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SEMINAR & EXHIBIT

March 9, 2015

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The Rechargeable Battery Market and Main Trends 2014-2025

Christophe PILLOT

Director, AVICENNE ENERGY

Presentation Outline

- The rechargeable battery market in 2014
- The Li-ion battery value chain
- Li-ion battery material market
- Forecasts & conclusions



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AGENDA

- The market in 2014 by technology, applications & battery suppliers
- Li-ion battery value chain
 - Raw materials market
 - Supplier / customer relationship
 - Raw material cost
 - New entrants strategy
 - Raw material road map 2000-2030
- xEV market in 2013/2014
- xEV forecasts up to 2025
- Could Lithium ion replace lead acid for industrial applications?
- Rechargeable battery market forecasts up to 2025

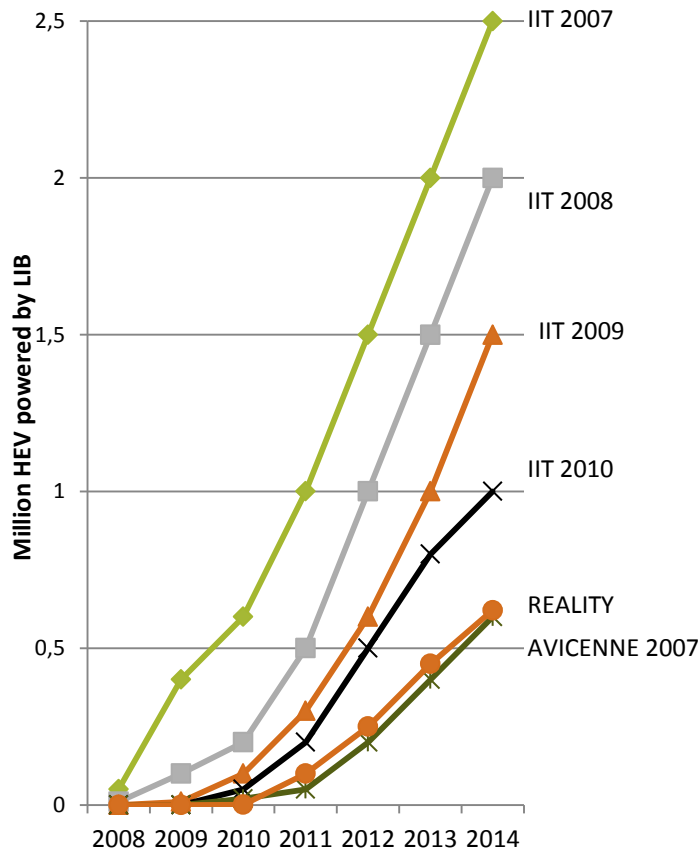


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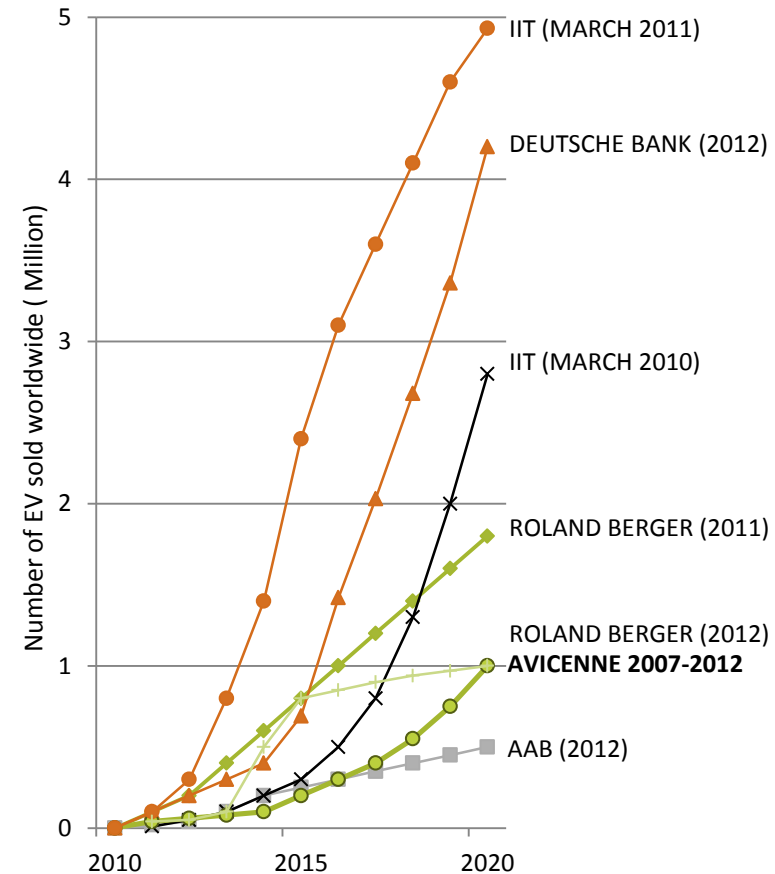
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AVICENNE ENERGY: RENOWNED TO HAVE REALISTIC FORECASTS

HEV powered by Lithium ion battery forecasts from 2008 to 2014



EV sold, in million units, worldwide, 2010 - 2020



Source : International Battery Conference, Fort Lauderdale 2007, 2008, 2009, 2010 & 2011

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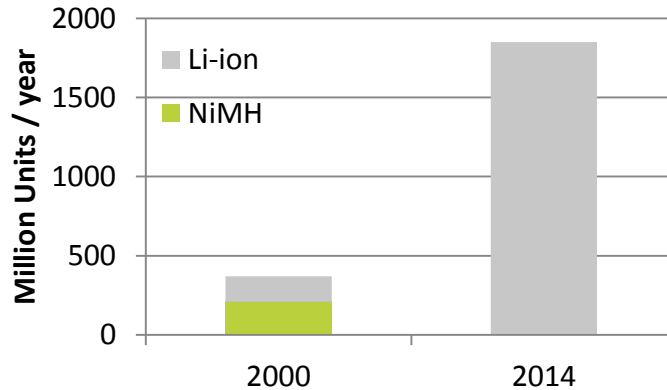
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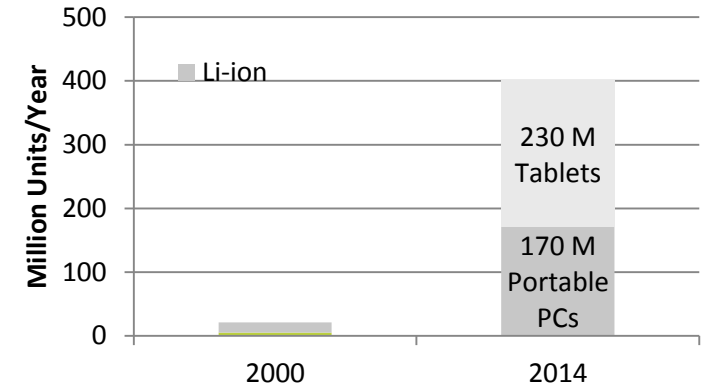
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THE BATTERY MARKET IS REALLY DYNAMIC

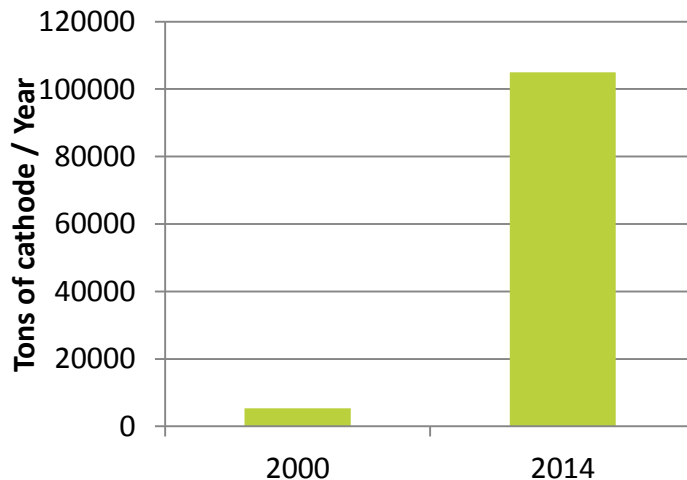
Cellular Phones sold per Year (Million)



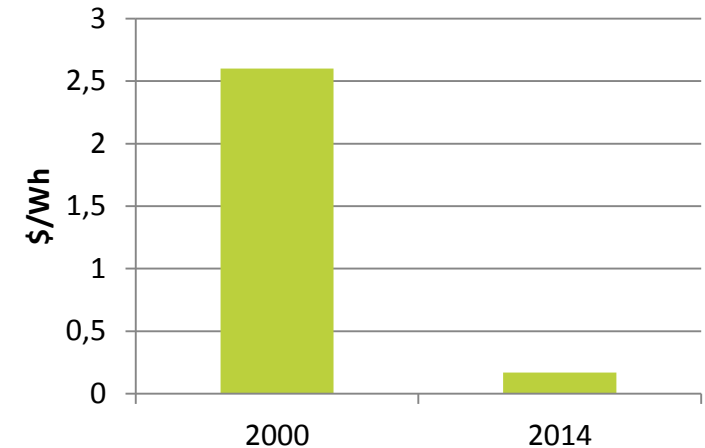
Portable PC sold per Year (Million)



Tons of Li-ion Cathode per year



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



Source: AVICENNE ENERGY Analyses 2015



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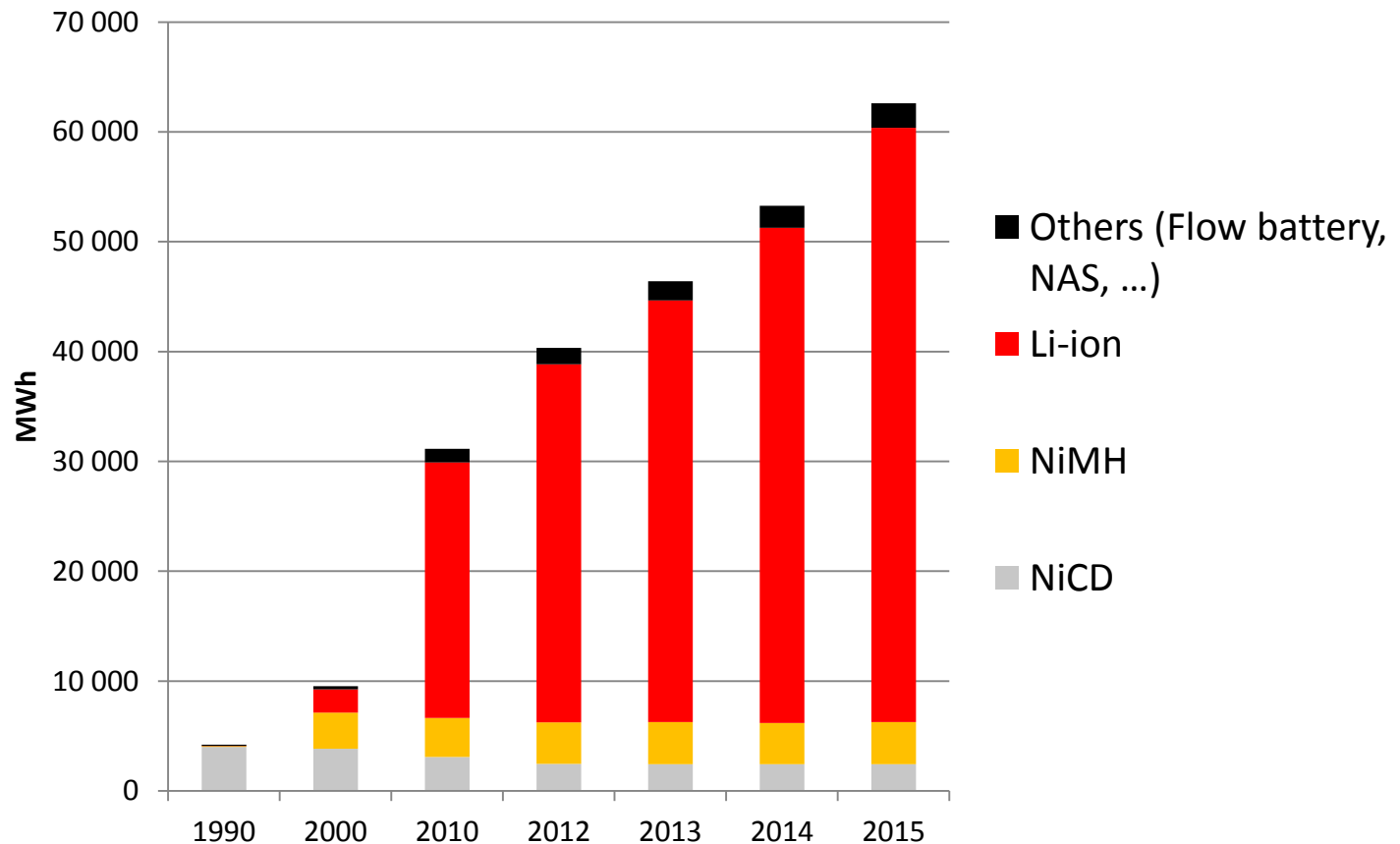
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THE WORLDWIDE BATTERY MARKET 1990-2015

Lithium Ion Battery: Highest growth & major part of industry investments



Source: AVICENNE ENERGY, 2015

2015: Estimations



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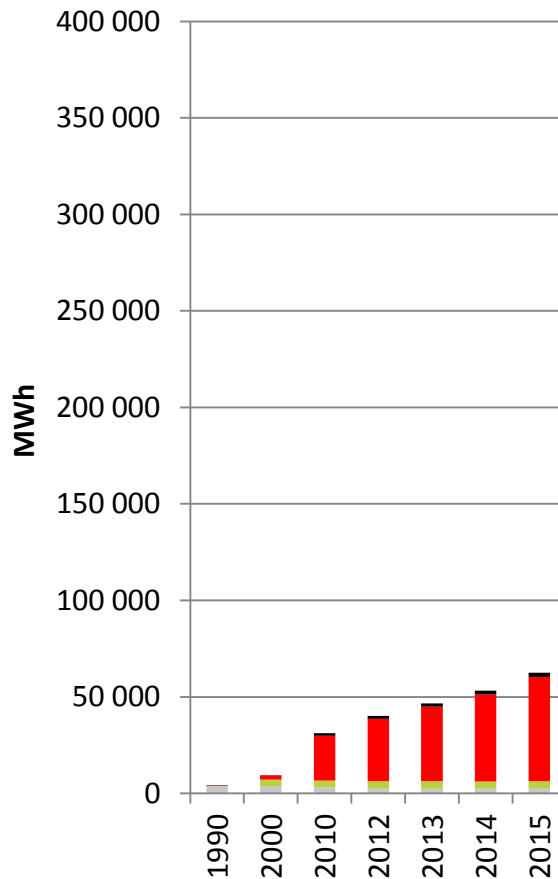
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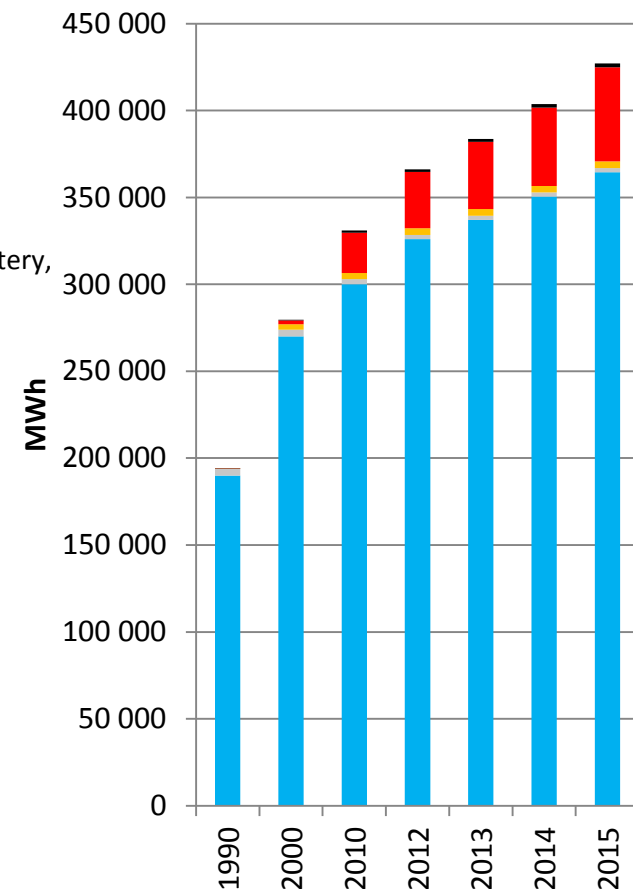
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THE WORLDWIDE BATTERY MARKET 1990-2015

Lithium Ion Battery: Highest growth & major part of the investments
Lead acid batteries: By far the most important market (90% market share)



Source: AVICENNE ENERGY, 2015



2015: Estimations



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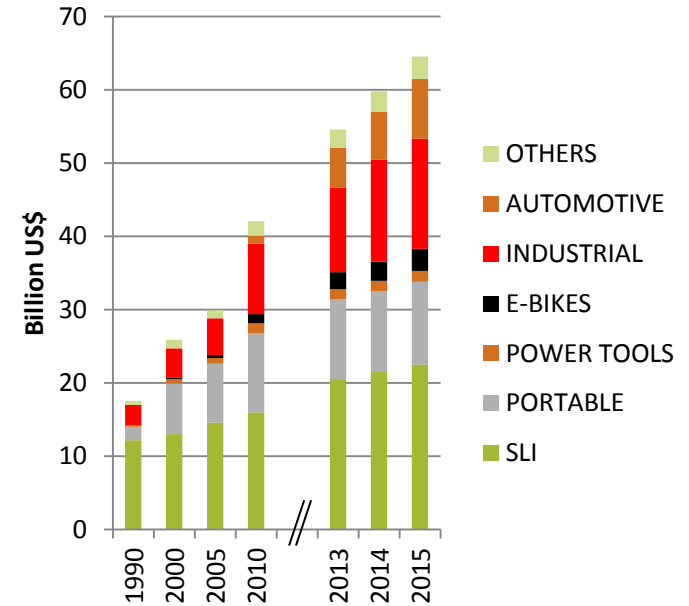
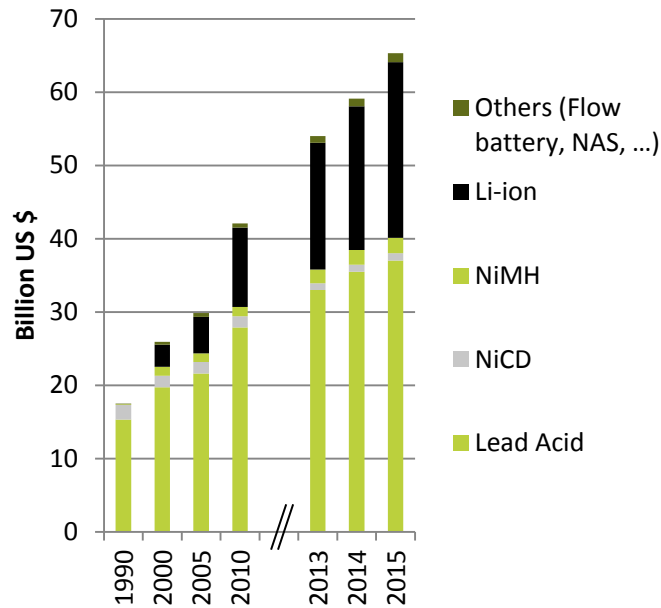
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THE WORLDWIDE BATTERY MARKET 1990-2015

60 BILLION US\$ in 2014 – Pack level¹

5% AVERAGE GROWTH PER YEAR (1990-2014)



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

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

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

Source: AVICENNE ENERGY, 2015

2015: Estimations



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THE WORLDWIDE BATTERY MARKET IN 2014: US \$ 60 BILLION

Battery market in 2014 (M\$)

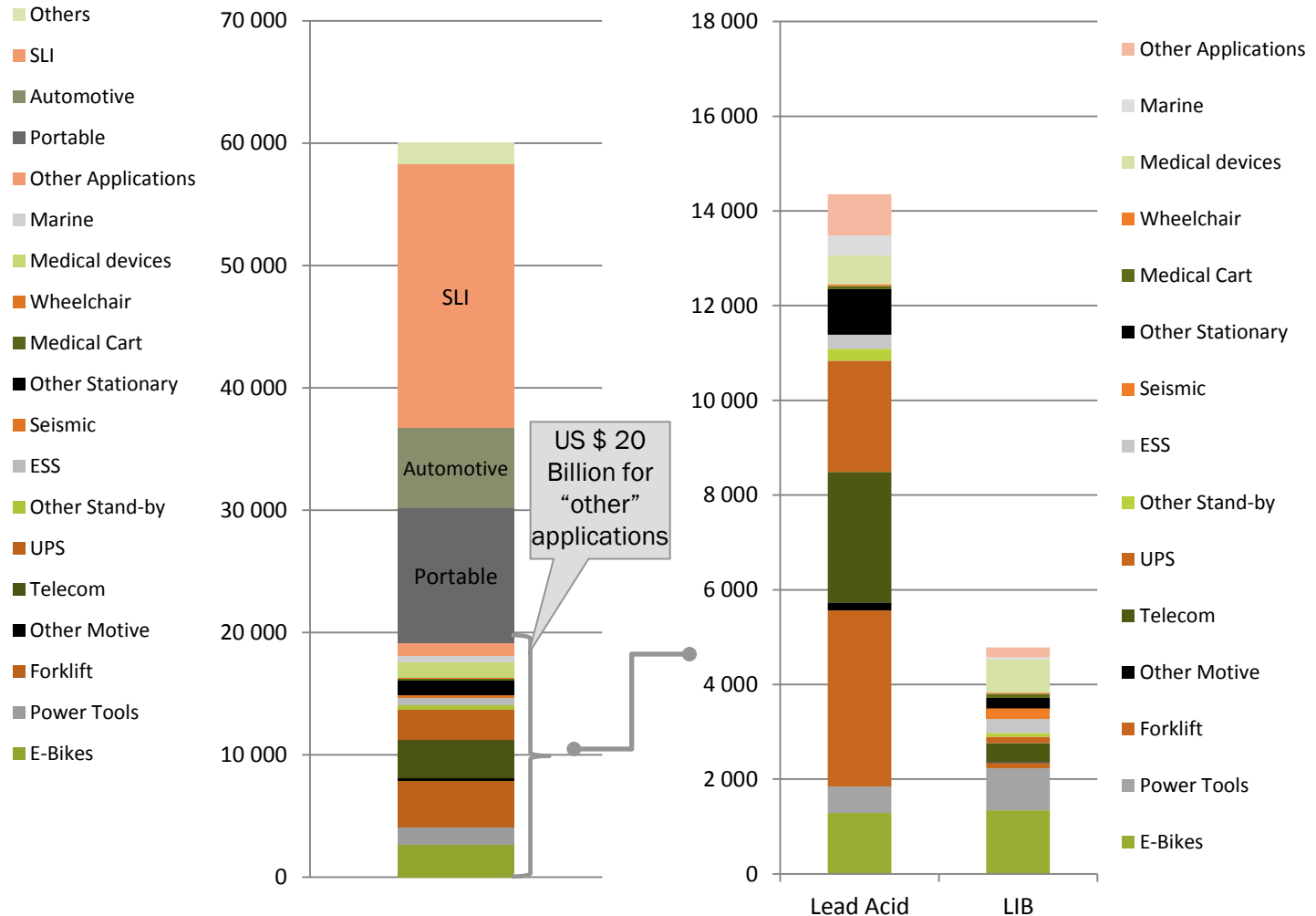
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1- Pack level: Pack including cells, cells assembly, BMS, connectors – Power electronics (DC DC converters, invertors...) not included

Source: AVICENNE ENERGY, 2015



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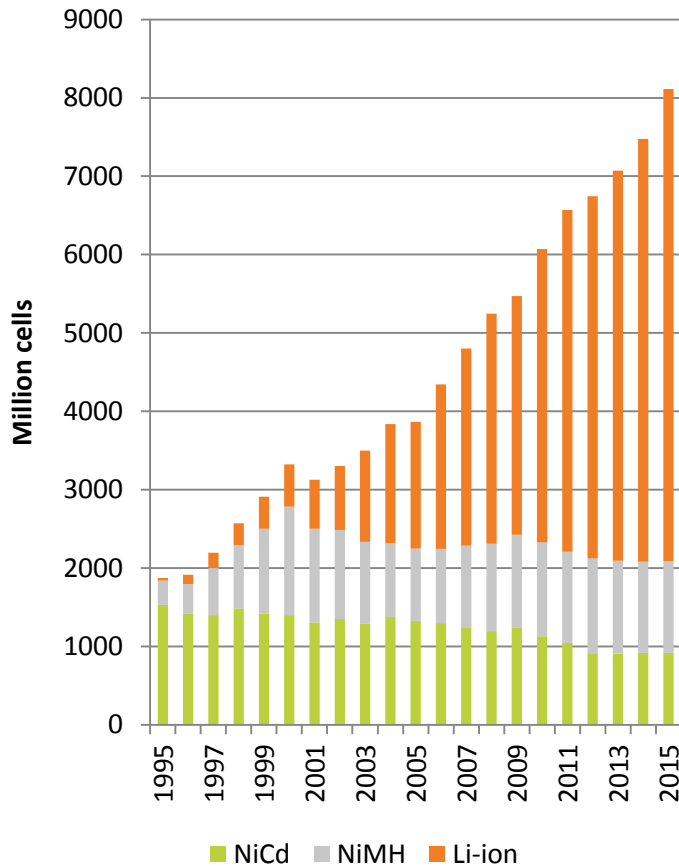
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WORLDWIDE BATTERY SALES BY CHEMISTRY, UNITS, 1995-2015

The worldwide rechargeable battery market, Million cells, 1995-2015



2015: estimation data

Which cell are we talking about?



