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BATTERIES EVENT 2021

Lyon, France

September 29th, 2021

CONTACT

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The rechargeable battery market and main trends 2020-2030

Christophe PILLOT

Director, AVICENNE ENERGY

Presentation Outline

- The rechargeable battery market in 2020
- Focus on xEV market
- xEV Forecasts
- Impact of recycling on raw material supply
- Conclusions

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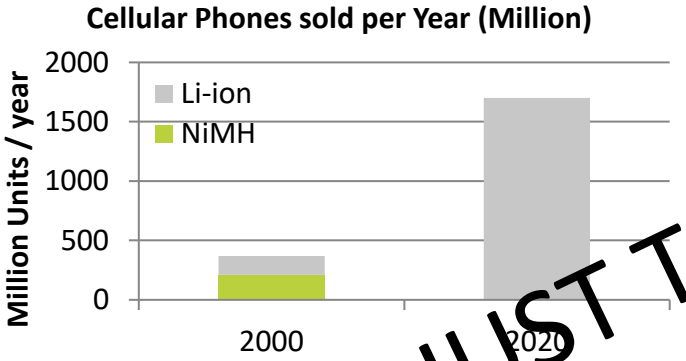
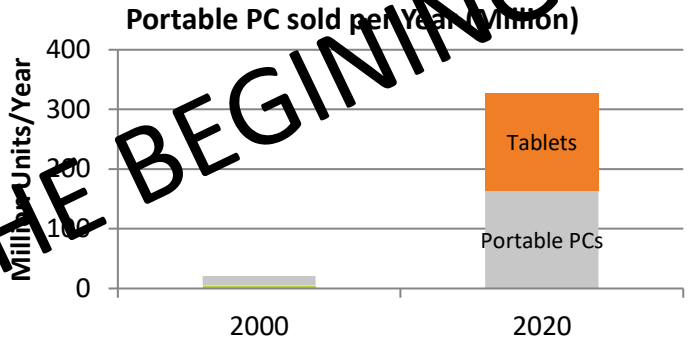
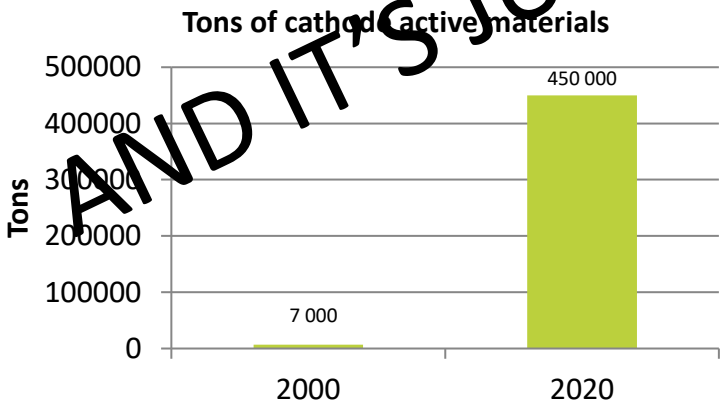
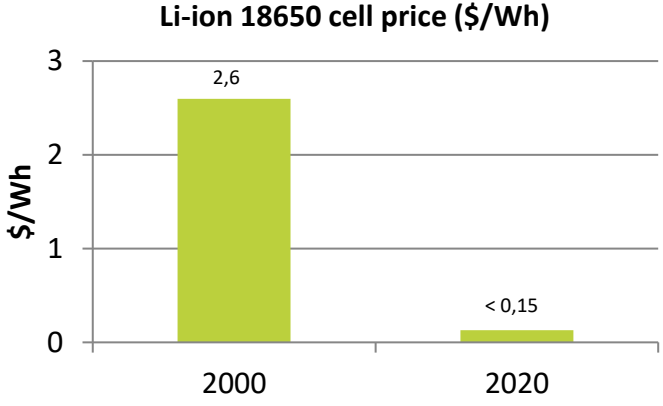
THE BATTERY MARKET IS REALLY DYNAMIC









AND IT'S JUST THE BEGINING !

Source: AVICENNE ENERGY, 2021

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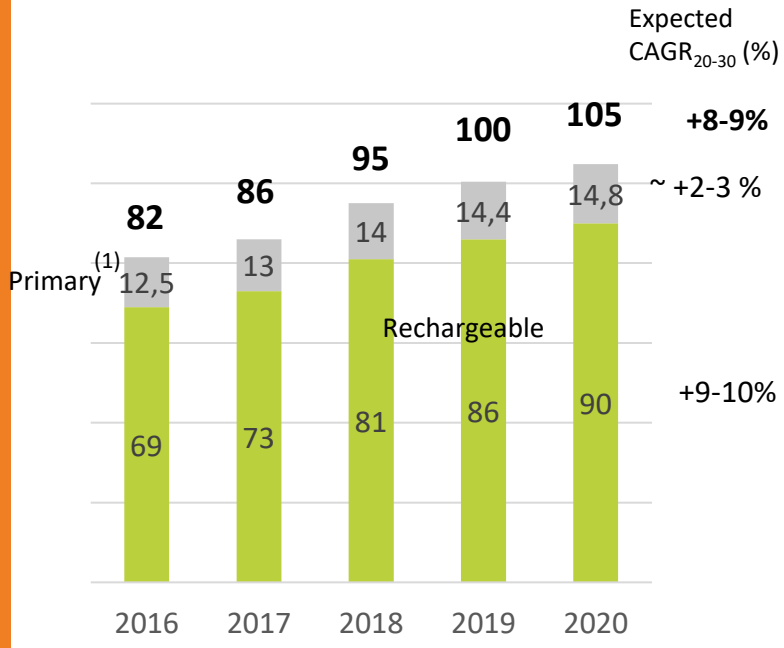
WORLDWIDE BATTERY MARKET OVERVIEW

Battery market in value (2016-2020, global, $bn, all market segments, all technologies)



Macro-trends driving the battery market

- Battery is a key technology for new concepts of mobility and energy (e.g. electric mobility, stationary storage) supported by the following trends:
  - **Population increase and city growth challenging existing mobility and energy solutions**
  - **Shift in energy production** with an increasing focus on renewable energies as an alternative to fossil fuel and nuclear
  - **Global awareness** regarding global warming **pushing for adoption of green solutions** (global objective of CO_2 emissions reduction, government regulations and incentives, social pressure for environmental-friendly solutions)

(1) Non rechargeable – Source: AT Kearney, Duracell, Avicenne – Based on selling price from manufacturer to retailer

