



avicenne
ENERGY

INFORMATION FOR GROWTH

www.avicenne.com

Micro hybrid, HEV, P-HEV and EV
market 2012-2025

Impact on the battery business

November 2013

CONTACT

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

Micro hybrid, HEV, P-HEV and EV market 2012-2025

Impact on the battery business

Christophe PILLOT

Director, AVICENNE ENERGY

Presentation Outline

- The rechargeable battery market in 2012/2013
- The x-EV market worldwide in 2012
- 2012-2025 Trends & forecasts
- Conclusions





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



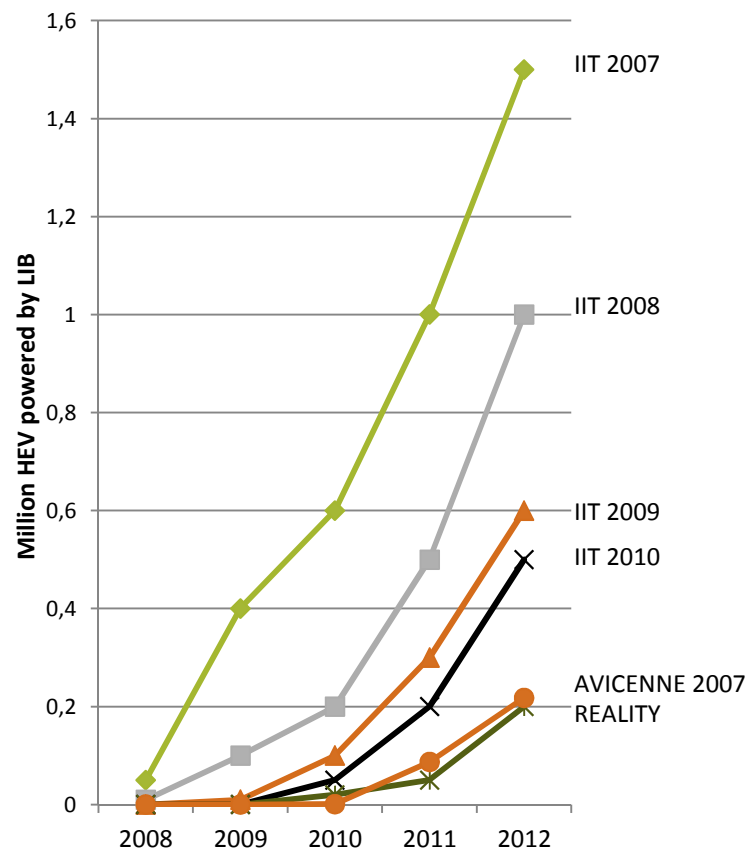
November 2013

CONTACT

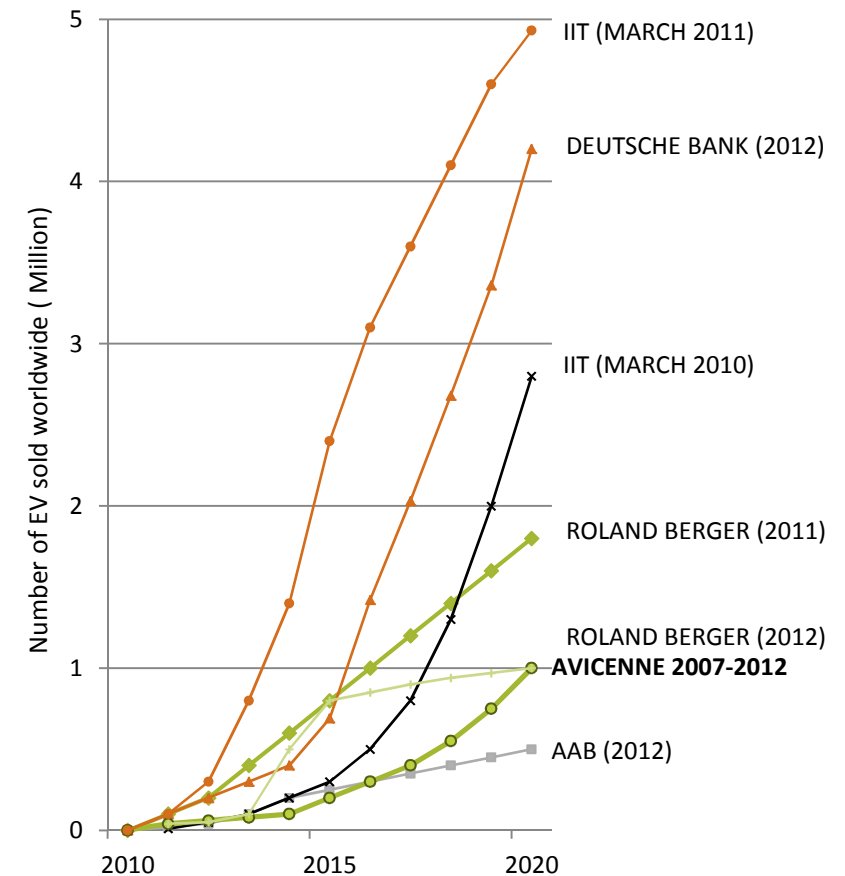
Christophe PILLOT
+ 33 1 47 78 46 00
c.pillot@avicenne.com

AVICENNE ENERGY: RENOWNED TO HAVE REALISTIC FORECASTS

HEV powered by Lithium ion battery
forecasts from 2008 to 2012



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



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



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

evs | 27

The 27th INTERNATIONAL
ELECTRIC VEHICLE
SYMPOSIUM & EXHIBITION.
Barcelona, Spain
17th-20th November 2013

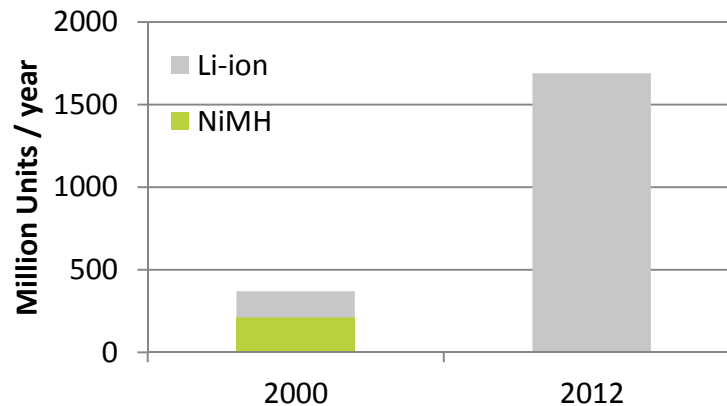
November 2013

CONTACT

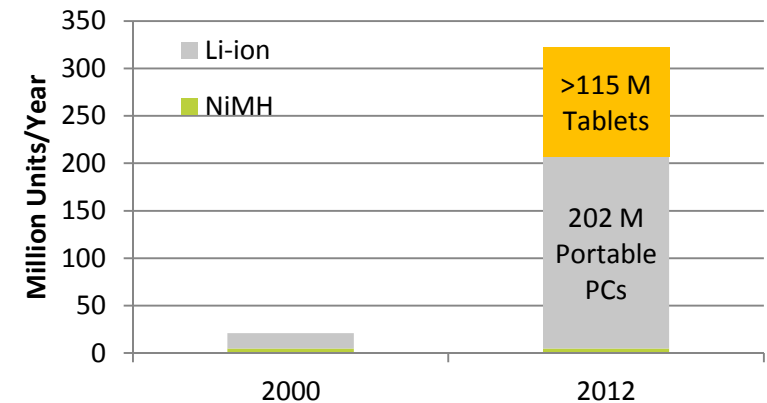
Christophe PILLOT
+ 33 1 47 78 46 00
c.pillot@avicenne.com

THE BATTERY MARKET IS REALLY DYNAMIC

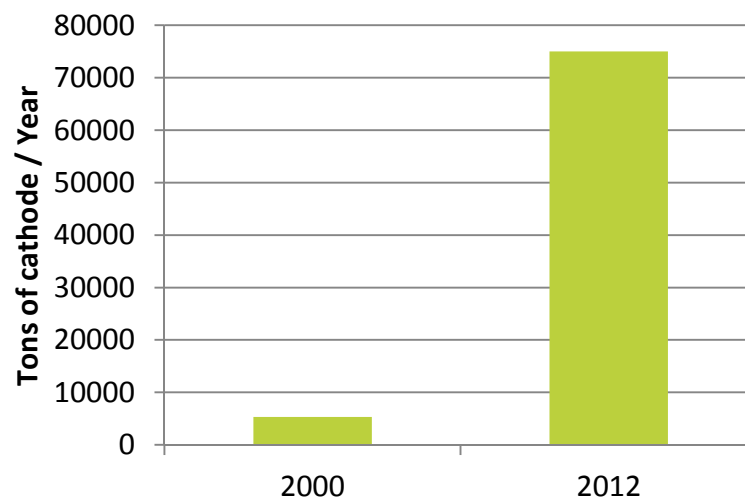
Cellular Phones sold per Year (Million)



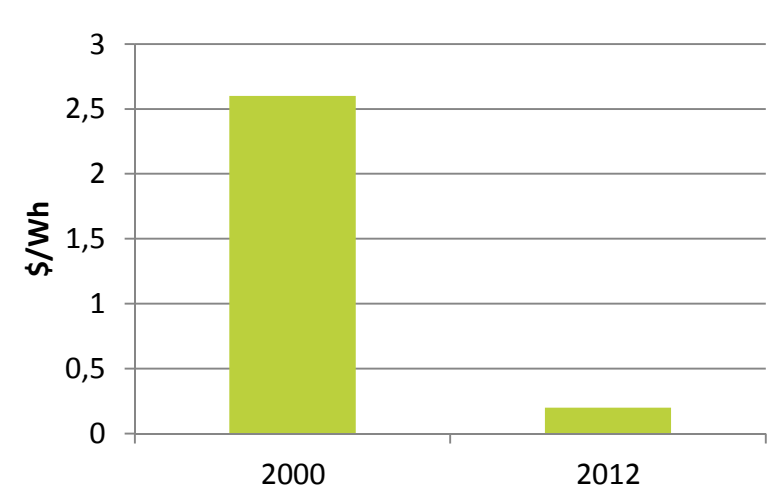
Portable PC sold per Year (Million)