Front Edge Technology, Inc



GS Yuasa International / Lithium Energy Japan



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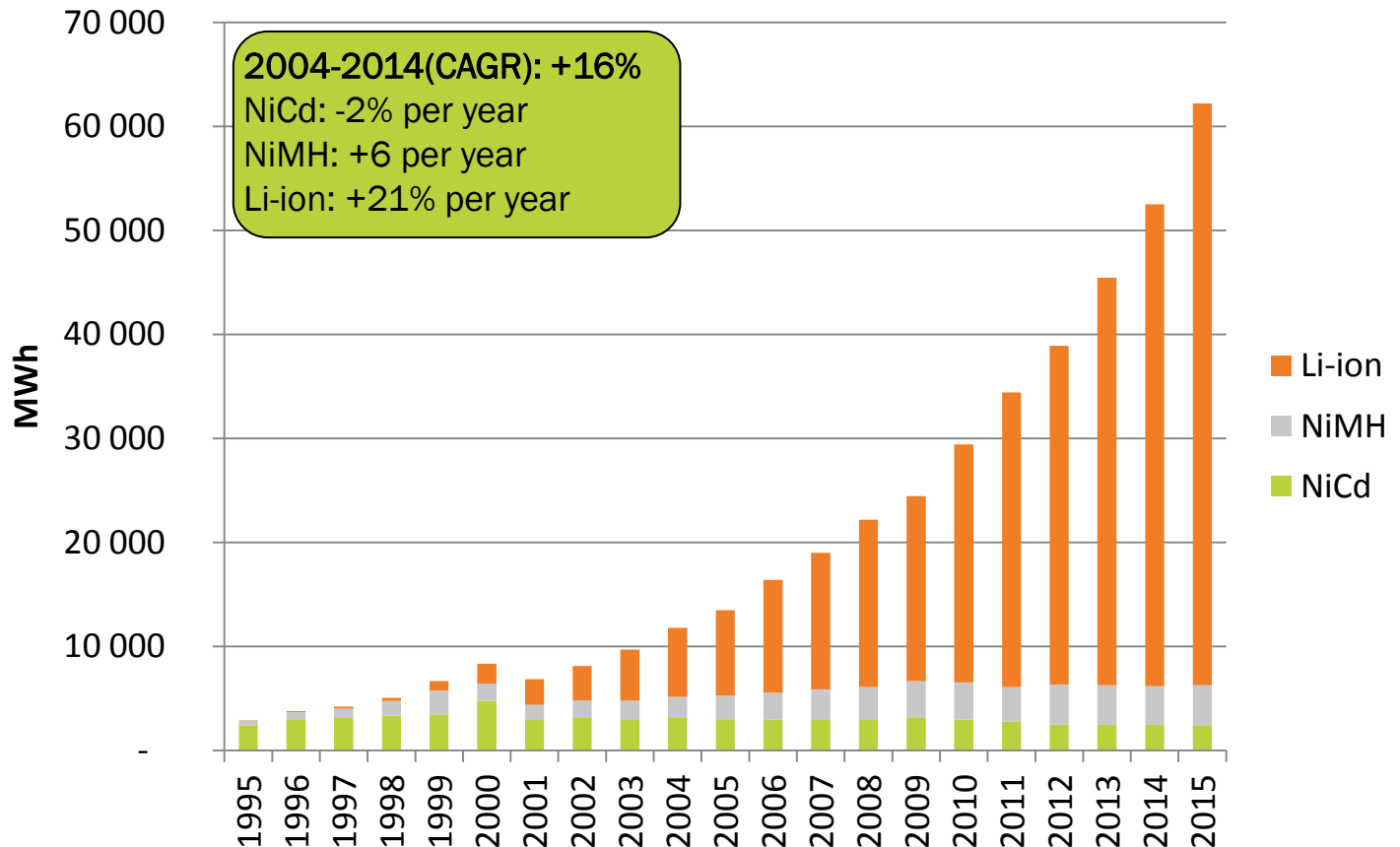
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WORLDWIDE BATTERY SALES BY CHEMISTRY, MWh, 1995-2015

The worldwide rechargeable battery market, in volume,
MWh, 1995-2015



2015: estimation data

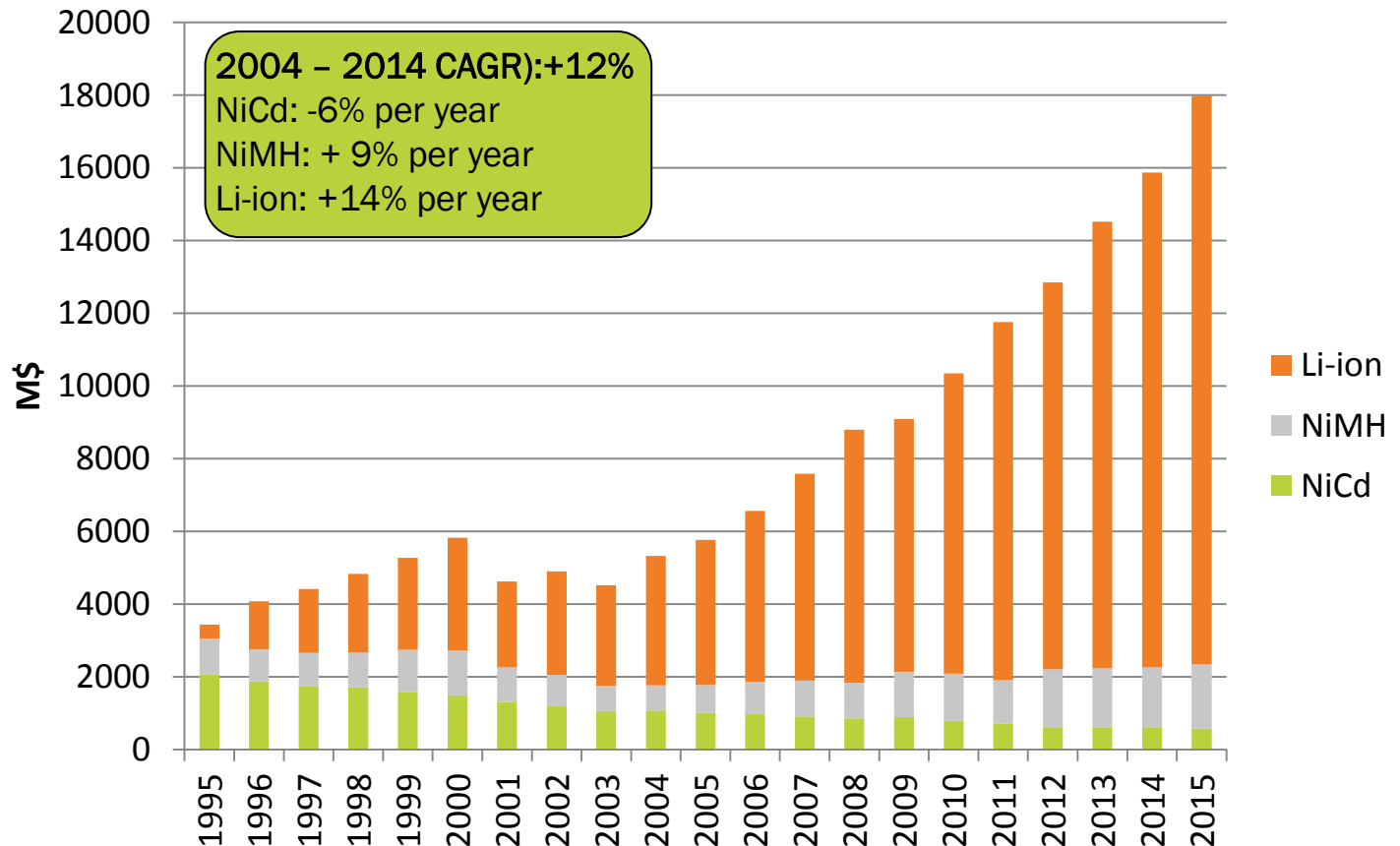


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WORLDWIDE BATTERY SALES BY CHEMISTRY, M\$, 1995-2015

The worldwide rechargeable battery market, in value, M\$, 1995-2015



Note: Cell level

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EACH BATTERY TECHNOLOGY HAS ITS SPECIFIC ABSOLUTE ADVANTAGES

Advantage ofOn		Lead Acid	Nickel Cadmium NiCd	Nickel Metal Hydride NiMH	Lithium-Ion	
					Conventional	Laminate
Lead Acid			<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Operating temperature range Self discharge rate Reliability (progressive extinction) 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Self discharge rate 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Voltage output Self discharge rate 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Self discharge rate Design characteristics
Nickel Cadmium NiCd		<ul style="list-style-type: none"> Higher cyclability Voltage output Price 		<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Voltage output Self discharge rate 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Self discharge rate Design characteristics
Nickel Metal Hydride NiMH		<ul style="list-style-type: none"> Higher cyclability Voltage output Price 	<ul style="list-style-type: none"> Operating temperature range Higher cyclability Self discharge rate Price 		<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Operating temperature range Higher cyclability Voltage output Self discharge rate 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Operating temperature range Self discharge rate Design characteristics
Lithium-Ion	Conventional	<ul style="list-style-type: none"> Higher cyclability Price Safety Recyclability 	<ul style="list-style-type: none"> Operating temperature range Higher cyclability Price Safety Recyclability 	<ul style="list-style-type: none"> Price Safety Discharge rate Recyclability 		<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density (potentially) Design characteristics Safety Price
	Laminate	<ul style="list-style-type: none"> Higher cyclability Price 	<ul style="list-style-type: none"> Operating temperature range Higher cyclability Price 	<ul style="list-style-type: none"> Volumetric energy density Higher cyclability Price 	<ul style="list-style-type: none"> Operating temperature range Higher cyclability 	
Absolute advantages		<ul style="list-style-type: none"> Higher cyclability Price 	<ul style="list-style-type: none"> Operating temperature range Price 	<ul style="list-style-type: none"> Volumetric energy density 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Self discharge rate Voltage output 	<ul style="list-style-type: none"> Gravimetric energy density Volumetric energy density Self discharge rate Voltage output Design characteristics

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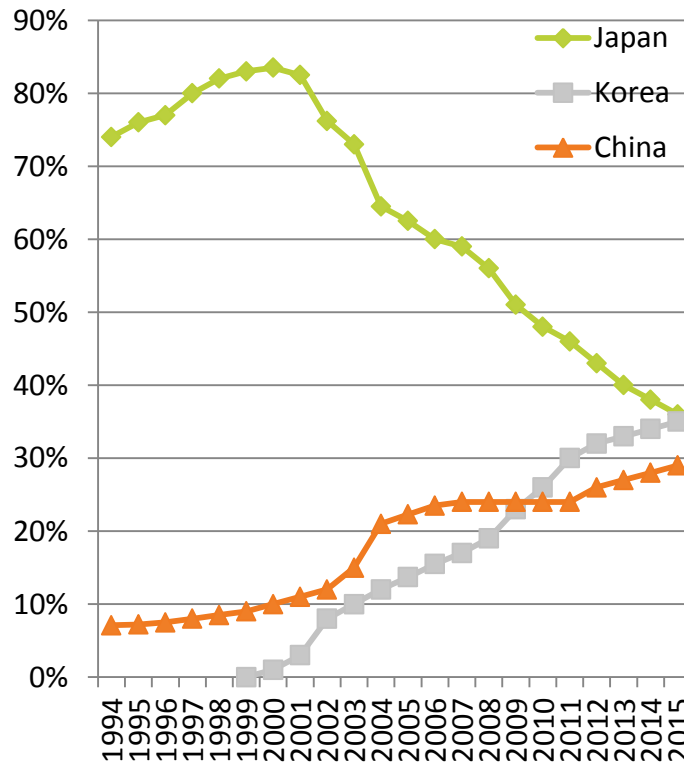
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JAPANESE, CHINESE & KOREAN MARKET SHARE

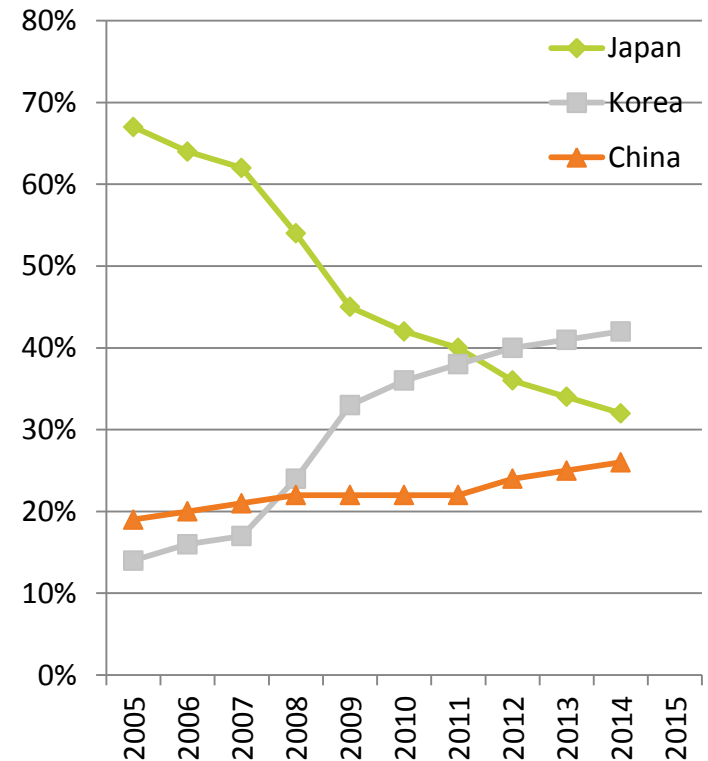
Japanese market share (value) decreasing: from 82 % of the market in 2001 to < 40% in 2014

Rechargeable battery⁽¹⁾ market by country



(1) Excluding lead acid batteries

LIB market by country



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Main Trends
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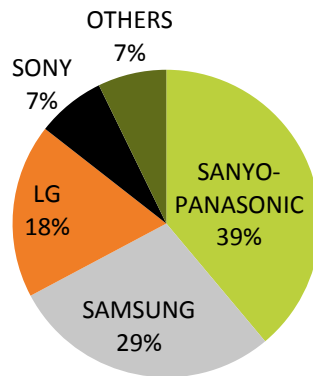
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CYLINDRICAL LI-ION BATTERY

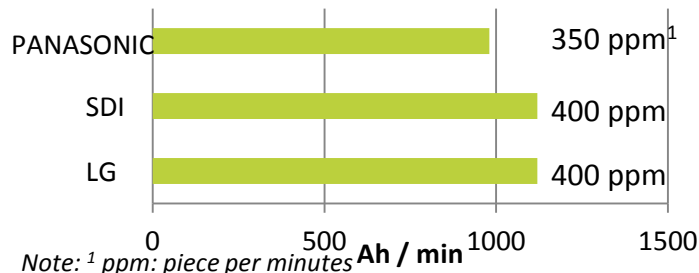
Cylindrical LIB market Company market share in 2014 in volume: 1925 Million cells (+3%)



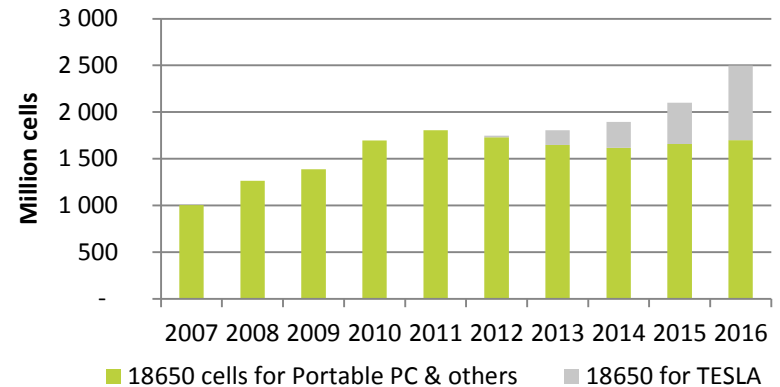
Key success factor

- Production speed (-> cost)
- Performances
- Customer (Portable PCs) access

Production Speed: 18650 – 2,8Ah cells

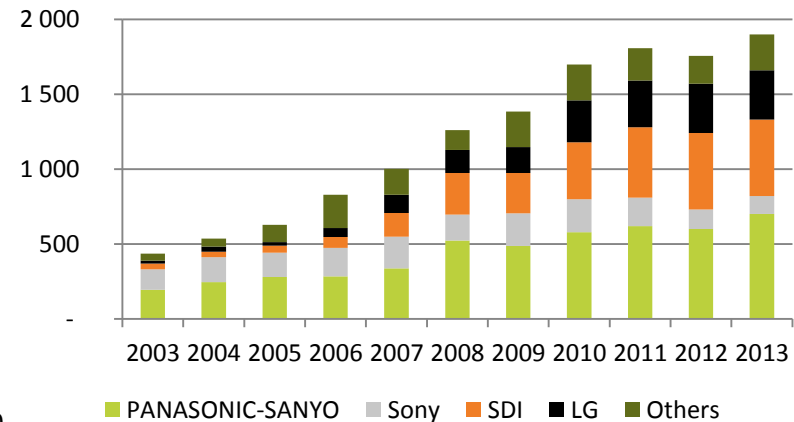


SANYO-PANASONIC, SDI & LG will share the market



Assumptions: TESLA sold 35 kEV in 2014, 55 kEV in 2015 and 100 kEV in 2016

Cylindrical cells (M) by mfg.



Source: Interviews with LG, SAMSUNG, SANYO-PANASONIC 14



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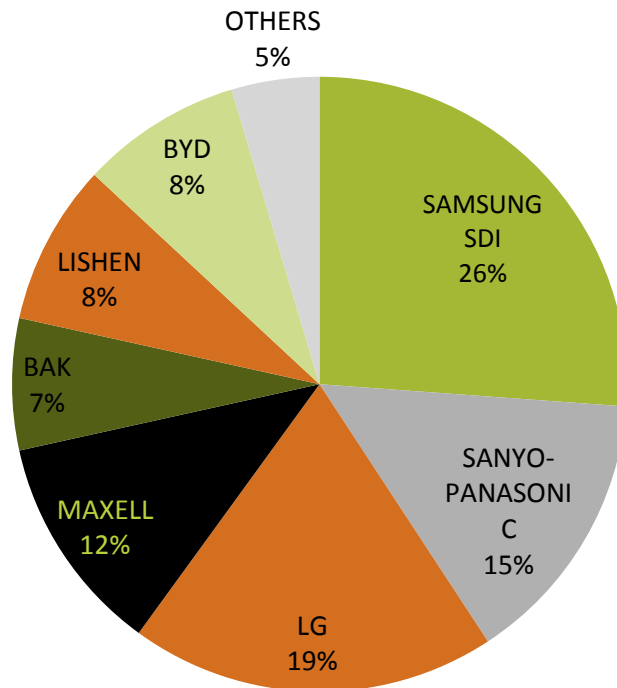
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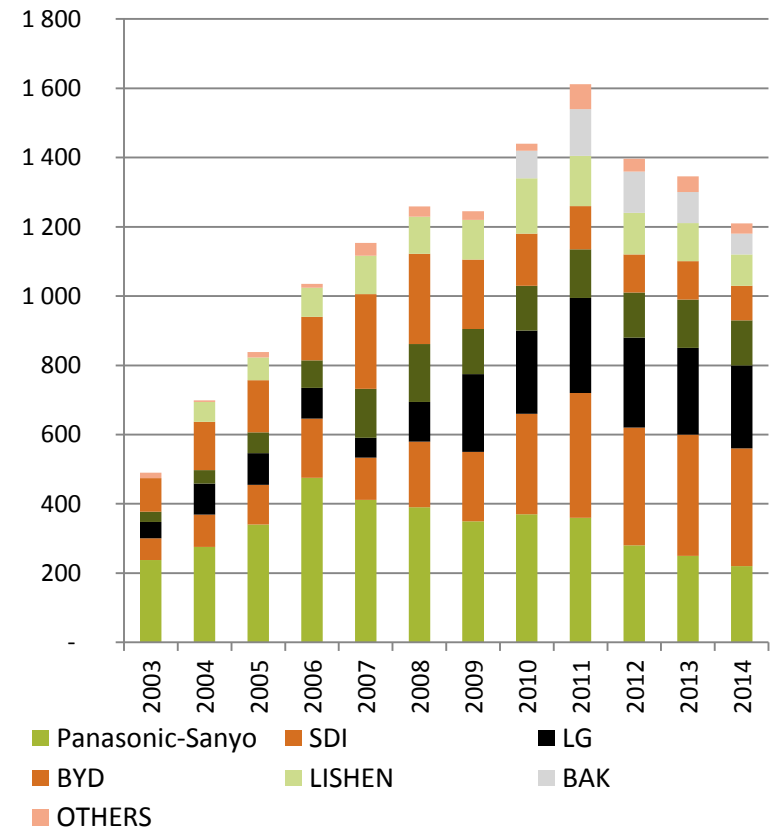
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PRISMATIC LI-ION BATTERY

Prismatic LIB market Company market share in 2014 in volume: 1200 Million cells (-5%)



Prismatic cells (M) by Mfg. : SAMSUNG is leading



Source: AVICENNE ENERGY Analyses 2015

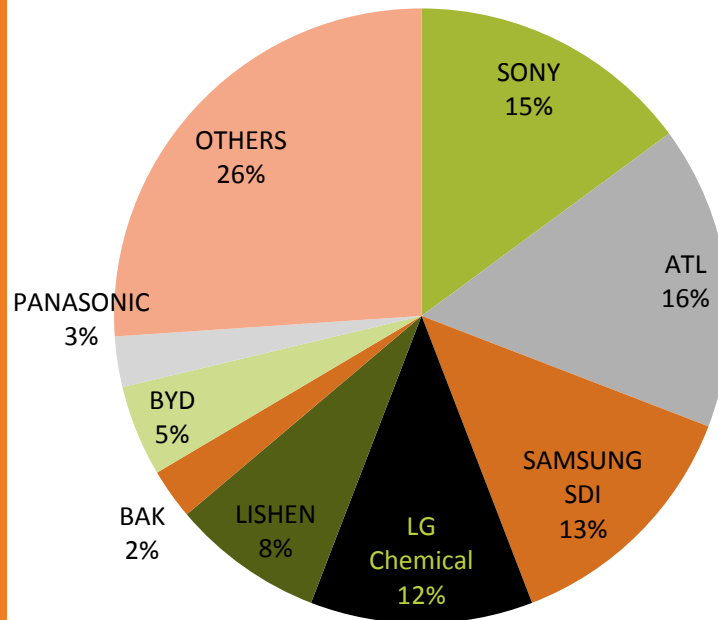


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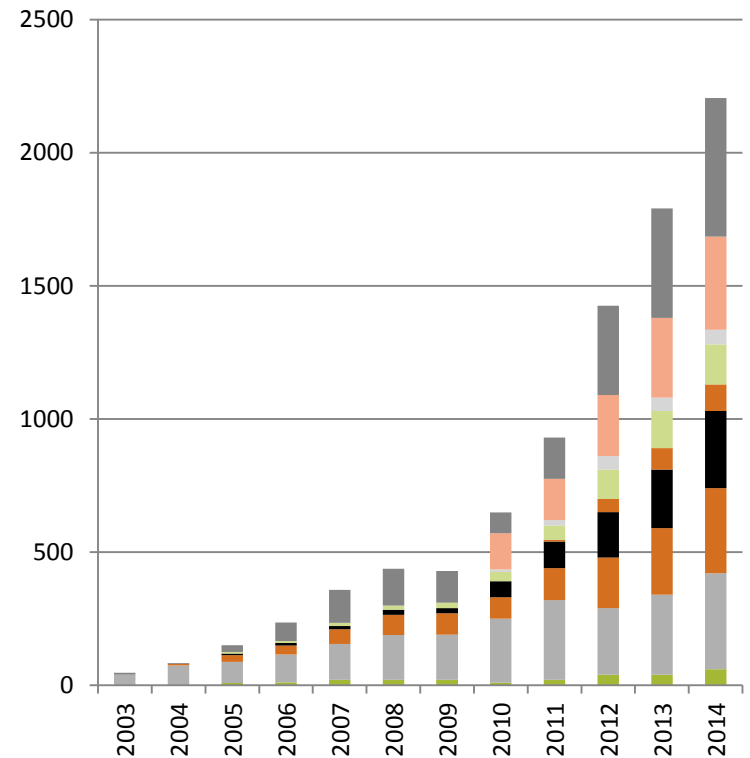
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LI-LAMINATE BATTERY

