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Athens, June 2023

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# The rechargeable battery market and main trends 2022-2030

**Christophe PILLOT**

Director, AVICENNE ENERGY

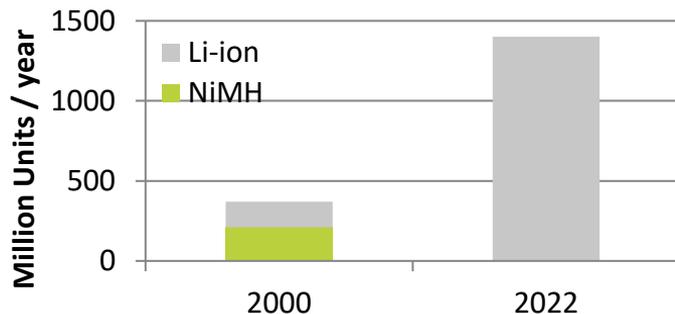
**Presentation Outline**

- The rechargeable battery market in 2022
- Focus on xEV market
- xEV Forecasts
- Impact of recycling on raw material supply
- Conclusions

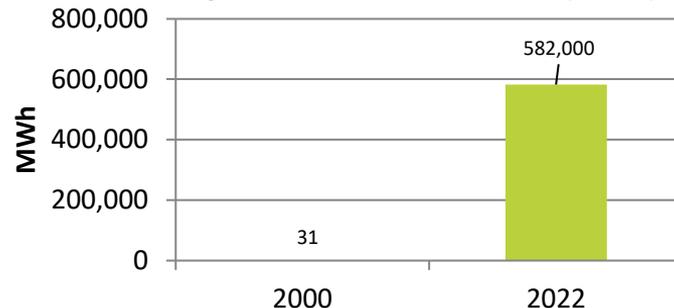


# THE BATTERY MARKET IS REALLY DYNAMIC

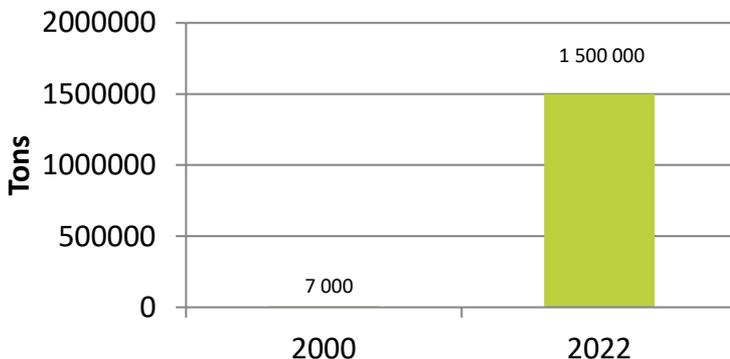
Cellular Phones sold per Year (Million)



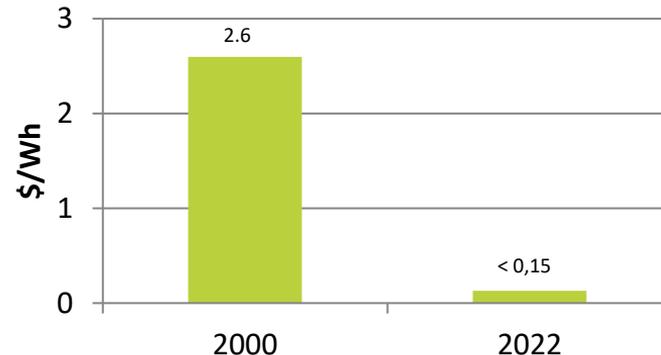
Battery demand for xEV, E-Buses (MWh)



Tons of cathode active materials



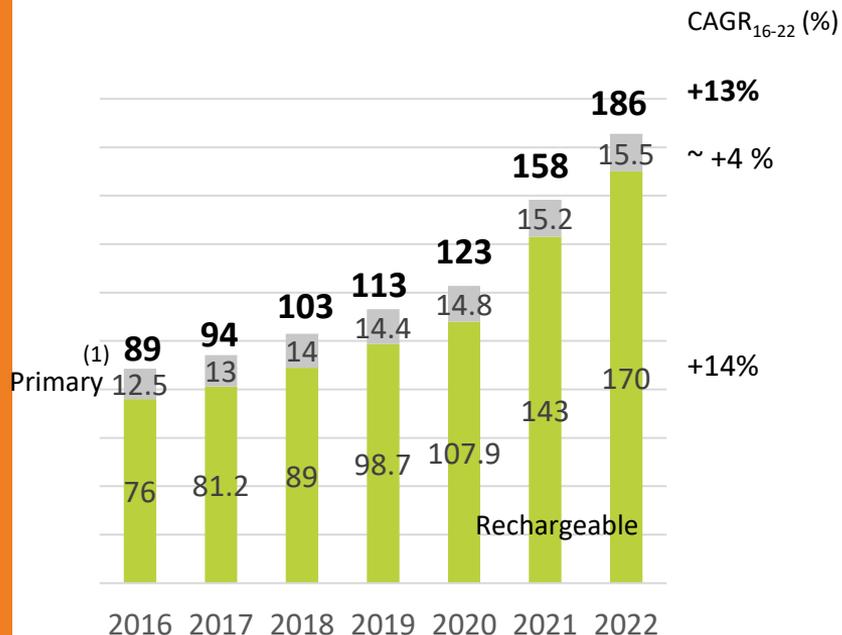
Li-ion 18650 cell price (\$/Wh)





# WORLDWIDE BATTERY MARKET OVERVIEW

Battery market in value 2016-2022, 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<sub>2</sub> 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

# THE WORLDWIDE BATTERY MARKET 1990-2022

Lithium-Ion Battery: Highest growth & major part of the investments  
Lead acid batteries: 43% market share in volume

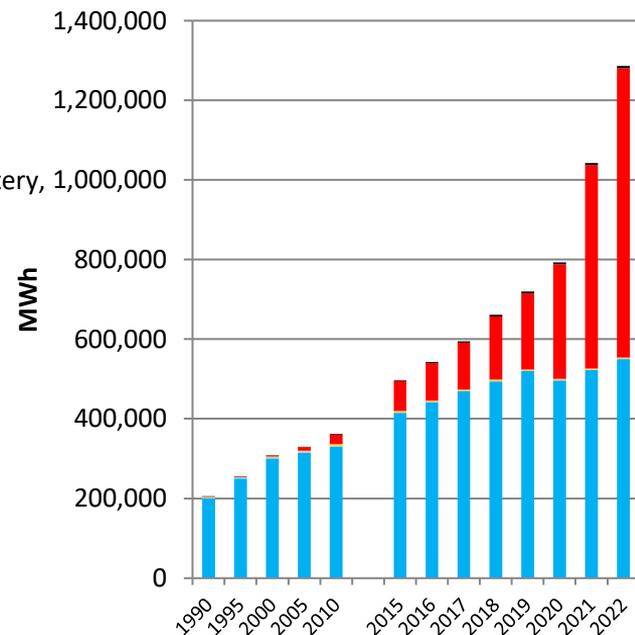
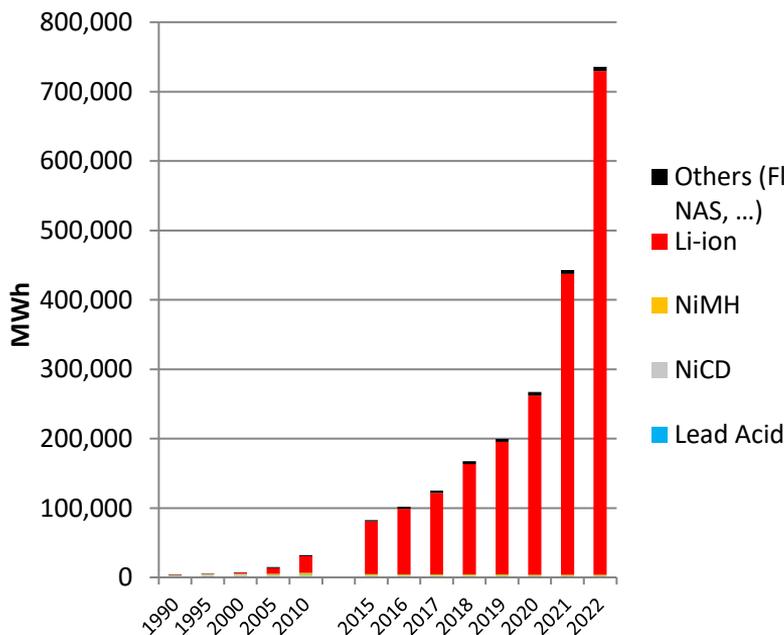
The Rechargeable battery  
market and main trends  
2022-2030



