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Micro hybrid, HEV, P-HEV and EV market 2012-2025 Impact on the battery business

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Abstract
The main goal of this survey [1] is to forecast the worldwide Hybrid Vehicle (HEV), Plug-in (PHEV) & Electric Vehicle (EV) market and its impact on the Battery Business (Lead acid, NiMH and Lithium ion batteries). In 8 years, from 2004 to 2012, the Hybrid Vehicle market increased from 165 000 to more than 1.5 million vehicles sold and stop/start car sales achieved 9 Million in 2012 [2]. With the financial and economic crisis, what will be the Car supplier's strategy? Will stop/start applications thanks to advanced lead acid batteries succeed? Some analysts forecasted that the market for stop/start vehicles will increase at a Compound Annual Growth Rate (CAGR) of 32% between 2011 and 2020, reaching a total market of 37 million vehicles sold annually by the end of the forecast period [3]. What will be the technology? Lead acid, super-capacitors, ultra-batteries, advanced flooded batteries, AGM? What will be the market for Micro-Hybrid or HEV batteries in 2015 & 2020? Will the Li-ion battery with a lower price cathode succeed? What will be the price level to compete with NiMH technology? Will the strategy of HEV battery suppliers be the same than electronic device battery suppliers? Can European or US battery players have an opportunity in the HEV battery market? How will Ford, General Motors, Chrysler, Renault, Peugeot, Volkswagen or BMW manage their battery needs if there are no battery suppliers in the US & in Europe?

Keywords: HEV, EV, P-HEV, Battery, Market, Nickel metal hydride, Lithium-ion

1 Introduction

In 2000, a large majority of cellular phones were powered by NiMH, and Li-ion was an expensive solution for high-end products... 400 M cellular phones were sold in 2000. It was more than 4 times more in 2012. In 2000, 21 M portable PCs were sold worldwide. It was more than 200 M in 2012 and we also have more than 115 M tablets. In the fourth quarter of 2012 alone, more than 50 Million of tablets were sold worldwide. In 2000, less than 5000 tons of cathodes were more than enough to supply the Li-ion battery industry. Today, we need 75 000 tons of cathodes! Then, to have an idea of the numbers involved, you have to remember that 1 M full EV will require almost the same amount of Li-ion cell that the whole market today. In 2000, Li-ion cell cost, was more than 2.6 $ per Wh for an 18650 cell. It is around 20 cents today. So, Battery industry is a very dynamic market with continuing changes in products, technologies and performances. It's a key component for portable electronics, electric vehicles, and renewable energy and may be smart grid applications in the future. It will be for sure the most important part of the full Electric Vehicle in term of cost.

But, in electronics, the Moore Law is quite simple: every year, performances double. However, for batteries, nothing happened for years and we had to wait the 90's to see the launch of 2 new technologies Nickel Metal Hydride & Lithium ion. But, each technology has its own strength & weakness in terms of technical performances and of course in term of price.

2 Batteries for xEV in 2012

2.1 The rechargeable battery market in 2012

In 2012, the rechargeable battery market was a 50 Billion US $ market. This include lead acid, NiCd, NiMH, and Li-ion batteries for Smart Light and Ignition batteries, for electronic

devices, for industrial applications, for HEV, E-bikes or energy storage. From 1990 to 2012, this market increase at a 5% average growth rate per year. Lead acid battery still dominates this market (Fig.1).

