



avicenne
ENERGY

INFORMATION FOR GROWTH

www.avicenne.com

 **NAAT Batt**
INTERNATIONAL

February 11th, 2020

Pasadena, CA

CONTACT

Michael SANDERS
+ 1 302 540 9457
m.sanders@avicenne.com

Market Report: Industrial Batteries in North America Forecast

Michael SANDERS

Senior Advisor, AVICENNE ENERGY

Presentation Outline

- The rechargeable battery market in 2019
- xEV changing market dynamics
- Industrial Market Growth
- Conclusions



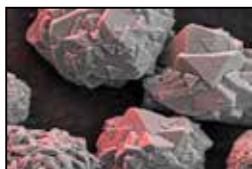
CONTACT

AVICENNE PROFILE

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

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

Worldwide expert for the battery value chain



WORLDWIDE BATTERY MARKET OVERVIEW

Battery market in value (2016-2019, global, \$bn, all market segments, all technologies)

Market Report:
Industrial Batteries

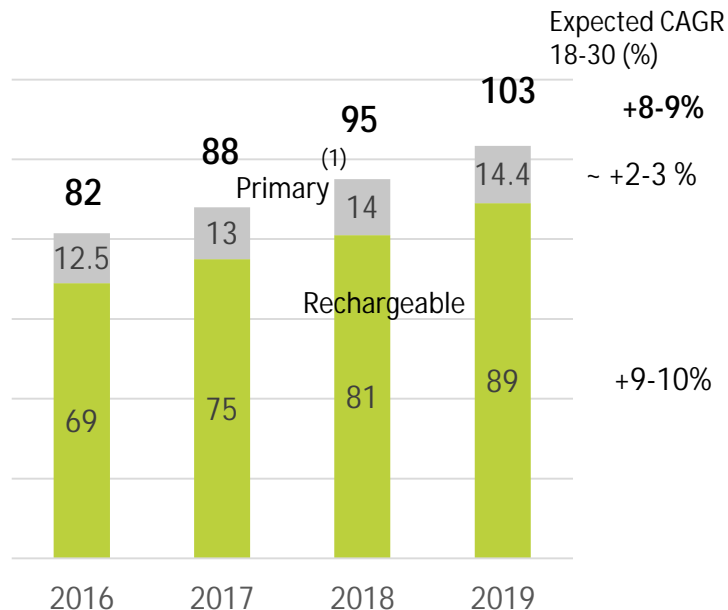


Pasadena, CA

February 11th, 2020

CONTACT

Michael SANDERS
+ 1 302 540 9457
m.sanders@avicenne.com



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

(2) CAGR: Compound Annual Growth Rate

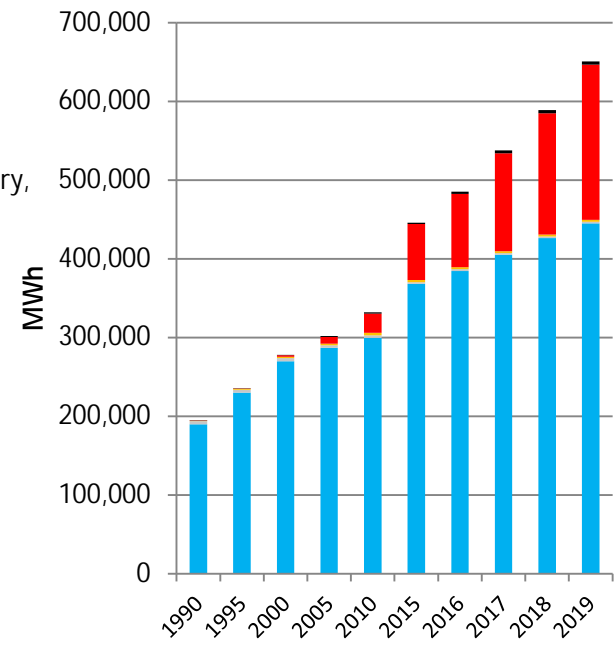
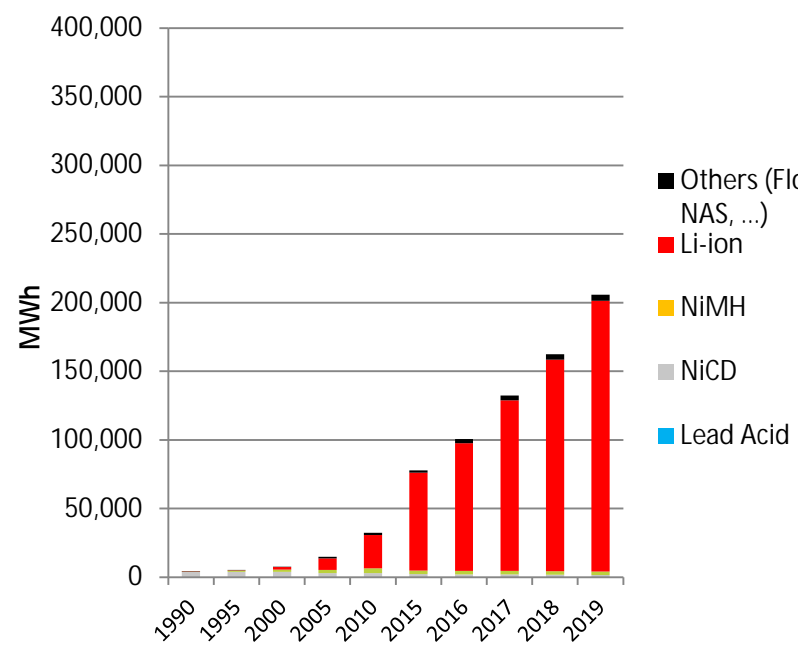
Source: AT Kearney, Duracell, AVICENNE ENERGY 2020



CONTACT

THE WORLDWIDE BATTERY MARKET 1990-2019

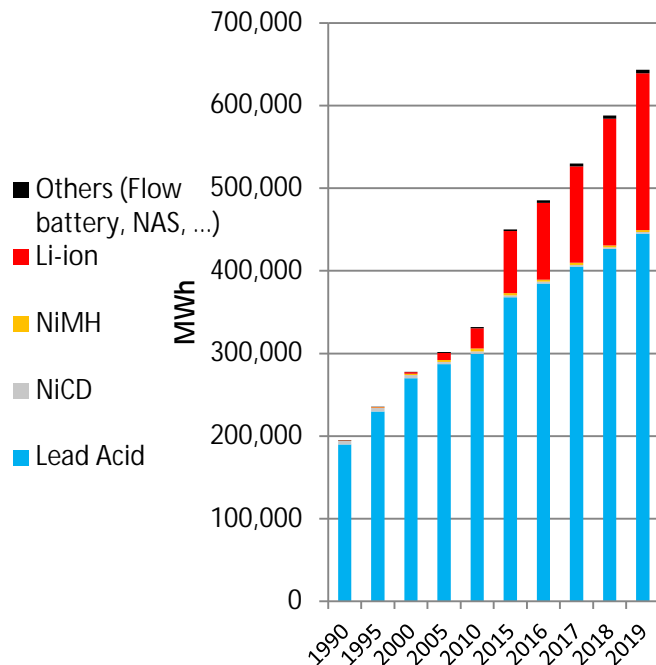
Lithium Ion Battery: Highest growth & major part of the investments
Lead acid batteries: By far the most important market (~70% market share)



Source: AVICENNE ENERGY, 2019

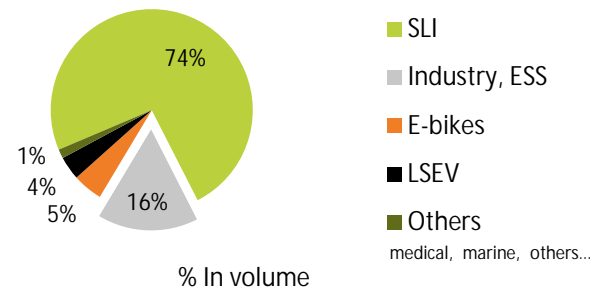
THE WORLDWIDE BATTERY MARKET 1990-2019

In volume (MWh)

