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Lead Acid Battery

LEAD ACID BATTERY SYMPOSIUM
December 15th, 2022

Michael SANDERS

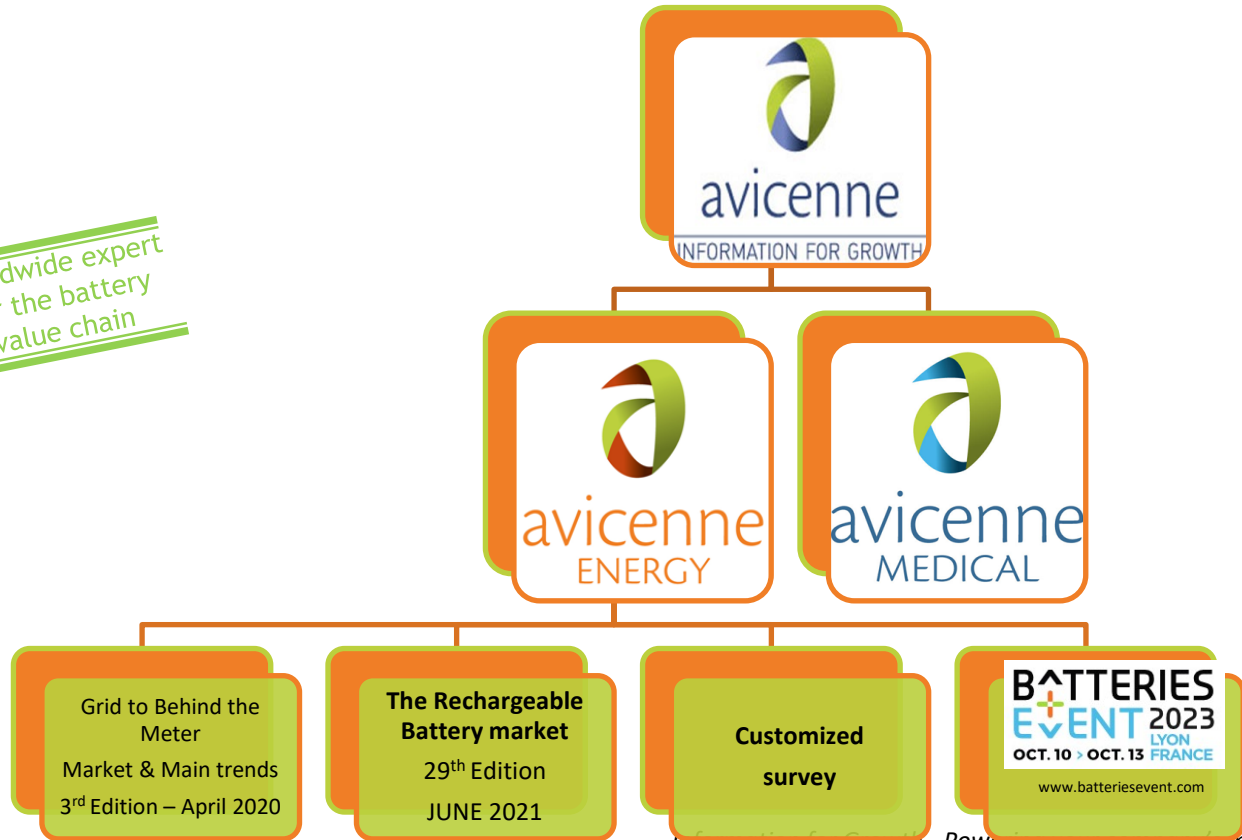
Senior Advisor, AVICENNE ENERGY

Presentation Outline

- Lead Acid Batteries – Market and Technology
- Rechargeable Battery Market
- Lead Acid Market and Segmentation
- Launching Technologies
- Conclusions