Tons of Li-ion Cathode per year



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



Source: AVICENNE ENERGY Analyses 2013



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



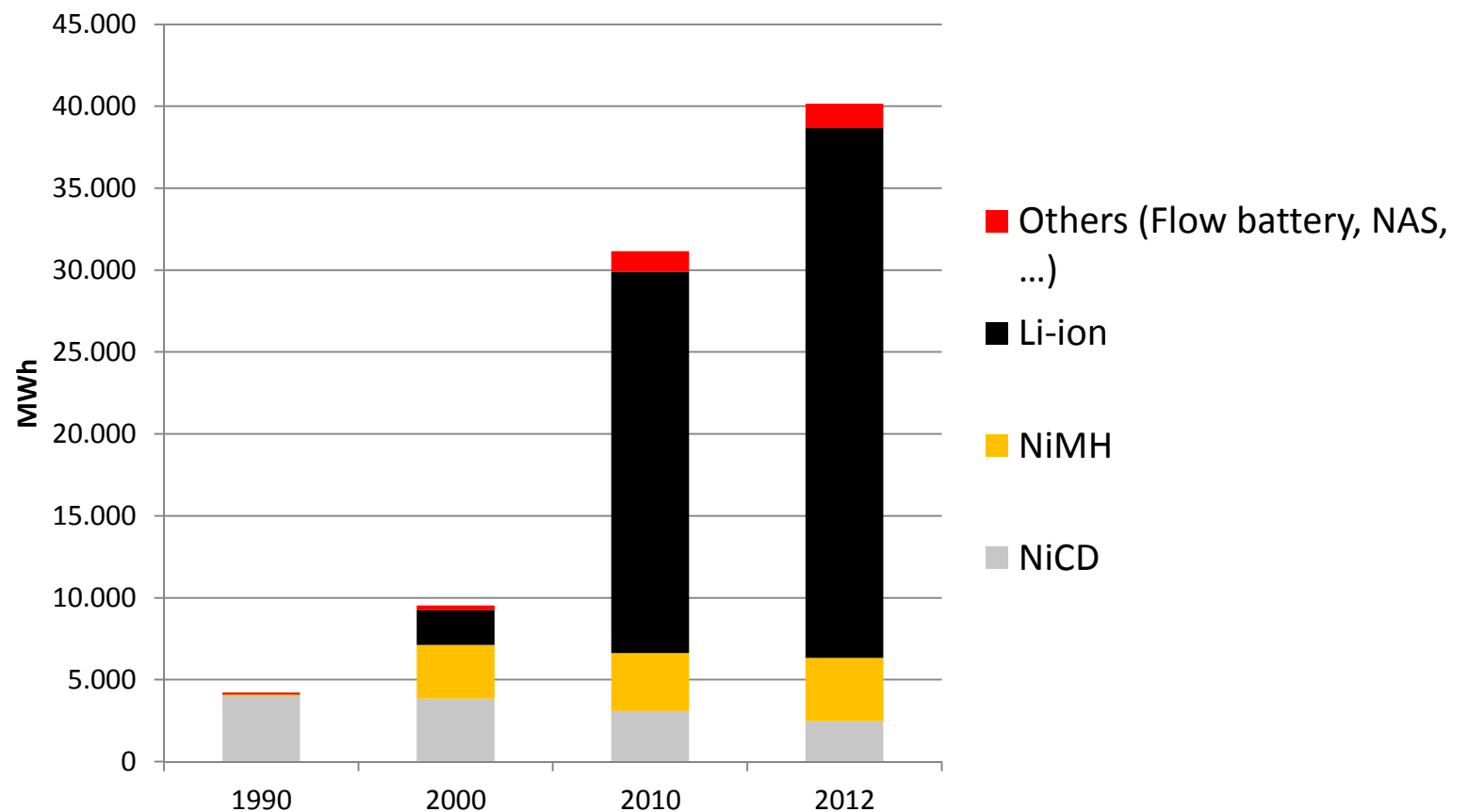
November 2013

CONTACT

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

THE WORLDWIDE BATTERY MARKET 1990-2012

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



Source: AVICENNE ENERGY, 2013



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

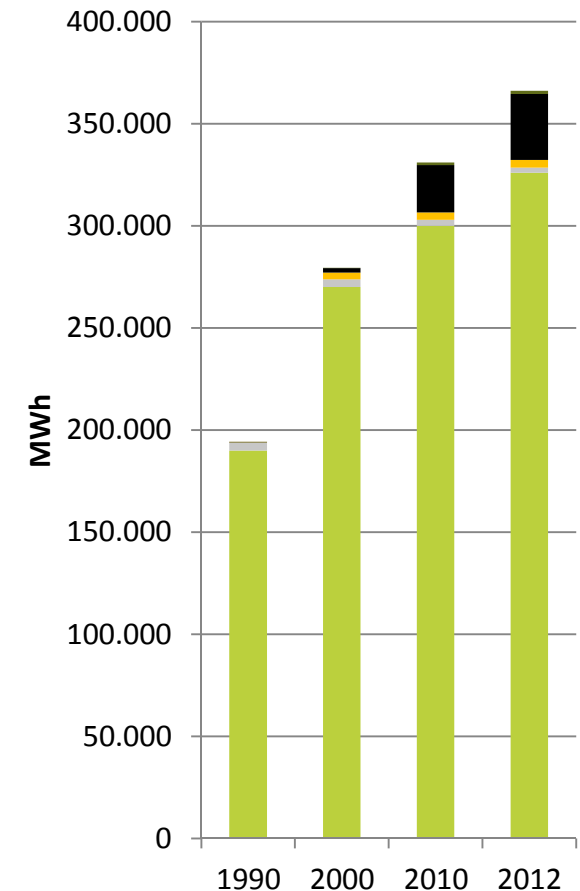
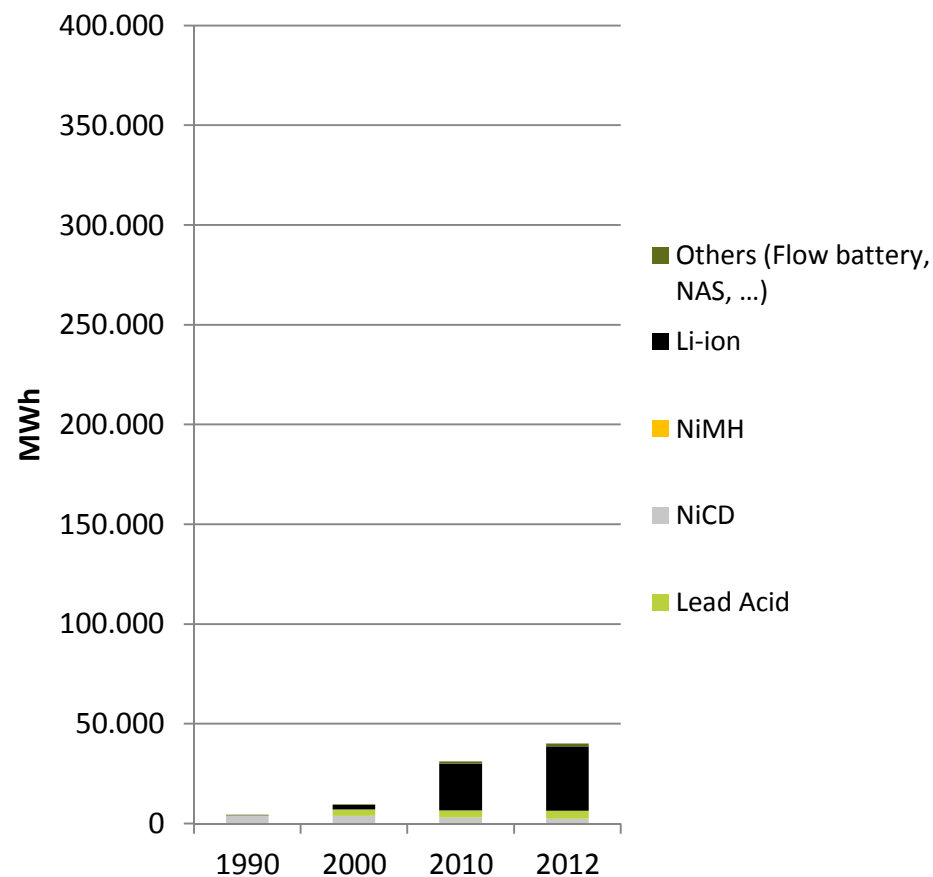
CONTACT

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

THE WORLDWIDE BATTERY MARKET 1990-2012

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, 2013



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

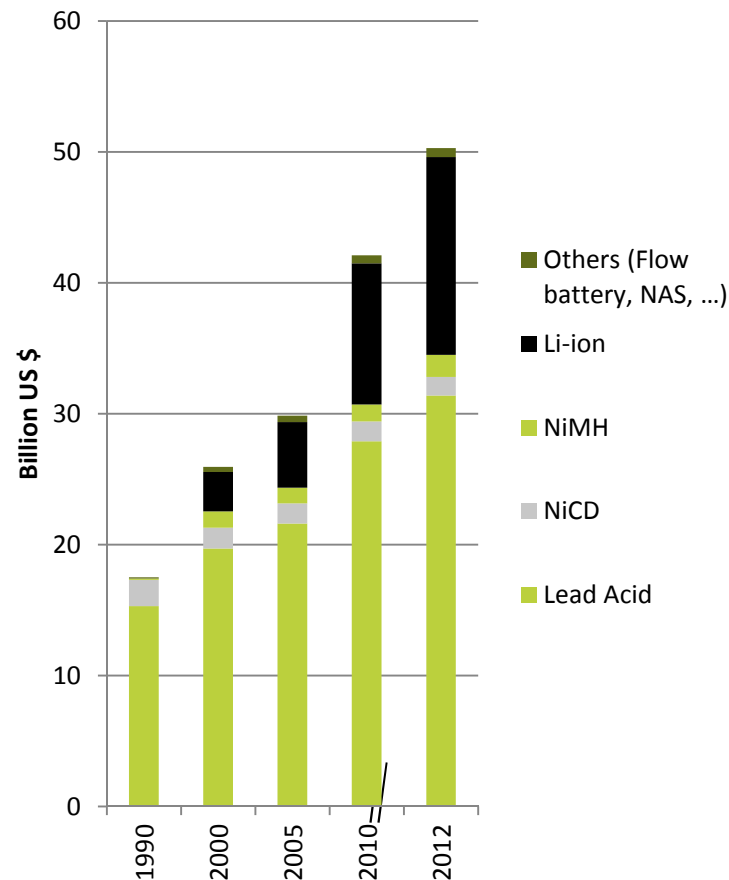
CONTACT

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

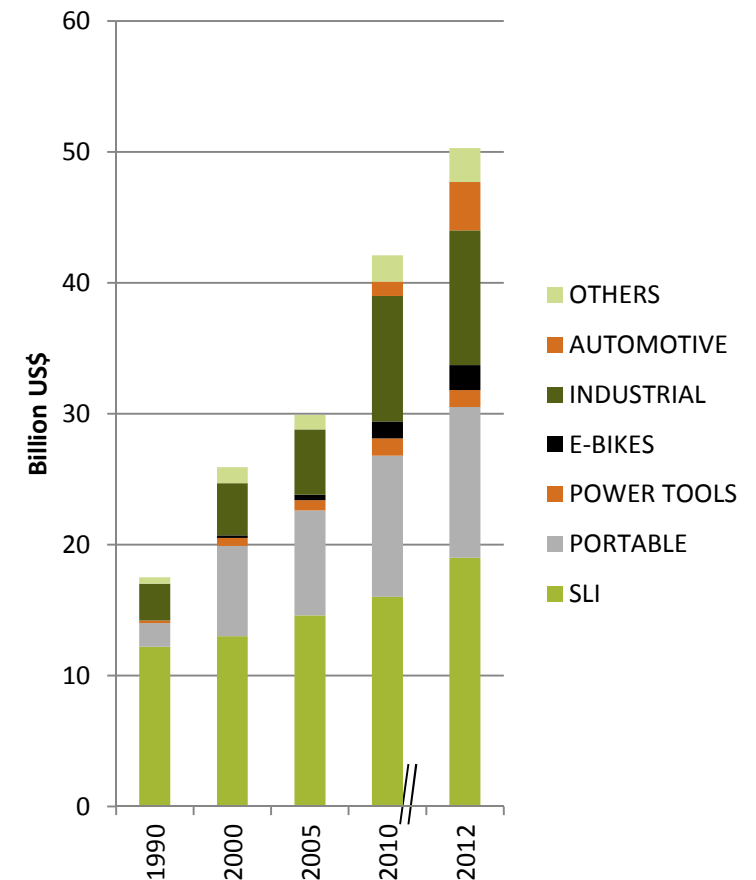
THE WORLDWIDE BATTERY MARKET 1990-2012

50 BILLION US\$ in 2012¹

5% AVERAGE GROWTH PER YEAR (1990-2012)