Source: AT Kearney, Duracell, AVICENNE ENERGY 2021

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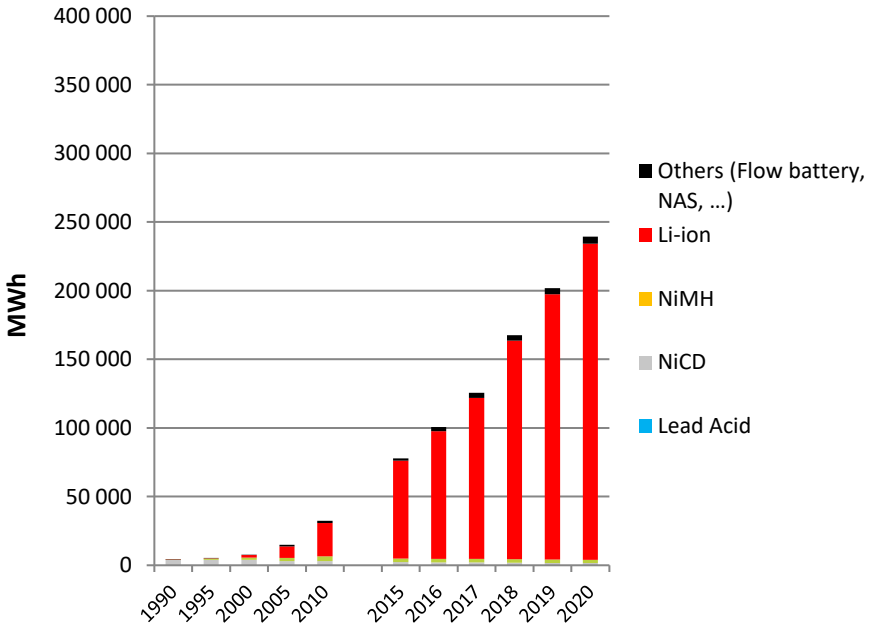
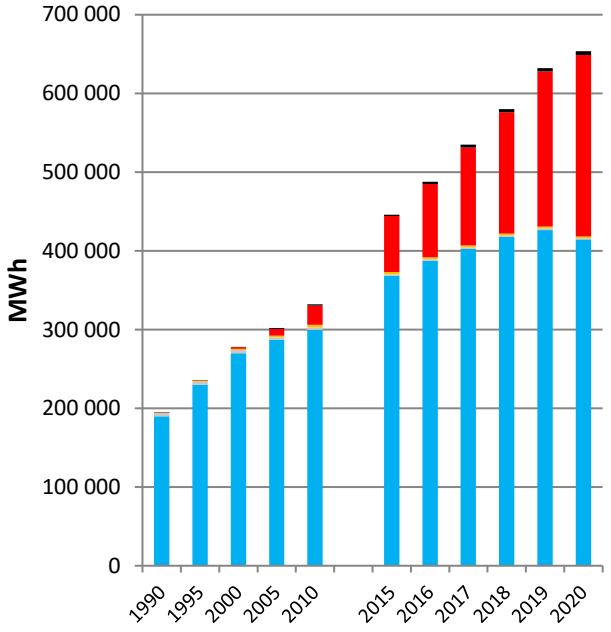
THE WORLDWIDE BATTERY MARKET 1990-2020

Lithium Ion Battery: Highest growth & major part of the investments
Lead acid batteries: By far the most important market (~60% market share)





Source: AVICENNE ENERGY, 2021

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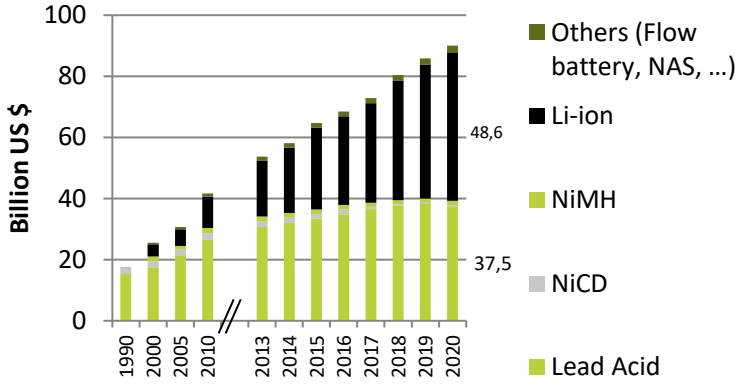
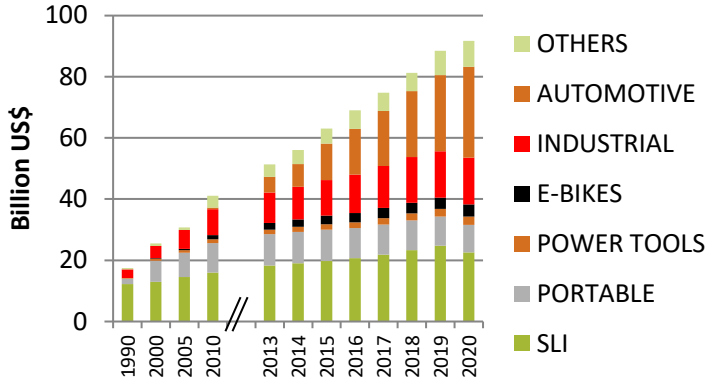
THE WORLDWIDE BATTERY MARKET 1990-2020

90 BILLION US$ in 2020 – Pack level[1]
8% AVERAGE GROWTH PER YEAR (2010-2020)





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

PORTABLE: concumer 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, 2021

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, drones, Light Electric Vehicles, Hoverboard, …

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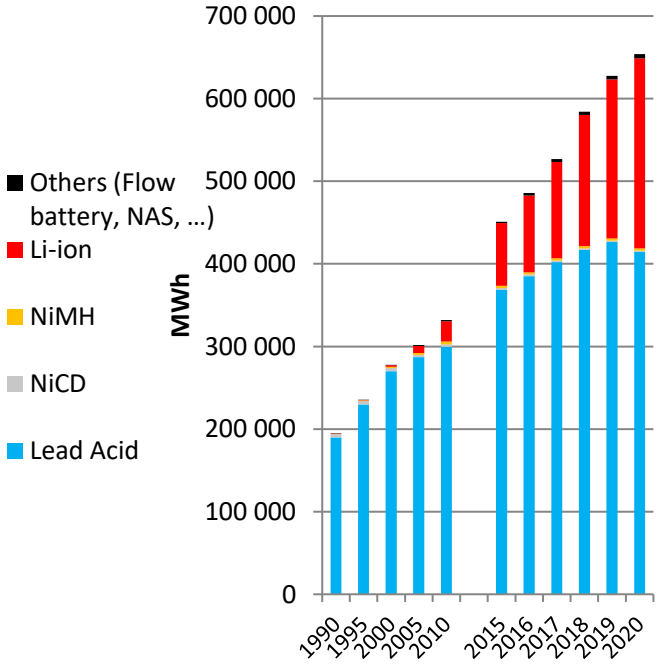
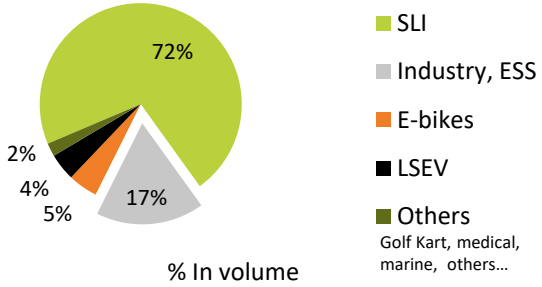
THE WORLDWIDE BATTERY MARKET 1990-2020

In volume (MWh)



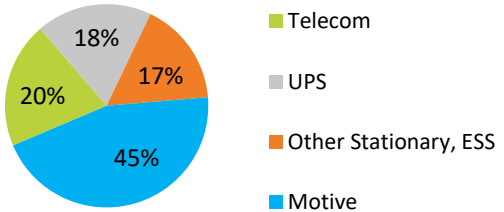
Source: AVICENNE ENERGY, 2021

Lead Acid Batteries 2020
415 GWh for > US $ 38 Billion



% In volume

Industrial Batteries – Lead acid batteries
72 GWh for US $ 10-11 Billion



% In volume

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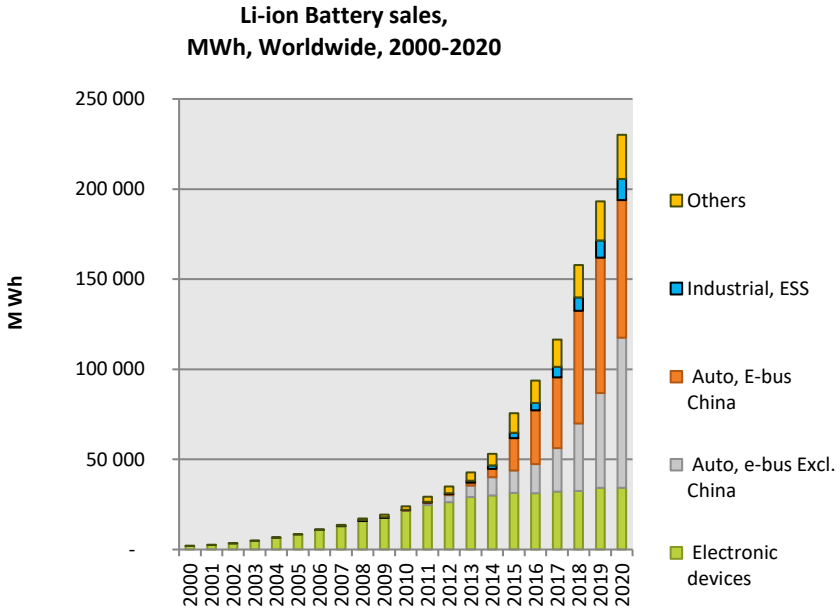
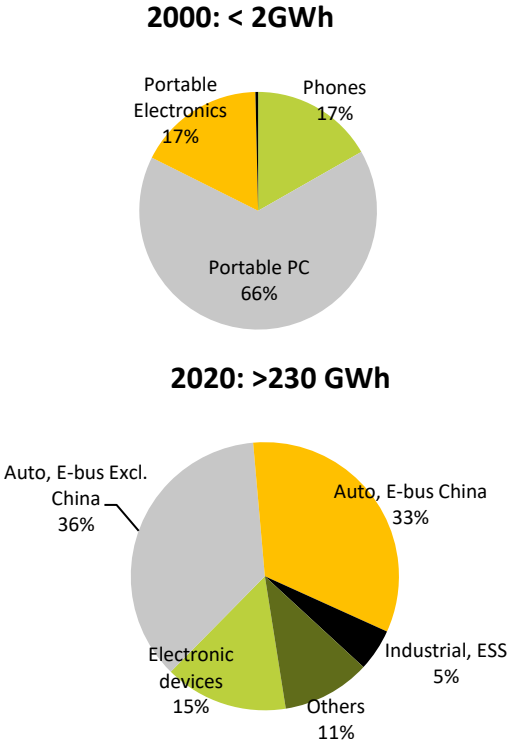
LI-ION IN 2020 - MAIN APPLICATIONS