AVICENNE PROFILE

Worldwide expert
for the battery
value chain



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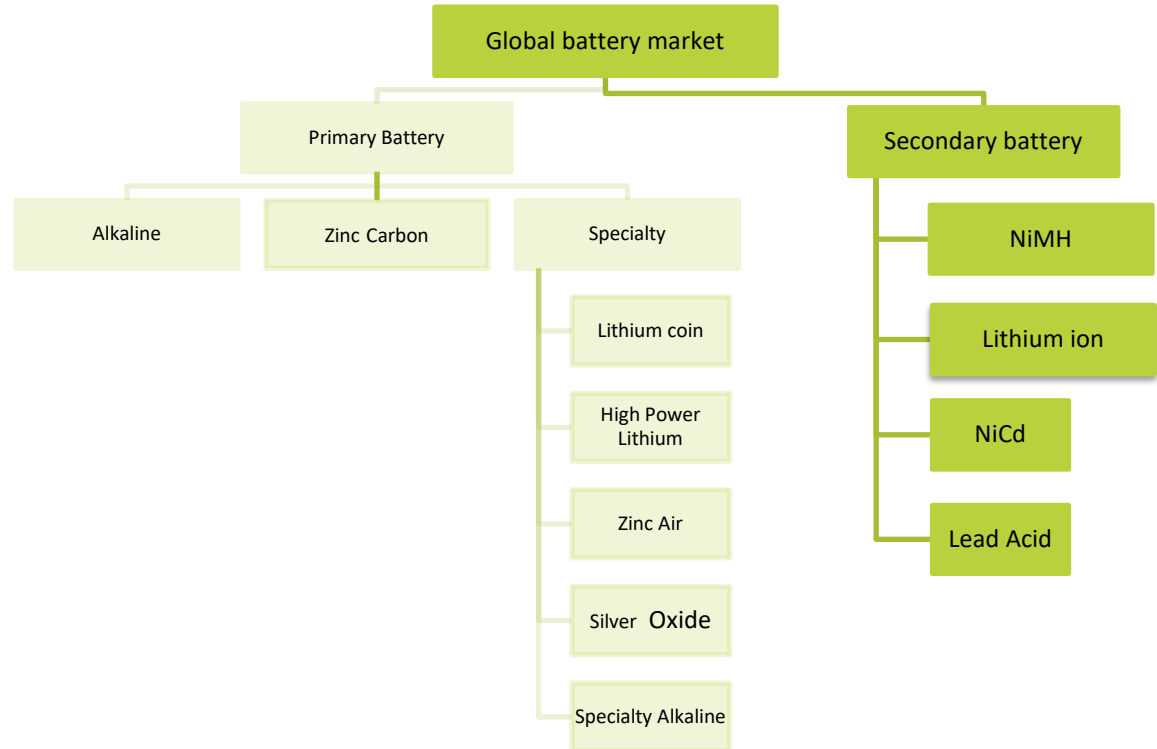


LEAD ACID MARKET AND TECHNOLOGY

Lead Acid Batteries continue to innovate to support growth

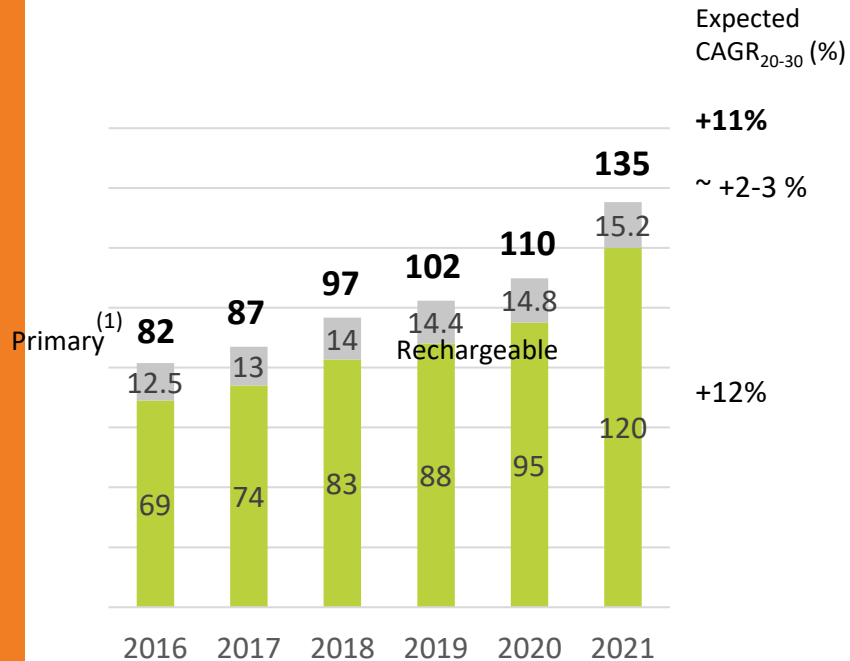
- Lead Acid remains the industry leader in volume, it is no longer the revenue leader
- Many of the applications have a strong value proposition for Lead Acid
- Innovation is continuing to drive competitiveness for Lead Acid technology, much work has been done on bi-polar and other innovations to improve charge acceptance and durability.
- Competitive landscape as Lithium-Ion pricing was falling was placing significant pressure on lead acid in markets that could be served by either technology, the pricing over 2022 for LIB has increased by about 20% reducing this intensity somewhat.
- Sodium Ion Batteries is an emerging technology that is viewed as being between lead acid batteries and lithium ion, will it become a significant offering and threat to lead acid
- Many of the lead acid producers and system suppliers have also diversified their offerings into LIB and SIB, will this effect the research, developments and launches of innovative lead acid technology?