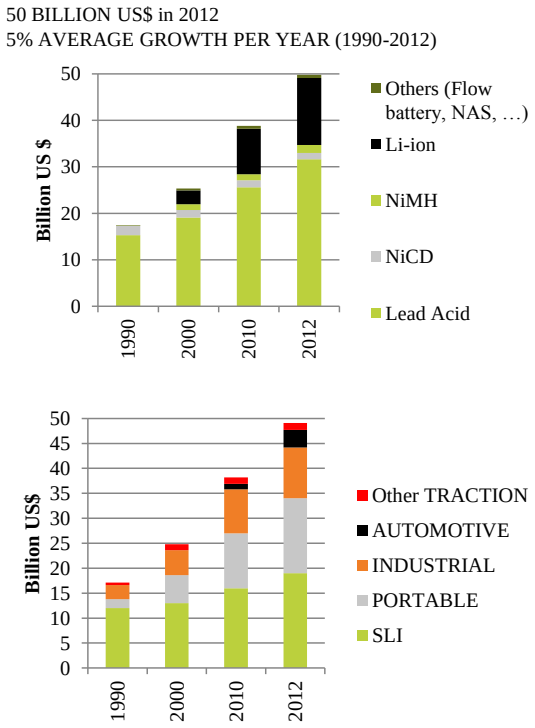


Fig 1: The rechargeable battery market worldwide

Li-ion technology as well as Li-Polymer technology had succeeded because they presented higher gravimetric & volumetric energy density than NiMH or NiCd technologies. Each technology as its specific absolute advantages. There is no miracle technology that is both cheap and able to satisfy all end users demand. The Li-ion battery market has grown from 2 GWh in 2000 to almost 28 GWh in 2011. Li-ion battery average growth rate per year in volume surpass 20% in the last 5 years.

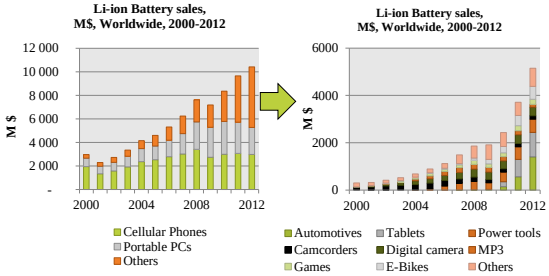


Figure 2: The Lithium ion battery market 2000-2012

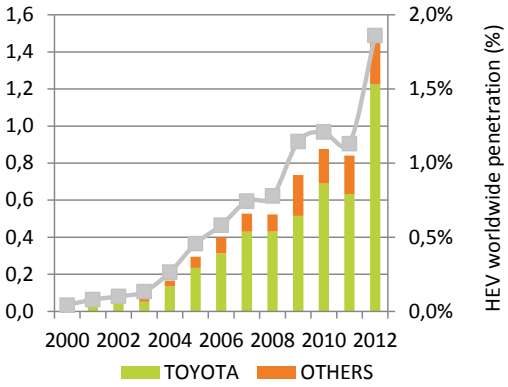
Cellular Phones, portable PCs and tablets are driving this 10.5 B$ at the cell level (Fig.2). Then, power tools or e-bike are more and more important. xEV is today a very small part of this market.

3 xEV market in 2012

3.1 HEV market in 2012

In 2012, more than 1.5 Million hybrids were sold worldwide. More than 400 000 were sold in the US alone, 800 000 in Japan and only 150 000 in Europe. In Japan, from 2008 to 2010, hybrid sales increase from 3% to 10% of the total car market. Then, in 2011 in this country, earthquake and tsunami impacts drastically the car & the battery production. In 2012, sales bounce back (Fig.3).

HEV sold per year, M units, worldwide



Penetration of hybrids in the global sales, 2000-2012

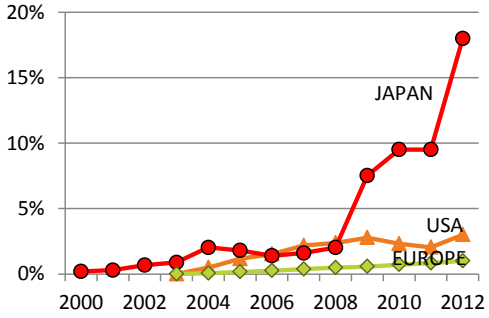


Fig 3: The HEV market worldwide, 2000-2012

Even with the March 2011 disaster, Toyota stay the leader of this market with more than 80% market shares. In 2012, Toyota sold 1.2 M HEV. On another scale, Honda sold 175 000 mild HEV in 2012. Hyundai is growing very fast with 50 000 HEV sold in 2012. GM sold 35 000 HEV, Ford 30 000. So even with new models, number of hybrids is not growing so fast for Toyota's competitors. In 2012, more than 90% of the HEV are powered by NiMH batteries.