Source: AVICENNE ENERGY Analyses 2013



1- Pack level



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

CONTACT

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

LI-ION IN 2012

MAIN APPLICATIONS: CELLULAR, NOTEBOOK

4 450 M cells – 32 000 MWh

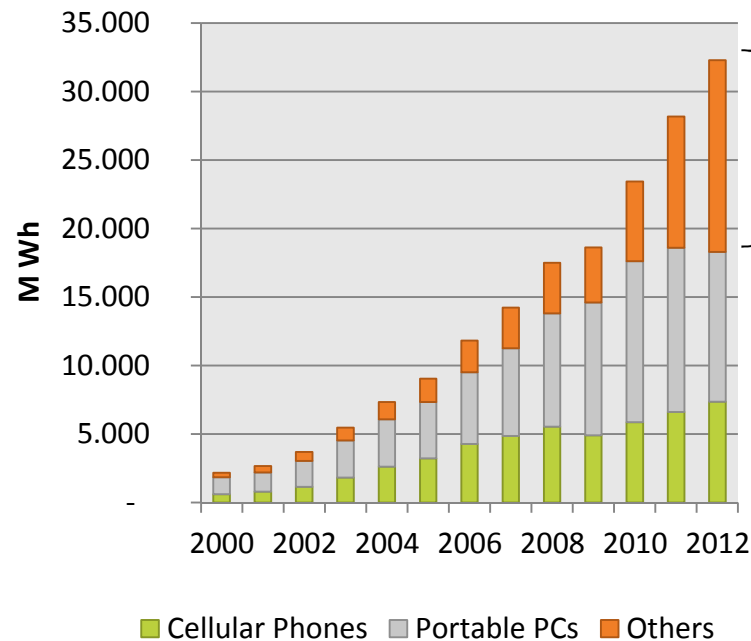
10 500 M\$

CAGR 2002/2012

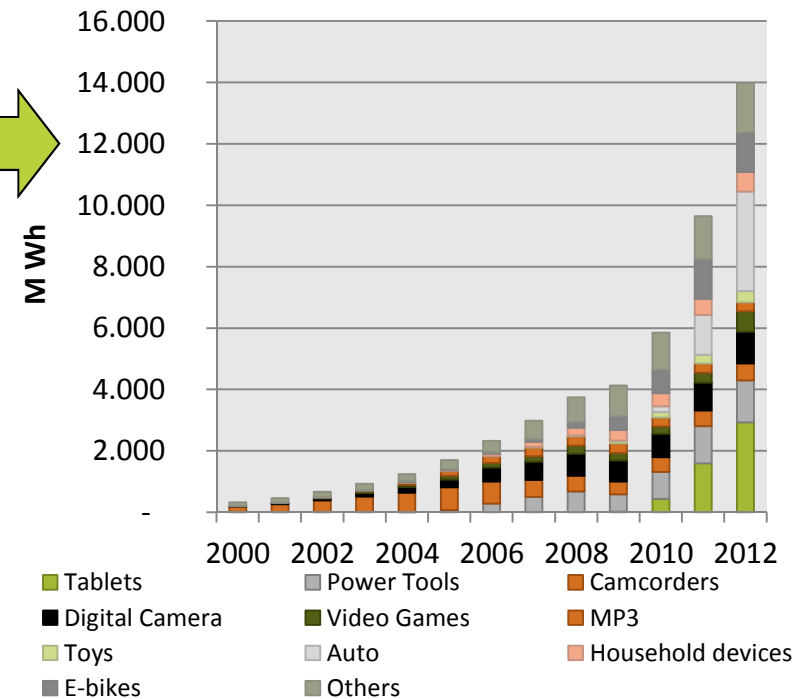
+25 % per year in Volume

+14% per year in value

Li-ion Battery sales,
MWh, Worldwide, 2000-2012



Li-ion Battery sales,
MWh, Worldwide, 2000-2012





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

CONTACT

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

LI-ION IN 2012

MAIN APPLICATIONS: CELLULAR, NOTEBOOK

4 450 M cells – 32 000 MWh

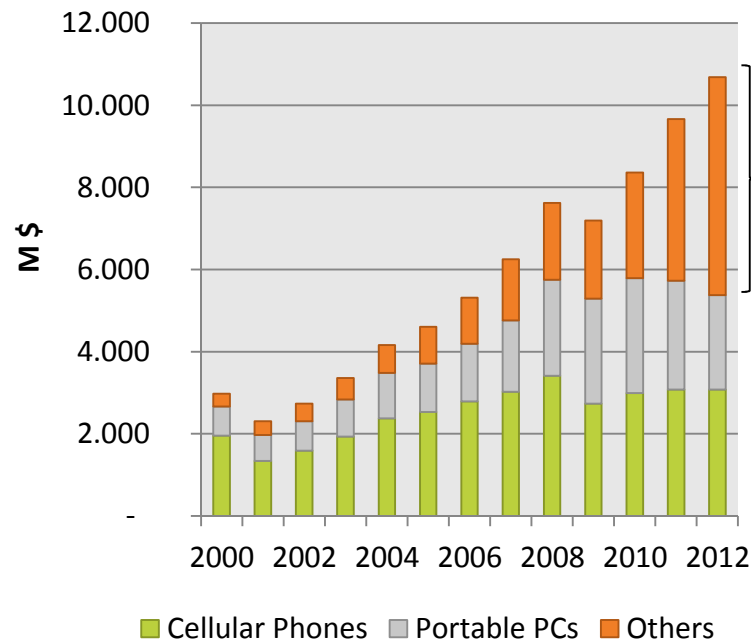
10 700 M\$ (cell level)

CAGR 2002/2012

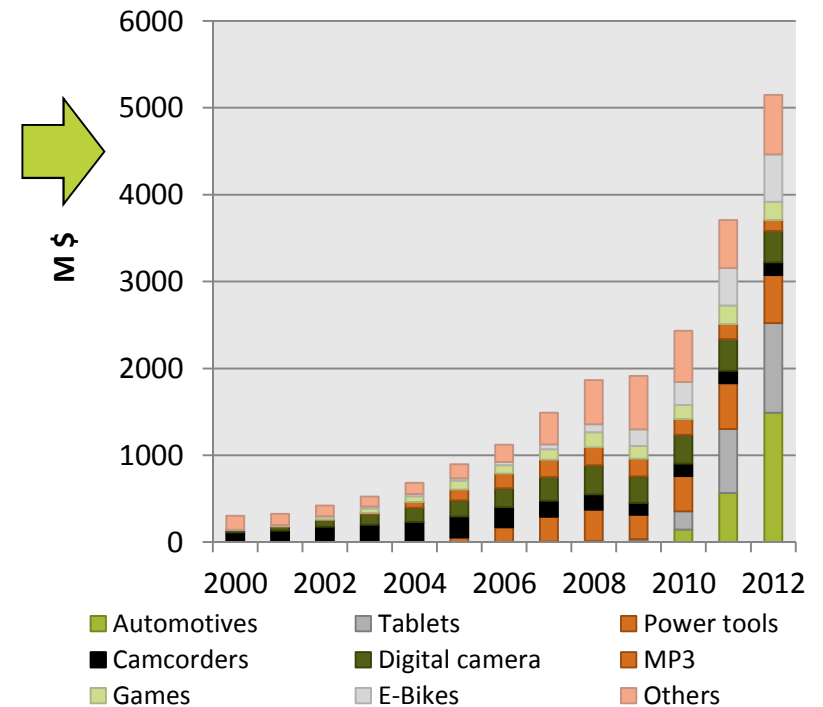
+25 % per year in Volume

+14% per year in value

Li-ion Battery sales,
M\$, Worldwide, 2000-2012



Li-ion Battery sales,
M\$, Worldwide, 2000-2012





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

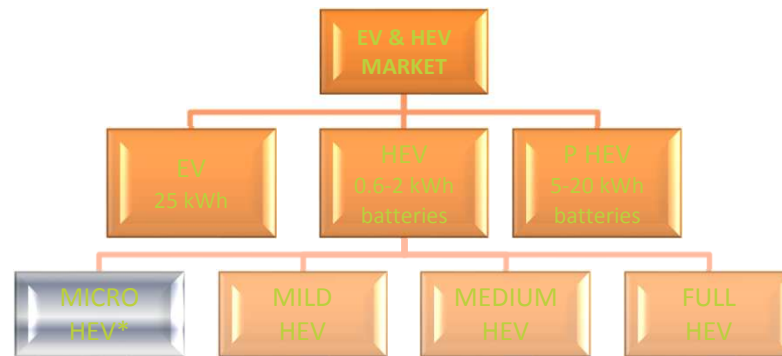


November 2013

CONTACT

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

HEV, P-HEV & EV DEFINITION & SEGMENTATION

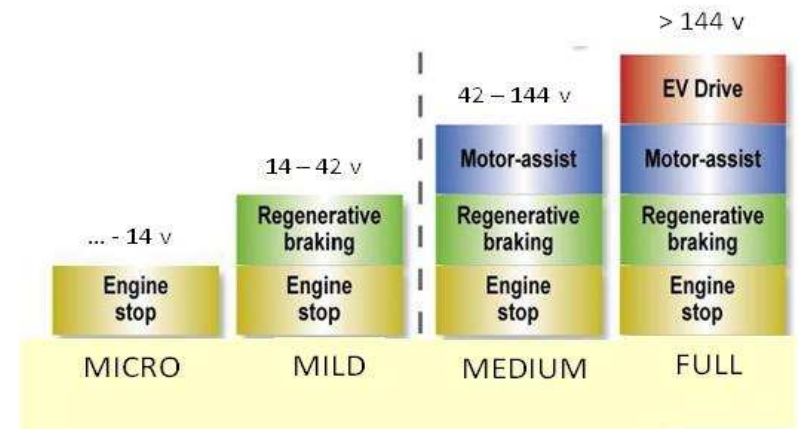


CITROEN C3
TOYOTA VITZ

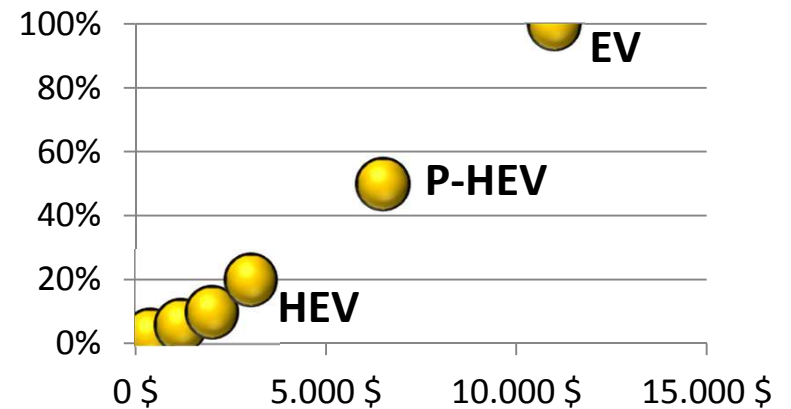
GM Saturn Vue
GM AURA
GM MALIBU
HONDA ACCORD

