

WORLD MOBILITY SUMMIT 2016





Electromobility

Regulations, Vehicles,
and Markets



Munich, October 20th, 2016

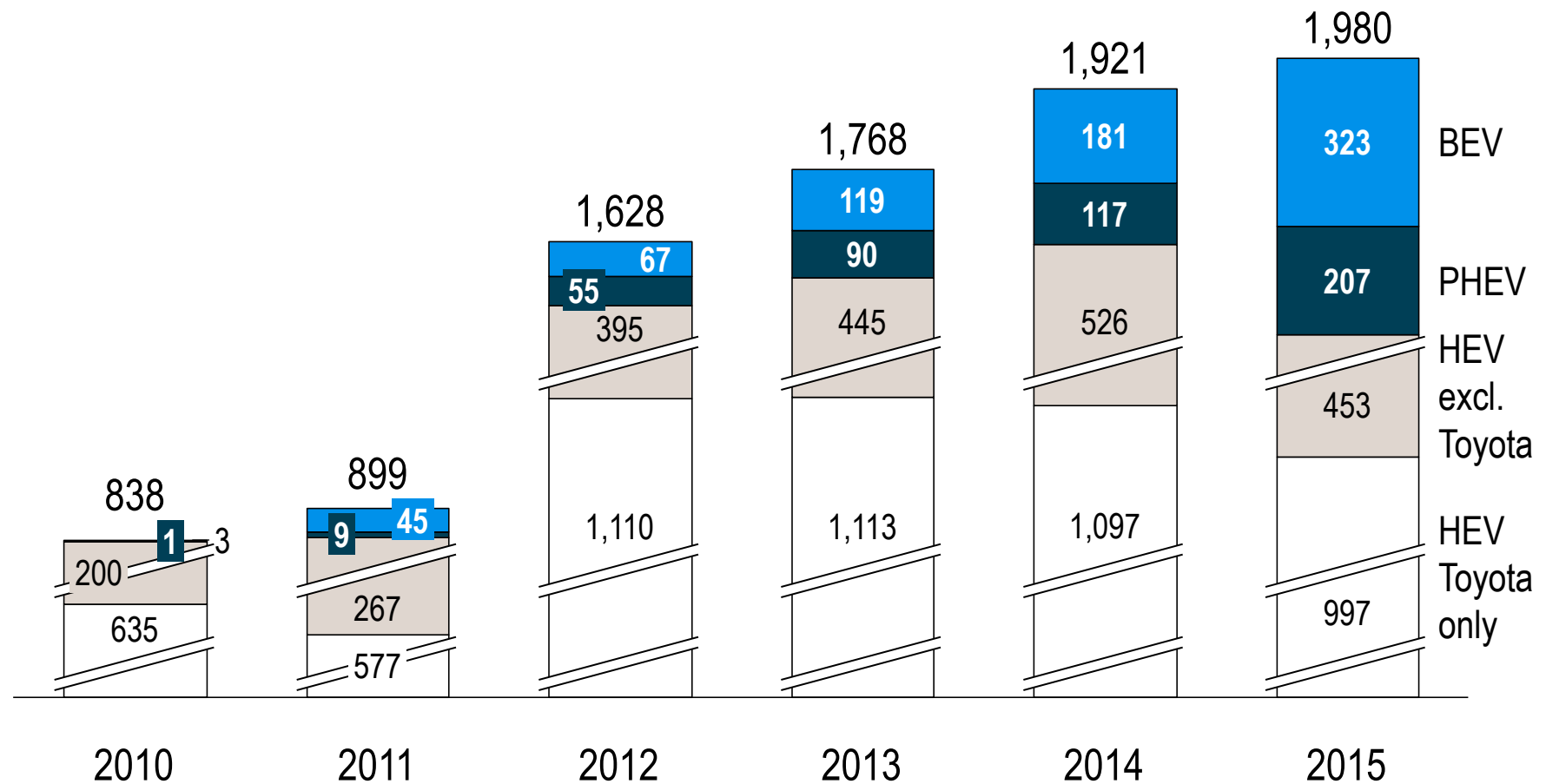
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In 2015 global BEV and PHEV sales totalled to around 530,000 units, about 60% thereof being BEVs

