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INFORMATION FOR GROWTH

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2017



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Lisbon, Portugal

The Rechargeable Battery Market and Main Trends 2016 – 2025

Christophe PILLOT
AVICENNE ENERGY

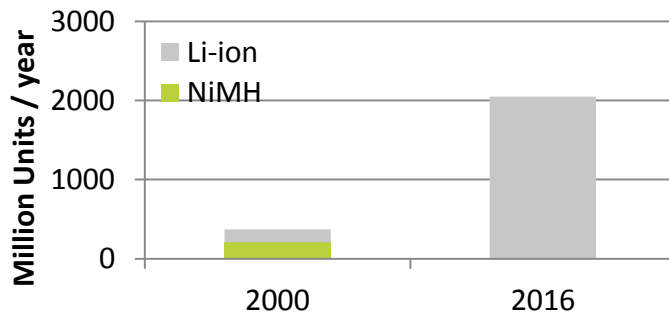
Presentation Outline

- The rechargeable battery market in 2016
- The Li-ion battery value chain
- xEV & ESS battery market
- Forecasts & conclusions

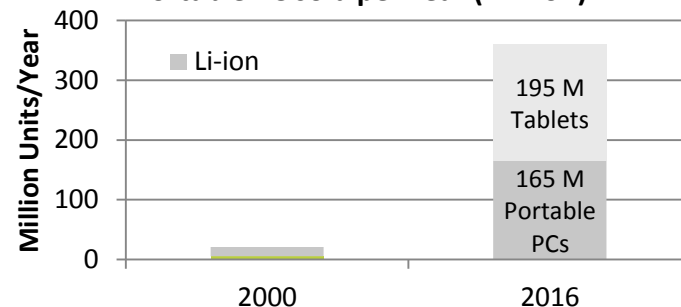


THE BATTERY MARKET IS REALLY DYNAMIC

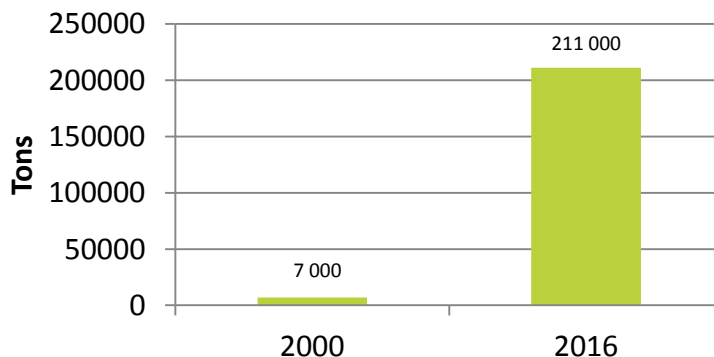
Cellular Phones sold per Year (Million)



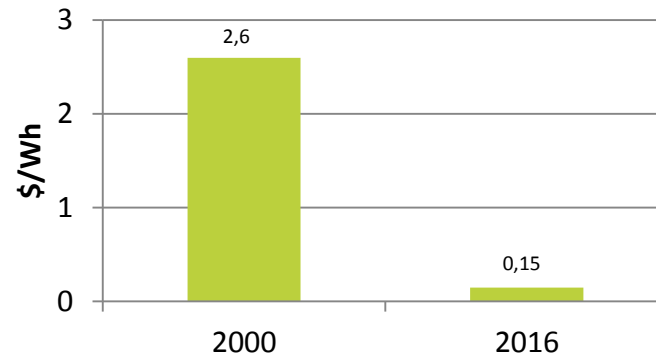
Portable PC sold per Year (Million)



Tons of cathode active materials



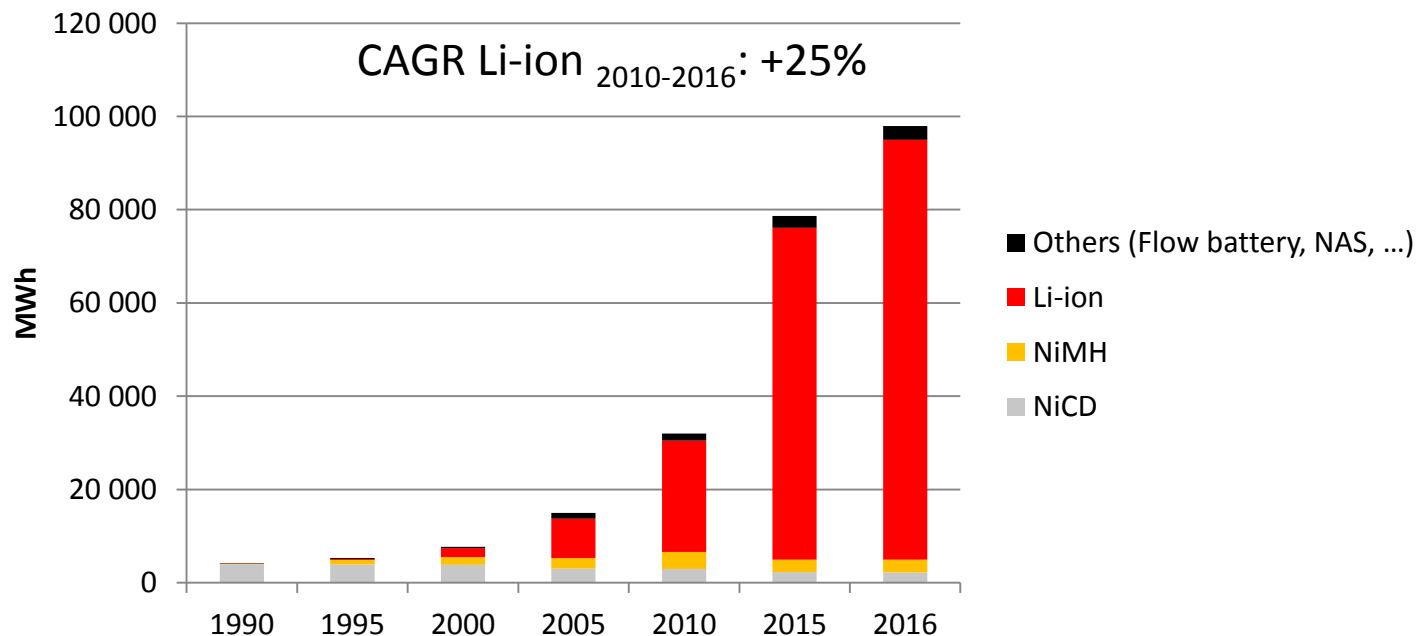
Li-ion 18650 cell price (\$/Wh)





THE WORLDWIDE BATTERY MARKET 1990-2016

Lithium Ion Battery: Highest growth & major part of industry investments

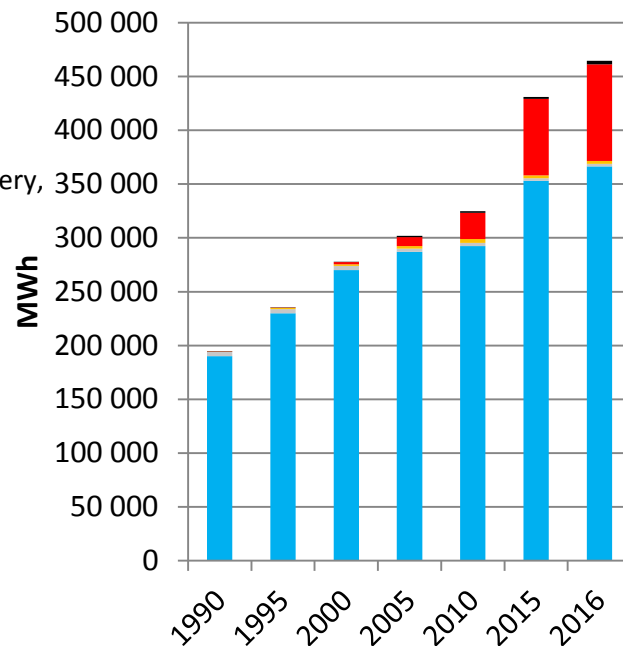
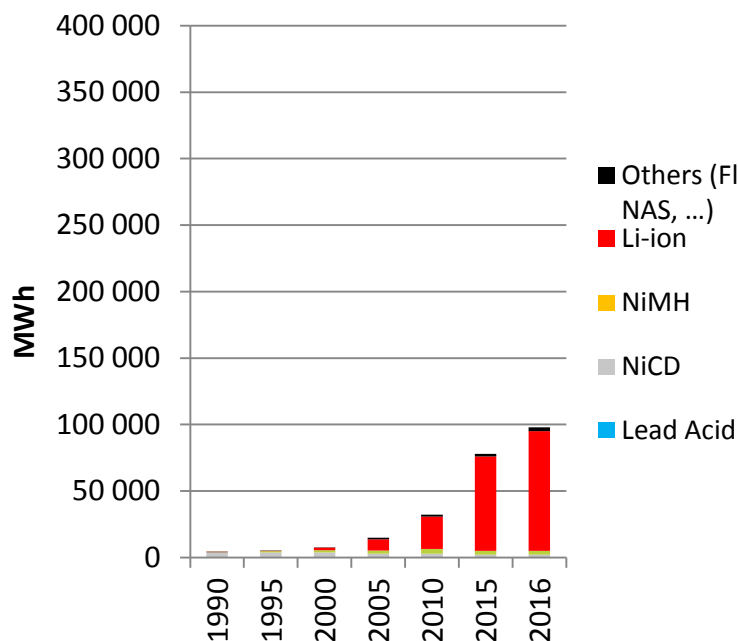


