

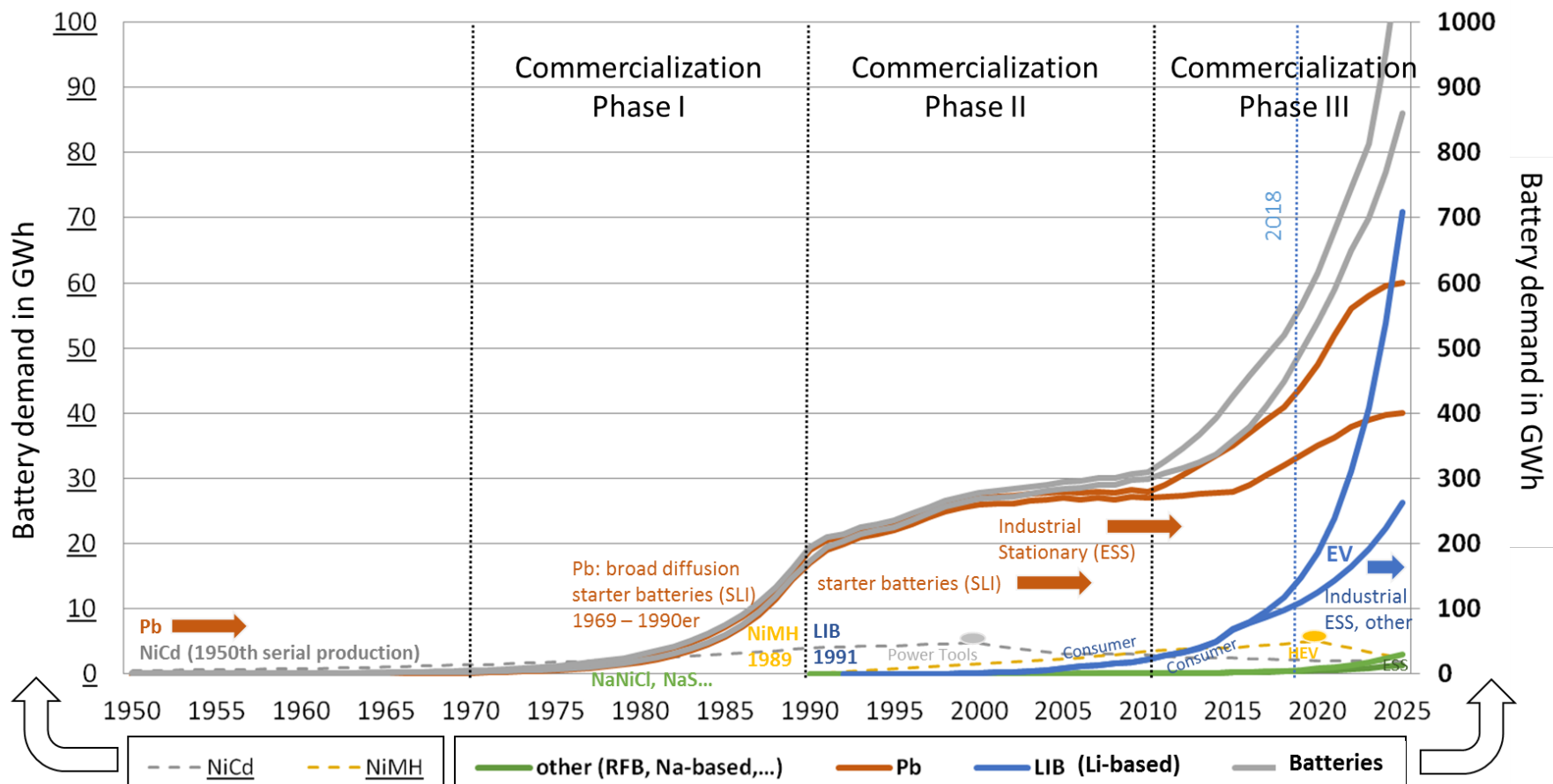
## ECODESIGN BATTERIES – TASK 2: MARKETS