HONDA CIVIC
INSIGHT
MERCEDES S400

TOYOTA PRIUS
TOYOTA CAMRY
FORD ESCAPE
FORD FUSION
MILAN
GM YUKON
GM TAHOE
NISSAN ALTIMA



Fuel saving Vs. Cost



Note: Micro HEV are not in the HEV statistics & HEV forecast



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



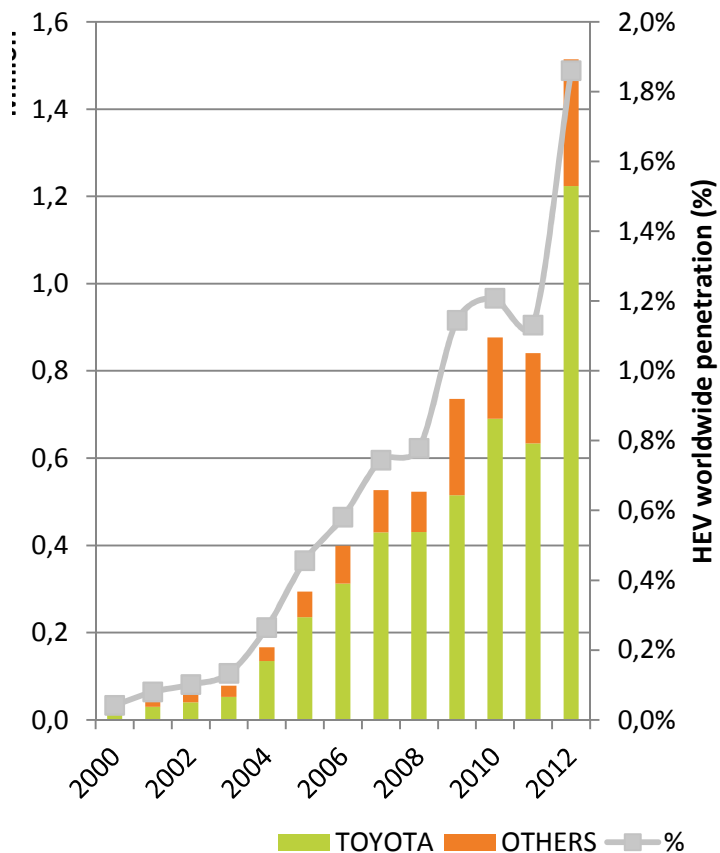
November 2013

CONTACT

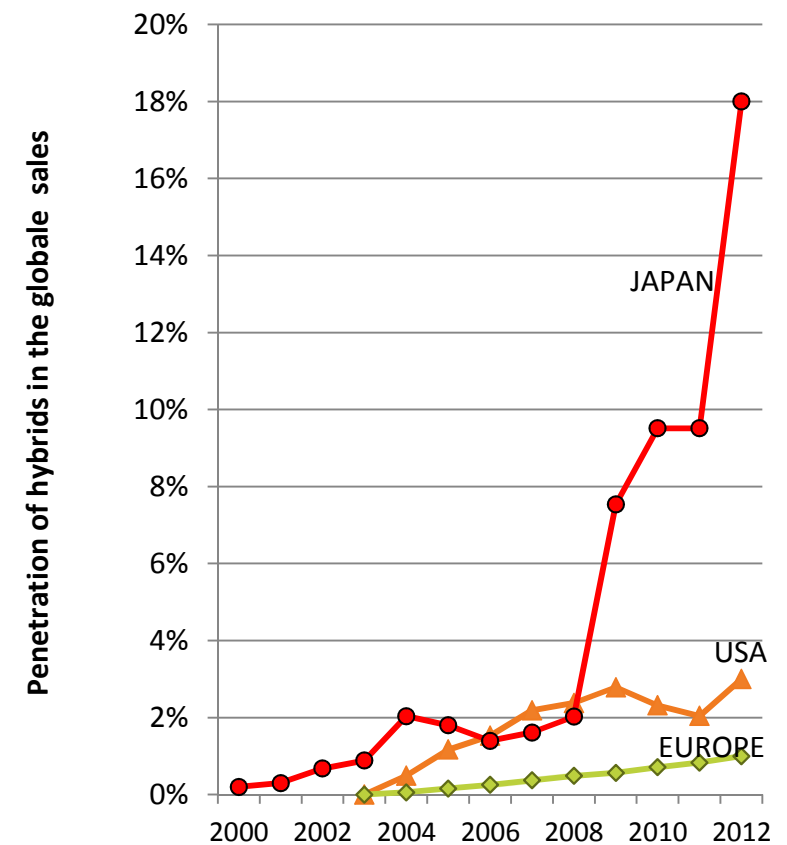
Christophe PILLOT
+ 33 1 47 78 46 00
c.pillot@avicenne.com

HEV WORLDWIDE IN 2012 1,5 M HEV

HEV sold per year, M units,
worldwide, 2000 - 2012



Penetration of hybrids in the global
sales, 2000-2012



Source: TOYOTA, HONDA, NISSAN, FORD, GM, HYUNDAI, MERCEDES, GM, BMW, VW, PORSCHE... Compilation AVICENNE ENERGY
Micro hybrid not included



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

evs | 27

The 27th INTERNATIONAL
ELECTRIC VEHICLE
SYMPOSIUM & EXHIBITION.
Barcelona, Spain
17th-20th November 2013

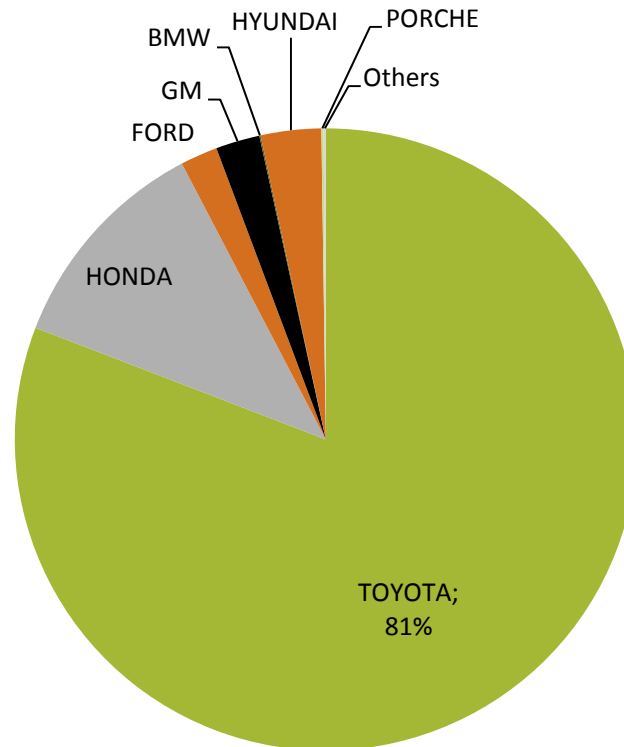
November 2013

CONTACT

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

HEV WORLDWIDE IN 2012 BY CAR SUPPLIER

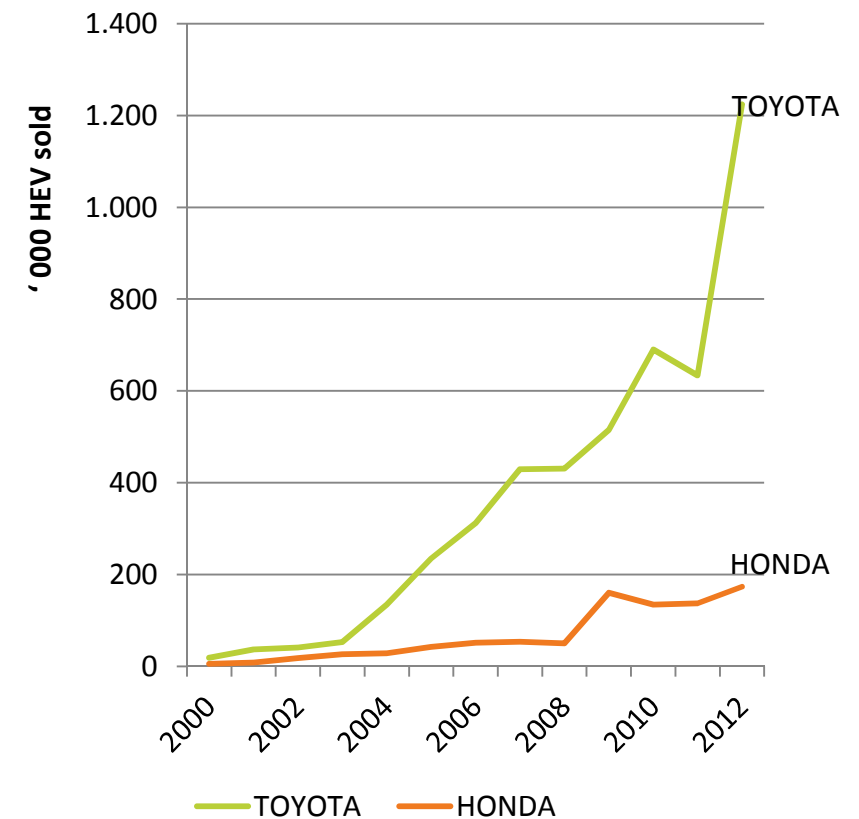
Total HEV Vehicles
+1,5 M in 2012



Others: Nissan, Mercedes, Mazda, VW, Audi

Source: TOYOTA, HONDA, NISSAN, FORD, GM, HYUNDAI, MERCEDES, GM, BMW, VW, PORSCHE... Compilation AVICENNE ENERGY
Micro hybrid not included

HEV sold per year, M units per car
manufacturers, 2000-2012





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

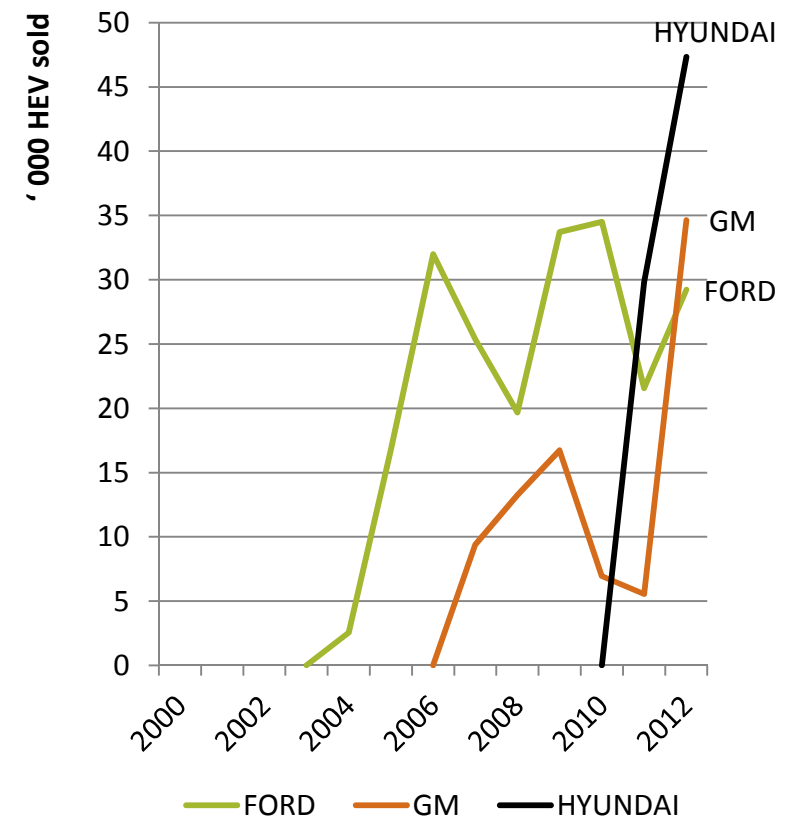
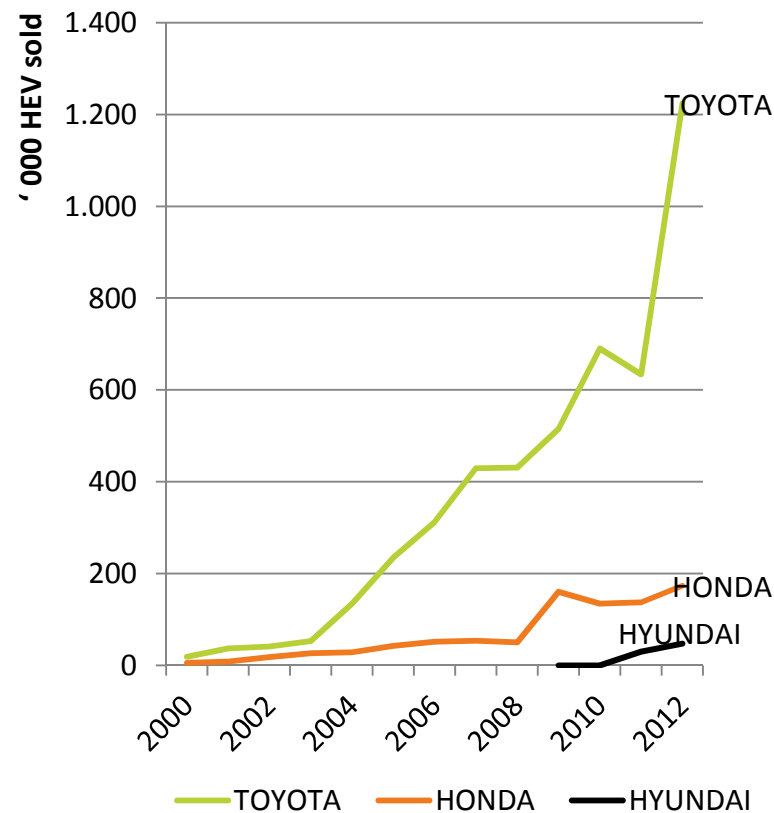
CONTACT

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

HEV WORLDWIDE IN 2012 BY CAR SUPPLIER

TOP 3: TOYOTA, HONDA,
HYUNDAI

OTHERS: FORD, GM, ...