BATTERY SEGMENTATION BY CHEMISTRY



WORLDWIDE BATTERY MARKET OVERVIEW

Battery market in value 2016-2021, global, \$bn, all market segments, all technologies)



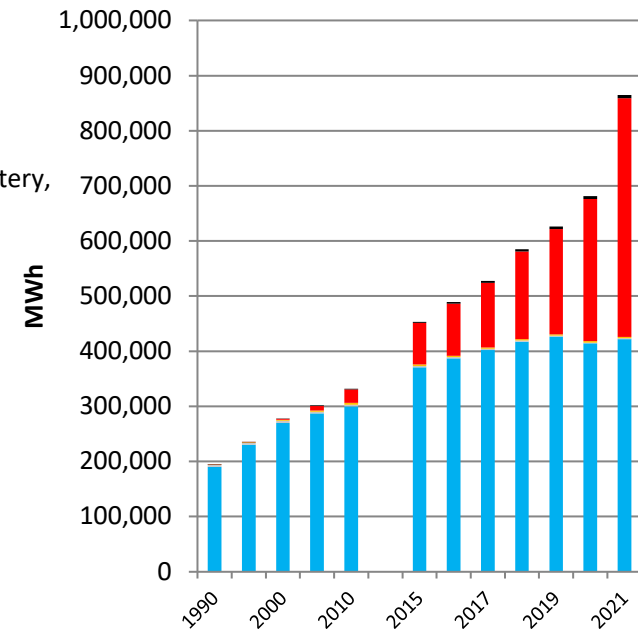
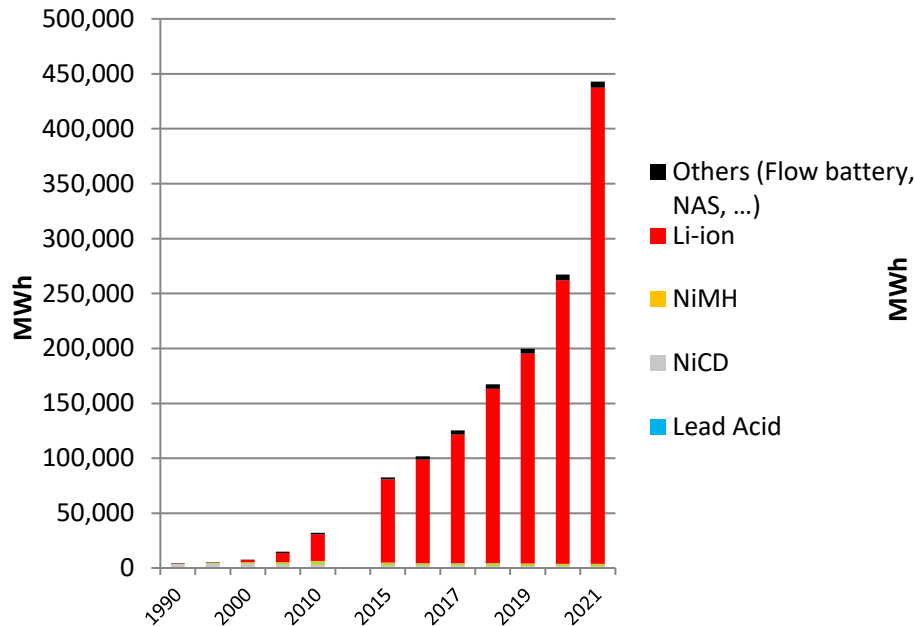
Macro-trends driving the battery market

- 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 CO₂ 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 1990-2021

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



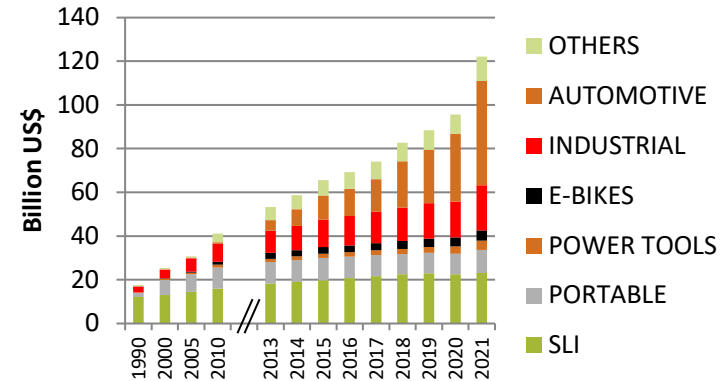
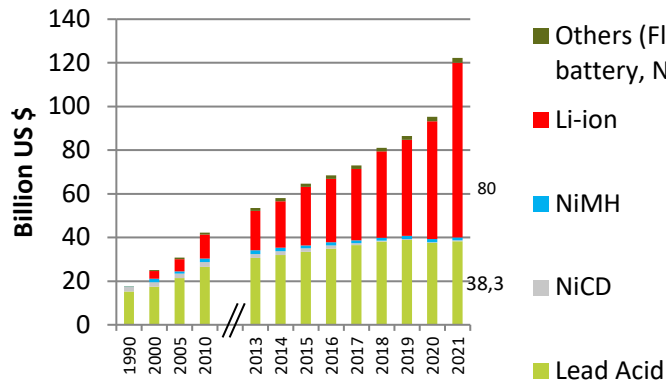
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THE WORLDWIDE BATTERY MARKET 1990-2021