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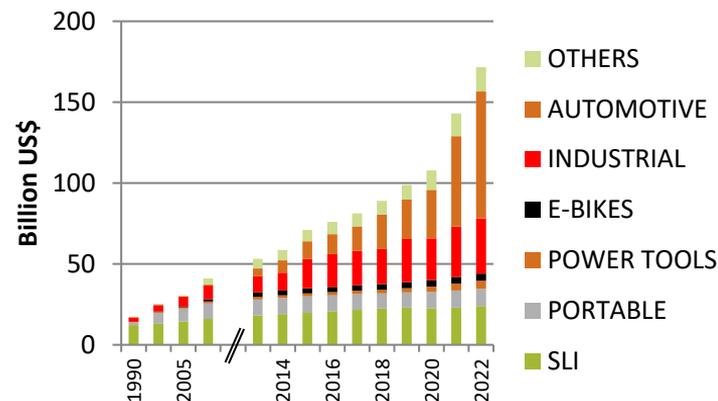
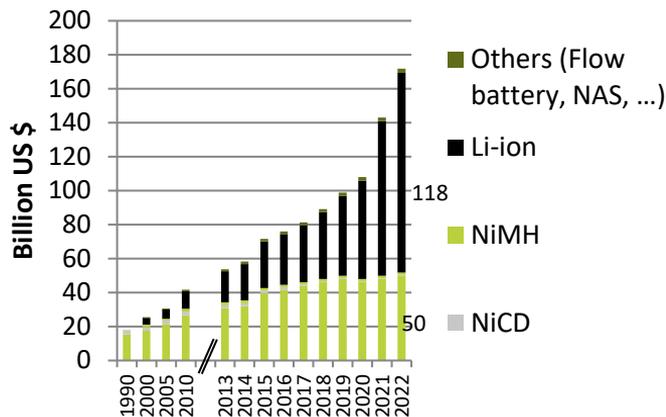


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# THE WORLDWIDE BATTERY MARKET 1990-2022

> 170 BILLION US\$ in 2022 – Pack level<sup>1</sup>

12,5% AVERAGE GROWTH PER YEAR (2010-2022)



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

PORTABLE: consumer electronics (cellular, portable PCs, tablets, 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, 2023

INDUSTRIAL

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

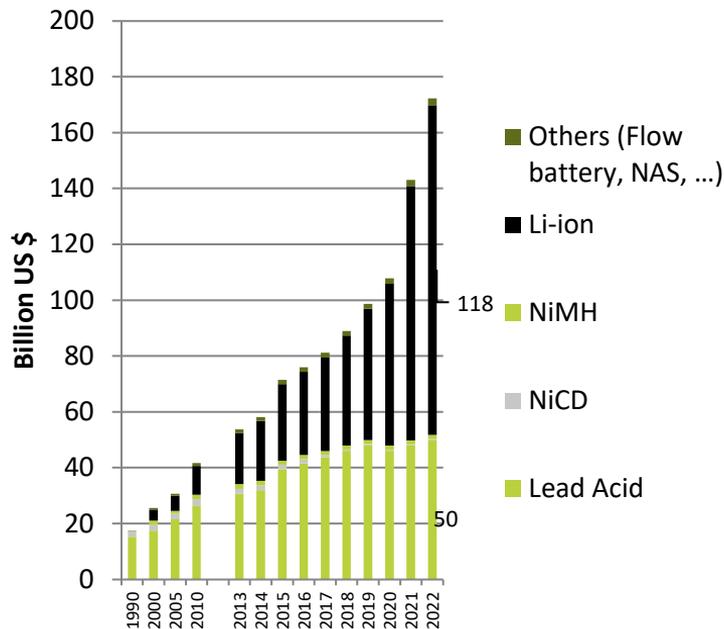
AUTOMOTIVE: HEV, P-HEV, EV

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, ...

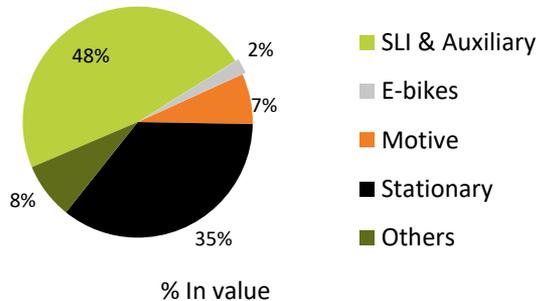


# THE WORLDWIDE BATTERY MARKET 1990-2022

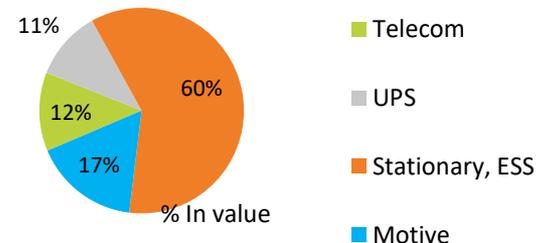
In Value (US\$ Bn)



Lead Acid Batteries 2022  
550 GWh for US\$ ≈50 Bn



Industrial Batteries – Lead Acid Batteries  
195 GWh for US\$ 21 Bn



# LI-ION BATTERY MARKET 2022, EV, E-BUSES & E-TRUCKS ACCOUNT FOR 80%

>725 000 MWh - > 118 B\$ (1)

CAGR 2015/2022  
+37 % per year in Volume

The Rechargeable battery market and main trends  
2022-2030

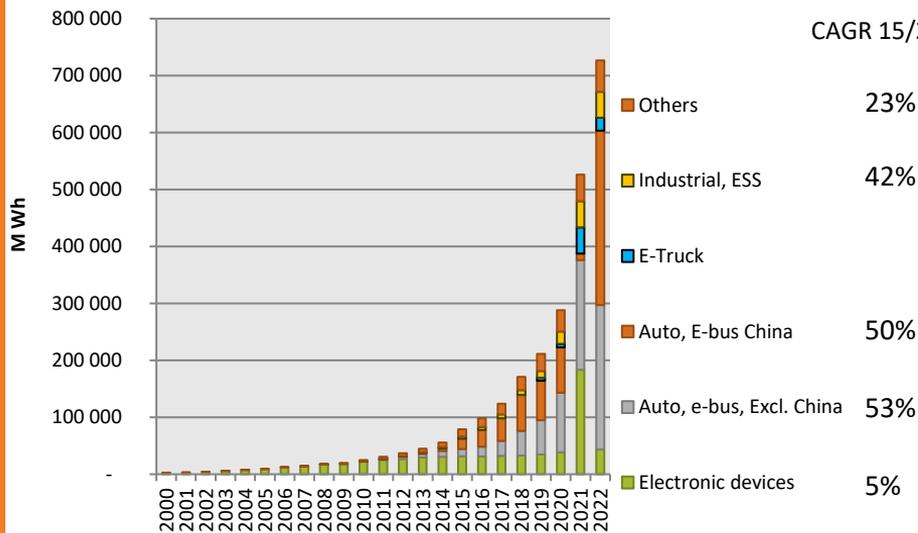


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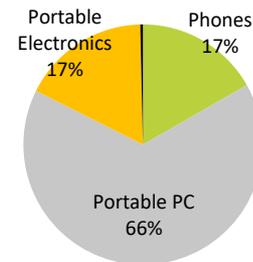
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Li-ion Battery sales,  
MWh, Worldwide, 2000-2022

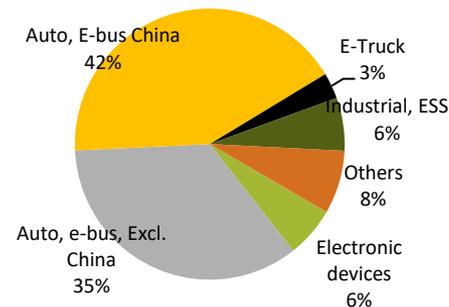


(1) Pack level  
Others: medical devices, power tools, gardening tools, e-bikes...  
Source: AVICENNE Energy 2023

2000: < 2GWh



2022:>720 GWh





# BATTERY MARKET FORECASTS 2020-2030

## Applications covered

- 🔋 Vehicles: HEV, P-HEV, EV, Start stop, 48v
- 🔋 Low Speed EV
- 🔋 Electronic devices
  - 🔋 Portable PCs, net-book
  - 🔋 Cellular Phones, Smartphones
  - 🔋 Tablets
  - 🔋 Camcorders
  - 🔋 Digital Camera
  - 🔋 Games, MP3
  - 🔋 Cordless Phones
  - 🔋 Shavers, Toothbrush,
  - 🔋 RC Cars
- 🔋 Drones
- 🔋 Cordless Tools, Gardening tools
- 🔋 E-bikes
- 🔋 Hoverboard
- 🔋 Security lighting
- 🔋 Energy Storage Systems
- 🔋 Other Non Portable applications
  - 🔋 Motive (forklift)
  - 🔋 Stationary (ESS, UPS, Telecom, medical...

