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March 13th, 2019

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Can Lead Acid Maintain Their Market Share?

**Does anyone put market share in the bank?
Revenue, Cash and Earnings better Metric!**

AVICENNE ENERGY US
Michael SANDERS

Presentation Outline

- The rechargeable battery market in 2018
- Lead Acid Segmentation
- Adoption Trends by Segment
- Growth Trend Continues for LA



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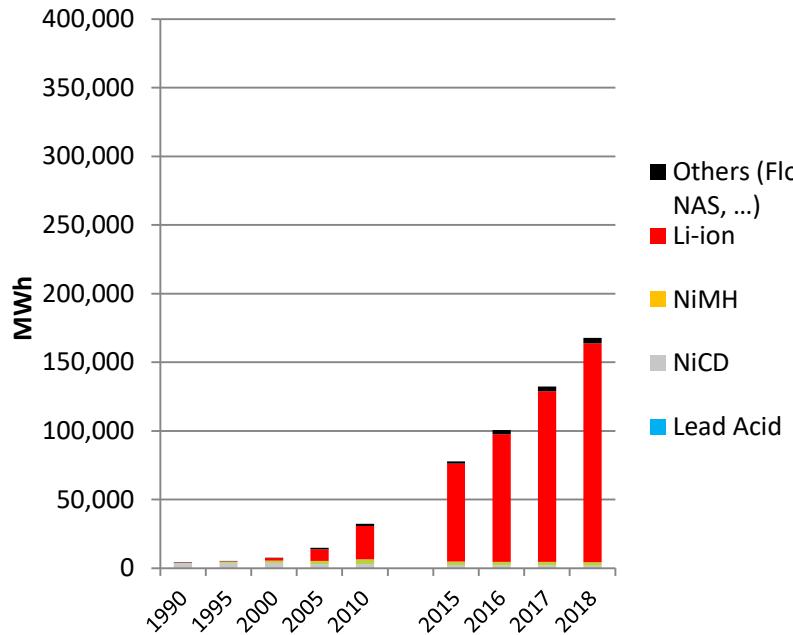
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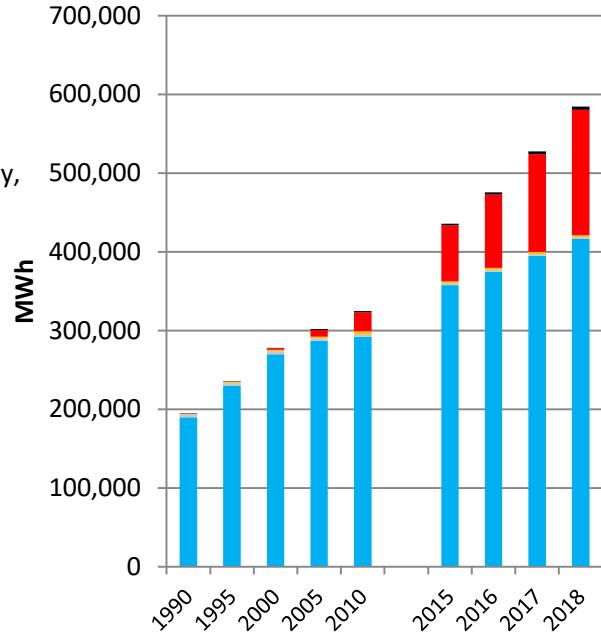
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THE WORLDWIDE BATTERY MARKET 1990-2018

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, 2018





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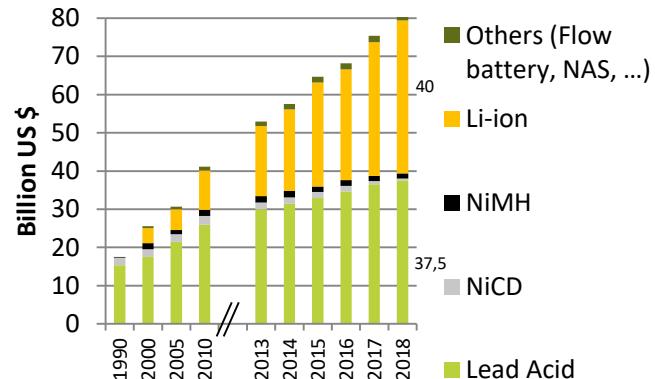
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THE WORLDWIDE BATTERY MARKET 1990-2018