Laminate battery market
Company market share in 2014
in volume: 2 220 Million cells
(+32%)



Pouch cells (M) by Mfg. SONY, ATL and SAMSUNG are leading this market



Source: AVICENNE ENERGY Analyses 2015

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LI-ION IN 2014

MAIN APPLICATIONS: CELLULAR, NOTEBOOK

5 400 M cells – 46 000 MWh

13 600 M\$ (2)

CAGR 2004/2014

+21 % per year in Volume

+14% per year in value

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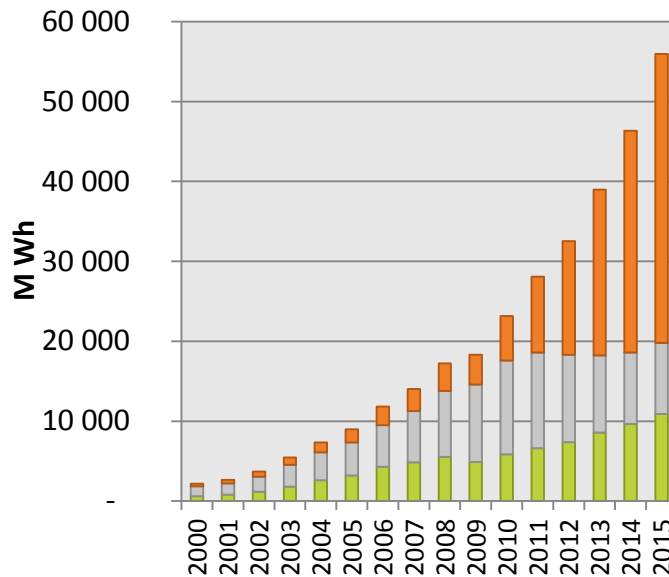
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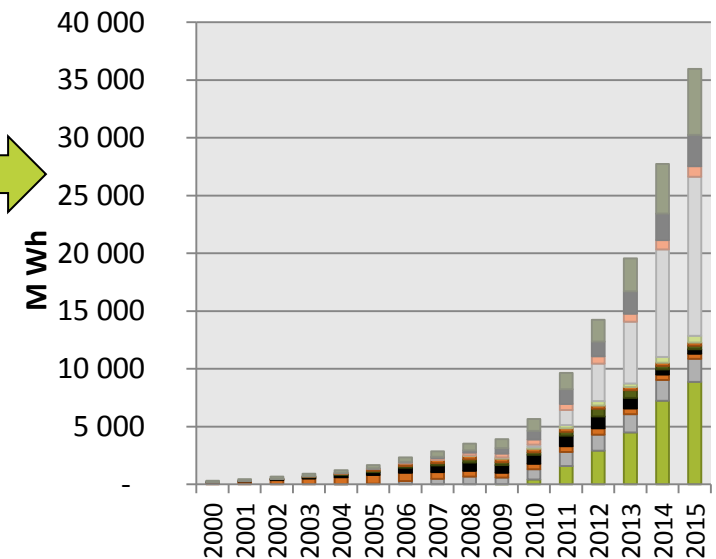
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Li-ion Battery sales,
MWh, Worldwide, 2000-2014



Cellular Phones Portable PCs Others

Li-ion Battery sales,
MWh, Worldwide, 2000-2014



Tablets Digital Camera Toys E-bikes Power Tools Video Games Auto Camcorders MP3 Household devices

2015 estimation data



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LI-ION IN 2014

MAIN APPLICATIONS: CELLULAR, NOTEBOOK

5 250 M cells – 45 000 MWh

13 300 M\$ (2)

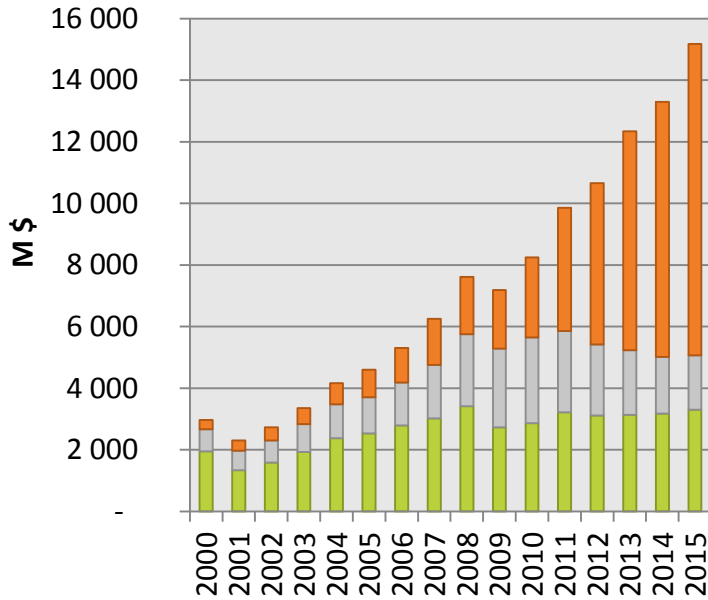
CAGR 2004/2014

+20 % per year in Volume

+14% per year in value

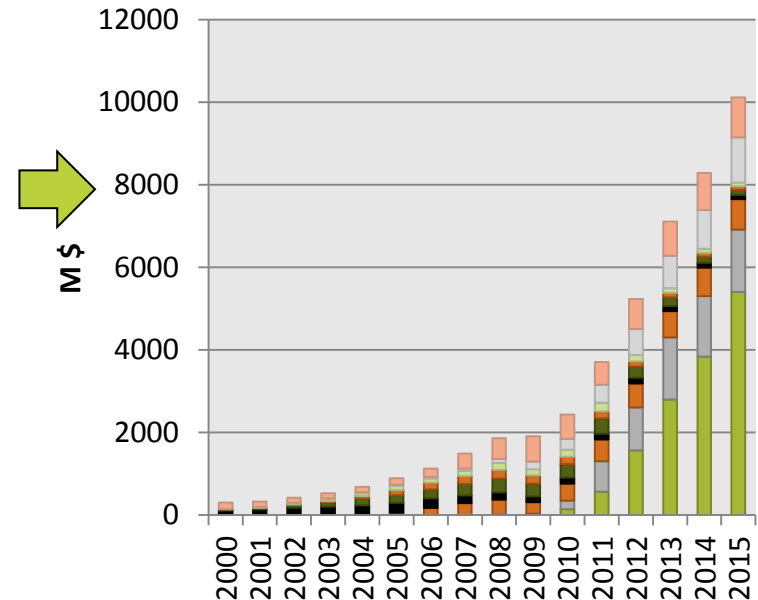
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Li-ion Battery sales,
M\$, Worldwide, 2000-2014 (1)



■ Cellular Phones ■ Portable PCs ■ Others

Li-ion Battery sales,
M\$, Worldwide, 2000-2014 (1)



■ Automotives ■ Tablets ■ Power tools
■ Camcorders ■ Digital camera ■ MP3
■ Games ■ E-Bikes ■ Others

Note: (1) 2013: Avicenne Forecasts (2) Cell level

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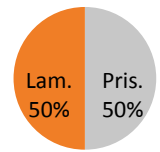
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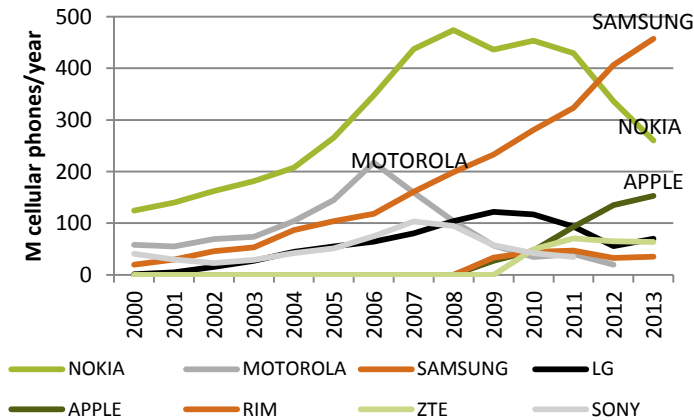
CELLULAR PHONES MARKET

> 1980 M LIB CELLS IN 2014

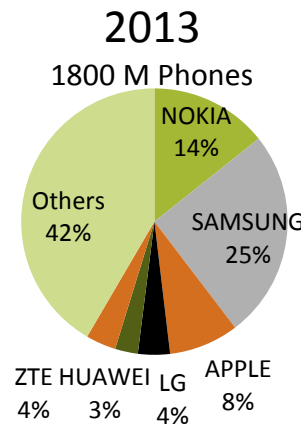
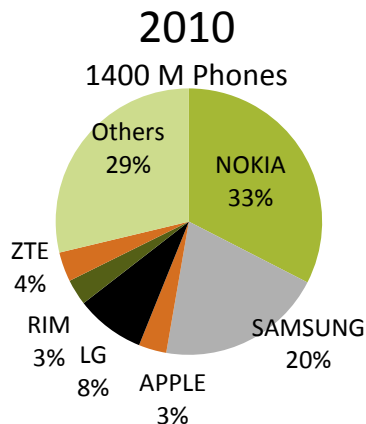
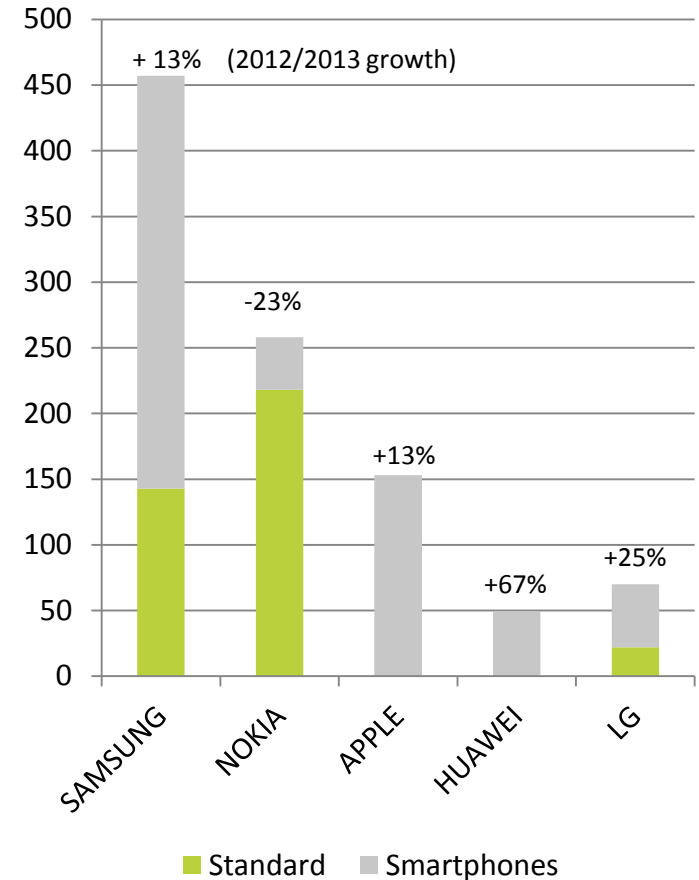


LIB cell format
(Volume) 2013

+1800 M cell phones sold in
2013 (+7% CAGR)



Samsung Galaxy & I-phone
change the game



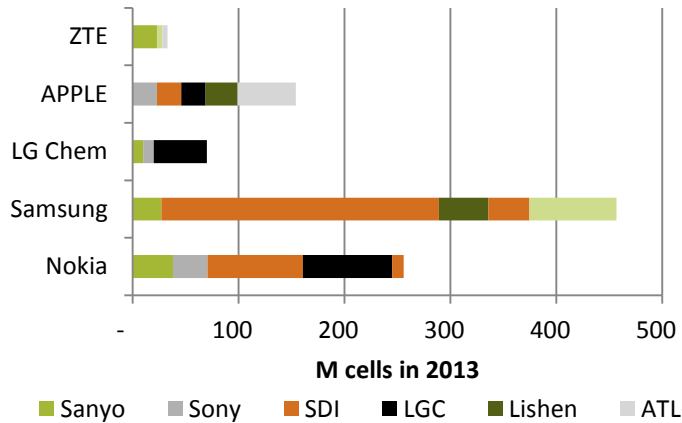


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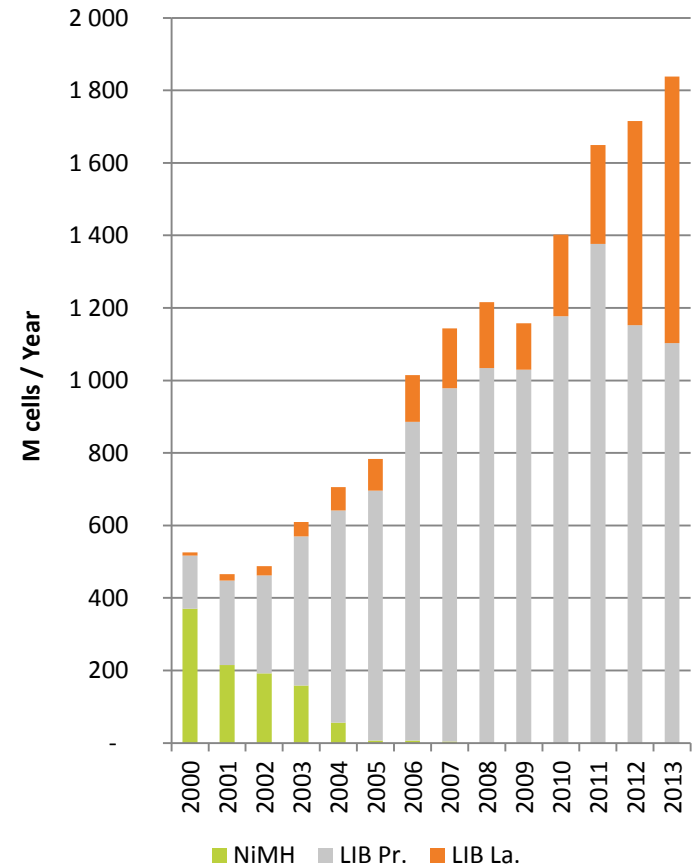
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CELLULAR PHONES/LIB SUPPLIERS RELATIONSHIPS

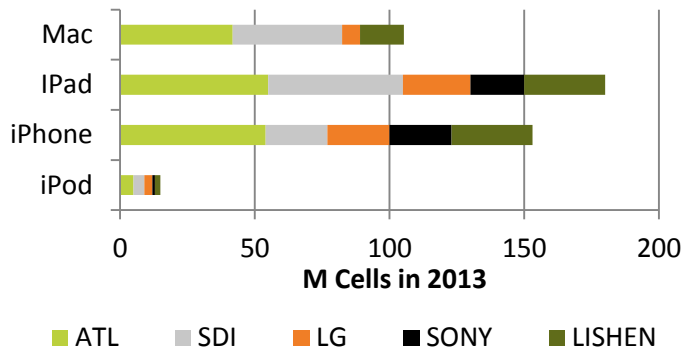
2013 Cellular Phone makers / battery suppliers relation



Smartphones / ie laminate LIB increasing



APPLE needs in 2013



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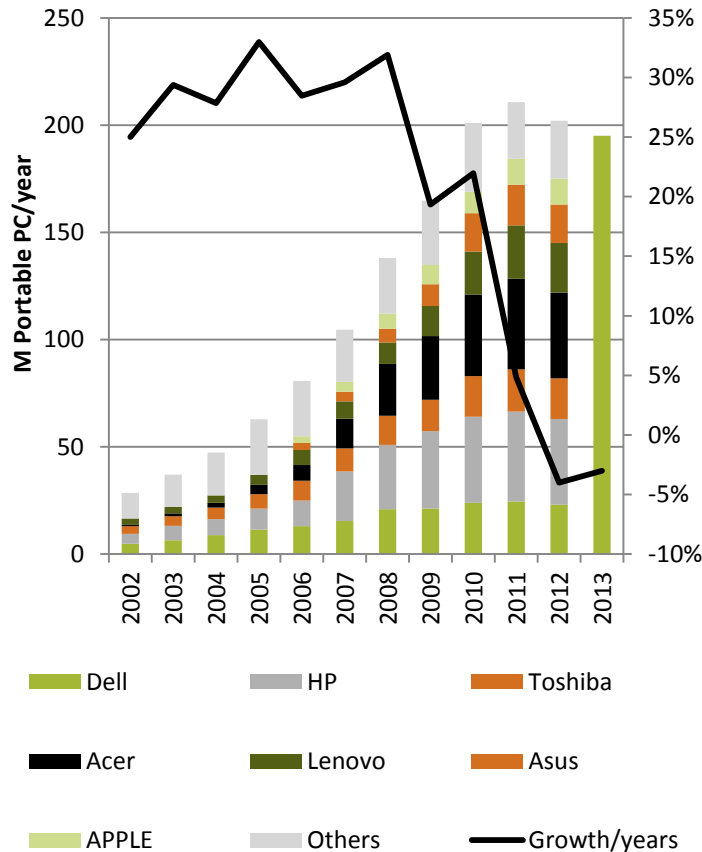
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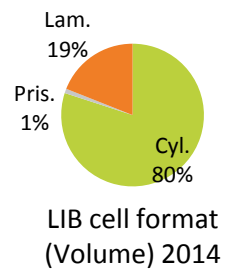
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PORTABLE PC MARKET 990 M LIB CELLS IN 2014

195 M portable PCs sold
2012/2013: -3%



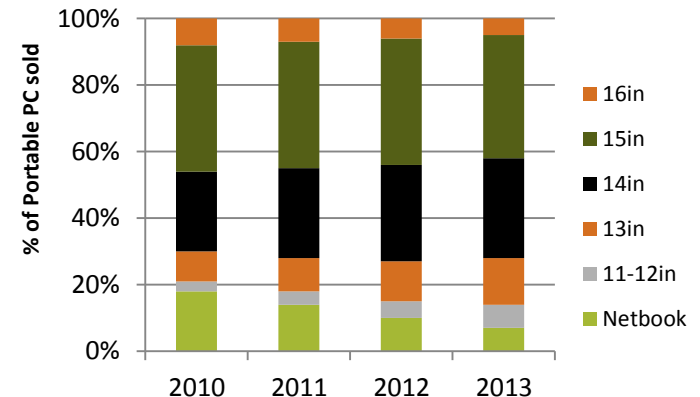
Note: Excluding Tablets



Market outlook 2014

- ⚠ Uncertain macro & weakness in both consumer & commercial growth
- ⚠ No sign for end-customer demand recovery
- ⚠ Decrease due to cannibalization by tablets
- ⚠ Small overall decrease only thanks to Emerging market growth

Increase of Ultra-thin Portable PCs





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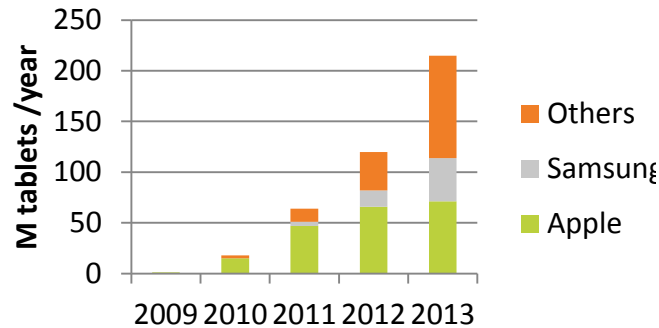
CONTACT

Christophe PILLOT
+ 33 1 47 78 46 00
c.pillot@avicenne.com

TABLET MARKET > 550 M CELLS IN 2013

Tablets sold (Million)

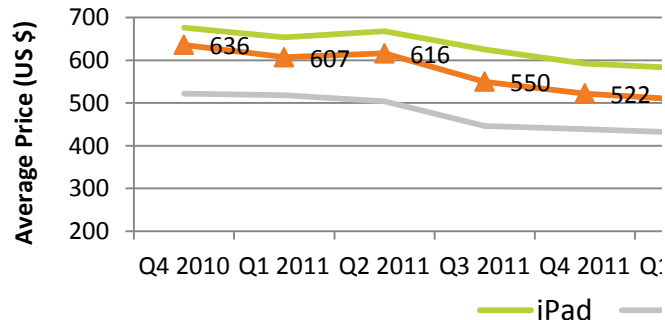
Apple leadership



Source: Gartner, IDC, Display search – 2013: AVICENNE Estimati

ASP tablets drop

From \$636 in Q4 2010 to \$335 in Q4 2011



Lam.
100%

LIB cell format
(Volume) 2014



30194148
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Main Trends
2014-2025

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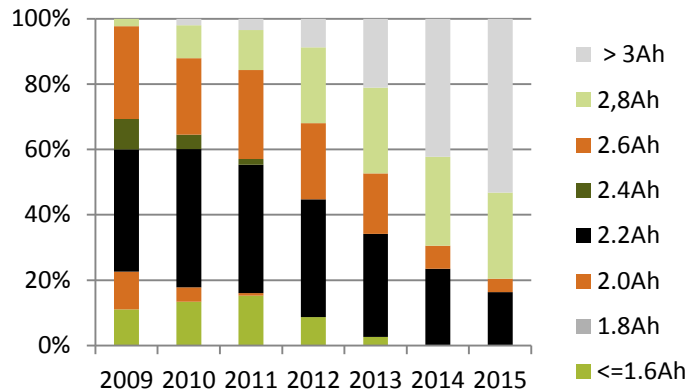
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LIB BATTERY SHORT TERM TRENDS

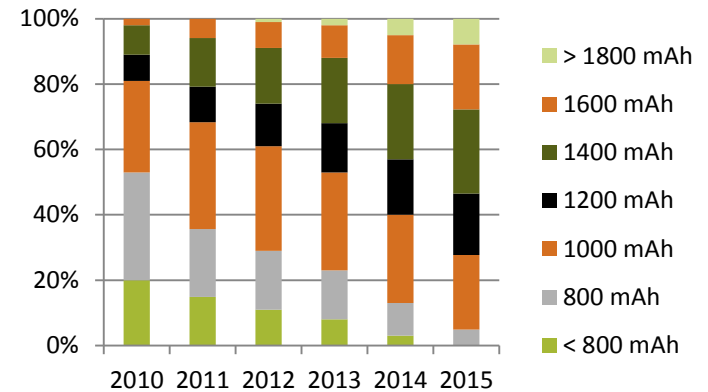
Higher capacity, thinner battery, Pouch cells have the highest growth

18650 battery capacity*

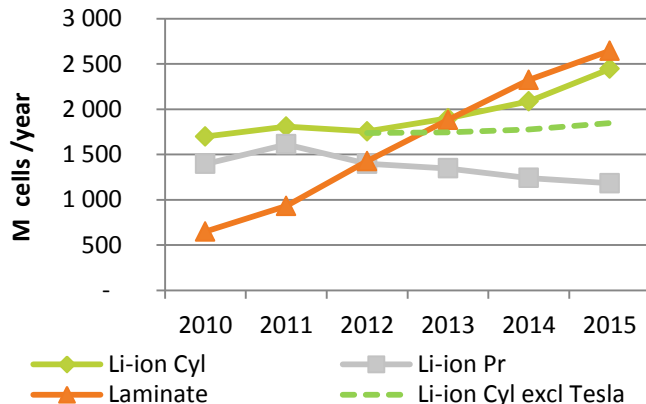


*1C rate or laptop type 18650 cells

Cellular phones battery capacity

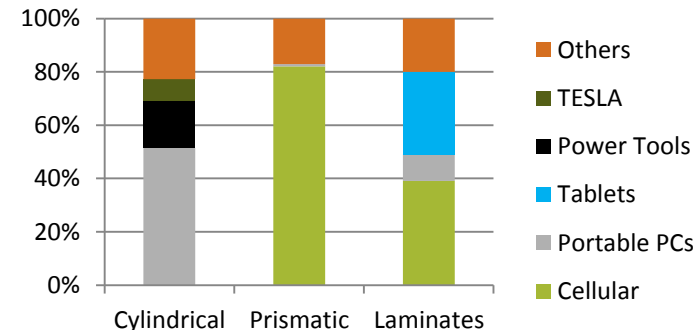


Cylindrical/Prismatic/Laminates



Li-ion cylindrical: "Tesla impact": 150 M cells in 2013, 300M in 2014, 600 M in 2015

