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Regione Lombardia

January 2022

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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 2020/2021
- Focus on xEV market
- xEV Forecasts
- Impact of recycling on raw material supply
- Conclusions

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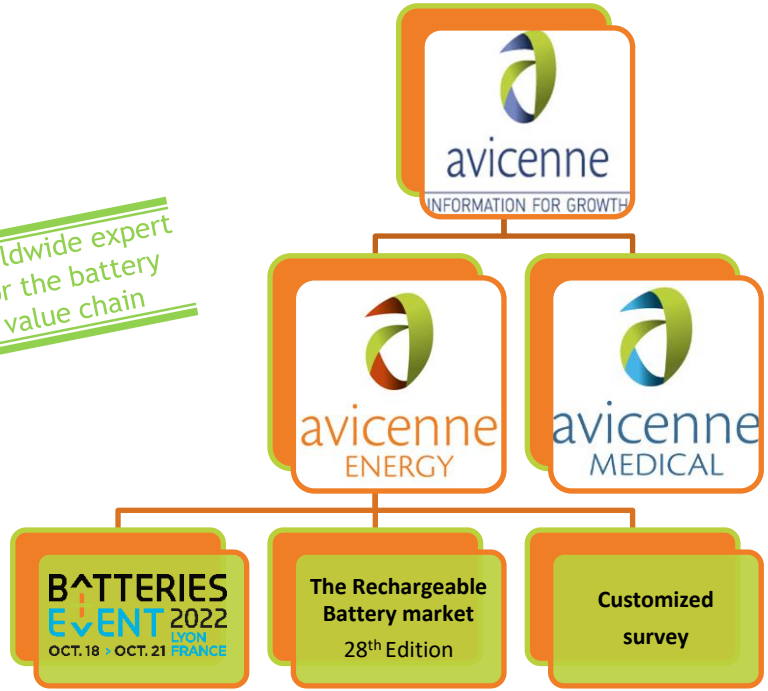
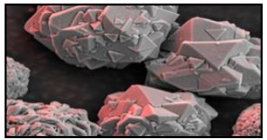
AVICENNE PROFILE

Information for Growth - Powering your company's market strategy with in-depth research

- Creation: 1992, by Ali MADANI
- Headquarter: Paris
- Liaison Office: USA, China
- AVICENNE Energy Director: Christophe Pillot
- 3 consultants
  - A Madani
  - C Pillot
  - JP Salvat
- 3 Senior advisors
  - M Sanders
  - F Renard
  - X Zhang
- Database: >20 000 contacts in the battery value chain

Worldwide expert for the battery value chain







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BATTERIES 2022

BATTERIES EVENT 2022 LYON FRANCE
OCT. 18 > OCT. 21

www.batteriesevent.com

- 3 days congress in France (Lyon)
- October 18th –21st, 2022
- 24th Edition (first edition in 1999)
- +600 attendees
- +50 Booths
  Battery makers, raw materials suppliers, IC & BMS suppliers, tests, machining, coating,
- +100 international speakers:
  Researchers, industrial process, marketing, financials,

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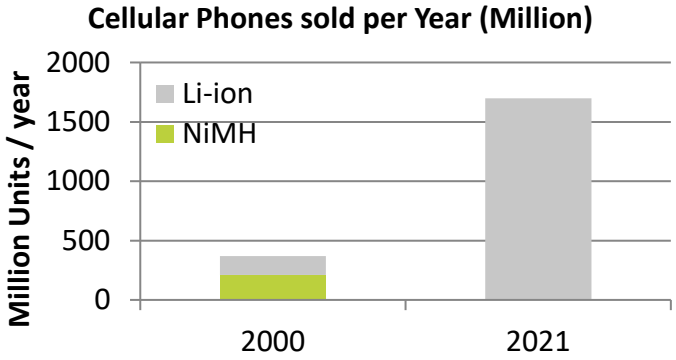
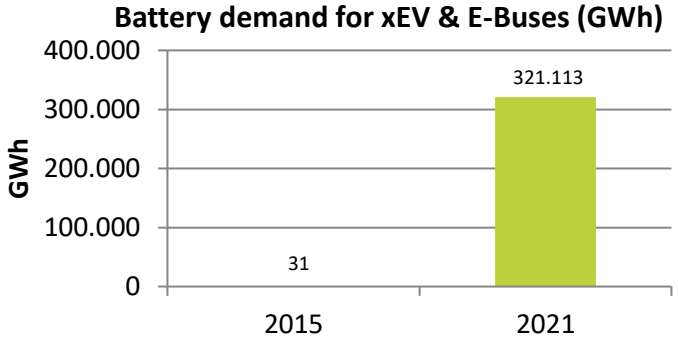
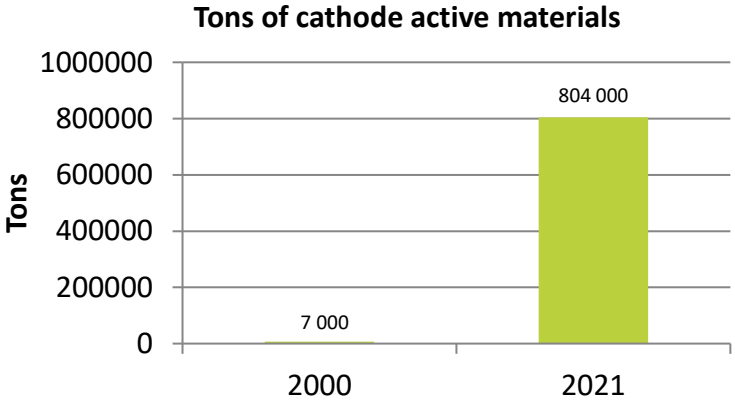
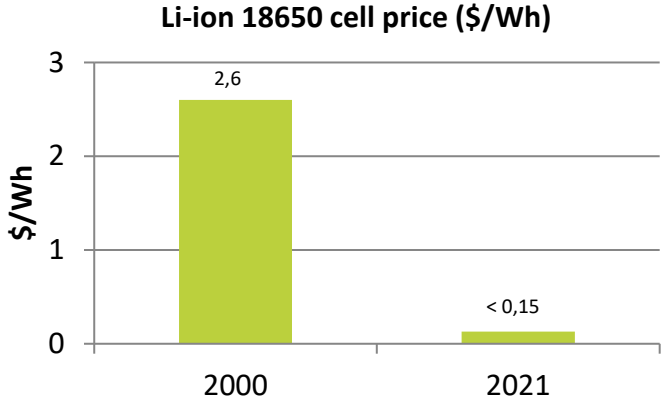
THE BATTERY MARKET IS REALLY DYNAMIC









Source: AVICENNE ENERGY, 2022

AND IT'S JUST THE BEGINNING!