>230 000 MWh - 50 B$ (1)

CAGR 2009/2020
+25 % per year in Volume





(1) Pack level
Others: medical devices, power tools, gardening tools, e-bikes…
Source: AVICENNE Energy 2021

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BATTERY MARKET FORECASTS 2020-2030

Applications covered

- Portable PCs, net-book, Ultra-book
- Cellular Phones, Smart-phones
- Tablets
- Power Bank
- Camcorders
- Cordless Tools, Gardening tools
- Digital Camera
- Games, MP3
- Cordless Phones
- Shavers, Toothbrush,
- RC Cars, Toys
- Drones
- Hoverboard
- E-bikes
- Power tools
- Security lighting
- Vehicles: HEV, P-HEV, EV, E-buses
- Industrial motive (forklift)
- Industrial stationary (UPS, Telecom)
- Medical
- Energy Storage (Small / large)

Parameters analysis

- Main segment trends
- Power need trends (volume, weight, capacity, running time)
- Penetration rate for each Chemistry, each form factor,
- 2020 -2030 Forecasts
- OEM strategies and positions
- Main drivers & limiters
- Technology Roadmap
- Disruptive technology

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The Rechargeable battery market and main trends 2020-2030

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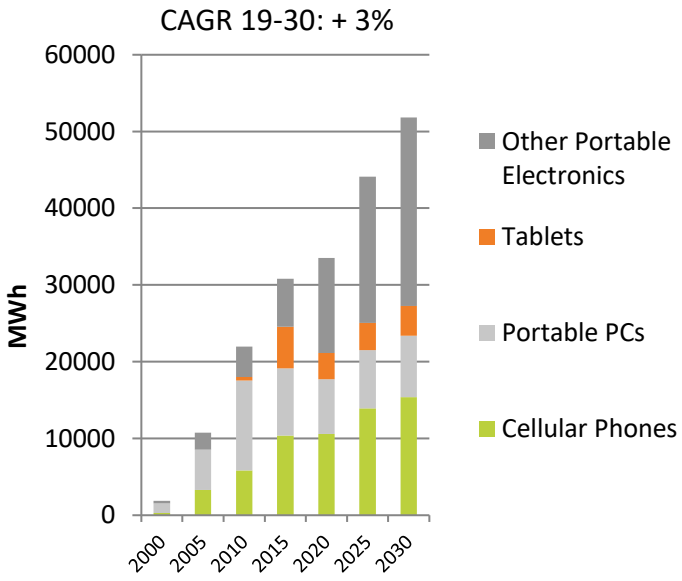
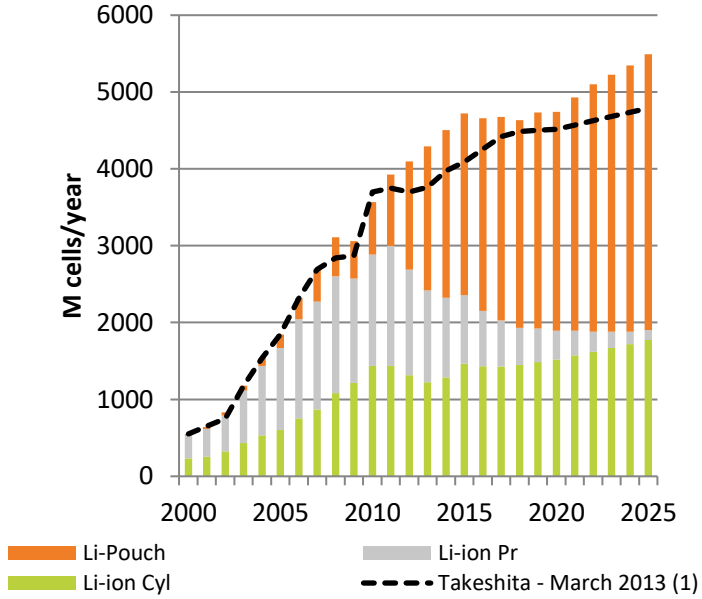
2030 LIB FORECASTS FOR PORTABLE ELECTRONIC DEVICES

2000-2030 LIB market, MWh, by application (3C)



Source: AVICENNE ENERGY 2021

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



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

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X-EV MARKET

- X-EV worldwide in 2020
  - > 175 GWh
  - $CAGR_{2019-2020}$: 25%
  - Main cell suppliers: CATL, LG,
  - Chemistries: NMC hi Ni, NCA, LFP
- X-EV forecasts
  - Realistic scenario: ~20% EV and PHEV sold per year in 2030
  - > 400 GWh in 2025 & 1,1 TWh in 2030
  - $CAGR_{2020-2030}$: > 20%
  - Battery cost forecasts: from 150 $/kWh to ~110 $/kWh in 2025

xEV sales 2020-2030

Base S.

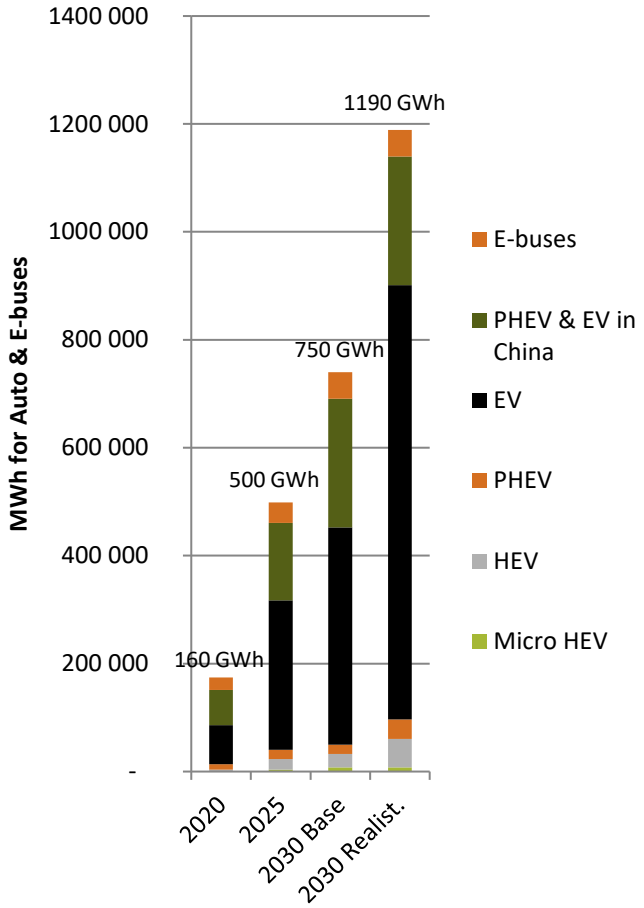
M of cars	China			EU, US, Others			World		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
HEV				3,1	5,8	8,7	3,1	5,8	8,7
P-HEV	0,2	0,3	0,3	0,7	0,9	1,2	0,9	1,2	1,5
EV	1,1	2	3,3	1,2	2,8	5,6	2,2	4,8	8,8

Realist. S.