>80 BILLION US\$ in 2018 – Pack level¹
9% AVERAGE GROWTH PER YEAR (2010-2018)



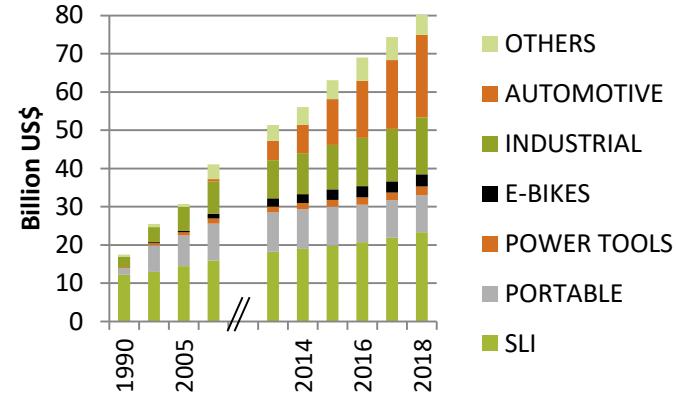
SLI: Start light and ignition batteries for cars, truck, moto, boat etc...

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, 2018



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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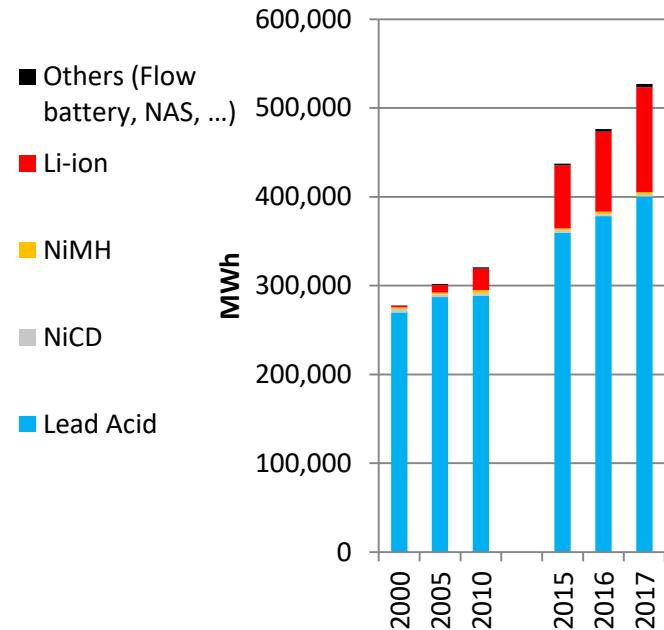


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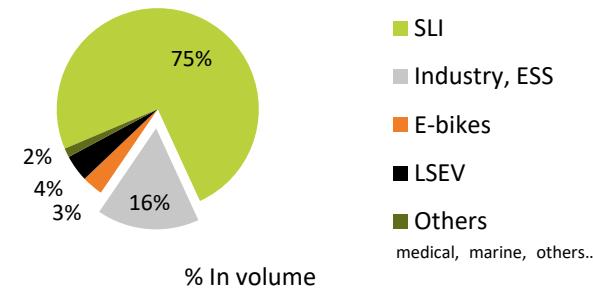
THE WORLDWIDE BATTERY MARKET 1990-2018

in volume (MWh)