Source: TOYOTA, HONDA, NISSAN, FORD, GM, HYUNDAI, MERCEDES, GM, BMW, VW, PORSCHE... Compilation AVICENNE ENERGY
Micro hybrid not included



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



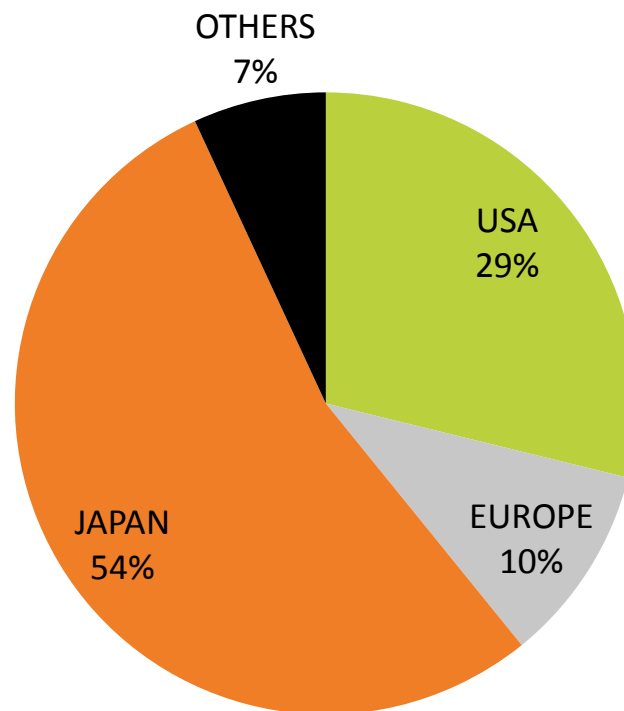
November 2013

CONTACT

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

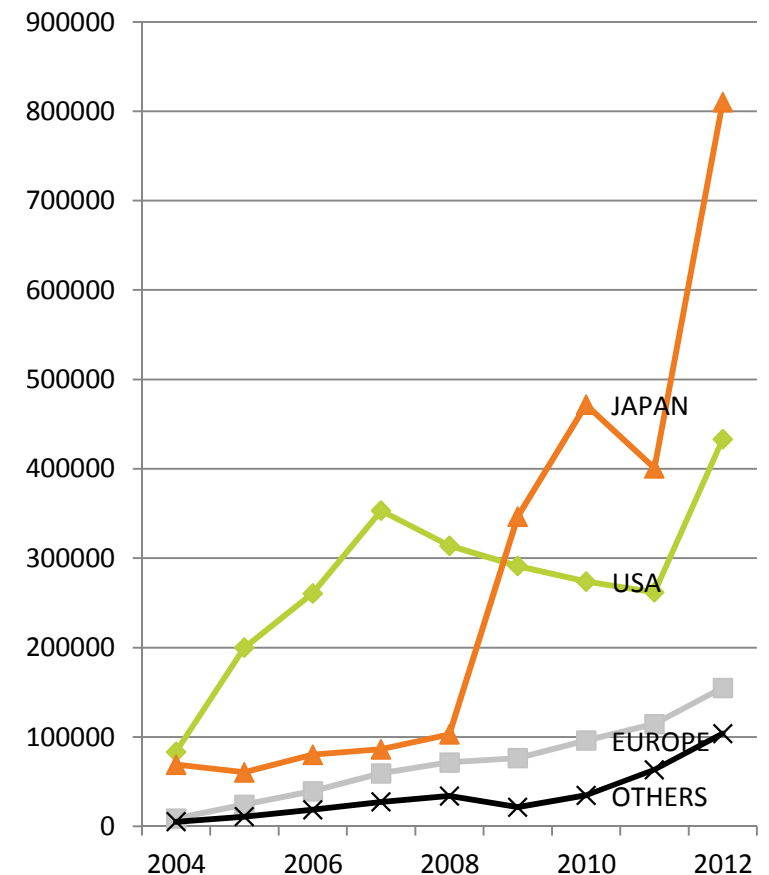
HEV WORLDWIDE IN 2012 BY COUNTRY

Total HEV Vehicles
+1,5 M in 2012



Source: AVICENNE ENERGY Analyses 2013

HEV sold per year, M units per
country, 2004-2012



Micro hybrid not included



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



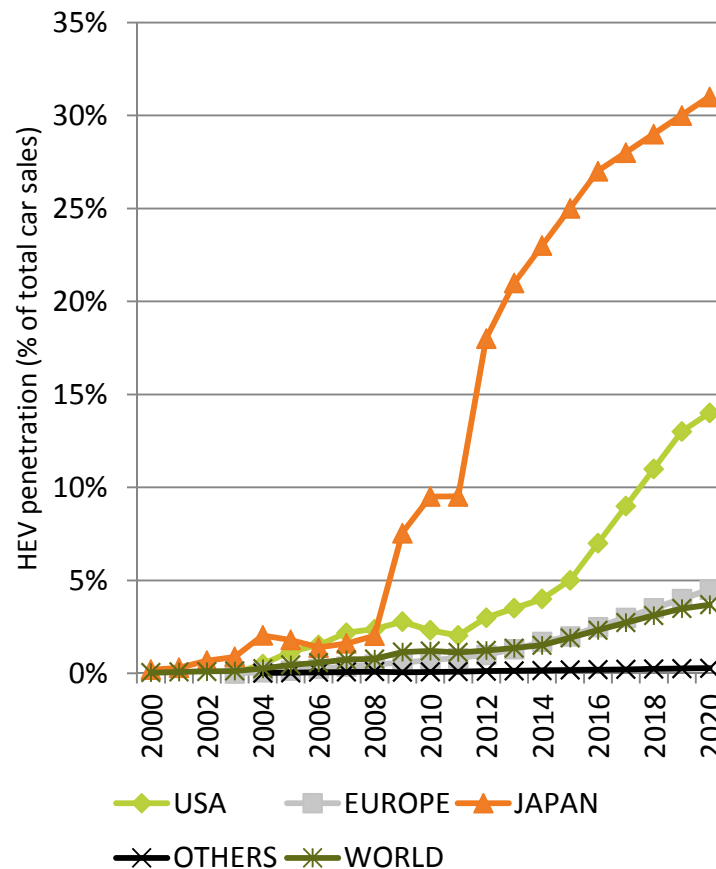
November 2013

CONTACT

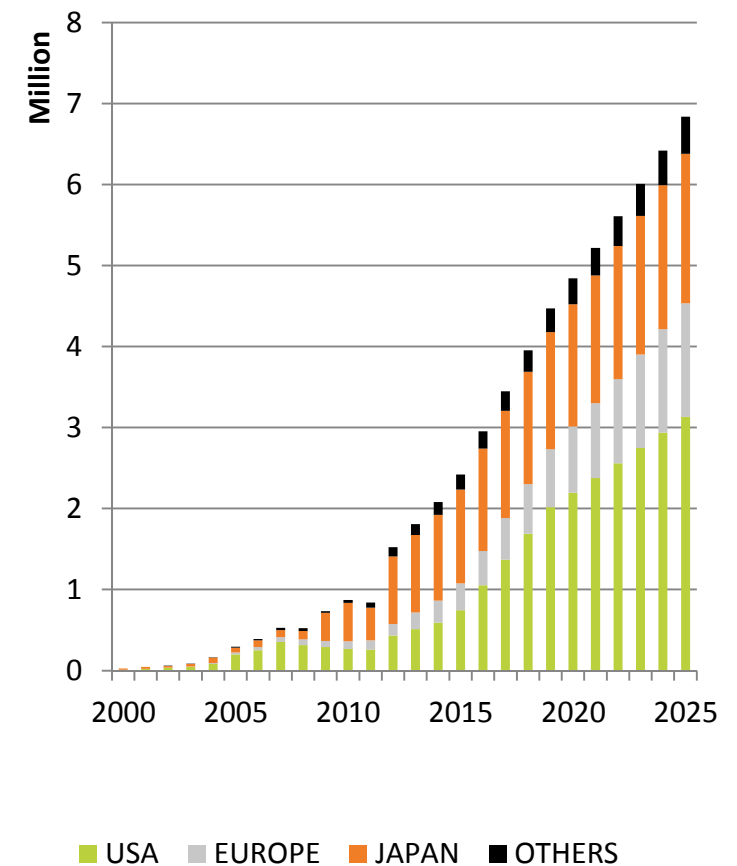
Christophe PILLOT
+ 33 1 47 78 46 00
c.pillot@avicenne.com

HEV FORECASTS 2012-2025

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



Micro hybrid not included



Source: AVICENNE ENERGY Analyses 2013

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

CONTACT

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

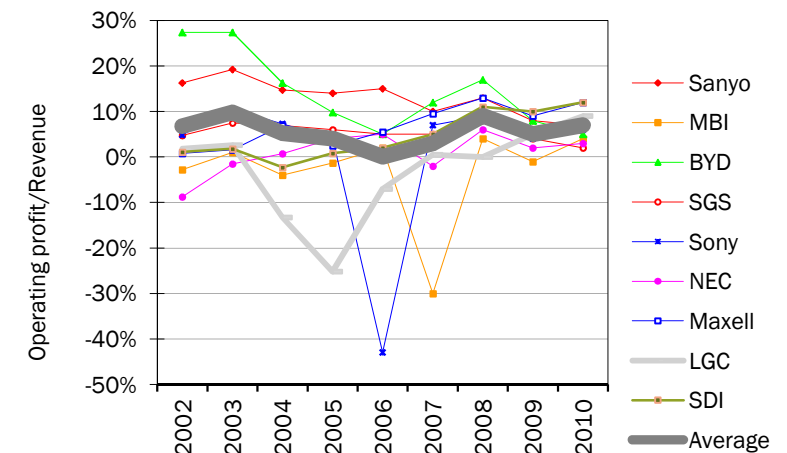
LI-ION BATTERY DEVELOPMENTS FOR HEV, P-HEV & EV

LIB >>> NiMH but
SAFETY & COST ISSUES

	PRIUS III NiMH	PRIUS x - Li-ion
Volts	201.6	201.6
Cells	168 (28*6)	56
Capacity	6.5 Ah	3.8 Ah
Energy	1310 Wh	766 Wh
Weight	38 kg	25 kg
T°C Range	+	+
Cyclability	+	++
Safety		
Cost		



Recall slash battery profit





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

CONTACT

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

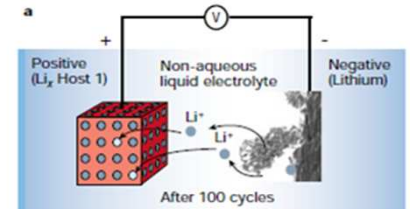
SAFETY ISSUES

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.



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

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

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	> 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.

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

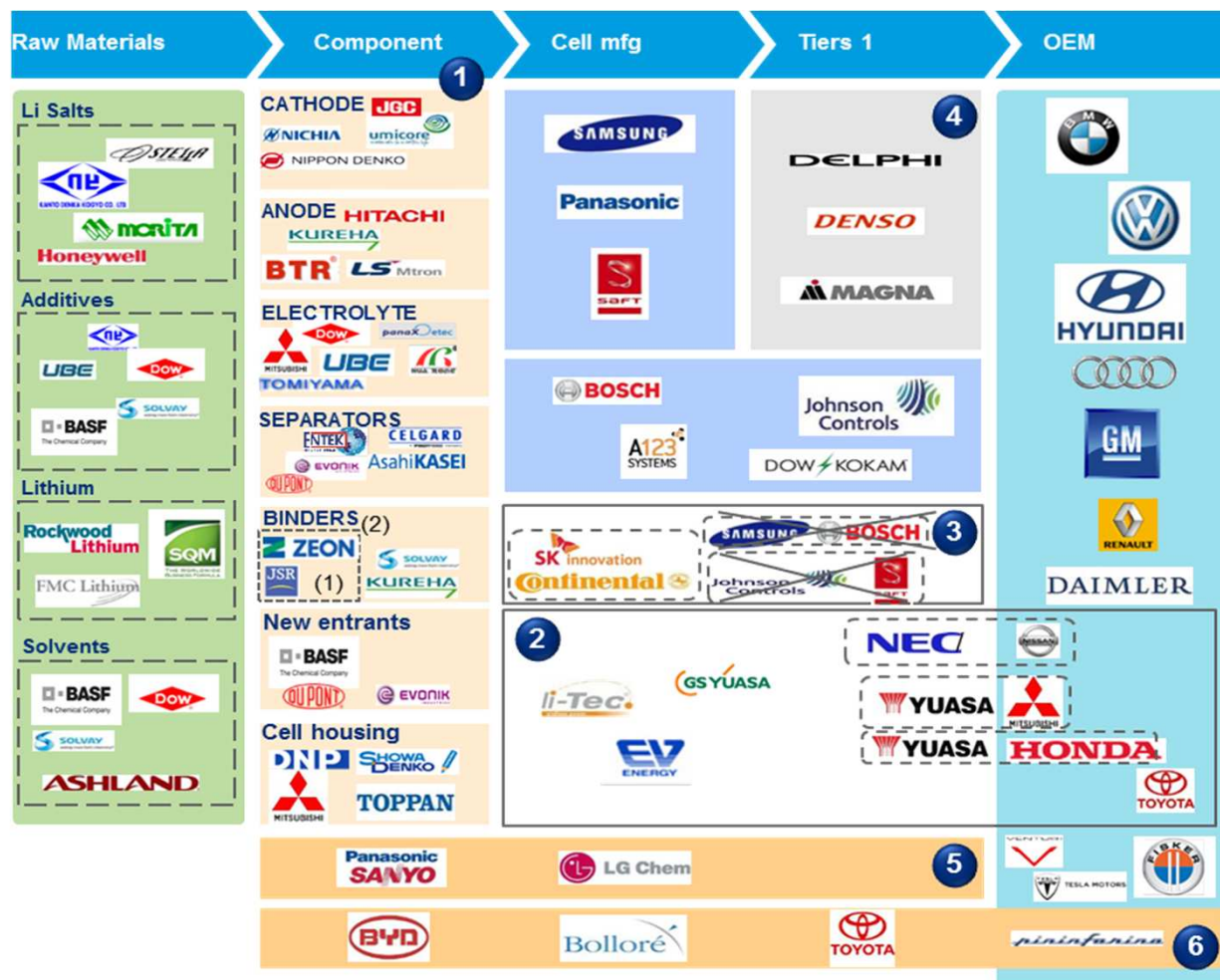


November 2013

CONTACT

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

LIB FOR AUTOMOTIVE VALUE CHAIN



Comments

- 1 The largest share of the value (40%) comes from cell components
- 2 Cell manufacturers & OEM alliance may be the winning model but comes with high risk if the wrong cell manufacturer is selected
- 3 Tiers 1- cell manufacturers alliance: most of them disappear (eg. Saft-Johnson Controls, Bosch-Samsung, Enerdel-Delphi...)
- 4 Tiers 1- OEM alliance on Battery are not successful
- 5 Panasonic and LG Chem, cell manufacturers develop raw -material in-house and make the pack integration for OEM
- 6 On a different scale, Toyota, BYD or BOLLORE are fully integrate