Cylindrical/Prismatic/Laminates in 2013



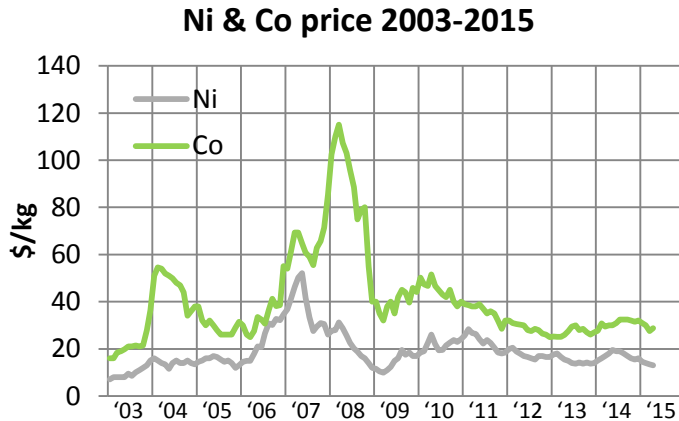


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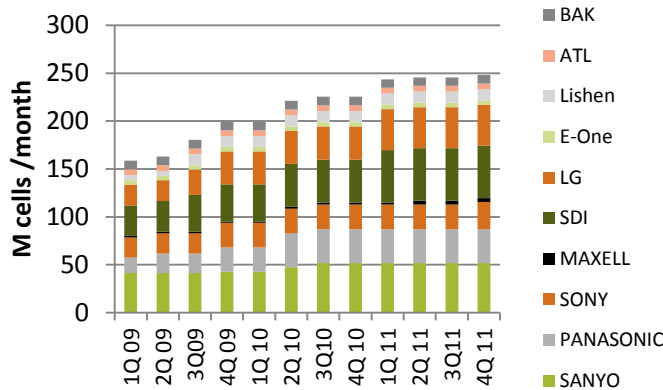
BATTERY PRICE IS DECREASING DRASTICALLY

In 10 Years 80% price decreasing
despite a fluctuating Co price

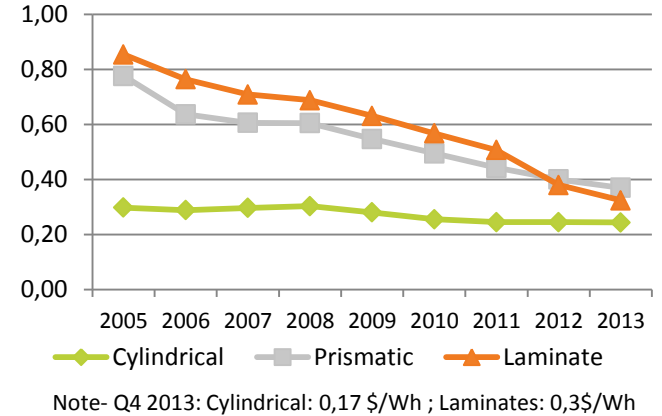


Source: LME

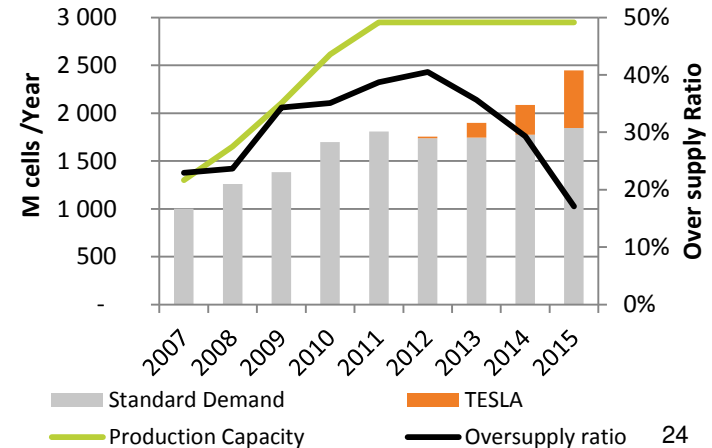
Production capacity 2009/2011:
from 150 to 250 M cells/month



Average LIB cell price (\$/Wh)



18650 oversupply ratio is
decreasing thanks to TESLA



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2014-2025

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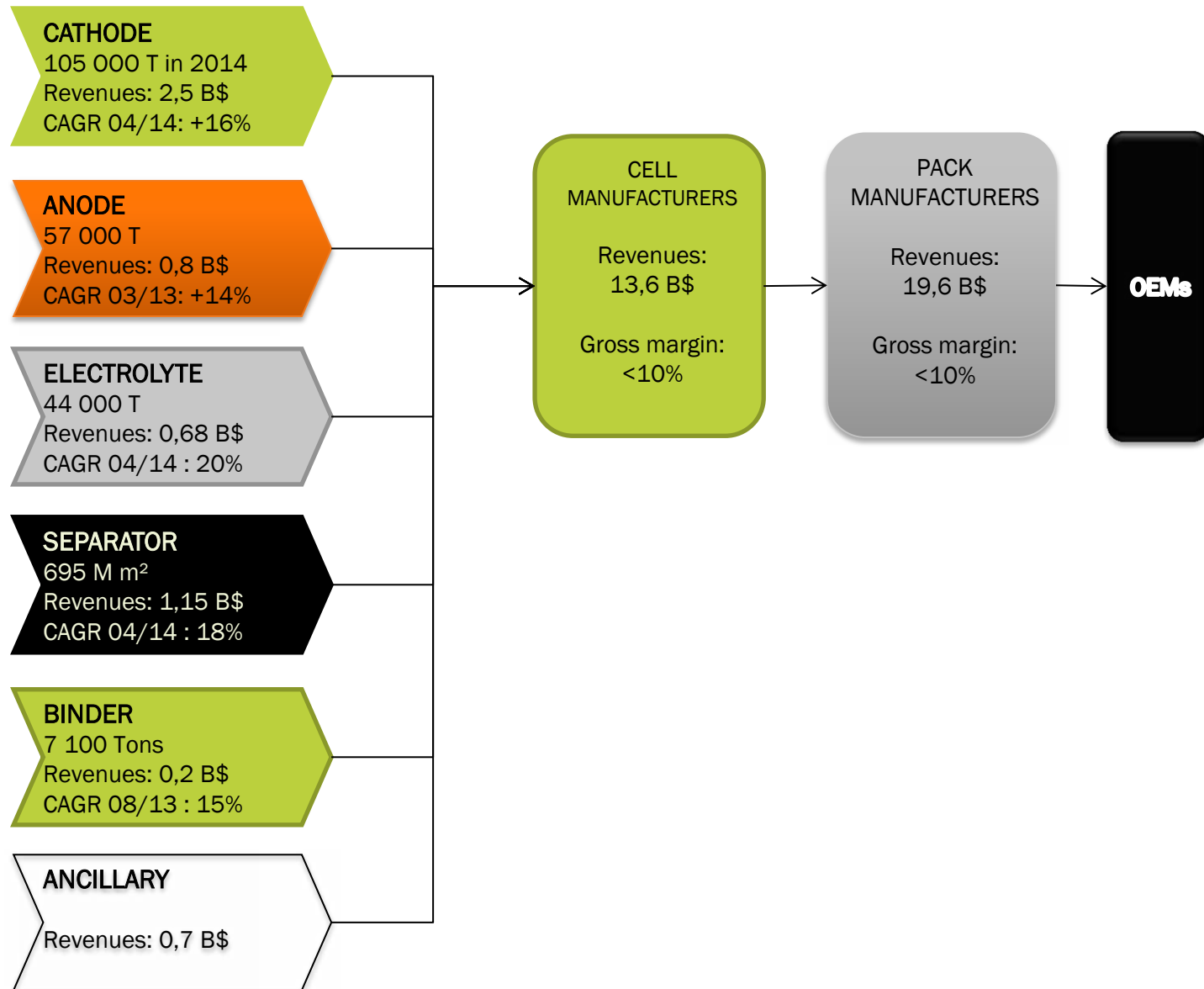
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LI-ION VALUE CHAIN – MARKET DEMAND



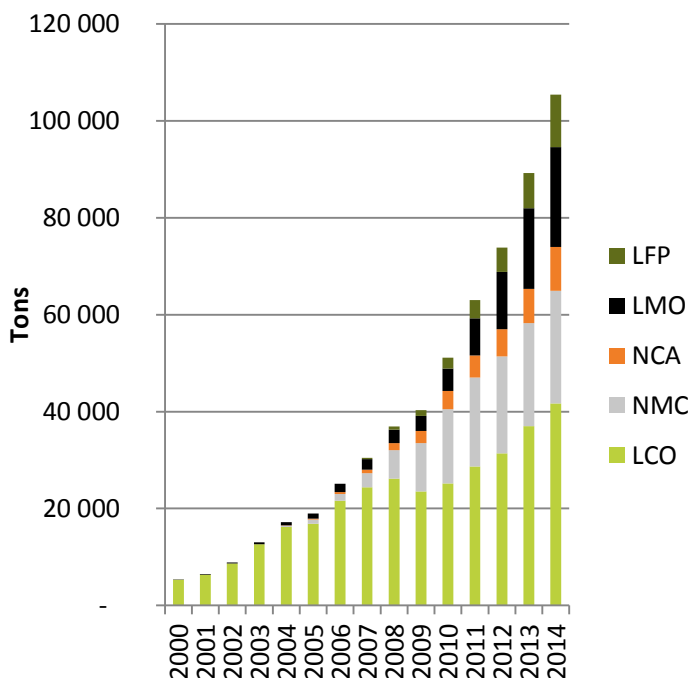


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CATHODE ACTIVE MATERIALS NEEDS BY CHEMISTRY

Cathode active materials for LIB in Tons, 2000-2014 (Demand)

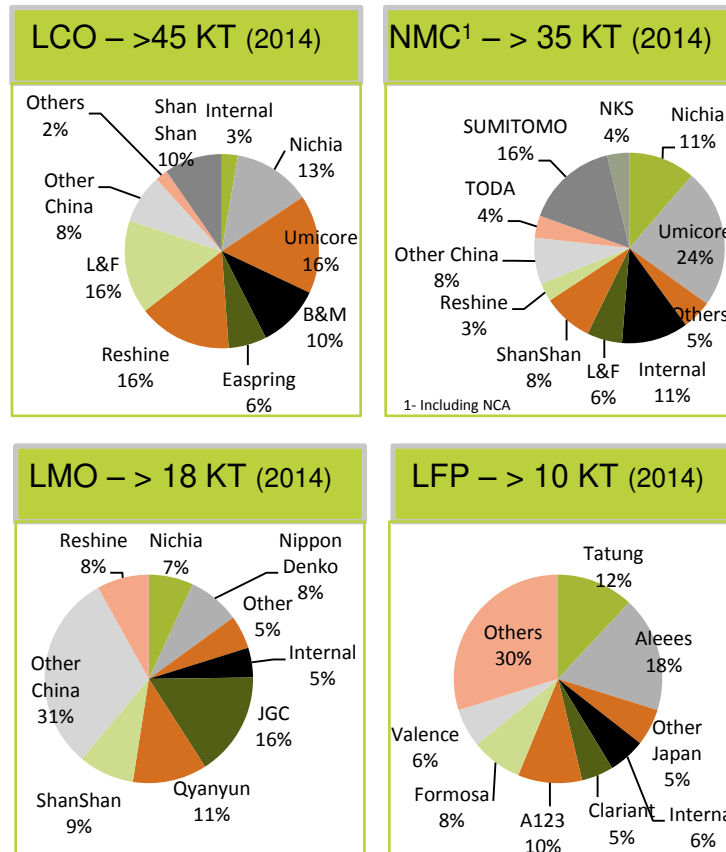


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Main Trends
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SUPPLY



LEADERS:



NEW ENTRANTS ON THE FIELD:



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2014-2025

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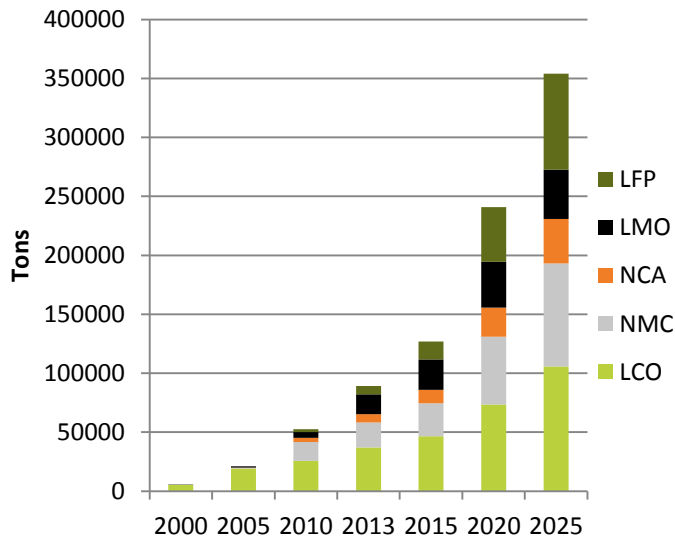
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CATHODE ACTIVE MATERIAL FORECASTS 2000-2025

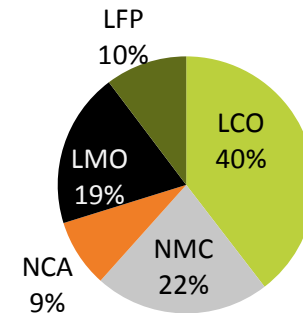
Cathode active materials 2000-2025 - Tons



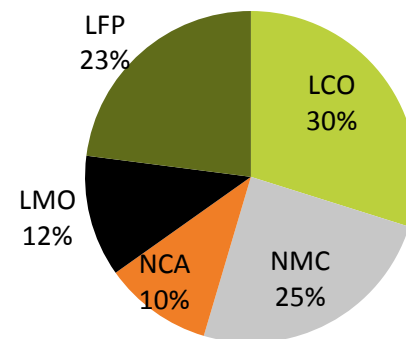
ASSUMPTIONS:

- 🔋 Portable devices:
2013-2025: +11% per year in volume
- 🔋 HEV
4,8 M HEV/year in 2020 - 35% LIB
6,8 M HEV in 2025 90% LIB
- 🔋 P-HEV
0,4 M P-HEV/year in 2020, 0,7 M in 2025
100% LIB
- 🔋 EV
1M EV/year in 2020, 1,5M/year in 2025
100% LIB
- 🔋 Industrial & stationary
2013-2025: +16% per year

Cathode active materials in 2014: 105 000 Tons



Cathode active materials in 2025: > 350 000 Tons



Assumption: Tesla keep NCA chemistry and have a relative success (200 000 EV sold per year in 2025 – TESLA forecast 500 000)



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Main Trends
2014-2025

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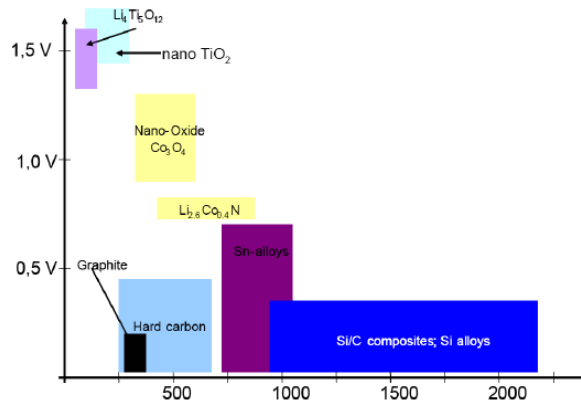
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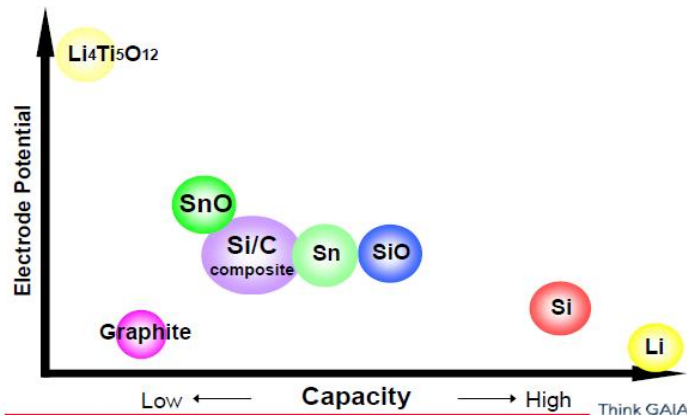
ANODE ACTIVE MATERIALS 57 000 TONS IN 2014

LIB Anode Materials



Source: A. Jossen, IRES 2007

LIB Anode Materials

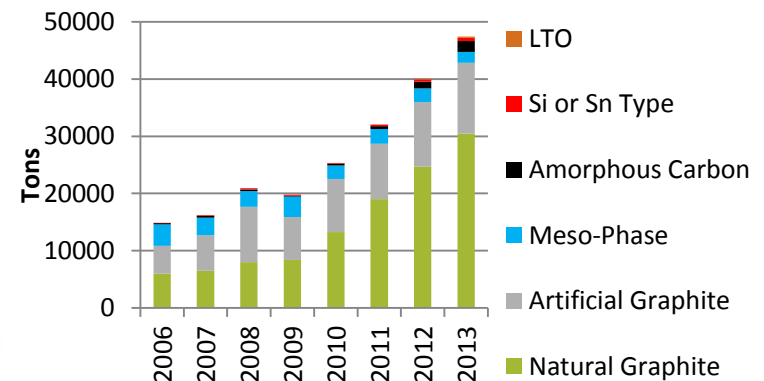


Source: Sanyo, March 2011



Source: Hitachi Chemical

LIB Anode market, (Tons)





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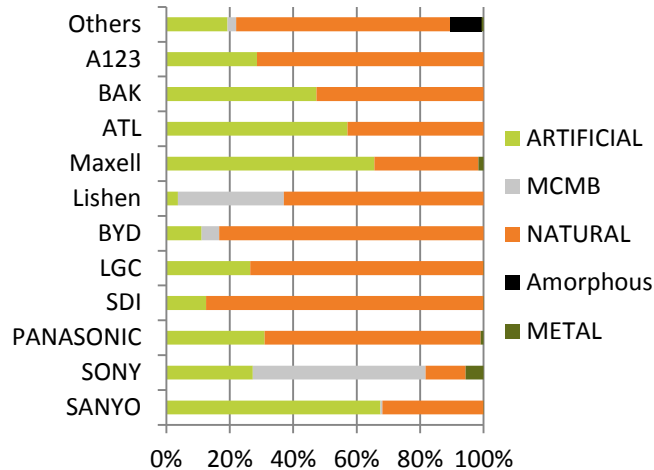
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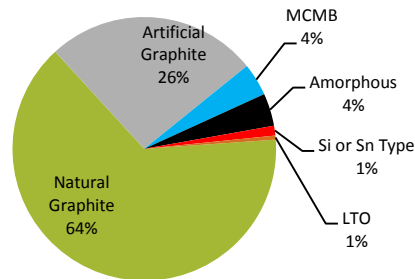
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ANODE FOR LIB IN 2014

Natural graphite become a commodity



Carbon for LIB anodes by type (2013)



Note: MCMB: Mesocarbon Microbeads

	Hard Carbon	Soft Carbon	Graphite
Capacity (/g)	400 mAh/g	250 mAh/g	325-375 mAh/g
Capacity (/cc)	++	0	+
Power	++	+	0
Stability	++	+	0
Cyclability	++	+	0
Precursors	Petroleum Pitch, Resin, cellulose, wood, coconuts...	Petroleum coke	Natural or petroleum coke
COST 2012->2020	30 -> 25 \$/kg	25->20 \$/kg	15 -> 10 \$/kg
SUPPLIERS	KUREHA	HITACHI	HITACHI BTR & many others

LEADERS:



HITACHI

Nippon Carbon

NEW ENTRANTS ON THE FIELD:



(...)



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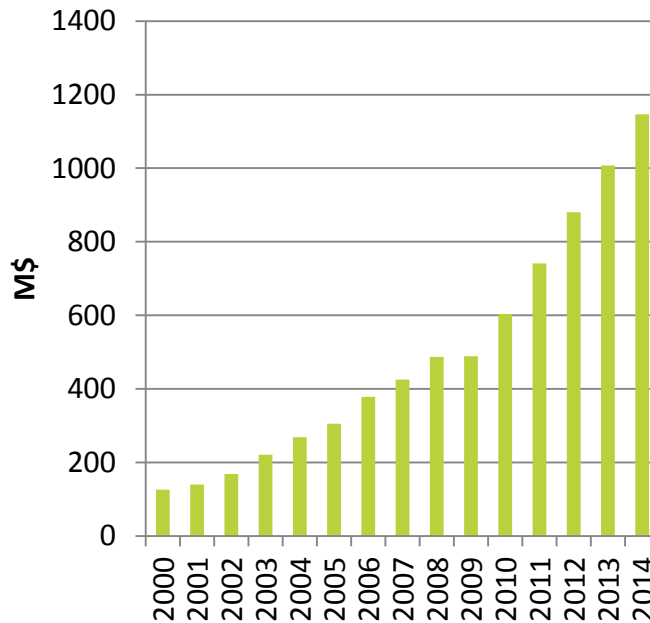
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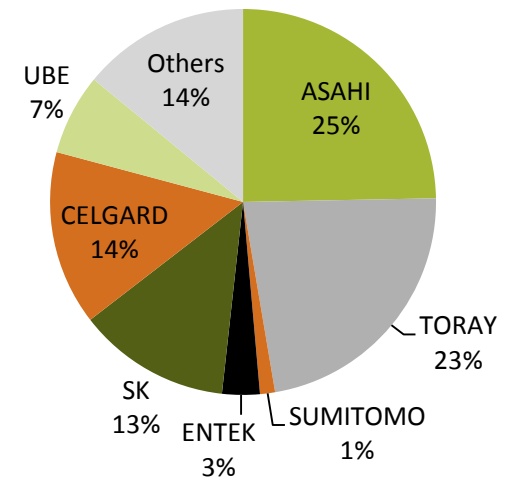
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LIB SEPARATOR MARKET 2014

LIB separator market, M\$,
CAGR 2004/2014: +17%



LIB Separator supplier, market
share in 2014



Others: TDK/Nitto Denko, Foshan Jinhui Hi-Tech, Shenzhen Senior Technology Material, Xinxiang Green next Energy, Dupont,...

LEADERS:

AsahiKASEI



UBE



TORAY

NEW ENTRANTS ON THE FIELD:



LG Chem



MITSUBISHI

Evonik, TEIJIN,
HIFUTURE, UBE-MAXELL (...)

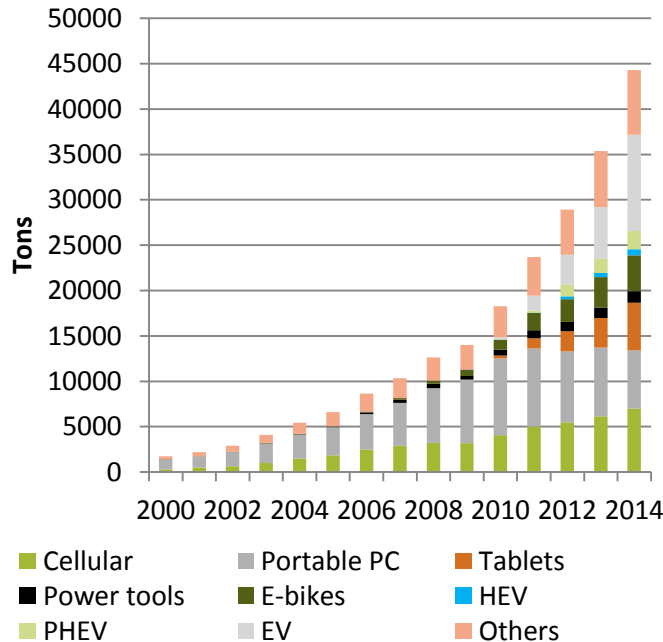


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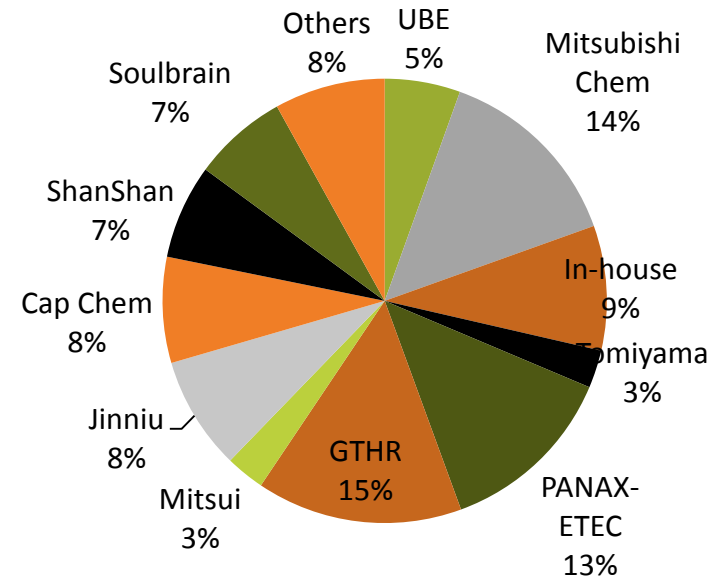
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ELECTROLYTE SUPPLIERS/CUSTOMERS 44 000 TONS IN 2014

LIB electrolyte market, Tons,
CAGR 2004/2014: +23%



LIB electrolyte supplier, market share in 2014



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Main Trends
2014-2025

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LEADERS:



Zhangjiagang
Guotai-Huang



JINNIU



SHANSHANTECH



新宙邦
CAPCHEM

NEW ENTRANTS ON THE FIELD:



LG Chem



The Chemical Company



UBE
UBE INDUSTRIES LTD.