**Christoph Neef**, Axel Thielmann – Fraunhofer ISI

December 20th, 2018 – DG Growth - Brussels

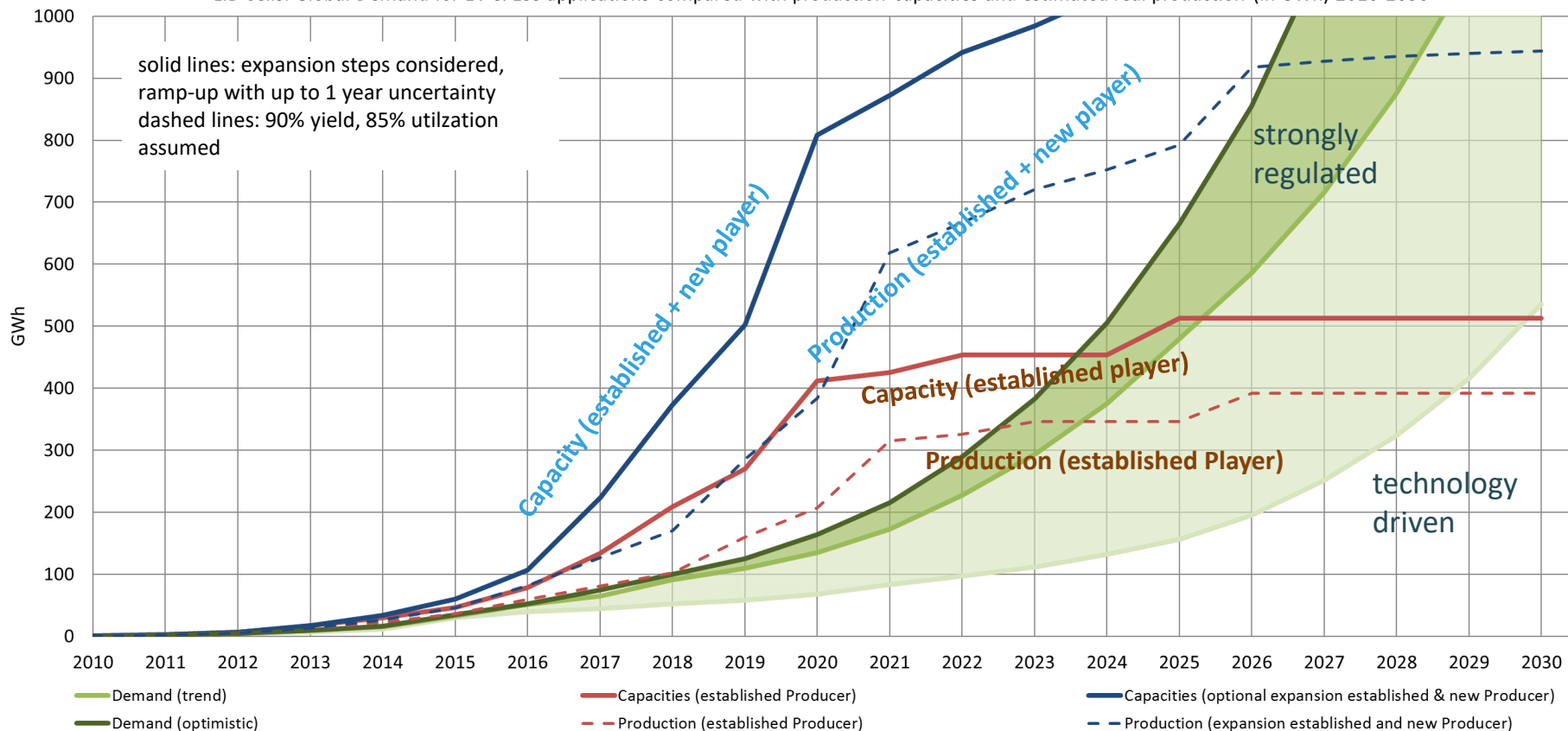
1. *Task 2 – Scope*
2. *Battery technology commercialization*
3. *LIB global markets and applications*
4. *Li-based technologies and roadmap*
5. *EU28: xEV markets – production and sales (2010-2020\*)*
6. *EU28: Forecast – xEV sales and ESS installations (2015-2050\*)*
7. *EU28: Battery demand and returns/decommissions*
8. *Model assumptions and discussion / Q&A*

# BATTERY TECHNOLOGY COMMERCIALIZATION – ALL TECHNOLOGIES



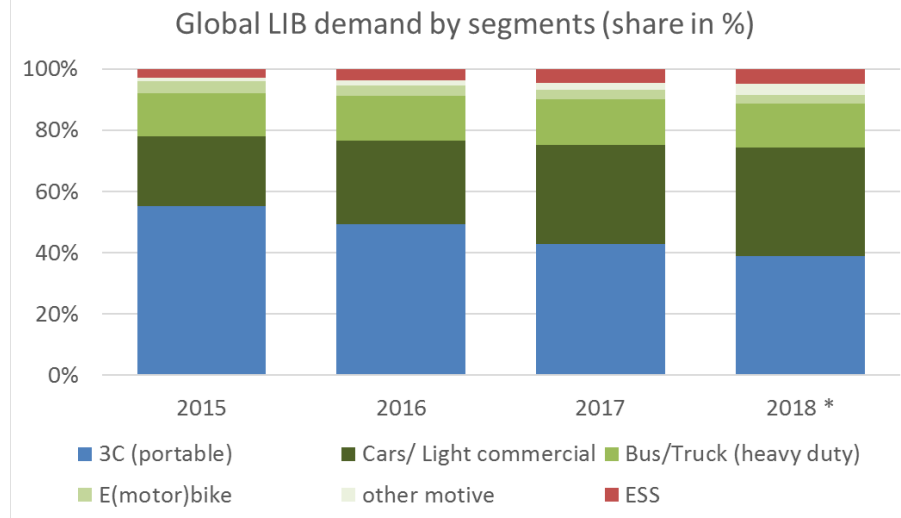
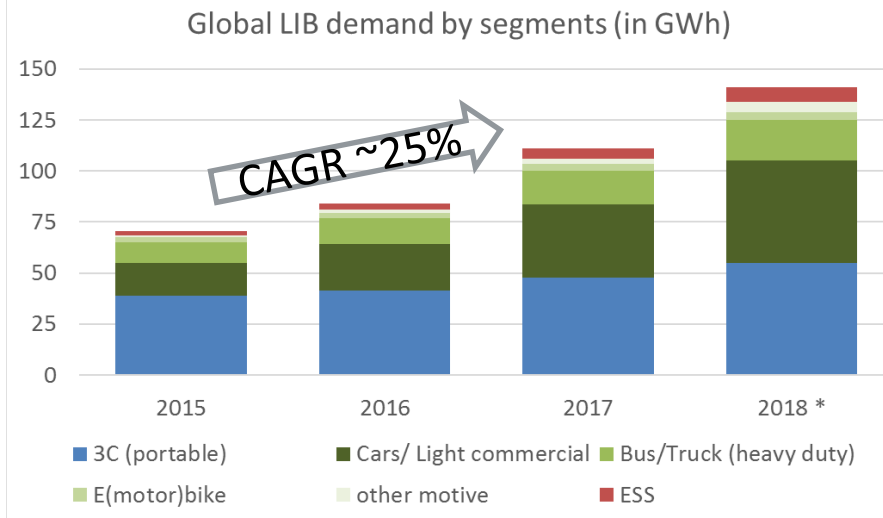
# BATTERY TECHNOLOGY COMMERCIALIZATION – LIB