## 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

# FEW COMMENTS BEFORE MAKING FORECASTS

🕒 The Moore's Law 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 delay this market



# X-EV MARKET

## X-EV worldwide in 2022

- > 580 GWh
- CAGR<sub>2021-2022</sub> : 50%
- Main cell suppliers: CATL, LG,
- Chemistries: NMC hi Ni, NCA, LFP

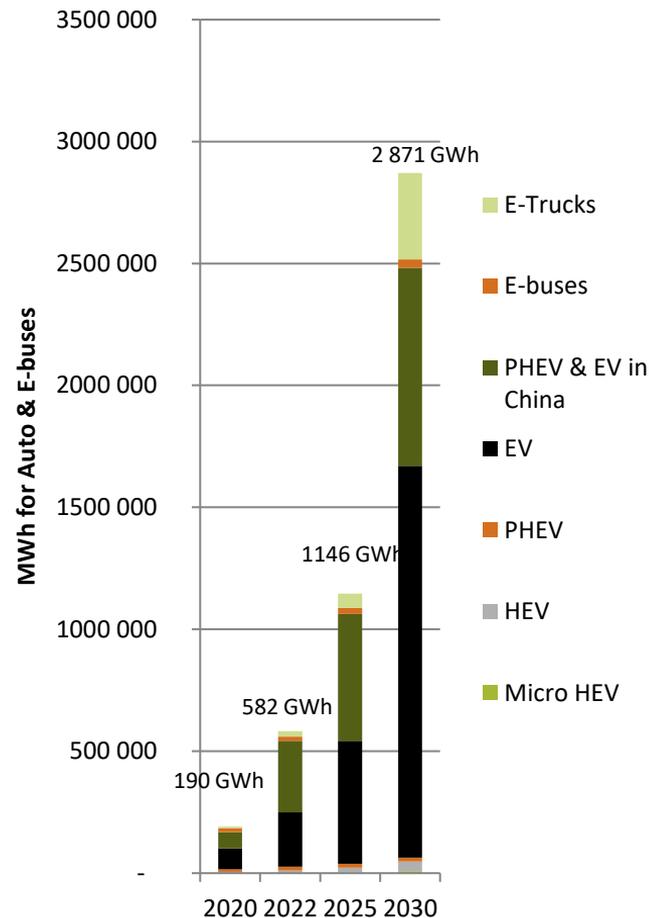
## X-EV forecasts

- ~30% - 35% EV and PHEV sold per year in 2030
- ~ 1,1 TWh in 2025 & 2,9 TWh in 2030
- CAGR<sub>2020-2030</sub>: > 30%

M of cars	China			EU, US, Others			World		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
HEV				4,7	10,5	16,8	4,7	10,5	16,8
P-HEV	0,24	2,1	3,1	0,7	1,1	1,1	0,9	3,2	4,2
EV	1,1	6,6	10	1,2	5,4	14	2,3	12,0	24

Source: AVICENNE ENERGY Analyses 2023

CAGR 2020-2030: +31%



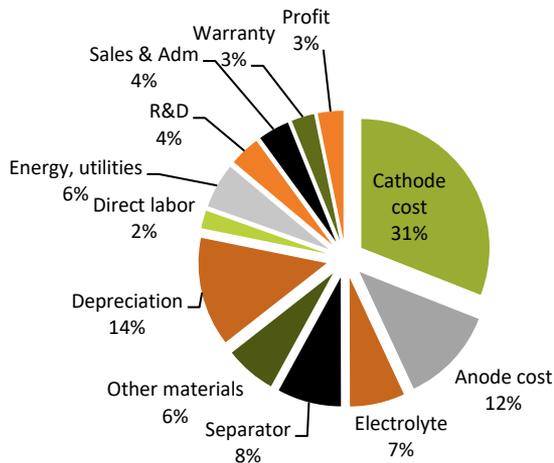


# LIB: THE BIGGEST PART OF THE PRICE IS RAW MATERIALS

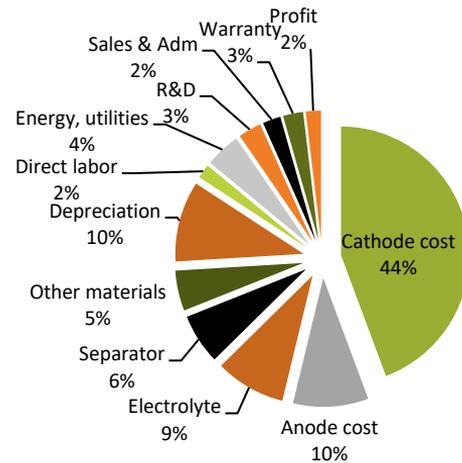
RAW MATERIALS ACCOUNT FOR 60 TO 70% OF LIB CELLS BUSINESS

RAW MATERIAL COST IMPACT DRASTICALLY ON THE BATTERY MAKERS PROFIT

**Average price structure of Li-ion cell – 65 Ah  
NMC 622 pouch cells in 2021 – 125\$/kWh**



**Average price structure of Li-ion cell – 65 Ah  
NMC 622 pouch cells in 2022 – 160 \$/kWh**

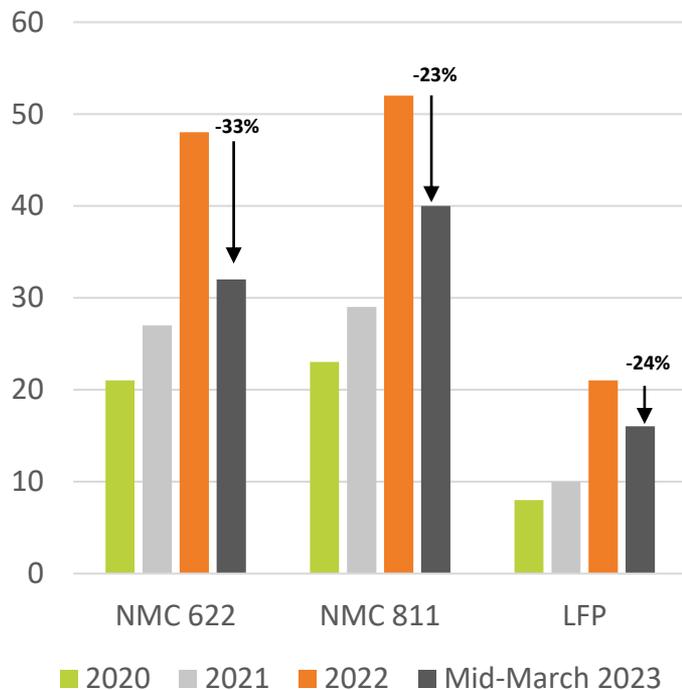




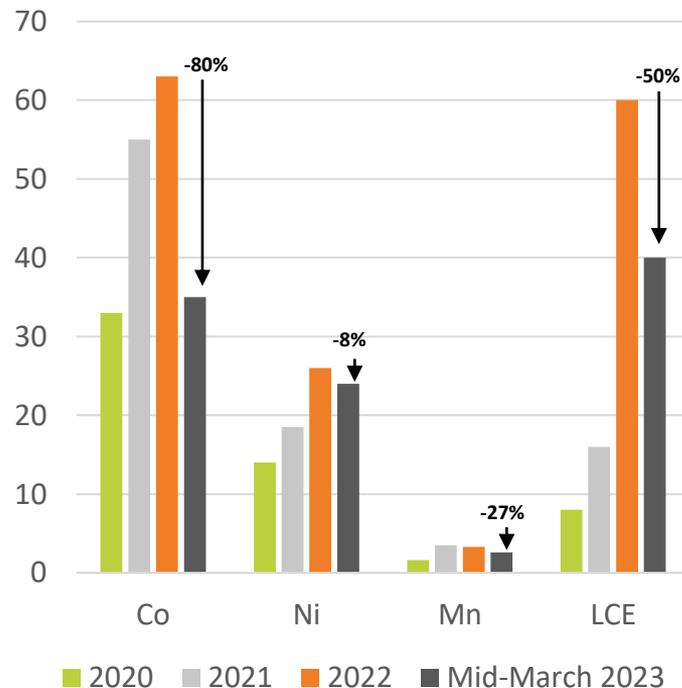
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# AVERAGE PRICE EVOLUTION 2020 => 2022