Source: AVICENNE ENERGY, 2017



THE WORLDWIDE BATTERY MARKET 1990-2016

Lithium Ion Battery: Highest growth & major part of the investments
 Lead acid batteries: By far the most important market (90% market share)



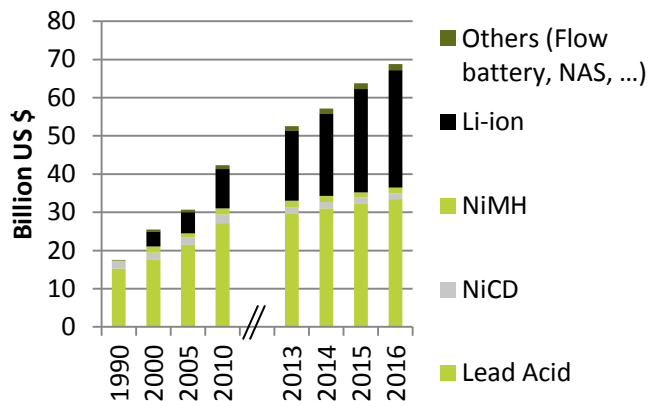


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THE WORLDWIDE BATTERY MARKET 1990-2016

69 BILLION US\$ in 2016 – Pack level¹

8% AVERAGE GROWTH PER YEAR (2006-2016)



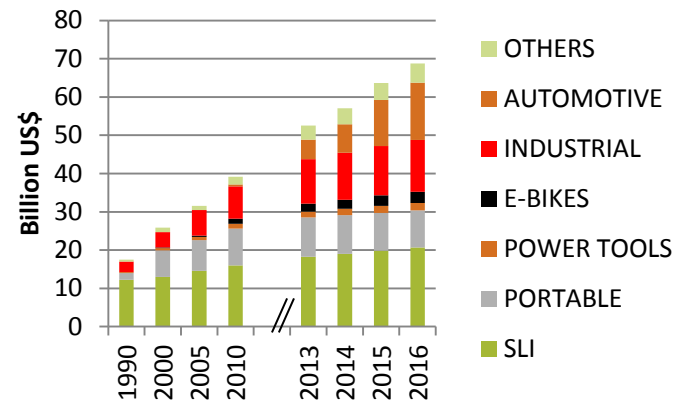
SLI: Start light and ignition batteries for cars, truck, moto, boat etc...

PORTABLE: consumer electronics (cellular, portable PCs, tablests, Camera, ...), data collection & handy terminals,

POWER Tools: power tools but also gardening tools

1- Pack: cell, cell assembly, BMS, connectors – Power electronics (DC DC converters, invertors...) not included

Source: AVICENNE ENERGY, 2017



INDUSTRIAL

- MOTIVE: Forklift (95%), others
- STATIONARY: Telecom, UPS, Energy Storage System, Medical, Others (Emergency Lighting, Security, Railroad Signaling,, Diesel Generator Starting, Control & Switchgear,

AUTOMOTIVE: HEV, P-HEV, EV

OTHERS: Medical: wheelchairs, medical carts, medical devices (surgical power tools, mobile instrumentation (x-ray, ultrasound, EKG/ECG, large oxygen concentrators



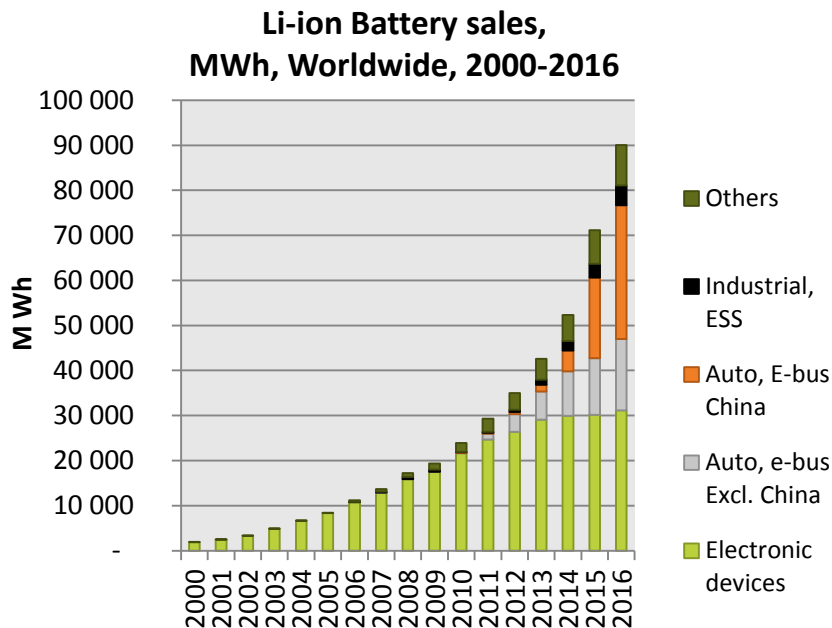
LI-ION IN 2016 - MAIN APPLICATIONS

90 000 MWh - 23 B\$ (1)

5 675 M small cells

CAGR 2006/2016

+23 % per year in Volume

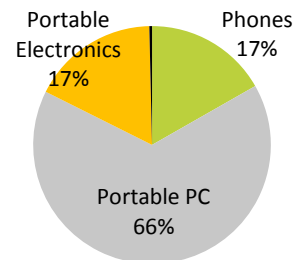


(1) Cell level

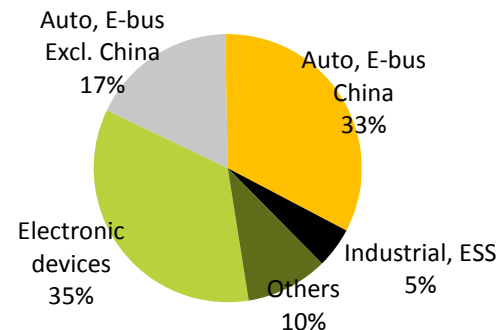
Others: medical devices, power tools, gardening tools, e-bikes...