LIB Cells: Global Demand for EV & ESS applications compared with production capacities and estimated real production (in GWh) 2010-2030



Source: Thielmann et al. 2017: Energiespeicher-Roadmap (update 2017) – Hochenergie-Batterien 2030+ und Perspektiven zukünftiger Batterietechnologien, Fraunhofer ISI 2017. + update 09/2019

# LIB GLOBAL MARKETS AND APPLICATIONS

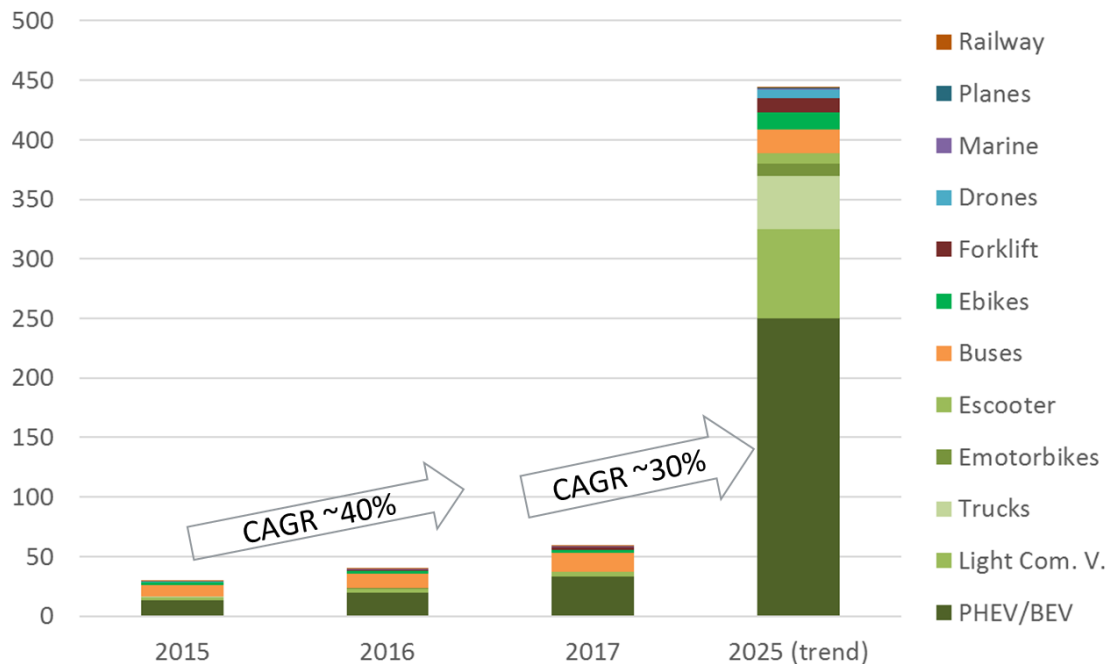


## Main segmentation:

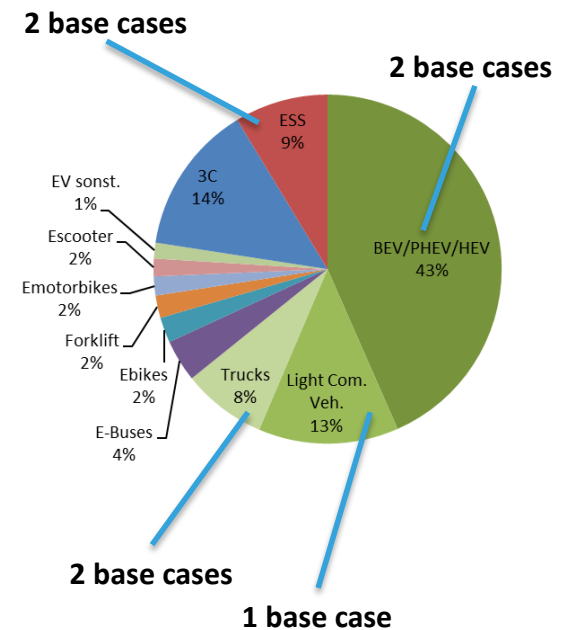
- 3C: computer, communication, consumer = batteries for portables
- Motive: xEV cars, commercial, trucks, buses, (motor)bikes, industrial mobility = batteries for traction
- ESS: stationary applications from small kWh home solar to above MWh installations = batteries for stationary applications