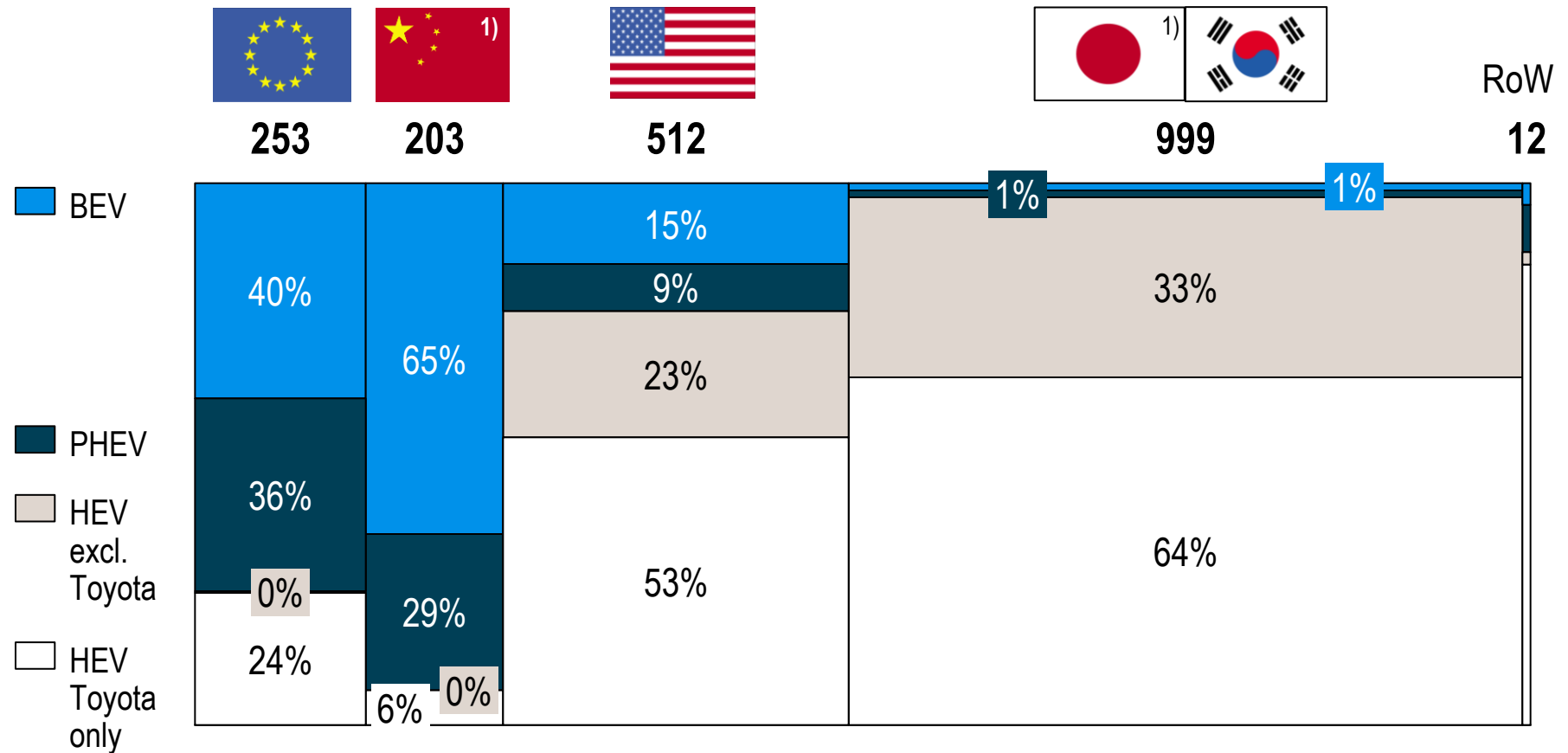
Global passenger cars BEV/HEV/PHEV sales volume [000 units]



Note: China/Japan sales data includes only domestically produced xEVs
 Source: MarkLines; Press Research; Roland Berger

Japan and North America are big HEV markets, whereas BEV/PHEV technologies are most significant in Europe and China

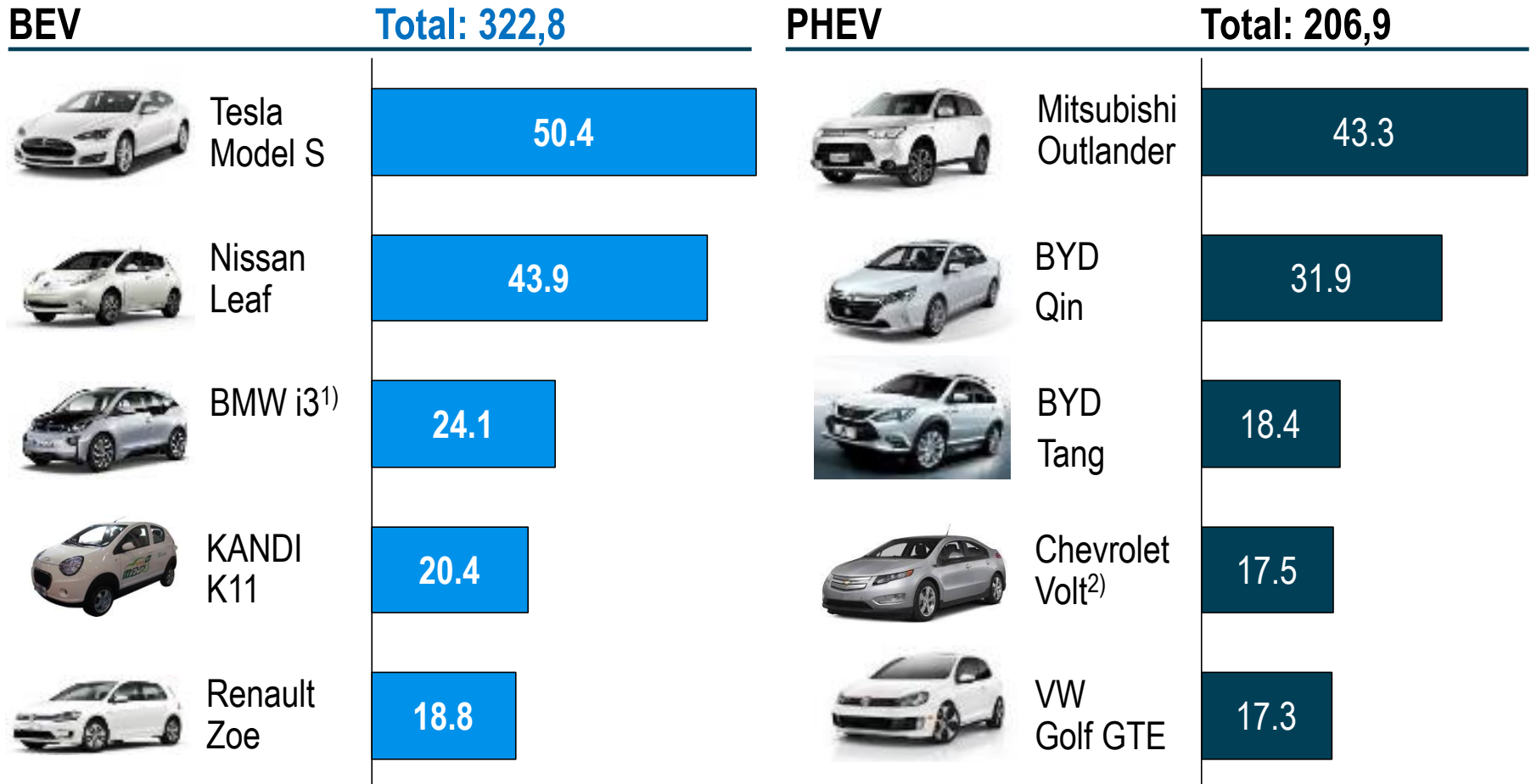
Global passenger cars xEV sales volume by region, 2015 [000 units]