Source: AVICENNE Energy 2017

2000: < 2GWh

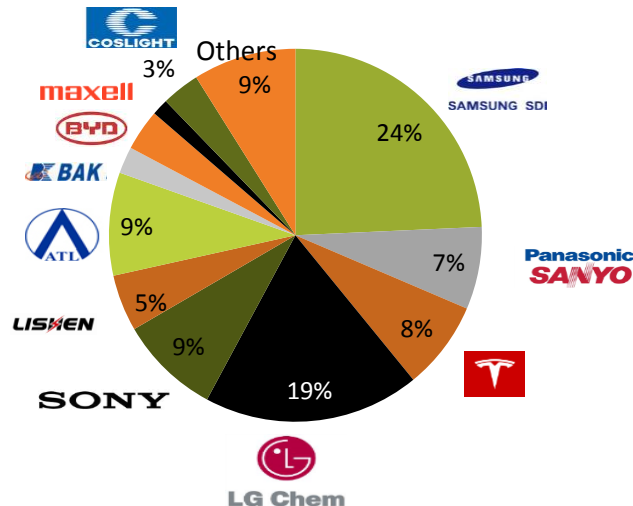


2016: 90 GWh



LI-ION BATTERY: MARKET SHARE IN 2016 WORLDWIDE

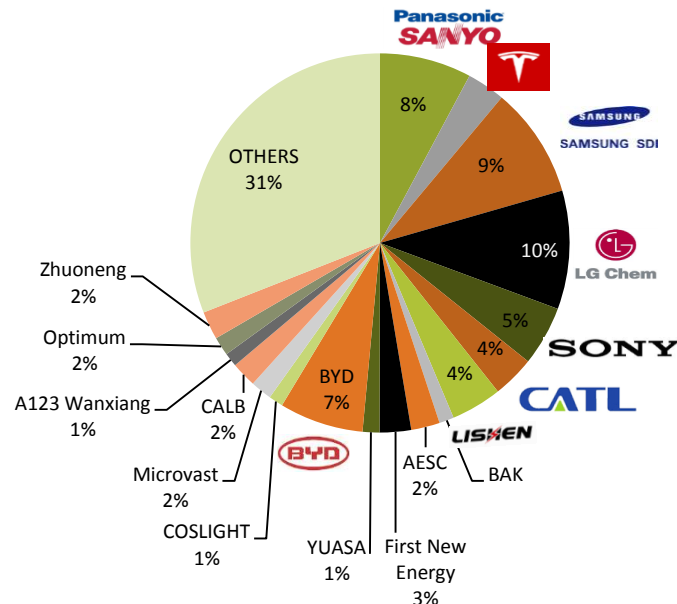
The worldwide Li-ion battery market
 Company market share in 2016 in volume
 (small cells only) 6,4 B cells



Others for Small cells: Chinese suppliers like Tenpower, DLG...
 (1) LIB battery pack market

Source: AVICENNE ENERGY Analyses 2017

The worldwide Li-ion battery market
 Company market share in 2016 in value⁽¹⁾
 Estimated at B\$ 31 in 2016

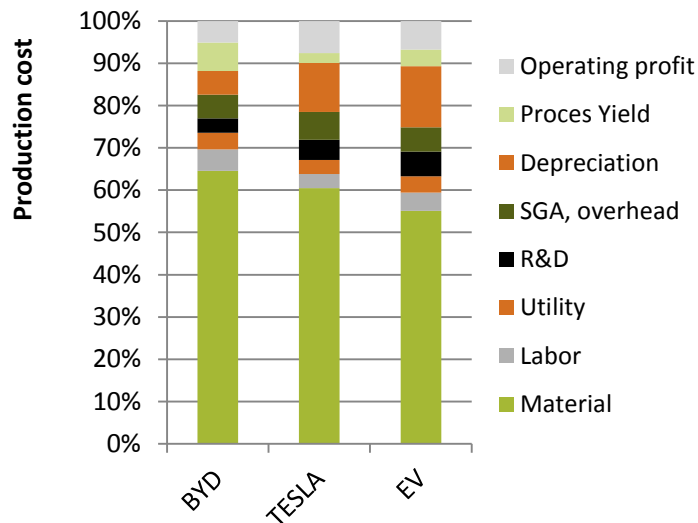


LIB: THE BIGGEST PART OF THE COST IS RAW MATERIALS

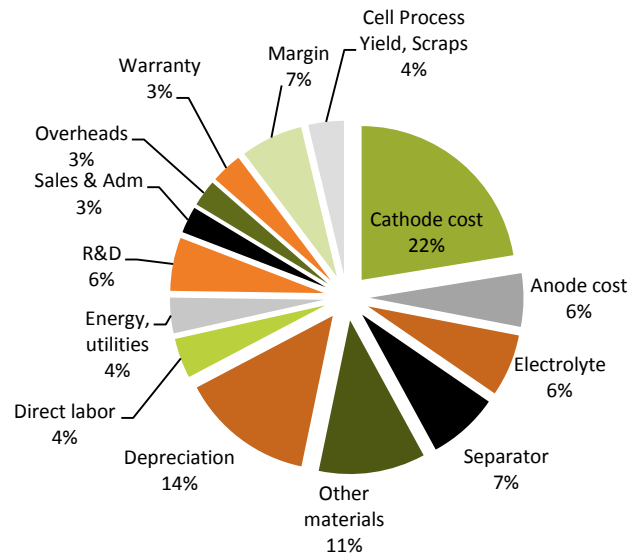
RAW MATERIALS ACCOUNT FOR 50 TO 70% OF LIB CELLS BUSINESS

RAW MATERIAL COST IMPACT DRASTICALLY ON THE BATTERY MAKERS PROFIT

LIB Cost structure for TESLA & 40 Ah EV pouch cell NMC

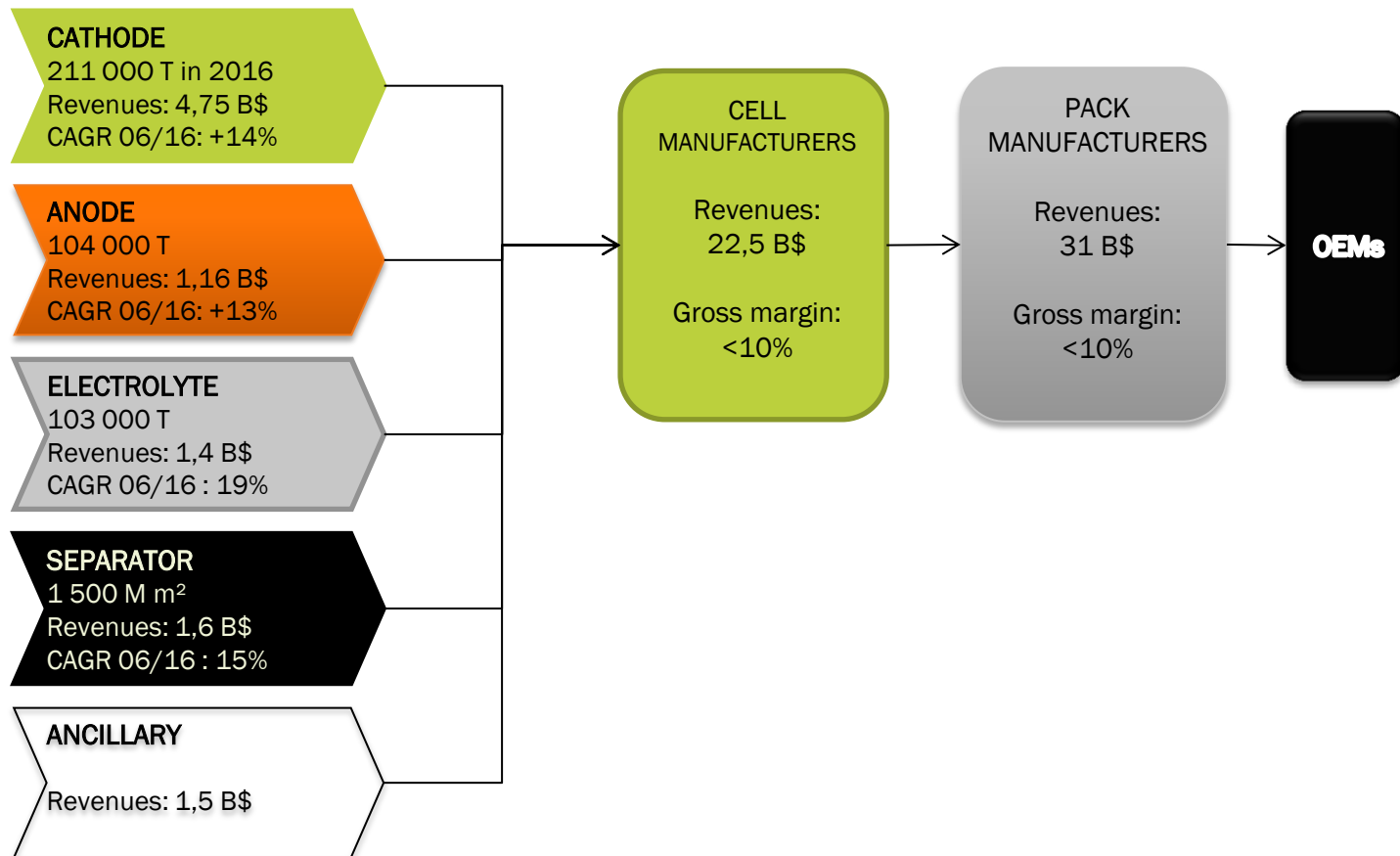


Average cost structure of Li-ion cell in 2016



Note: Average mix of cylindrical, prismatic & laminate cells
 Sources: AVICENNE ENERGY 2017