# LIB GLOBAL MARKETS AND APPLICATIONS

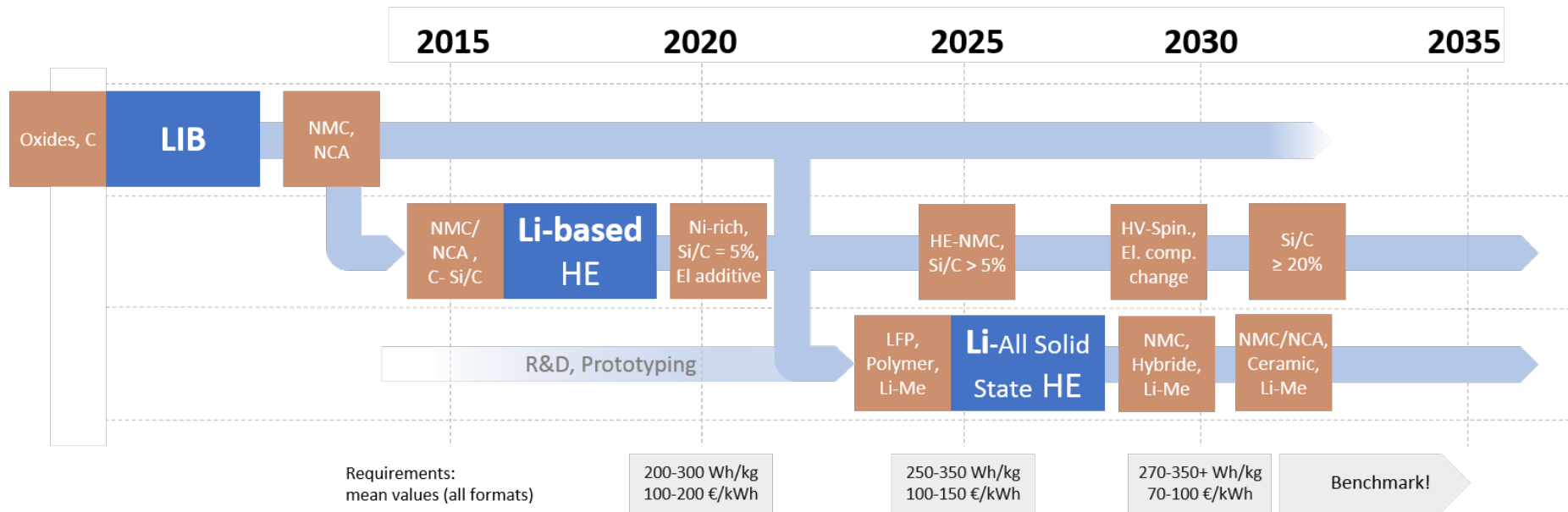
Global LIB demand for Motive applications (in GWh)



FhG ISI scenario 2025  
~ 600 GWh LIB demand



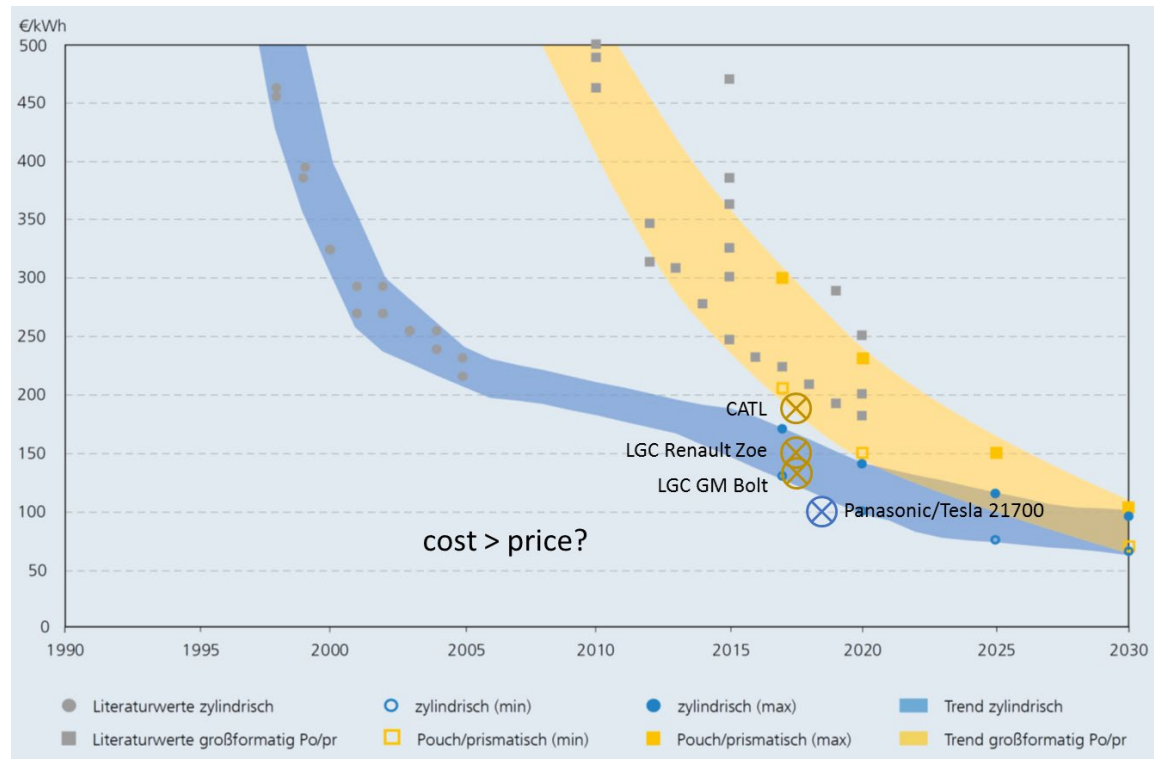
# LI-BASED TECHNOLOGIES AND HE-ROADMAP



- Technology development for HE-automotive batteries by gradual change of cell components (cathodes, electrolyte/separator, anode)
- Towards solid electrolyte (solid-state) batteries with Li-Me-Anode and HE-cathode

# LI-BASED TECHNOLOGIES AND HE-ROADMAP

- Development of LIB cell costs (€/kWh) by cell format (cylindrical vs. large format prismatic, pouch)
- Average cell costs today:
  - cyl. < 150 €/kWh (Tesla: ~110 \$/kWh)
  - large Po/Pr ~ 200 €/kWh (GM Bolt: ~145 \$/kWh)
- Module/system cost higher for high power as compared to high energy