>120 BILLION US\$ in 2021 – Pack level¹
10% AVERAGE GROWTH PER YEAR (2010-2021)



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, 2022

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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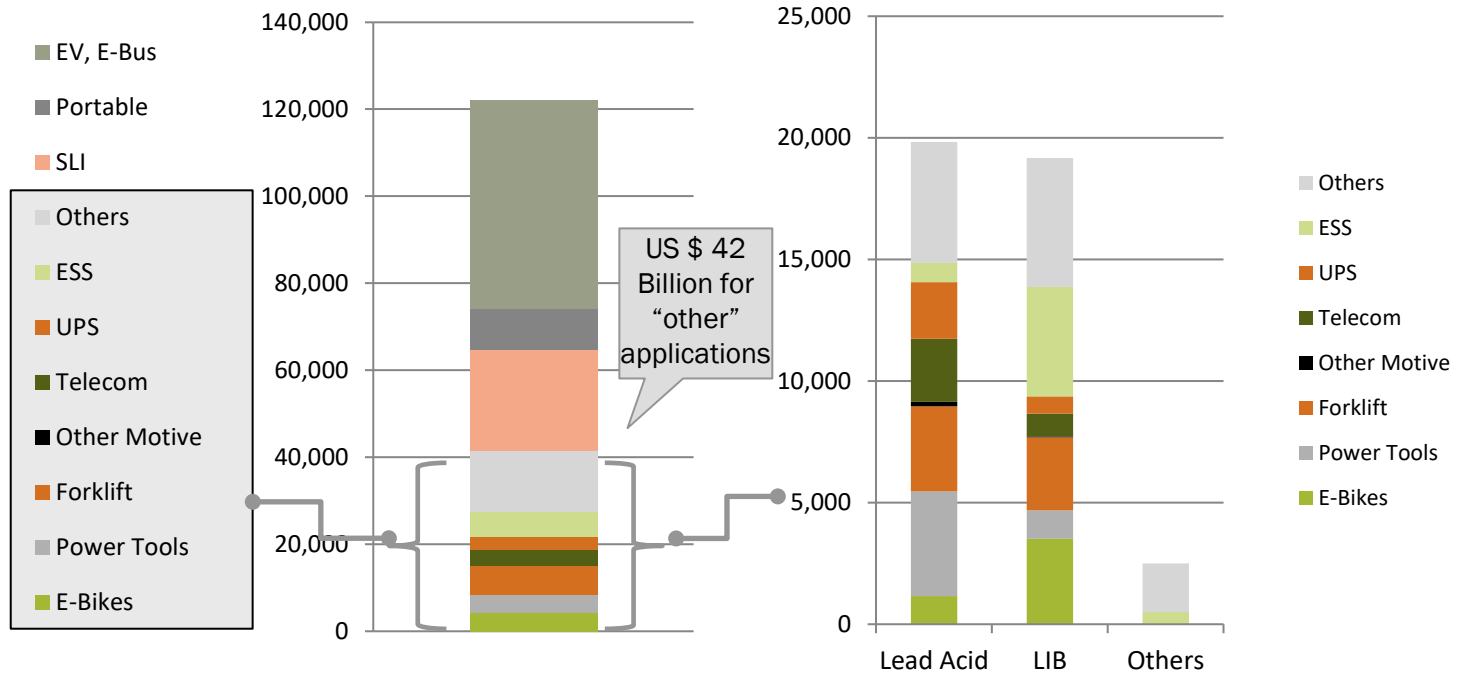
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THE WORLDWIDE BATTERY MARKET IN 2021: US \$ +122 BILLION