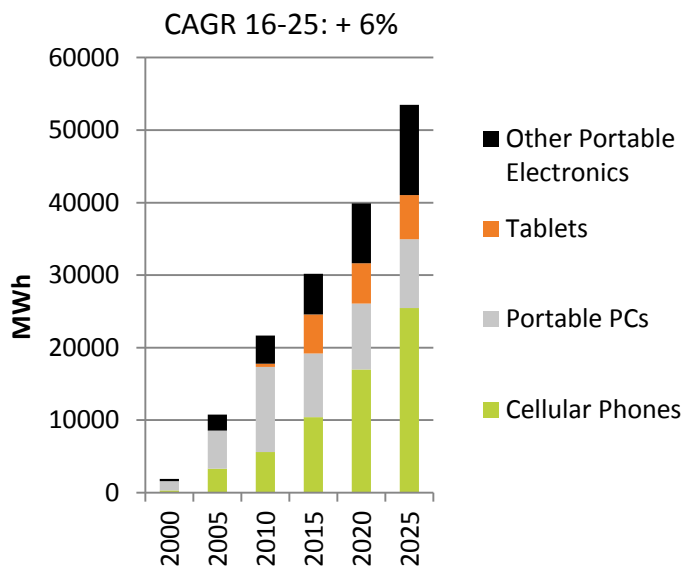
LI-ION VALUE CHAIN – MARKET DEMAND





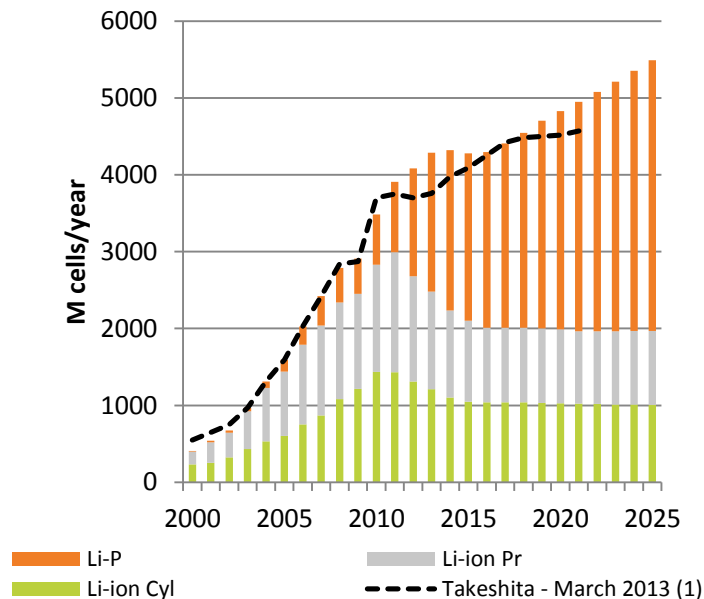
2025 LIB FORECASTS FOR PORTABLE ELECTRONIC DEVICES

2000-2025 LIB market, MWh, by application (3C)



Source: AVICENNE ENERGY Analyses

2000-2025 LIB market, M cells, by form factor (3C)

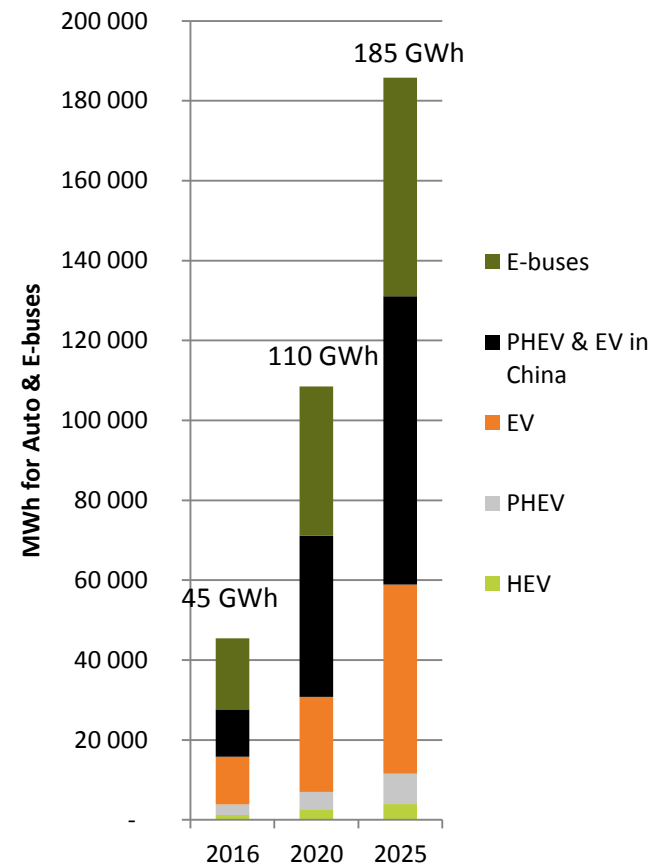


(1) Source: Takeshita, Battery Japan 2013 BJ-3 conference Slide p 4

X-EV MARKET

- Why x-EV ?
- Definition & segmentation
- X-EV worldwide in 2016
 - By country
 - By car makers
 - By battery chemistry
- X-EV forecasts
 - AVICENNE ENERGY & other analyst forecasts
 - Battery chemistry forecasts
 - Battery cost forecasts
- X-EV battery forecasts

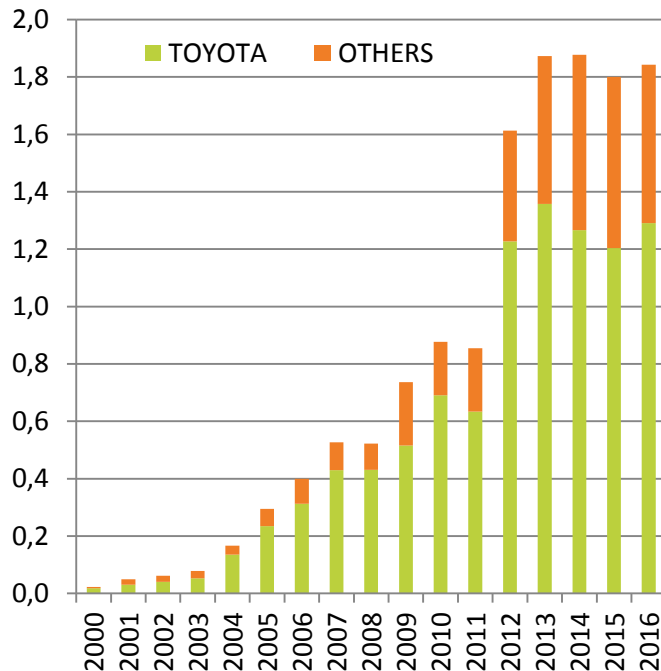
CAGR 2016-2025: + 17%



HEV WORLDWIDE IN 2016

1,8 M HEV

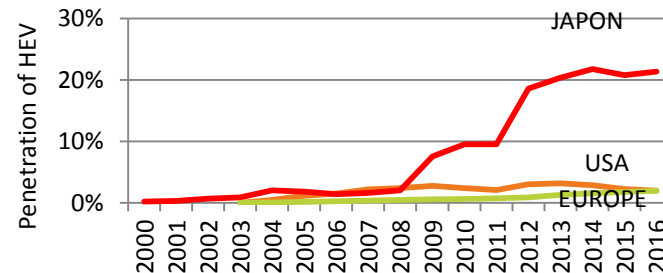
HEV sold per year, M units, worldwide, 2000 - 2016



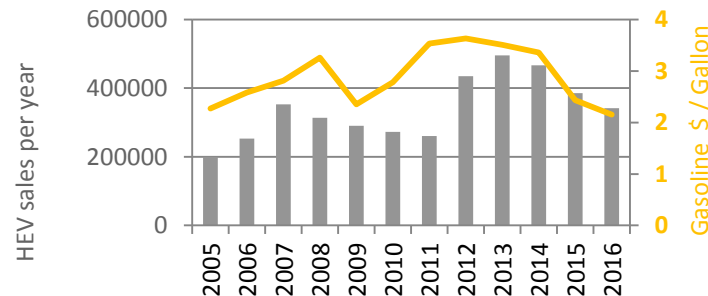
Source: TOYOTA, HONDA, NISSAN, FORD, GM, HYUNDAI, MERCEDES, GM, BMW, VW, PORSCHE... Compilation AVICENNE ENERGY
 Micro hybrid not included