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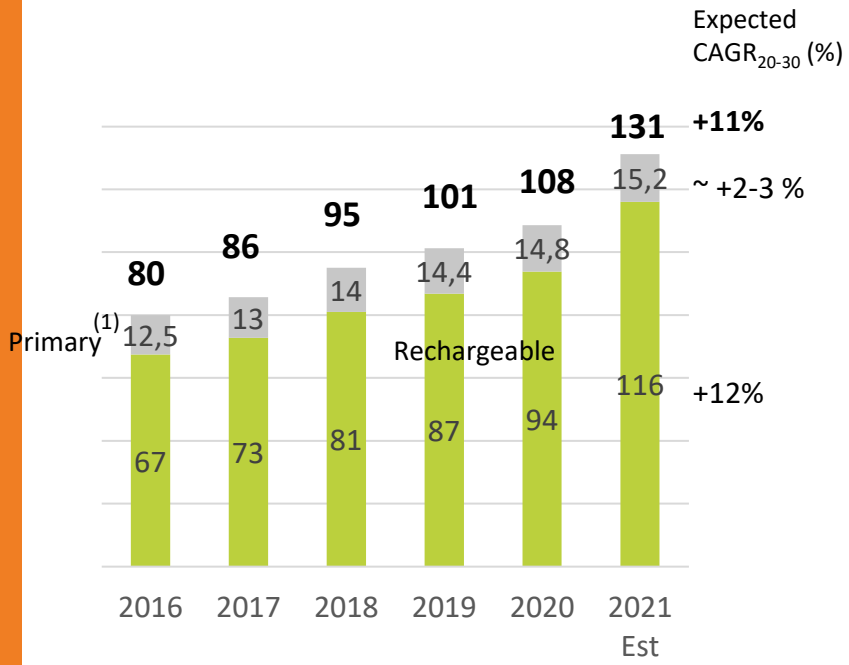
WORLDWIDE BATTERY MARKET
OVERVIEW

Battery market in value 2016-2021, 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 2022

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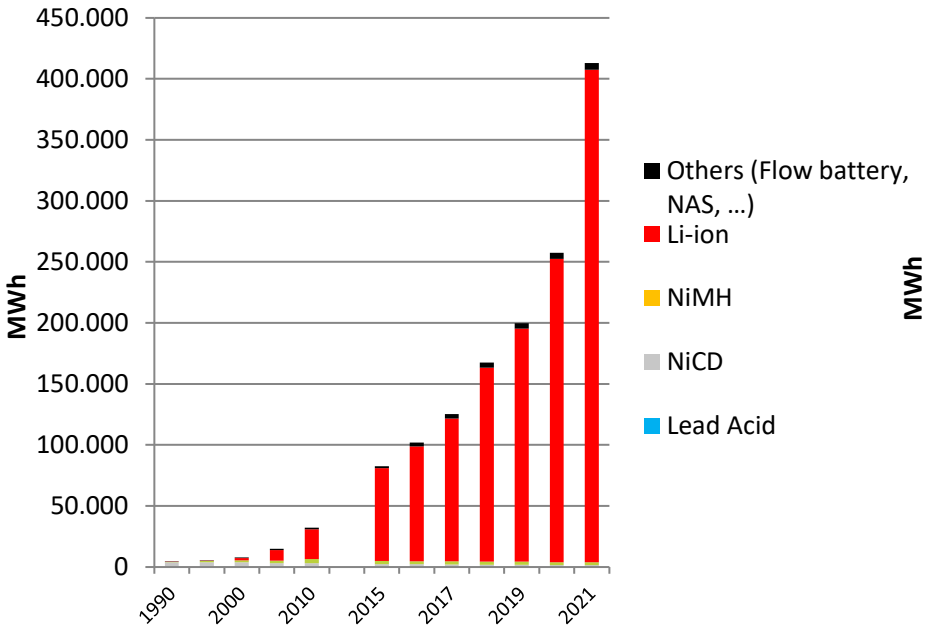
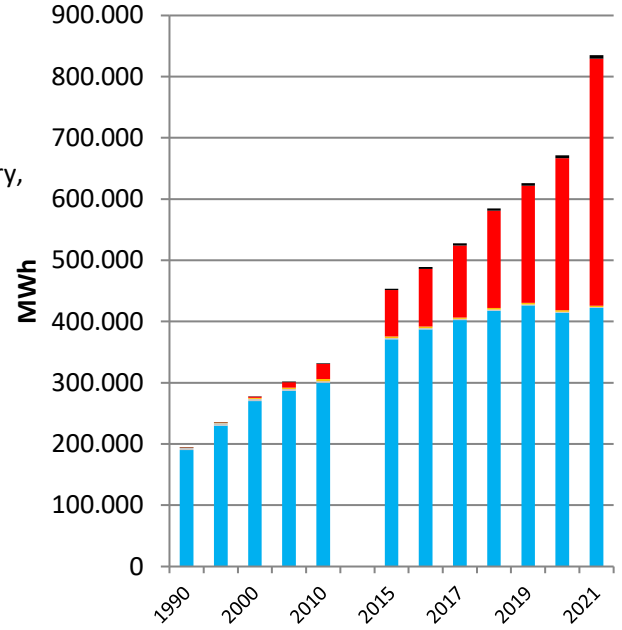
THE WORLDWIDE BATTERY MARKET 1990-2021[1]

Lithium-Ion Battery: Highest growth & major part of the investments
Lead acid batteries: 50% market share in volume





2021: Estimations

Source: AVICENNE ENERGY, 2022

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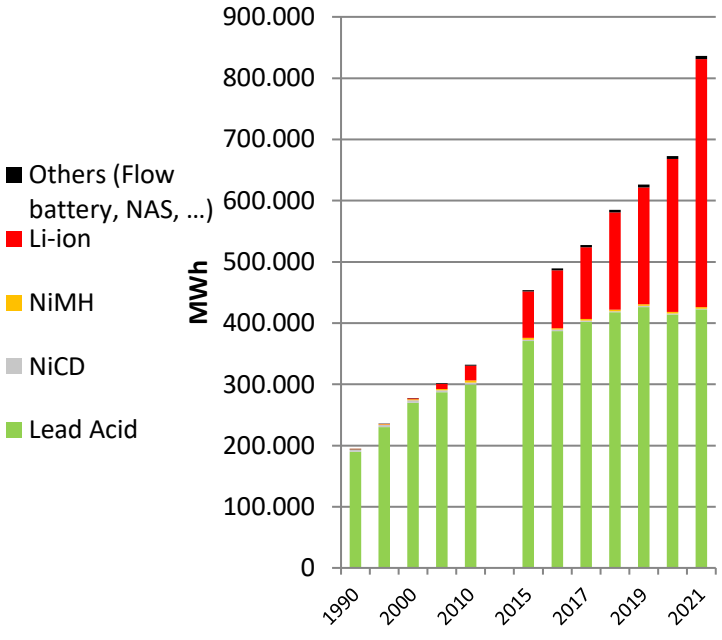
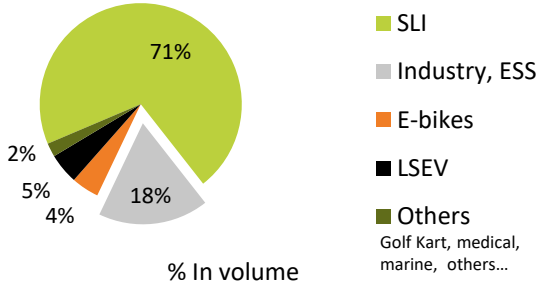
THE WORLDWIDE BATTERY MARKET 1990-2021

In volume (MWh)