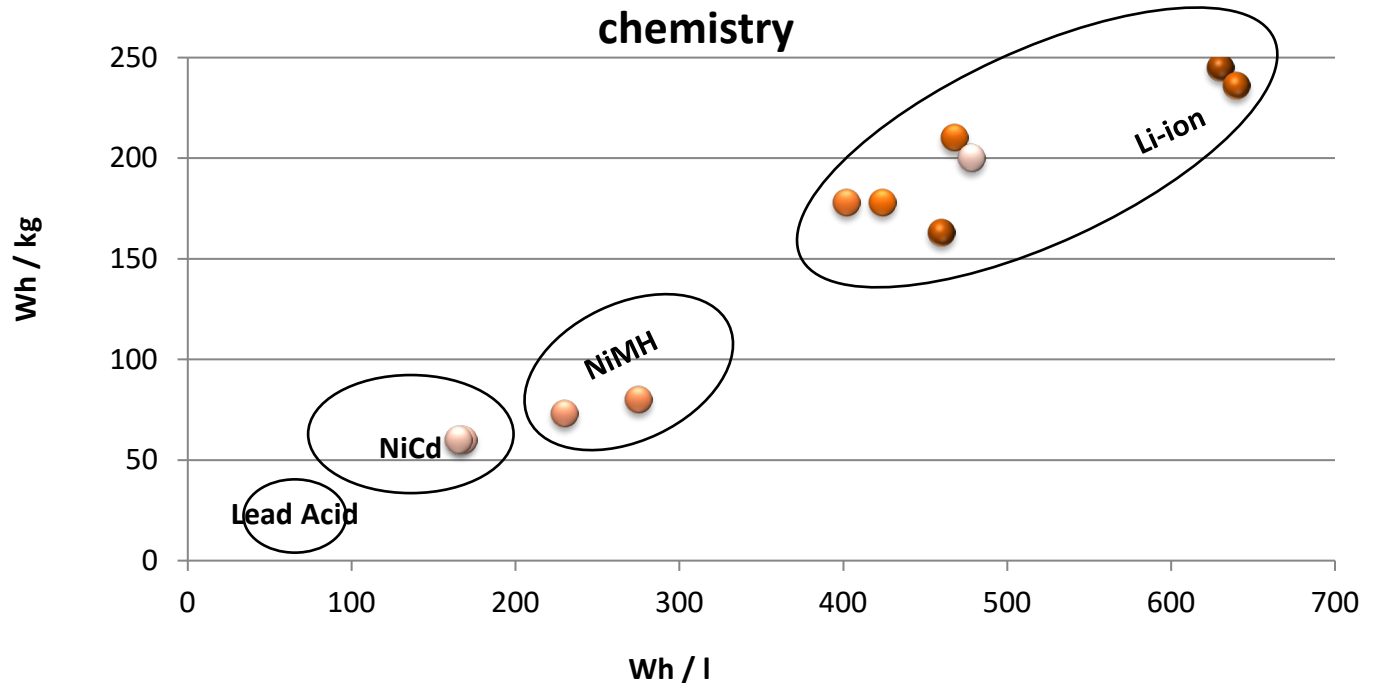


1- Pack level: Pack including cells, cells assembly, BMS, connectors – Power electronics (DC DC converters, invertors...) not included