Growth 2015-2016: +2%
 From 1,8 M to 1,84 M HEV

Penetration of hybrids in the global sales, 2000-2016



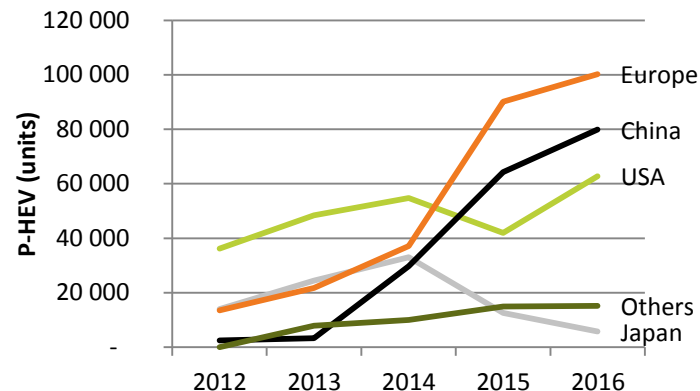
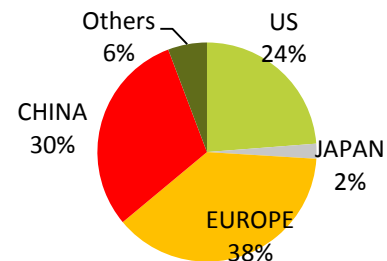
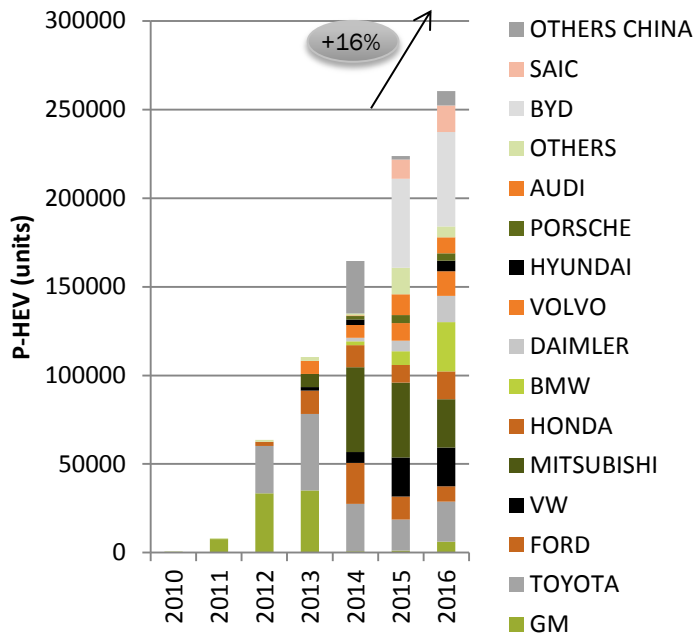
Gazoline price impact on HEV market in the US



PHEV SOLD WORLDWIDE

World excl. China growth +14%
 Chinese Growth + 21%

China is leading the P-HEV
 market thanks to high incentives

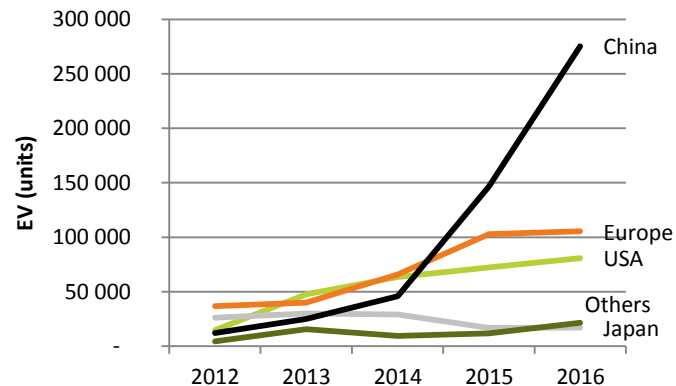
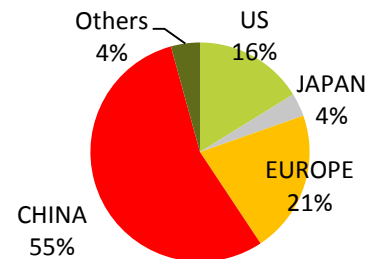
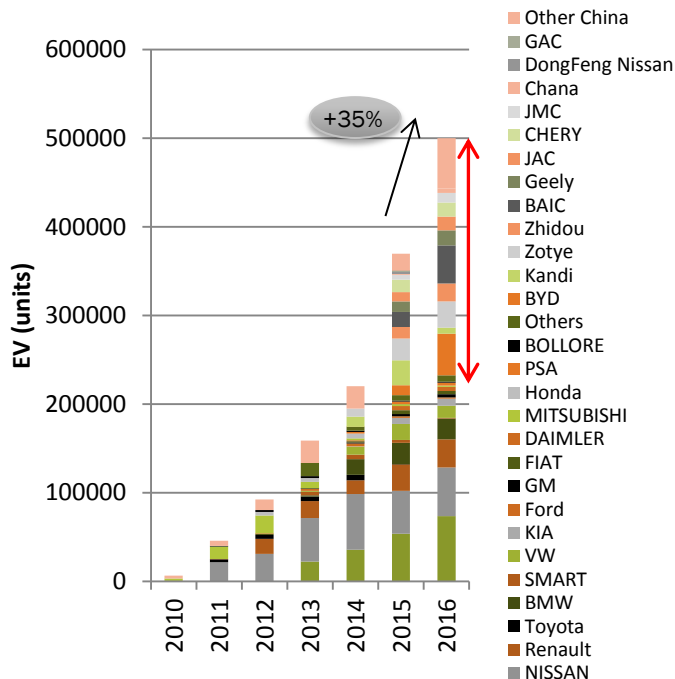




EV SOLD WORLDWIDE

World excl. China growth +14%
 Chinese Growth + 68%

China is leading the EV market
 thanks to high incentives

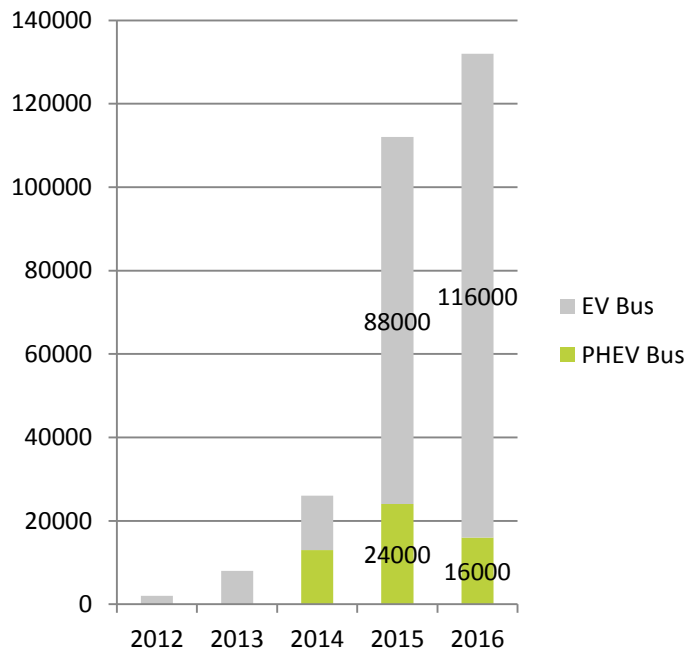


Source: AVICENNE ENERGY Analysis, 2017


XEV BUSES MARKET IN CHINA

xEV buses market in China:

132 000 xEV Buses sold in 2016



Rationales

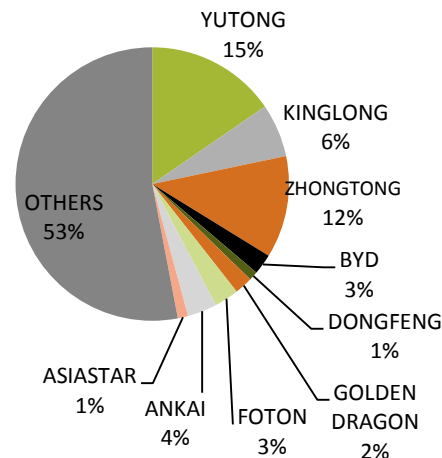
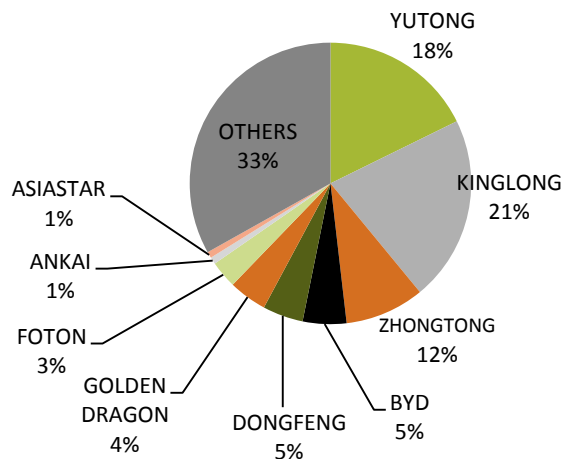
-  The Chinese government is working on addressing environmental issues. Central and local governments are engaged in subsidy policies to promote EV/PHV/FCV as new energy vehicles. The amount of subsidy for EV/FCV with low environmental impact is set high. As the subsidy policy is announced to be carried out until 2020, it is predicted that this market will be on an expansion trend centering on EV. However, due to the occurrence of the case of receiving subsidies illegally in 2015, the government has begun to strictly control the production of new energy vehicles after 2016.