1) China/Japan sales data includes only domestically produced xEVs

In 2015, Tesla Model S was the best-selling BEV model globally, Mitsubishi Outlander the bestselling PHEV

Best-selling BEVs and PHEVs globally (2015, thsd. units)

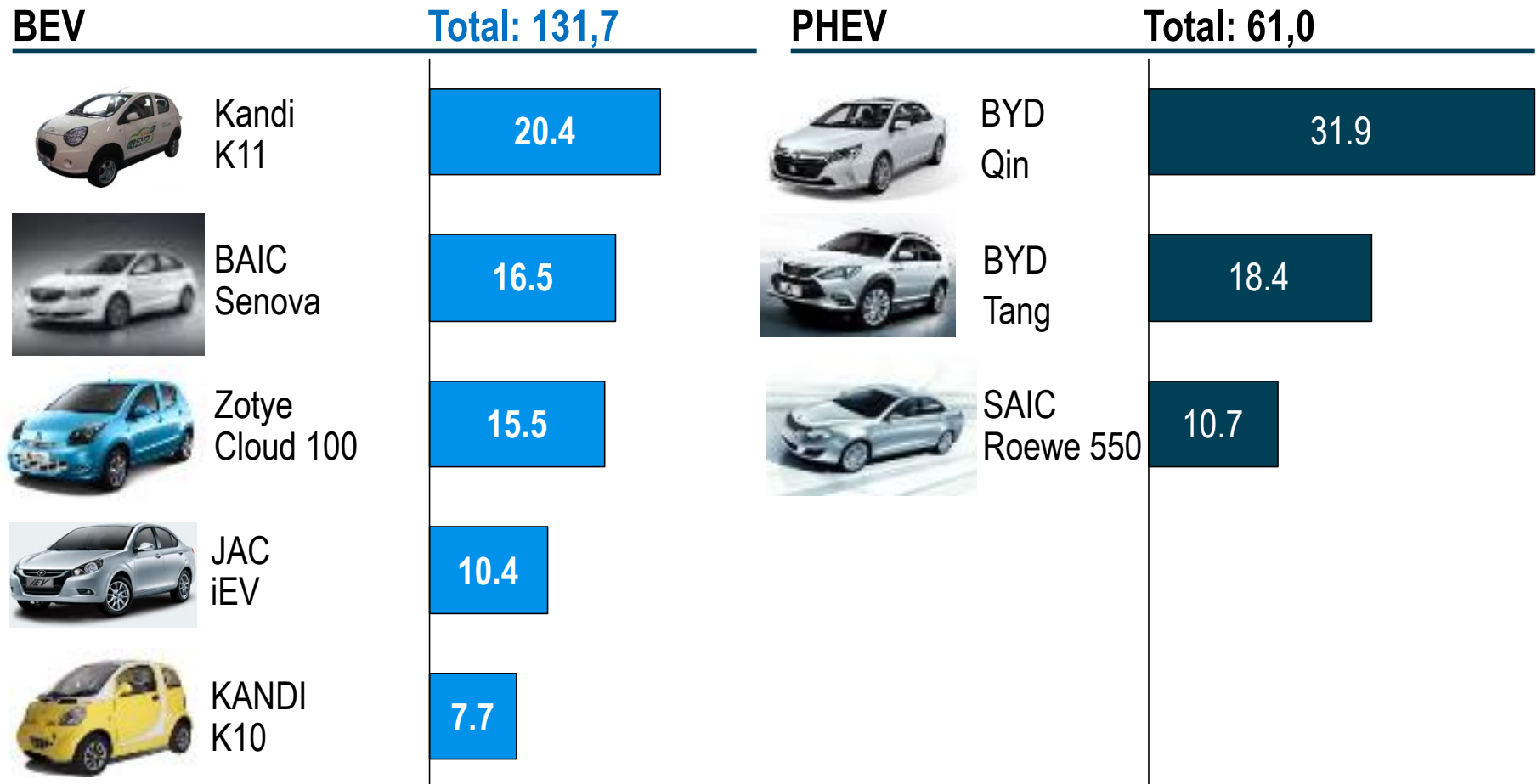


1) incl. REEV 2) incl Chevrolet Volt I and II, Holden Volt, Opel and Vauxhall Ampera