M of cars	China			EU, US, Others			World		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
HEV				3,1	9,3	18,4	3,1	9,3	18,4
P-HEV	0,2	0,3	0,3	0,7	1,5	2,5	0,9	1,8	2,8
EV	1,1	2	3,3	1,2	4,5	11,2	2,2	6,4	14,4

Source: AVICENNE ENERGY Analyses 2021

CAGR 2020-2030:
+ 16% (Base) - +21% (Realist)



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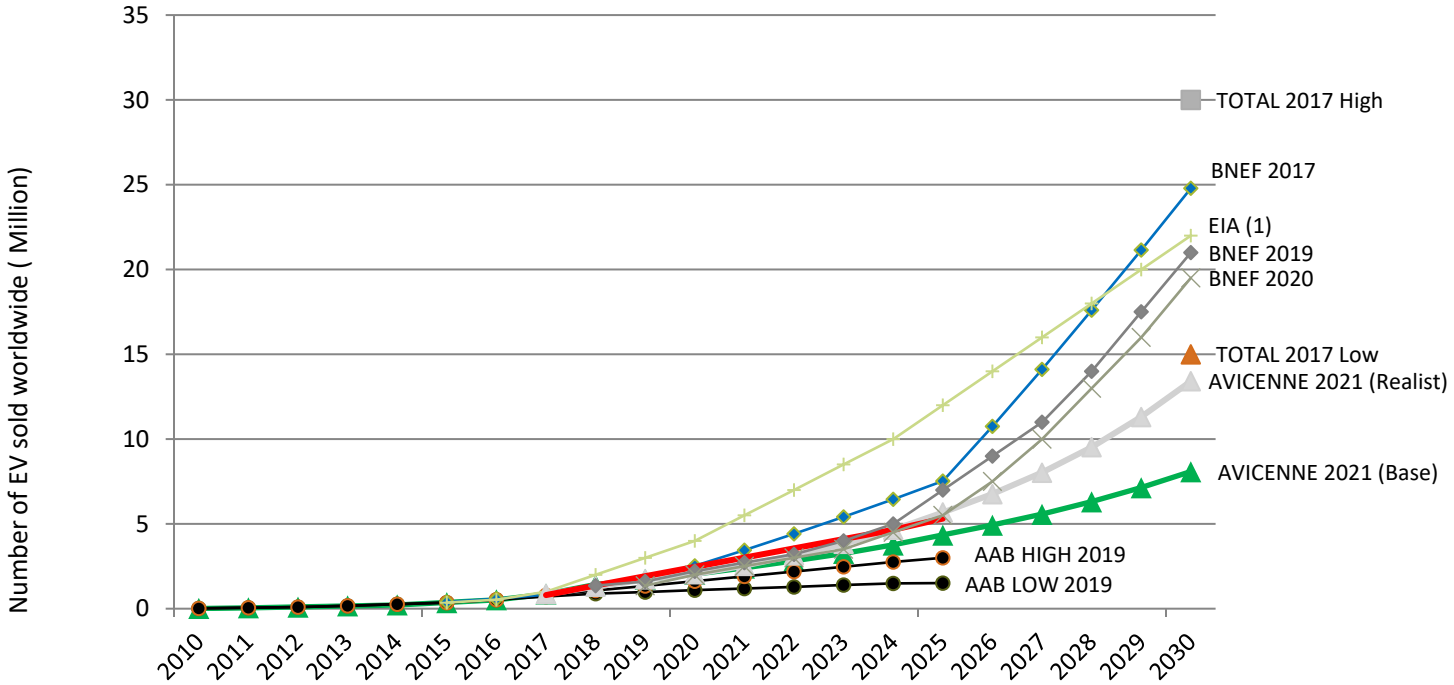
LONG TERM EV FORECAST

EV sold, in million units, worldwide, 2010 – 2030



AAB, AABC US, June 2017, 2018, 2019
BNEF, BATTERIES 2017, October 2017
AVICENNE Analysis 2021
COVID 19 impact partially implemented as the crisis is not over - Impact could be worst

(1) EIA – Avicenne estimation based on "Stock" numbers

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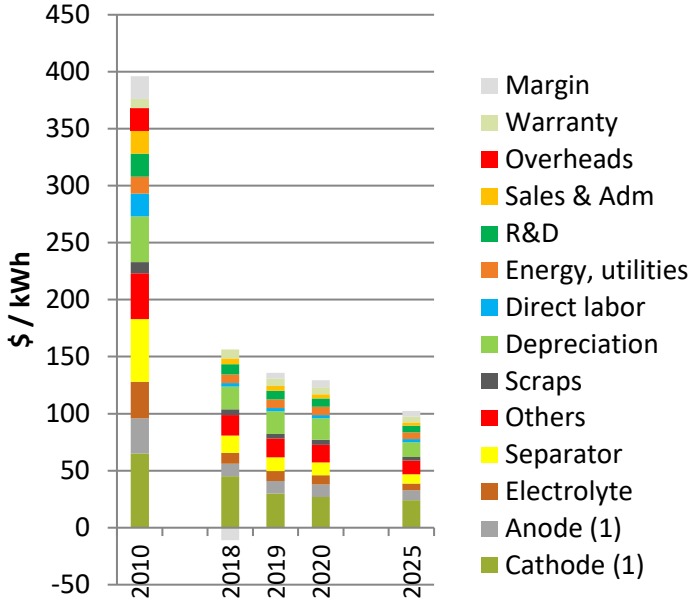
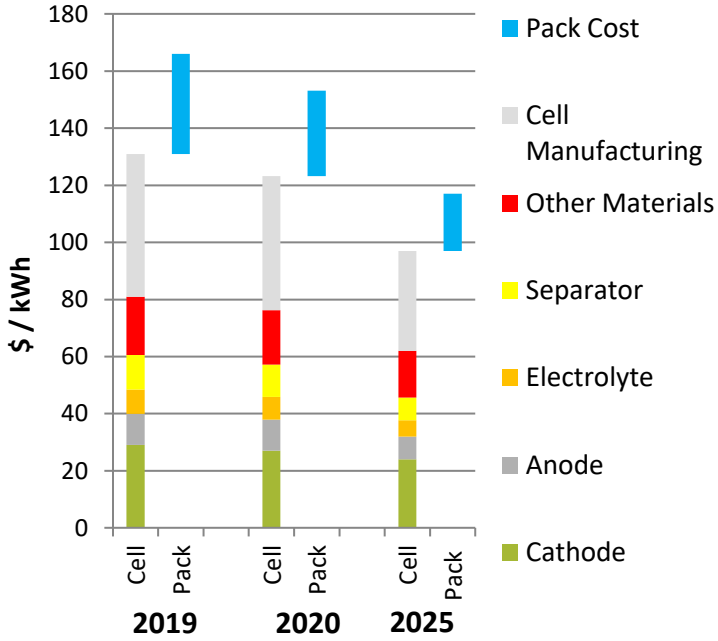
LI-ION BATTERY COST 2019-2025

LIB cell average **cost** (40 Ah pouch) (EV design ; NMC622 cathode)



