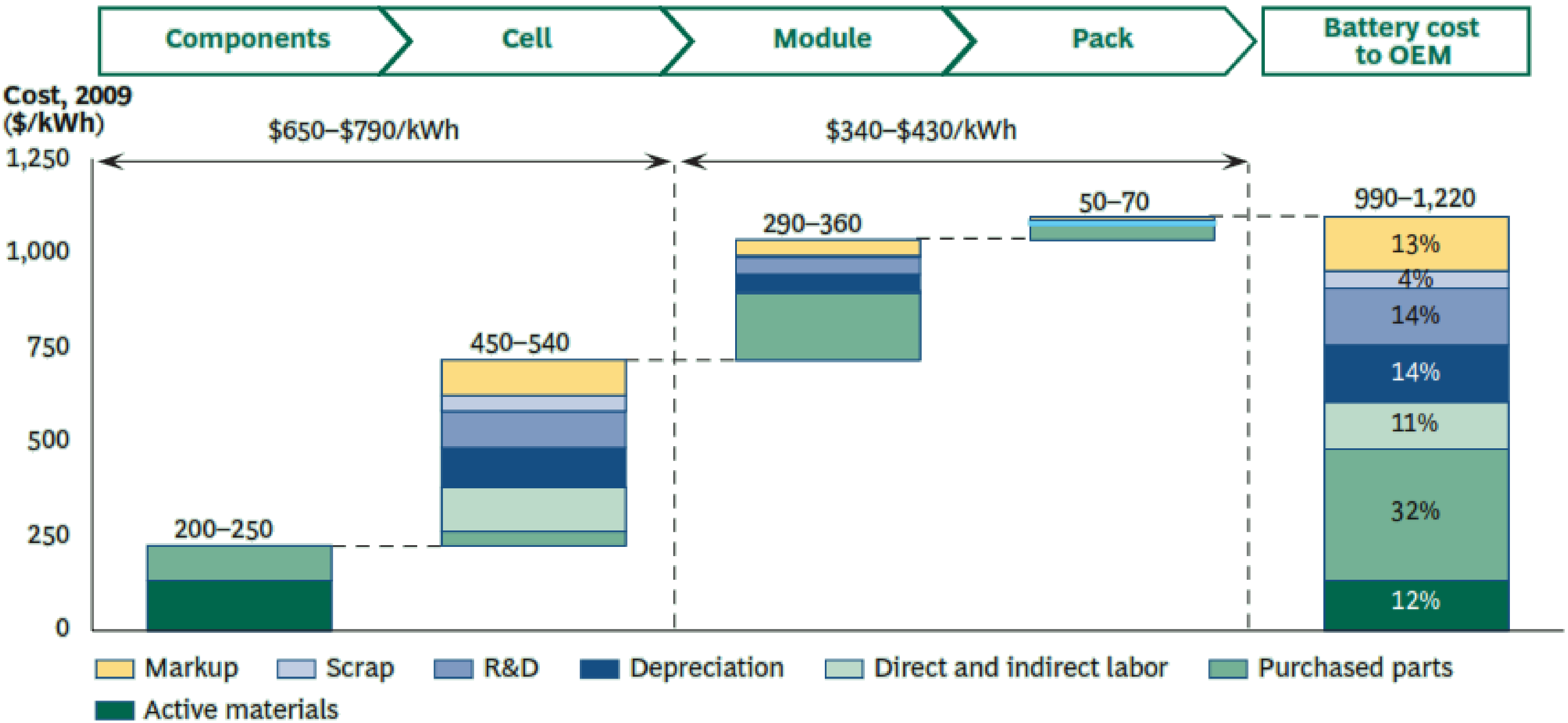
Trade-off among the 5 Principal Li-ion Technologies



Source: BCG research.

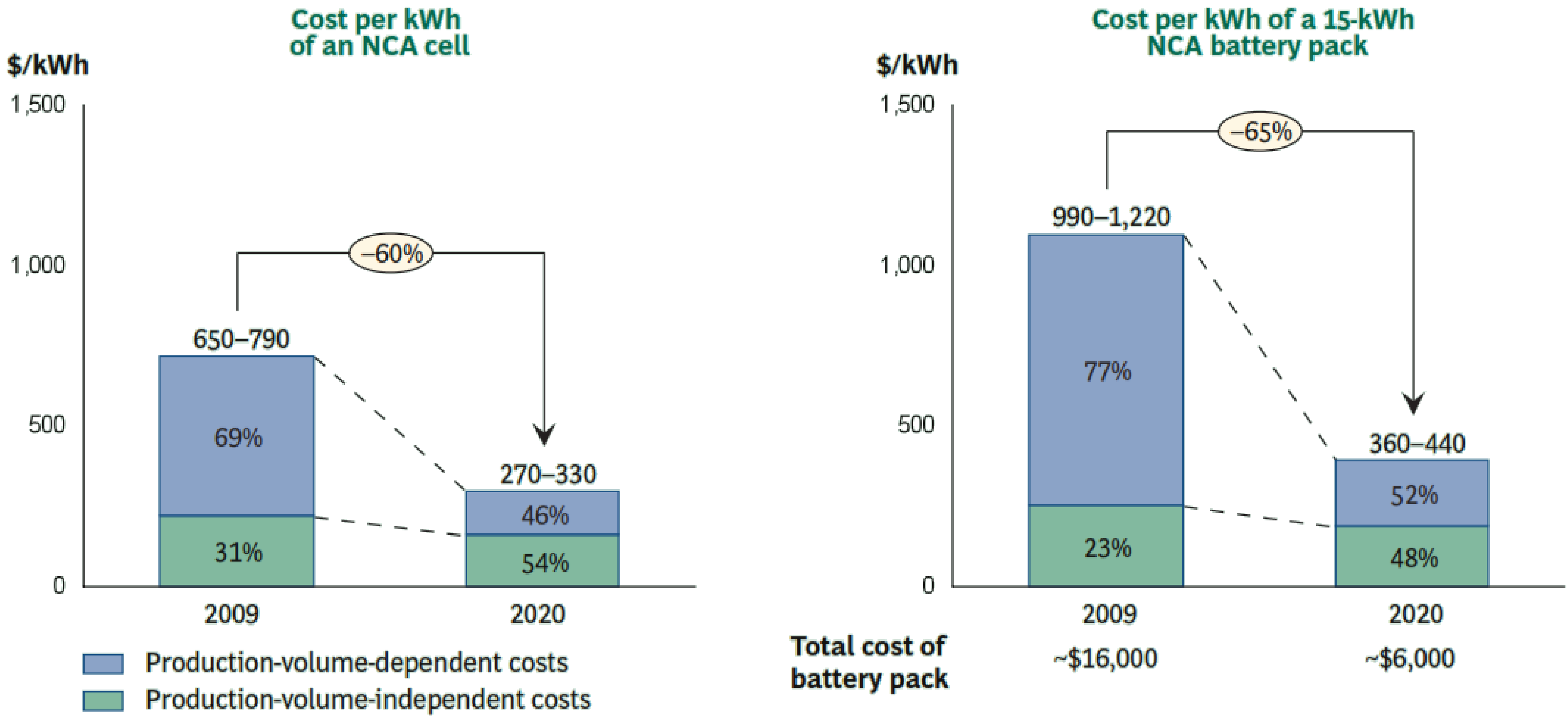
Note: The farther the colored shape extends along a given axis, the better the performance along that dimension.

Batteries Manufacturing Cost



Sources: Interviews with component manufacturers, cell producers, tier one suppliers, OEMs, and academic experts; Argonne National Laboratory; BCG analysis.
Note: Exhibit shows the nominal capacity cost of a 15-kWh NCA battery and assumes annual production of 50,000 cells and 500 batteries, as well as a 10 percent scrap rate at the cell level and a 2 percent scrap rate at the module level. Numbers are rounded.