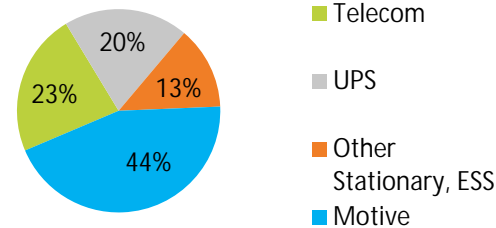


Source: AVICENNE ENERGY, 2019

Lead Acid Batteries 2019
445 GWh for > US \$ 40 Billion



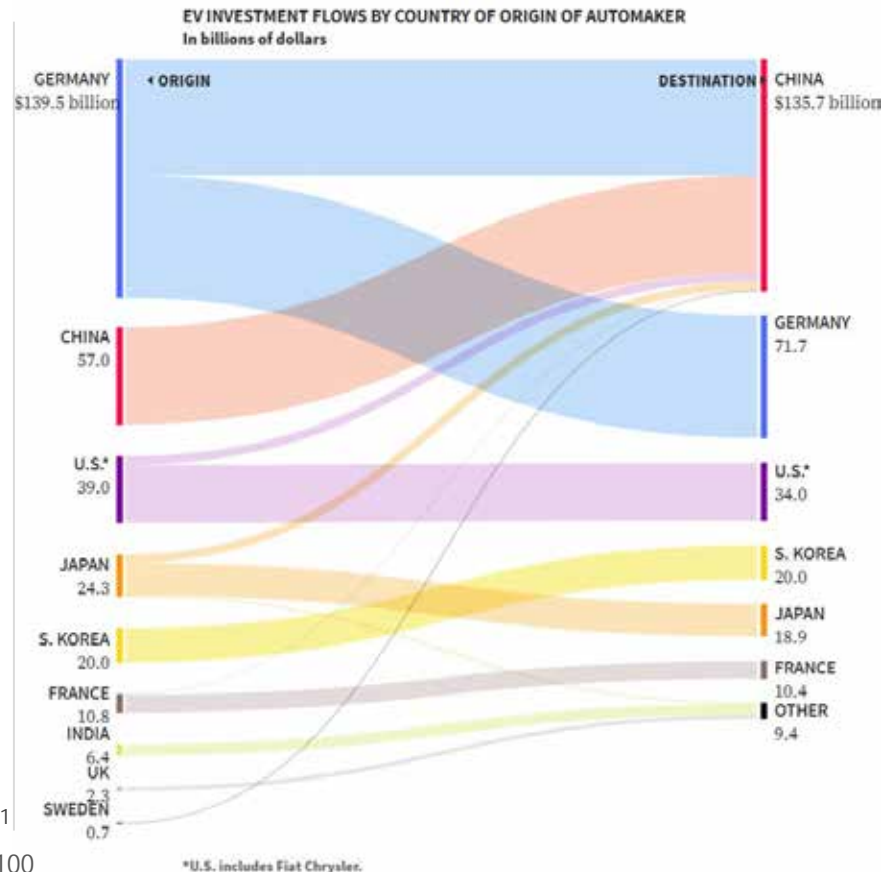
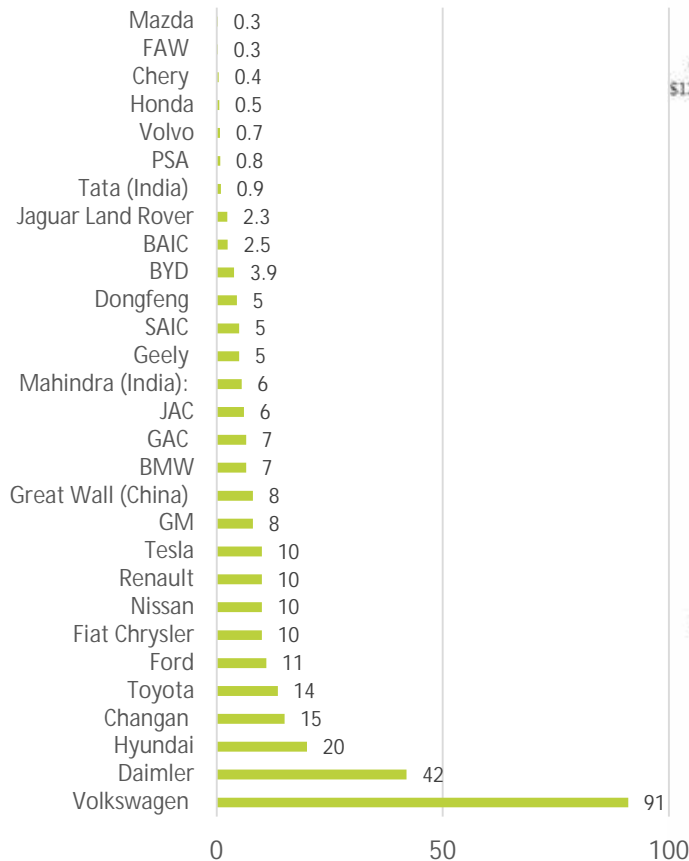
Industrial Batteries – Lead acid batteries
72 GWh for US \$ 11 Billion