## Cathode active Material \$/kg



## Metal \$/kg

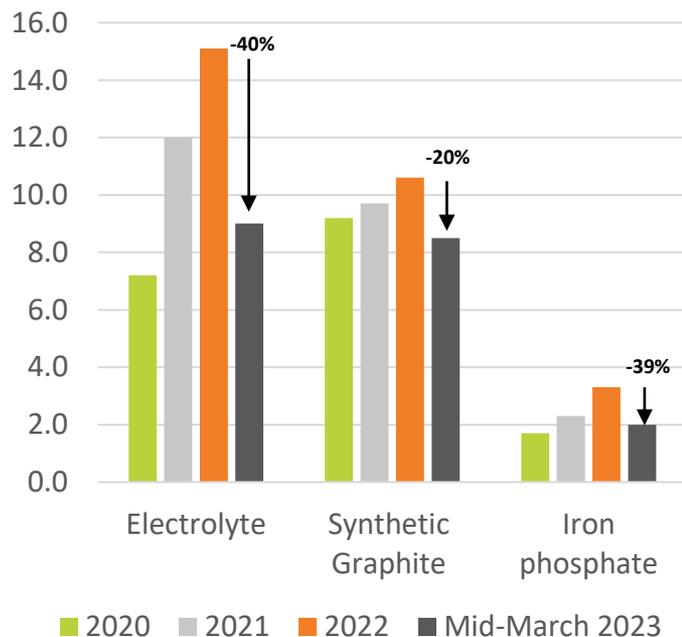




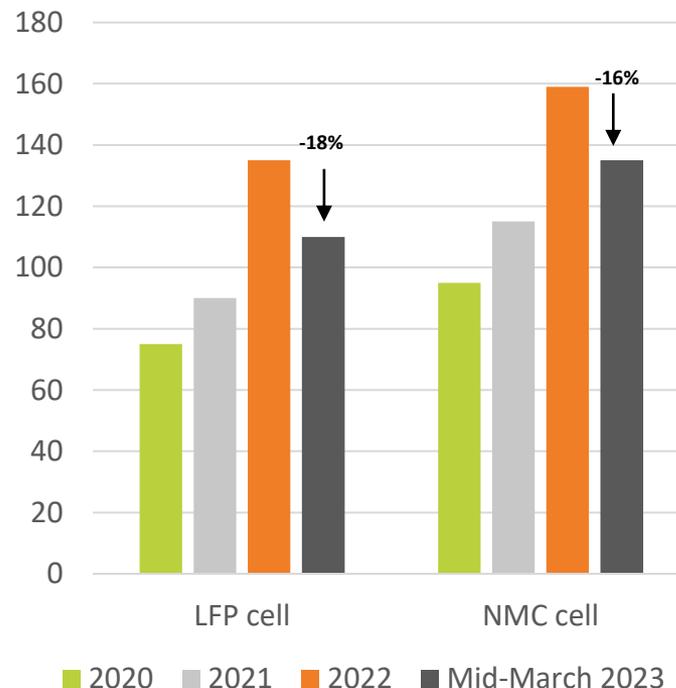
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# AVERAGE PRICE EVOLUTION 2020 => 2022