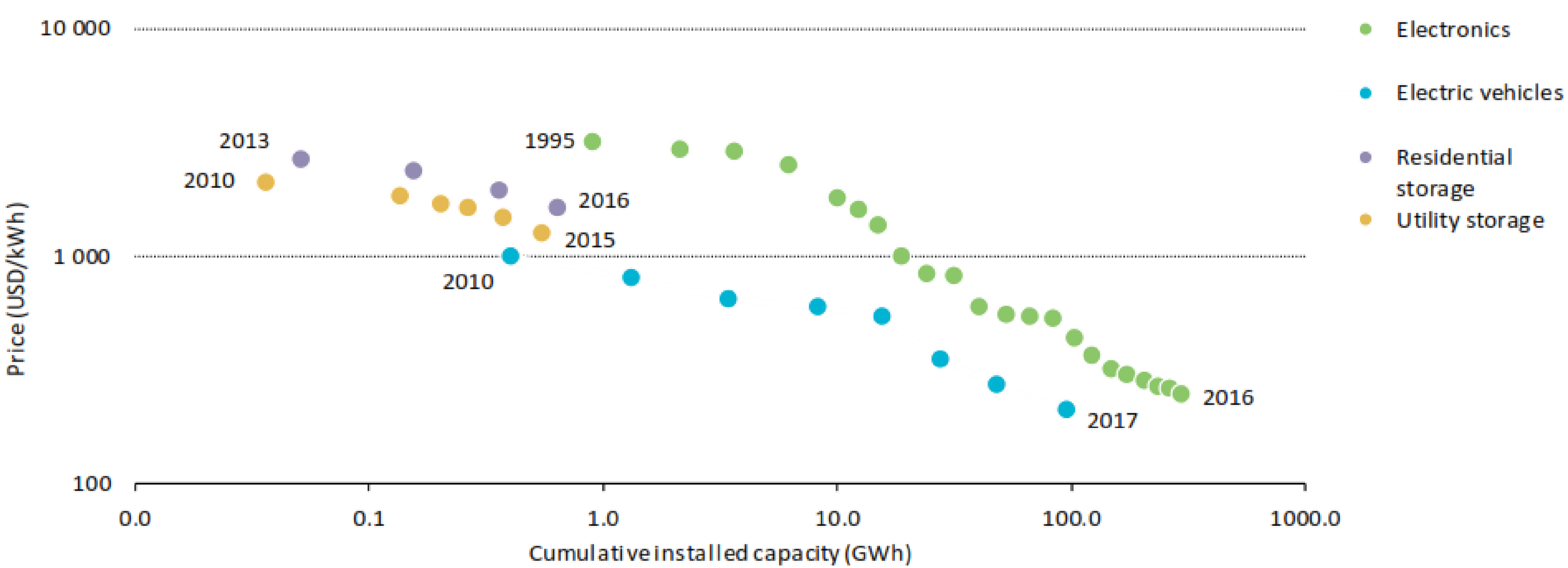
Battery Cost will Decline from 2009 to 2020



Sources: Interviews with component manufacturers, cell producers, tier one suppliers, OEMs, and academic experts; Argonne National Laboratory; BCG analysis.

Note: Exhibit assumes annual production of 50,000 cells and 500 batteries in 2009 and 73 million cells and 1.1 million batteries in 2020. Numbers are rounded.

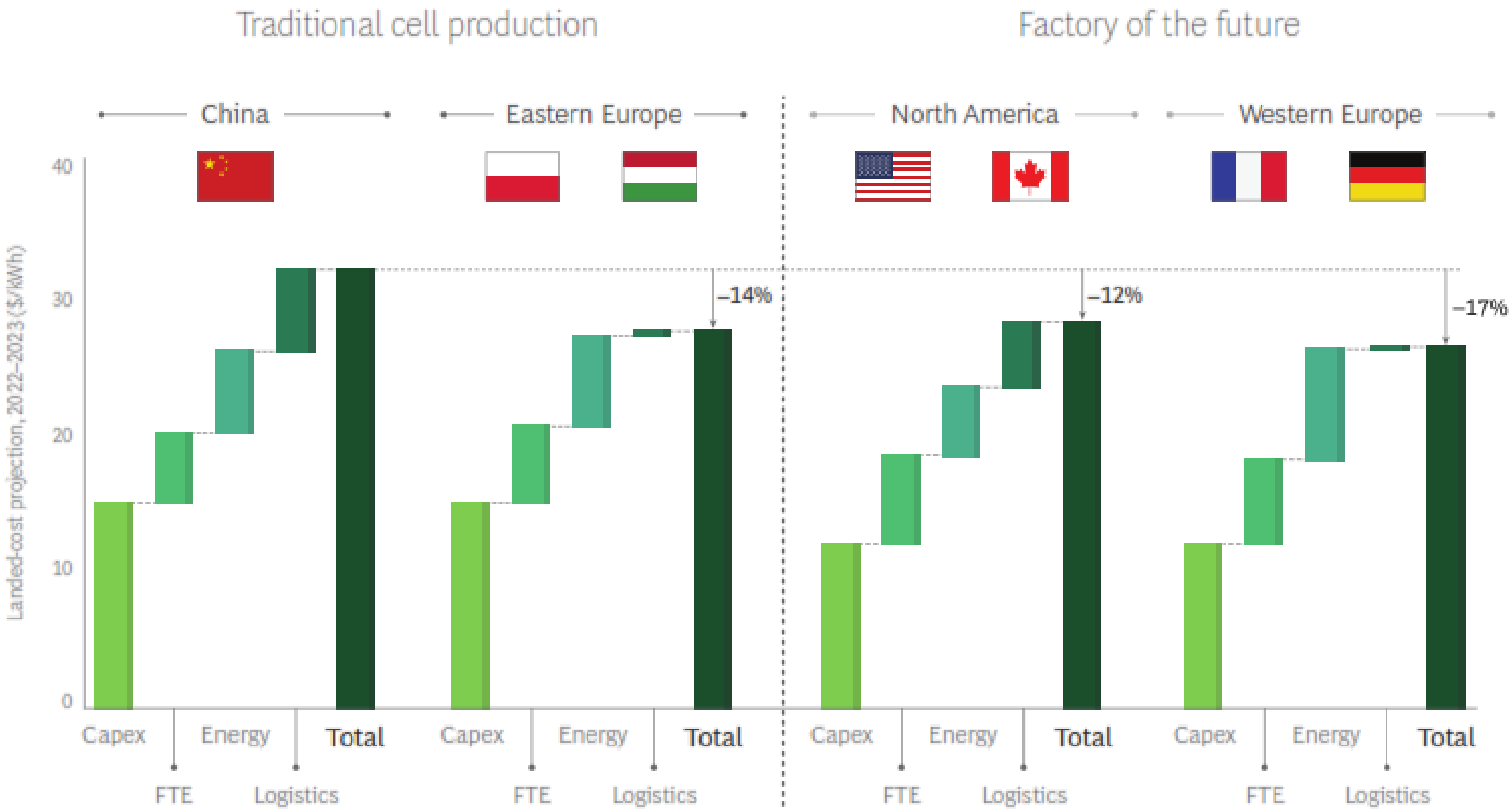
Lithium-ion Storage Technology Price Development



Notes: Axes are on a logarithmic scale. Electronics refer to power electronic batteries (only cells); electric vehicles refer to battery packs for EVs; utility and residential storage refer to Li-ion battery packs plus power conversion system and includes costs for engineering, procurement and construction.

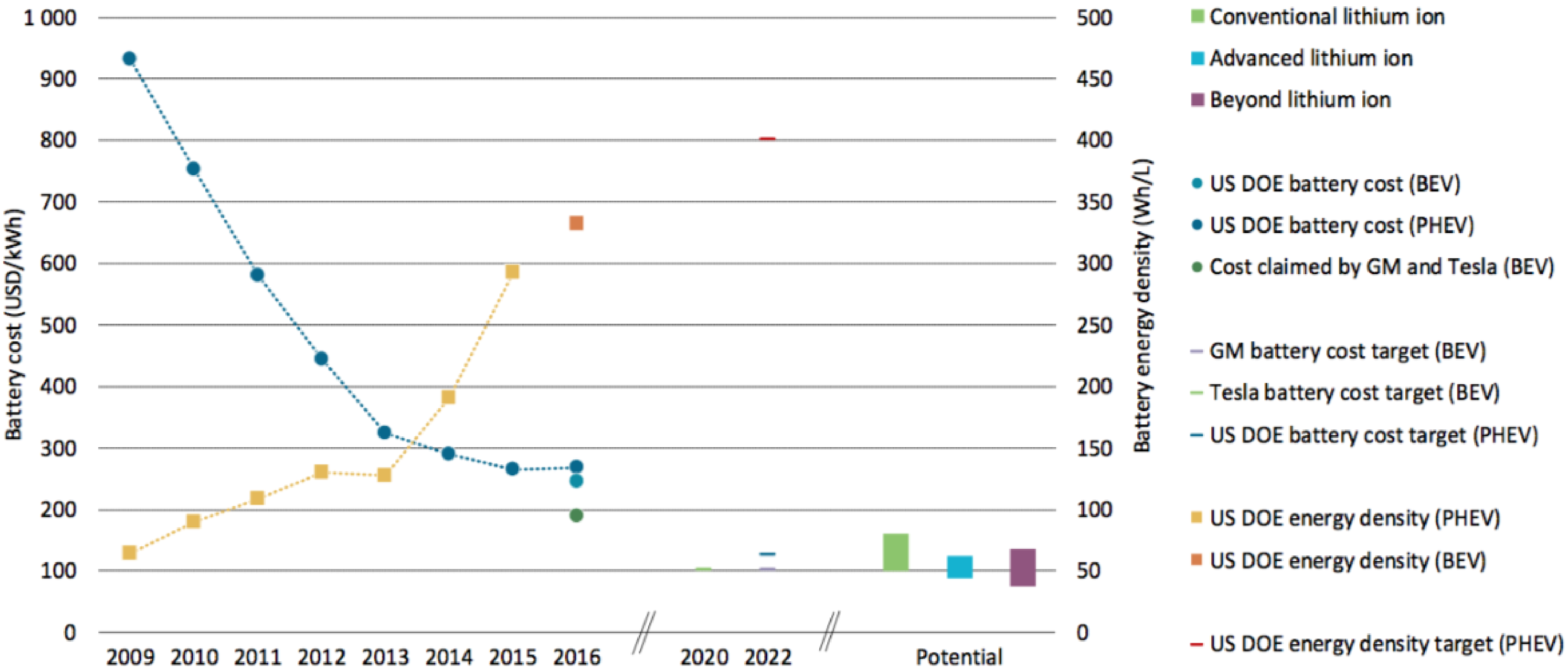
Source: Adapted and updated from Schmidt et al. (2017).