% In volume



CARMAKERS TO INVEST MORE THAN **\$300** BILLION IN EV



Source: Reuters January 2019, Avicenne Energy

HEV, P-HEV, EV 2030 FORECASTS

Realistic Scenario: 30% HEV, 7% PHEV and 14% EV in 2030

Market Report:
Industrial Batteries



Pasadena, CA

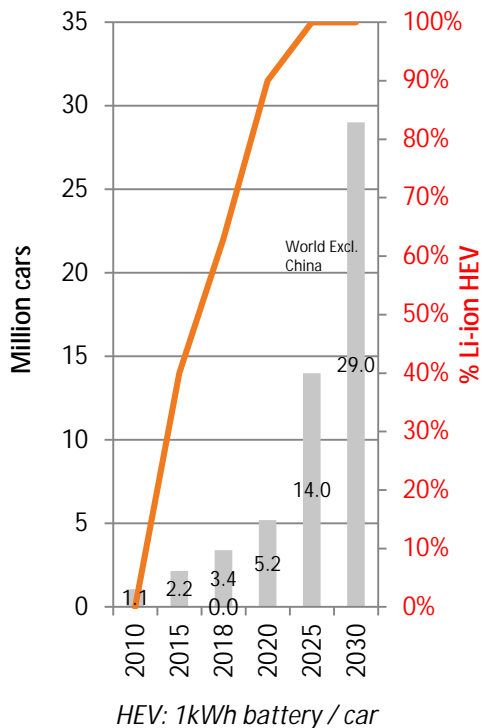
February 11th, 2020

CONTACT

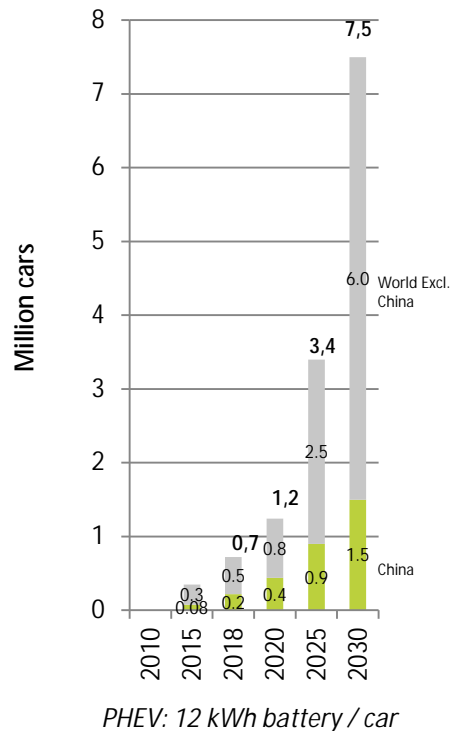
Michael SANDERS
+ 1 302 540 9457

m.sanders@avicenne.com

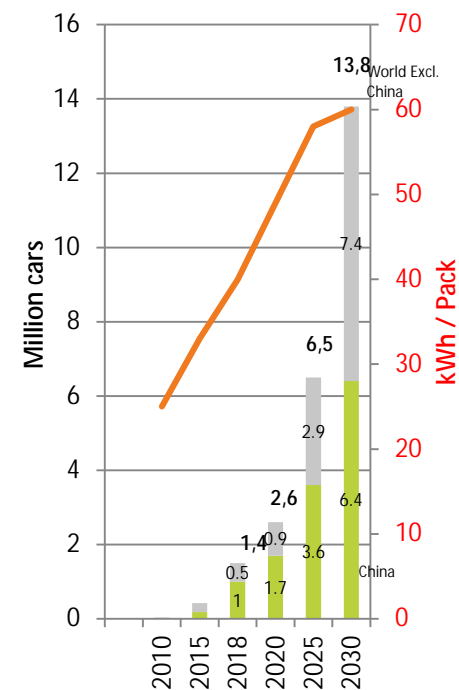
HEV manufactured



PHEV manufactured



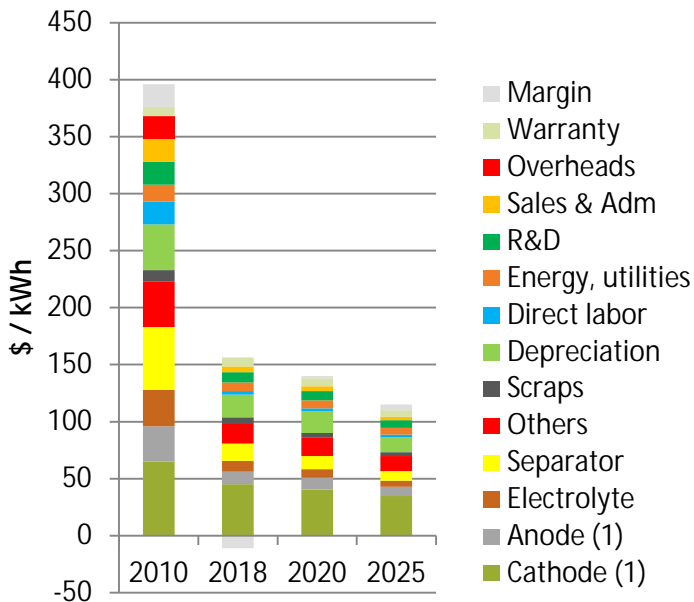
EV manufactured



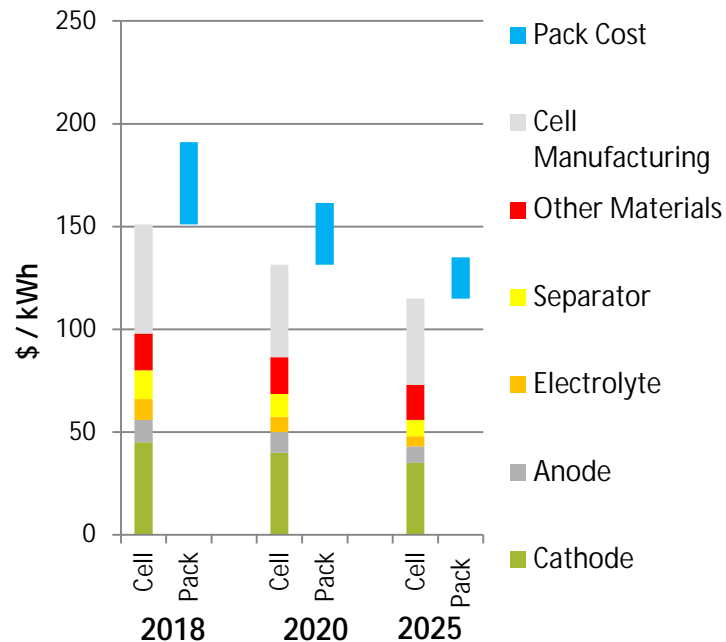


LI-ION BATTERY COST 2018-2025

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



LI-ION BATTERY PACK COST FOR
EV

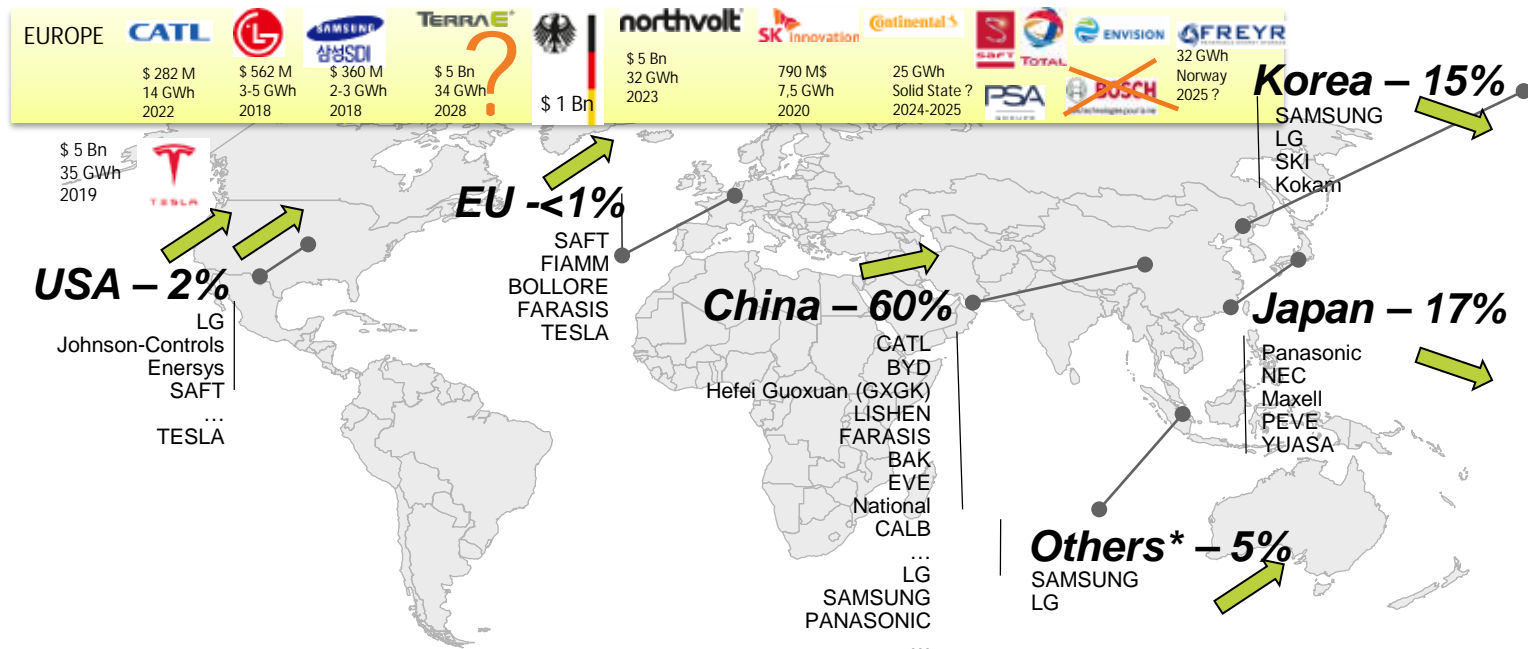


(1) Active materials only
Source: AVICENNE ENERGY 2019

* For Production > 100 000 packs/year

LITHIUM ION CELL PRODUCTION

European market demand
~150 GWh in 2025



Market Report:
Industrial Batteries