3.2 P-HEV & EV market in 2012

Then, P-HEV and EV market are niche market in 2012. (Table 1)

	Company	Model	2010	2011	2012
USA	**GM**	GM Volt	326	7 671	23 328
	TOYOTA	Prius			11 546
	FORD	C-Max			2 703
	TOTAL				**37 577**
Europe	**OPEL - GM**	Ampera			10 000
	TOTAL				**10 000**
JAPAN	**TOYOTA**	PRIUS			14 000
	TOTAL				14 000
CHINA			450	550	1 000
TOTAL P-HEV			776	8 221	**62 577**

Table 1: The P-HEV market worldwide 2010-2012

Country	Company	Model	2010	2011	2012
USA	NISSAN	Leaf	19	9 674	9 819
	MITSUBISHI	i-Miev		80	563
	Ford				415
	Smart			388	162
	Tesla				805
	BMW	Active E			1 163
	HONDA	FIT			37
	Toyota	Rav4 EV			145
	Total		19	10 142	13 109
EUROPE	NISSAN	Leaf		2 000	10 000
	Renault	Tweezy			8 000
	MITSUBISHI	i-Miev		6 000	9 300
	Total		3 000	8 000	27 300
JAPAN	NISSAN	Leaf		8 000	8 000
	MITSUBISHI	i-Miev	3 000	6 000	8 300
	Others			3 000	8 000
	Total		3 000	17 000	24 300
OTHERS	NISSAN	Leaf			2 000
	MITSUBISHI	i-Miev		2 000	4 000
	Renault	Fluence			5 000
	Others		6 231	8 458	14 591
	Total		6 231	10 458	25 591
TOTAL			12 250	45 600	90 300

Table 2: The EV market worldwide 2010-2012

All the P-HEV & EV are powered by Lithium ion batteries.

4 Li-ion battery for Automotive in 2012

An impressive number of players triess to penetrate the LIB market to make packs, cells, or raw materials. This number increase with the electric car promises and the Energy Storage System dream. For different reasons, lot of players try to penetrate the market. The reasons are often a strategic postponement as a key energy device for environmental society. Then, other reasons could be apparent low tech image, quite low entry barriers, easy to make in the lab, and looks lucrative. Then, it is difficult to succeed on this market for different reasons. The misconception that design is just the gathering together of materials, the difficulty of achieving differentiation in performances & costs, the very long Time to Market, the gap between lab prototype, pilot production and real mass production, the difficulty to achieve a good material consistency, the difficulty of ensuring safety, quality and reliability. The battery can burn, the cell factory can burn, and the EV can also burn. Then, the true cause of thermal runaway has unfortunately remained unknown ever since the dawn stage of the LIB.
Remember that, in 2006, in one recall, Sony lost all the money they earn in the battery business in all their history.

Lot of players are today on the field to penetrate this new battery market. At the end, no more than 5 to 6 companies have a chance to succeed.
It is quite sure that SANYO-PANASONIC, AESC, SAMSUNG and LG will succeed and be the major suppliers in the future. Johnson Controls will also probably have a card to play.

To achieve scale economy and enough volume, each battery supplier has to invest quite a lot of money to build their battery plants. On average, to make 100 000 EV packs or 2.5 GWh, a battery company has to invest around 5 to 600 M$. An average of 250 $/kWh. All together, more than 12 Billion USD have to be invested in the next 3 to 4 years to reach a production capacity for large battery exceeding 50 GWh in 2015 (Fig 4).