Cost Comparison of Battery Cell Production



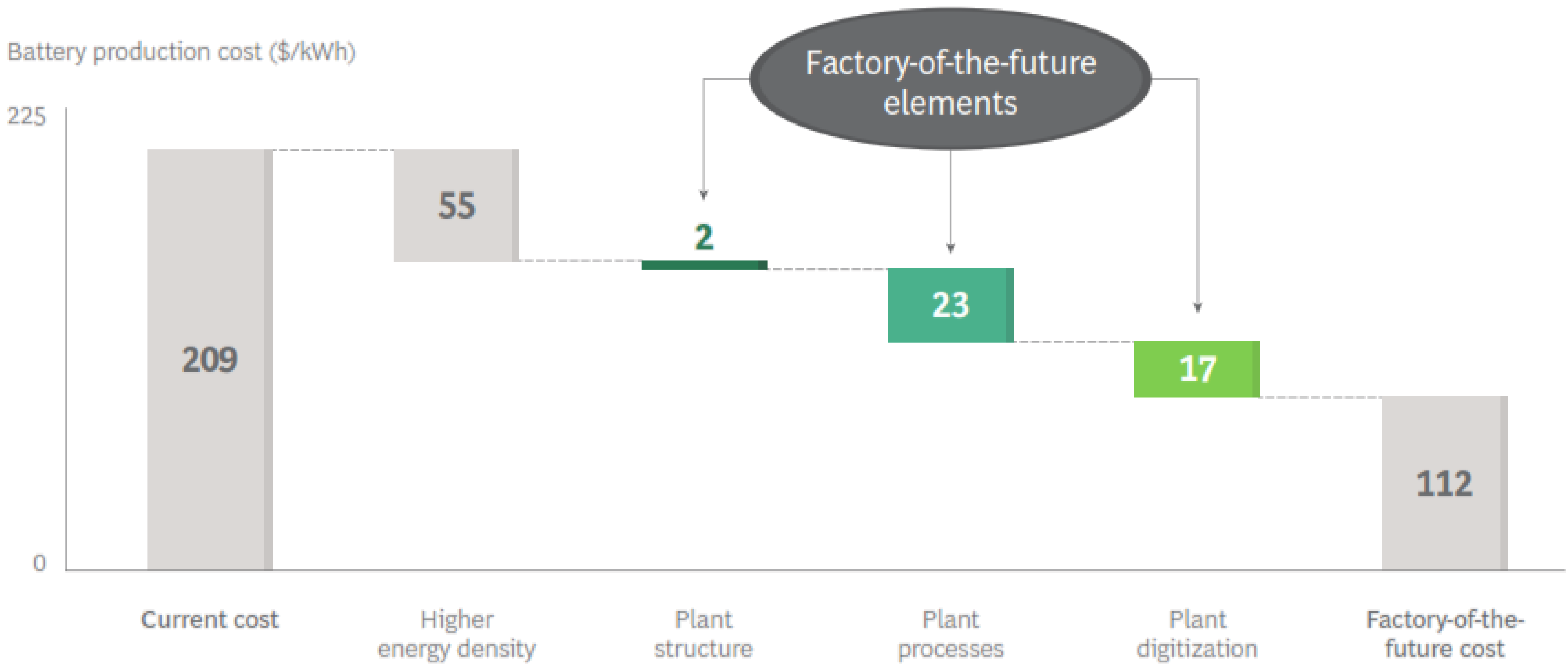
Source: BCG analysis.
Note: FTE = full-time equivalent. Battery cell costs exclude the cost of materials. In all cases, logistics costs are projected for delivering battery cells to a German automotive plant.

Evolution of Battery Energy Density and Cost



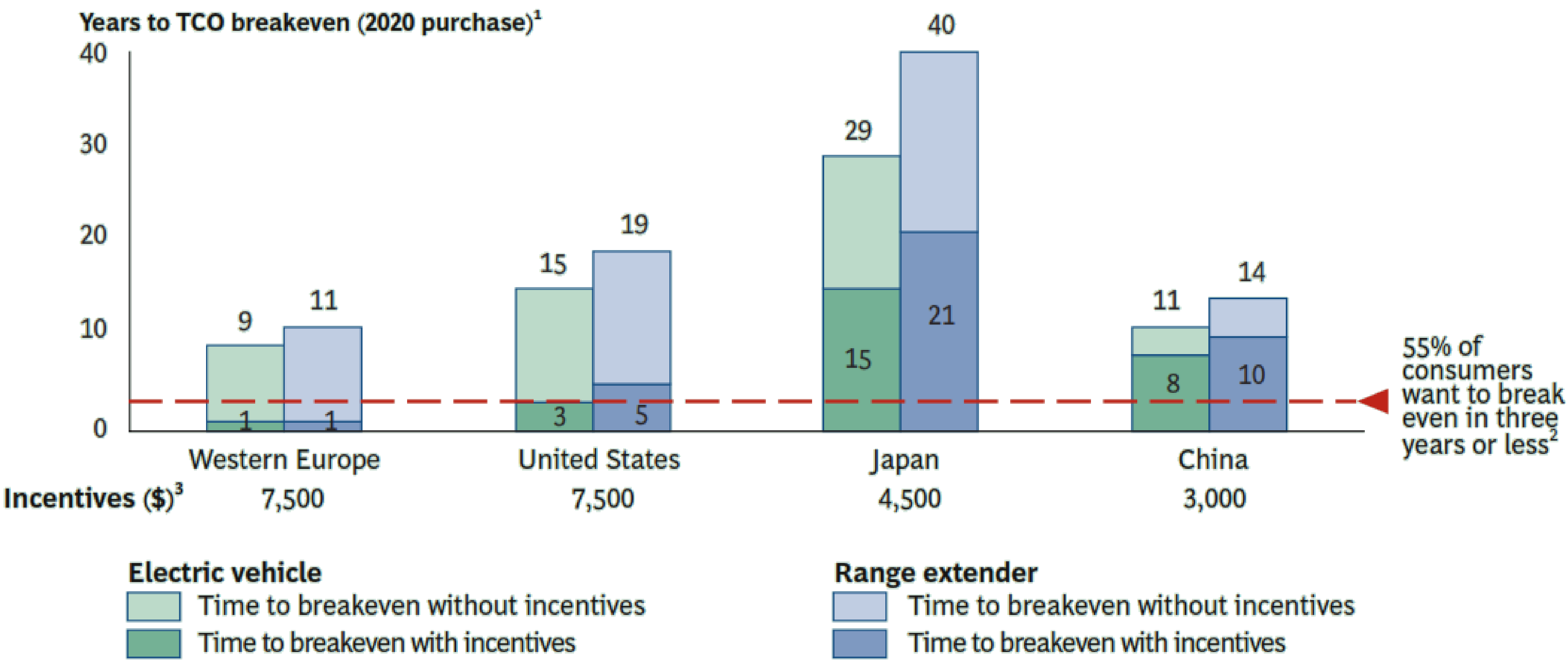
Source: IEA (2017), page 14.

Factory-of-Future Concept for Reducing Cost



Source: BCG analysis.

Purchasers of Electric Cars Could Break Even Point (BEP) in 1 – 5 Years



Source: BCG analysis.