(1) Active materials only
Source: AVICENNE ENERGY 2021

LI-ION BATTERY PACK **COST** FOR EV



** For Production > 100 000 packs/year*

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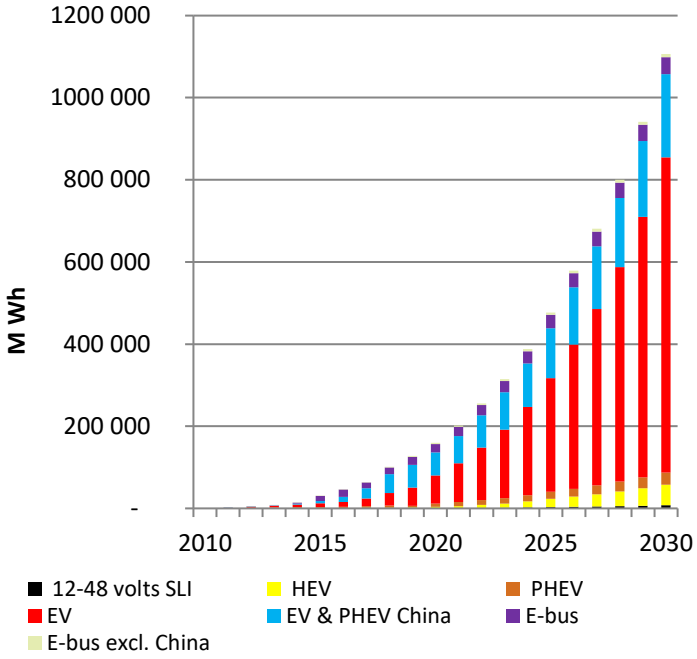
TOTAL BATTERY DEMAND FOR XEV 2030 FORECASTS (REALISTIC SCENARIO)

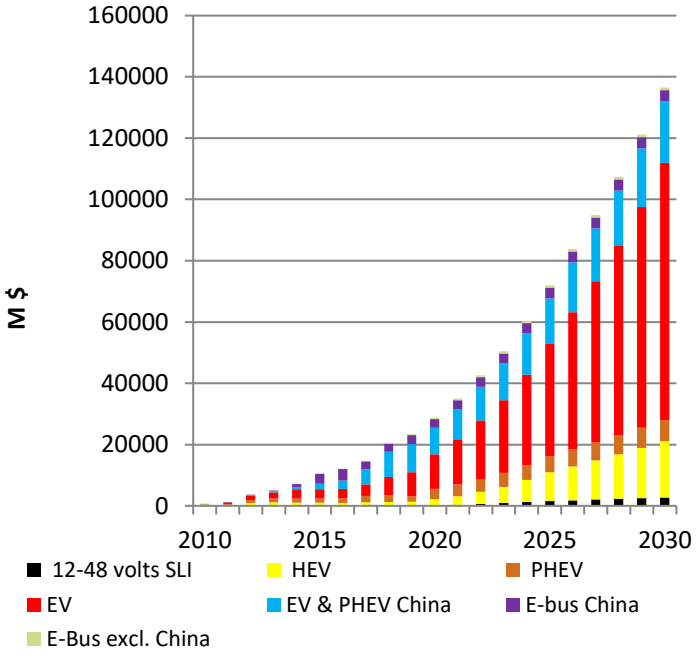
Li-ion for EV, HEV & P-HEV Battery needs (MWh)

CAGR 2015-2030: +27%



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

CAGR 2015-2030: +19%



Source: AVICENNE ENERGY Analysis, 2021

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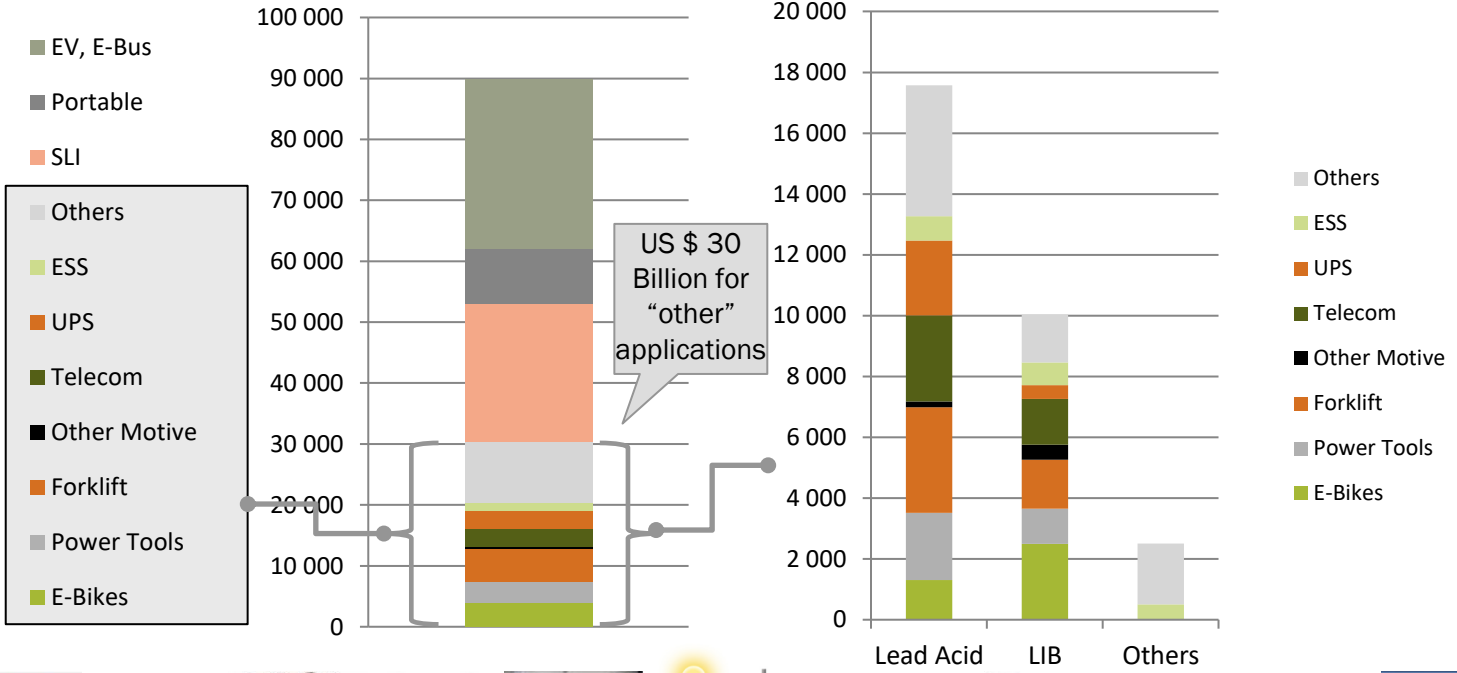
THE WORLDWIDE BATTERY MARKET IN 2020: US $ +90 BILLION



1- Pack level: Pack including cells, cells assembly, BMS, connectors – Power electronics (DC DC converters, invertors…) not included

Source: AVICENNE ENERGY, 2021

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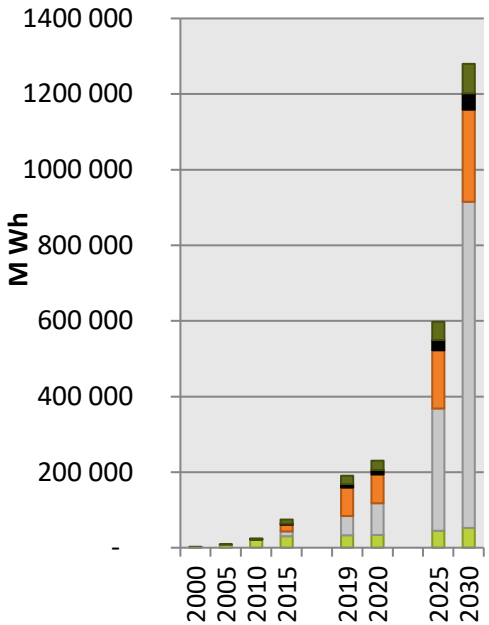
LI-ION BATTERY MARKET FORECASTS

From 230 GWh in 2020 to 1,3 TWh

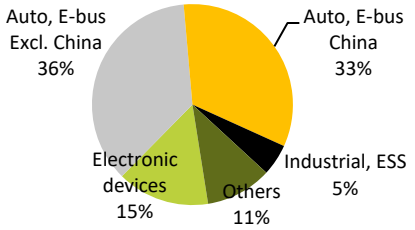
CAGR 2020/2030
+20 % per year in Volume

Li-ion Battery sales, MWh, Worldwide, 2000-2030

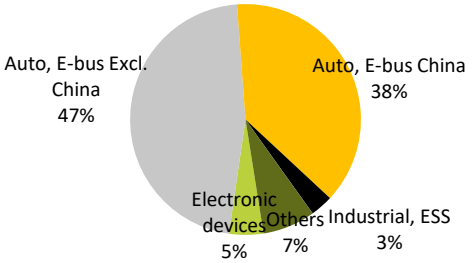


	CAGR 15/30 (Realistic)
Others	14%
Industrial, ESS	21%
Auto, E-bus China	20%
Auto, e-bus Excl. China	30%
Electronic devices	4%