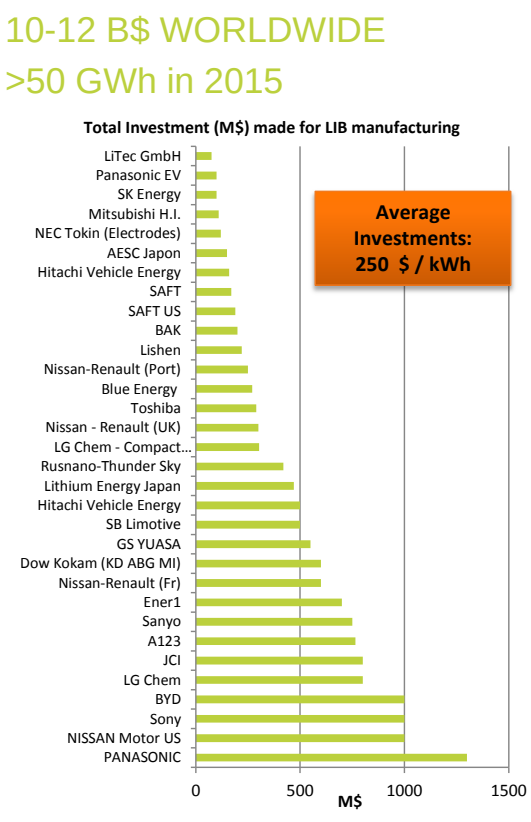


Fig. 4: Lithium ion battery investments 2010-2015

But, we also have to note that in fact, all manufacturers will base on future capacity investments on market demand. While battery companies are making initial investments slightly ahead of the market to optimize cost and

scale, future investments will be made only when the market conditions justify such an investment.

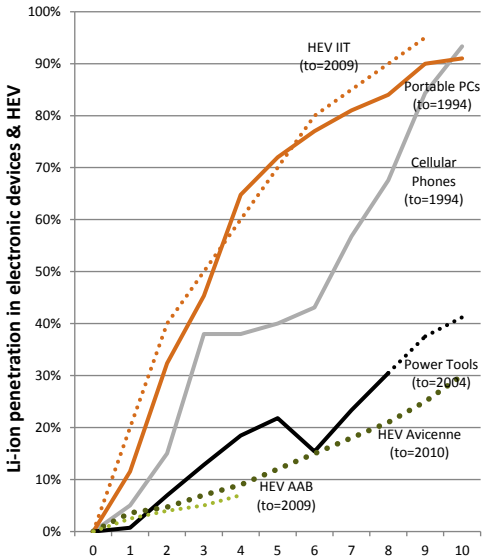
Capacity expansions will not take place in one step—they will be rolled out in several phases, through 2015 and beyond. Many companies plan to build large facilities capable of supporting future volume, but initial machinery CAPEX will remain relatively small.

5 xEV market trends

5.1 Hybrid vehicles

For the future, we believe that Hybrid vehicles market will increase in the next few years. We expected to see the penetration of hybrid cars in the US growing from 3% in 2012 to 5% in 2015 & 14% in 2020 & 20% in 2025. With those assumptions which are quite conservative and suggest a relative low increase of the fuel price, the total hybrid vehicles market will achieve 2.4 million units in 2015 or 3% penetration worldwide, around 5 M units in 2020 only for HEV cars again and not including micro hybrids, P-HEV or full EV. For HEV, forecasts from different analysts are not so far away. Let say between 2 and 4 M HEV in 2015 and, for 2020, between 4 M and 8 M HEV that means between 5 and 10% of the automotive market.

Then, analysts forecast may vary to choose which battery will power those cars. Today, NiMH batteries dominate the power-assisted hybrid market. NiMH is a proven and secure technology.