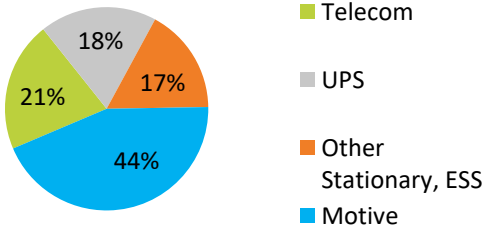
Source: AVICENNE ENERGY, 2022

Lead Acid Batteries 2021
423 GWh for > US $ 38 Billion



% In volume

Industrial Batteries – Lead acid batteries
75 GWh for US $ 11 Billion



% In volume

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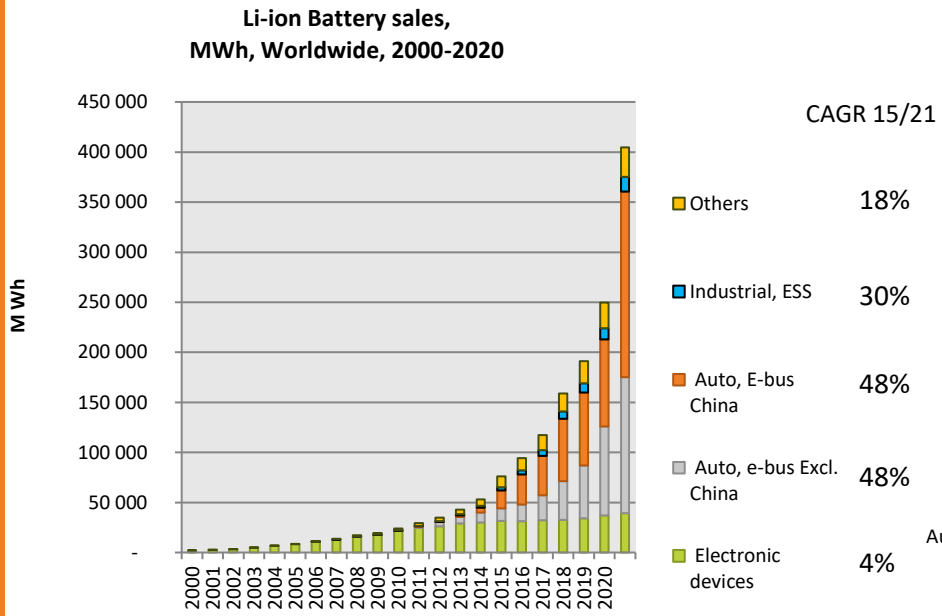
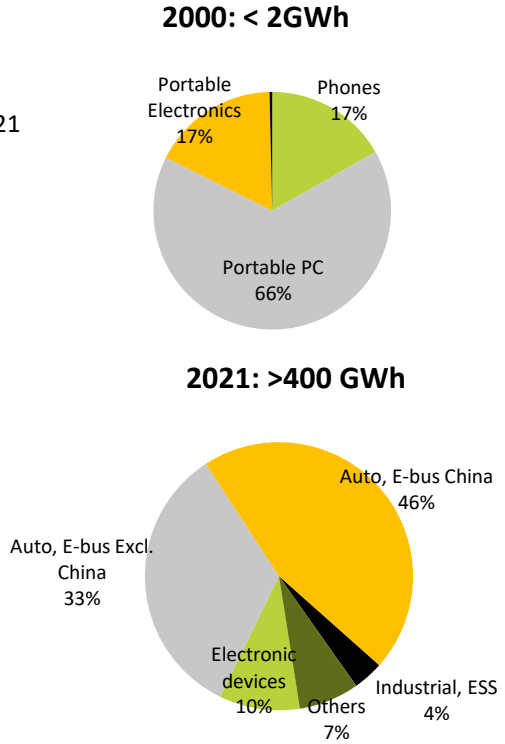
LI-ION IN 2021 - MAIN APPLICATIONS

>400 000 MWh - 74 B$ (1)

CAGR 2010/2021
+29 % per year in Volume





(1) Pack level
Others: medical devices, power tools, gardening tools, e-bikes…
Source: AVICENNE Energy 2022

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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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FEW COMMENTS BEFORE MAKING FORECASTS

- The Moore low we know in electronics do not work in electrochemistry : we do not expect any revolution in the EV battery technology in the next 10 years ; Evolution but no revolution

- Long time to market

- Safety issue could kill this market

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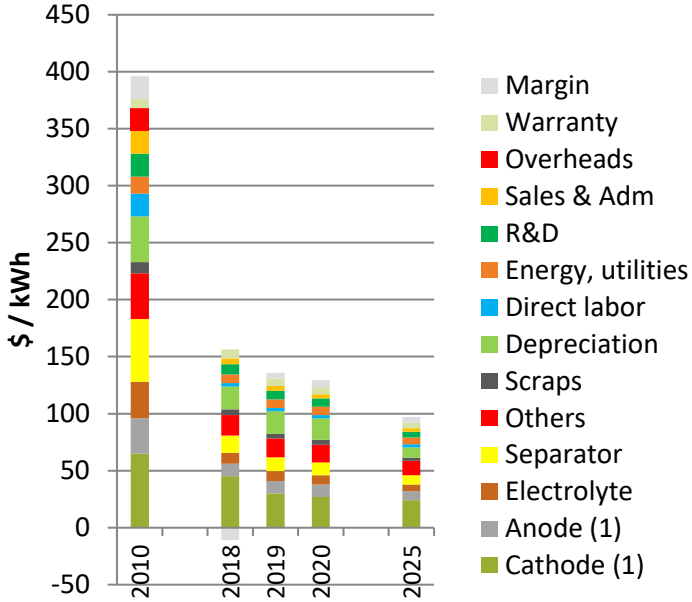
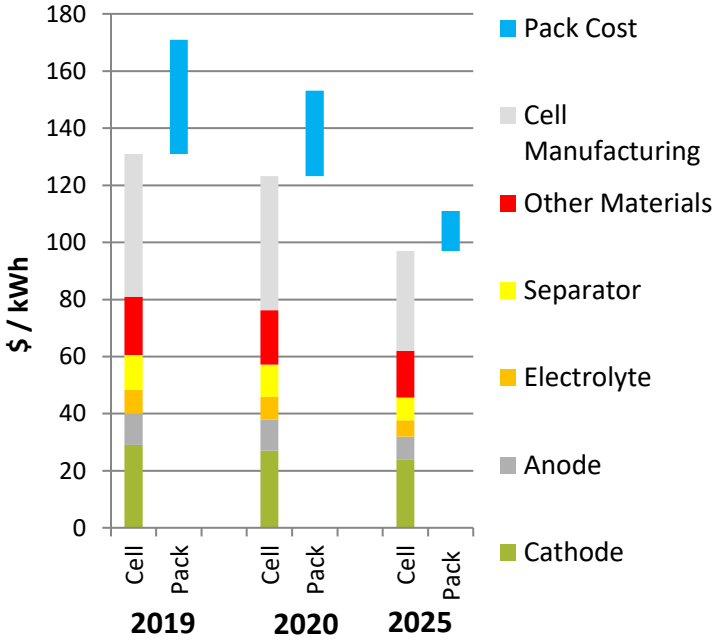
LI-ION BATTERY COST 2019-2025