2020: >230 GWh



2030: 1300 GWh



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

Source: AVICENNE Energy 2021 - COVID 19 impact partially implemented as the crisis is not over - Impact could be worst

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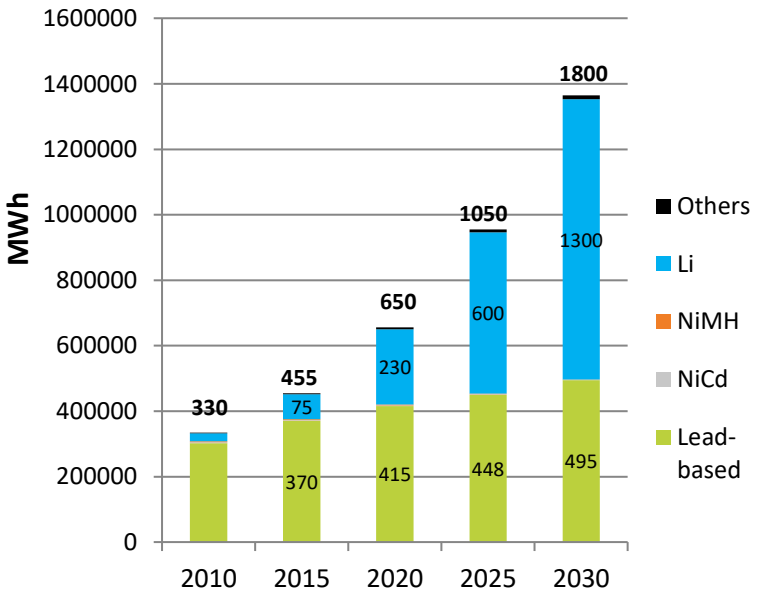
BATTERY MARKET 2010-2030

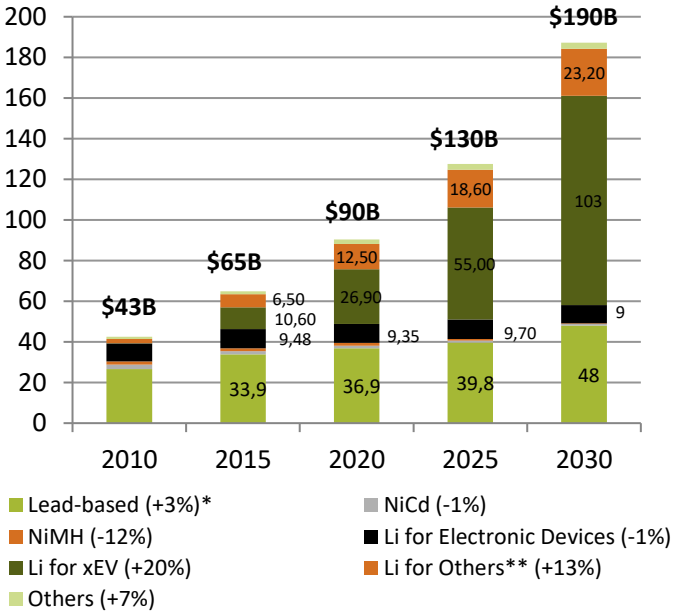
Lead-based and Li-ion batteries will remain the most important markets



(1) Pack level: pack including cells, cell assembly, BMS, connectors – power electronics (DC DC converters, invertors, etc.) not included

Source: AVICENNE Energy 2021

Market value will reach $190b in 2030 – Pack level(1)



* CAGR 2020-2030

**Others: automatic handling equipment, robots, forklifts, UPS, telecom, medical devices, residential ESS, grid ESS, drones, hoverboards, etc.

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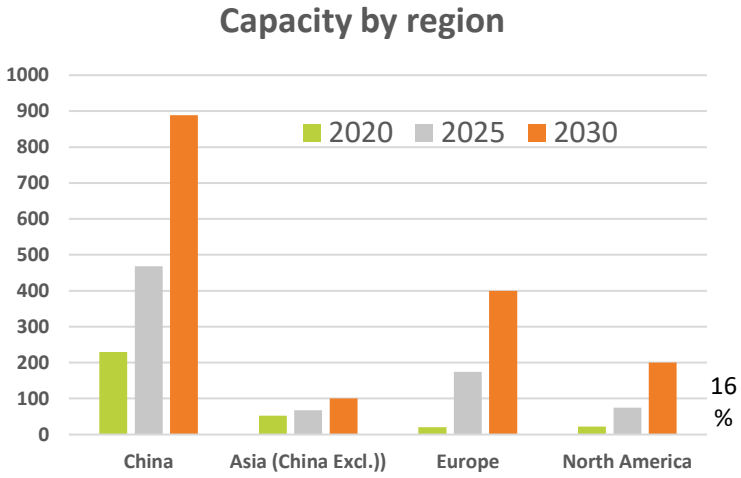
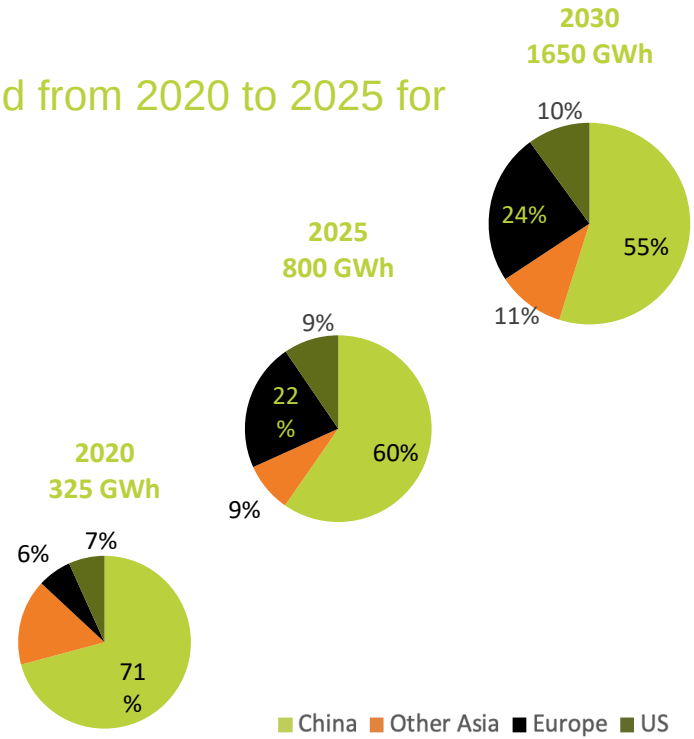
PRODUCTION CAPACITY FORECAST

In Europe, capacity should increase from few GWh before 2020 to 175 GWh in 2025

9 to 11 billion Euros investment required from 2020 to 2025 for cell manufacturing