Pasadena, CA

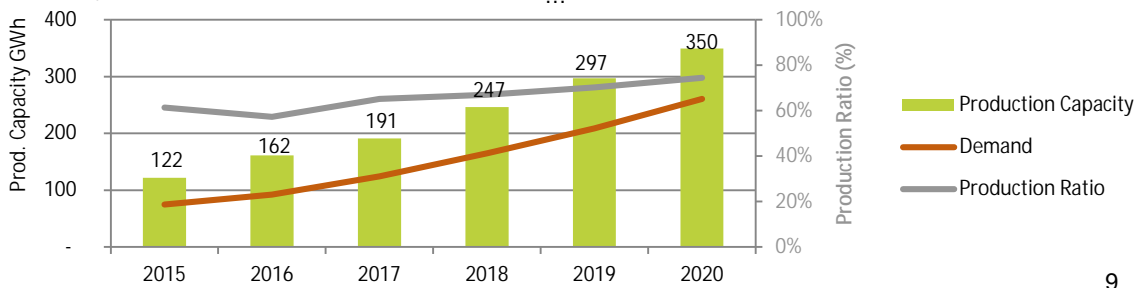
February 11th, 2020

CONTACT

Michael SANDERS
 + 1 302 540 9457
 m.sanders@avicenne.com

Source: AVICENNE 2019

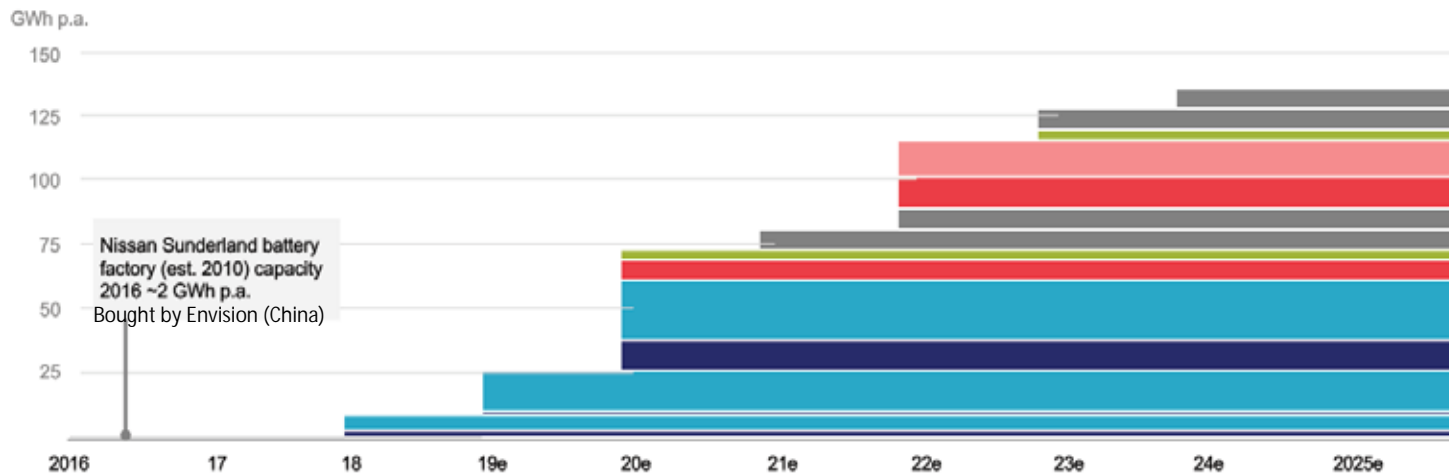
* OTHERS: Malaysia mostly



EUROPEAN LI-ION CELL PRODUCTION CAPACITY

> 125 GWh en 2023

European lithium-ion battery capacity ramp-up until 2025



LI-ION IN 2019 - MAIN APPLICATIONS

>190 000 MWh - 34 B\$ (1)

CAGR 2009/2019
+25 % per year in Volume

Market Report:
Industrial Batteries



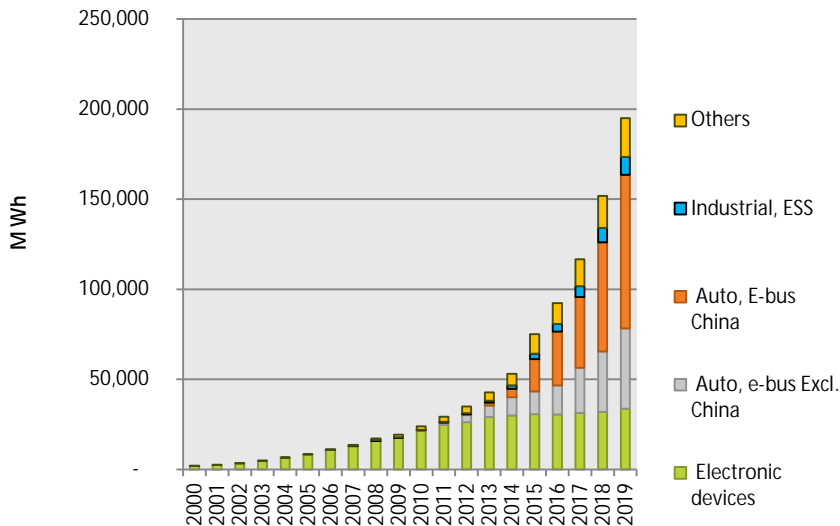
Pasadena, CA

February 11th, 2020

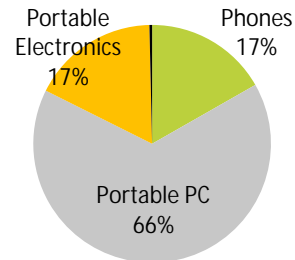
CONTACT

Michael SANDERS
+ 1 302 540 9457
m.sanders@avicenne.com

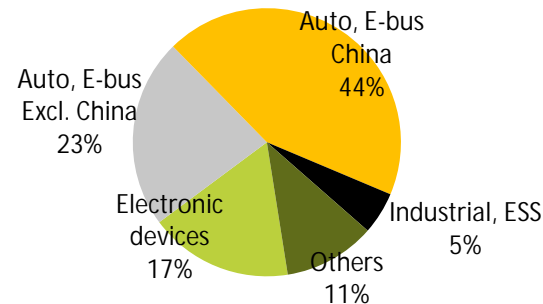
Li-ion Battery sales,
MWh, Worldwide, 2000-2018



2000: < 2GWh

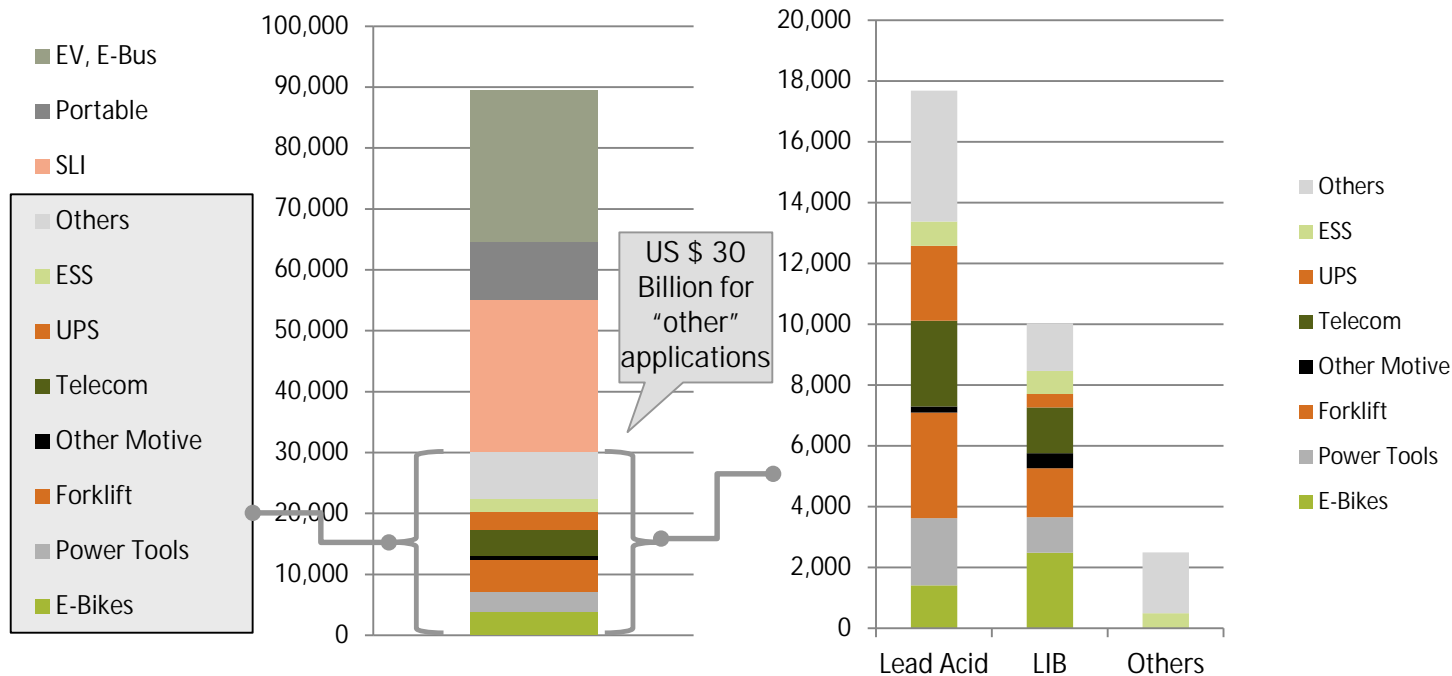


2019: >190 GWh



(1) Cell level
Others: medical devices, power tools, gardening tools, e-bikes...
Source: AVICENNE Energy 2019