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



(1) Active materials only
Source: AVICENNE ENERGY 2022

LI-ION BATTERY PACK PRICE FOR EV



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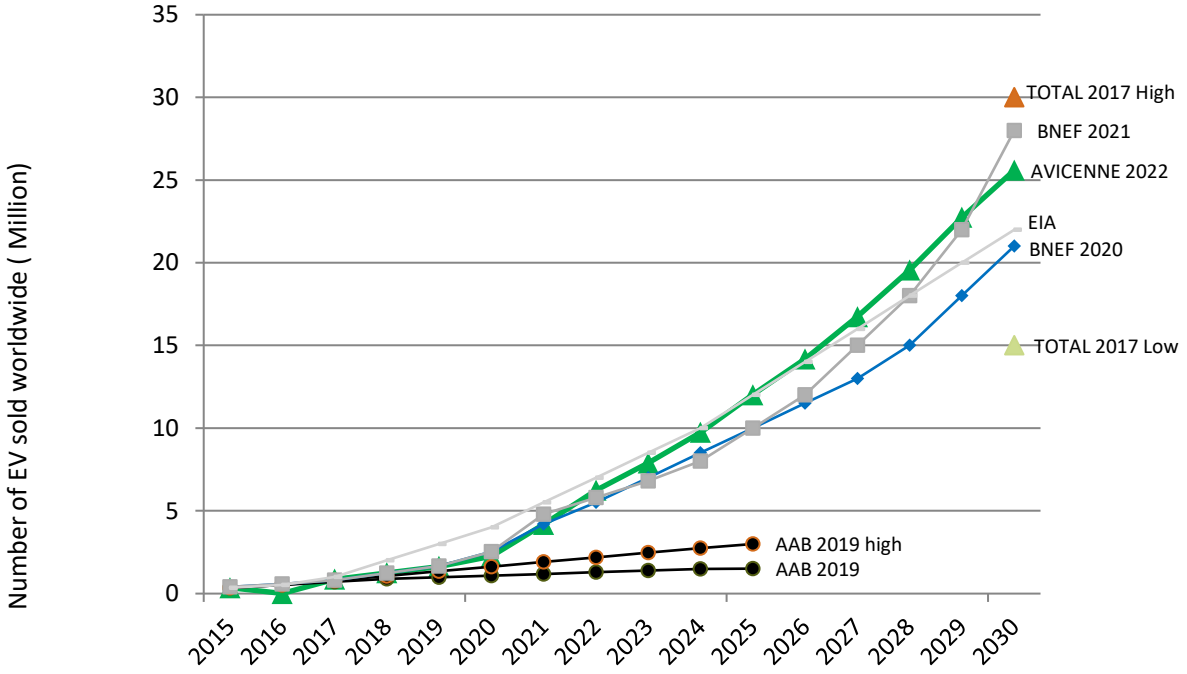
EV FORECAST

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



AAB, AABC US, June 2017, 2018, 2019,2021
BNEF, October 2020, 2021
AVICENNE Analysis 2022

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

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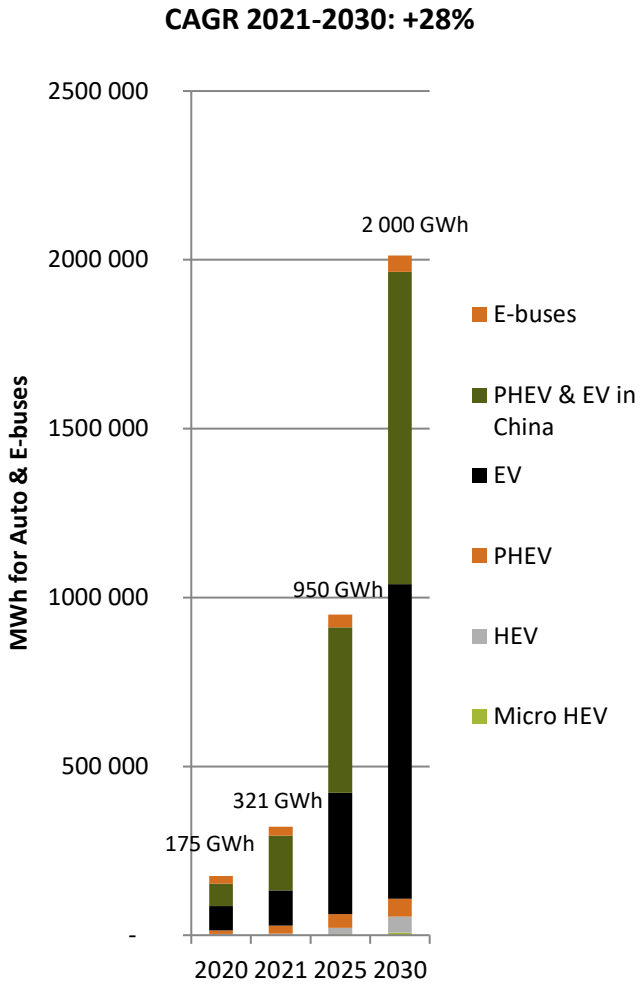
X-EV MARKET

- X-EV worldwide in 2021
  - > 320 GWh
  - $CAGR_{2020-2021}$: 83%
  - Main cell suppliers: CATL, LG,
  - Chemistries: NMC hi Ni, NCA, LFP
- X-EV forecasts
  - ~30% - 35% EV and PHEV sold per year in 2030
  - ~ 1 TWh in 2025 & 2 TWh in 2030
  - $CAGR_{2020-2030}$: > 25%
  - Battery cost forecasts: from 150 $/kWh to ~100 $/kWh in 2025

M of cars	China			EU, US, Others			World		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
HEV				3,0	8,2	16,6	3,1	8,2	16,6
P-HEV	0,3	0,7	0,8	0,8	2,9	3,6	1,0	3,5	4,4
EV	1,1	6,9	12,6	1,2	5,1	12,9	2,3	12,0	25,5



Source: AVICENNE ENERGY Analyses 2022

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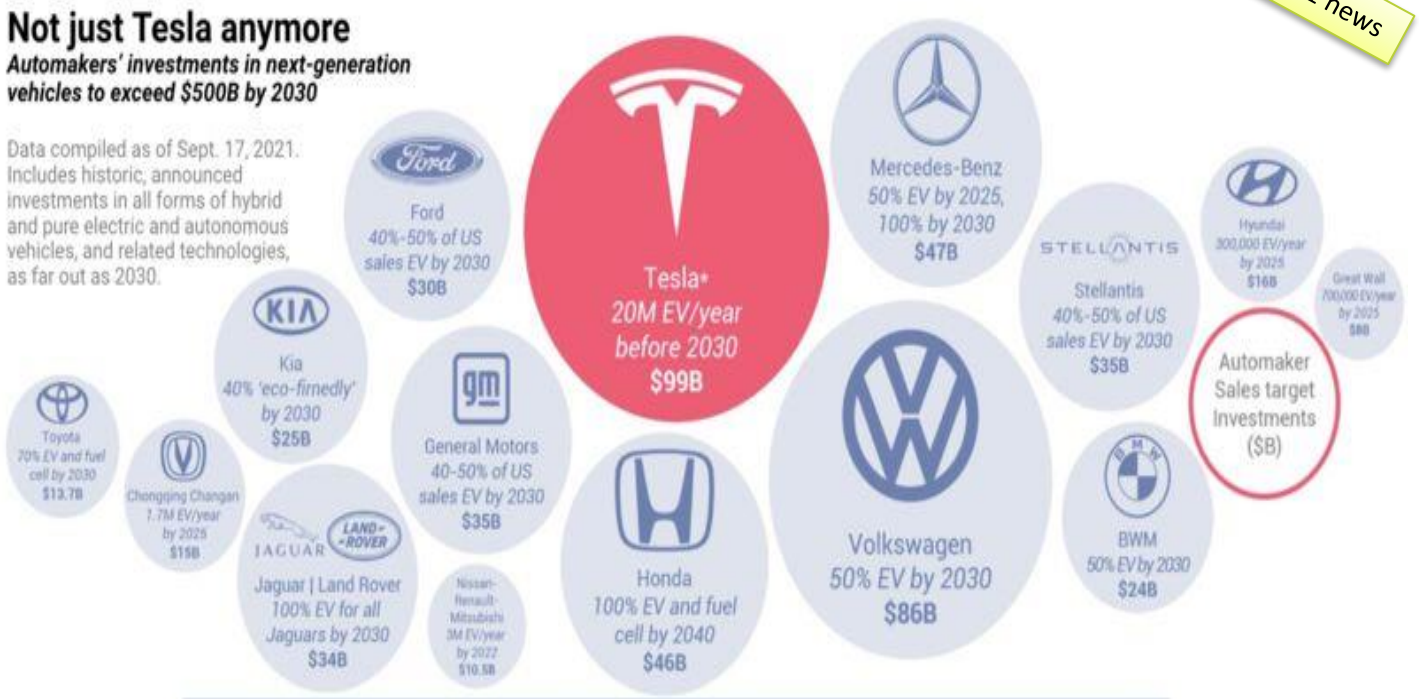
CARMAKERS TO INVEST MORE THAN $500 BILLION IN EV