Source: AVICENNE ENERGY, 2022

NICD, NIMH & LI-ION PRODUCT PERFORMANCES

Gravimetric & volumic energy density by battery chemistry

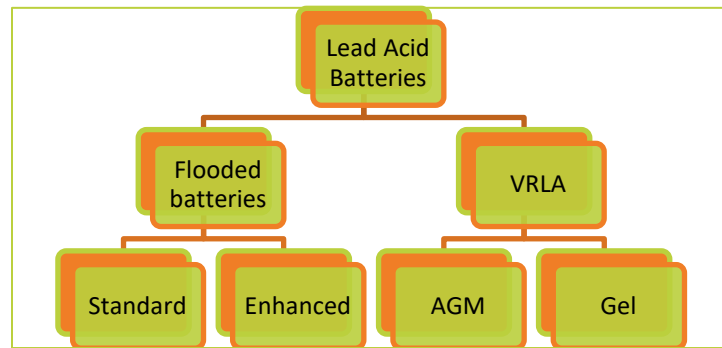


LEAD ACID BATTERY SEGMENTATION

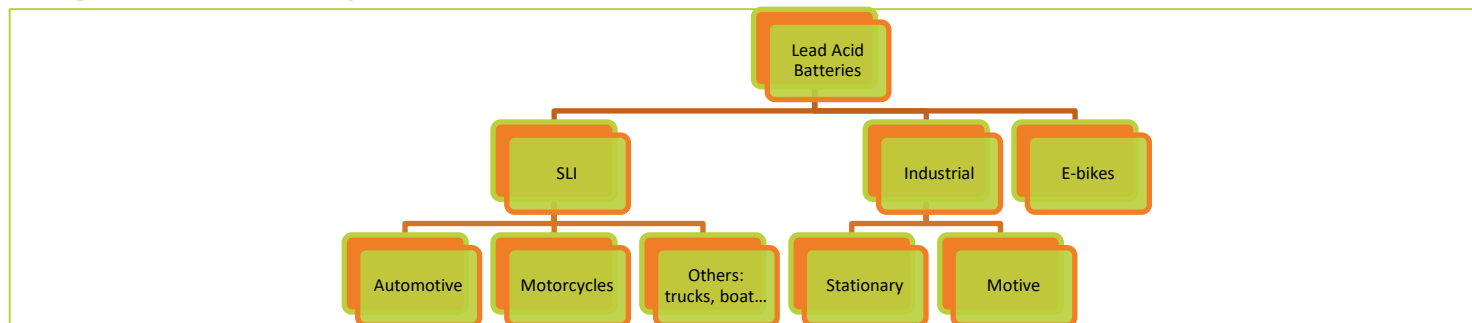
Technology / Application

	Flooded batteries (Wet)		VRLA (Sealed)
Applications	Standard	Enhanced	AGM
Auto standard	√ (100%)		
Moto	√ (80%)		√ (20%)
Micro-hybrid		√ (35%)	√ (65%)
Stationary	√ (25%)		√ (75%)
Motive	√ (90%)		√ (10%)
E-bikes			√ (100%)

Segmentation by technology



Segmentation by Application



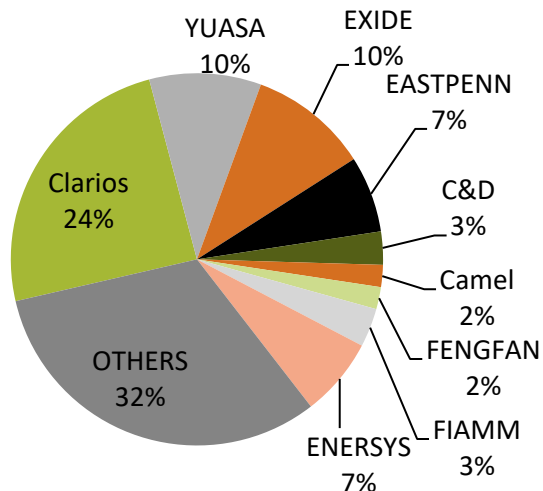
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LEAD ACID BATTERY SUPPLIERS 2021

Global market share on lead acid battery market (B\$ 38)



	SLI	Others	TOTAL
Clarios (ex JCI)	36%	4%	24%
YUASA	9%	11%	10%
EXIDE	10%	11%	10%
EASTPENN	7%	6%	7%
C&D		8%	3%
Camel	3%		2%
FENGFAN	3%		2%
FIAMM	3%	4%	3%
ENERSYS		19%	7%
OTHERS	29%	37%	32%

JCI battery business was bought by Brookfield Business Partners L.P., a publicly traded limited partnership, and a group of institutional investors, including Caisse de dépôt et placement du Québec, which manages public pension plans in Quebec

Over the past 15 years, the global lead-acid battery industry has experienced significant consolidation and currently the main international players are EnerSys, Exide Technologies, Johnson Controls, Inc., and GS Yuasa Corporation ("GS Yuasa").

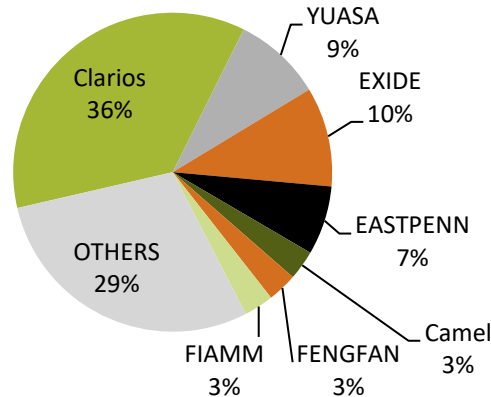
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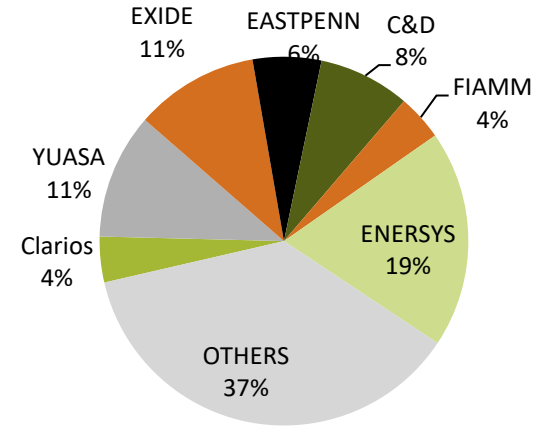
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LEAD ACID BATTERY SUPPLIERS 2021

Lead Acid battery Market share : Clarios is leading the SLI market (B\$ 22,8)