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

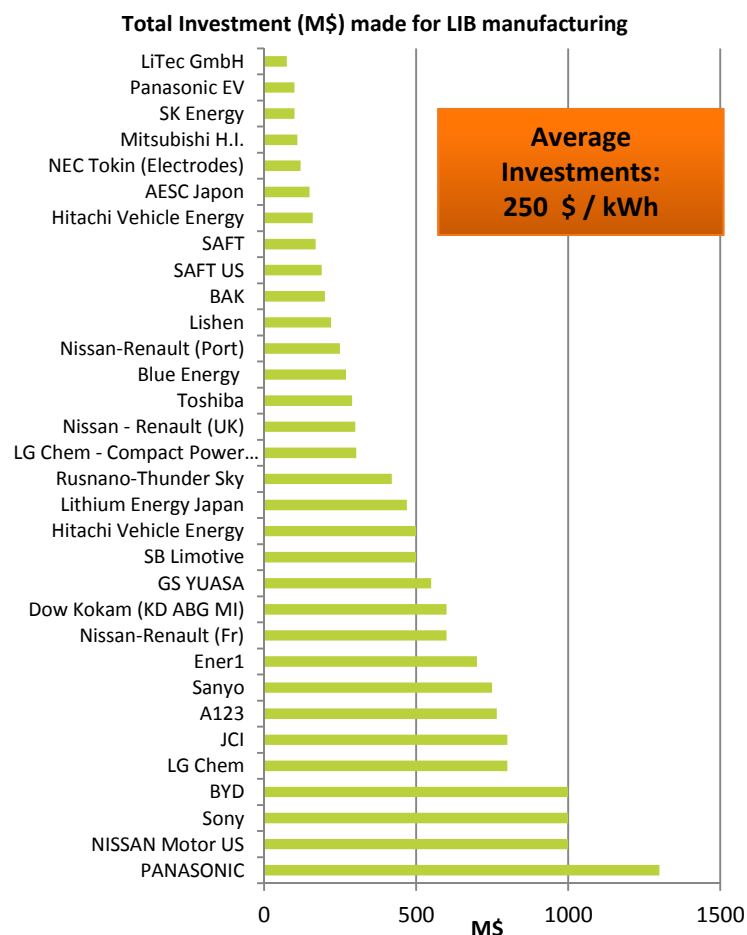
CONTACT

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

LIB MANUFACTURING INVESTMENTS 2009-2015

10-12 B\$ WORLDWIDE

>50 GWh in 2015



Source: AVICENNE ENERGY Analyses 2013



A123 Michigan Plant - Photo courtesy of A123 Systems



Liotech Plant, Novosibirsk – 1,5 GWh production capacity



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

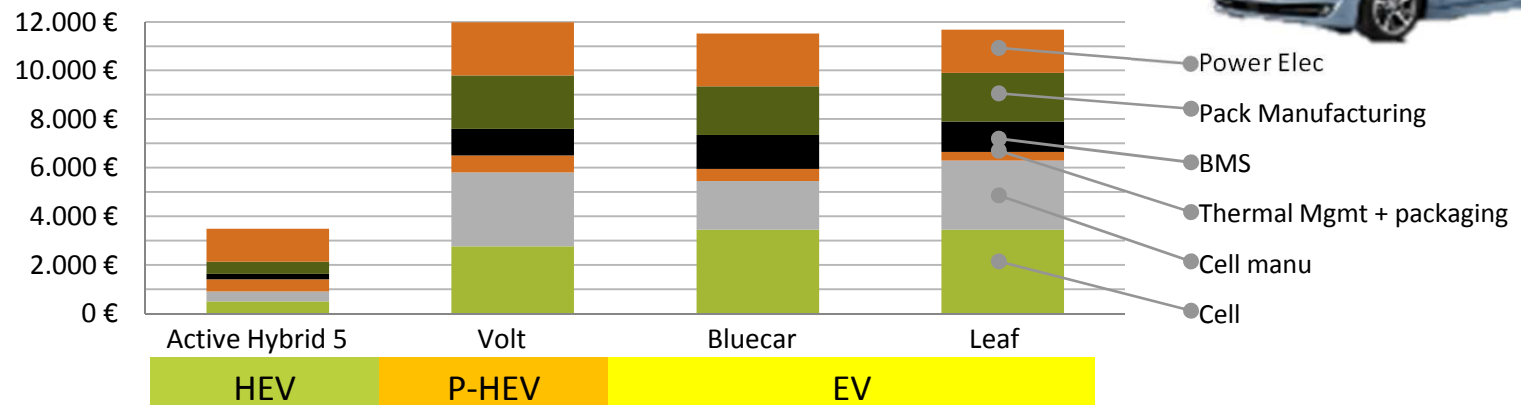
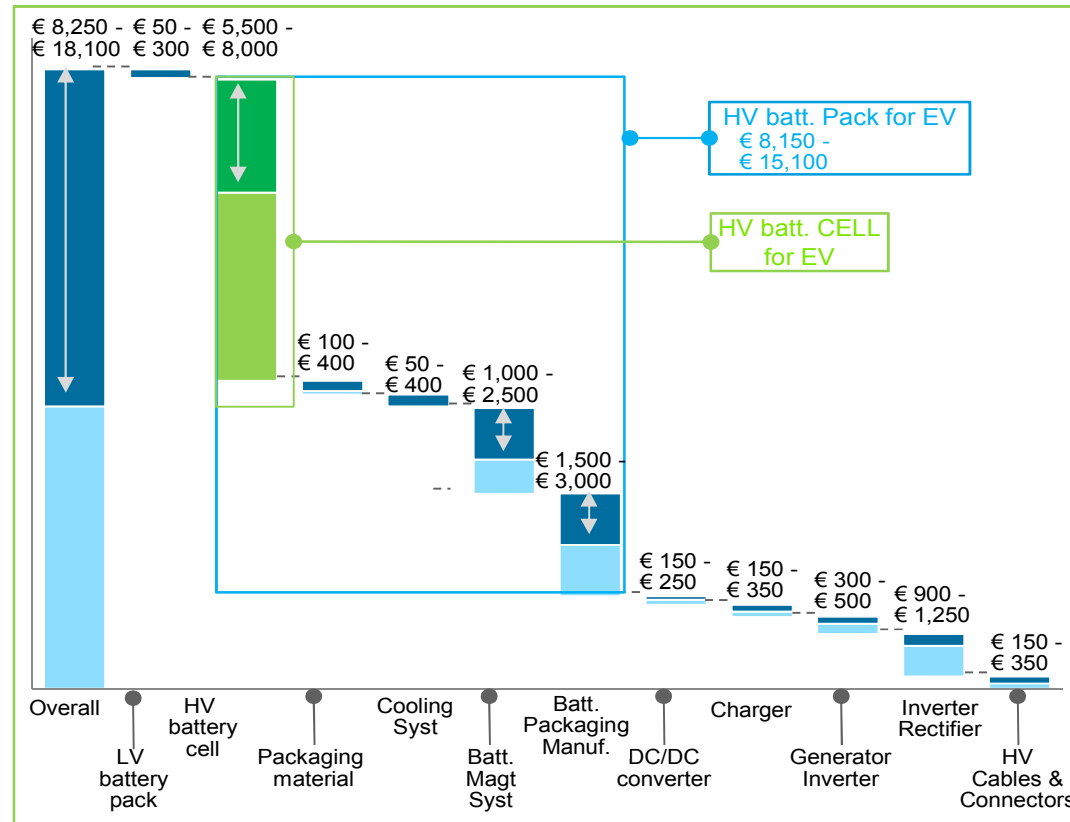