September 2021 news



Source: Reuters 2021, Avicenne Energy 2021

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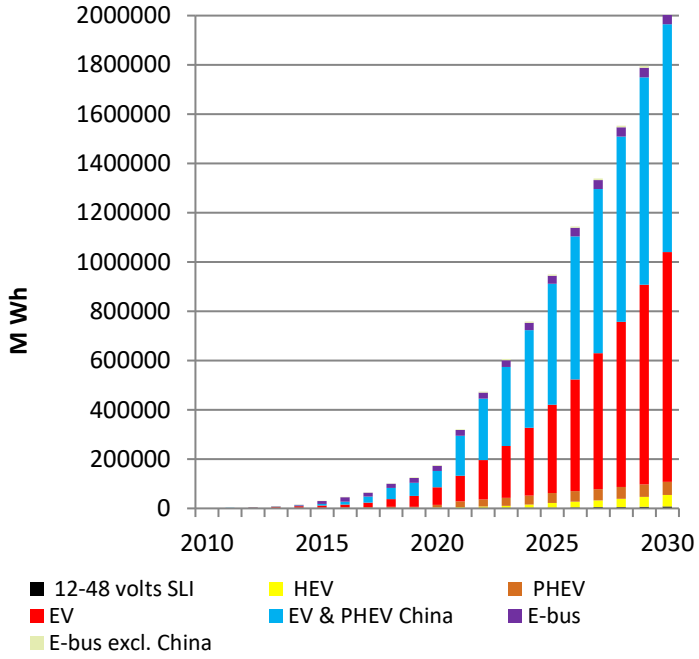
TOTAL BATTERY DEMAND FOR XEV 2030 FORECASTS

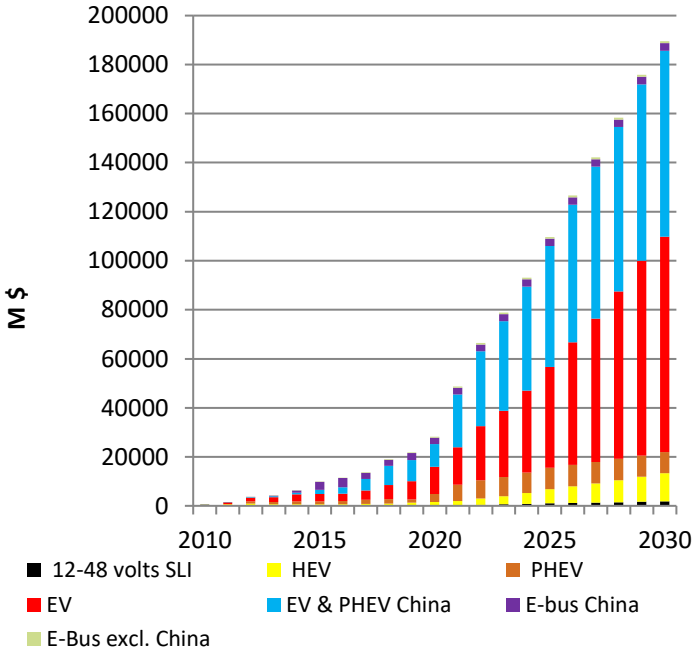
Li-ion for EV, HEV & P-HEV Battery needs (MWh)

CAGR 2020-2030: +28%



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

CAGR 2020-2030: +21%



Source: AVICENNE ENERGY Analysis, 2022

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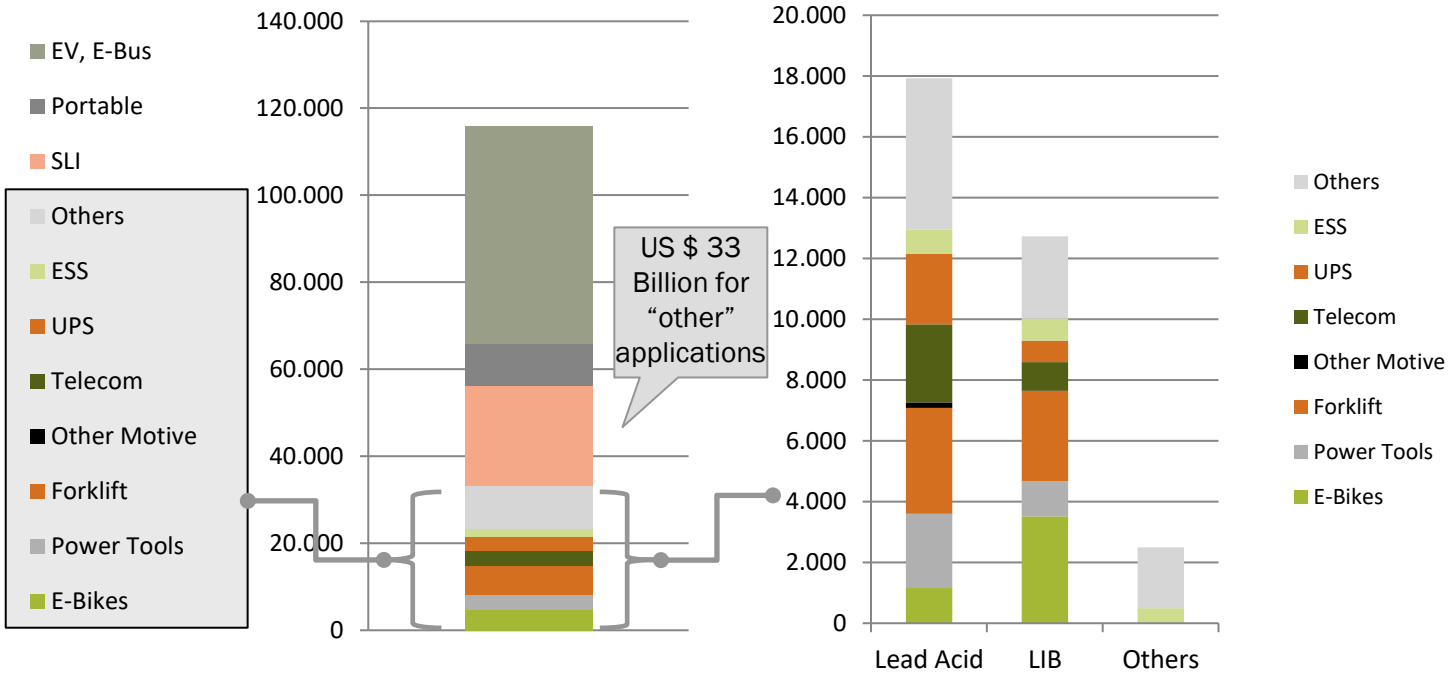
THE WORLDWIDE BATTERY MARKET IN 2021: US $ +116 BILLION