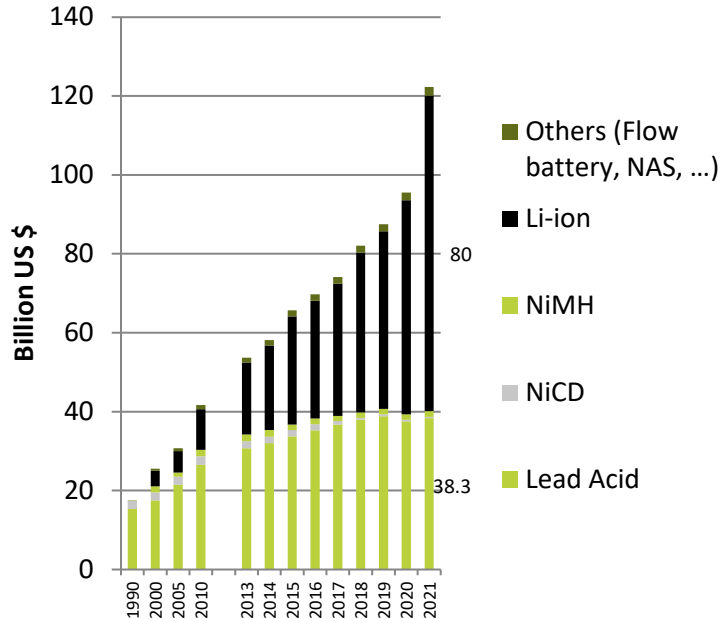
Lead Acid battery Market share : EnerSys is leading the Industrial market (B\$ 15)



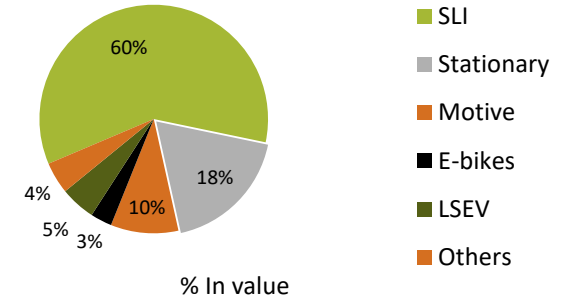
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THE WORLDWIDE BATTERY MARKET 1990-2021

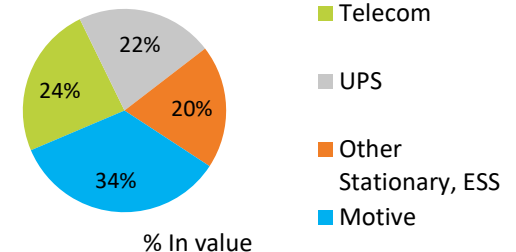
In Value (B\$)



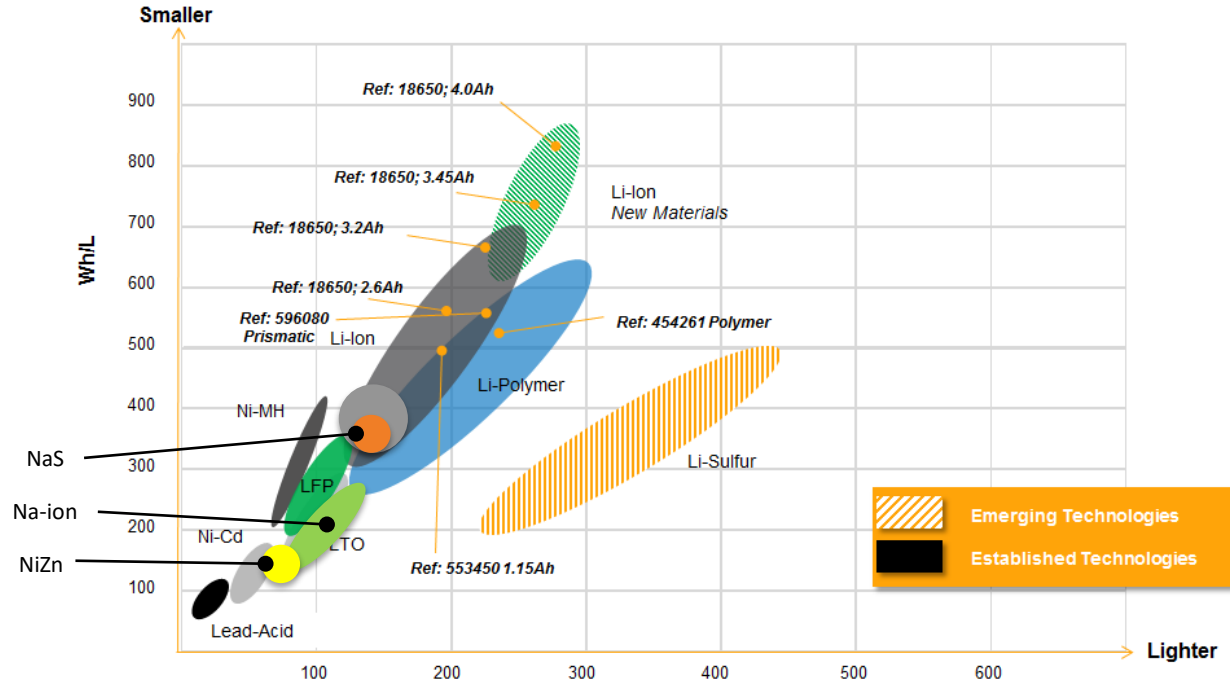
Lead Acid Batteries 2021
423 GWh for > US \$ 38 Billion