(1)AVICENNE HEV Forecasts, march 09, Relevant scenario

[3] *AVICENNE HEV Forecasts, march 09, Li-ion Optimistic scenario*

[4] *IIT, TAKESHITA, March 08, THE 25th INTERNATIONAL BATTERY SEMINAR & EXHIBIT, Slide 8 & March 2009, 26th Battery Seminar,*

[5] *AAB, Menahem ANDERMAN, Ph.D, Tampa, Florida, May 2009*

Fig 5: Li-ion penetration in Electronics & HEV

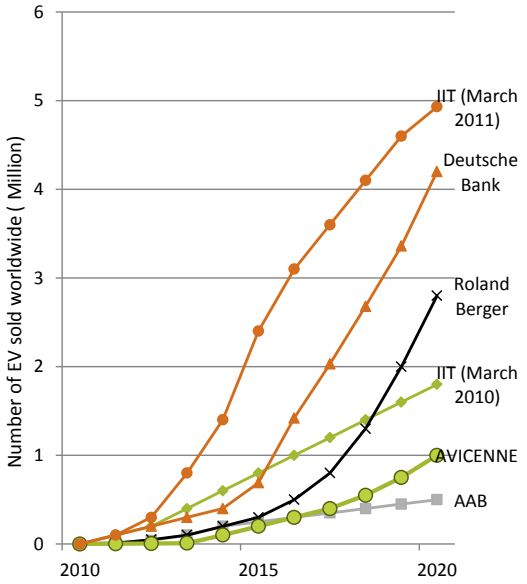
Even new models are using NiMH batteries. Developments and improvements of energy, power, temperature range and cyclability continue even if most of the money is going today in research to develop Li-ion products.

In mapping the future path of a technology, it is wise to look back. Fig 5 shows the penetration of Li-ion batteries in a range of devices. First, for cellular phones, we had to wait six years after the commercial launch of Li-ion batteries in these devices to see a penetration level of Li-ion of 40%. For portable PCs, it took three years for Li-ion to achieve a 40% penetration, sand even to eight years to achieve 80%. For power tools, the penetration of Li-ion is slow and it took already 8 years to achieve 30%. AVICENNE forecasts for HEVs indicate expectations of a 12% penetration of Li-ion after five years and 35% by 2020.

5.2 EV Trends

Forecasting the full EV market is quite difficult. Assuming that on average an EV will need 25 kWh battery pack, the impact of the EV penetration on the battery market is huge. Analysts forecast are divergent and AVICENNE is known to be one of the most conservative one, I should say a realistic one (Fig. 6)

With the assumption of 400,000 P-HEVs in 2020 and 1 000,000 EVs the battery market for HEVs, P-HEVs and EVs will reach 35 GWh.



[6] *IIT, March 2011 Fort Lauderdale*

[7] *IIT, March 2010 Fort Lauderdale*

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[9] *Roland BERGER, Oct 2011, Batteries 2011 Cannes*

[10] *AAB, AABC Europe, Mainz, June 2011*

Fig 6: EV market forecasts 2012-2025

5.3 Micro-hybrid trends

Then, for the automotive market and to decrease the CO2 emissions, we have to remind that we also have micro-hybrids. The cost is 10 times less than full hybrid system and fuel saving is 4 times less. So, it is easy to calculate that micro-hybrids are 2,5 times more efficient than full hybrid. Forecasts on this market suggest that almost 50% of the car sales will be micro-hybrids in 2020, ten times more than full hybrid. Those micro-hybrid cars will be powered by advanced lead acid batteries: AGM, ultra-batteries, or advanced flooded batteries.

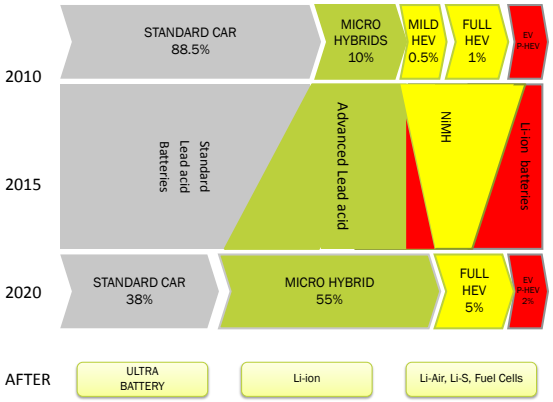


Figure 7: Battery for car mapping 2010-2020

My key message here (Fig. 7) is that today and in 2020, micro-hybrids will impact much more on fuel saving or CO2 emission than PHEV or EV. In 2020, micro hybrids will be the standard while full HEV will stay under 5% of the market and EV still a small niche market. But, again, even a very small EV or P-HEV market will impact drastically the battery business: 1 million EVs on the market will represent roughly $5 billion for battery makers, if we achieve a 20 cents per Wh (Fig. 8, 9) battery cost which will be very challenging.