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

Source: AVICENNE ENERGY, 2022

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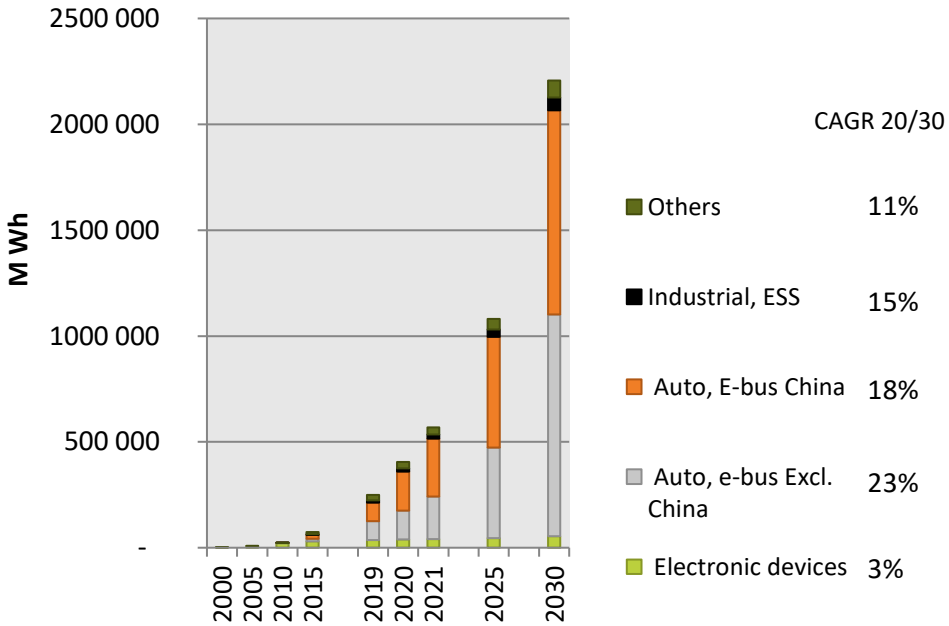
LI-ION BATTERY MARKET FORECASTS

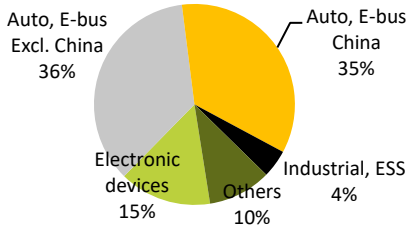
From 250 GWh in 2020 to 2,2 TWh

CAGR 2020/2030
+18 % per year in Volume

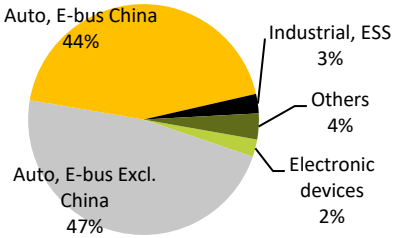
Li-ion Battery sales, MWh, Worldwide, 2000-2030



2020: 250 GWh



2030: 2200 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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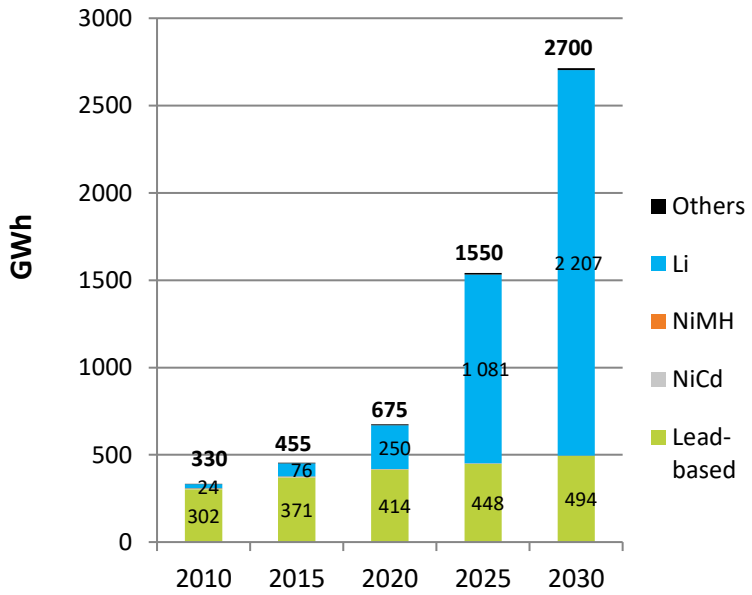
BATTERY MARKET 2010-2030

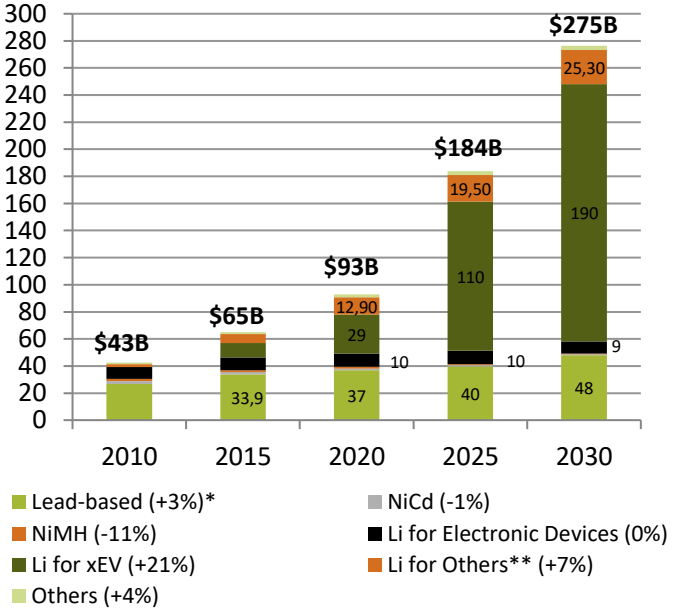
Lead-based and Li-ion batteries will remain the most important markets



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

Source: AVICENNE Energy 2022

Market value will reach $275b in 2030 – Pack level(1) - $CAGR_{20-30}$: +12%



* CAGR 2020-2030

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

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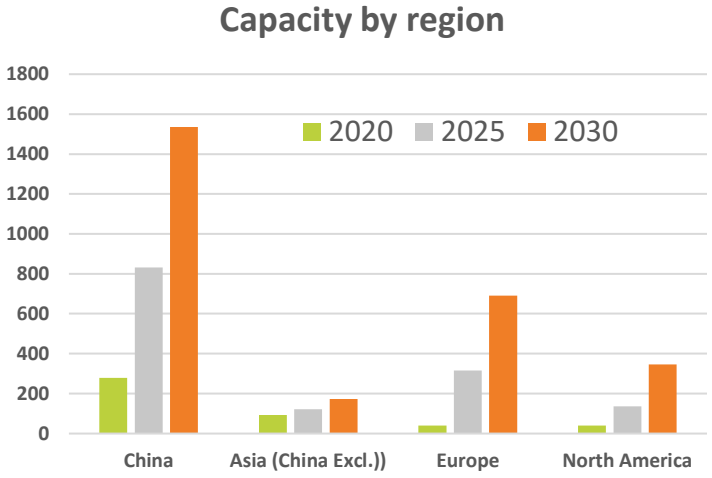
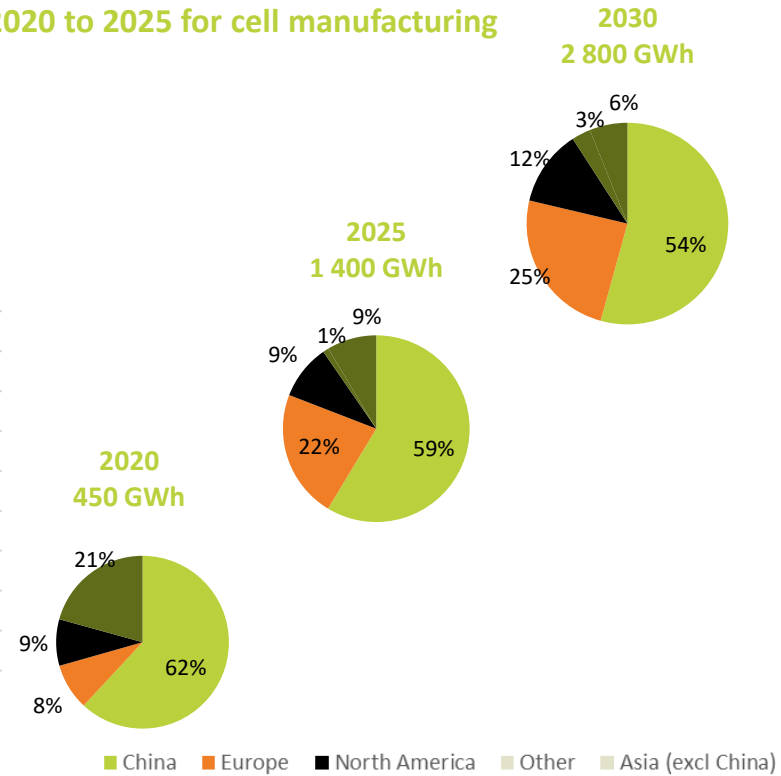
PRODUCTION CAPACITY FORECAST