THE WORLDWIDE BATTERY MARKET IN 2019: US \$ +80 BILLION

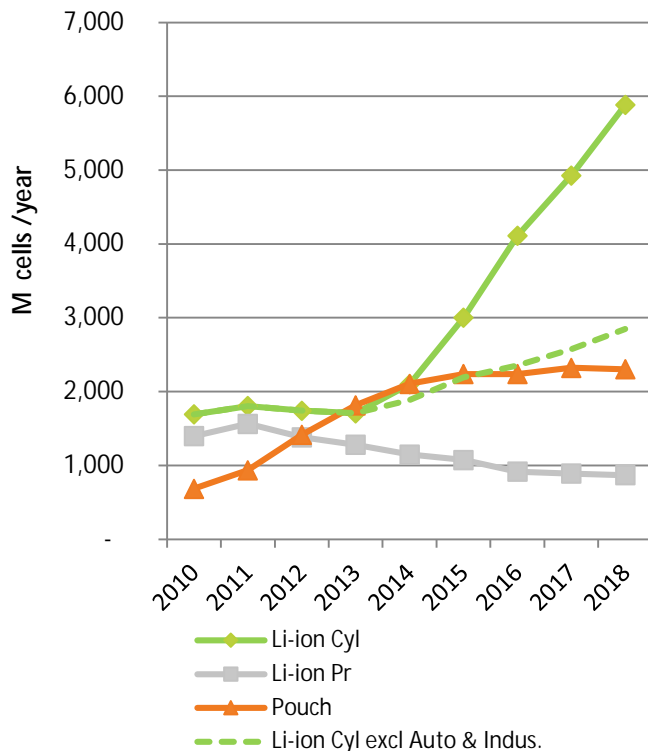


1- Pack level: Pack including cells, cells assembly, BMS, connectors – Power electronics (DC DC converters, invertors...) not included

Source: AVICENNE ENERGY, 2019

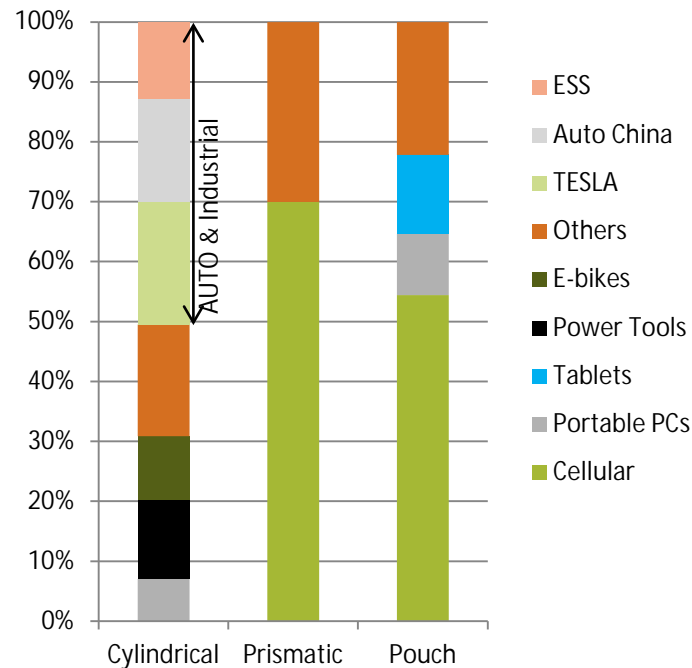
LITHIUM ION SMALL CELL MARKET

Cylindrical/Prismatic/Pouch



Li-ion cylindrical: "Tesla impact": >1200 M cells in 2018 – Auto in China: > 1000 M cells (Avicenne)

Cylindrical/Prismatic/Pouch in 2018



Others:

Cylindrical: hoverboards, medical, power bank

Prismatic: portables

Pouch: drones, BT, wearables, power bank

Source: AVICENNE Energy 2019

BATTERY MARKET FORECASTS 2018-2030

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,
- 🔋 2018 -2030 Forecasts
- 🔋 OEM strategies and positions
- 🔋 Main drivers & limiters



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Market Report:
Industrial Batteries



Pasadena, CA

February 11th, 2020

CONTACT

Michael SANDERS
+ 1 302 540 9457

m.sanders@avicenne.com

COMMERCIAL VEHICLE ACCELERATION

Anheuser Busch BYD Class 8



Anheuser-Busch announced plans to deploy 21 battery electric trucks built by BYD in southern California as part of a state project. The companies said the "Zero Emission Beverage Handling and Distribution at Scale" project represents the largest Class 8 electric truck deployment in North America.

Daimler Truck and Bus



CATL will be supplying lithium-ion cell modules for Daimler's series-produced electric trucks from 2021 onwards. The battery systems and battery pack assembly will be developed and produced by Daimler Trucks & Buses.



Tesla Truck



PepsiCo's 100 trucks add to orders by more than a dozen companies such as Wal-Mart Stores Inc (WMT.N), fleet operator J.B. Hunt Transport Services Inc (JBHT.O), and food service distribution company Sysco Corp (SYN.N). Tesla has at least 285 truck reservations in hand, according to a Reuters tally

Coca Cola

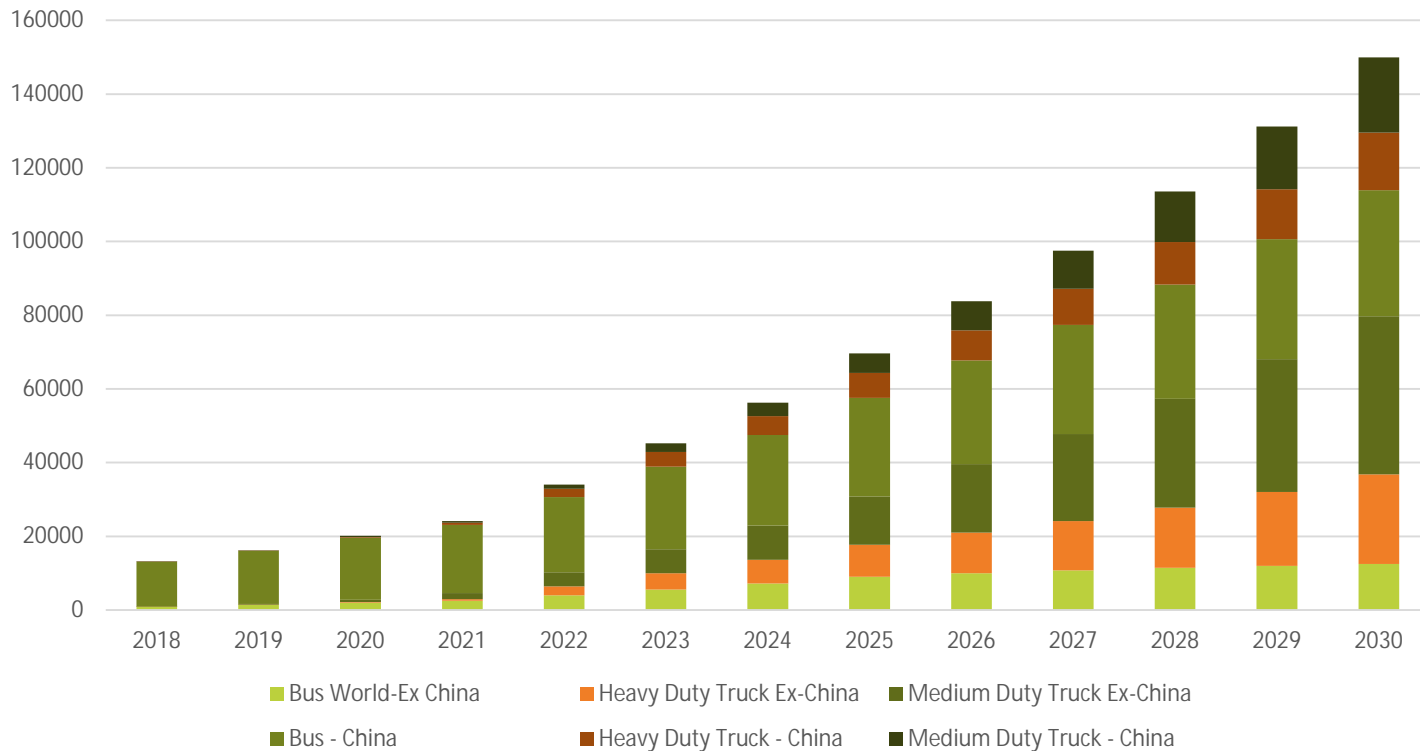


Six all-electric, zero-emissions trucks delivering Coca-Cola just hit the roads. They are part of Coca-Cola Refreshments' (CCR) growing fleet of alternative fuel vehicles in North America, which will surpass 750 by year's end. The trucks run up to 100 miles and can be fully recharged in 6-8 hrs. A quick-change cassette-type battery can be swapped out in 20 minutes, enabling around the clock operation.