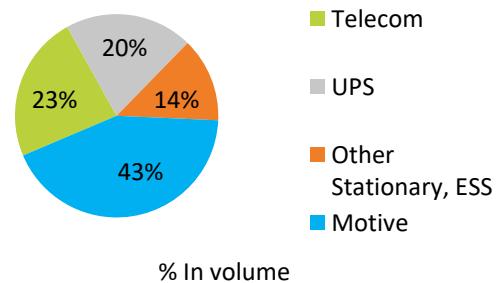


Source: AVICENNE ENERGY, 2018

Lead Acid Batteries 2018
+400 GWh for > US \$ 37.5 Billion



Industrial Batteries – Lead acid batteries
66 GWh for US \$ 11.5 Billion





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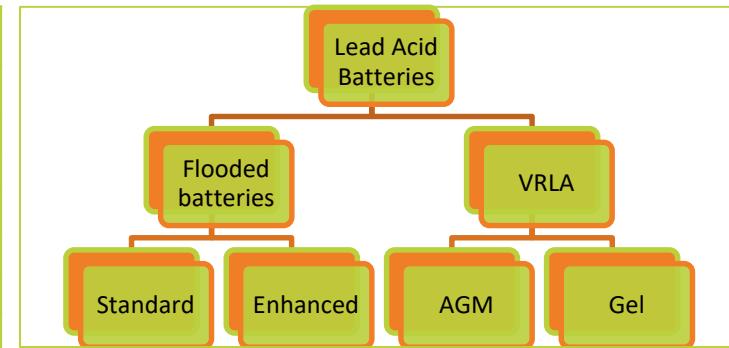
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LEAD ACID BATTERY SEGMENTATION

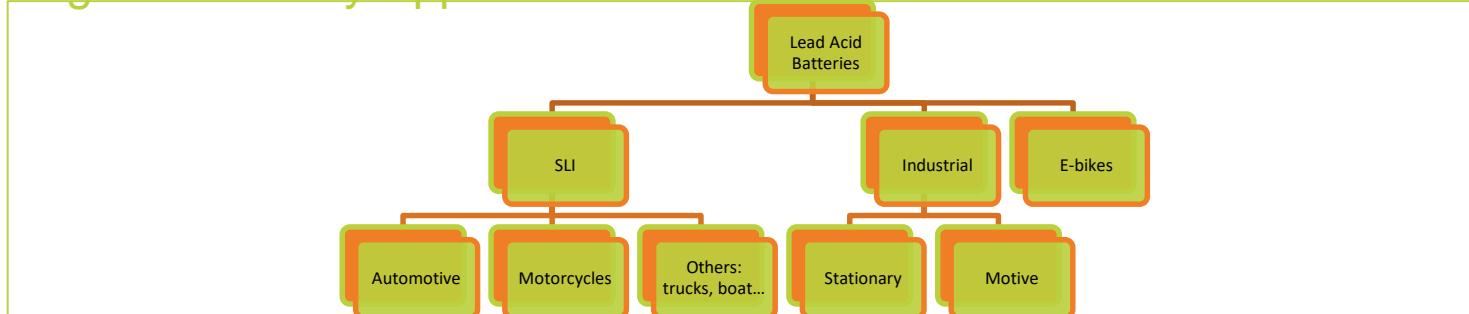
Technology / Application

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

Segmentation by technology



Segmentation by Application



Source: AVICENNE ENERGY 2018



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TECHNOLOGY ADOPTION PER MARKET SEGMENT

Li-ion batteries are being adopted by all market segments, allowing new market development or replacing legacy technologies

Segments	Sub-segments	Lead acid (PbA)	Nickel-cadmium (NiCd)	Nickel-Metal Hybrid (NiMH)	Lithium-ion (Li-ion)
Civil Electronics	Consumer electronics			↗	↗
	Medical devices	↘			↗
	Other			↗	↗
Road transportation & Marine	Starters	↘			↗
	Electric car			↘	↗
	Electric bus	↘			↗
	Electric truck				↗
Railway & Aviation	Marine				↗
	Railway	↘			↗
	Aviation	↘			↗

Relative technology adoption: High Medium Low Marginal/Null

Trend: ↗ Growing → Stable ↘ Declining

Other technologies exist but adoption is marginal

Source: AT Kearney, AVICENNE ENERGY 2018



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Industrial stationary	Utilities	↘	↗		↗
	Energy Storage Systems (ESS)	↘	↗		↗
	Industrial & Commercial				
	Residential	↘			↗
	Stationary back-up power	↘			↗
Motive industrial	Uninterruptible power supply (UPS)	↘			
	Power continuity	↘	↗		↗
Industrial vehicles		↘			↗
Space & Defense	Space		↘		↗
	Defense		↘		↗