In Europe, capacity should increase from few GWh before 2020 to +300 GWh in 2025

15 to 18 billion Euros investment required from 2020 to 2025 for cell manufacturing (Capex: ~ 50 - 60 € / kWh)





Source: AVICENNE ENERGY, 2022

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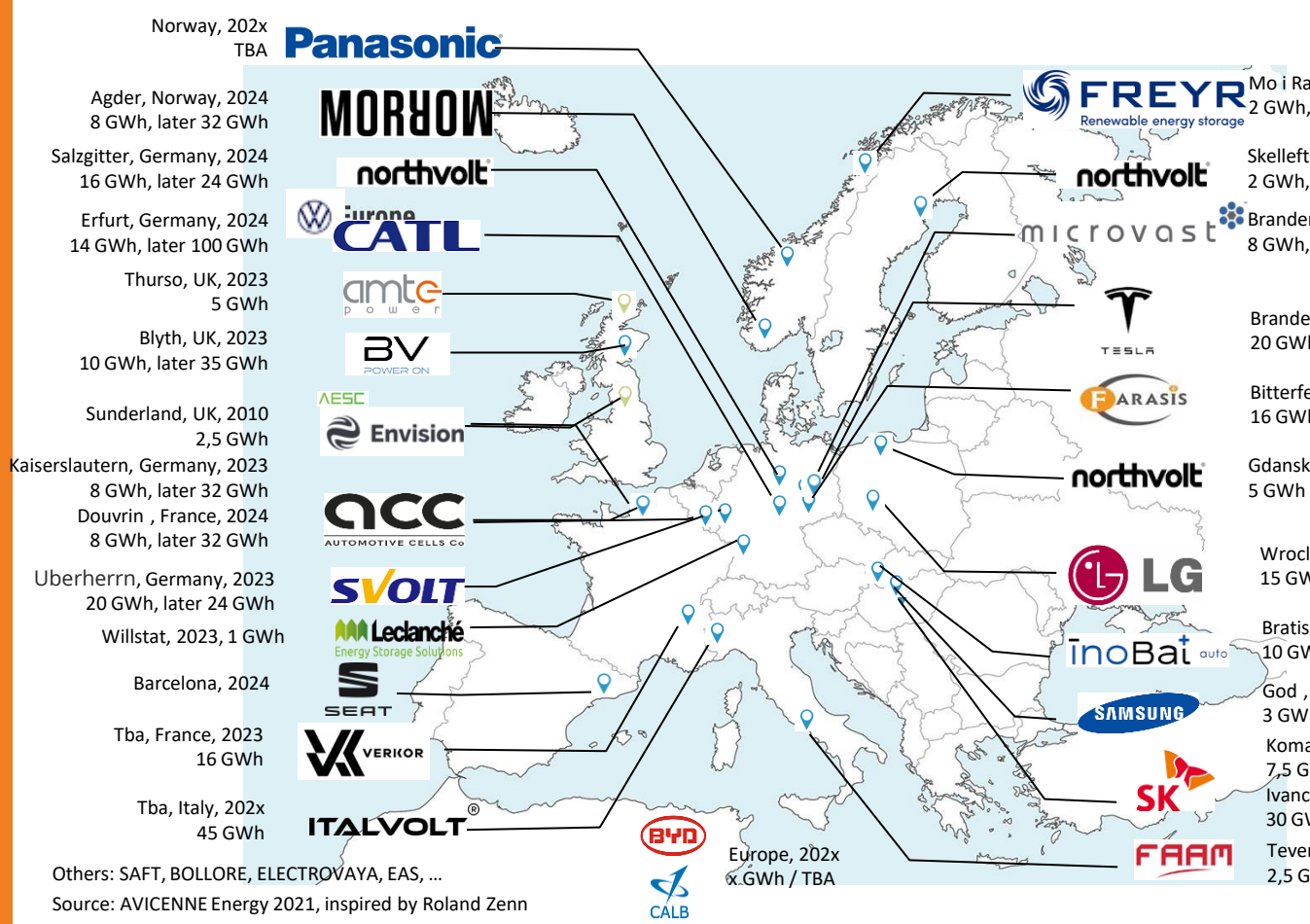
EUROPE PRODUCTION CAPACITY: FROM SEVERAL GWH IN 2020 TO 300 GWH IN 2025 & 700 GWH IN 2030



Source: AVICENNE Energy 2021, inspired by Roland Zenn

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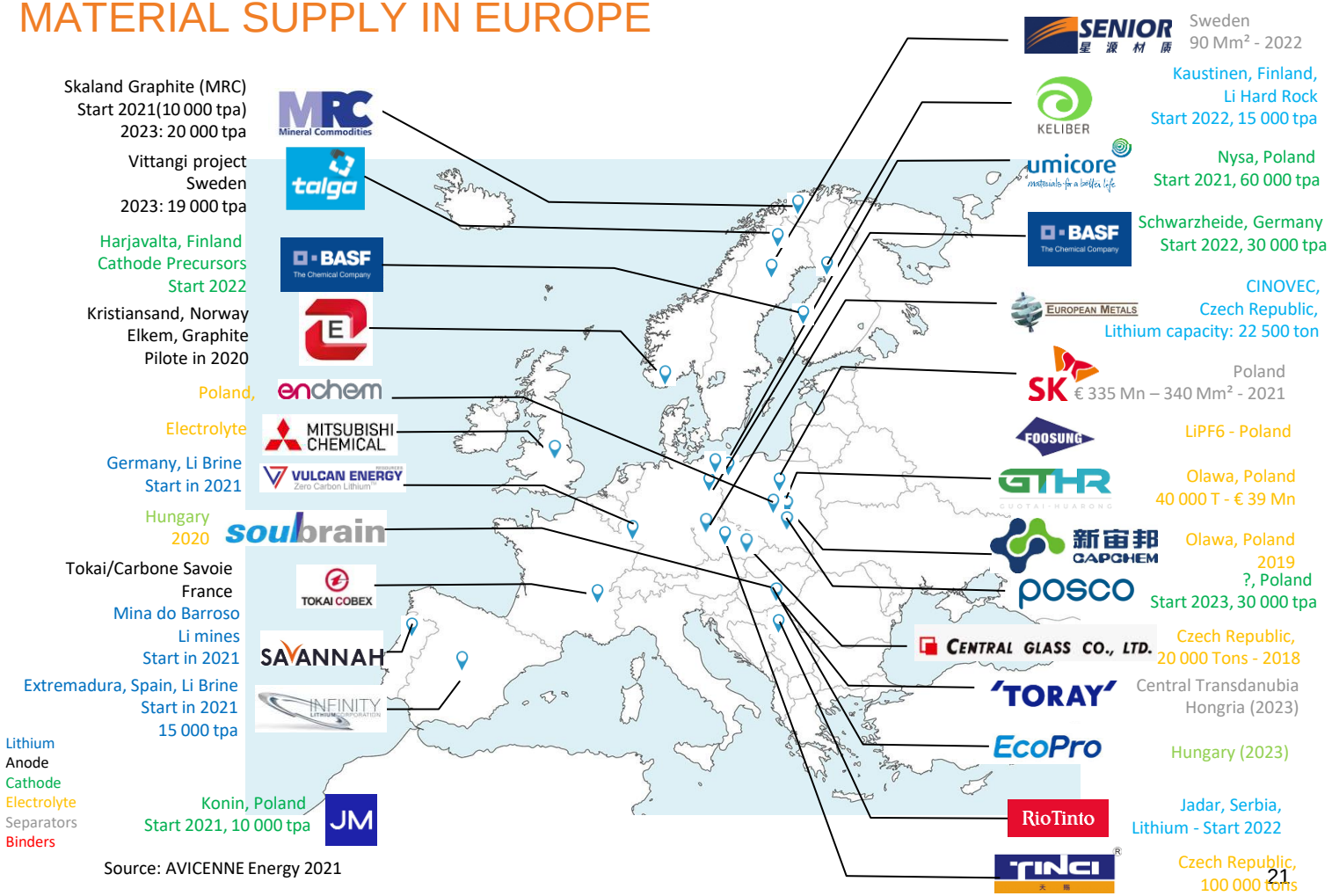
MATERIAL SUPPLY IN EUROPE