With central and local governments' favored policy, Chinese OEMs are dominate both the BEV as well as the PHEV market



Best-selling BEVs¹⁾ and PHEVs in China (2015, thsd. units)

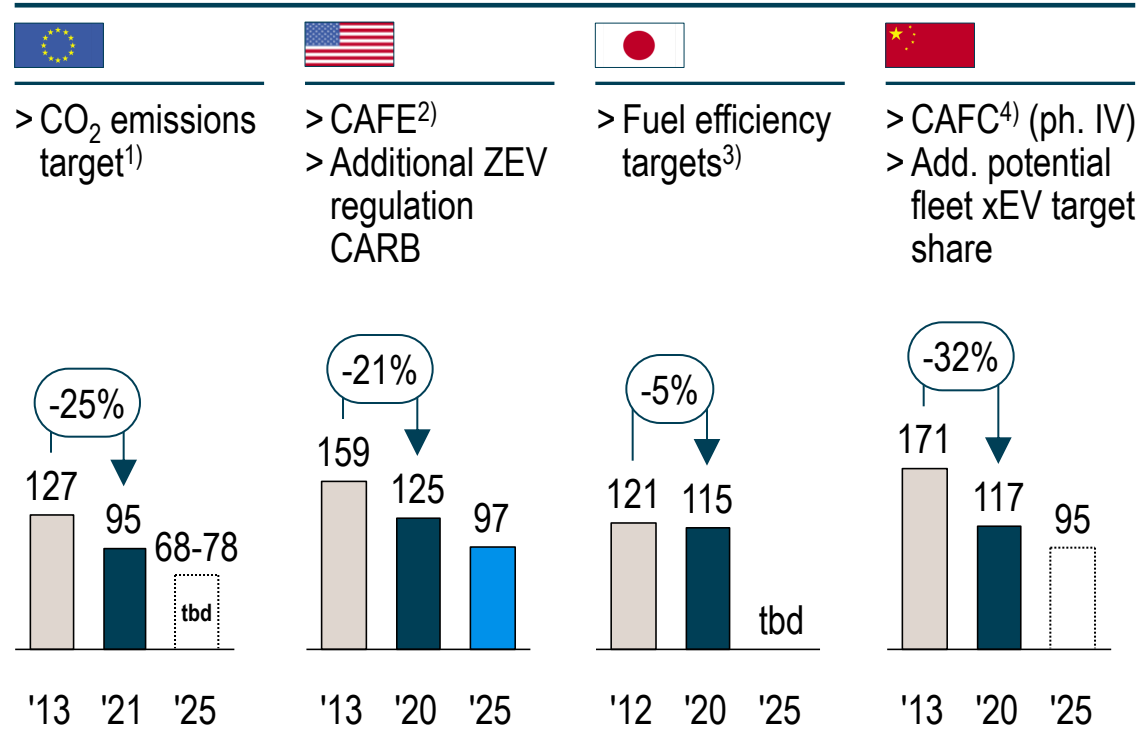


1) Excluding microcars (e.g. ZD D1)
 Source: MarkLines; Press Research; Roland Berger

Emission regulations force automotive OEMs to introduce an increasing share of xEVs from 2020 onwards

Passenger car GHG emissions/fuel consumption [g/km] and toxic emission regulations

GHG emissions/fuel consumption (CO₂)