Source: AVICENNE ENERGY, 2021

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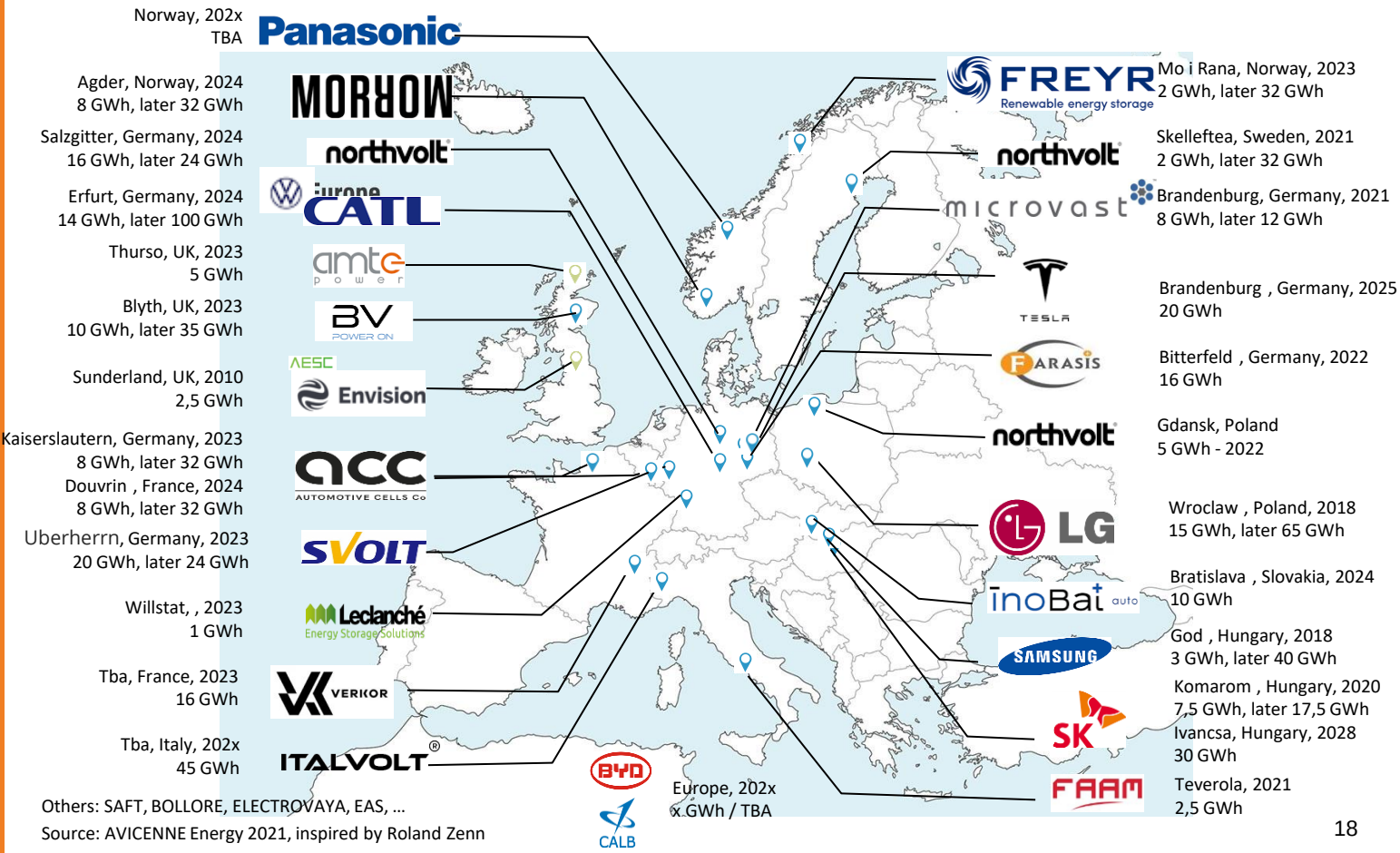
EUROPE PRODUCTION CAPACITY: FROM SEVERAL GWH IN 2020 TO 100-150 GWH IN 2023 & 500 GWH IN 2028



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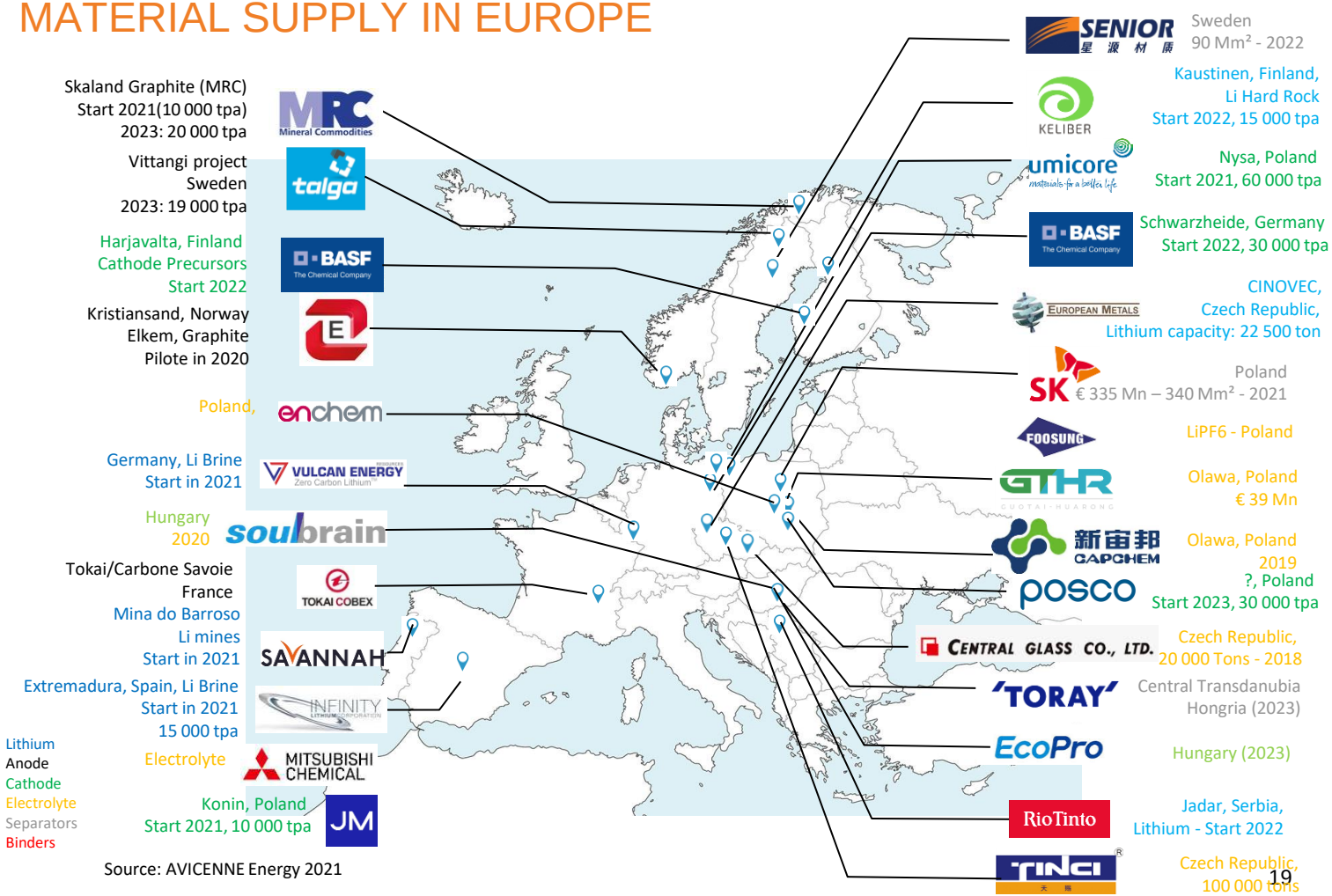
MATERIAL SUPPLY IN EUROPE



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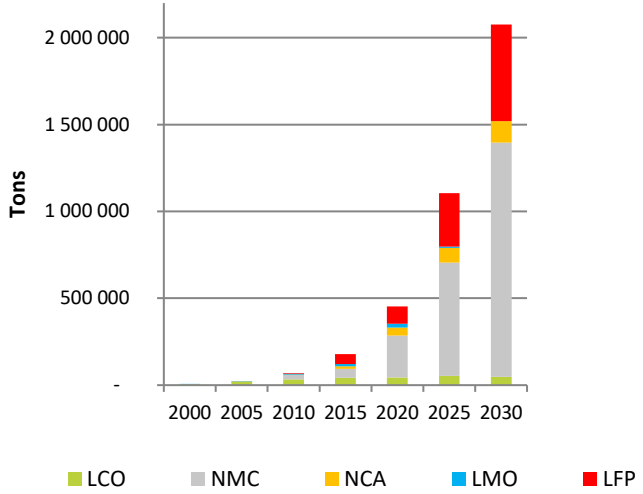
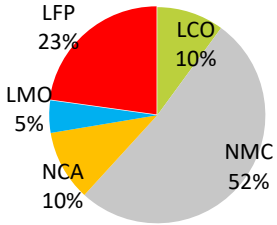
CATHODE ACTIVE MATERIAL FORECASTS 2000-2030