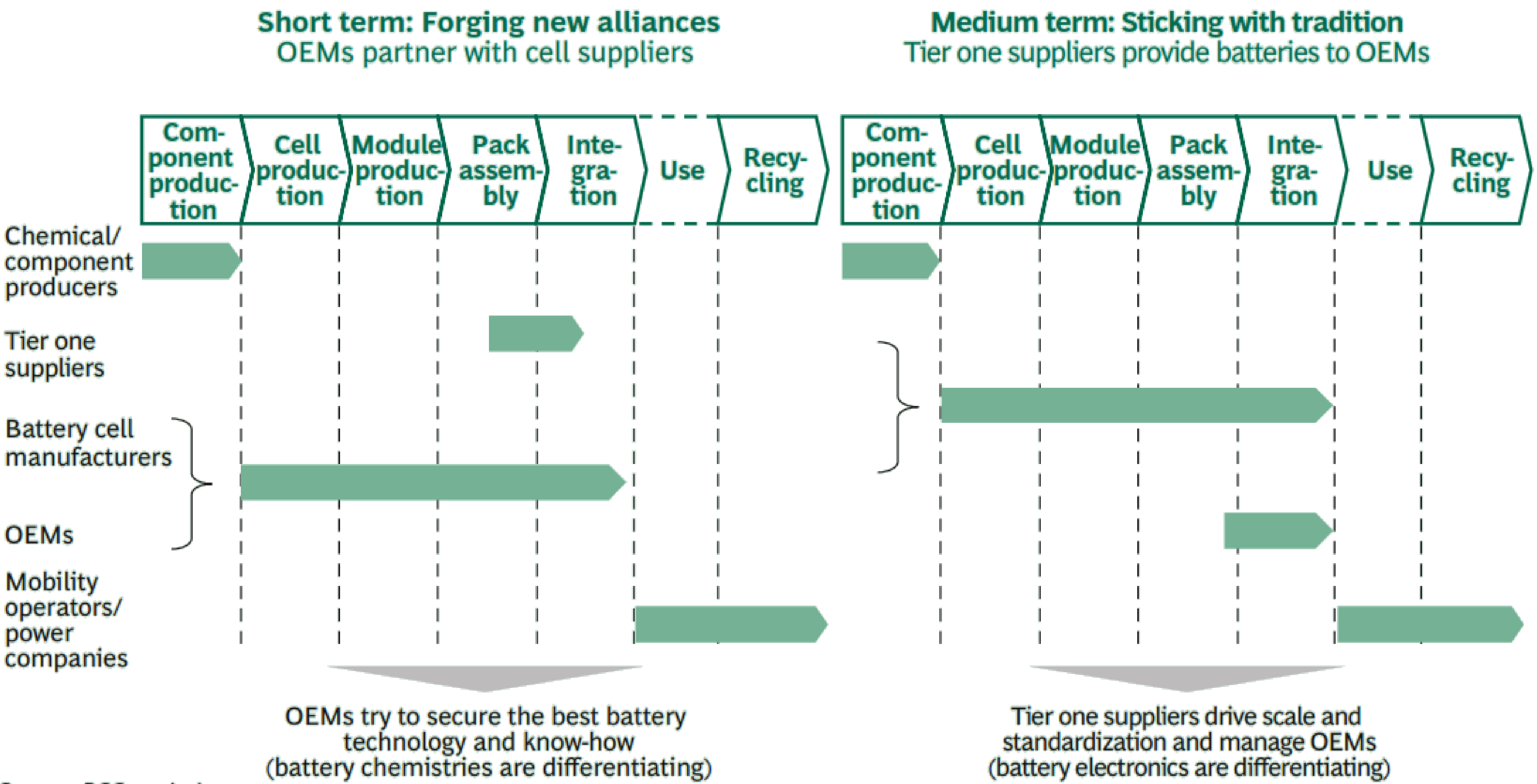
Note: Breakeven calculations based on the following assumptions for 2020: oil = $100 per barrel; ICE-based vehicle with mileage of 40 mpg; electric vehicle with a 20-kWh battery; and a battery range of 100 miles per 24 kWh.

[1]Reflects the net-purchase-price and operating-cost differences between an electric and an ICE-based vehicle, including taxes.

[2]Continental Corp., Hybrid and Electric Vehicle Survey, 2008.

[3]Incentives assume the extension of 2009 announced benchmarks.

Alliances are Likely to Following the Shift



Source: BCG analysis.

Recent Lithium Contract with Manufactures

DATE	LITHIUM PRODUCERS	BUYER	TERMS
May 2018	Kidman Resources	Tesla	Lithium hydroxide; 3 years on fixed-price take-or-pay basis and two 3-year term options
Jul 2018	Nemaska Lithium	LG Chem	Lithium hydroxide; 5 years starting in Oct 2020 on take-or-pay basis at 7,000 ton per year
Aug 2018	Ganfreng Lithium	LG Chem	Lithium carbonate & hydroxide; 2018-2020; 5 years to the end of 2025 at 92,600 tons
Sep 2018	Ganfreng Lithium	Tesla	Lithium hydroxide; 2018-2020; 20% of production capacity and 3-year extendable
Sep 2018	Ganfreng Lithium	BMW	Lithium compounds; 5 years, according to BMW requirements and 3 years extendable
Feb 2019	Pilbara Minerals	Posco	Spodumene concentrate; life-of-mine for an initial 80,000 tons per year
Apr 2019	Ganfreng Lithium	Volkswagen	Lithium compounds; 10 years

Source: Company Filings, News, Bloomberg Intelligence

Original Equipment Manufacture Ambitions

OEM	Announcement
BMW	0.1 million electric car sales in 2017 and 15-25% of the BMW group's sales by 2025
Chevrolet (GM)	30 thousand annual electric car sales by 2017
Chinese OEMs	4.52 million annual electric car sales by 2020
Daimler	0.1 million annual electric car sales by 2020
Ford	13 new EV models by 2020
Honda	Two-thirds of the 2030 sales to be electrified vehicles (including hybrids, PHEVs, BEVs and FCEVs)
Renault-Nissan	1.5 million cumulative sales of electric cars by 2020
Tesla	0.5 million annual electric car sales by 2018 1 million annual electric car sales by 2020
Volkswagen	2-3 million annual electric car sales by 2025
Volvo	1 million cumulative electric car sales by 2025

Source : IEA (2017)

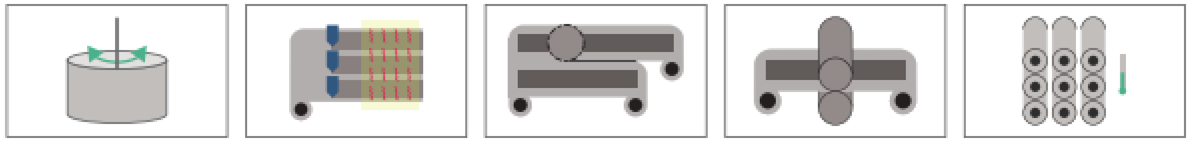
Recent Capacity Expansion Announcements

COMPANY	ANNOUNCEMENT
SQM	**Nov 21, 2018:** The ramp-up of the overhaul and expansion of the lithium carbonate plant has confronted difficulties. This has led to production short falls.
Nemaska	**Feb 13, 2019:** Financing shortfall of CAD 375 million was announced after a revision of the overall project costs.
Orocobre	**Feb 19, 2019:** Recent rainfall at the Olaroz Lithium Facility has exceeded that which occurred in 2017 and 2018. Production has been lower due to dilution of the brine feedstock.
Albemarle	**Mar 28, 2019:** Production issues at the company's La Negra, Chile, site due to the disruption in the supply of fresh water as a result of the rain event in Chile earlier in the year.