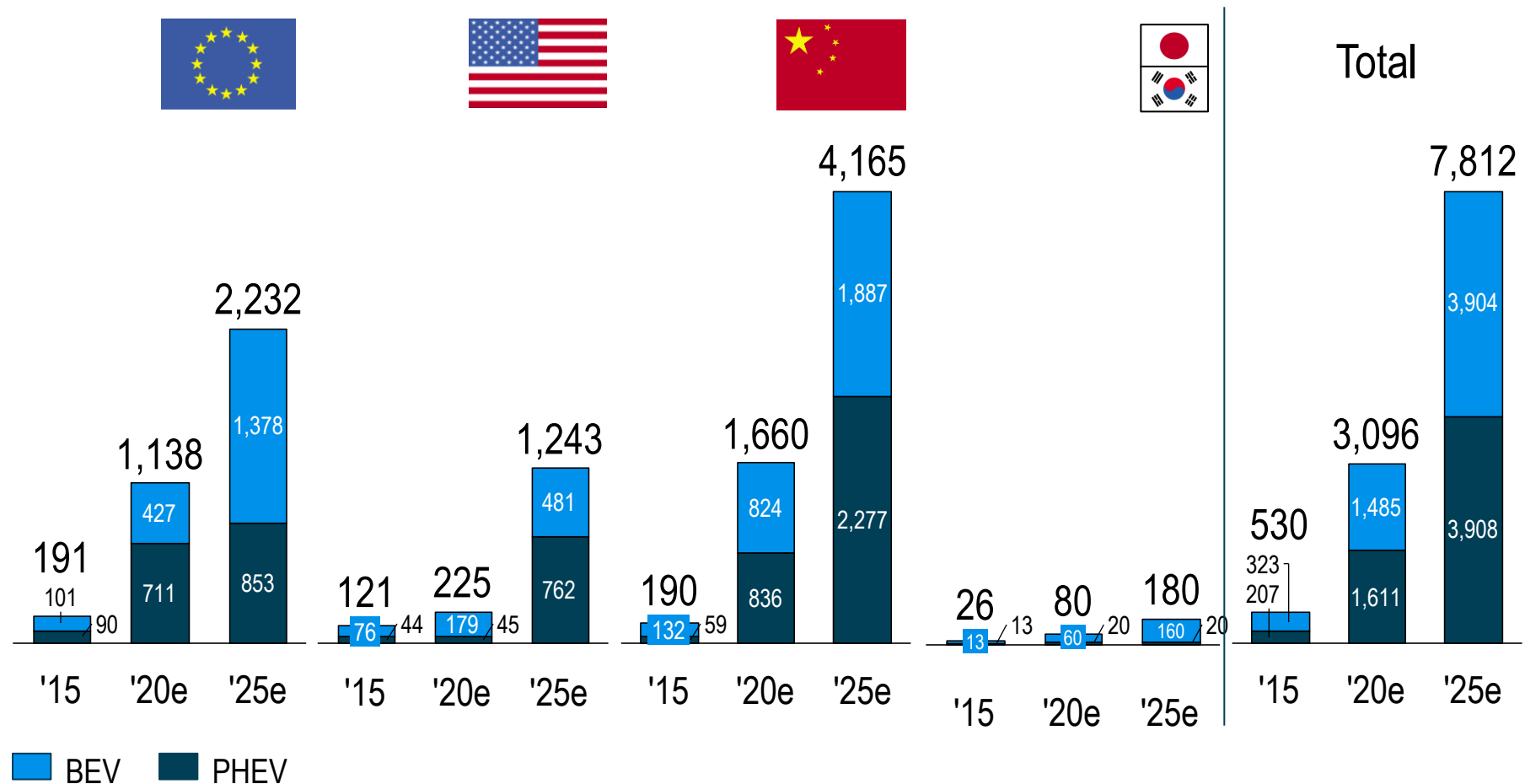
Toxic emissions (NO_x, PM, HC, ...)

- EU**
 - >2014: Euro 6b
 - >2017: Euro 6c w/ RDE, additionally WLTP
- USA**
 - >2015: CARB LEV III
 - >2017: EPA Tier 3 Standards
- Japan**
 - >2009: Post new long-term JC08 mode cycle
 - >2018: Post-PNLT (PPNLT)
- China**
 - >2016: China 5 and Beijing 5

1) Weight-based corporate average 2) Footprint-based corporate average; converted to NEDC 3) Weight-class based corporate average; showing JC08
4) Weight-class based per vehicle and corporate average

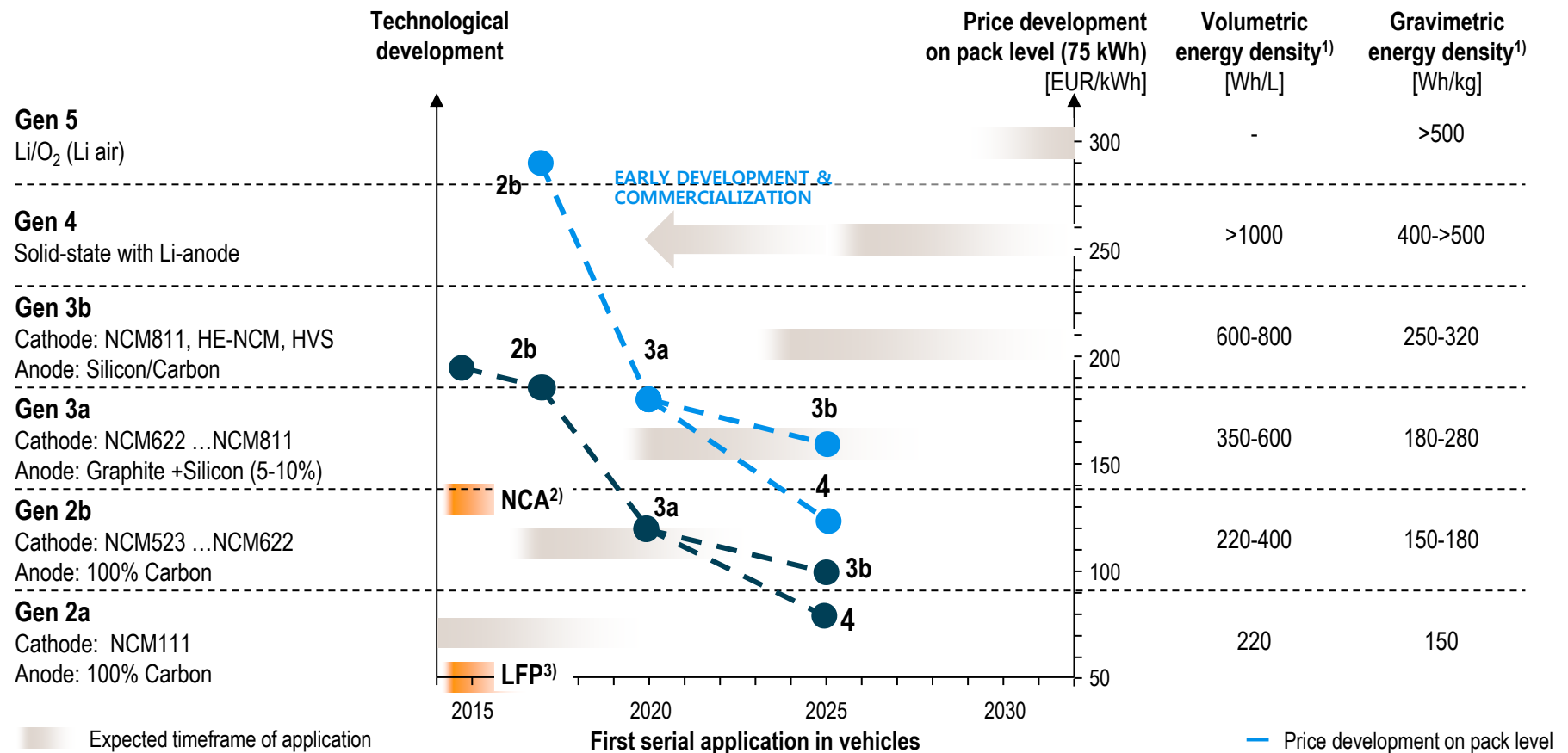
Global PHEV/BEV sales will increase from 0.5 m units (2015) to 7.5 m units in 2025 – China becomes the largest PHEV/BEV market