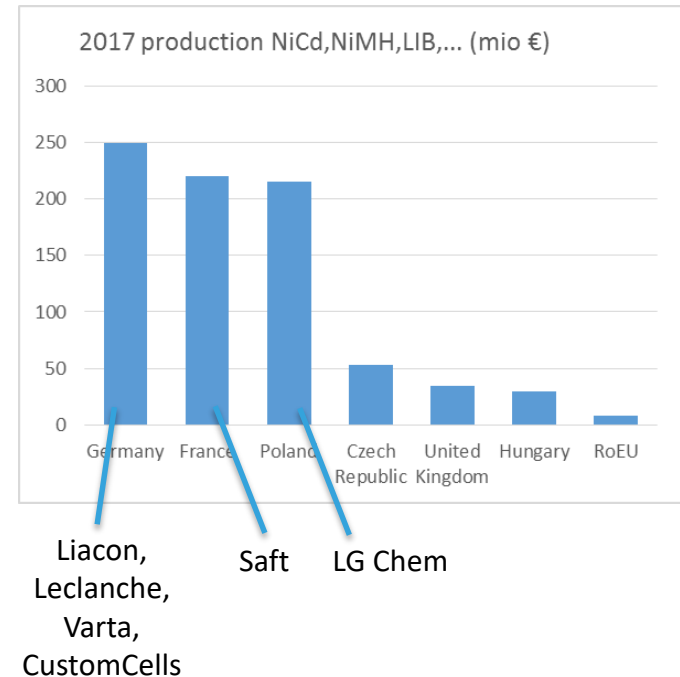
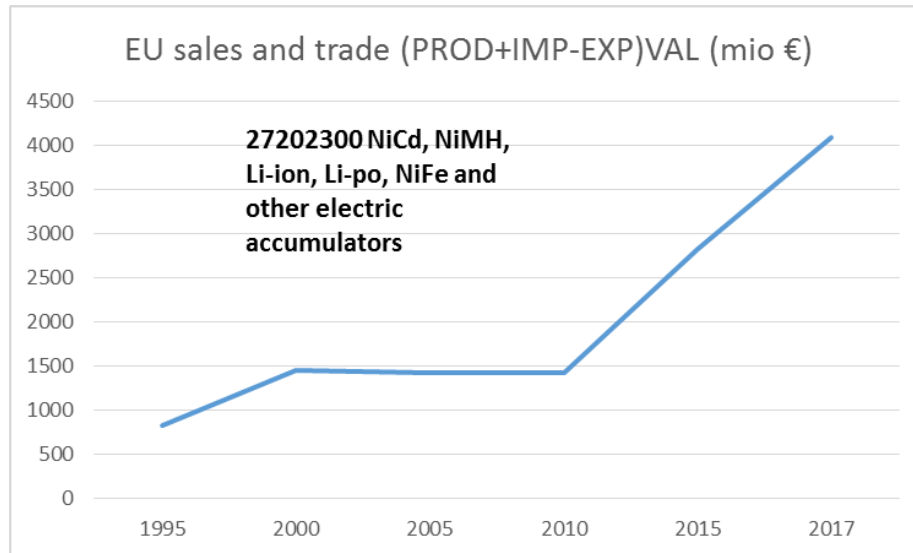


Source: Thielmann et al. 2017: Energy Storage Roadmap (update 2017) – High energy batteries 2030+ and prospects for future battery technologies, Fraunhofer ISI 2017.



## BATTERY MARKETS EU28

- Eurostat collects information on production and sales values (€) of non-Pb batteries



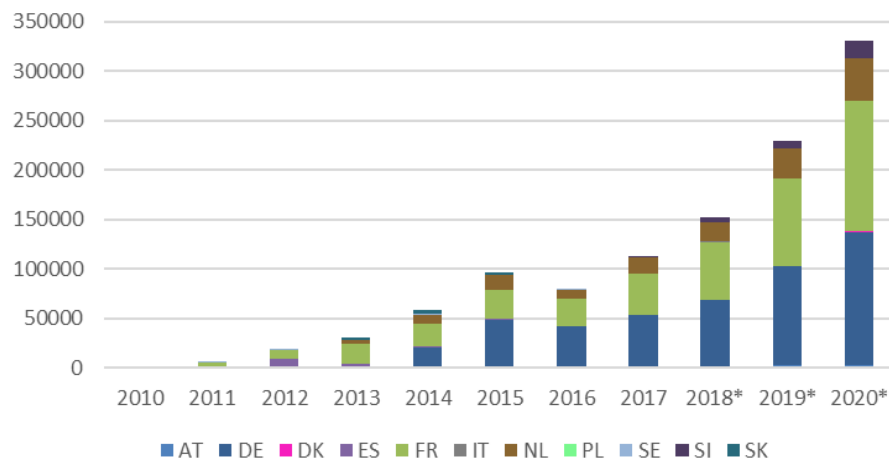
→ No information on unit price, capacity demand and battery technology (presumably dominated by LIB), as well as battery packs and systems.

- Other "bottom-up" data sources are required for a more detailed picture and input for forecasts.