## Electrolyte, Synthetic graphite & Iron phosphate (\$/kg)



## Cell \$/kWh



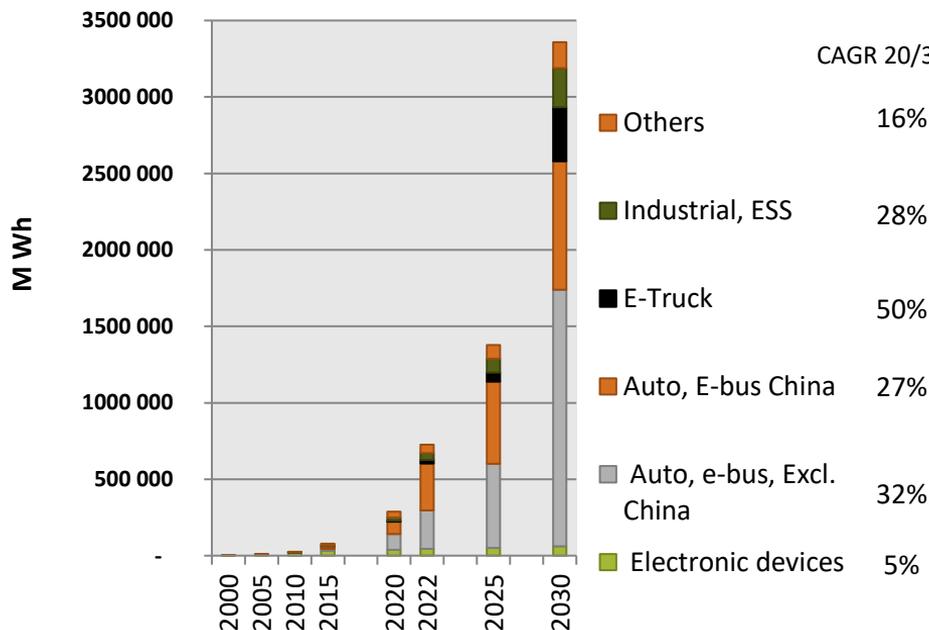


# LI-ION BATTERY MARKET FORECASTS

From 285 GWh in 2020 to 3,36 TWh in 2030

**CAGR 2020/2030**  
**+28% per year in Volume**

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



CAGR 20/30

16%

28%

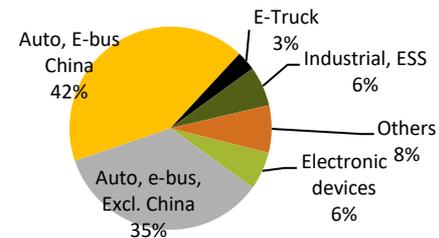
50%

27%

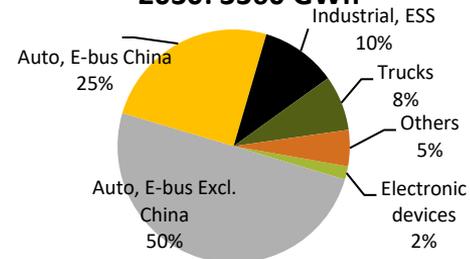
32%

5%

**2022: 725 GWh**



**2030: 3360 GWh**



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

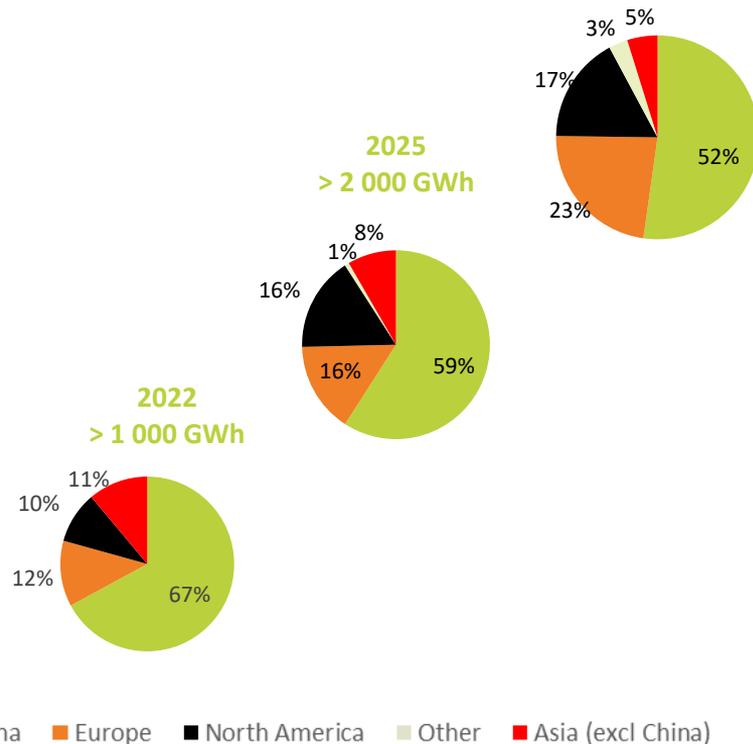
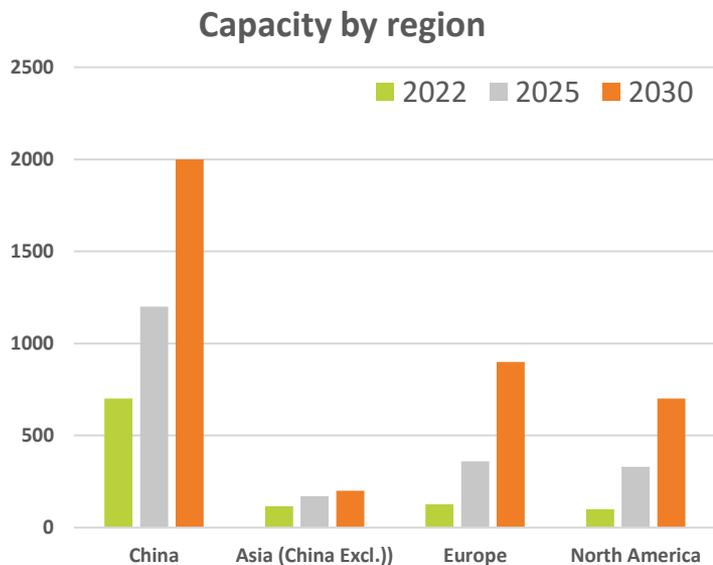
Source: Avicenne Energy 2023



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# PRODUCTION CAPACITY OUTSIDE ASIA WILL REACH 1,8 TWH IN 2030 (40%)

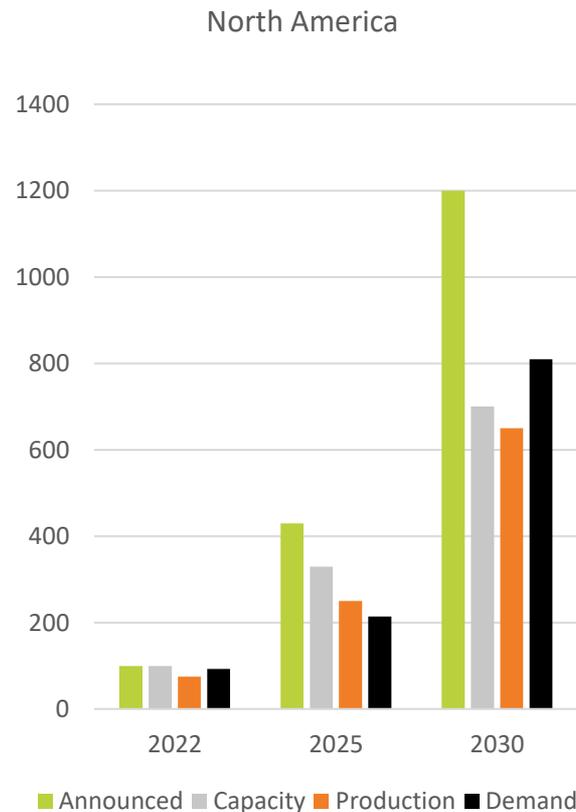
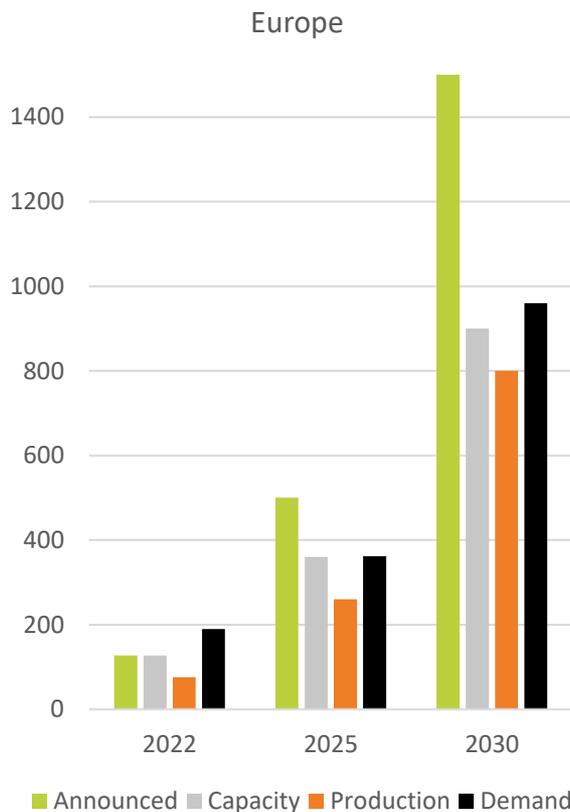
In North America, capacity should increase from few GWh before 2020 to +300 GWh in 2025  
15 to 20 billion US\$ investment required from 2020 to 2025 for cell manufacturing  
(Capex: ~ 50 - 70 \$ / kWh)



Source: AVICENNE ENERGY, 2023



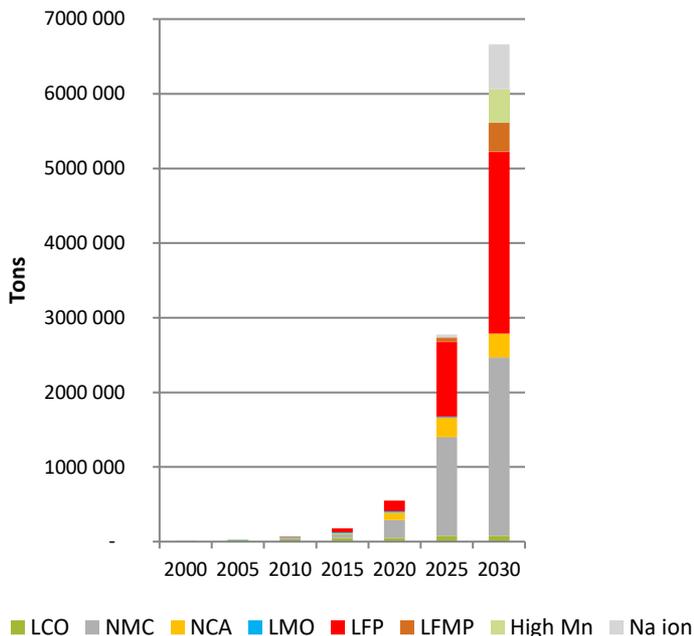
# LIB DEMAND & SUPPLY 2022-2030 (GWH)





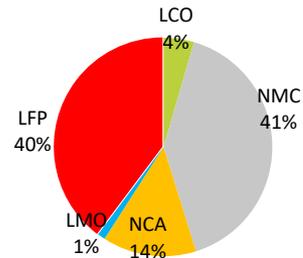
# CATHODE ACTIVE MATERIAL DEMAND 2030 FORECASTS