PHEV/BEV market forecast by region, 2015-2025 [000 units]



NCM as CAM has further potential for significant increase of energy density and thus decreasing costs

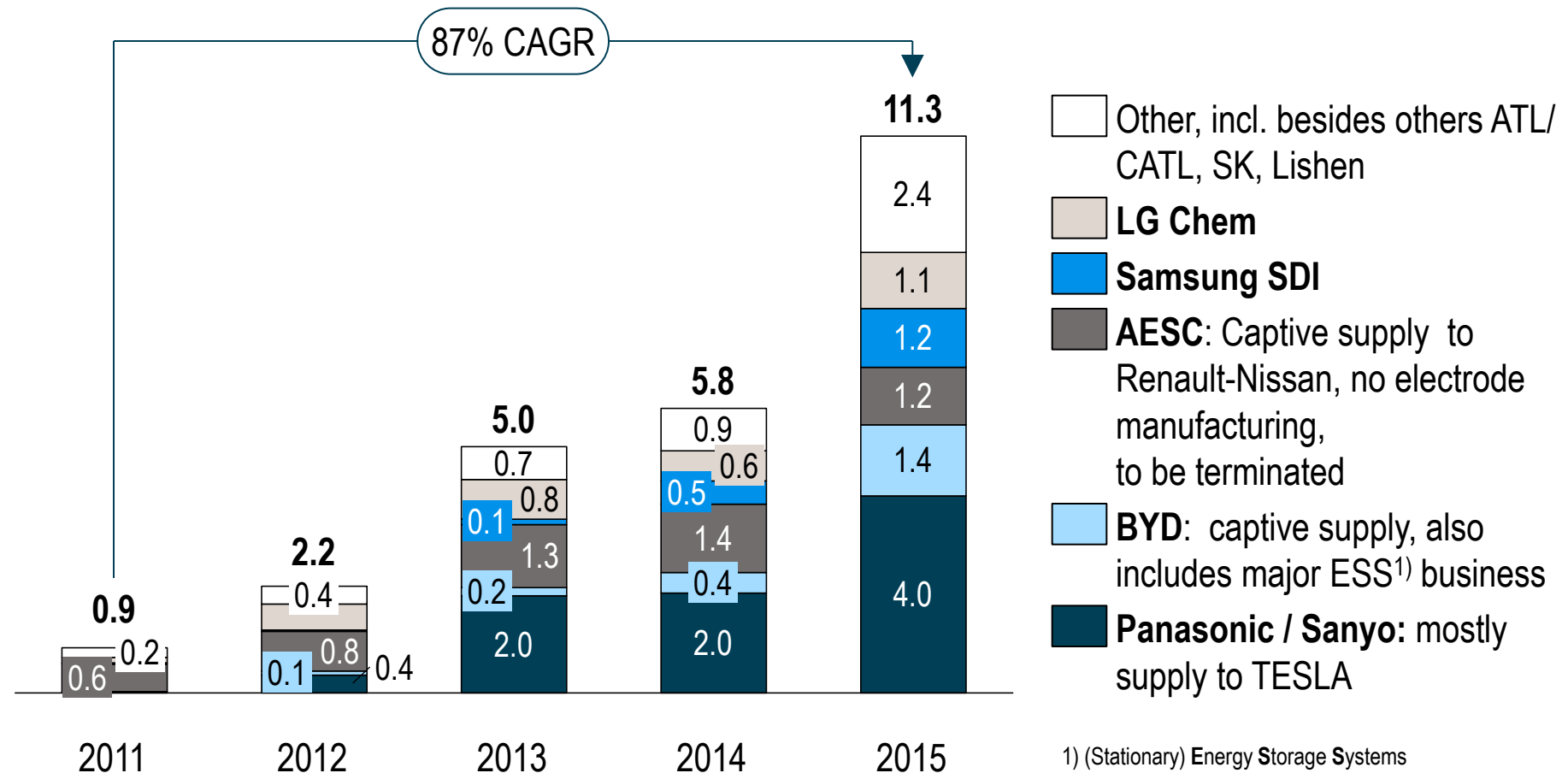
Roadmap for NCM based cell technology and expected price development [EUR/kWh]



1) Energy density in cell level 2) NCA as CAM in configuration used by Tesla on cell level 3) LFP in average configuration for CAM on cell level

Samsung SDI and LG Chem dominated the non-captive market for Automotive Lithium-Ion cells, which has grown by nearly 90% y.o.y.

xEV LiB supply by cell manufacturer 2011-2015 [GWh p.a.]