Source : The Global X Lithium & Battery Tech ETF, 2019

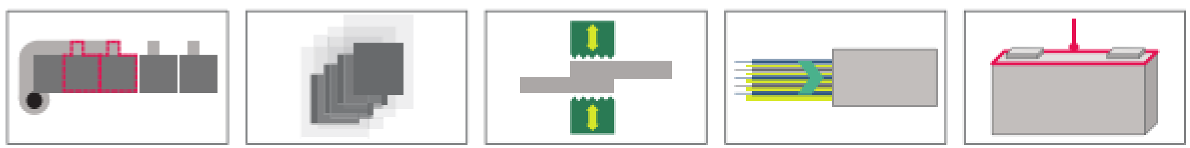
Battery Cell Production Process

ELECTRODE PRODUCTION: 39% of battery cell production costs



	Mixing	Coating and drying	Slitting	Calendaring	Vacuum drying
Process	Mixing	Coating and drying	Slitting	Calendaring	Vacuum drying
Description	Mixing of raw material powder	Pasting slurry on foil; removing solvent	Cutting coated metal foil into strips	Compressing electrode foils	Removing leftover solvent in electrodes
Cost	8% of electrode	54% of electrode	4% of electrode	11% of electrode	23% of electrode
Challenges	Material quality Slurry waste	Processing time Utilization losses	Edge quality Tool wear	Process settings Electrode waste	Processing time Yield rate

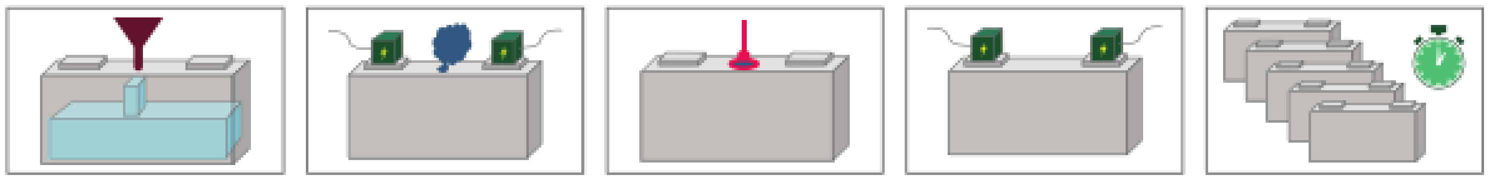
CELL ASSEMBLY: 20% of battery cell production costs



	Electrode shaping	Compound generation	Electric contacting	Case insertion	Case closure
Process	Electrode shaping	Compound generation	Electric contacting	Case insertion	Case closure
Description	Cutting out electrode shapes from coils	Generating active material compounds	Creating an electrically conductive joint	Inserting compound into cell housing	Closing cell housing using laser welding
Cost	29% of assembly	54% of assembly	5% of assembly	4% of assembly	8% of assembly
Challenges	Edge quality Particle generation	Assembly tolerance Processing speed	Particle generation Processing stability	Insulation quality Particle generation	Particle generation Yield rate

Battery Cell Production Process

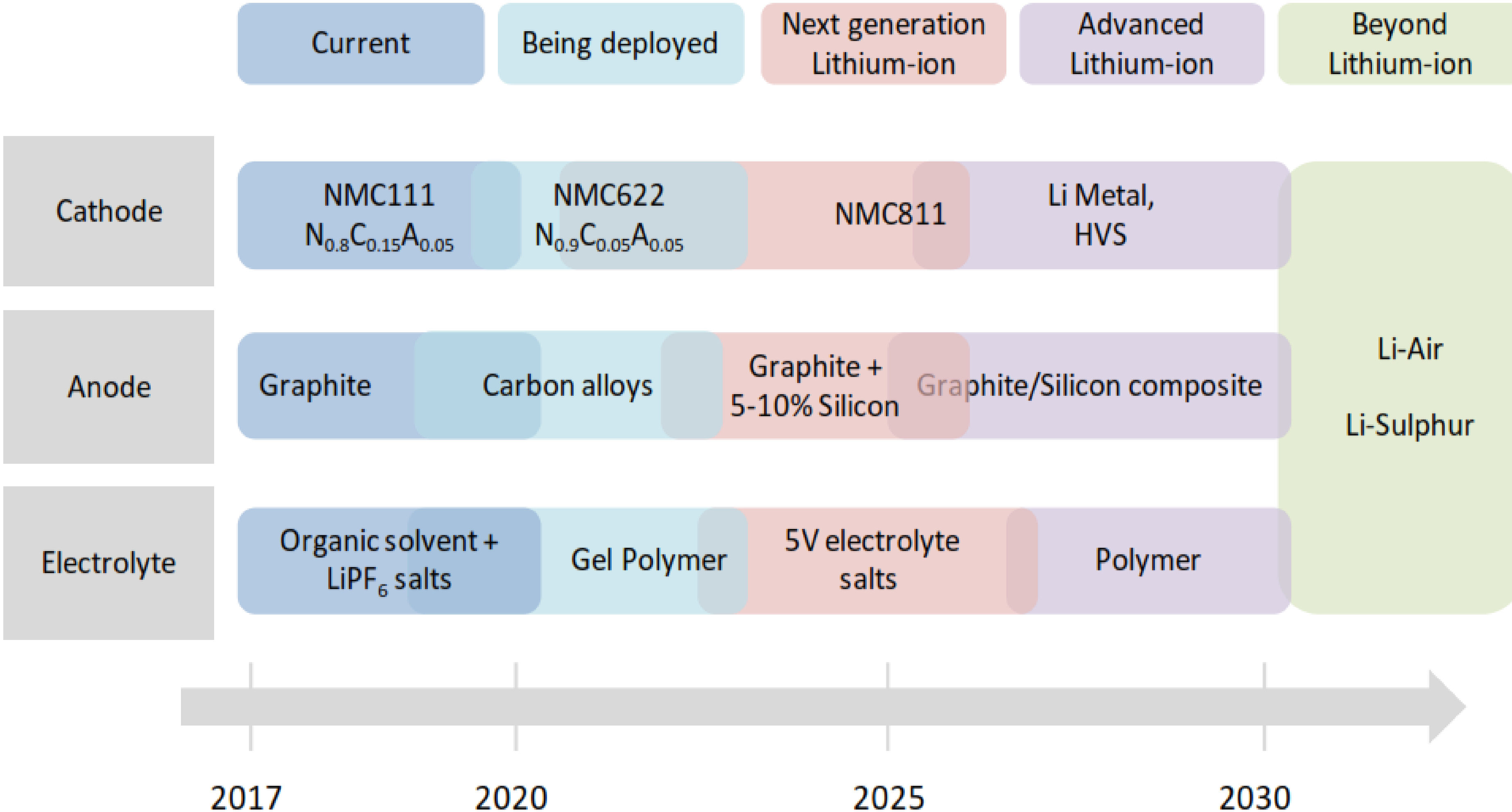
CELL FINISHING: 41% of battery cell production costs



Process	Electrolyte filling	Precharging	Filling hole closure	Formation	Aging
Description	Filling ion-conductive liquid into cell	Precharging cell after filling	Closing electrolyte filling hole	Initiating battery and defining performance	Identifying micro short circuits in cells
Cost	10% of finishing	7% of finishing	3% of finishing	35% of finishing	45% of finishing
Challenges	Soaking time Number of filling steps	Processing safety Yield rate	Particle generation	Processing time Yield rate	Processing time Yield rate

Source: BCG analysis.

Expected Battery Commercialization Timeline



Notes: HVS = high voltage spinel. The diagram shows the likely beginning of commercialisation of a given technology.

Sources: IEA analysis based on Howell (2016); Meeus (2018); Nationale Plattform Elektromobilitat (2016); NEDO (2018); Pillot (2017).

Battery Related Investment

Investment	USD Bn
Tesla/Panasonic: planned a 35 GWh "gigafactory" for 2020 as part of a $5 billion investment	5.0
CATL of China: announced a $2 billion investment to build 2 battery plants (one at 24 GWh capacity)	2.9
Asahi Kasei: purchased Polypore to dominate the battery separator market ($2.2 billion)	2.2
Dyson: planned a $1.4 billion battery market invest-ment, including the acquisition of start-up Sakti3	1.4
Daimler: plans to invest $1.1 billion in the battery market over the next five years	1.1
Total: acquired battery manufacturer Saft for $1.1 billion	1.1

AES/Siemens: created joint-venture Fluence to supply companies and enterprises (hospitals, universities), as well as provide larger arrays incorporated into regional electrical grids

Comment: Investments that are done or planned, 2016 and 2017, USD Bn
Source: reported news – various secondary sources, Arthur D. Little Analyses