XEV BUSES MARKET IN CHINA

xEV buses market in China:

132 000 xEV Buses sold in 2016

112 000 xEV Buses sold in 2015

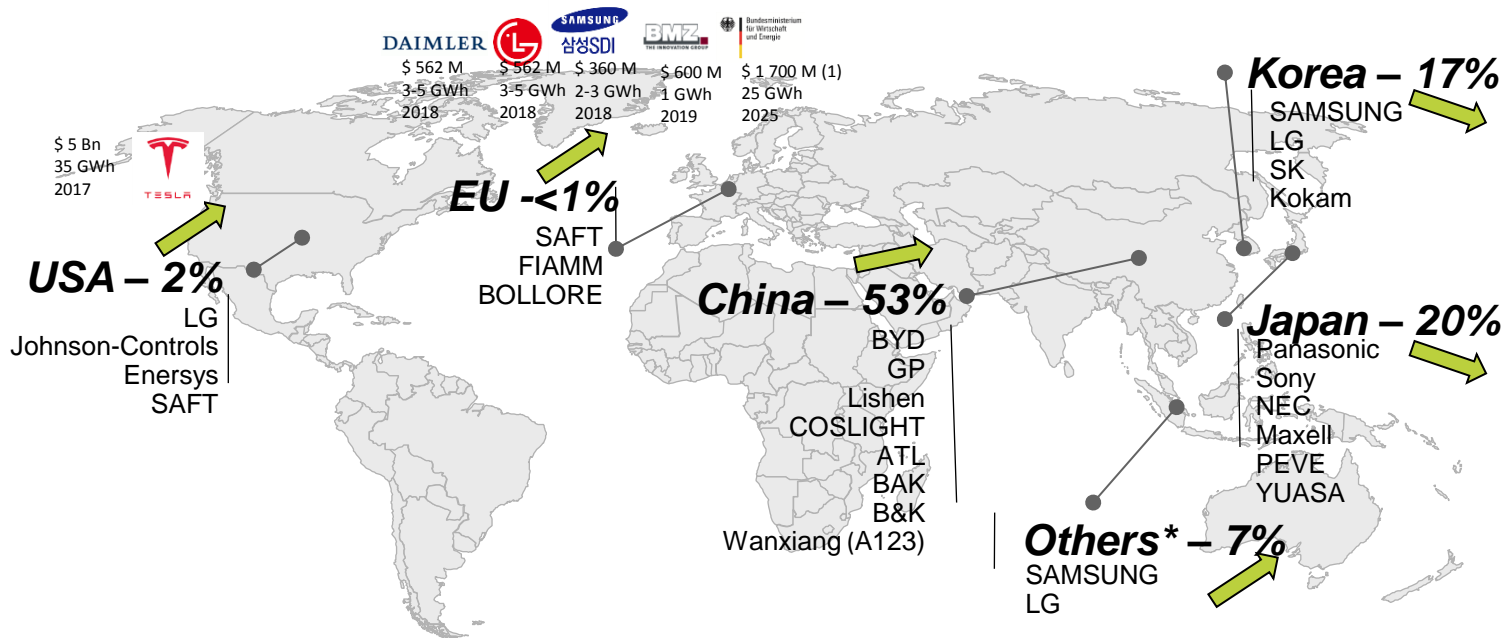


-  The new energy bus market in China is mainly made up of EV with a large amount of subsidy from the government, and there are many cases where older makers also produce PHV.
-  As a result of the illegal receipt of subsidy occurred in 2015, publication of the company name and administrative guidance (penalty) from the government were carried out. Consequently, several makers including King Long have significantly reduced their market share in 2016, and old makers such as Yutong and Zhong Tong are expanding their market shares.

LITHIUM ION CELL PRODUCTION

Korean companies start to move in Malaysia

New production capacity in Europe and US



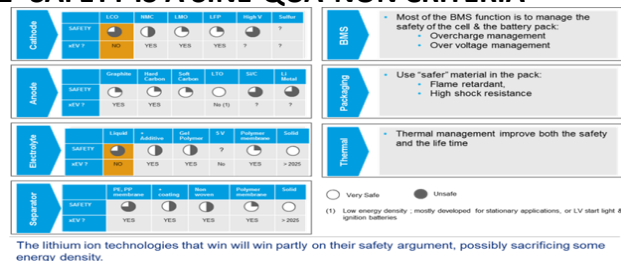
Source: AVICENNE 2017

* OTHERS: Malaysia mostly
 (1) Government subsidies only

THE LITHIUM ION BATTERY MARKET FORECASTS

3 major limiters on batteries, for the development of electric vehicle

1- SAFETY IS A SINE-QUA-NON CRITERIA



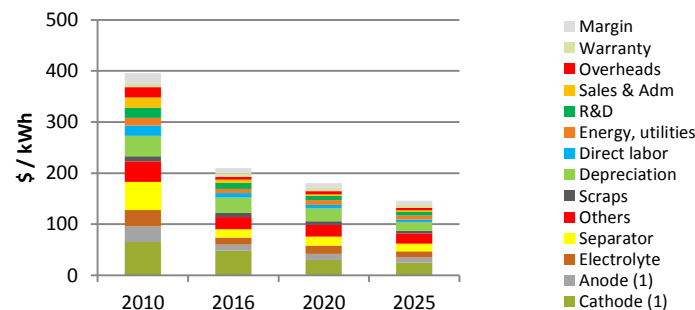
2- TIME TO MARKET

- The research and development in this industry is very long and time consuming.
- Time to market to commercialize a new material is long. Remember that the first Li-ion battery was launched by Sony in 1991 with LCO cathode, graphite, LiPF₆ electrolyte & polyolefin membrane. It was 20 years ago.
- LTO was invented by Matsushita in 1993 (22 years ago)
- Lithium iron phosphate was invented in 1995 (20 years ago).
- So, it takes between 10 & 20 years to commercialize a new material in the battery industry.