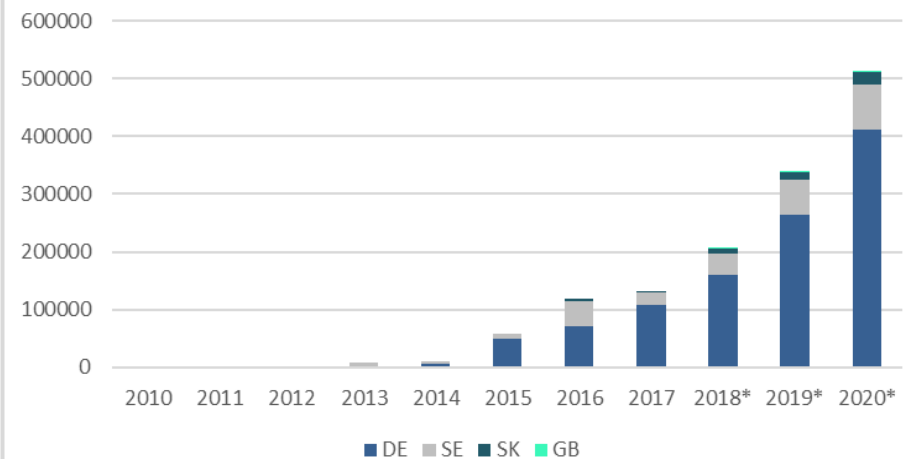
## EV MARKET EU28 – PRODUCTION

- BEV models: BMW i3, Nissan Leaf, Jaguar I-Pace, Daimler B-Class, Renault Kangoo, Renault Zoe, Smart, VW Golf, VW up!, ...
- (P)HEV models: Audi A3, Audi Q8, BMW 2;3;5;i8;X5, Daimler C-Class;E-Class, Porsche Cayenne; Panamera, Volvo S;V;XC, VW Golf, ...

Production of BEVs in EU28 countries



Production of PHEVs in EU28 countries

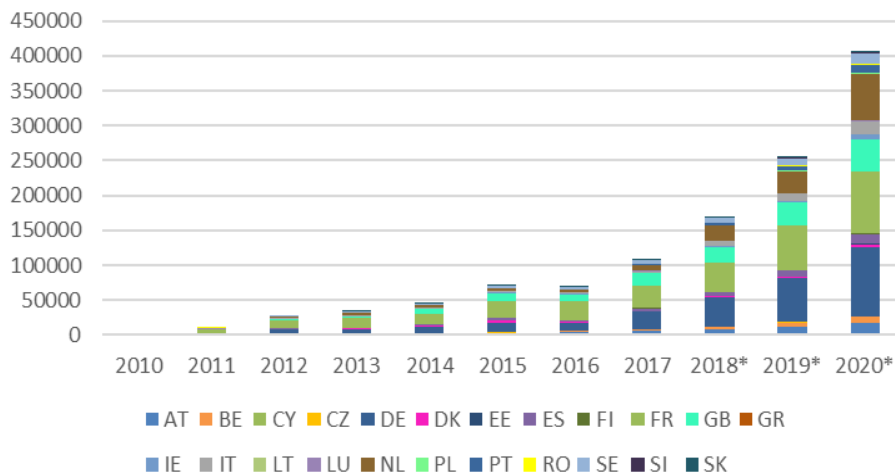


Source: Fraunhofer ISI xEV database, 2018.

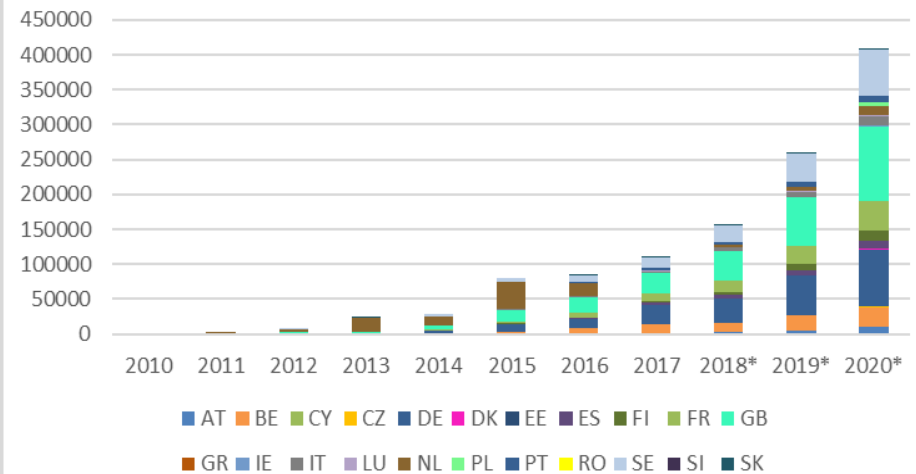
## EV MARKET EU28 – SALES

- BEV models: BMW i3, PSA C-Zero; iOn, Hyundai Ioniq; Soul, Nissan Leaf; NV, Opel Ampera, Jaguar I-Pace, Daimler B-Class, Renault Kangoo, Renault Zoe, Smart, Tesla Model S; X, VW Golf, VW up!, ...
- (P)HEV models: Audi A3; Q8; Q7, BMW 2; 3; 5; i8; X5, Hyundai Ioniq, Kia Niro; Optima, Land Rover, Lexus CT; GS, Daimler C-Class; E-Class; GLS; GLE, Ford Mondeo, Porsche Cayenne; Panamera, Mini Countryman, Mitsubishi Outlander, Volvo S; V; XC, VW Golf; Passat, Suzuki Swift, Toyota Auris; C-HR; Prius; RAV4; Vitz (Yaris), ...