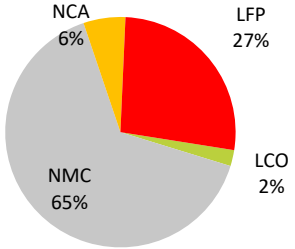
Cathode active materials 2000-2030 - Tons



Cathode active materials in 2020 450 000 Tons



Cathode active materials in 2030 2 100 000 Tons



ASSUMPTIONS:

- Portable devices: 2019-2030: +4% per year in volume
- HEV: 3,1 M HEV/year in 2020, 9,3 M HEV in 2025 & 18,4 M in 2030
- P-HEV: 0,9 M P-HEV/year in 2020, 1,8 M in 2025 & 2,8 M in 2030
- EV: 2,2 M EV/year in 2020 (1 M in China) / 6,4 M/year in 2025 (2 M in China) 100% LIB, 14,4 M EV in 2030 (3,3 M in China)
- Industrial, stationary & other applications 2019-2030: +15% per year in volume

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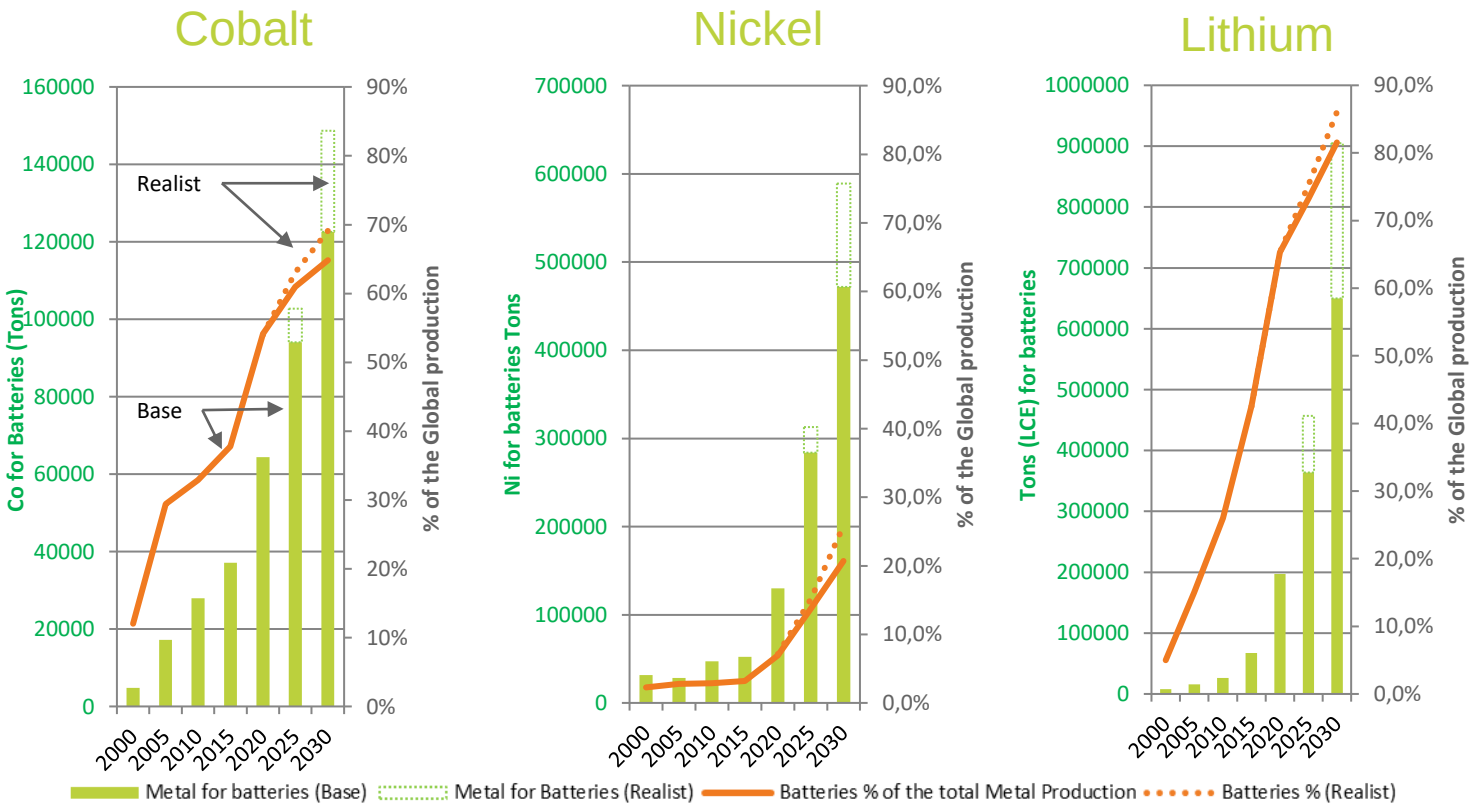
METAL NEEDS FOR RECHARGEABLE BATTERY WILL INCREASE RAPIDLY



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LITHIUM ION BATTERY RECYCLING

Assumptions

End Of Life battery – Assumptions

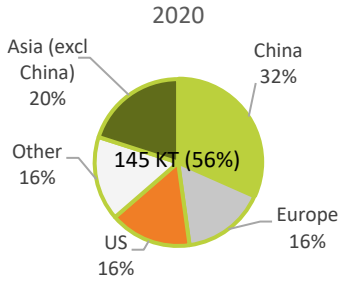
- **Warranty/ Recall**: a conservative 2% is considered of battery packs either tested at the manufacturer or placed on the market that may have performance problems and should be recycled
- **End of Life**: of batteries put on the market before recycling includes possible second-hand use and the collection process
- **Collection rate**: mainly impacted by the regional regulation and the concerned application

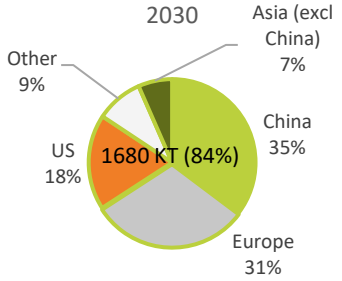
Scrap

- **Production Scrap** : composed on the one hand of electrode cutting scrap which is incompressible by a few percent and on the other hand of process capability by the various producers
- **Scrap Rate**: in total, the best-in-class could reach 5%, whereas during the start-up phases, the rate can exceed 20 to 30% over a very long period
- **Quality of the scrap**: scrap material has particular characteristics compared to a new or used complete cell or battery pack; it is composed of part of the cell elements, with a well known in composition., In the model, we retain on average a value of 70 % of the weight of the cell (situating itself at electrode level without electrolyte, cell housing…)
- **Energy density at cell level**: average energy density for lithium ion at cell level varies in the model from 100 Wh/kg in 2010 to 320 Wh/kg in 2030

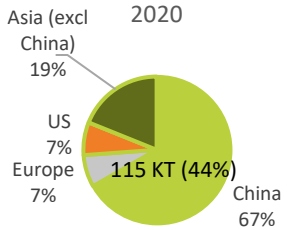
	End of Life in years (including potential second Life and collecting process)	Collection Rate
Electronic devices	3	25%
E-Bikes	4	65%
xEV	10	95%
Industrial, ESS	10	80%
Others	5	25%
E bus	10	90%
Warranty / Recall (2%)	2	100%

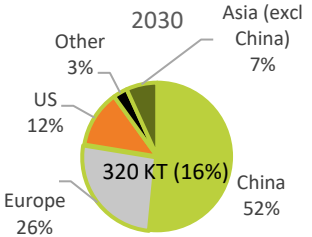
End Of Life 145 KT in 2020 – 1680 kT in 2030





Scrap: 115 KT in 2020 – 320 KT in 2030





In 2030 metal from recycling could account for 15 to 25% of the metal needs to produce Li-ion batteries

Source: Avicenne Energy 2021

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THANK YOU

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