Strategies for Current and Future Battery Players

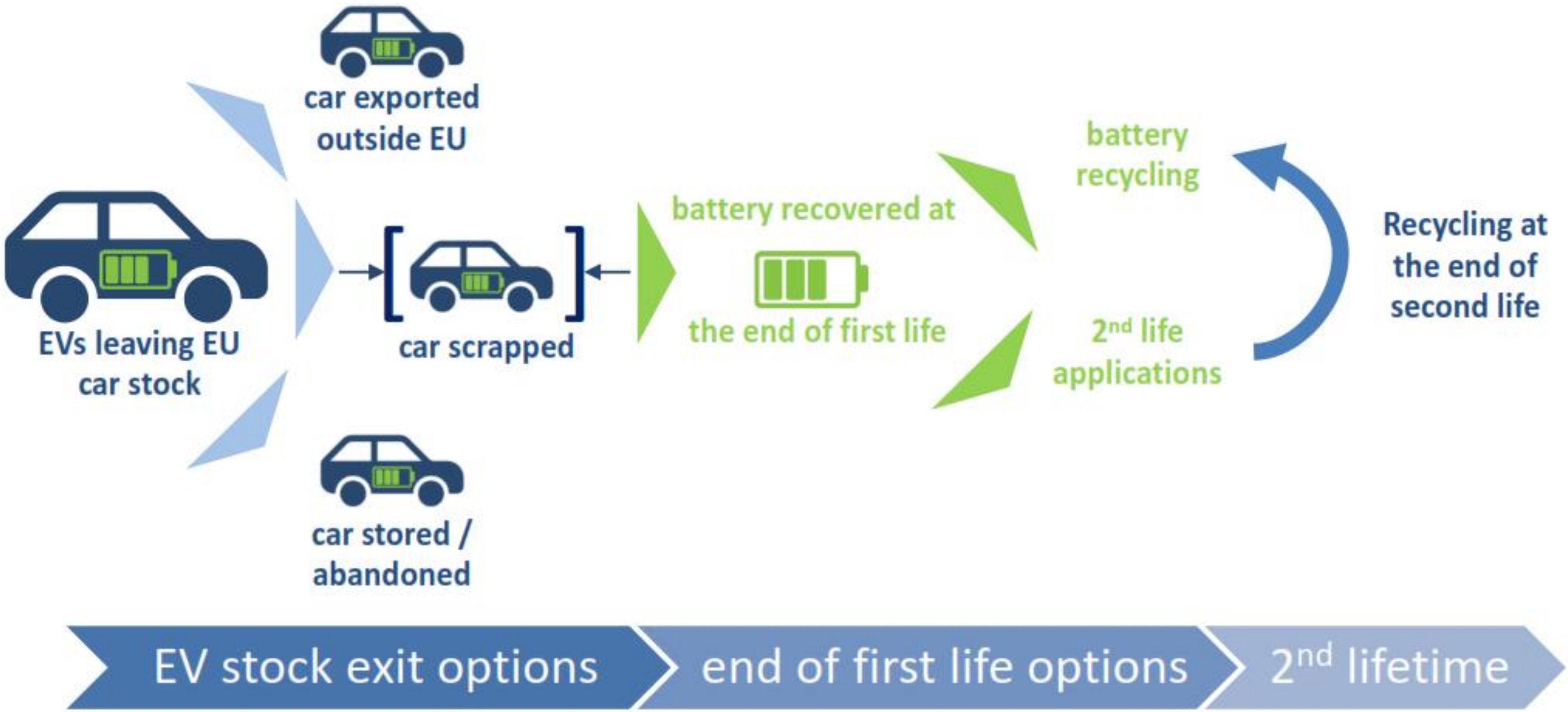
Battery value chain

Battery importance

	Providers	Users
Emerging/ optional	A ■ Invest in select next-gen technology platform(s) ■ Prepare for market entry in high-value niche markets/ segments	C ■ Define critical performance tipping points ■ Develop conditional technology and product roadmaps
Established/ locked-in	B ■ Remain/become top-3 player in commoditizing current-gen markets ■ Closely monitor next-gen evolution and hedge technology position	D ■ Define critical performance tipping points ■ Invest in relevant next-gen "knowledge stakes"

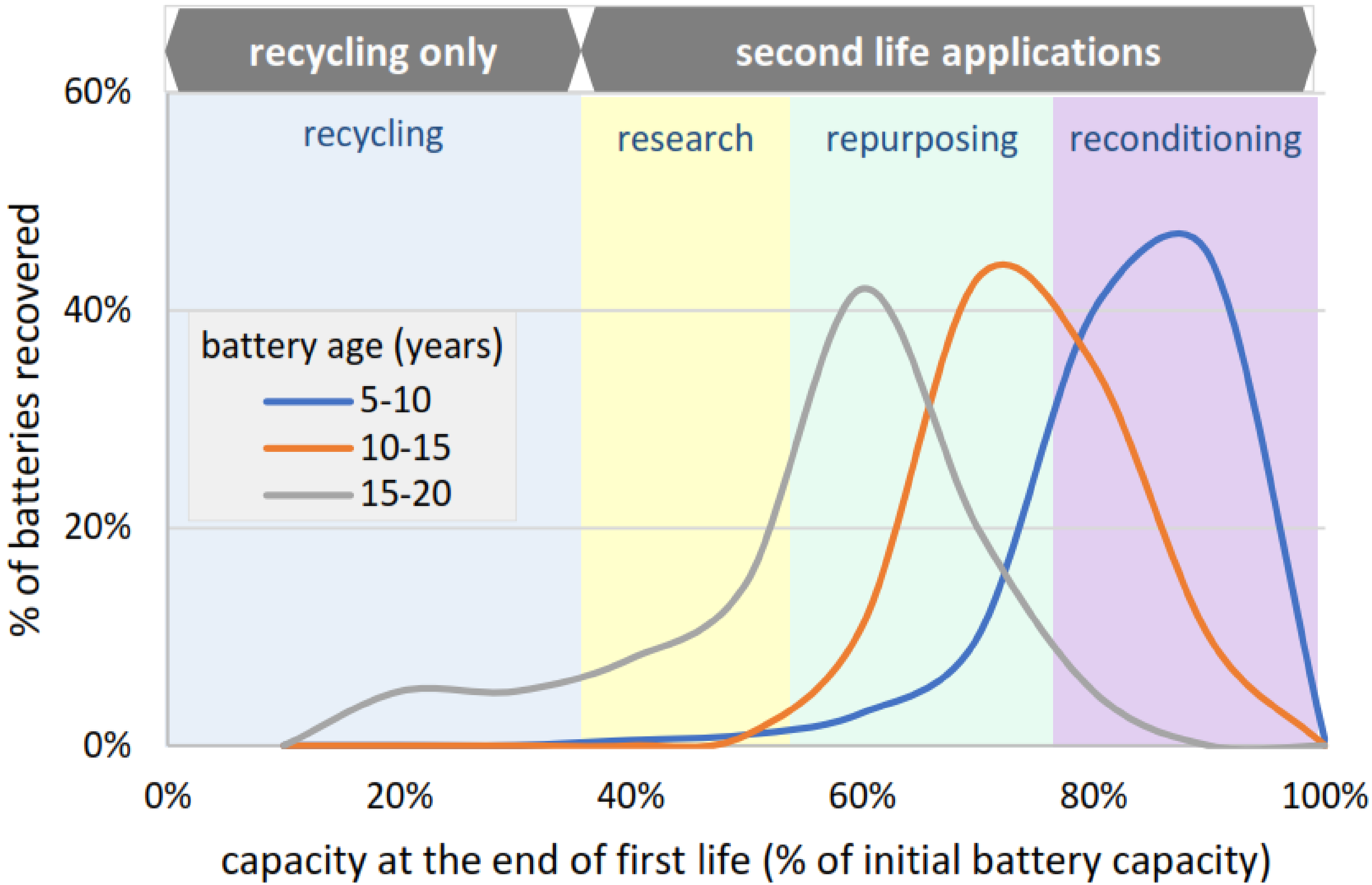
Source : Arthur D. Little analysis

Batteries End of Life Options



Source : the role of battery electric cars in the EU power system and beyond, 2019

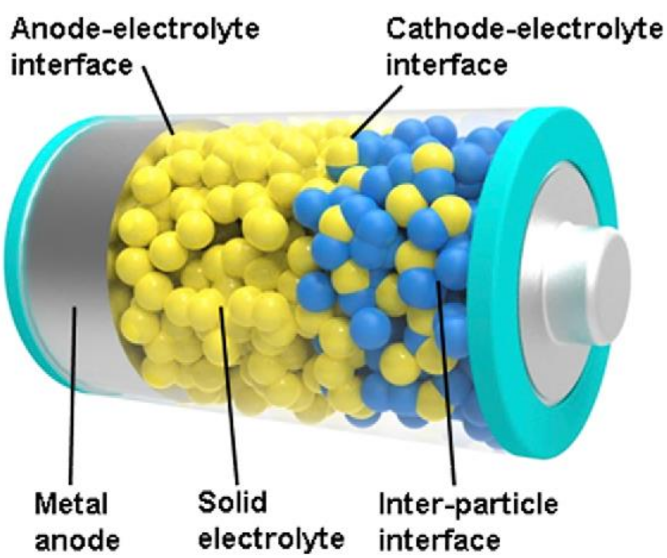
The Fate of Recovered Batteries



Source : the role of battery electric cars in the EU power system and beyond, 2019