CONTACT

Michael SANDERS
+ 1 302 540 9457
m.sanders@avicenne.com

ELECTRIC BUS, HEAVY AND MEDIUM DUTY TRUCKS - MWH





POWER TOOLS

LIB: FROM US\$ 2 BILLION IN 2018 TO 3,5 B IN 2030¹ – CAGR₁₅₋₃₀: +7%

Market Report:
Industrial Batteries



Pasadena, CA

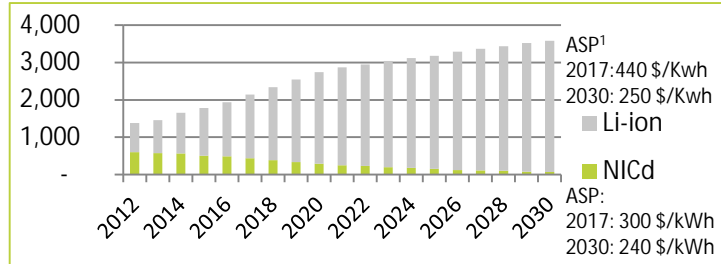
February 11th, 2020

CONTACT

Michael SANDERS
+ 1 302 540 9457

m.sanders@avicenne.com

Market 2017-2025 (US \$, Million) – CAGR:+5%



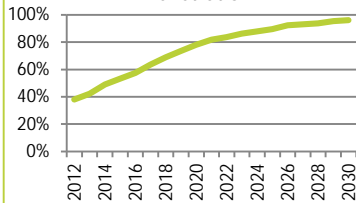
Battery 2013 by Area

- >75% of the power tools are made in China
- But, battery pack could be made on the end-user area (Ex: Bosch – Axeon Poland)

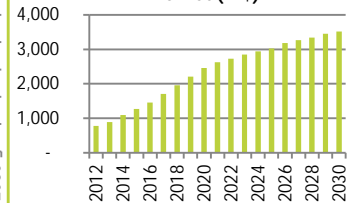
LIB 2020 by Area

- Power tools will be made in China
- Local demand in Europe, US, next to the end user to increase flexibility & Just in Time mfg.

LIB Penetration



LIB market (M\$)



LIB Main drivers

- Higher voltage
- NiCd substitution
- NiCd regulation
- Cordless power tools & gardening tools market increase (+4% per year)
- Higher energy density, less weight

LIB main Limiters

- LIB average sales price
- Reliability
- High rate discharge
- Fast charge
- Life time

Competitors

- Cell/Pack Mfg.: TOP3: Samsung, Panasonic, Sony (> 75%)
- Pack makers: AXEON (Bosch),

Customers

- Bosch
- B&D
- TTI
- Makita
- Jingding
- Hilti
- ...

Battery needs

- Important characteristic:
 - Higher power & capacity
 - Fast recharge
- 2012 ASP NiCd: 350 \$/kWh
- 2012 ASP LIB: 550 \$/kWh
- Average Capacity: 60 Wh

LIB needs

- Most valuable improvements
 - Price decrease
 - Fast charge
 - High rate discharge
- Form factor: Cylindrical
- No standardization

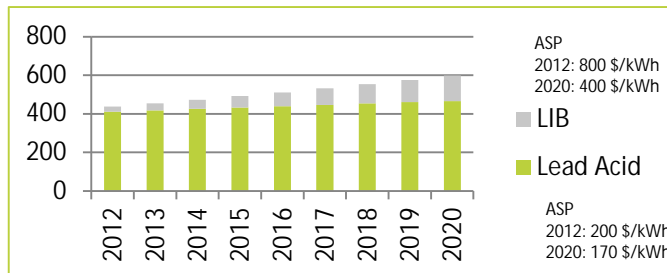
MARINE

LIB: FROM US\$ 30 MILLION IN 2012 TO 130 IN 2020¹ – CAGR: +22%

Market 2012-2020 (US \$, Million) –
CAGR: 4%

Main drivers

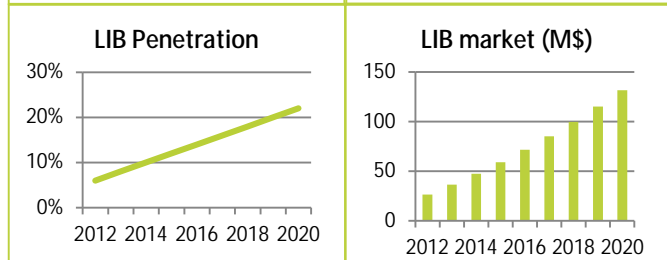
Main Limiters



- | | |
|---|---|
| <ul style="list-style-type: none"> Decreased emissions Reduced noise Less pollution Increased reliability Li-ion life time | <ul style="list-style-type: none"> Li-ion cost (x 4 to 6 compare to lead acid batteries) |
|---|---|

- | | |
|--|---|
| <p>Main countries</p> <ul style="list-style-type: none"> US coast Mediterranean sea Japan ... | <p>Main application</p> <ul style="list-style-type: none"> Replace lead acid batteries in the boat Hybrid Boat, E Boat Harbor Material handling equipment |
|--|---|

- | | |
|---|--|
| <p>Competitors</p> <ul style="list-style-type: none"> Marine specialist: Corvus Energy ARC3 Mastervolt Lithionics Battery Lithium Pros Electrochem BMZ | <p>Customers</p> <ul style="list-style-type: none"> ABB Siemens Wartsila Behr And a lot of different boat mfg. |
|---|--|



- | | |
|---|--|
| <p>Battery needs</p> <ul style="list-style-type: none"> Most important performances characteristic 1- Life time 2- Energy density 3- Weight & volume Boat: Average Capacity: 12 v * 50 to 300 Ah (0,6 to 5 kWh) | <p>LIB needs</p> <ul style="list-style-type: none"> Most valuable improvements 1-cost, 2- energy/power density Size Standardization to replace lead acid Customized product for now boat |
|---|--|



MOTIVE INDUSTRIAL: FORKLIFTS¹

LIB: FROM US\$1,7BN IN 2019 TO \$5,8BN IN 2025 - CAGR₁₉₋₂₅: +22%

Market Report:
Industrial Batteries



Pasadena, CA

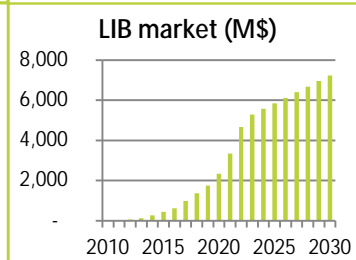
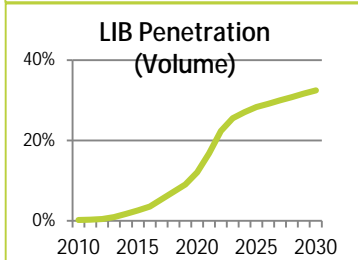
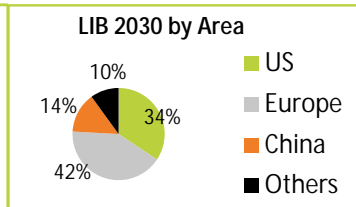
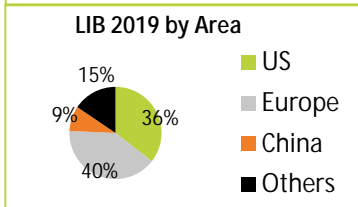
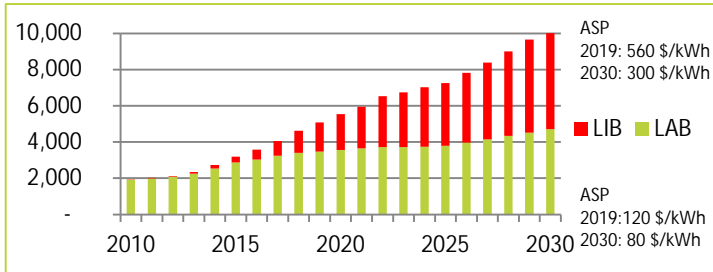
February 11th, 2020

CONTACT

Michael SANDERS
+ 1 302 540 9457

m.sanders@avicenne.com

Market 2010-2030 (US \$, Million) – CAGR₁₉₋₂₅: 9%



Main drivers 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 life time (* 3 to 5)
- Multiple shift operation where battery change is required (time consuming)

Competitors

- Lead Acid & LIB: Enersys (35%), Exide (10%), East Penn (10%), Hoppecke (10%), Crown (10%)
- LIB systems: BMZ, Lithium Balance ...