Note: (1) GTHR: Zhangjiagang Guotai-Huarong



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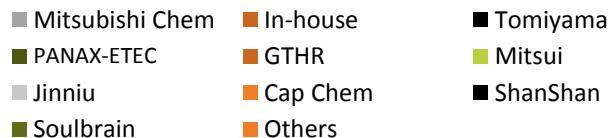
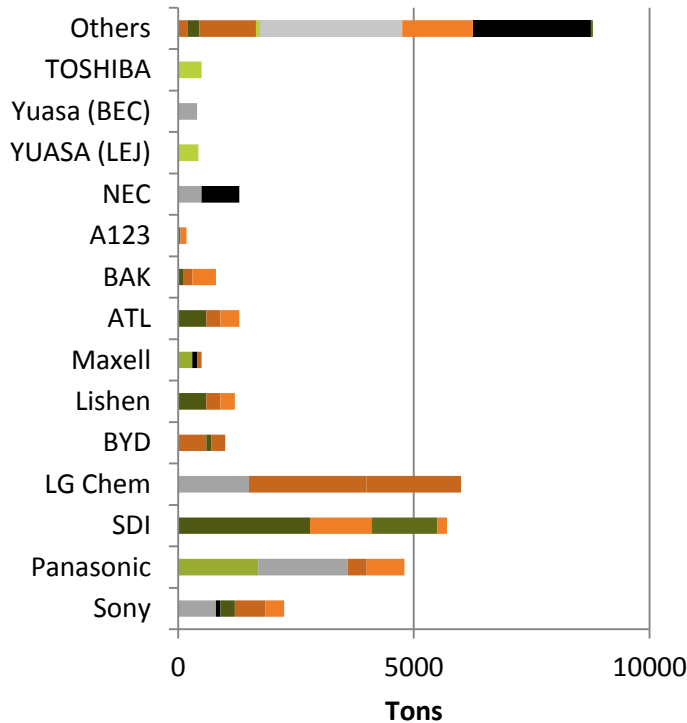
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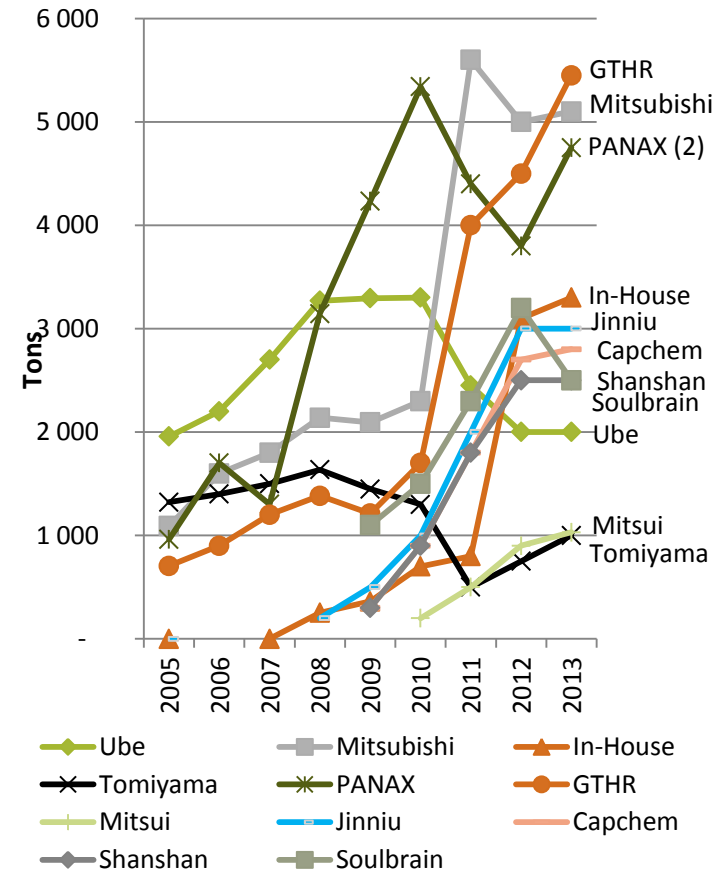
LIB ELECTROLYTE MARKET 2014

Electrolyte Battery makers & suppliers relation in 2014



(1) Full electrolyte formulation in-house

Electrolyte maker sales 2005-2013



(2) Panax-Etec bought Samsung Chiel activities in 2010



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BATTERY MARKET FORECASTS 2014-2025

Applications covered

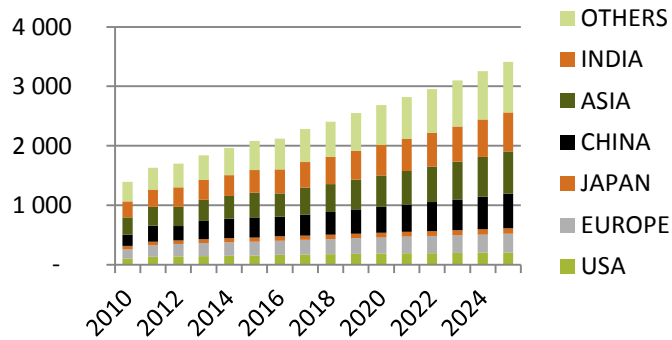
- 🔋 Portable PCs, net-book, Ultra-book
- 🔋 Cellular Phones, Smart-phones
- 🔋 Tablets
- 🔋 Camcorders
- 🔋 Cordless Tools, Gardening tools
- 🔋 Digital Camera
- 🔋 Games, MP3
- 🔋 Cordless Phones
- 🔋 Shavers, Toothbrush,
- 🔋 RC Cars
- 🔋 E-bikes
- 🔋 Power tools
- 🔋 Security lighting
- 🔋 Vehicles: HEV, P-HEV, EV
- 🔋 Industrial motive (forklift)
- 🔋 Industrial stationary (UPS, Telecom)
- 🔋 Medical
- 🔋 Energy Storage (Small / large)

Parameters analysis

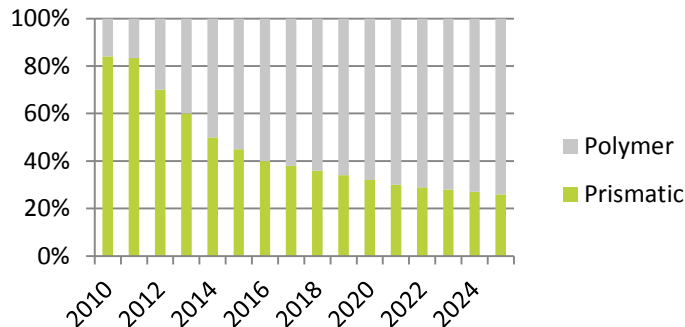
- 🔋 Main segment trends
- 🔋 Power need trends (volume, weight, capacity, running time)
- 🔋 Penetration rate for each Chemistry, each form factor,
- 🔋 2013 -2025 Forecasts
- 🔋 OEM strategies and positions
- 🔋 Main drivers & limiters

CELLULAR PHONES FORECASTS 2010-2025

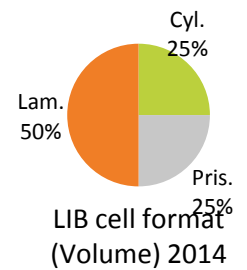
Cellular phones demand (M Units)
CAGR 2010-2025: +6%



LIB cells demand 2014-2025
Polymer penetration: 50% -> 75%



Source: AVICENNE ENERGY Analyses



Cellular Phones market Drivers

- Emergent market
- Renewal ratio increase
- Smartphone penetration increase



LIB cells for cellular phones trends

- Laminates ratio increase
- Increase of Thickness
- Increase of >1400 mAh capacity



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Main Trends
2014-2025

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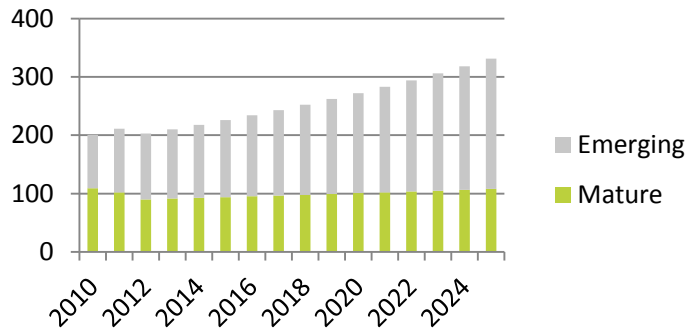
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PORTABLE ELECTRONIC DEVICES FORECASTS 2010-2025

Portable PCs demand (M Units) 2010-2025 CAGR: +4%



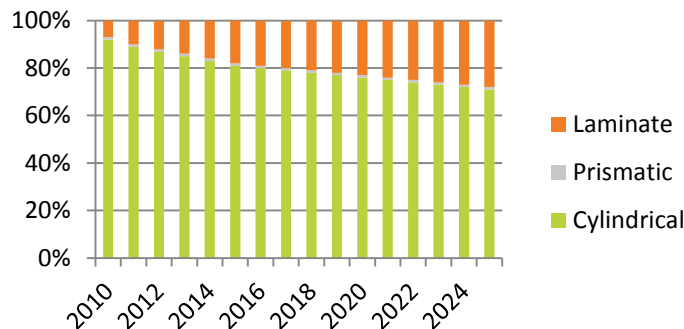
Source: IDC, Gartner, AVICENNE Energy

Portable PCs market trends

- 🔗 Mature market stable or decreasing
- 🔗 Growth driven by Emerging market
- 🔗 Ultrabook is increasing (20⁽¹⁾ to 60% in 2013⁽²⁾)
- 🔗 ASP decreasing (<499\$ Portable PCs increase from 25% in 2010 to 33% in 2012)

(1) Samsung & AVICENNE (2) Intel

LIB cells demand 2010-2025 Polymer penetration: 7% -> 28%



Source: AVICENNE ENERGY Analyses

LIB cells for portable PCs trends

- 🔗 Thinner cells
- 🔗 Polymer penetration increasing from 7% in 2010 to 28% in 2025
- 🔗 > 2800 mAh for Premium/corporate
- 🔗 2.2 Ah for consumer, emerging market

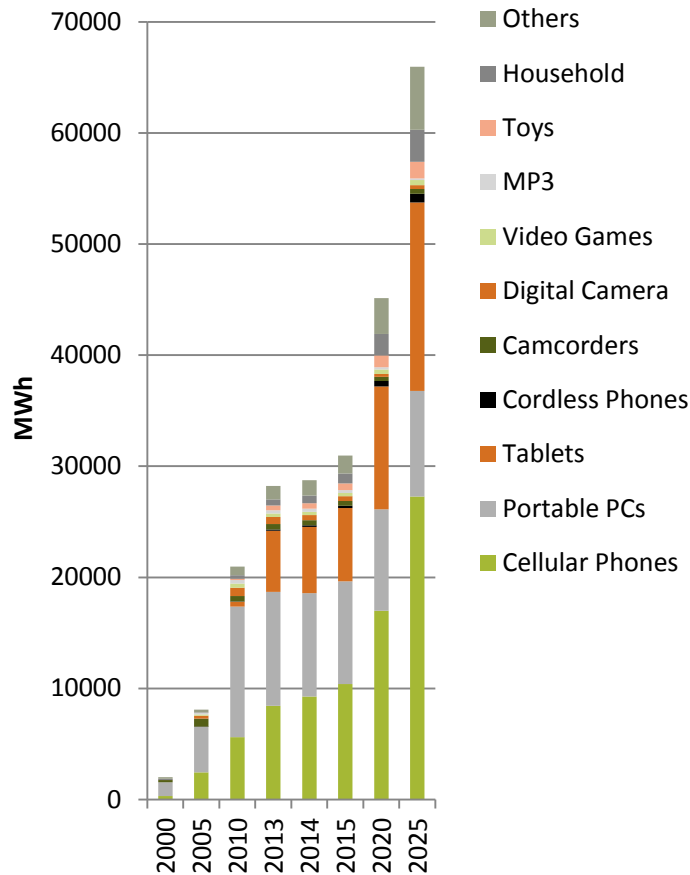


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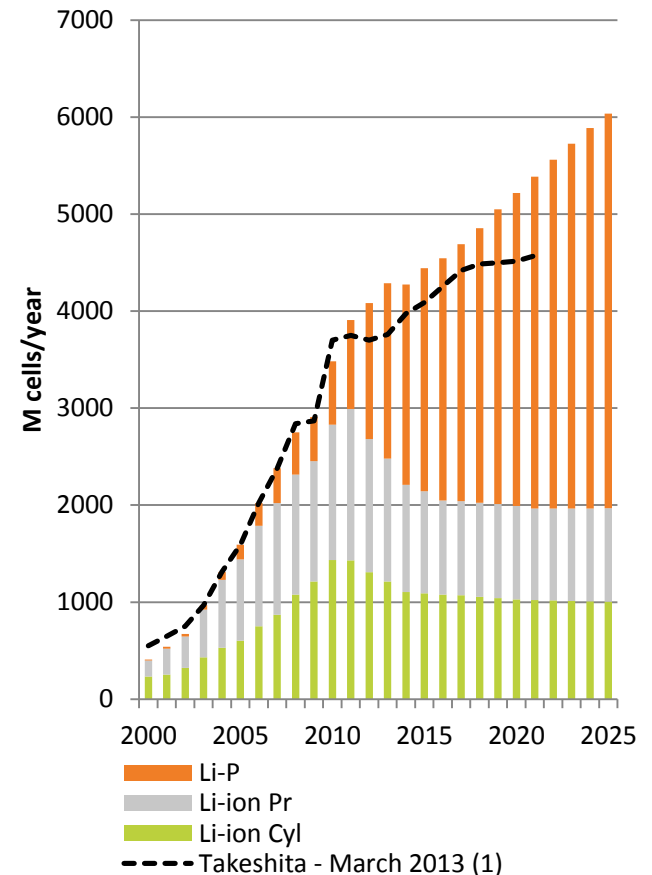
2025 LIB FORECASTS FOR PORTABLE ELECTRONIC DEVICES

2000-2025 LIB market, MWh, by application (3C)



Source: AVICENNE ENERGY Analyses

2000-2025 LIB market, M cells, by form factor (3C)



(1) Source: Takeshita, Battery Japan 2013 BJ-3 conference – Slide p 4

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X-EV MARKET

- Why x-EV ?
- Definition & segmentation
- X-EV worldwide in 2013
 - By country
 - By car makers
 - By battery chemistry
- X-EV forecasts
 - AVICENNE ENERGY & other analyst forecasts
 - Battery chemistry forecasts
 - Battery cost forecasts
- X-EV battery forecasts



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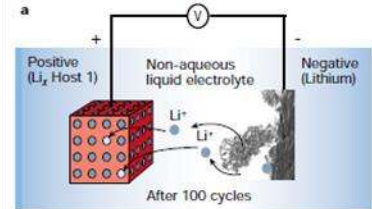
SAFETY ISSUES

Li-ion and LMP are not thermally stable what raises serious safety concerns

Background

In the 80's, lithium metal batteries were put into the markets (Moli Energy). Their further development has for a long time been slow because of a low cycle efficiency and safety issues: High chemical reactivity and a low melting point enable strong chemical reactions, even explosions. In the charging-discharging process, lithium metal can form dendrite and accumulate on electrodes. The growing lithium dendrite could puncture the separator and result in an internal short circuit.

- CONSEQUENCES: Except BOLLORE, all the companies developing Li metal batteries cancelled their projects



Mobile

Li-ion batteries for mobile devices mostly used a Lithium Cobalt Oxide Cathode and liquid electrolyte. In case of overcharging or short-circuit (contact between anode & cathode) a chain reaction starts -> heating & gasing -> fire ("Thermal runaway")

- CONSEQUENCES: In 2006, SONY had to recall millions of portable PCs for total costs of 400 million USD, more than their profit-to-date



Automotive

With new cathode chemistry, most of the automotive today on the markets experienced safety concerns:

- (1) BYD Taxi in China with a lithium iron phosphate cathode
- (2) GM Volt in the US with a LG Chemical battery using LMO cathodes (as a result of a crashed tested Chevrolet Volt caught three weeks after the testing !)
- (3) PRIUS P-HEV in the US (converted from HEV Prius by a local engineering company without any authorisation by Toyota)



Aircraft

Boing 787: The fire that burned near the tail of a parked Boeing 787 in Boston was caused by an overheating Lithium ion battery pack. The battery fire could have been hot enough to melt the carbon-fiber reinforced plastic that makes up the plane's shell.

- CONSEQUENCES: All the 787 worldwide are grounded. Considerable losses for Boing.



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Battery Market and
Main Trends
2014-2025

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SAFETY IS A SINE-QUA-NON SELECTION CRITERIA FOR BATTERY TECHNOLOGIES

Some technologies are already out of the game due to stability issues

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Main Trends
2014-2025

Cathode		LCO	NMC	LMO	LFP	High V	Sulfur
	SAFETY						
xEV ?	NO	YES	YES	YES	?	?	

Anode		Graphite	Hard Carbon	Soft Carbon	LTO	Si/C	Li Metal
	SAFETY						
xEV ?	YES	YES		No (1)	?	?	

Electrolyte		Liquid	+ Additive	Gel Polymer	5 V	Polymer membrane	Solid
	SAFETY					?	
xEV ?	NO	YES	YES	No	YES	> 2025	

Separator		PE, PP membrane	+ coating	Non woven	Polymer membrane	Solid
	SAFETY					
xEV ?	YES	YES	YES	YES	YES	> 2025

BMS

- Most of the BMS function is to manage the safety of the cell & the battery pack:
 - Overcharge management
 - Over voltage management

Packaging

- Use "safer" material in the pack:
 - Flame retardant,
 - High shock resistance

Thermal

- Thermal management improve both the safety and the life time

Very Safe Unsafe

(1) Low energy density ; mostly developed for stationary applications, or LV start light & ignition batteries

The lithium ion technologies that win will win partly on their safety argument, possibly sacrificing some energy density.

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2014-2025

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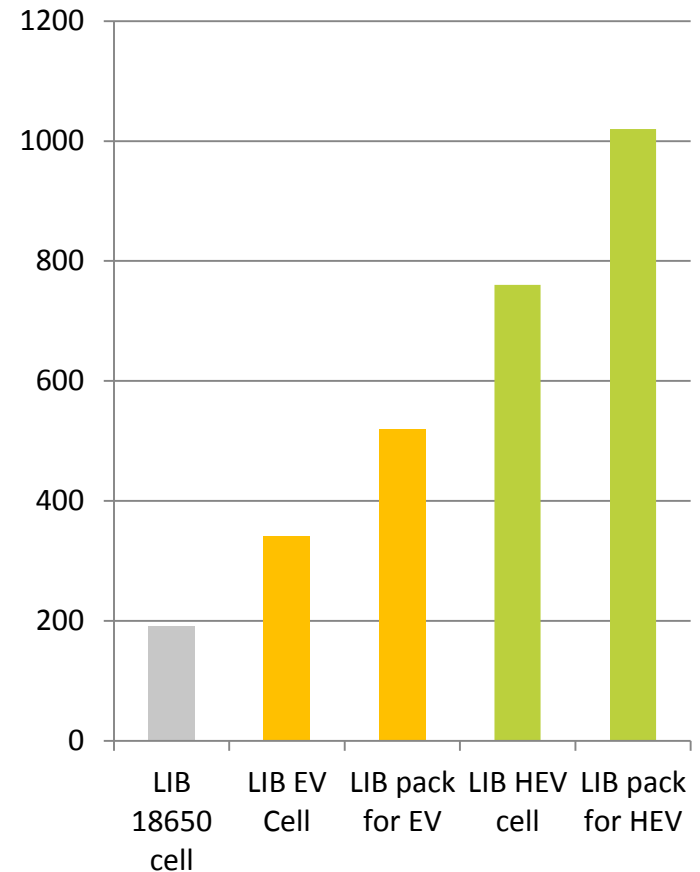
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LIB BATTERY COST

Costs analysis

- ⌚ Raw material cost (Co, Mn, Ni, Al, Cu, ...)
- ⌚ Anode, cathode, Electrolyte , separator, binders, Cu & Al foil, etc... cost structure :
 - ⌚ CAPEX,
 - ⌚ labor cost,
 - ⌚ R&D
 - ⌚ Marketing, Adm, Overhead, margin)
- ⌚ Raw material needs / mAh
- ⌚ Electrode process Yield
- ⌚ Assembly Process Yield
- ⌚ Cell manufacturing cost
- ⌚ Module manufacturing cost
- ⌚ Pack assembly cost
- ⌚ ...

Battery price in 2013 \$/kWh





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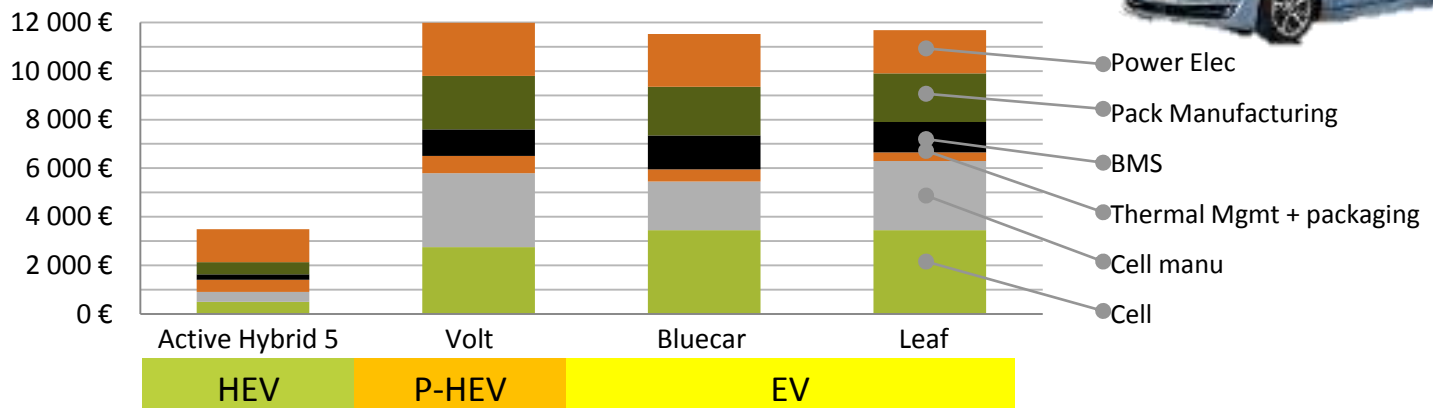
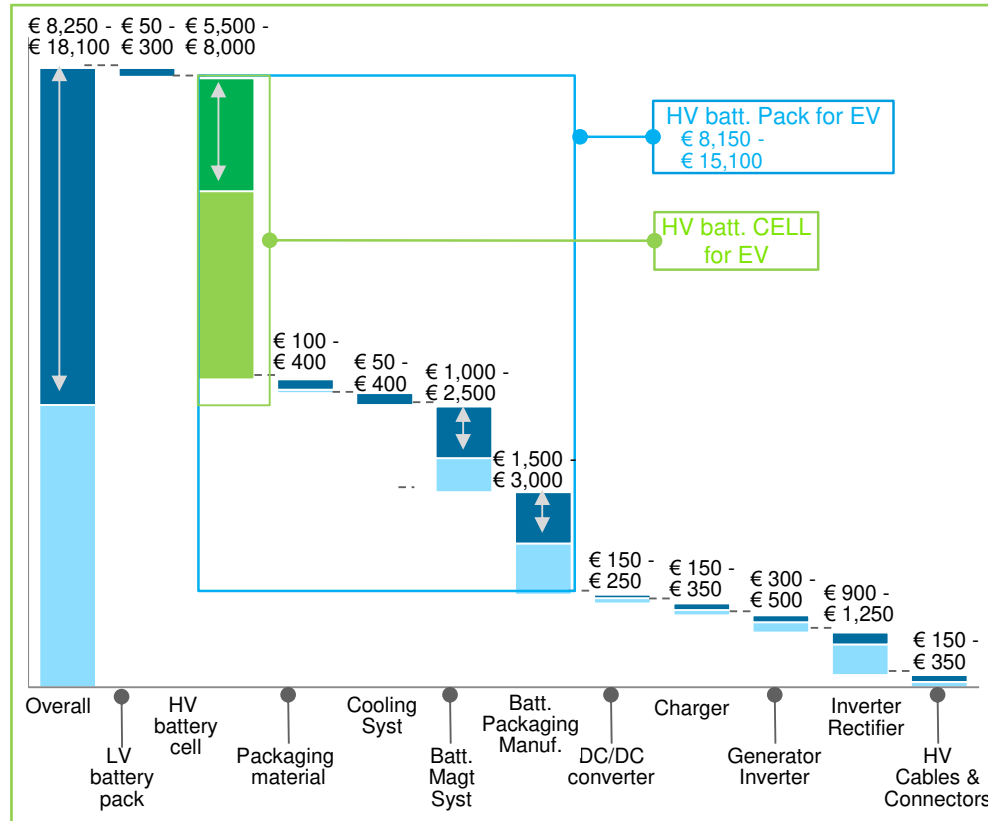
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BATTERY & POWER ELEC. COST IN EV