Sales of BEVs in EU28 countries



Sales of PHEVs in EU28 countries

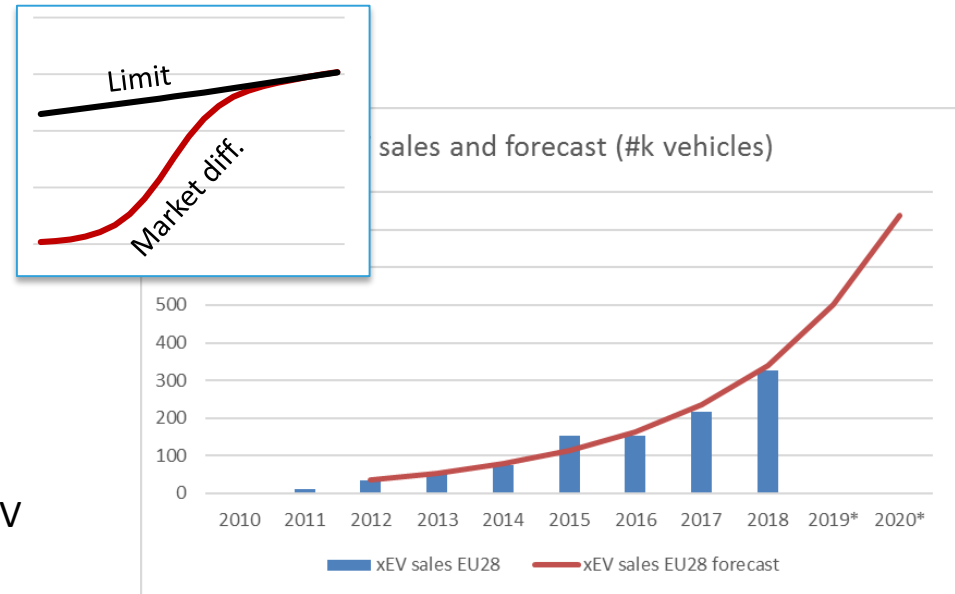


Source: Fraunhofer ISI xEV database, 2018.

## FORECAST MODEL

### Electric vehicles

- Market diffusion model: EV market forecast based on logistic function: "bounded growth limited by saturation"
- Moving limit:  
Sales of all vehicles (EV + ICE)
- Calibrated on 2012 to 2018 data segmented by BEV, PHEV (Fraunhofer xEV database)



Source: Fraunhofer ISI xEV database, 2018.

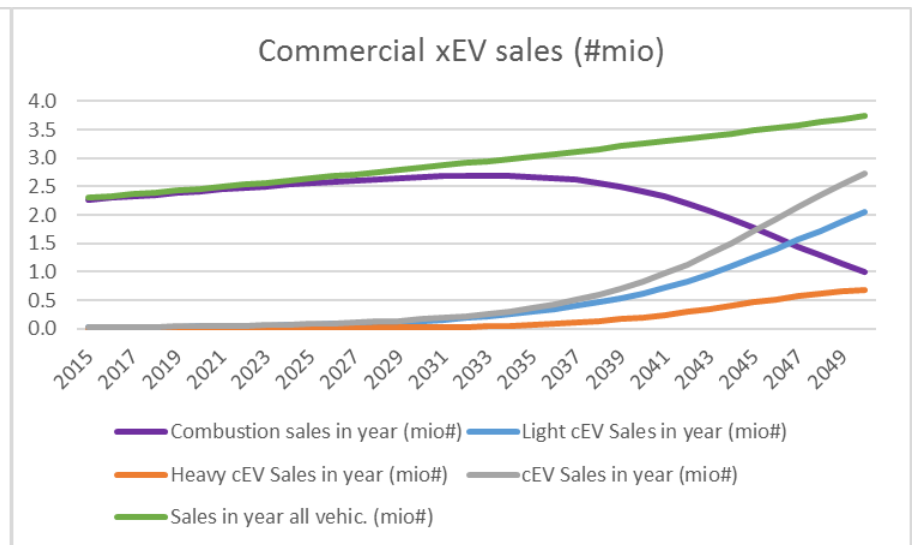
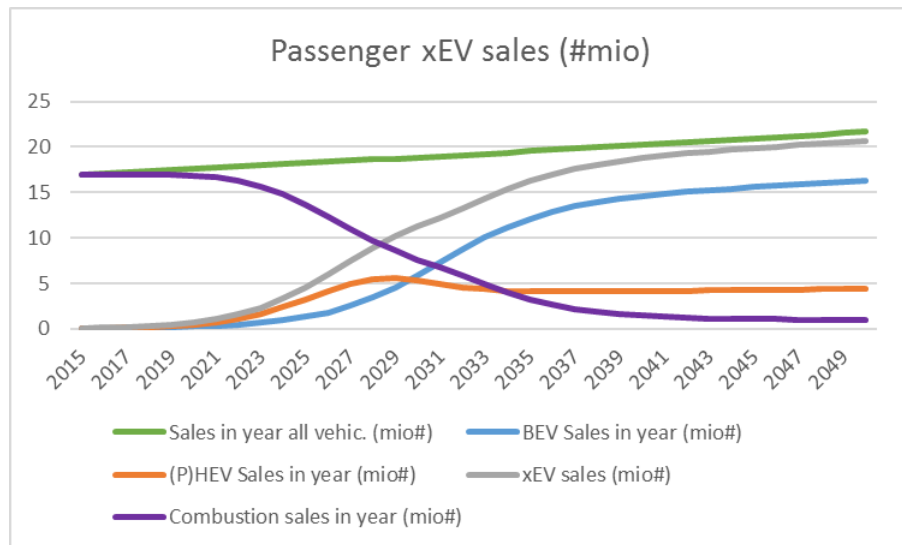
### Energy storage systems

- Existing markets (diffusion): Retrofit of existing PV systems with home storage
- Emerging markets (synchronized growth): Further expansion of fluctuating renewable electricity generation
  - Home storage (PV)
  - Large ESS (PV, wind)