Source: AVICENNE Energy 2021

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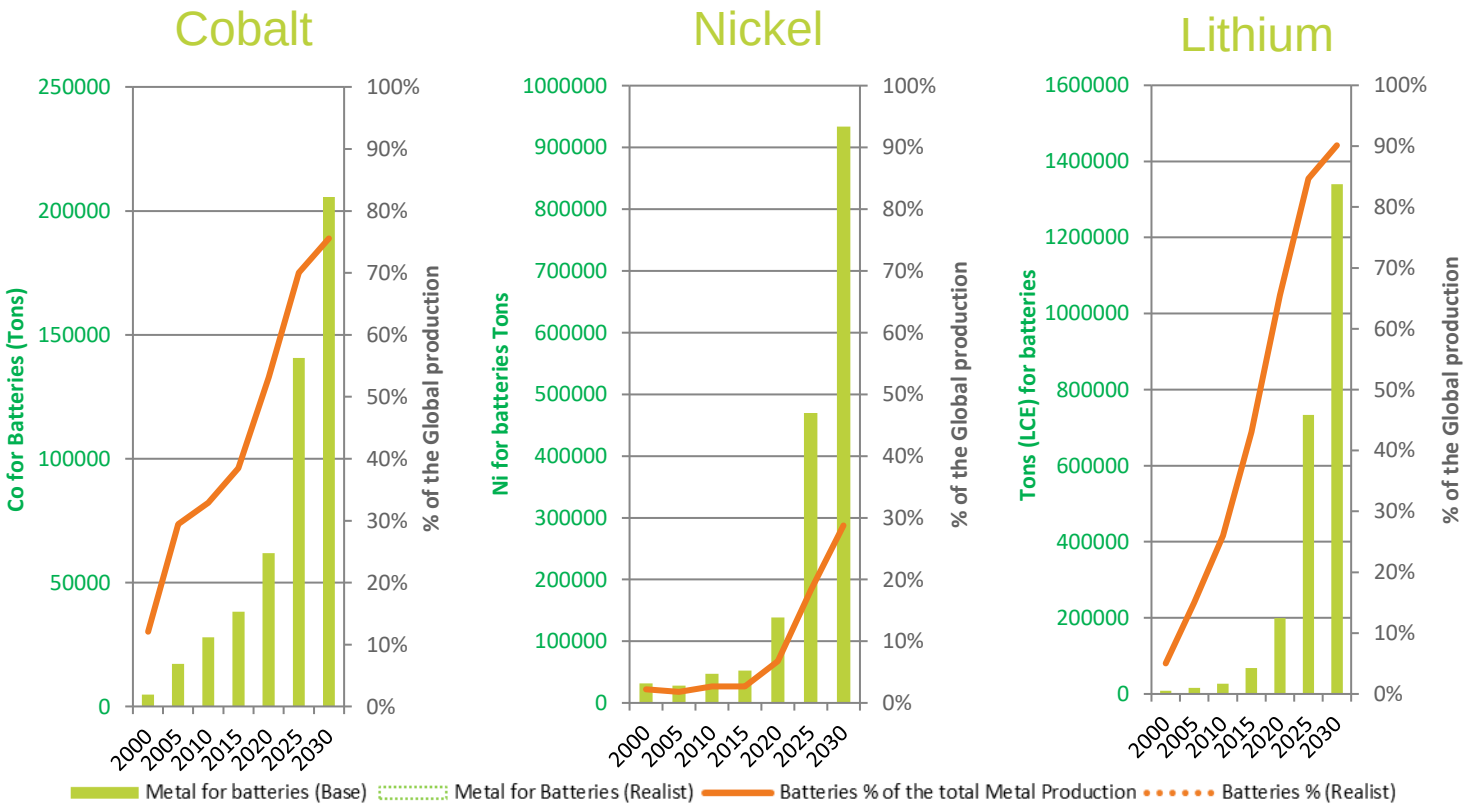
METAL NEEDS FOR RECHARGEABLE BATTERY WILL INCREASE RAPIDLY



Sources: AVICENNE ENERGY 2022

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The Rechargeable battery market and main trends 2020-2030

January 2022

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LITHIUM ION BATTERY RECYCLING

Assumptions

End Of Life battery – Assumptions

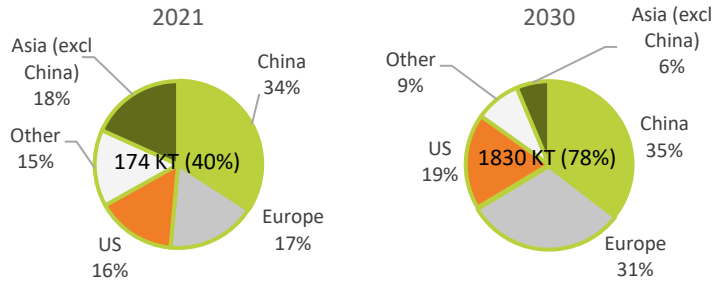
- **Warranty/ Recall**: a conservative 2% is considered of battery packs either tested at the manufacturer or placed on the market that may have performance problems and should be recycled
- **End of Life:** of batteries put on the market before recycling includes possible second-hand use and the collection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

Scrap

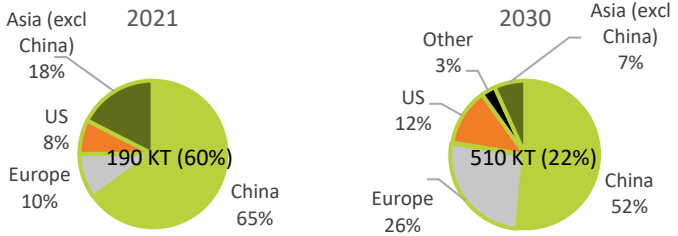
- **Production Scrap** : composed on the one hand of electrode cutting scrap which is incompressible by a few percent and on the other hand of process capability by the various producers
- **Scrap Rate**: in total, the best-in-class could reach 5%, whereas during the start-up phases, the rate can exceed 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 174 KT in 2021 – 1830 kT in 2030



Scrap: 190 KT in 2021 – 510 KT in 2030



In 2030 metal from recycling could account for 15 to 20% of the metal needs to produce Li-ion batteries

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THANK YOU

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