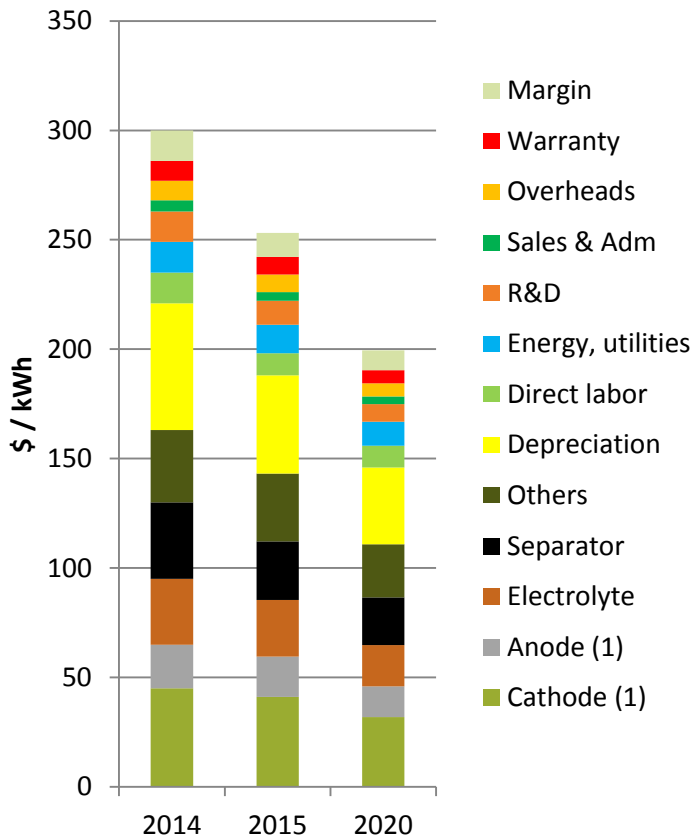
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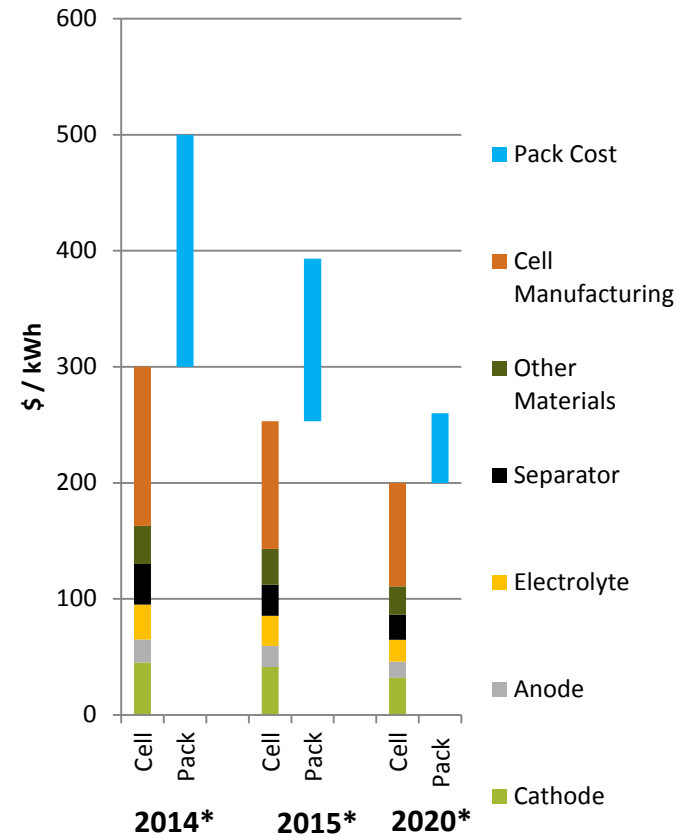
LI-ION BATTERY COST 2013-2020

LIB cell average cost (36Ah pouch)
(EV design ; LMO/NMC cathode)

LI-ION BATTERY PACK COST
FOR EV



(1) Active materials only



* For Production > 100 000 packs/year

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HEV FORECASTS 2000-2020

HEV MARKET: 2,5 Million units in 2015 – 5 M in 2020 – 7 M in 2025

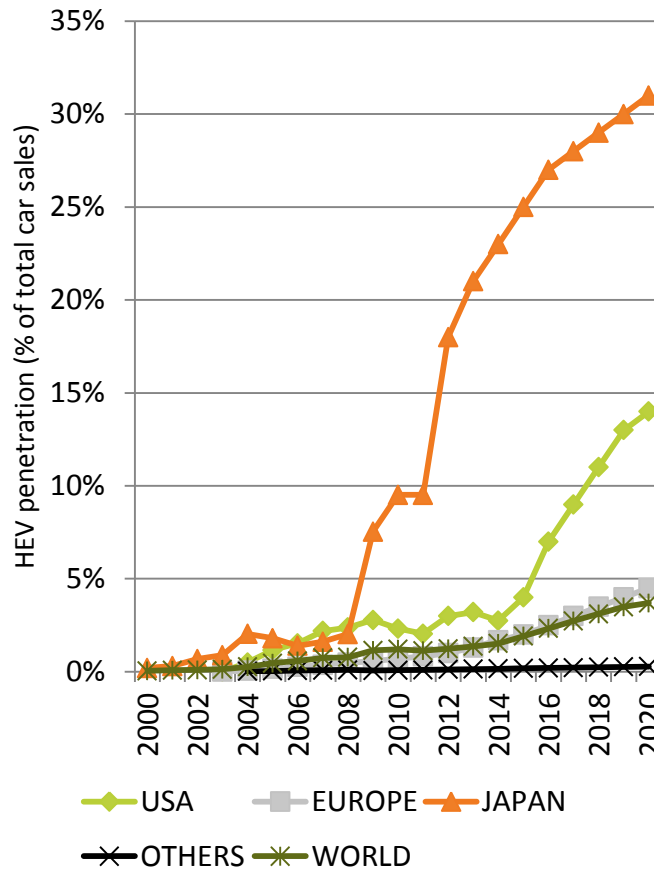
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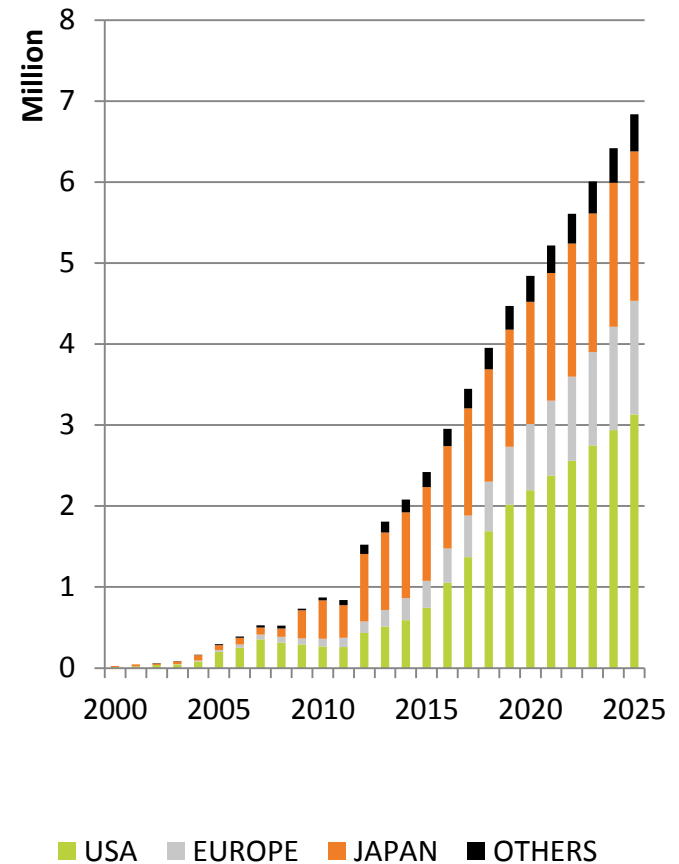
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Micro hybrid not included



Source: AVICENNE ENERGY Analyses 2013

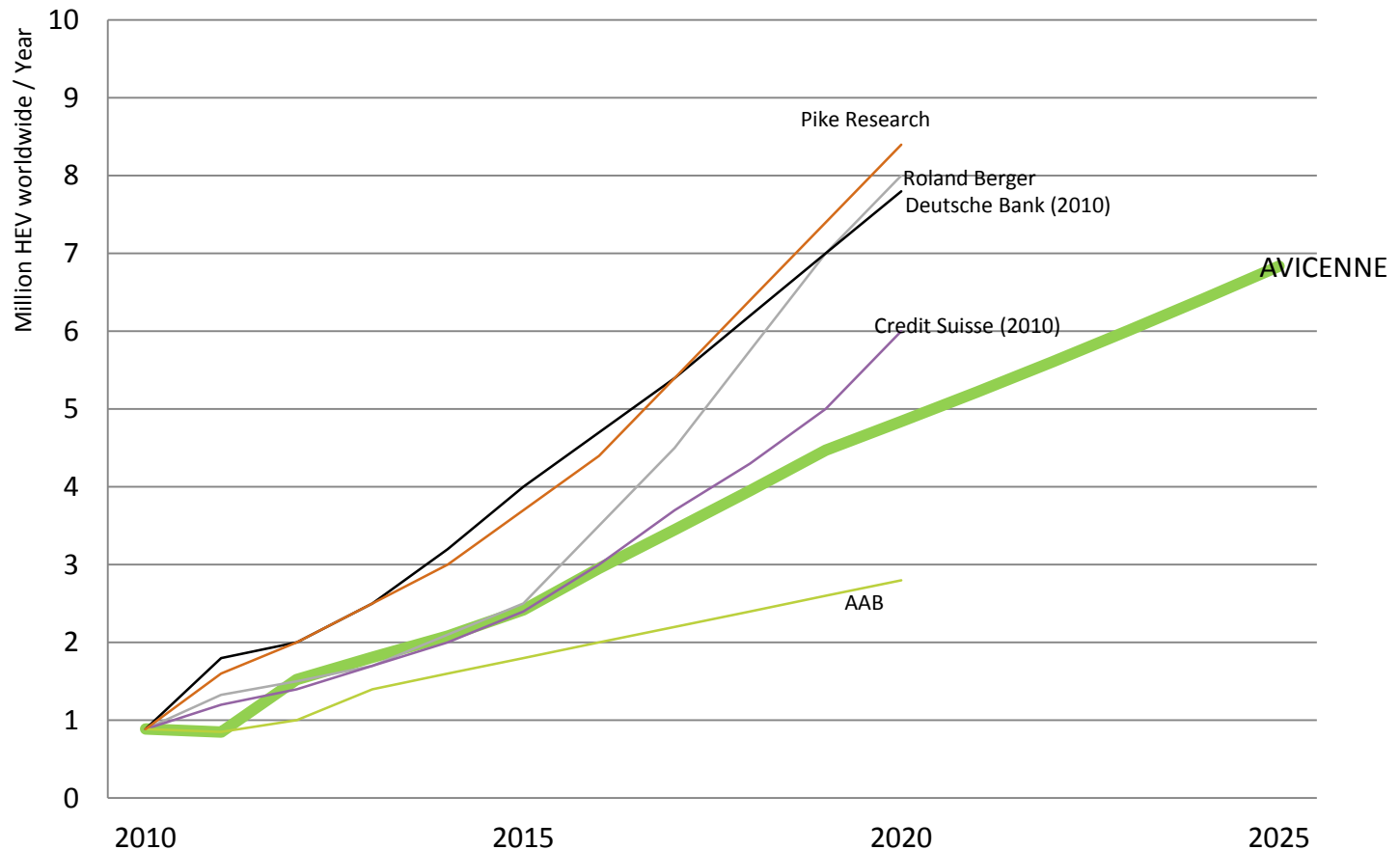


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LONG TERM HEV FORECAST FROM 3 TO 8 M HEV IN 2020

AVICENNE ENERGY FORECASTS ARE REALISTIC COMPARE TO OTHER ANALYSTS



Source: AVICENNE ENERGY Compilation, February 2013
Micro hybrid not included

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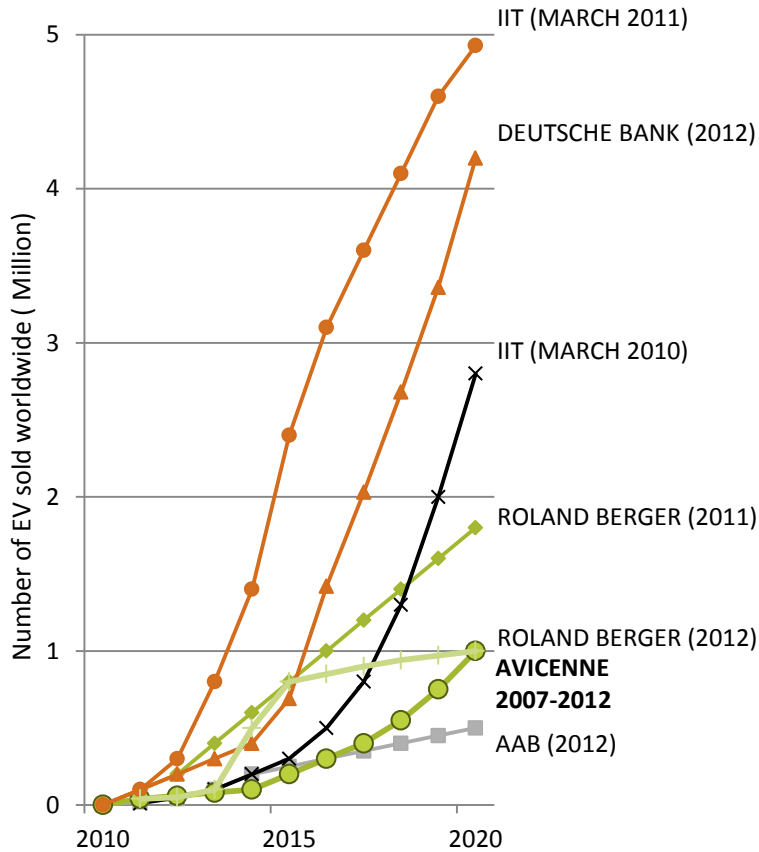


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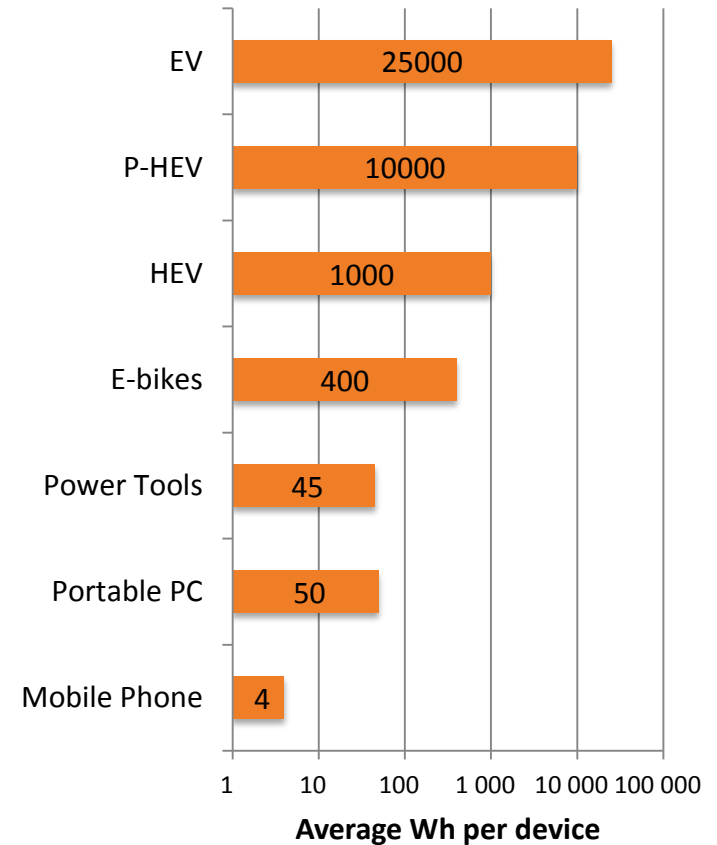
X EV FORECASTS 2011-2020

EV sold, in million units,
worldwide, 2010 - 2020



IIT, March 2011 Fort Lauderdale
 IIT, March 2010 Fort Lauderdale
 Deutsche Bank, Electric Cars: Plugged In 2 – Nov 2009
 Roland BERGER, Oct 2011, Batteries 2011 Cannes
 AAB, AABC Europe, Mainz, June 2011

EV impact on the LIB & raw
material market is HUGE



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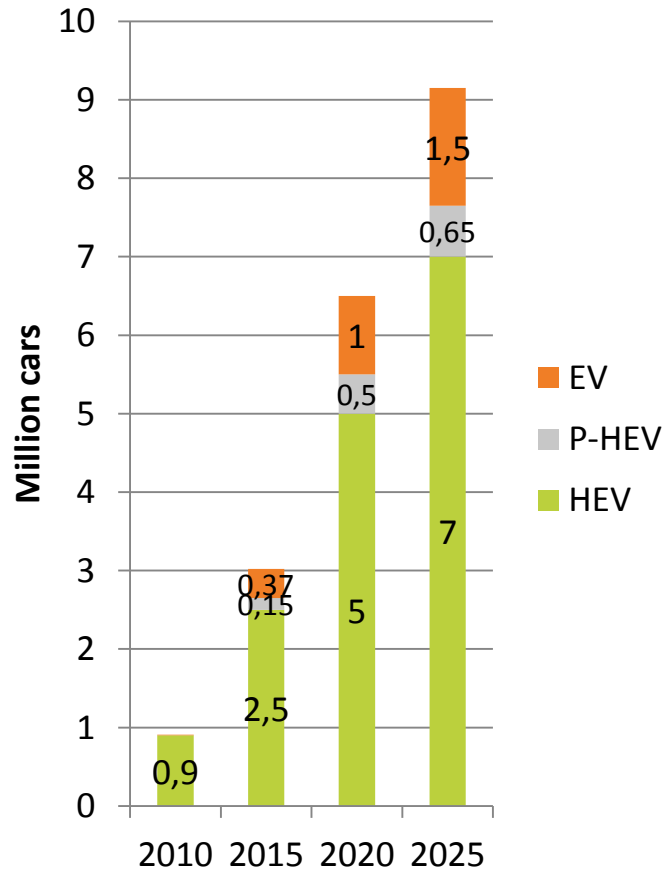
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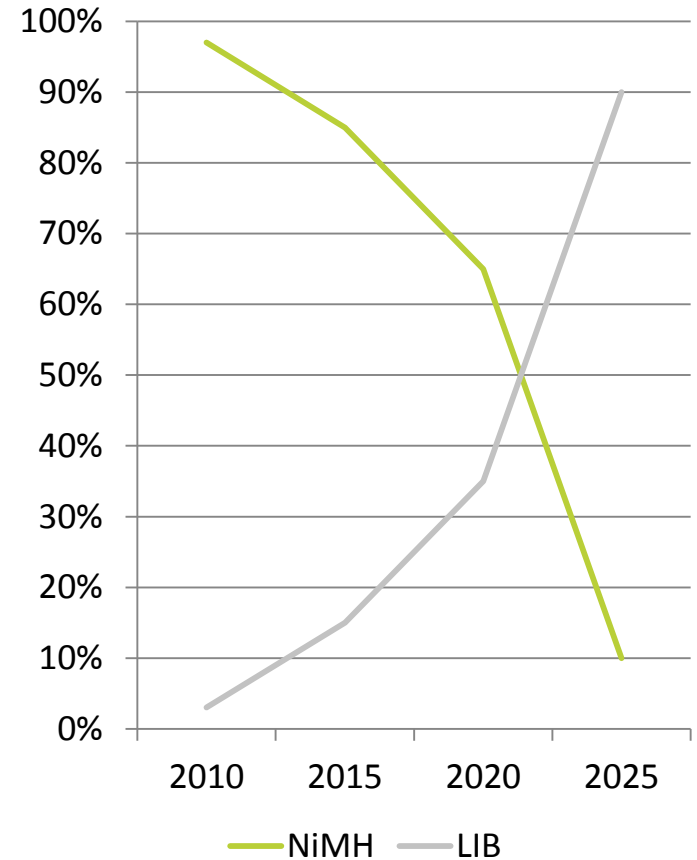
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XEV 2025 FORECASTS

HEV, P-HEV & EV market forecasts up to 2025



LIB penetration in HEV 2010-2025





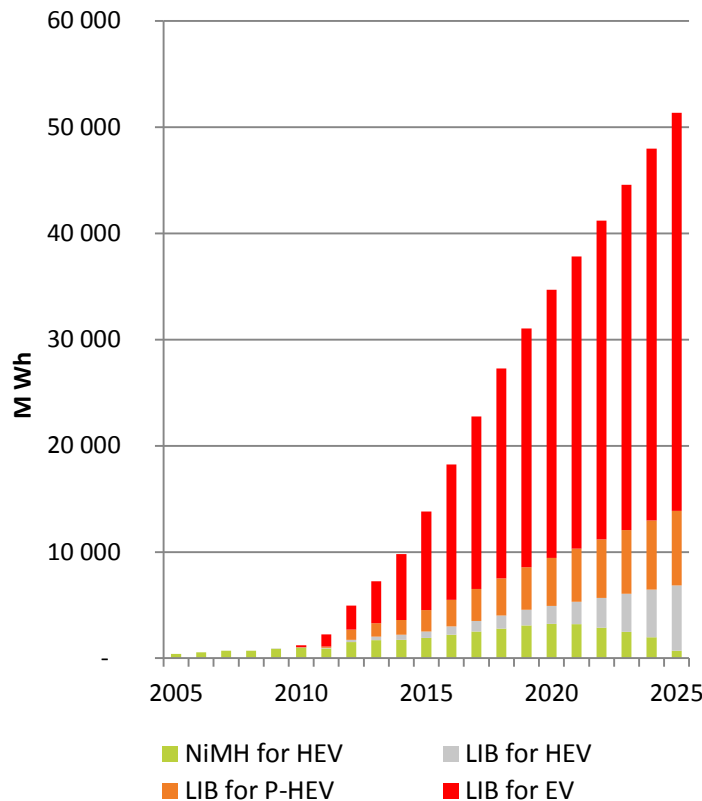
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TOTAL BATTERY DEMAND FOR AUTO FORECASTS

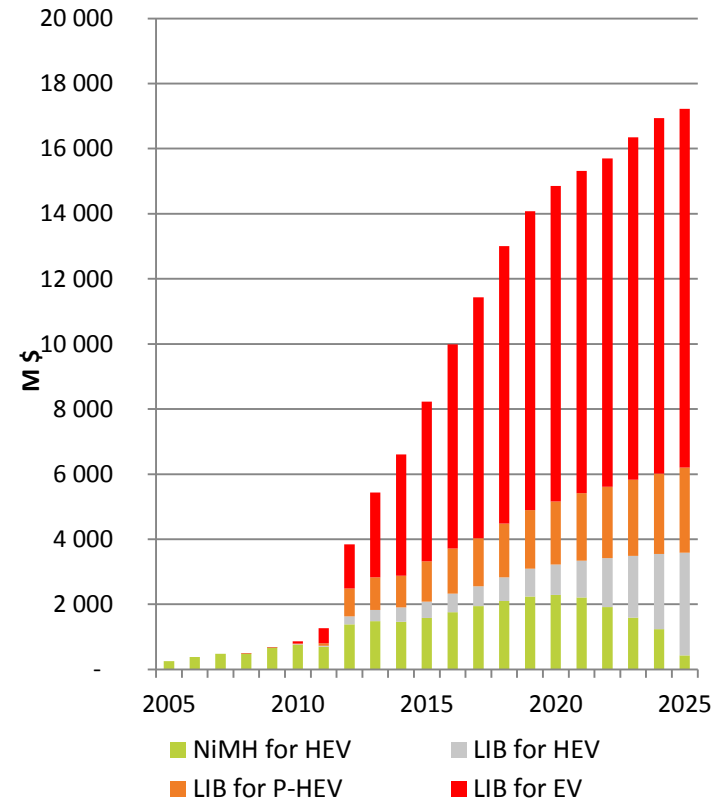
EV, HEV & P-HEV Battery needs (MWh)

CAGR 2013-2020: +23%



Rechargeable battery market for Auto⁽¹⁾, M\$ for x-EV 2000-2025

CAGR 2014-2020: +14%



Source: AVICENNE ENERGY Analyses 2013

(1) Pack level

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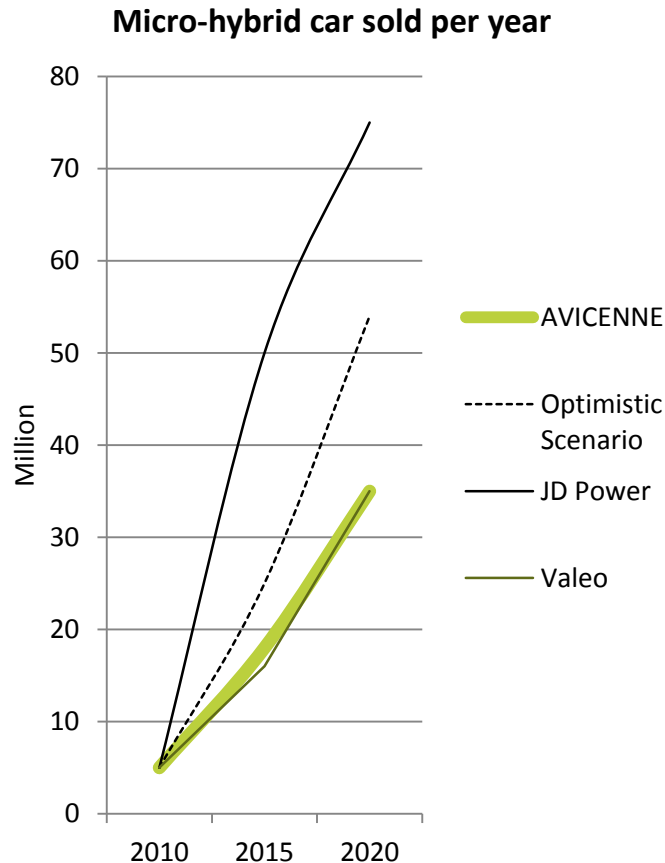
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35 MILLION MICRO-HYBRIDS CAR IN 2020