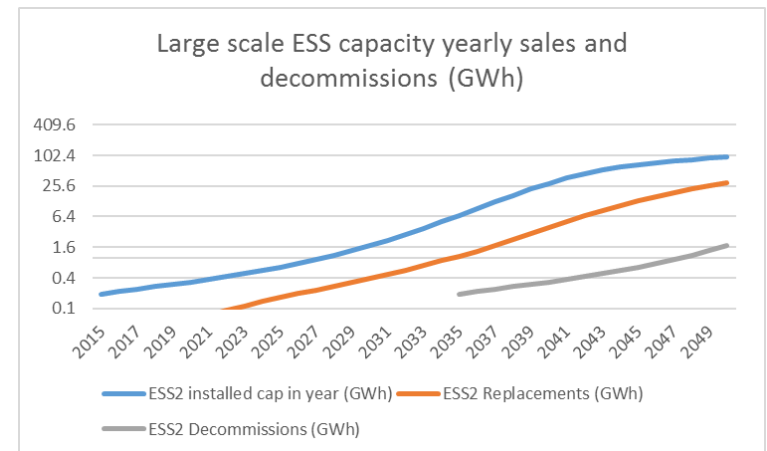
## FORECAST MODEL EV

- Model: purely EV based, no FCEV or ICE-EV based on alternative fuels
- Passenger cars CAGR: 0.7%; Commercial vehicles: 1.4%

Share of passenger vehicle market addressable by BEV	75 %
Share of passenger vehicle market addressable by (P)HEV	100%
Share of light commercial vehicle market addressable by xEV (BEV + (P)HEV)	75%
Share of heavy commercial vehicle market addressable by xEV (BEV + (P)HEV)	20%



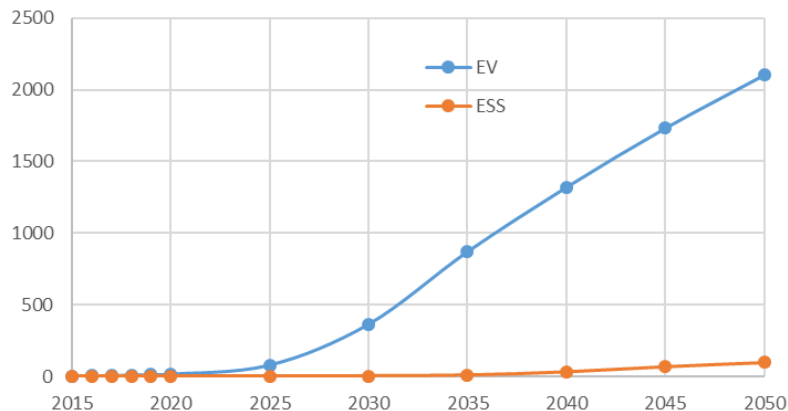
- ESS as enabler for renewable energy generation
- EU28 electricity consumption(2014-2017) ~  $3 \cdot 10^6$  GWh
- Additional electricity consumption due to EV? (~  $10^6$  GWh)



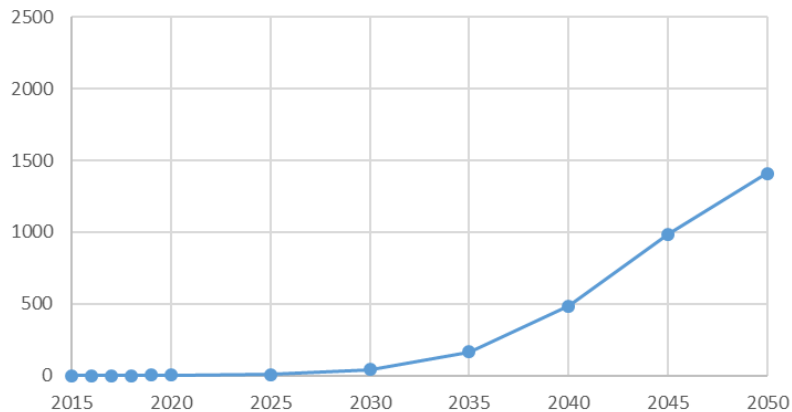
Rooftop PV new installations EU28, 2017	190 k
Rooftop new installations EU28 2030 / 2050	310 k / 470 k
Share of rooftop PV new installations equipped with ESS 2014 / 2050	30% / 60%
Large scale ESS battery capacity installations EU28, 2017	300 MWh
Share of renew. electricity generation in EU28 2017 / 2020 / 2030 / 2050	17% / 20% / 27% / 40%
Threshold of renewable electricity generation in EU28 requiring the use of ESS	17%
ESS storage demand	70% of average daily renewable el. gen. above threshold

# BATTERY CAPACITY DEMAND 1<sup>ST</sup> LIFE AND DECOMMISSIONS

Battery capacity new installations EU28 (GWh)



Battery replacements and decommissions (GWh)



- Demand generated by 1st life applications (EV+ESS)
- 2030: 300 - 500 GWh
- 2050: 1.5 - 3 TWh

- **2nd life for batteries?**
- Decommissioned battery capacity: More than 10 times the demand of ESS

Passenger BEV lifetime (EU28)	12 years
Passenger PHEV lifetime (EU28)	12 years
Light commercial xEV lifetime (EU28)	9 years
Heavy commercial xEV lifetime (EU28)	12 years
Passenger BEV battery replacement rate	15%
Passenger (P)HEV battery replacement rate	15%
Light commercial xEV battery replacement rate	25%
Heavy commercial xEV battery replacement rate	80%

## *Thank you for your attention!*

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### **EV:**

- Market development: (P)HEV as bridge technology?
- Market penetration: xEV registrations in 2030 (55%), 2050 (95%)?
- Vehicle lifetime in EU: km, cycles, modernization?
- After EoL: →Export? Decommissioning?

### **ESS:**

- Electricity grid: Buffer demand caused by renewable electricity?
- Role of battery ESS: Buffer for one day - week?
- ESS lifetime: home-storage, grid support, others: years, cycles?

### **Consumer expenditure base data:**

- Repair and maintenance costs (e.g. battery pack)
- Installation cost (particularly ESS)
- Disposal methods / tariffs.