November 2013

CONTACT

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

BATTERY & POWER ELEC. COST IN EV





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

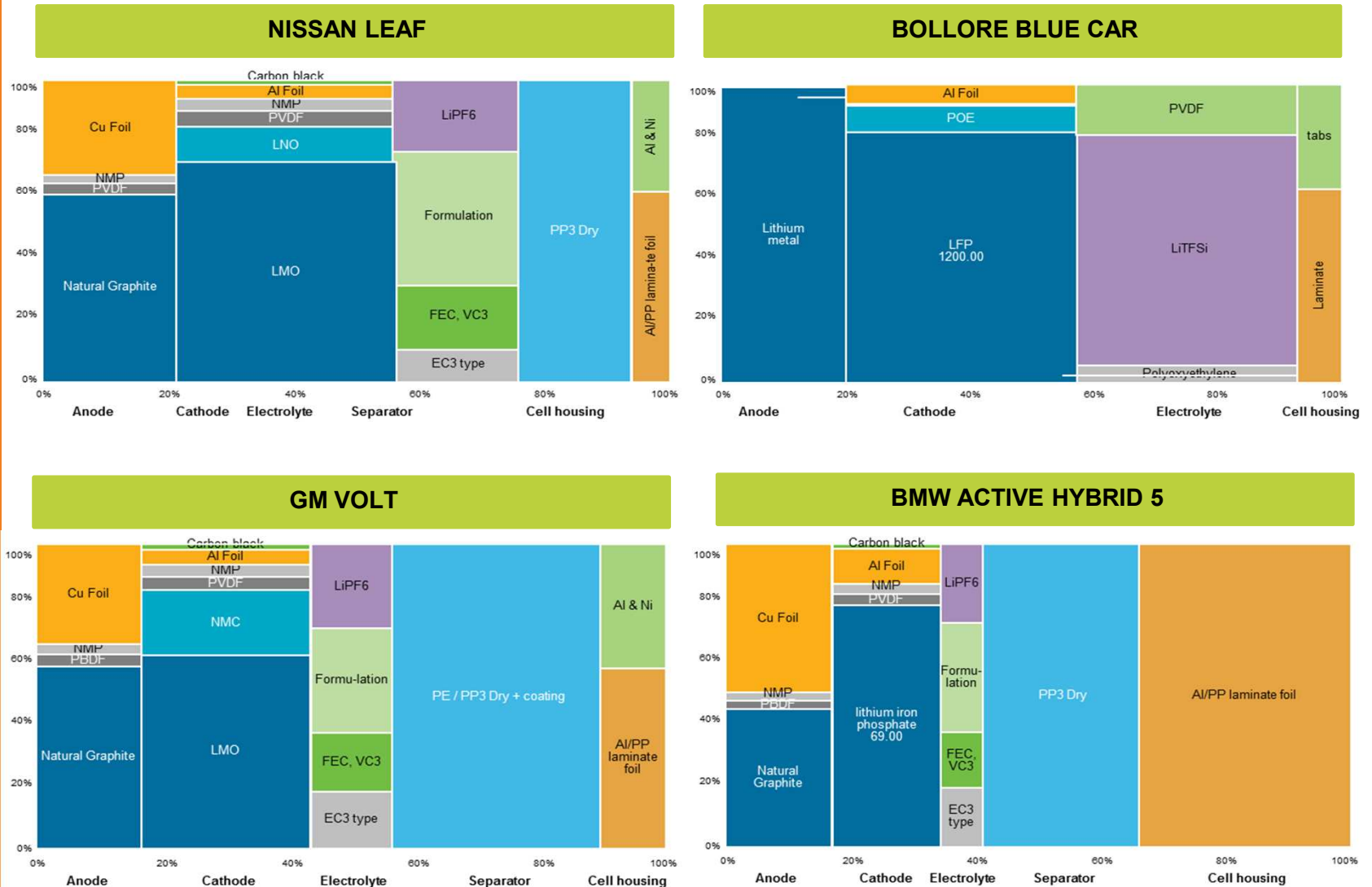


November 2013

CONTACT

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

LIB CELL BILL OF MATERIALS





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



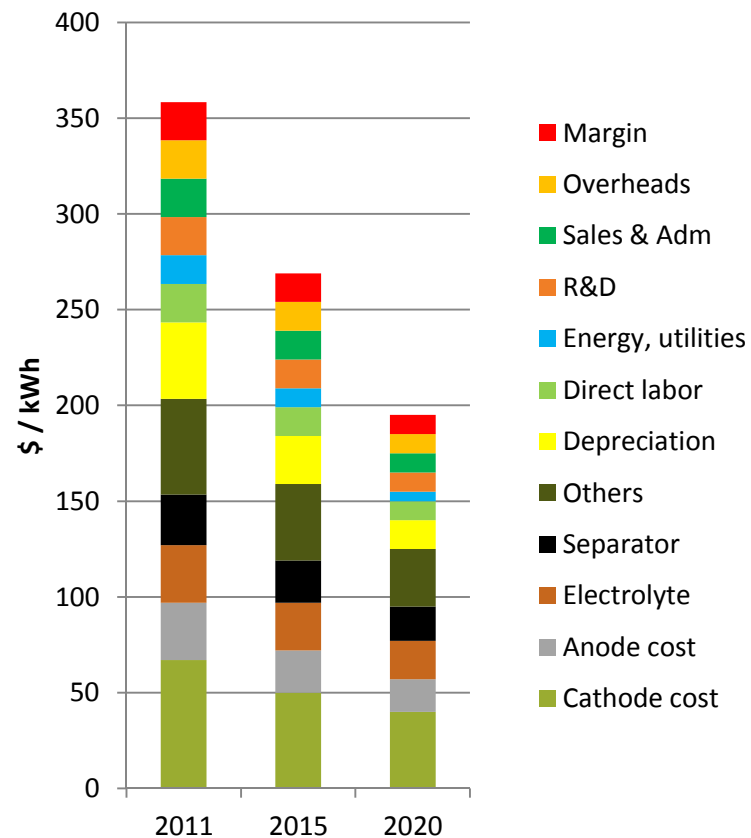
November 2013

CONTACT

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

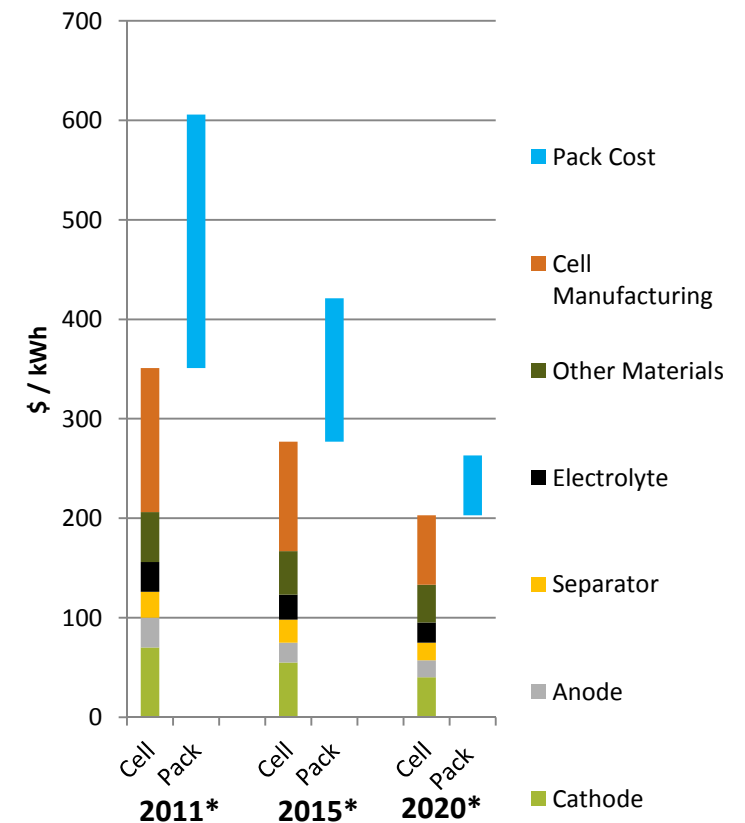
LI-ION BATTERY COST 2011-2020

LIB cell average cost
(EV design ; NMC cathode)



Source: AVICENNE ENERGY Analyses 2013

LI-ION BATTERY PACK COST
FOR EV



* For Production > 100 000 packs/year



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



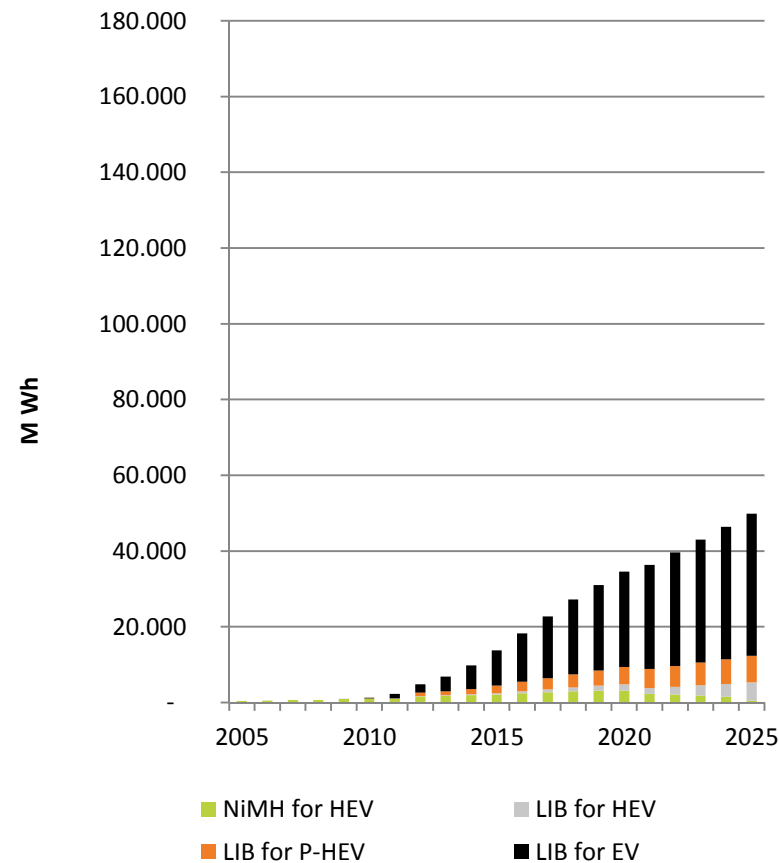
November 2013

CONTACT

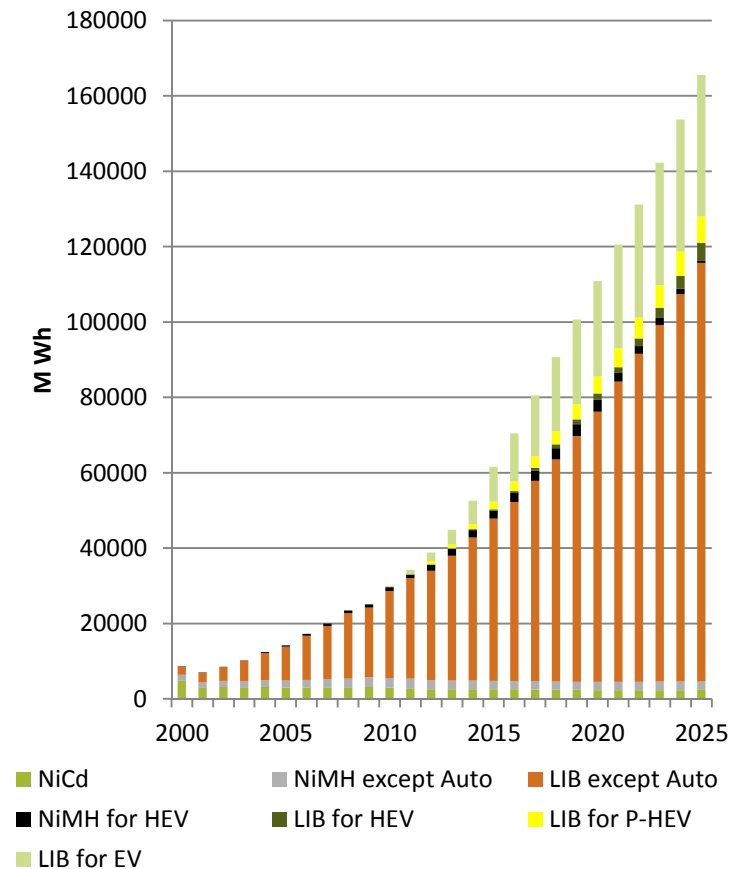
Christophe PILLOT
+ 33 1 47 78 46 00
c.pillot@avicenne.com

TOTAL BATTERY DEMAND 2025 FORECASTS

EV, HEV & P-HEV Battery needs (MWh)
CAGR 2012-2025: +20%



Total battery demand (MWh)
CAGR 2012-2025: +12%



Source: AVICENNE ENERGY Analyses 2013



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



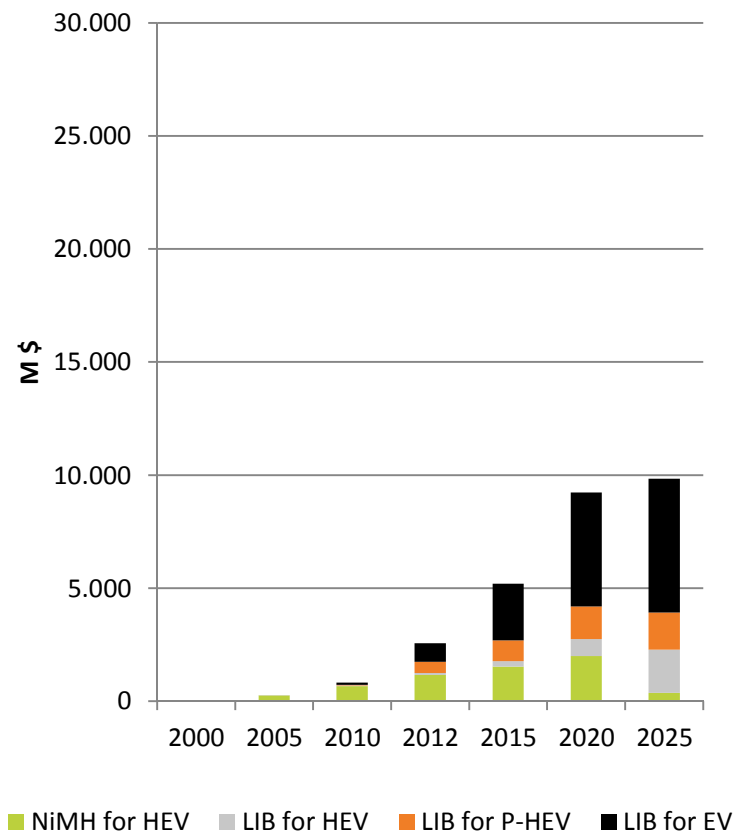
November 2013

CONTACT

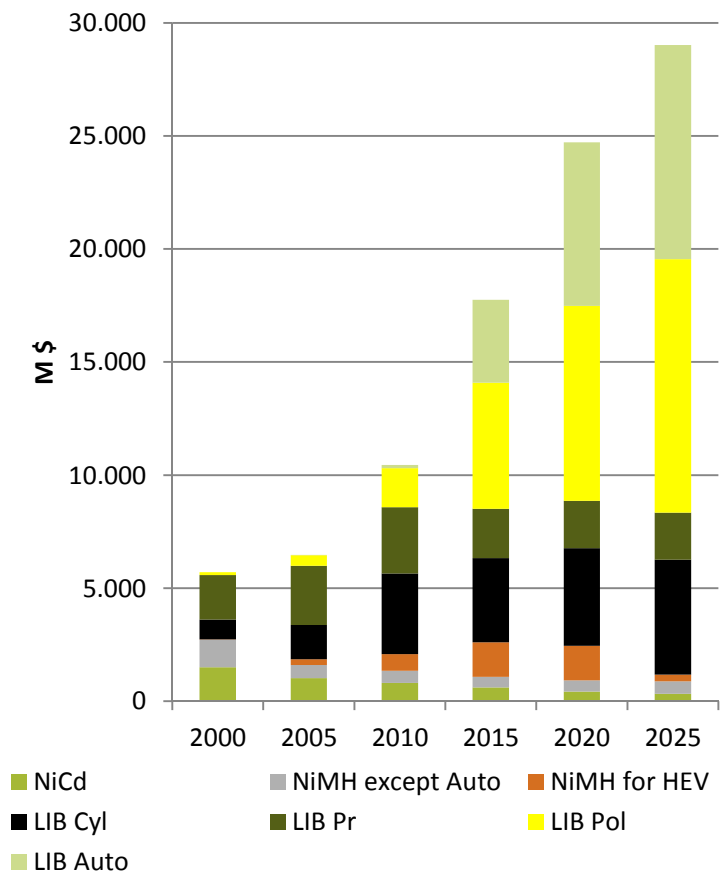
Christophe PILLOT
+ 33 1 47 78 46 00
c.pillot@avicenne.com