Relative technology adoption: High Medium Low Marginal/Null

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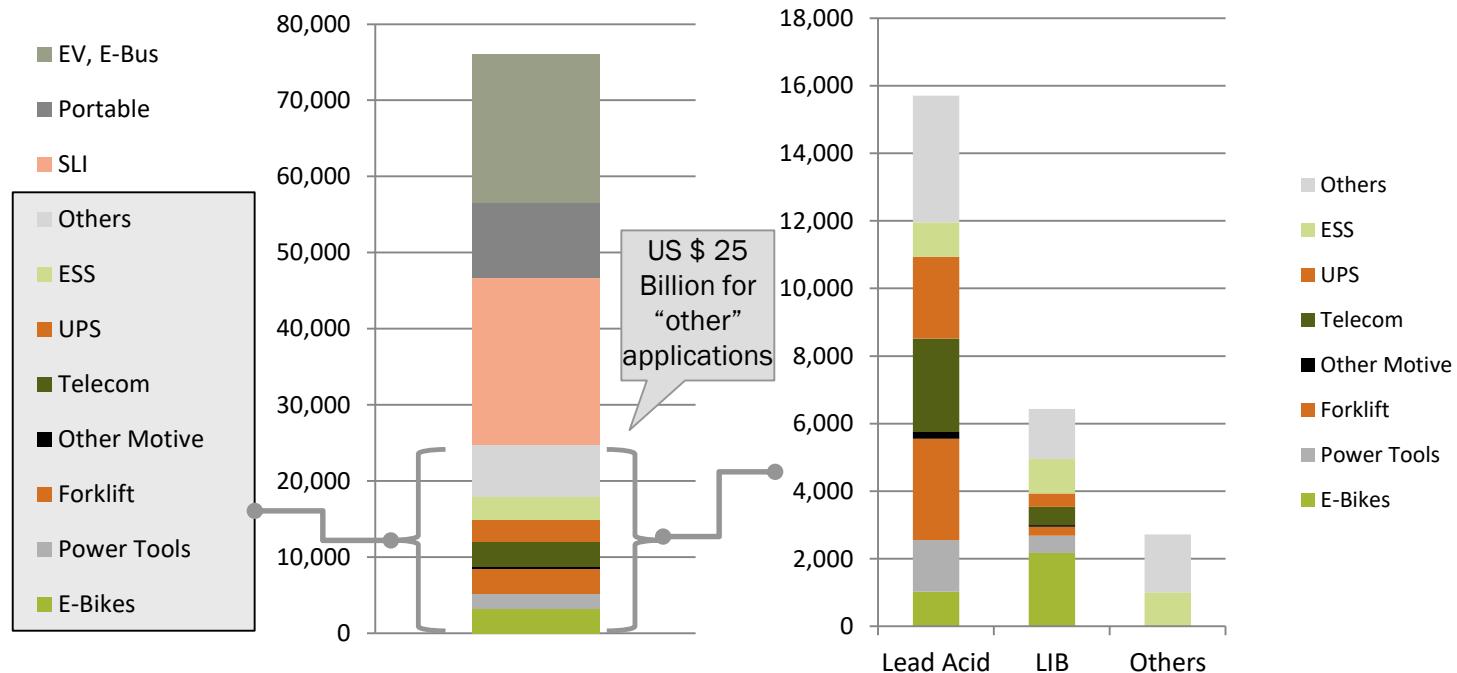
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THE WORLDWIDE BATTERY MARKET IN 2017: US \$ +75 BILLION