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



2019-2025 BATTERY TECHNOLOGY AVAILABLE



Source: AVICENNE Analysis 2020, Inventus Power

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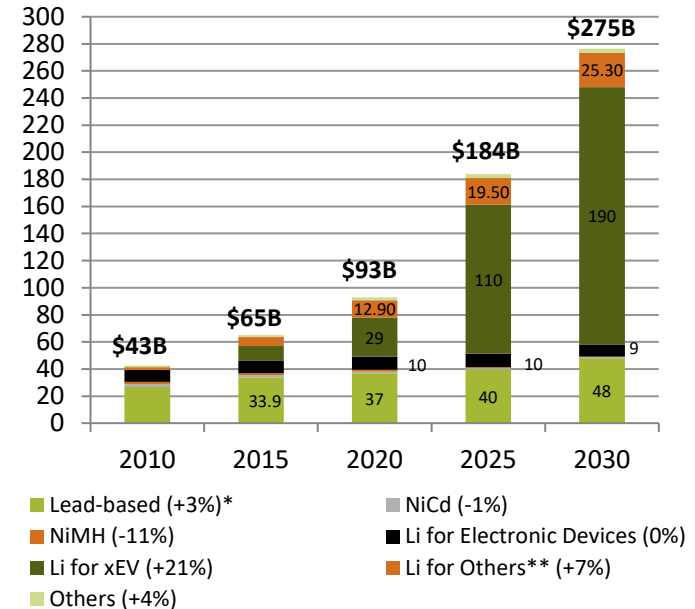
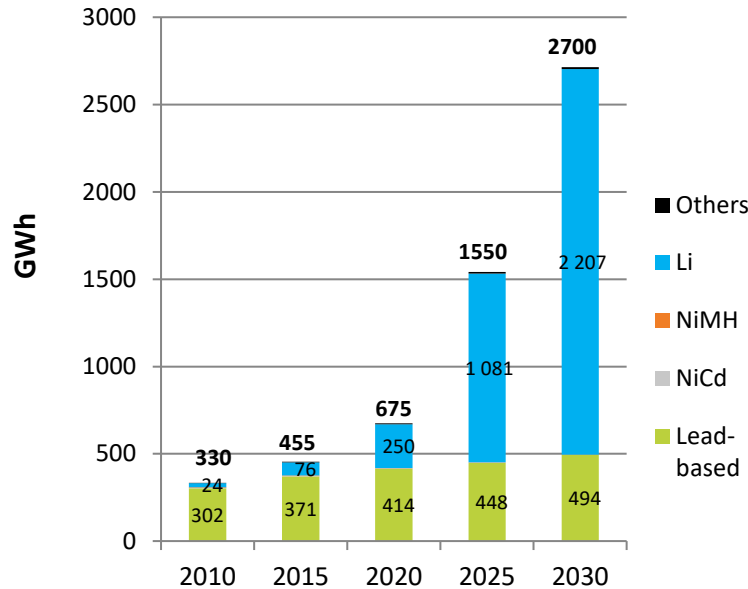
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BATTERY MARKET 2010-2030

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

Market value will reach \$275b in 2030 – Pack level⁽¹⁾ - CAGR₂₀₋₃₀: +12%



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

Source: AVICENNE Energy 2022

* CAGR 2020-2030

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

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LEAD ACID MARKET CONCLUSION

Innovation is critical innovate to support growth

- Lead Acid will remain the industry leader in volume for a few more years, it is no longer the revenue leader
- Many of the applications have a strong value proposition for Lead Acid
- Innovation is continuing to drive competitiveness for Lead Acid technology, much work has been done on bi-polar and other innovations to improve charge acceptance and durability.
- Competitive landscape will continue to evolve with Lithium-Ion pricing increasing and likely to remain flat or somewhat higher, along with the emerging Sodium Ion competition.
- You will hear today from many of the industry leaders in Lead Acid Batteries on their offerings, innovations and the relevancy of lead acid technology.

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