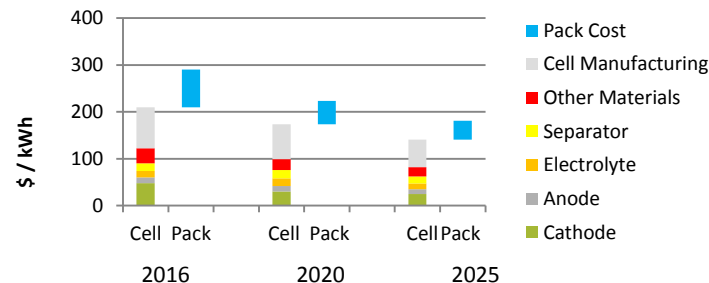
(1) Active material only

3- BATTERY COST

Average Cell price



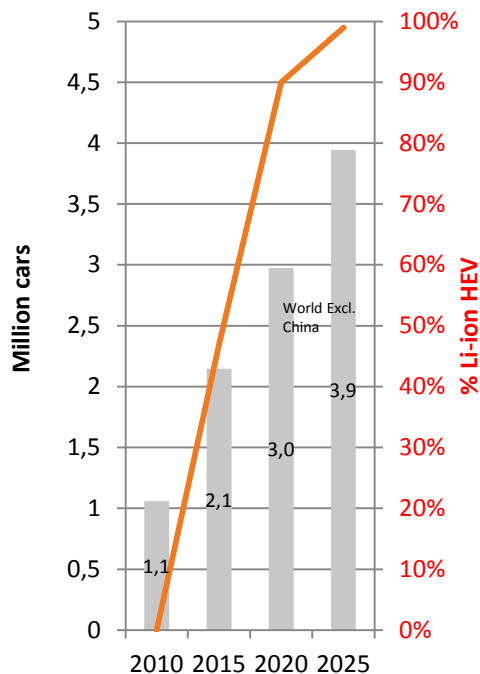
Average Pack price





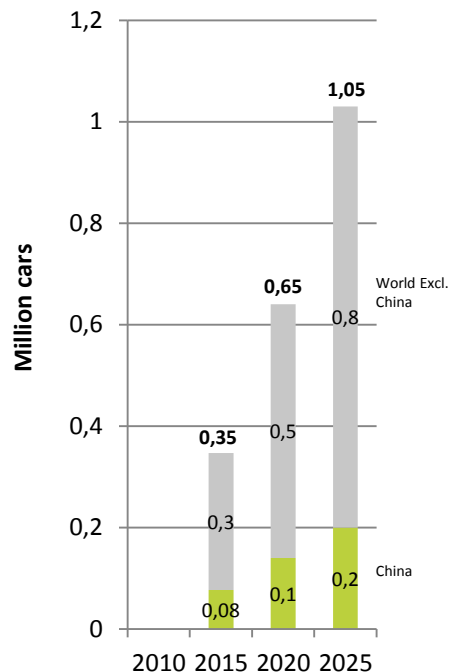
HEV, P-HEV, EV 2025 FORECASTS

HEV manufactured



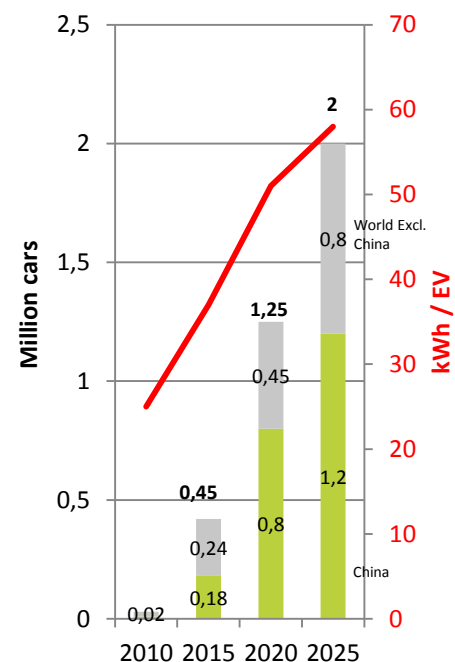
HEV: 1kWh battery / car

PHEV manufactured



PHEV: 12 kWh battery / car

EV manufactured

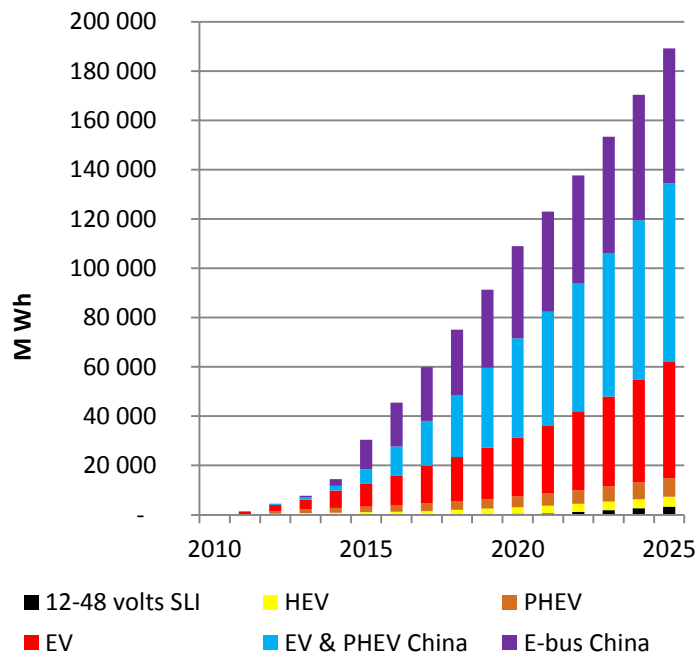




TOTAL BATTERY DEMAND 2025 FORECASTS

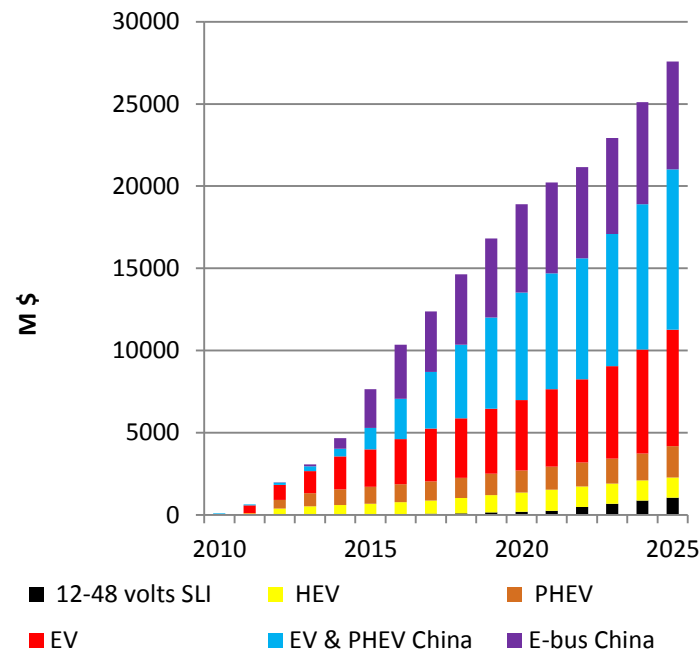
Li-ion for EV, HEV & P-HEV Battery
needs (MWh)

CAGR 2016-2025: +17%



Li-ion for EV, HEV & P-HEV Battery
needs (M\$)