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

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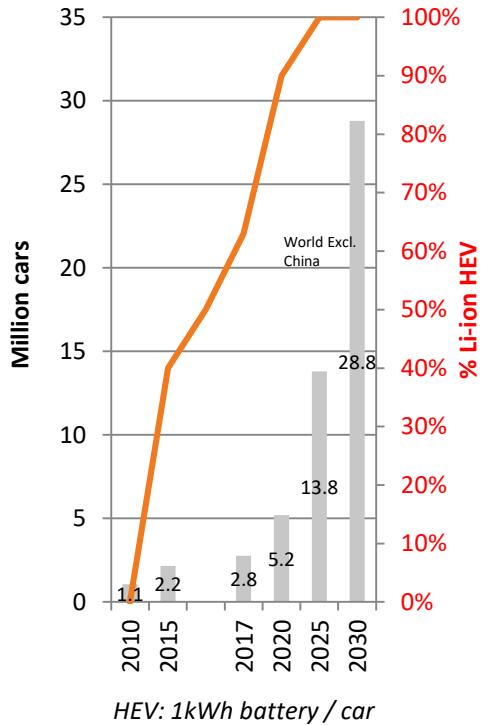
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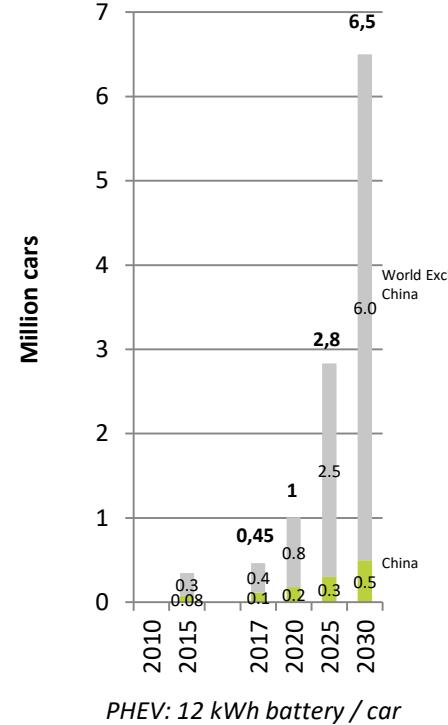
HEV, P-HEV, EV 2030 FORECASTS

Realistic Scenario

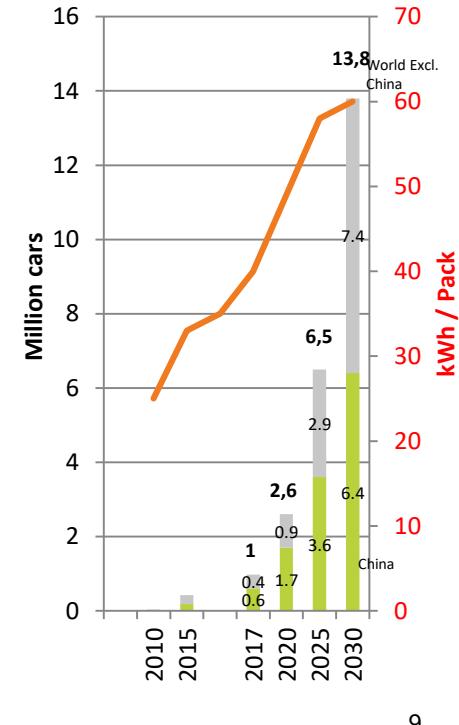
HEV manufactured



PHEV manufactured



EV manufactured





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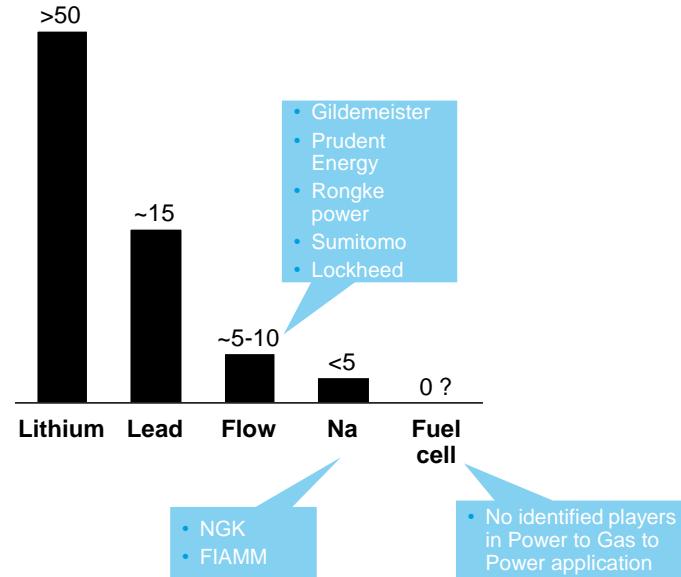