It will represent 6.5 B$ on the pack level. In the same way, 1 M EV will need 25 GWh and more than 60,000 tons of cathode materials for instance. That is roughly the total Li-ion battery market today for all the portable electronics & power tools.

LI-ION BATTERY PACK COST FOR EV

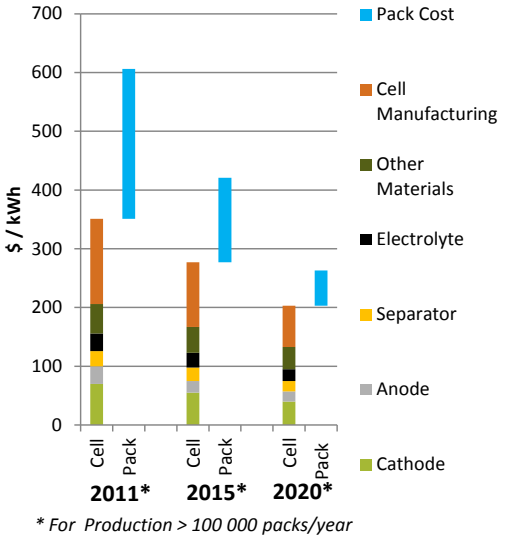
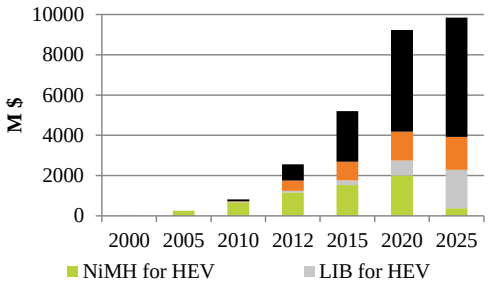


Fig 8: Lithium ion battery cost decrease 2011-2020

Rechargeable battery market, M$ for x-EV 2000-2025



Rechargeable battery market, M$, 2000-2025

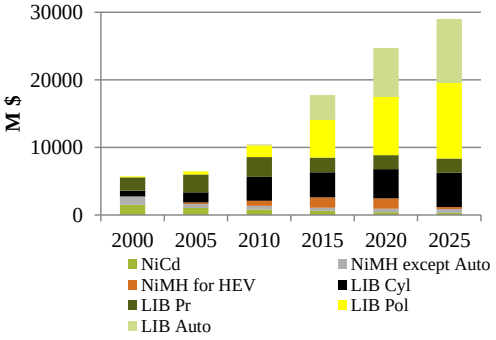


Fig 9: Battery market forecasts 2000-2025

6 Conclusions

Over the next decade we will see a marked movement in vehicle technology that will bring with it a significant rise in vehicle electrical power requirements. Hybrids, whether PHEV or EV, will not simply take over the automobile market. But it is clear that hybrid systems have already muscled their way into acceptance and this trajectory can only increase.

However, while changes are inevitable, it may not be swiftand the changes should take time to happen.

Battery makers, raw material suppliers, power managers, designers, developers, and integrators are searching for new innovations to build new products and concepts at reasonable costs. I really think that innovation for new concepts, new products, new developments are the key to success and the gap to achieve user dreams are still long on the battery market.

We have to think new & create new dream.

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Christophe has built up considerable expertise in the area of battery market. He joined AVICENNE 17 years ago and Spend 3 years in Japan. Christophe gained large experience in marketing, strategy analysis, technology and financial studies for the battery and power management fields. Christophe published several annual surveys like "The rechargeable battery market 2012-2025". He is also the founder & chairman of Batteries congress in France since 1999. He is now Director of AVICENNE ENERGY.