Future Batteries

Solid State Lithium Battery

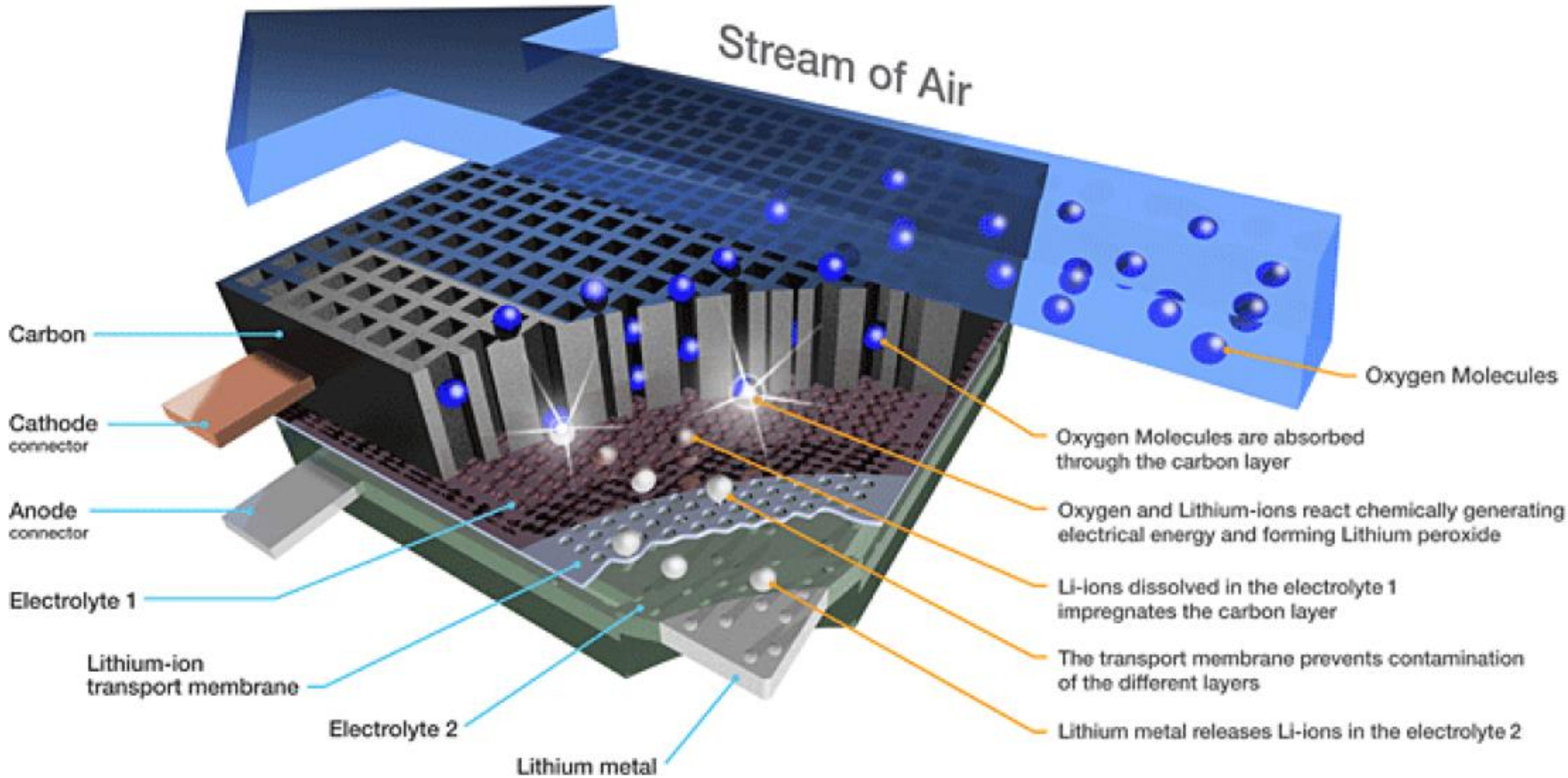


→ **Replaces highly flammable liquid electrolyte by solid electrolyte**
Higher energy density and safer
Could be the next generation of EV battery:
Among the major players working on this technology are *Toyota, BMW, Saft* in partnership with *Solvay, Siemens*…

Source : Xu, Lin et al. "Review Interfaces in Solid-State Lithium Batteries." (2018).

Future Batteries

Lithium Air Battery



Source : IBM looking to put lithium-air batteries on the road, 2012

6-Key Policies in the Next-Generation Vehicles Strategy

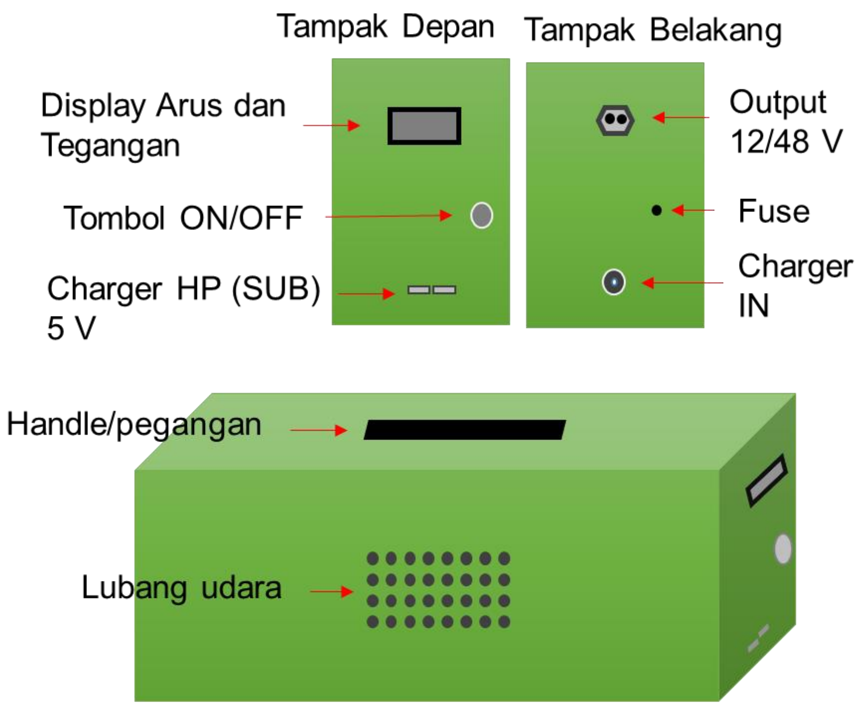
	Targets	Action Plan
Overall Plan	Next Gen vehicle development and production	Next gen vehicles account for up to 50% in 2020 Promote the use of various fuels Promote the siting of low-emission industries
Batteries	Secure battery technology by R&D	Improve performance of LiB Develop post-LiB Achieve economies of scale by promoting EVs
Rare Metals	Secure rare metals and build recycling systems	Strategically secure rare metals Develop batteries and motors free of rare metals Establish battery recycling system
Infrastructure	Install 2 million normal chargers and 5,000 quick chargers	Build infrastructure during market preparation phase Collaborate with the private sector for further penetration
Systems	systemize the vehicles	Establish new business model Verify the system in the social demonstration program Promote global standardization
Global Standards	strategic global standardization	Establish global standards for battery performance and safety level Set a global standards for charging connectors/systems Promote collaboration of public-private organization

Source: Citi Research.

OUR EXPERIENCES

LIB-based Portable Energy Sources for DC House System and Emergency Response

TABUNG LISTRIK (TALIS) PROTOTYPE



TaLis 0.6 kWh 48 V

Prototype 1

Prototype 2

TaLis can be designed according to the needs. We have made prototypes with 500 – 700 Wh, and output voltage of 12/48 VDC as well as 220 VAC.

TALIS FOR SCHOOL'S BUILDING

Solar Rooftop + TaLis has been implemented in Sekolah Master Indonesia, Terminal Depok, Nov. 2017 supported by WIKA.
TaLis is designed to be working as free-maintenance system

Inauguration Ceremony of DC House System

3 kWp Solar Rooftop

3 Unit Implemented TaLis

Inauguration

A Class Room Powered by TaLis

November 2017

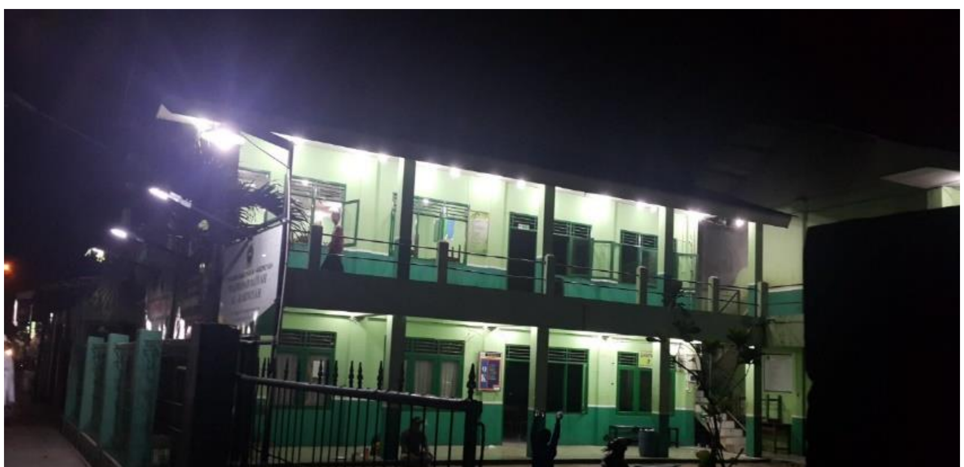
DC HOUSE SYSTEM : PONPES ALKARIMIYAH

Solar Rooftop and DC House System at Pondok Pesantren Al-Karimiyah.
Community service Program from DRPM UI (IDB Prize for Science and Technology)