Micro-hybrids car market 2010-2020



Advantages of micro-hybrid compare to HEV

- ⌚ Powered by Advanced lead acid batteries
- ⌚ Much more profitable than full HEV: 8 to 10 times less expensive than full HEV to save 5% gasoline instead of 20% (4 times less)
- ⌚ Much more impact on CO2

	Micro-hybrid	Full HEV
Battery	Advanced lead acid	NiMH or LIB
Cost (\$)	300	3000
Fuel saving	5%	20%
Million Vehicle sold per year in 2020	35	3.5



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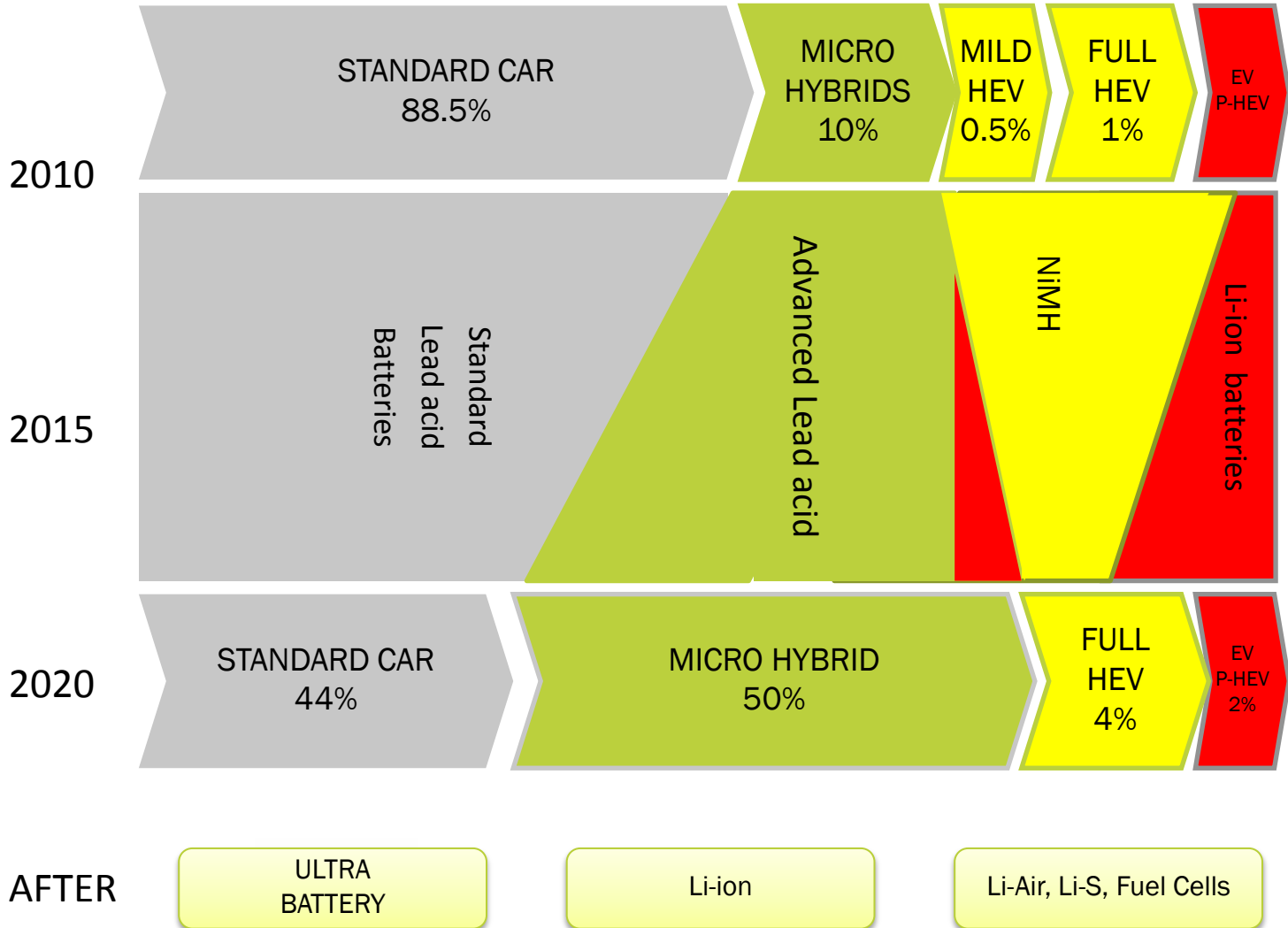
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HEV, P-HEV AND EV REALITY OF THE MARKET WILL BOOST MICRO HYBRID AND ADVANCED LEAD ACID BATTERIES





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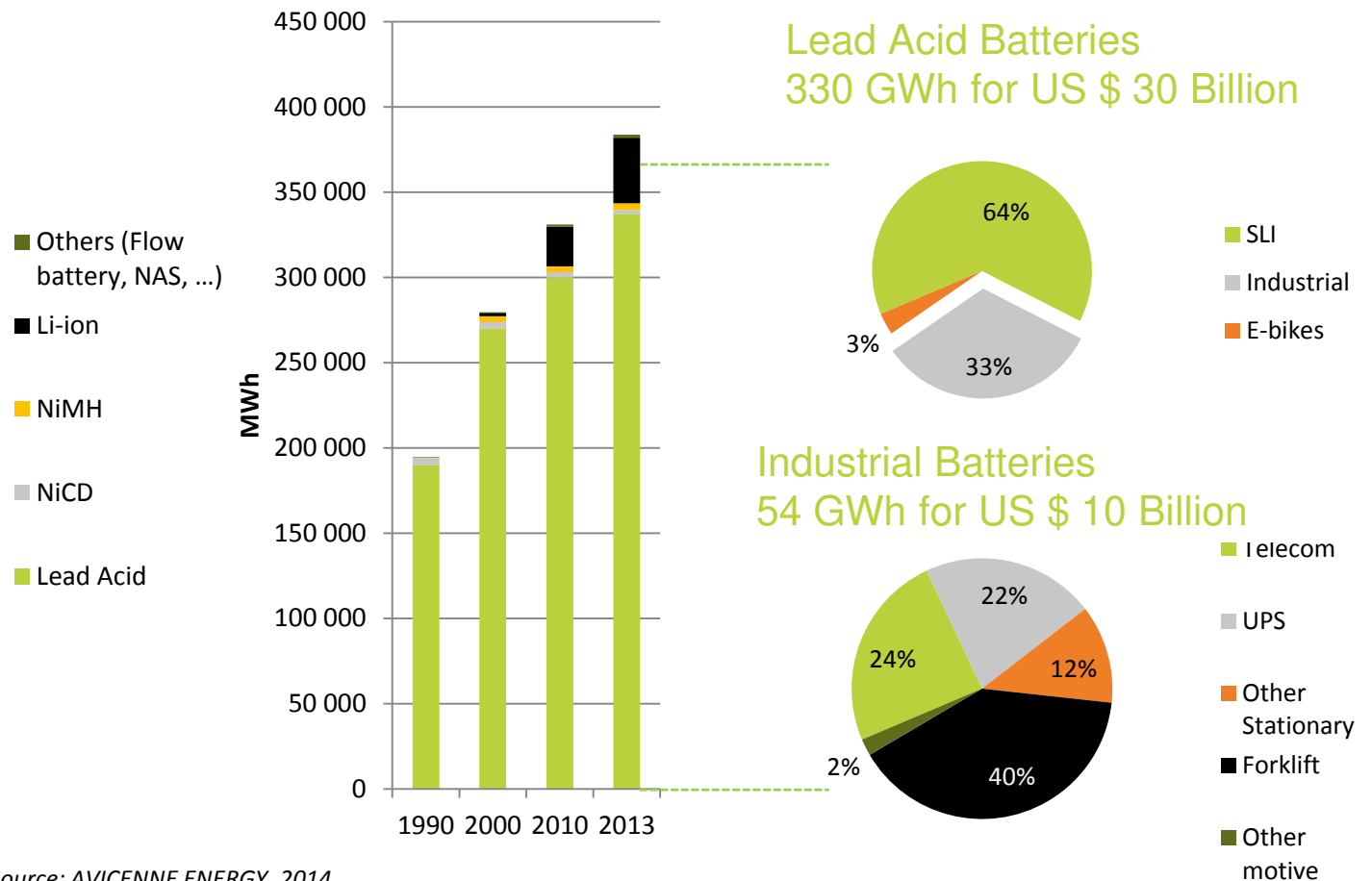
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THE WORLDWIDE BATTERY MARKET 1990-2013

Lithium Ion Battery: Highest growth & major part of the investments
Lead acid batteries: By far the most important market (90% market share)



Source: AVICENNE ENERGY, 2014



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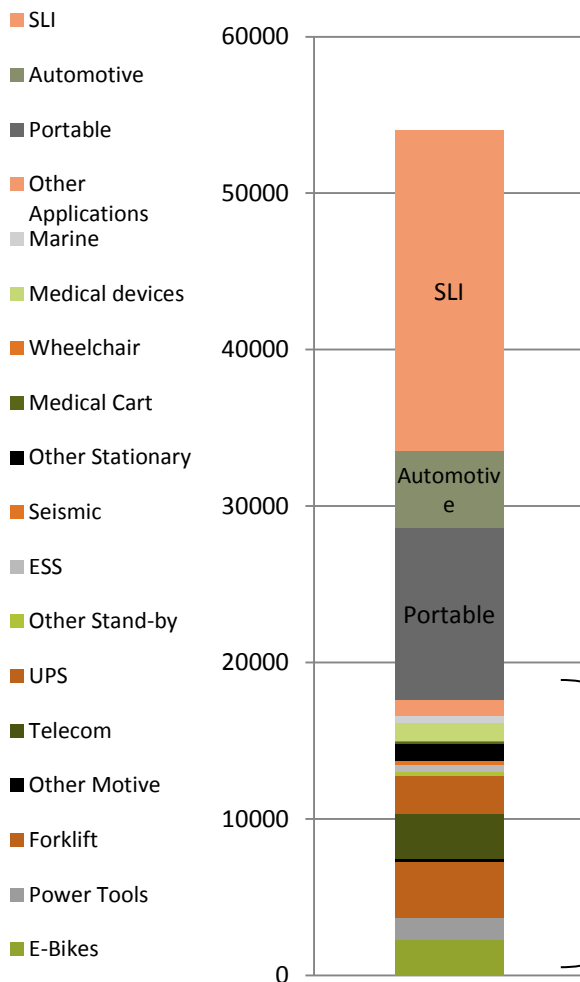
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BATTERY FOR OTHER APPLICATION US\$ 18 BILLION¹ MARKET

Battery market in 2013 (M\$)



Battery Market		M\$	
Power Tools		1400	
E-bikes		2290	
Industrial	Motive	Forklifts	3 570
		Others	180
		TOTAL MOTIVE	3 750
	Stationary	Telecom back-up	2 900
		UPS	2 400
		Misc. Standby	315
		ESS	450
		Seismic (1)	210
		Other Stationary	1090
		Total STATIONARY	7 370
TOTAL INDUSTRIAL	11 120		
Medical Cart		150	
Wheelchair		47	
Medical Device (1)		1150	
Marine		450	
Others		1 000	
TOTAL		17 600	

(1) 500 M\$ for Li-ion - Source: Zprime 2011

1- Pack level: Pack including cells, cells assembly, BMS, connectors – Power electronics (DC DC converters, invertors...) not included
Source: AVICENNE ENERGY, 2014



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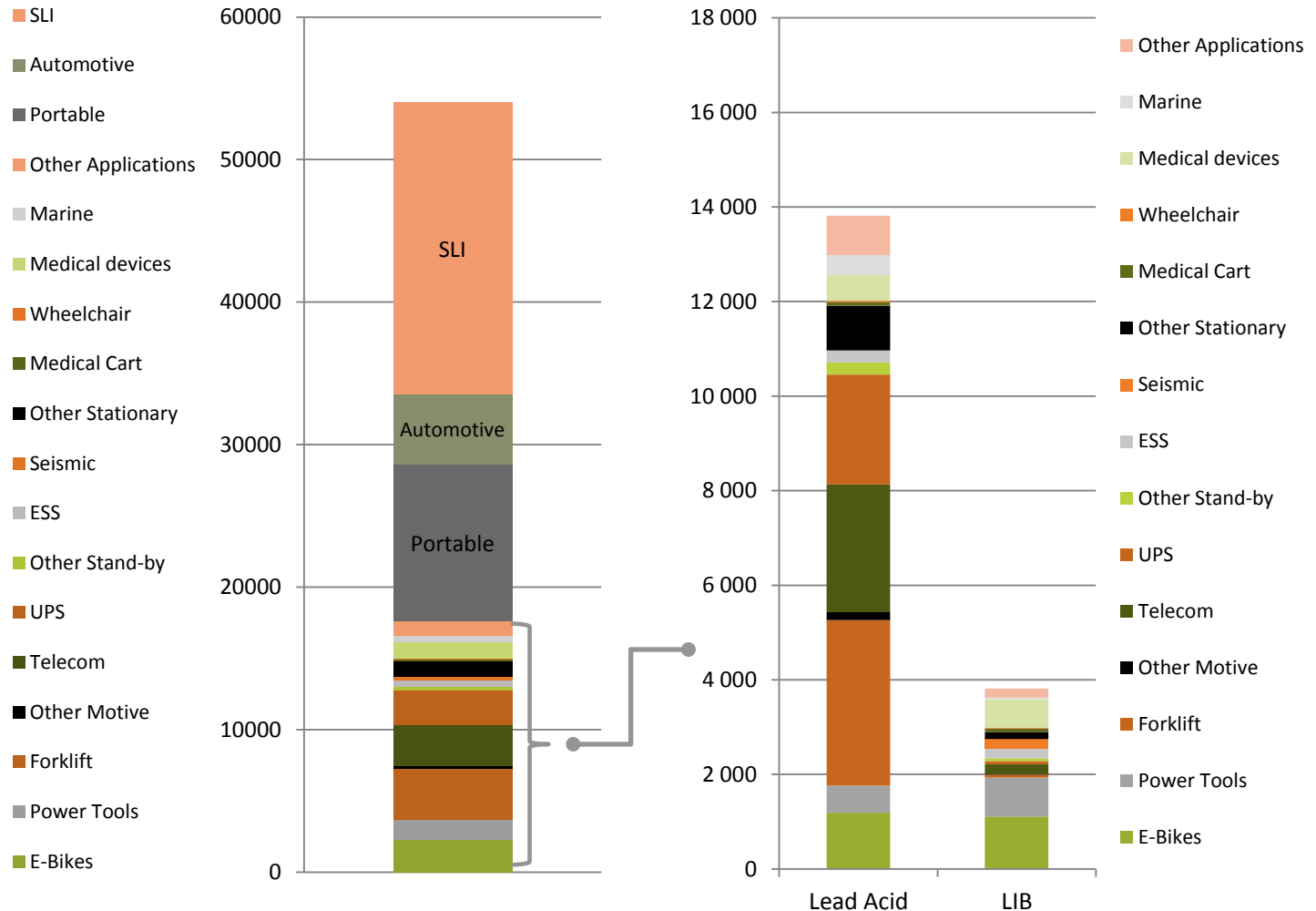
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THE WORLDWIDE BATTERY MARKET IN 2013: US \$ 54 BILLION

Battery market in 2013 (M\$)



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

Source: AVICENNE ENERGY, 2014



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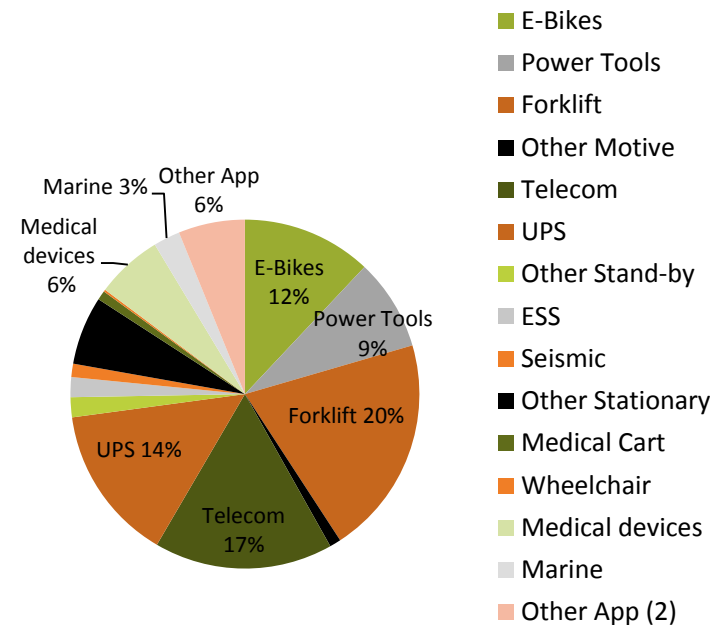
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TOTAL POTENTIAL MARKET ANALYZED IN THE SURVEY (M\$, PACK LEVEL¹)

Application details

Battery Market		M\$	
Power Tools		1400	
E-bikes		2290	
Industrial	Motive	Forklifts	3 570
		Others	180
		TOTAL MOTIVE	3 750
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US\$ 18 Billion in 2013



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Source: AVICENNE ENERGY 2013

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,...

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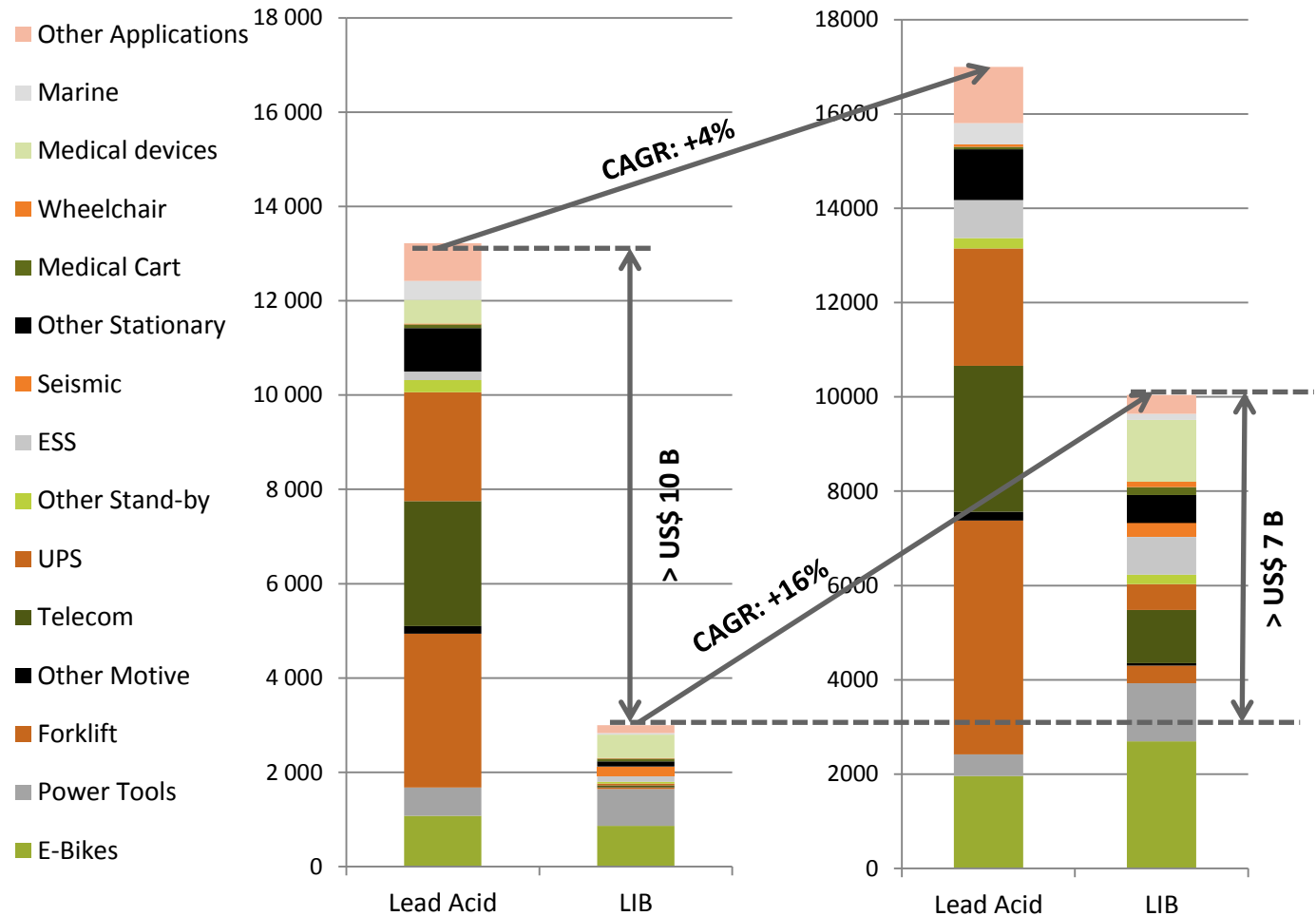
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“OTHER APPLICATIONS” 10 B\$ POTENTIAL MARKET¹

Battery market in 2012 (M\$)

Battery market in 2020 (M\$)



Source: AVICENNE ENERGY, 2013

For Power tools, NiCd batteries are used rather than lead acid batteries
1- Pack level



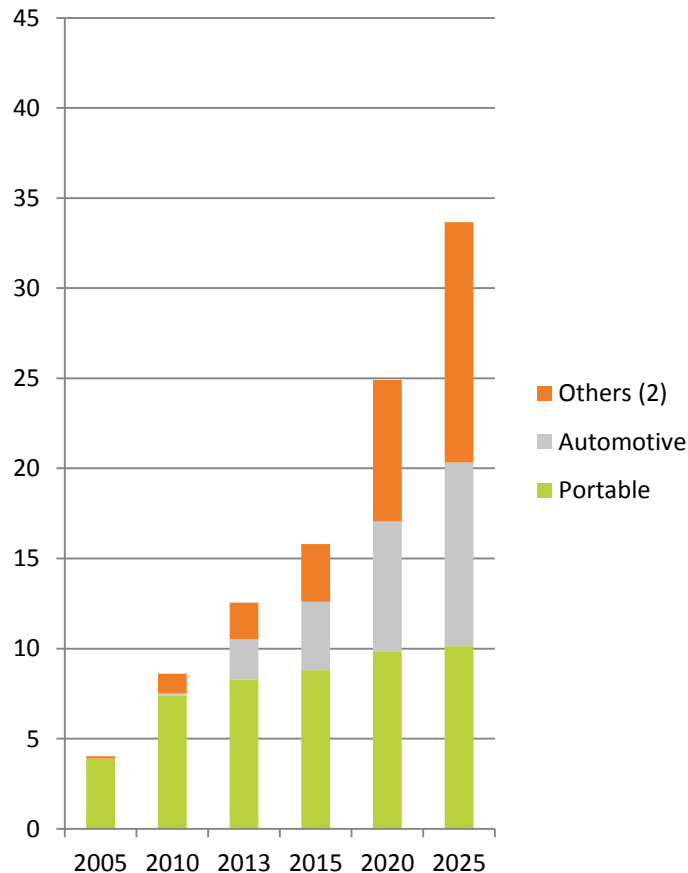
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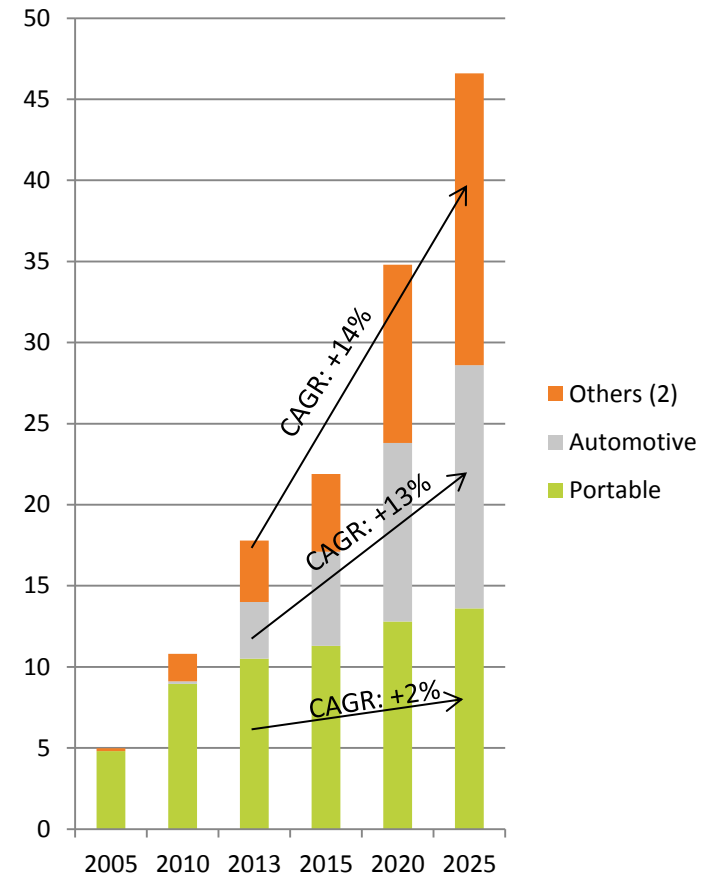
LI-ION CELL & PACK MARKET DETAILS

2013 -2025 { Portable: from 28 to 83 GWh
Automotive: from 6 to 50 GWh
« Others »: from 5 to 30 GWh

Li-ion cell market (B\$)



Li-ion Pack market¹ (B\$)



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

2- Others: Batteries for Power tools, E-bikes, Industrial, medical...