RECHARGEABLE BATTERY MARKET 2000 – 2025

Rechargeable battery market, M\$
for x-EV 2000-2025 (cell level)



Rechargeable battery market, M\$,
2000-2025 (cell level)



Source: AVICENNE ENERGY Analyses 2013



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



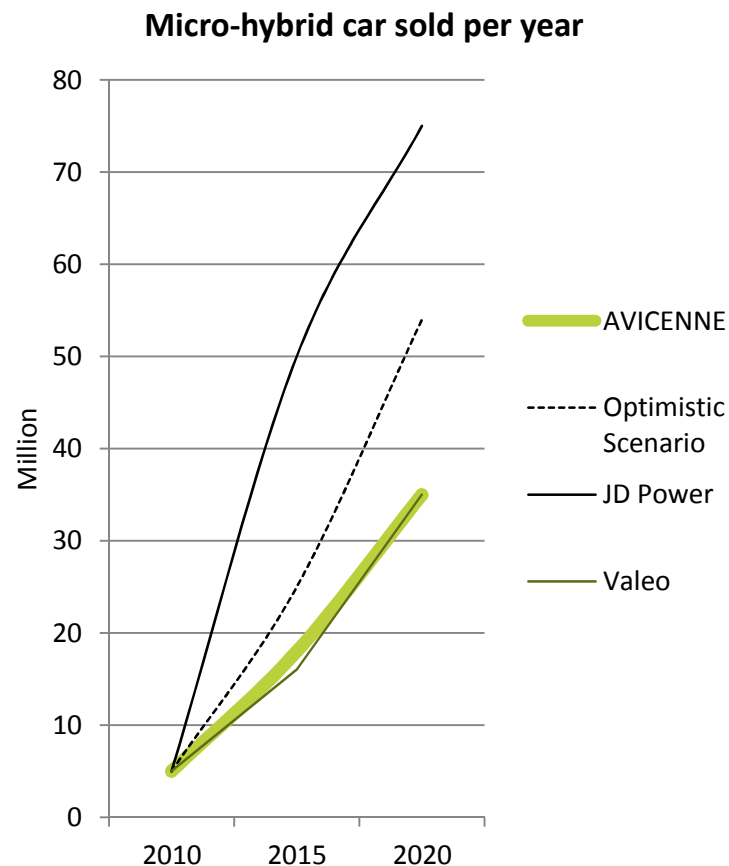
November 2013

CONTACT

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

35 MILLION MICRO-HYBRIDS CAR IN 2020

Micro-hybrids car market 2010-2020



Source: AVICENNE ENERGY Analyses 2013

Micro-hybrid batteries

- ⌚ Powered today by Advanced lead acid batteries (sometimes in conjunction with super capacitors)
- ⌚ LTO will also penetrate this market (Toshiba -> Suzuki)
- ⌚ Panasonic develop new NiMH cell to adress the micro-hybrid market

Advantages of micro-hybrid compare to HEV

- ⌚ 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



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

evs | 27

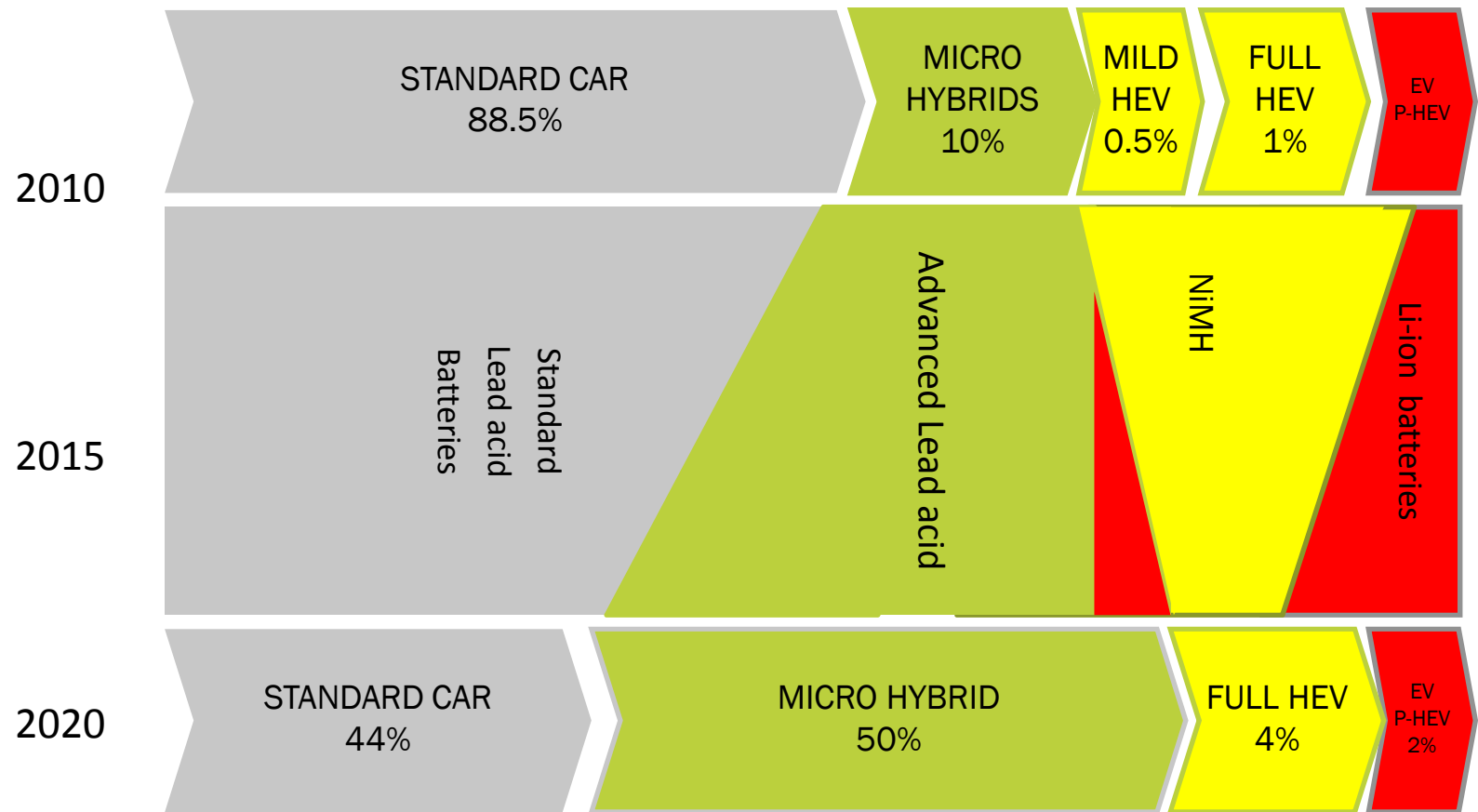
The 27th INTERNATIONAL
ELECTRIC VEHICLE
SYMPOSIUM & EXHIBITION.
Barcelona, Spain
17th-20th November 2013

November 2013

CONTACT

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

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



AFTER

ULTRA
BATTERY

Li-ion

Li-Air, Li-S, Fuel Cells

Source: AVICENNE ENERGY Analyses 2013



avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business



November 2013

CONTACT

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

TAKEAWAYS

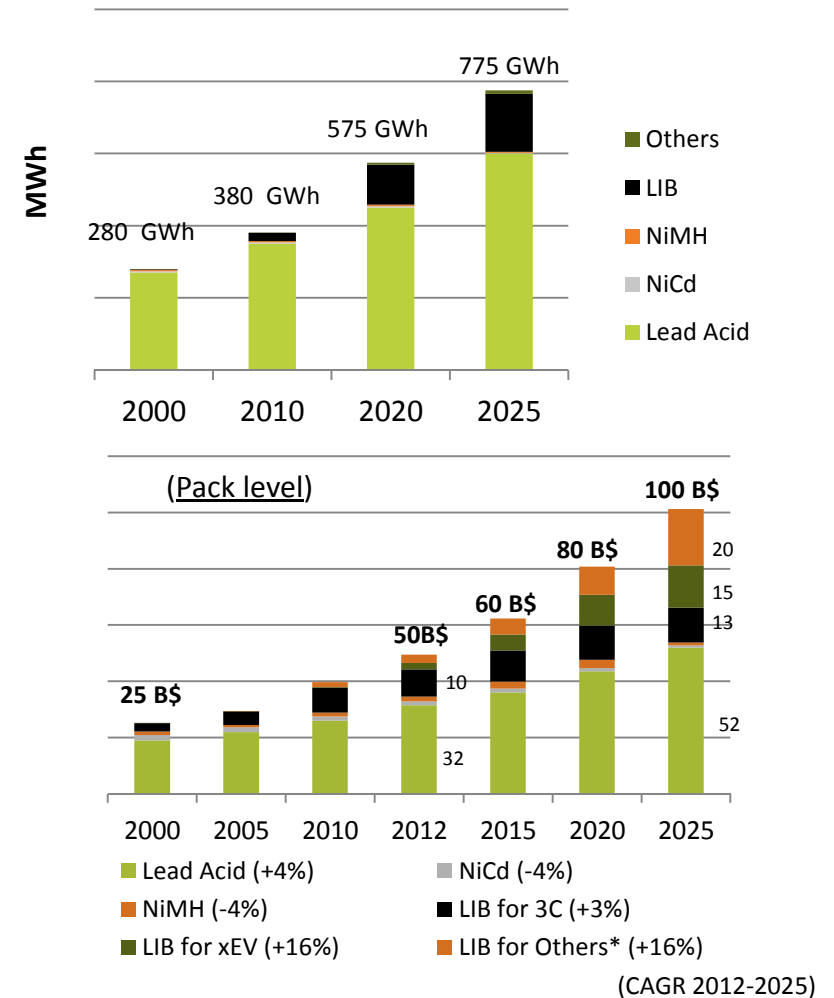
Battery Market 2010-2025

CAGR = +10%

- Li-ion battery is driven today by Portable PCs & electronic devices
- 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

RECHARGEABLE BATTERY MARKET WORLDWIDE

2000-2025





avicenne
ENERGY

INFORMATION FOR GROWTH
www.avicenne.com

Micro hybrid, HEV, P-HEV
and EV market 2012-
2025

Impact on the battery
business

evs | 27

The 27th INTERNATIONAL
ELECTRIC VEHICLE
SYMPOSIUM & EXHIBITION.
Barcelona, Spain
17th-20th November 2013

November 2013

CONTACT

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

THANK YOU



Christophe PILLOT

AVICENNE ENERGY

c.pilot@avicenne.com

Phone: +33 1 47 78 46 00

Mobile: + 33 6 88 82 79 49



avicenne
ENERGY