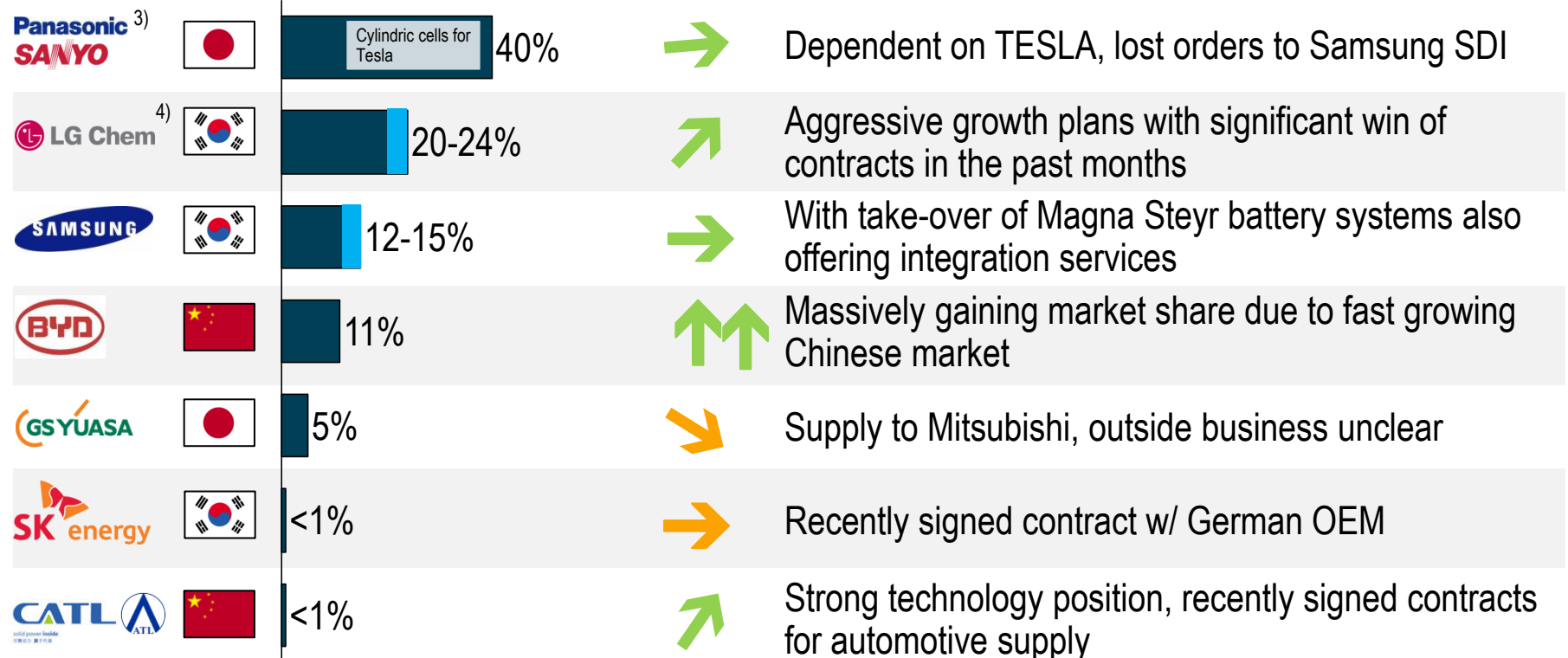
1) (Stationary) Energy Storage Systems

Automotive relevant LiB-market will further consolidate – with clear dominance of Asian players

Automotive xEV global market share 2017¹⁾

Projected global market share, 2017²⁾

Mid-term outlook



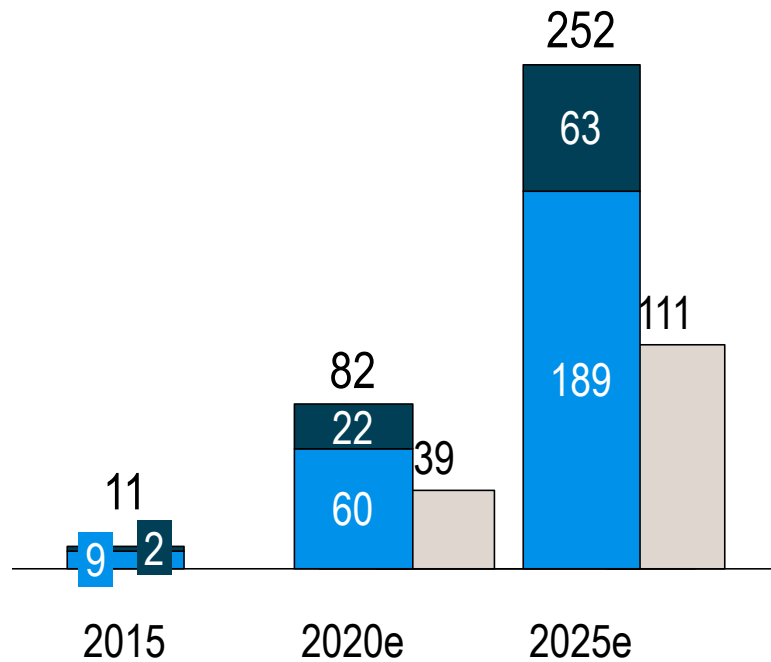
1) Only supplier for automotive LiB cells – Calculation based on sales forecast with acc. battery pack capacities