Inauguration Ceremony

Inauguration Ceremony

An auditorium powered by DC House



Pondok Pesantren at Night

- Implemented at Pondok Pesantren Al-Karimiyah, Depok
- The system was composed of 3 kWp solar PV rooftop (DC House System) and 1 kWp solar-powered submersible pump

Agustus 2018

TALIS FOR EMERGENCY : CACAR ASMAT PAPUA

Penyerahan TaLis oleh Direktur DRPM kepada Bupati Asmat

Para Relawan dan Personel TNI di Kolf Braza

Penyerahan TaLis oleh Direktur DRPM kepada Dansatgaskes TNI

TaLis Sumbangan ILUNI FTUI untuk Asmat, Papua

Februari 2018

TALIS FOR EMERGENCY : EARTHQUAKE IN LOMBOK

PT. Wijaya Karya (Persero), PT. Astra, KAGATRIK UI, Pegawai Bank Mandiri, under auspice of DRPM UI (UI Peduli) donated TaLis for volunteers during emergency response in Lombok earthquake

Penyerahan TaLis + Lampu LED dari WIKA

TaLis saat digunakan relawan

ASTRA menyerahkan Talis ke Walikota Mataram

TaLis untuk backup Pendingin vaksin

Penyerahan TaLis kepada Warga/RT

Solar Charger 2 x 50 Wp

September 2018

TALIS FOR EARTHQUAKE & TSUNAMI IN PALU

2 Unit TaLis + Lampu LED + Solar Charger dari KAGATRIK UI dan Masjid Almukhlisun GDA, Depok

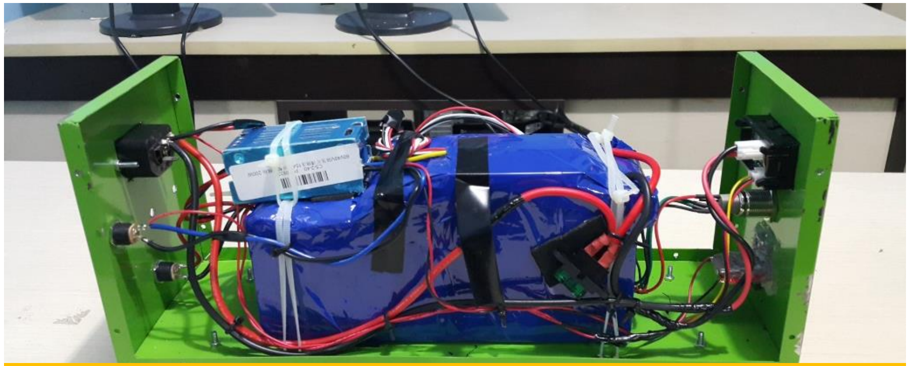
2 TaLis + LED + Solar Charger dari IEEE Indonesia

TaLis ketika digunakan oleh Para Relawan di Palu

Donasi TaLis kepada Kadinkes Prov. Sulteng

TALIS FOR ANY PORTABLE ENERGY NEEDS

Prof. Danardono, Dr.-Ing. Nasrudin, dan Dr.-Ing. Mohammad Adhitya (DTM FTUI) menggunakan TaLis untuk mengecas HP



Rangkaian Dalam TaLis UI terdiri dari Baterai dan Konverter

INFORMASI LEBIH LANJUT

Alamat : Departemen Teknik Elektro, Fakultas Teknik Universitas Indonesia, Kampus Baru UI Depok 16424 INDONESIA
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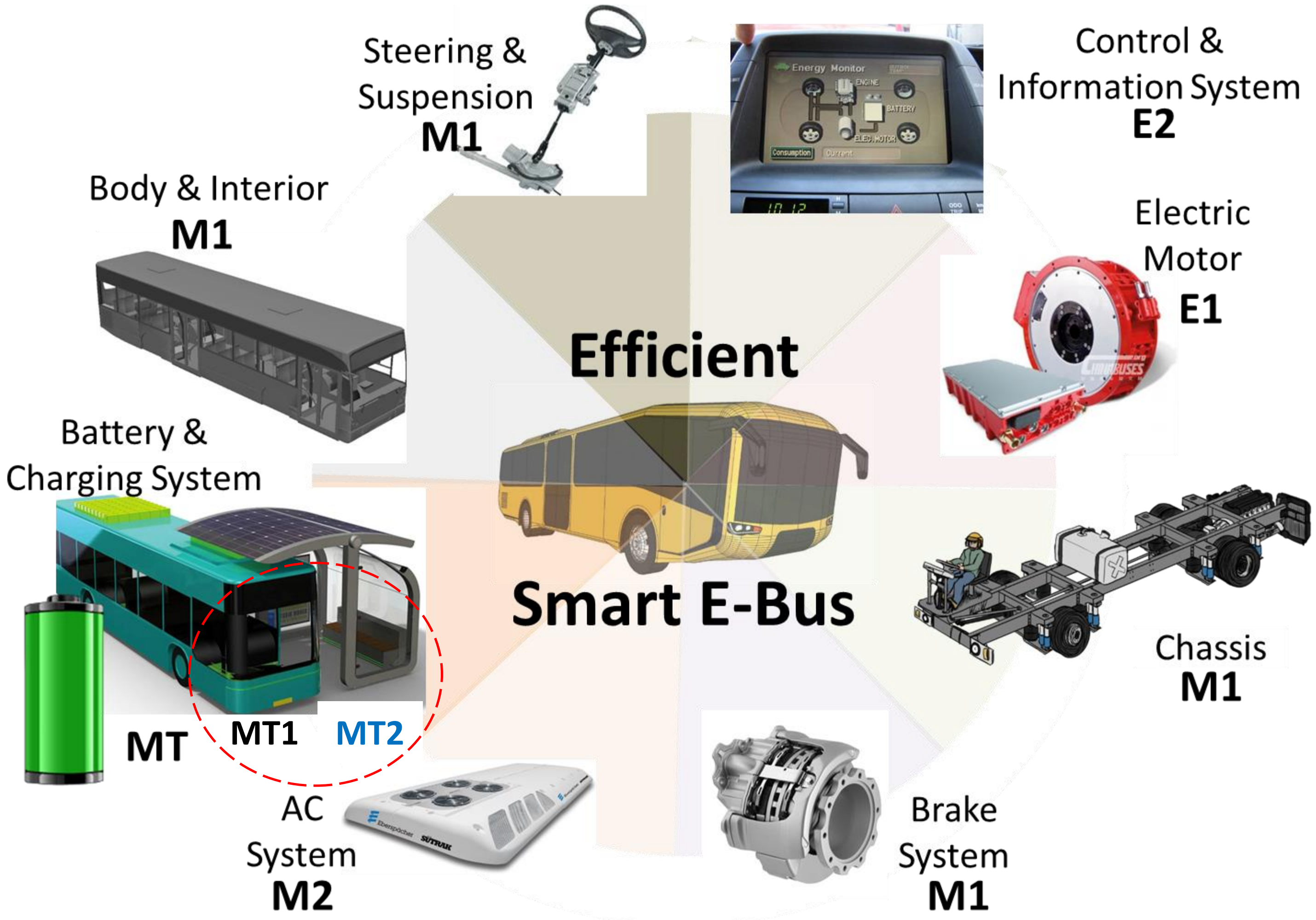
Ir. Chairul Hudaya, ST., M.Eng., Ph.D., IPM
SMS/WA : 081295166665
Email : c.hudaya@eng.ui.ac.id

ELECTRIC VEHICLES : BUS AND PASSENGER CAR

- RCAVe (Research Center for Advanced Vehicle) is a research center in UI aimed at **solving the environmental and transportation challenges**.
- We are **a multi-disciplinary research center** combining the **expertise and experiences** from various engineering fields

RCAVe TEAM DIVISION



RESEARCH ACTIVITIES AT RCAVe

Converting conventional car

Charging Station

Battery Assembly

Battery Management System

Reference

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THANK YOU FOR YOUR ATTENTION

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http://www.ee.ui.ac.id/epes/emat