## Cathode active materials 2000-2030 - Tons

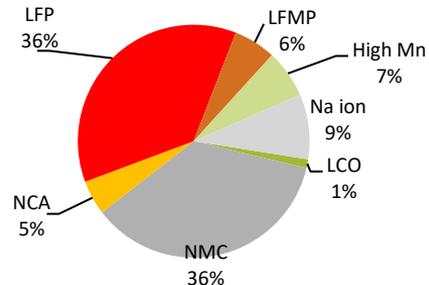


Sources: AVICENNE ENERGY 2023

## Cathode active materials in 2022 > 1 500 000 Tons



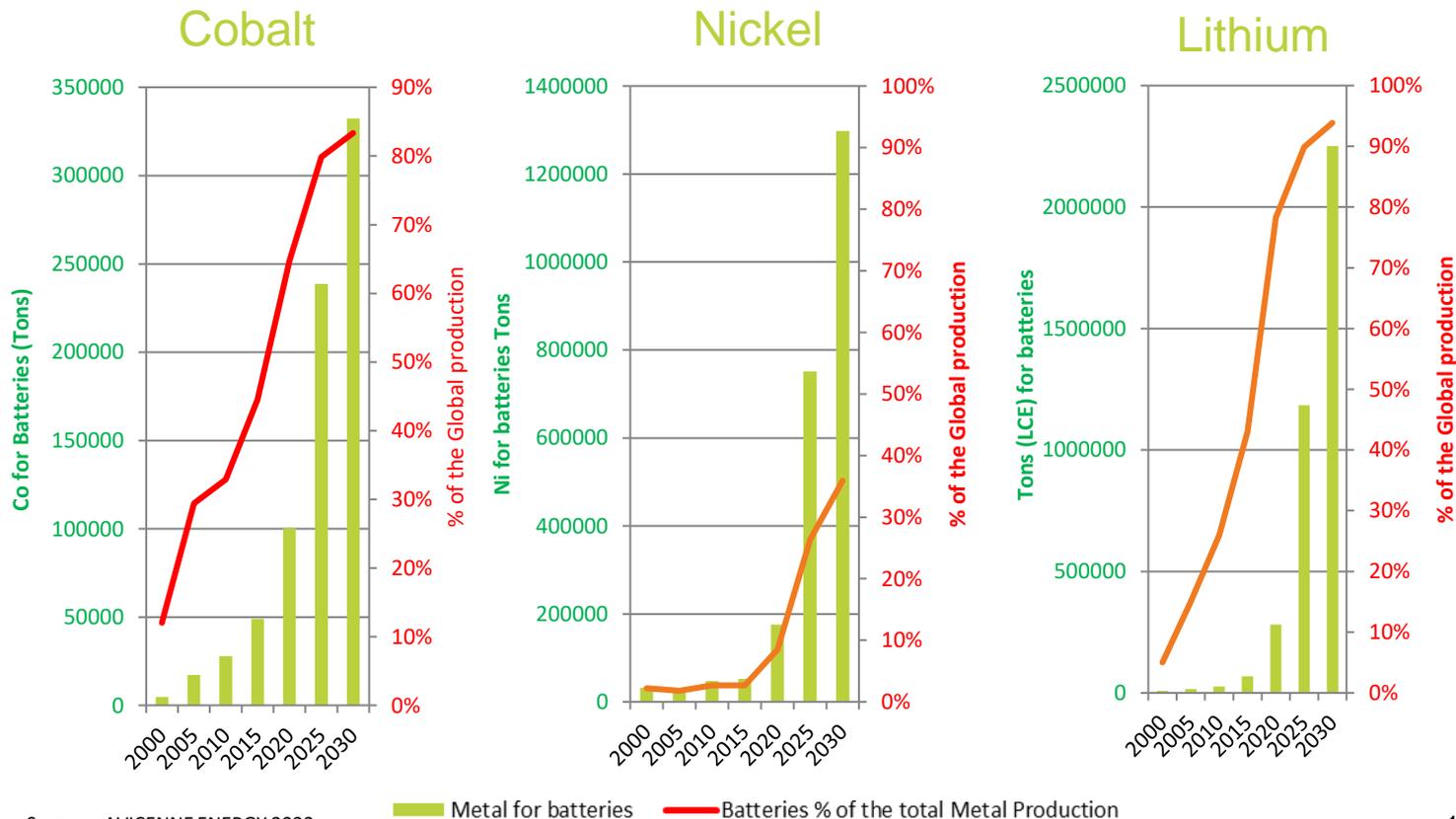
## Cathode active materials in 2030 > 6 600 000 Tons





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# METAL NEEDS FOR RECHARGEABLE BATTERY WILL INCREASE RAPIDLY



Sources: AVICENNE ENERGY 2023

# LITHIUM ION BATTERY RECYCLING: 3 000 KT IN 2030

## Assumptions

### End Of Life battery – Assumptions

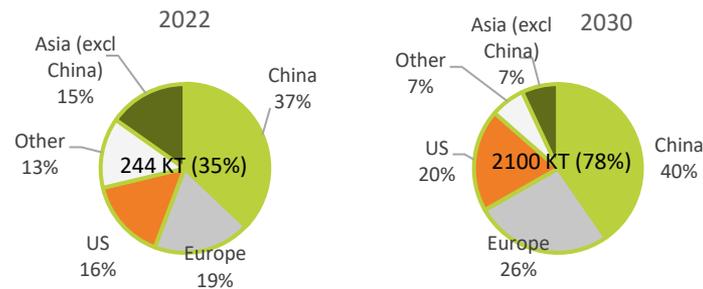
- Warranty/ Recall: a conservative 2% is considered of battery packs either tested at the manufacturer or placed on the market that may have performance problems and should be recycled
- End of Life: of batteries put on the market before recycling includes possible second-hand use and the collection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

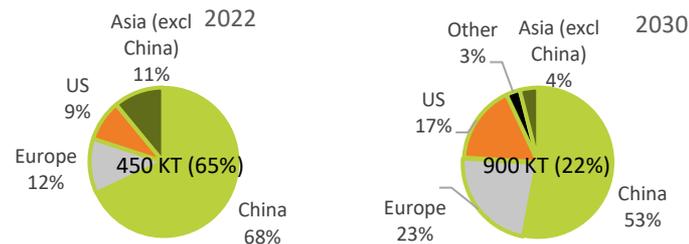
➔ In 2030 metal from recycling could account for 10-15% of the metal needs to produce Li-ion batteries

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

### End Of Life 244 KT in 2022 – > 2 100 kT in 2030



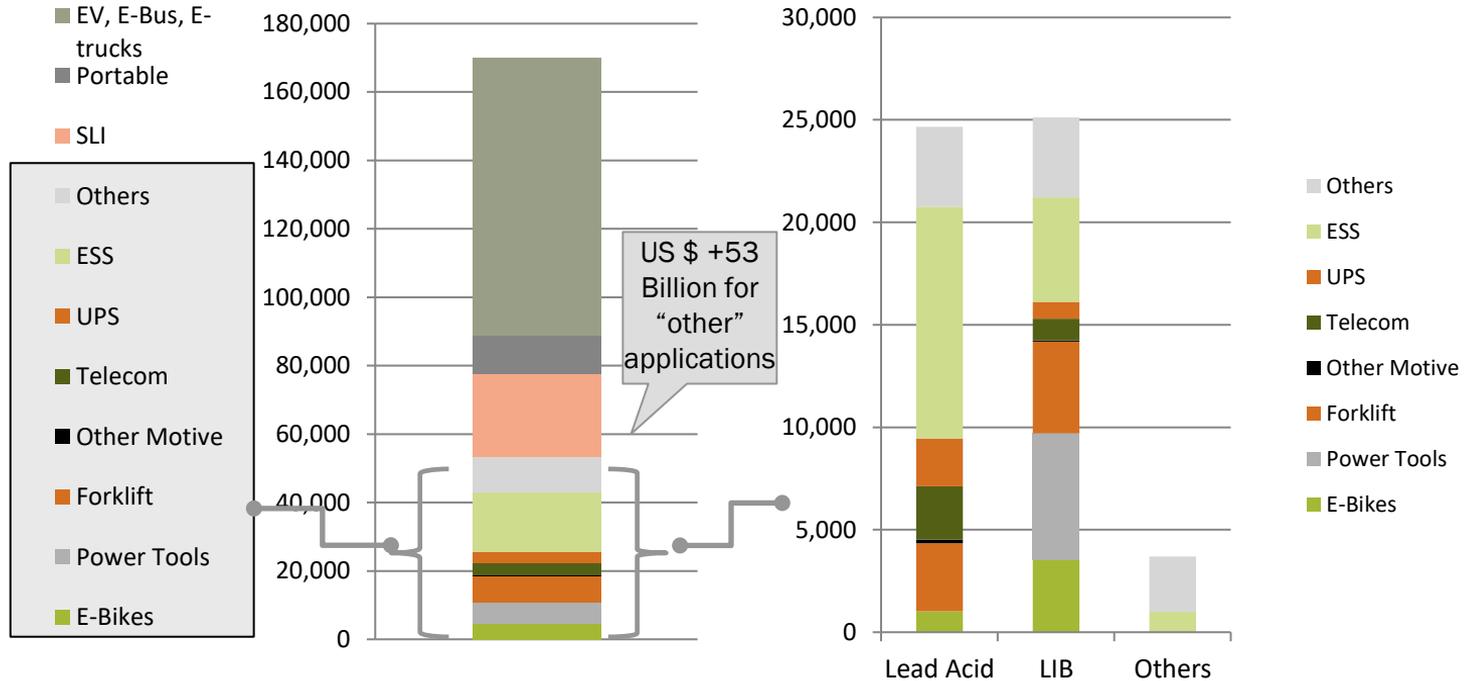
### Scrap: 450 KT in 2022 – 900 KT in 2030