Main restrictions for LIB

- 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

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 life time, range,
- Average Capacity: 22 kWh

LIB needs

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

NUMBER OF PACK SOLD FOR MOTIVE APPLICATIONS

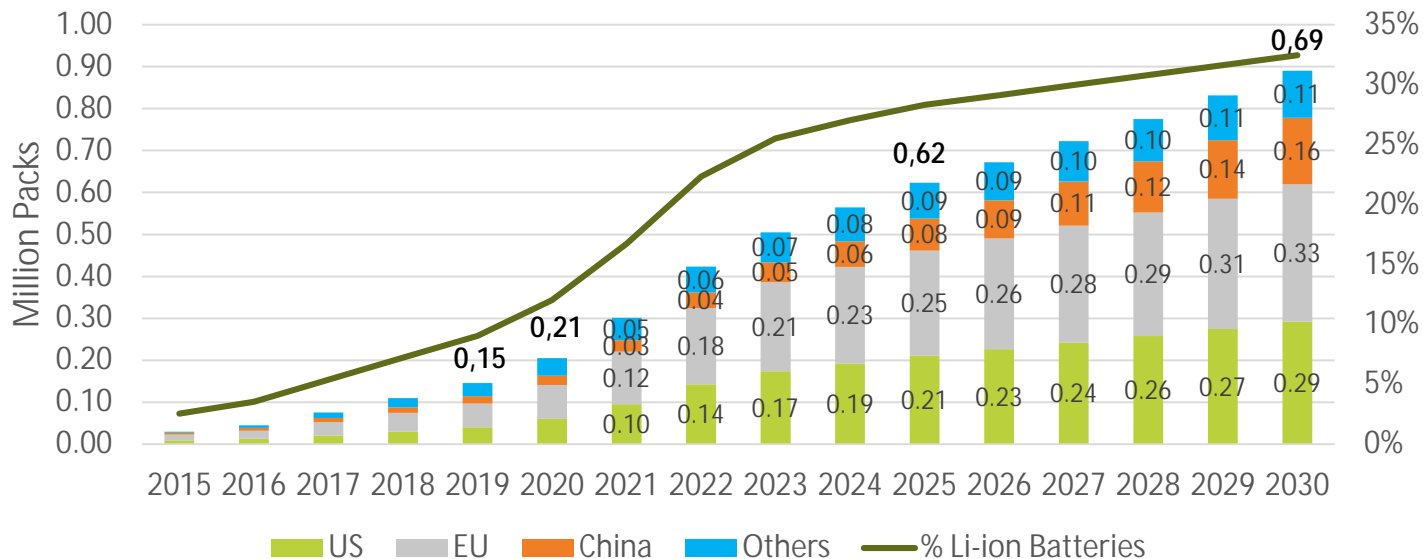
Million of pack for motive industrial application:
CAGR₁₉₋₂₅: +27%

Market Report:
Industrial Batteries



Pasadena, CA

February 11th, 2020



CONTACT

Michael SANDERS
+ 1 302 540 9457
m.sanders@avicenne.com



STATIONARY: TELECOM MARKET

LIB: FROM US\$ 0,6 BILLION IN 2019 TO 0,7 IN 2025¹ – CAGR₁₉₋₂₅: 3%

Market Report:
Industrial Batteries



Pasadena, CA

February 11th, 2020

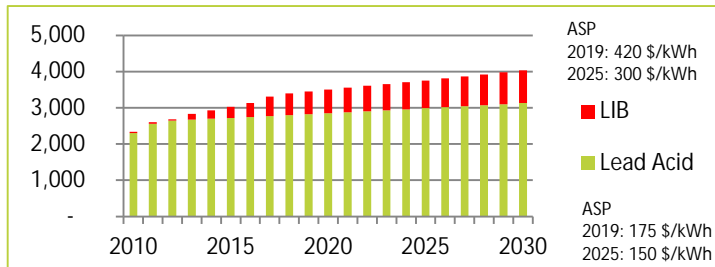
CONTACT

Michael SANDERS
+ 1 302 540 9457

m.sanders@avicenne.com

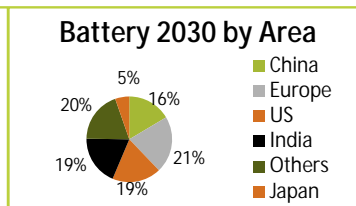
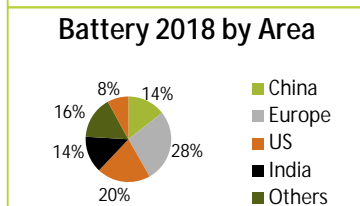
Market 2015-2030 (US \$, Million) – CAGR₁₅₋₃₀: +1% Main drivers for LIB

Main restrictions for LIB



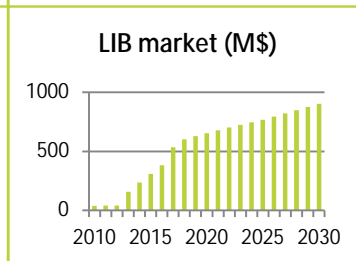
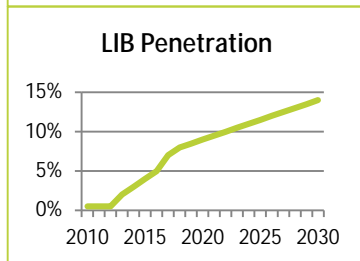
- ③ LIB developed for new equipment
- ③ Increased bandwidth requirements
- ③ Wireless market driving growth
- ③ Strong network growth in China, India, E. Europe & S. America
- ③ 3G-> 4G-> 5G ... need new equipment
- ③ LIB: Especially in hot climates

- ③ Lead-acid vs Li-ion...
- ③ Lead-acid capital cost 5 times cheaper
- ③ Total cost of ownership could be compare with lead-acid



- Competitors**
- ③ Lead-acid and LIB: Energys (35%), Exide (10%) and local suppliers in each country
 - ③ LIB systems: 'large companies': SAFT, others

- Customers**
- ③ Few customers: large telecom carriers in each country



- Battery needs**
- ③ Most important performances characteristic
 - 1- High temperature performance
 - 2- Customised for the new equipment network
 - ③ Average capacity: 5-10 kWh modules (100 Ah)

- LIB needs**
- ③ Most valuable improvements
 - 1- Capital costs
 - 2- Safety
 - 3- Reliability
 - ③ Customised batteries developed for new equipment

Source: AVICENNE ENERGY Analyses

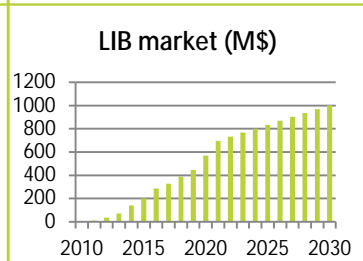
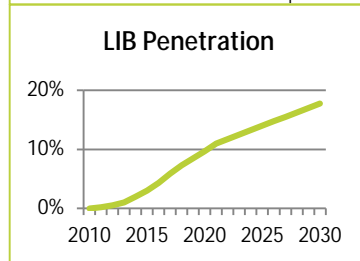
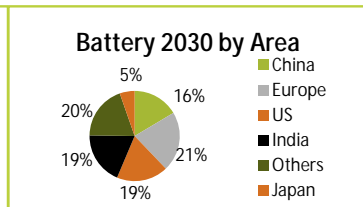
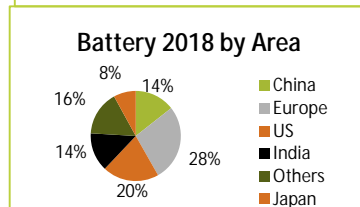
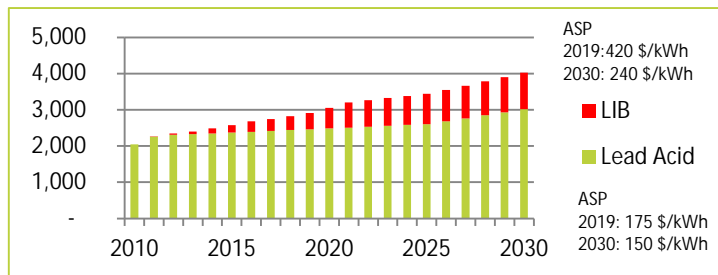
Note: : 1- Pack level