Source: AVICENNE ENERGY Analysis 2014



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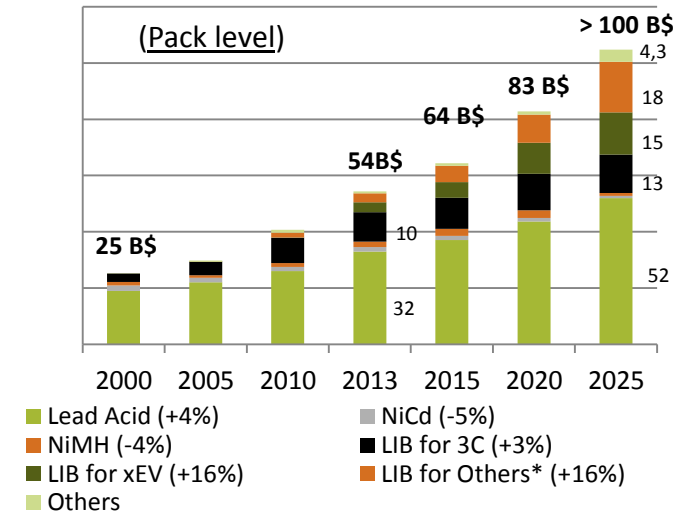
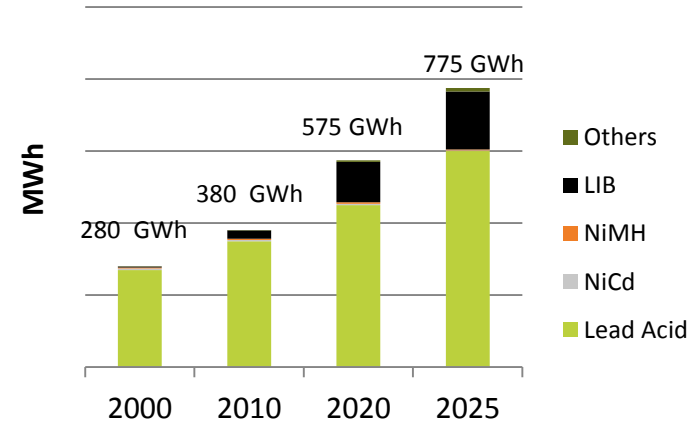
TAKEAWAYS

Battery Market 2010-2025

CAGR = +10%

- 🕒 Li-ion battery is driven today by Portable PCs & electronic devices (smartphones, tablets)
- 🕒 For HEV, the battery technology is today the NiMH
- 🕒 In 2012, most of the car makers (except Toyota) switch to Li-ion
- 🕒 P-HEV & EV will be powered by Li-ion: 6 B\$ market in 2015 - 11 B\$ in 2020 & 15 B\$ in 2025
- 🕒 EV expectations attract large Chemical companies
- 🕒 New materials are needed to meet Automotive standards
- 🕒 HEV will account for less than 5% of the automotive sales in 2020
- 🕒 P-HEV & EV < 2% by 2020
- 🕒 Micro-hybrid will achieve >50%
- 🕒 Lead acid battery will be the first market in 2025 in volume & value
- 🕒 A very small EV market in the automotive world will represent a huge market for batteries
- 🕒 New LIB applications: UPS, Telecom, Forklift, Medical, Residential ESS, Grid ESS: CAGR > 15% in the next 15 years
- 🕒 In 2020, Energy storage will represent less than 5% of the total battery market

RECHARGEABLE BATTERY MARKET WORLDWIDE 2000-2025



(CAGR 2012-2025)

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



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THANK YOU



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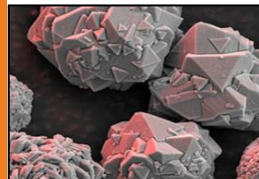
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AVICENNE PROFILE

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

Creation: 1992, by Ali MADANI

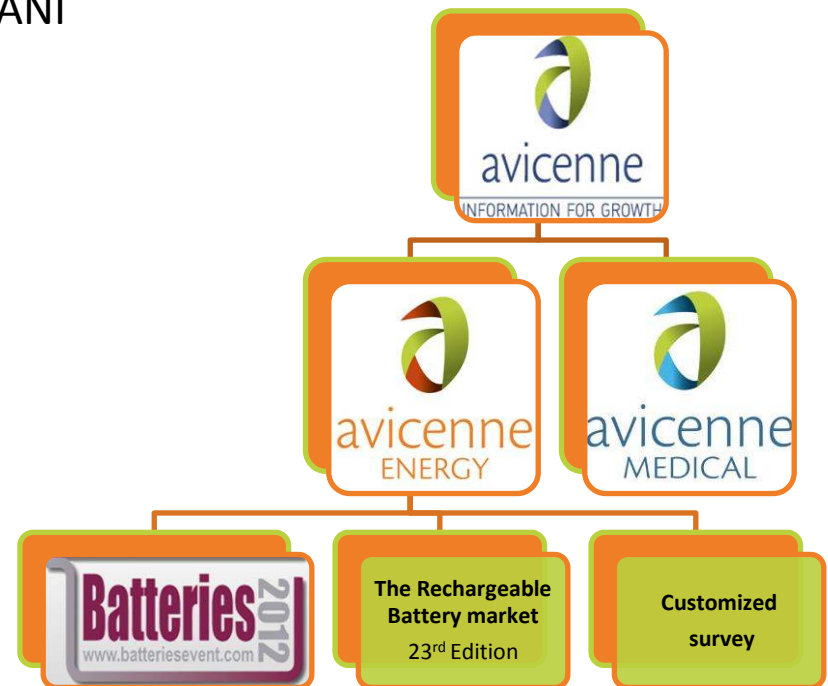
Headquarter: Paris

Liaison Office: Japan, USA

AVICENNE Energy Director:
Christophe Pillot

5 consultants

- A Madani
- C Pillot
- JP Salvat
- X Zhang
- A Yassari





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OUR BUSINESS STORY

- 1992** • AVICENNE Creation
- 1994** • AVICENNE advised French Industry Ministry on the European battery business opportunities
• AVICENNE open its office in JAPAN
- 1999** • « BATTERIES » congress 1st edition in Paris
- 2003** • AVICENNE work on the due diligence process for the sales of SAFT by ALCATEL
- 2008** • AVICENNE: expert witness in the NTT-Hydro Quebec conflict
- 2009** • AVICENNE presented its market forecasts to industrials (CIAPS) in Beijing – China
- 2010** • Avicenne developed partnership with BATTERY JAPAN
• 20th Edition of “The rechargeable battery market worldwide 2010-2020”
- 2011** • AVICENNE Energy division is created
• 13th Edition of BATTERIES Congress
- 2012** • 21st Edition of “The rechargeable battery market worldwide 2011-2025”
- 2014** • 23rd Edition of our Battery Market Survey
• 16th Edition of BATTERIES Congress in NICE, France
• 1 month mission in China: Qinghai EV Rally, CIBF, 50 companies visited



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OUR METHODOLOGY

Track valuable
Information's



Strategic
Analysis



Presentation of
the results



Q&A with
customers



Customer
Evaluation

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DEMAND
SIDE

Primary Research

- Executive Interviews
- Vendor Briefings
- Product Demos and Tours

Secondary Research

- Company News & Financials
- Technology & Product Specs
- Government Data
- Economic, Demographic Data

- Consumer Surveys
- Business Leader Surveys

- Case Studies
- Reference Customers

MARKET & STRATEGIC ANALYSIS

Qualitative

- Business Models & Trends
- Technology Issues
- Policy & Regulatory Factors
- Competitive Landscape
- Profiles of Key Players

Quantitative

- Company News & Financials
- Technology & Product Specs
- Government Data
- Economic, Demographic Data

Strategic

- SWOT Analysis
- Gap Analysis
- Business Plan
- Value Proposition
- Due Diligence
- Merger & Acquisition



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METHODOLOGY: EXTENSIVE FIELD RESEARCH TO RETRIEVE & CROSS CHECK INFORMATION

Top management
contact network
> 19 000 contacts

Conferences &
Exhibitions



2nd Int'l Rechargeable Battery Expo
BATTERY JAPAN



In Depth analysis
Of applications



Cross Check
Analysis



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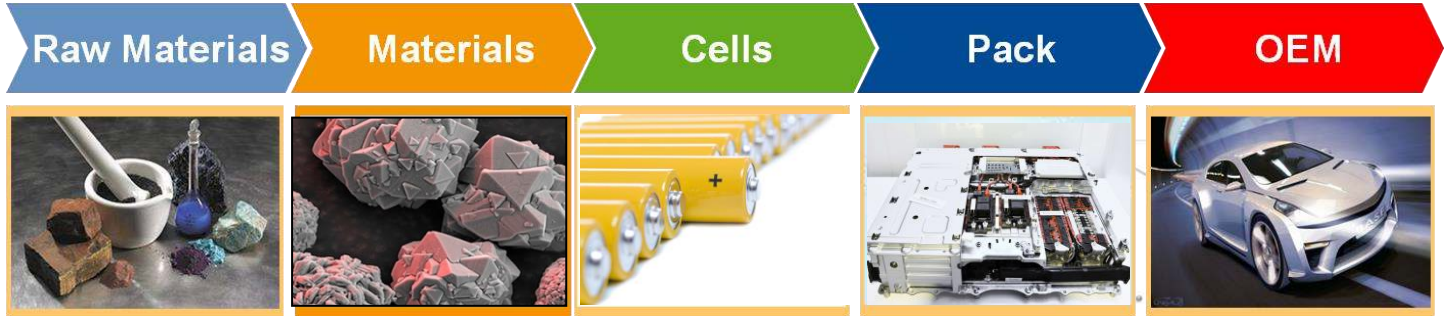
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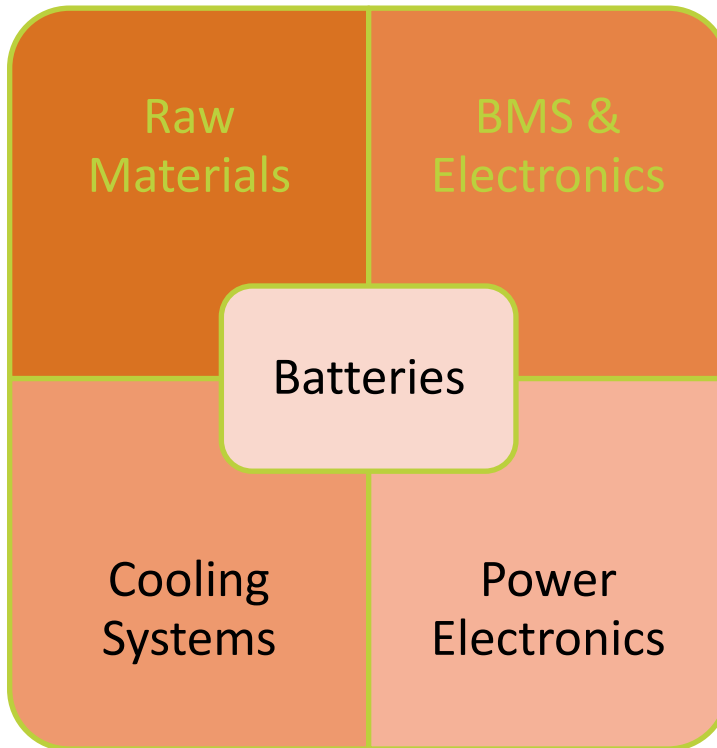
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REPORT 2011-2025 *Source : Photo from BASF*
WORLDWIDE RECHARGEABLE BATTERY MARKET



- 14 Detailed applications: Mobile, smartphone, Portable PCs, Tablets, Power Tools, xEV, ...
- Market in volume & value
- Market by application, battery size, battery design, suppliers
- 15 years forecasts scenario
- Raw materials market 2011-2020 (anode, cathode, separators, electrolyte)
- Main Trends: technological, price, materials,
- Battery supply chain and value added products

2012 Edition - Up-date every month !

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& EXHIBIT

March 9, 2015

CONTACT

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MORE THAN 200 REFERENCES WORLDWIDE

- 3M
- A123
- AIR LIQUIDE
- AIR PRODUCT
- AHLSTROM
- ALCATEL
- AMPEREX (ATL)
- APPLIED MATERIALS
- ARKEMA
- AROS SECURITIES
- ARC
- ASHLAND
- ATL AMPEREX
- AT KEARNEY
- AUSTRIAN INSTITUTE OF TECHNOLOGY
- AXEON
- BAIN
- BASF
- BATTERY ASSOCIATION OF KOREA
- BAYER
- BLACK & DECKER
- BHP BILLITON
- BRAND LICENCING PARTNERS (BLP)
- BOURNS
- BOSCH
- BOOZ
- BRUCKNER
- BUHLER GMBH
- BYD
- CABOT
- CALL2RECYCLE
- CAP X
- CATELLA
- CARBONE LORRAINE
- CARLYLE
- CATELLA
- CATERPILLAR INC.
- CDN COBALT
- CEA/LITEN
- CELGARD
- CHEMETALL
- CHEMISHE FABRIK BUDENHEIM
- CIBA
- CIAPS CHINA
- COGEMA
- CONOCO PHILIPS
- CRU GROUP
- CSC CHALLENGE STRATEGY CHANGE
- DELTA
- DGA
- DIALOG SEMICONDUCTOR
- DOW CHEMICAL
- DOW CORNING
- DUPONT
- DURACELL
- EDF
- ELECTRO ENERGY
- ENER 1
- ENERGIZER
- EOLITE
- EPCOS OHG
- ERAMET
- ETC AB
- FACOM
- FALCON BRIDGE
- FAIRCHILD SEMICONDUCTOR
- FAMEART
- FIST
- FLORIDIENNE DE CHIMIE
- FMC
- FORTU POWER CELL
- FRANCE TELECOM
- FREUDENBERG VLIESTOFFE SE & CO
- FRAUNHOFER INSTITUTE
- FULTON INNOVATION
- GAIA
- GIL IMPORT BATTERIES LTD.
- GS MELCOTEC
- HC STARCK
- HILTI
- HITACHI MAXELL
- HOLLINGSWORTH & VOSE CIE
- HONEYWELL
- HPL (HIGH POWER LITHIUM)
- HUTCHINSON
- ICC NEXERGY
- IER
- IGL EXPORT.
- INTERNATIONAL COMPONENT CORP.
- INTERNATIONAL RECTIFIER
- INTEK
- INTEL
- INTERSIL
- INCO
- ISRAEL CONSULTING
- ITRI
- ITS
- JBC
- JETRO
- JOHNSON CONTROLS
- JOHNSON MATTHEY
- KODAK
- KRUGER
- LAZARD
- LECLANCHÉ
- LEGRAND
- LG CHEMICAL
- LION CELLS
- LITTLE FUSE
- LILIPUCIAN
- LYNAS CORP
- MATSUSHITA
- MICROSOFT
- MTI MICRO FUEL CELLS
- MOLTECH
- MOLYCORP
- MOMENTIVE
- MOSAID TECHNOLOGIES
- MOTOROLA
- MUNSTER UNIVERSITY
- NANOCYL
- NCCP – RUSSIA
- NEC
- NITECH
- NKKPC
- NORILSK NICKEL
- NOVALED
- NTK POWERDEX
- OLIVER WYMAN
- OMG INC
- ORANGE
- OSKR
- PANASONIC
- PHILIPS
- PHOTON
- PK & WISE
- PLEXTRONICS
- POWER GENIX
- PRAYON
- PRISMARK
- PSA
- RAYOVAC
- RECHARGE
- RENAULT
- RHODIA
- ROLAND BERGER
- ROSKILL INFORMATION SERVICES
- SAFT
- SAGENTIA
- SAINT GOBAIN
- SAKTI
- SAMSUNG SDI
- SANIK
- SCHRODER VENTURE
- SCOTENT ENTREPRISE
- SEPCELL
- SFPZ
- SHENZHEN HIGH POWER TECHNOLOGY
- SCHOTT AG
- SKC
- SQM
- SVE - DASSAULT
- SOLVAY
- SONY
- STIBAT
- STORCK
- STRATEGY ANALYSIS
- TERRAROSSA CAPITAL
- TIGER GLOBAL
- TODA KOGYO
- TOTAL
- TOTAL WIRELESS SOLUTION
- TOYO
- TOYOTA
- TREOFAN
- TYCO
- UMICORE
- UNIROSS
- URALELEMENT
- US NAVY
- VARTA
- VOLTRACK
- WACKER CHEMIE AG
- WARBURGPINCUS
- WILDCAT
- WORLD INDUSTRIAL INFORMATION CENTER
- WR GRACE & CIE
- YASLAMEN
- ZEBRA
- ZPOWER



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The Rechargeable
Battery Market and
Main Trends
2014-2025

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SPEAKER, CHAIRMAN OR WORKSHOP MODERATOR

Tens of INTERNATIONAL CONFERENCES per year

- ✪ Extended Battery Life Working Group on battery technology development for mobile devices Meeting Tokyo Japan , Dec 2014 – 1h30 Presentation *"The battery market for mobile 2013-2025"*
- ✪ BATTERIES 2014, FRANCE – (1999-2014) Owner, chairman & speaker *"The battery market 2013-2025"*
- ✪ INTERNATIONAL Li-ion BATTERY SUMMIT – Dec 2013, Shenzhen, China *"The Li-ion battery raw materials market 2012-2020"*
- ✪ AABC Europe, Mainz (2012, 2013, 2015) *"The Lithium ion raw material battery market 2010-2020"*
- ✪ THE INTERNATIONAL BATTERY SEMINAR - FLORIDA Fort Lauderdale, Florida , March 2014 – 2h tutorial *"HEV, PHEV & EV market 2010-2020 ; Battery is the key"* (From 2004 to 2014)
- ✪ EVER 2009, 2011, MONACO *"Challenges for EV market in Europe"*
- ✪ EVS 2011, 2013 *"Battery market for automotive industry"*
- ✪ CIAPS (China Industrial Association of Power sources), BEIJING, Dec 2009 *"Advanced battery market & raw materials worldwide"*
- ✪ Advanced Battery for Vehicles, IQPC, Frankfurt, 2009, 2010, 2012 Chairman & speaker, *"The battery business 2009-2020"*
- ✪ EET-2008 European Ele-Drive, MOTOR SHOW GENEVA, International Advanced Mobility Forum – Geneva Motor Show (Professor Gaston Maggetto Award: C. Pillot as the best rated paper & presentation by EET-2008 Scientific Reviewing Committee) *"The HEV & EV market trends & main challenges"*
- ✪ China Industry Battery Fair 2006, 2010, 2014 *"The Chinese battery Industry"*
- ✪ ...



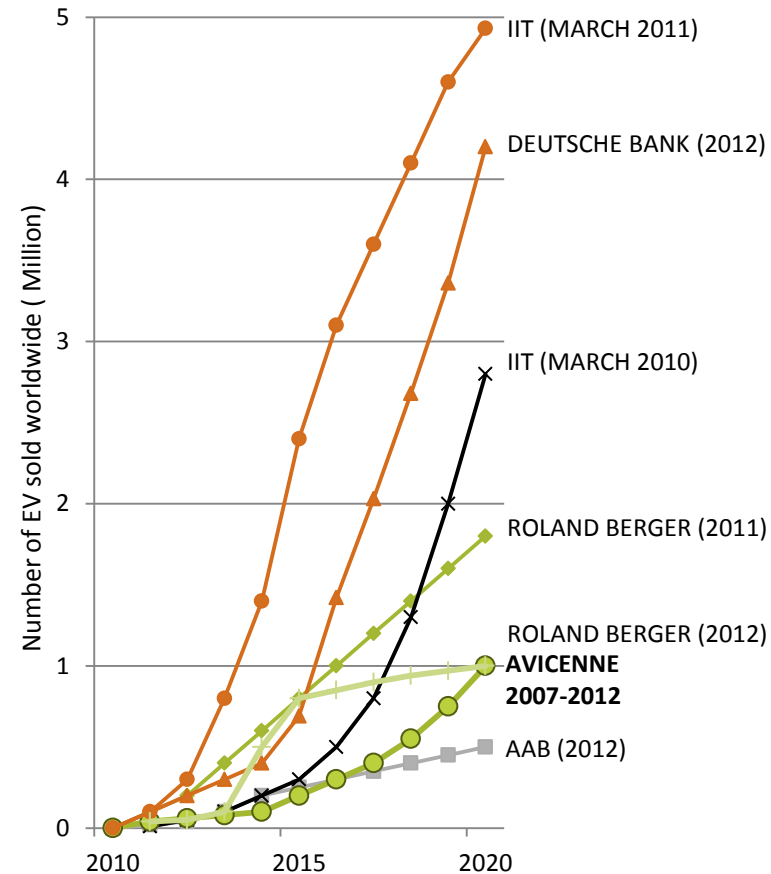
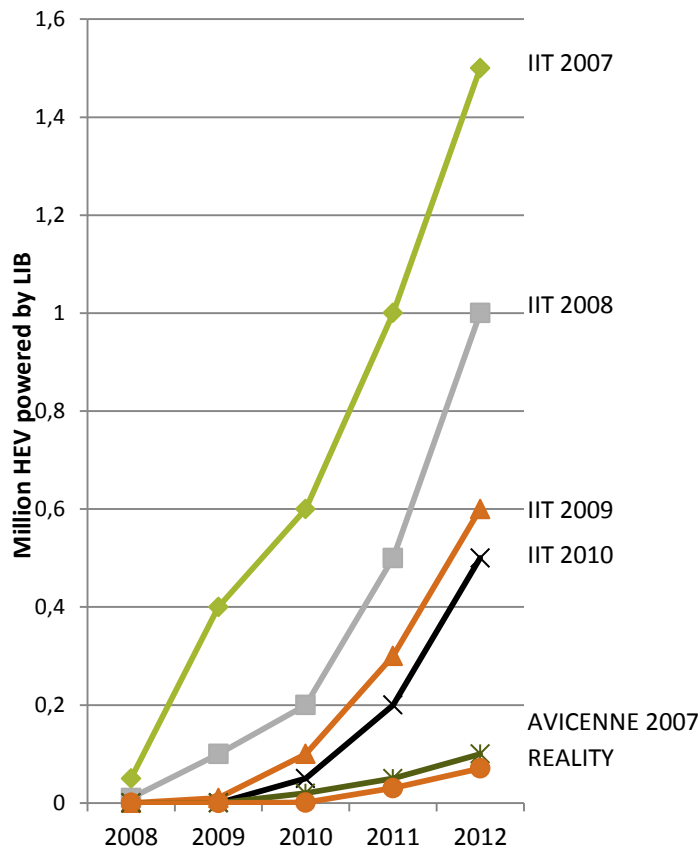


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AVICENNE ENERGY: RENOWNED TO HAVE REALISTIC FORECASTS

EV sold, in million units, worldwide, 2010 - 2020



Source : International Battery Conference, Fort Lauderdale
2007, 2008, 2009, 2010 & 2011
HEV powered by Lithium ion battery
forecasts from 2008 to 2012

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BATTERIES 2015

www.batteriesevent.com



- 🕒 3 days congress in France (Paris, Nice, Cannes)
- 🕒 17th Edition (first edition in 1999)
- 🕒 500 attendees
- 🕒 40 Booths
Battery makers, raw materials suppliers, IC & BMS suppliers, tests, machining, coating,
- 🕒 80 international experts:
Researchers, industrial process, marketing, financials,



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SUMMARY

- A small team dedicated on the battery industry since almost 20 years
- Working with large group worldwide: FMC, Umicore, Dupont, Dow, Panasonic, LG, Samsung, JCI, Nokia, Bosch, Siemens, Toyota, Renault, ...
- Synthetic presentation to management & CEO of major groups

We will help and support your growth