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# THE WORLDWIDE BATTERY MARKET IN 2022: US \$ +170 BILLION



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



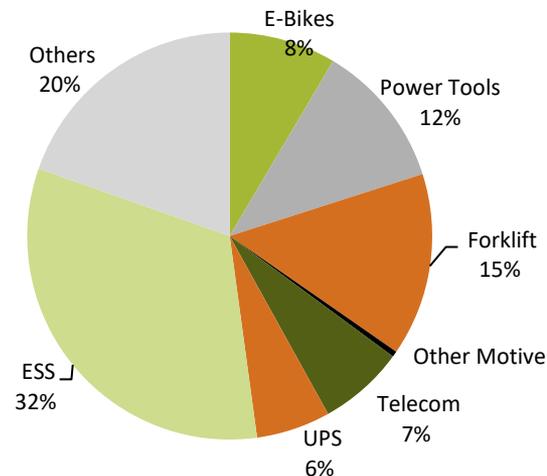
# “OTHERS” MARKET (M\$, PACK LEVEL<sup>1</sup>)

## Other Applications:

US\$ 53,5 Bn in 2022 (1)

All the app except PC, tablets, Phones, xEV, Buses,  
Trucks:

- E-bikes
- Power tools including gardening tools, cordless vacuum cleaner
- Forklift, Automatic handling equipments, industrial cleaners...
- Stationary including ESS, Telecom, UPS, Back-up
- Medical
- Marine
- Aviation
- Railways
- Others...



Source: AVICENNE ENERGY 2023



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

2- Other App: Military, aerospace, Oil & Gas, Railways, Aviation, Utility metering,...

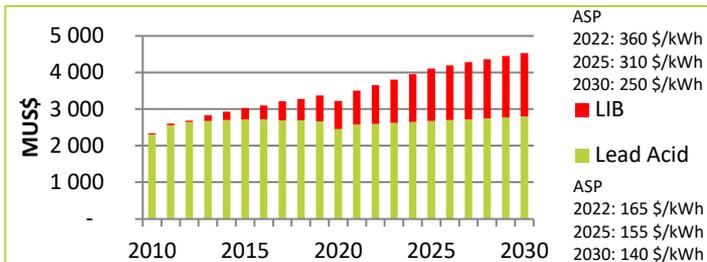


# STATIONARY: TELECOM MARKET

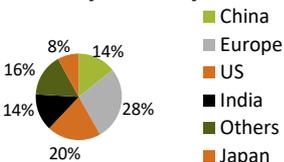
LAB: from US\$ 2,6 Billion in 2022 to 2,8 in 2030 – CAGR<sub>20-30</sub>: 1,3%

LIB: from US\$ 1,1 Billion in 2022 to 1,7 in 2030 – CAGR<sub>20-30</sub>: 8,4%

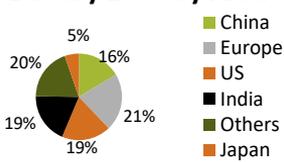
Market 2010-2030 (US\$, Million) – CAGR<sub>20-30</sub>: 3,5%



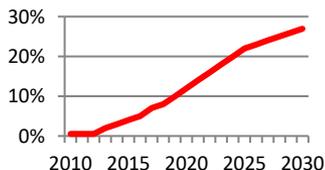
## Battery 2022 by Area



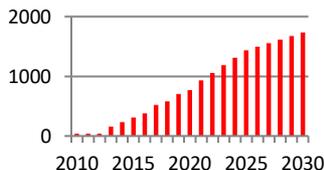
## Battery 2030 by Area



## LIB Penetration



## LIB market (M\$)



## Main drivers for LIB

- LIB developed for new equipment
- Increased bandwidth requirements
- Wireless market driving growth
- Strong network growth in China, India, E. Europe & S. America
- 4G -> 5G ... need new equipment
- LIB: **Especially in hot climates**

## Main restrictions for LIB

- Lead-acid vs Li-ion...
- Lead-acid capital cost 2-3 times cheaper
- Total cost of ownership could be compared with lead-acid

## Competitors

- Lead-acid and LIB: Enersys (35%), Exide (10%) and local suppliers in each country
- LIB systems: 'large companies': SAFT, others

## Customers

- Few customers: large telecom carriers in each country

## Battery needs

- Most important performances characteristic
  - High temperature performance
  - Customized for the new equipment network
- Average capacity: 5-10 kWh modules (100Ah)
- Frequency of use: Good network <15 cycles/year / bad network: 300 cycles/year <sup>(2)</sup>

## LIB needs

- Most valuable improvements
  - Capital costs
  - Safety
  - Reliability
- Customized batteries developed for new equipment



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The Rechargeable battery market and main trends 2022-2030



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Source: AVICENNE ENERGY Analysis 2023

Note: : (1) Pack level – (2) All the battery details in the Excel file



# MOTIVE INDUSTRIAL: FORKLIFTS<sup>1</sup>



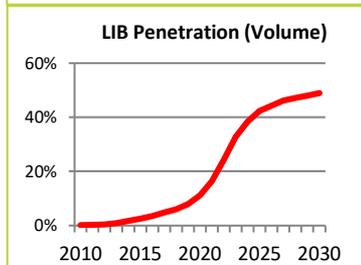
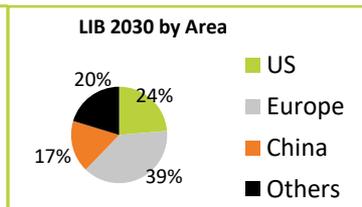
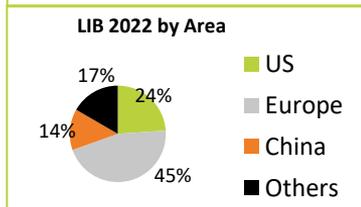
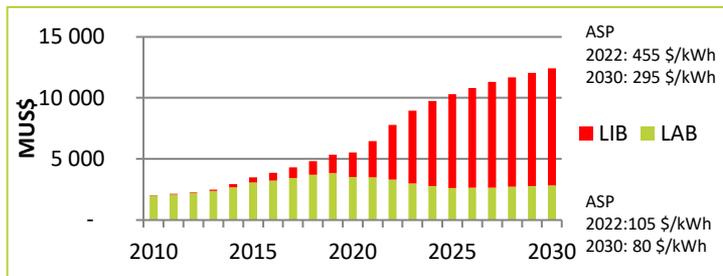
LIB: from US\$ 4,5 Billion in 2022 to 9,6 in 2030 - CAGR<sub>20-30</sub>: 17%

LAB: from US\$ 3,3 Billion in 2022 to 2,8 in 2030 - CAGR<sub>20-30</sub>: -2%

Market 2010-2030 (US \$, Million) – CAGR<sub>20-30</sub>: 8%

Main drivers for LIB

Main restrictions for LIB



- Where economies are healthy, they reflect strong motive power production
- Europe and US have high E-forklift ratio compare to Asia
- LIB higher lifetime (\* 3 to 5)
- Multiple shift operation where battery change is required (time consuming)

- Low penetration of E-forklift in Asia
- High LIB capital price (x 5 compare to lead acid)
- Safety concerns
- In two of the lift truck types, sit-down rider and high reach, the counterbalance for the lift truck is supplied mainly by a lead-acid battery

- Competitors**
- Lead Acid & LIB: Enersys (>25%), Sunlight (n<sup>2</sup>), Exide (10%), East Penn (10%), Hoppecke (10%), Crown (10%)
  - LIB systems: BMZ, Triathlon, Lithium Balance, ...