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MOST PLAYERS ARE FOCUSING ON LI-ION, WHILE DOING TECHNOLOGY WATCH ON OTHER TECHNOLOGIES

Main battery vendors involved by technology (excl. start-ups) (# ESS battery vendors, 2016)

Estimates



- Li-ion players originally in automotive pushing for ESS market as EV delayed emergence
- Strong historical presence of Pb-acid players in stationary storage with large distribution network
- Na and flow players mostly start-ups with only 2-4 main vendors actually on the market
- Large players doing technology watch on Na-ion and other technologies for the next generation (e.g. Naiades project on Na-ion batteries involving Saft with Solvay, CEA, CERN, etc.)
- No commercial activity on fuel cells for Power to Gas to Power applications
- “A player that wants to develop flow technology should have strong financial back-up to sustain R&D” (ESS player)

Source: Avicenne

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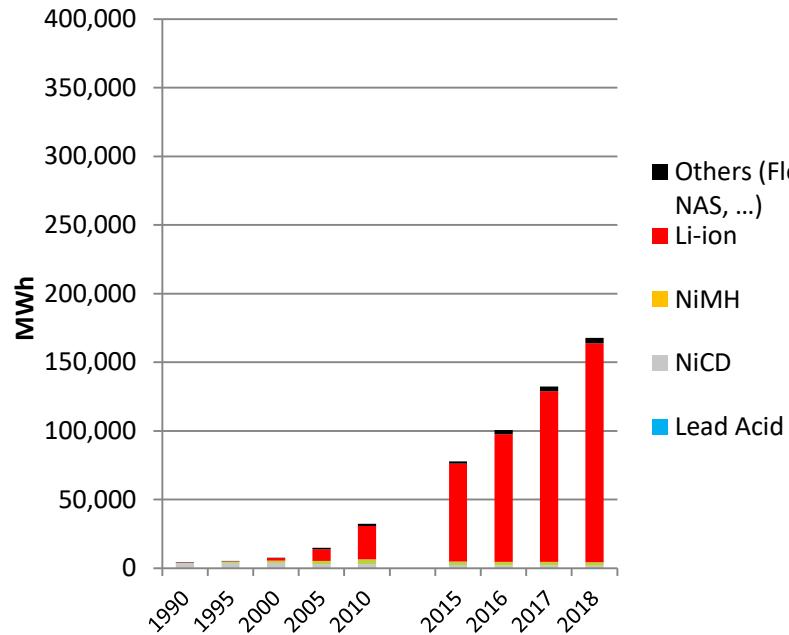
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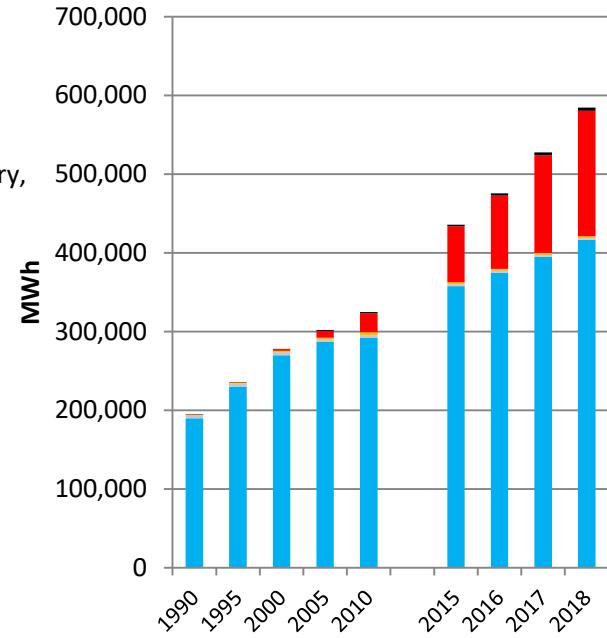
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THE WORLDWIDE BATTERY MARKET LEAD ACID CAGR – 4-5% 2019 - 2025

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Thank You