2) Based on projected market share in GWh 3) Including Primearth's market share 4) Assuming LG Chem will take over most of AESC market shares

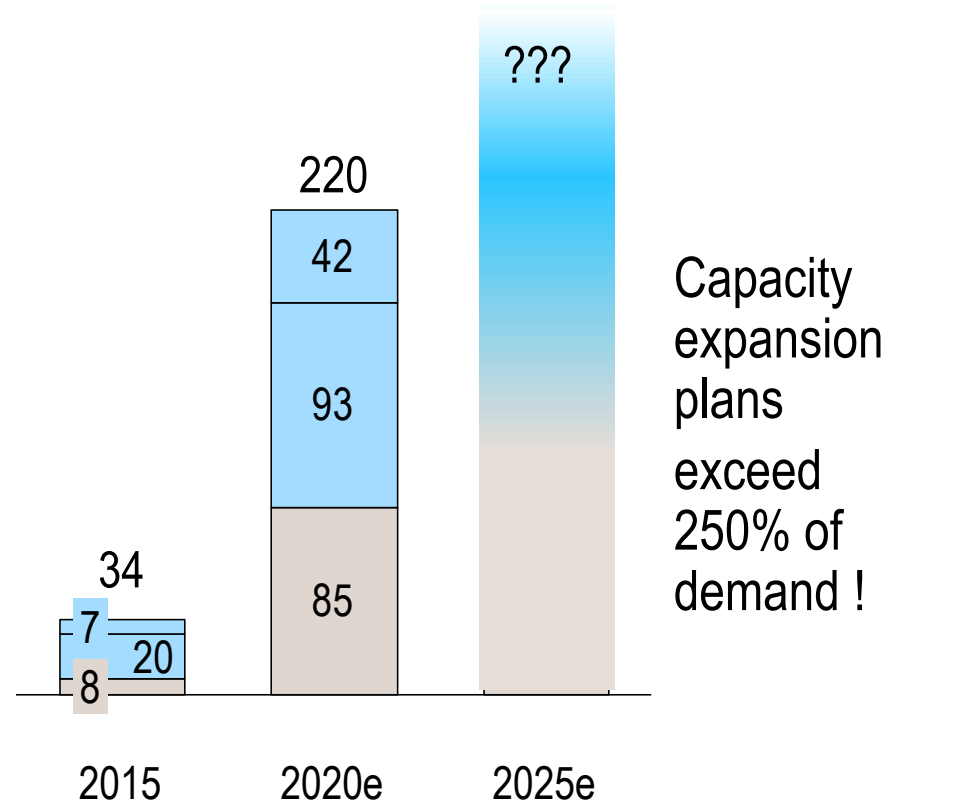
Source: Roland Berger

While there is a continued growth of LiB demand with approx. 35% p.a. until 2025, capacity expansion plans may result in overcapacity

Automotive LiB demand¹⁾



Capacity forecast [GWh p.a.]



Capacity expansion plans exceed 250% of demand !

PHEV
 BEV
 thereof China

Non-automotive formats (18650, etc.) excl. Chinese manuf.
 Passenger car excl. Chinese manufacturer
 Chinese manufacturer for automotive

1) BEV and PHEV demand only
Source: Roland Berger

Capacity increase has strong consequences on price level, supply risk and supply structure

Implications on Automotive LiB supply chain

- **Pressure on cell prices will continue**, together with the already clear advancements in volumetric energy density this can lead to significant further cost reductions well **below** currently expected **150 EUR / kWh on pack level in 2020**.
- At the same time, **supply risks**, especially for battery grade Graphite and Cobalt **increase significantly**.
- In **2020**, Automotive **cell supply** will most likely be clearly **dominated by four to five large players** who can afford the necessary investments in capacity expansion and research on new cell generations: BYD, LG, Samsung SDI, Panasonic and potentially another Chinese.

Automotive OEMs need to ensure they are "ready" for eMobility

Action areas for Automotive OEMs

1. **Supply chain strategy** incl. **raw material risk management**, e.g. through off-take agreements with mining companies
2. **Converged connectivity strategy** to ensure optimized operating strategies for the electric vehicle and a superior user experience
3. **Cross-OEM cooperation** to ensure availability of **interoperable charging infrastructure**: private, destination, metropolitan and highway charging
4. **Revised Core-/Non-Core-strategy** to cope with other technological challenges ahead at same time.

Automotive suppliers need to prepare for disruptive scenarios

Action areas for Automotive Suppliers

1. **Understand impact of electrification** (and – longterm – autonomous mobility) **scenarios** on own markets / portfolio
2. Prepare for the worst, **develop a long-term strategy**
3. **Think about** building a **"second leg"**

Roland
Berger