STATIONARY: UPS MARKET

LIB: FROM US\$0,4BN IN 2019 TO \$0,8BN IN 2025 – CAGR₁₉₋₂₅: : +11%



Market 2015-2030(US \$, Million) – CAGR₁₅₋₃₀: +3%



Main drivers for LIB

- ⌚ UPS Drivers:
 - ⌚ New data storage centres
 - ⌚ Mobile Society
- ⌚ LIB drivers:
 - ⌚ Less volume, less place
 - ⌚ > Life time
 - ⌚ LIB is needed more where data are sensitive
 - ⌚ Li-ion battery could also help to save electricity during peak time

Main restrictions for LIB

- ⌚ Safety could be an important issue here

- Competitors**
- ⌚ Lead-acid & LIB: Enersys (35%), Exide (10%) and local suppliers in each country
 - ⌚ LIB systems: local companies providing > services

- Customers**
- ⌚ Few leaders/many products: Emerson/Liebert, Schneider/APC, Eaton Powerware, Gamatronic, Riello

Battery needs

- ⌚ Most important performance characteristic
 - 1- Back-up at high current
 - 2- Weight, volume
 - 3- Life time
- ⌚ Average Capacity: 3-5 kWh modules

LIB needs

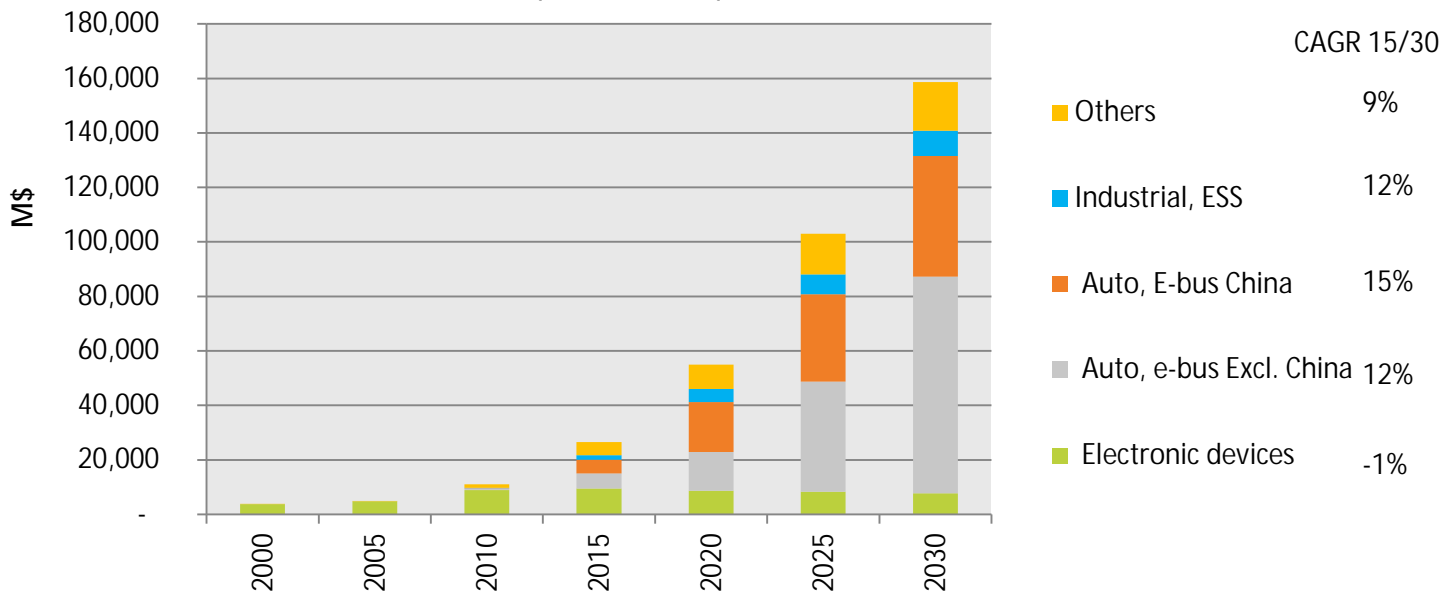
- ⌚ Most valuable improvements
 - 1- Convince on safety
 - 2- Capital Cost
 - 3- Reliability
- ⌚ Form factor: Cylindrical
- ⌚ New development for new equipment

LI-ION BATTERY MARKET FORECAST

Realistic scenario

CAGR 2015/2030: +24 % per year in Volume
Pack: +11% per year in value

Li-ion Packs
M\$, Worldwide, 2000-2030



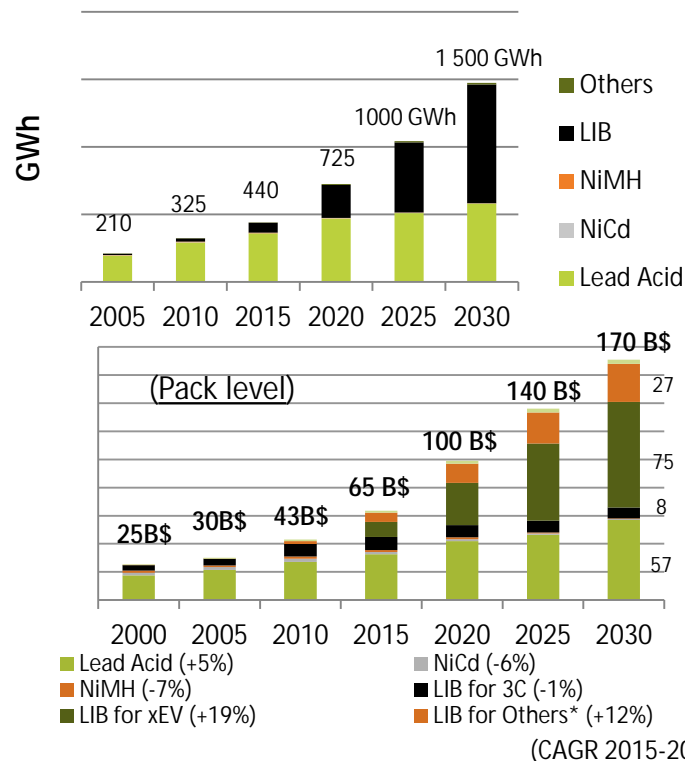
Others: medical devices, power tools, gardening tools, e-bikes...
Source: AVICENNE Energy 2019

TAKEAWAYS

Battery Market 2015-2030 - CAGR = +7% / Li-ion > +10%

- ① Li-ion battery is driven today by Automotive: 1-2% of the automotive market consume +60% of the LIB
- ② Lead acid battery will be the first market in 2025 in volume, but Li-ion market (US\$ 40 Bn) is higher than Lead acid in value in 2018 (US\$ 38 Bn)
- ③ A very small EV market in the automotive world will represent a huge market for batteries
- ④ New LIB applications: UPS, Telecom, Forklift, Medical, Residential ESS, Grid ESS, hoverboard, drones: CAGR > 10% in the next 15 years
- ⑤ Lithium battery for other application (ESS, stationary, industrial...) will reach 10 Billion \$ market at the pack level in the next 5 years
- ⑥ ESS market could be much more important if the price of LIB at the system level is in the range of 100 US\$/kWh

RECHARGEABLE BATTERY MARKET WORLDWIDE 2000-2030 (base scenario)



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

7/9 OCTOBER 2020

Lyon, France

Batteries 2020

Conferences, Exhibitions & Networking

CONTACT

Michael SANDERS
+ 1 302 540 9457
m.sanders@avicenne.com

THANK YOU



Christophe PILLOT
AVICENNE ENERGY
c.pillot@avicenne.com
Phone: +33 1 44 55 19 90
Mobile: + 33 6 88 82 79 49



Michael SANDERS
AVICENNE ENERGY US
m.sanders@avicenne.com
Mobile: 302-540-9457