- Customers**
- For lead-acid, aftermarket represents 40% of the market: lot of different customers (industrials)
- For LIB, OEM Forklift: TOYOTA, Kion, Jungheinrich, NACCO, Crown, Mitsubishi Caterpillar ...

- Battery needs**
- Important characteristics
    - High charge/discharge rates and capacity
    - Long lifetime, range,
  - Average Capacity per pack in 2022: 22,7 kWh

- LIB needs**
- Most valuable improvements
    - Price
    - Convince customers on "total cost of ownership"
  - Form factor: large format prismatic – size standardization

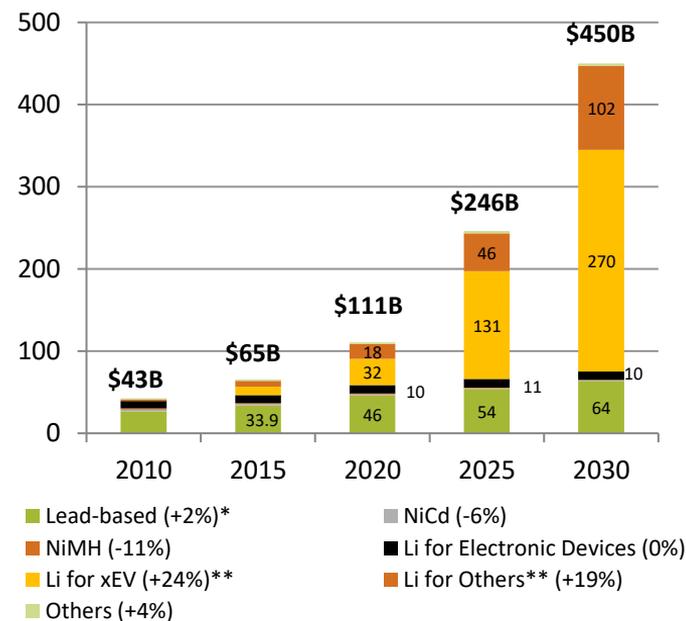
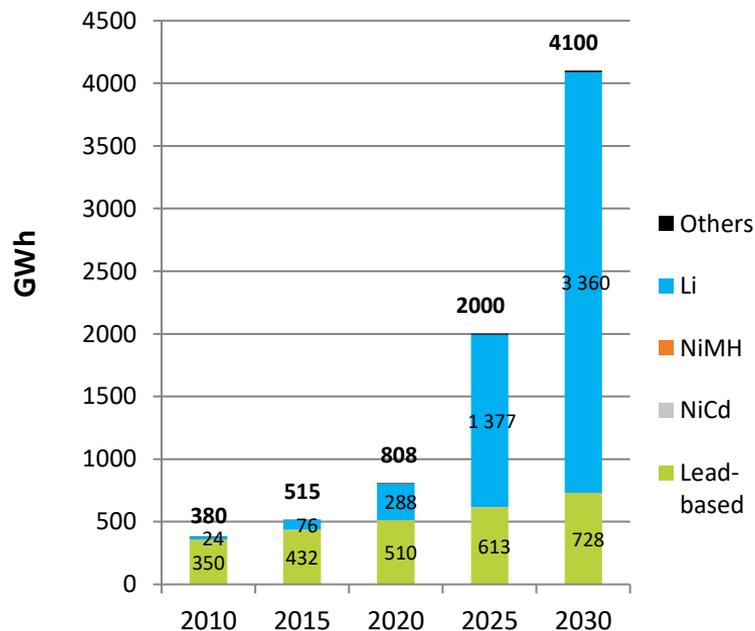


CONTACT

# TOTAL BATTERY MARKET WILL REACH +4 TWH & BN\$ >400 IN 2030

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

Market value will reach \$450 Bn in 2030 – Pack level<sup>(1)</sup> - CAGR<sub>20-30</sub>: +15%



\* CAGR 2020-2030

\*\* Li for xEV, e-bus, e-trucks

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

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

Source: AVICENNE Energy 2023



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CONTACT

# BATTERIES 2023

[www.batteriesevent.com](http://www.batteriesevent.com)

- 🕒 3 days congress in France (Lyon)
- 🕒 October 10–13, 2023
- 🕒 25<sup>th</sup> Edition (first edition in 1999)
- 🕒 +1 000 attendees
- 🕒 100 Booths  
Battery makers, raw materials suppliers, IC & BMS suppliers, tests, machining, coating,
- 🕒 +150 international speakers:  
Researchers, industrial process, marketing, financials,



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# THANK YOU



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The Rechargeable battery  
market and main trends  
2022-2030



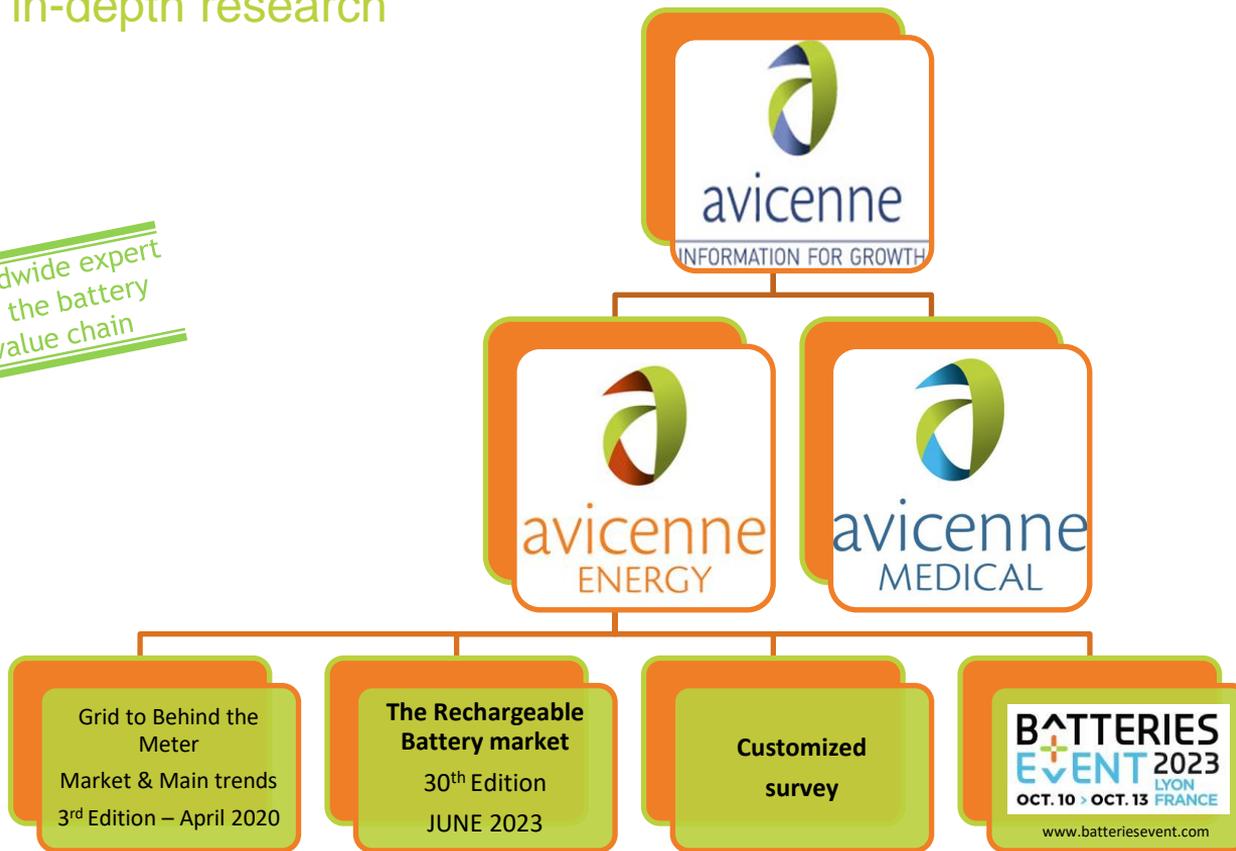
Athens, June 2023

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# AVICENNE PROFILE

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

Worldwide expert  
for the battery  
value chain



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# REFERENCES

More than 400 customers all over the world



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