CAGR 2016-2025: +12%

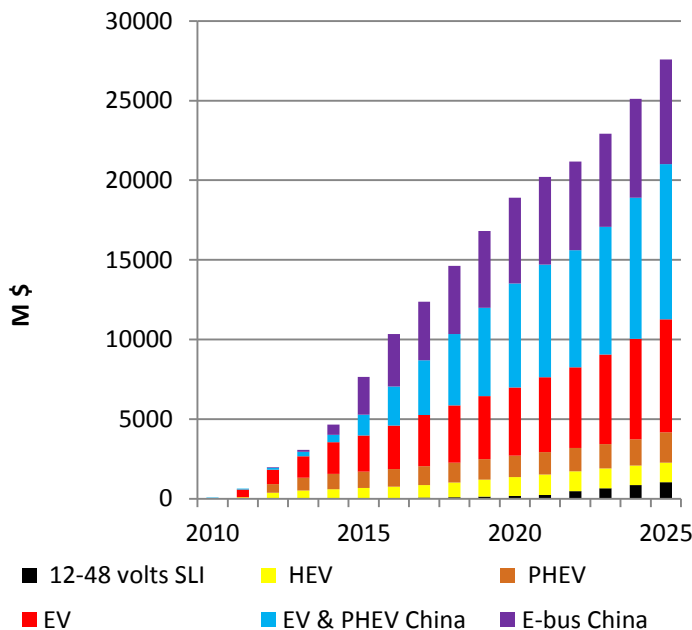




X-EV BATTERY MARKET 2000 – 2025 IN M\$

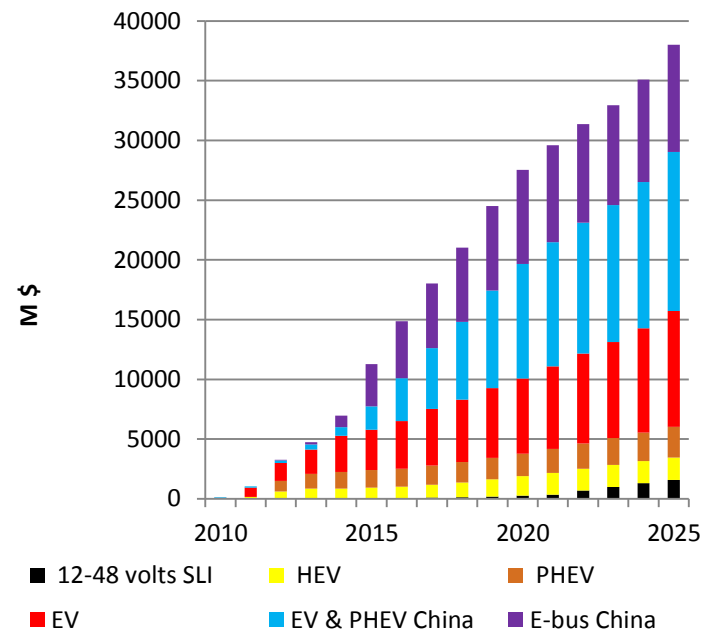
Cell Level

CAGR 2016-2025: +12%



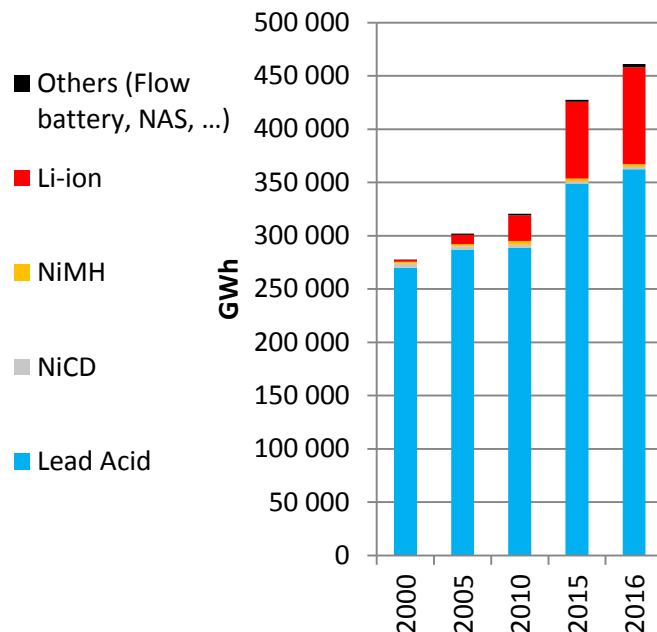
Pack Level

CAGR 2015-2025: +11%



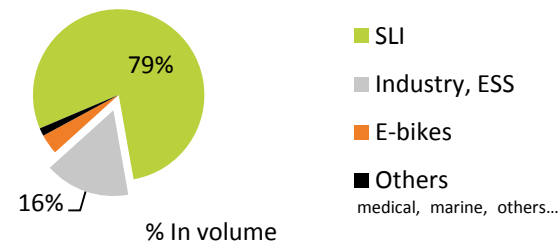
THE WORLDWIDE BATTERY MARKET 1990-2016

In volume (MWh)

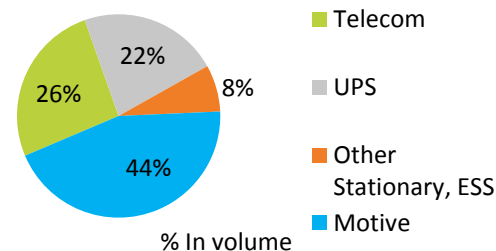


Source: AVICENNE ENERGY, 2017

Lead Acid Batteries 2016
 +367 GWh for > US \$ 33,4 Billion



Industrial Batteries – Lead acid batteries
 58 GWh for US \$ 10,4 Billion



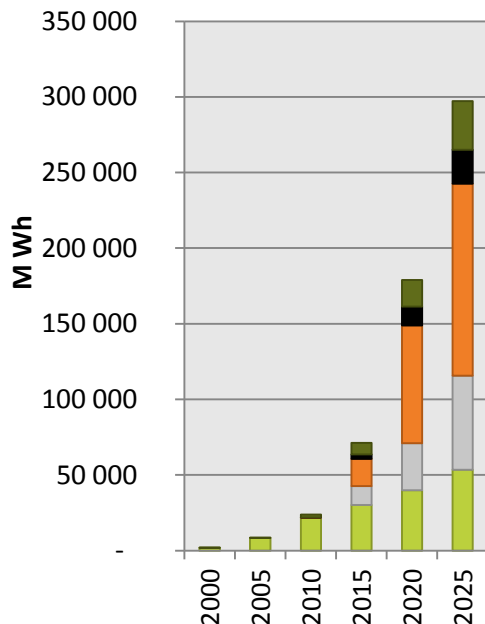


LI-ION BATTERY MARKET FORECASTS

From 90 GWh in 2016 to 300 GWh

CAGR 2016/2025
 +15 % per year in Volume

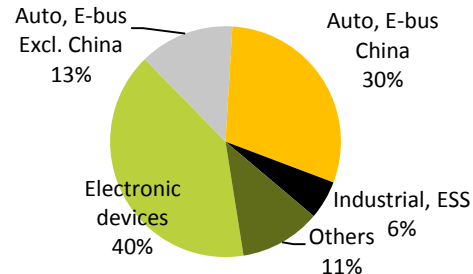
Li-ion Battery sales,
 MWh, Worldwide, 2000-2015



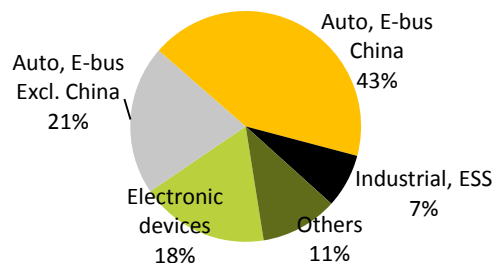
CAGR 15/25 (Realistic)

Others	16%
Industrial, ESS	22%
Auto, E-bus China	22%
Auto, e-bus Excl. China	17%
Electronic devices	6%

2016: 90 GWh



2025: 300 GWh



Others: medical devices, power tools, gardening tools, e-bikes...

Source: AVICENNE Energy 2016



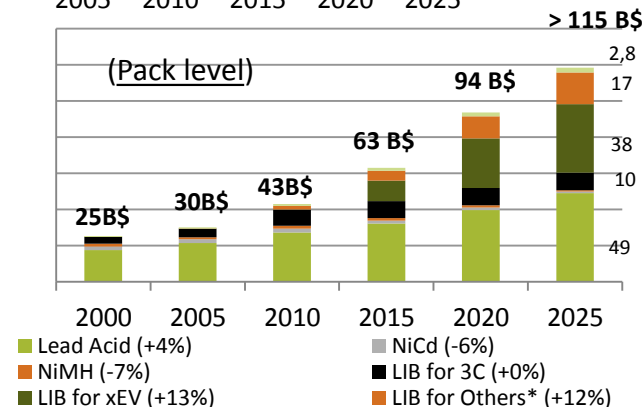
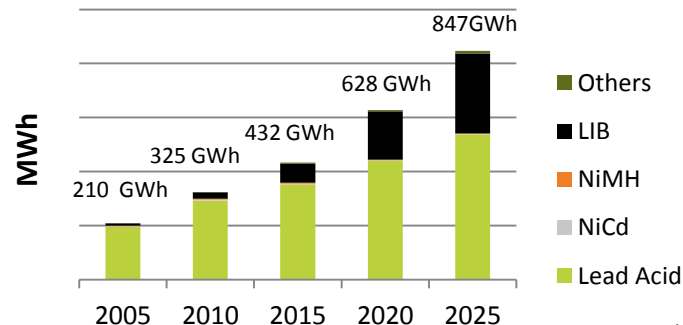
TAKEAWAYS

Battery Market 2015-2025

CAGR = +6% / Li-ion > +10%

- Li-ion battery is driven today by Automotive & Industrial applications
- In 2012, most of the car makers (except Toyota) switch to Li-ion for HEV
- P-HEV, EV and E-buses will be powered by Li-ion:
15 B\$ market in 2016 - 28 B\$ in 2020 & 38 B\$ in 2025 with high numbers in China (2016: US\$ 3,6 Billion for xEV and US\$ 4,8 Billion for xE-Buses)
- EV expectations attract large Chemical companies
- New materials are needed to meet Automotive standards
- HEV will account for less than 3% of the auto sales in 2020
- P-HEV & EV < 2% by 2020
- Micro-hybrid will achieve >50% in 2020/25
- Lead acid battery will be the first market in 2025 in volume, but Li-ion market will be higher than Lead acid from 2020.
- A very small EV market in the automotive world will represent a huge market for batteries
- New LIB applications: UPS, Telecom, Forklift, Medical, Residential ESS, Grid ESS: CAGR > 10% in the next 15 years
- Lithium battery for other application (ESS, stationary, industrial...) will reach 10 Billion \$ market at the pack level in the next 5 years
- ESS market could be much more important if the price of LIB at the system level is under 150 \$/kWh

RECHARGEABLE BATTERY MARKET WORLDWIDE 2000-2025



(CAGR 2016-2025)

Others: Automatic handling equipment, forklifts, back-up, UPS, Telecom, medical devices, Residential ESS, Grid ESS, ...

THANK YOU



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