HEV, P-HEV, and EV market 2011-2025

Battery is the key

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

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METHODOLOGY: EXTENSIVE FIELD RESEARCH TO RETRIEVE & CROSS CHECK INFORMATION

Conferences & Exhibitions

In Depth analysis Of applications

Cross Check Analysis

Top management contact network > 19 000 contacts

Battery is the Key

HEV, P-HEV and EV market 2011-2025

EEVC-2012
European Electric Vehicle Congress
BRUSSELS 20th-22nd November 2012

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CUSTOMIZED & MULTICLIENT SURVEY FOR ALL THE VALUE CHAIN

Raw Materials

Materials

Cells

Pack

OEM

Battery is the Key

Source: Photo from BASF
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

THE BATTERY MARKET IS REALLY DYNAMIC

**Cellular Phones sold per Year (Million)**

- Li-ion
- NiMH

**Portable PC sold per Year (Million)**

- Li-ion
- NiMH

**Tons of Li-ion Cathode per year**

**Li-ion 18650 cell price ($/Wh)**
THE WORLDWIDE BATTERY MARKET 1990-2010

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

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

Graph showing the worldwide battery market from 1990 to 2010, with different battery types such as Li-ion, NiMH, NiCD, and Others (Flow battery, NAS, ...).
THE WORLDWIDE BATTERY MARKET 1990-2010

35 BILLION US$
5% AVERAGE GROWTH PER YEAR (1990-2010)
LI-ION IN 2011
MAIN APPLICATIONS: CELLULAR, NOTEBOOK

>4 200 M cells – 28 000 MWh
9 700 M$

CAGR 2006/2011
+21% per year in Volume
+13% per year in value
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Li-ion Battery sales,
M$, Worldwide, 2000-2011

Li-ion Battery sales,
M$, Worldwide, 2000-2011
WHY X-EV?

Petroleum consumption worldwide 1960-2030

Price of the WTI barrel of oil, US $

CO2 density in the atmosphere increase

Source: Energy Information Administration, US Government

Source: IPCC, Intergovernmental Panel on Climate Change, Climate Change 2007, Synthesis Report p38
HEV, P-HEV & EV
DEFINITION & SEGMENTATION

Battery is the Key

EV & HEV MARKET
- EV 25 kWh
- HEV 0.6-2 kWh batteries
- P-HEV 5 kWh batteries

MICRO HEV
- CITROEN C3
- TOYOTA VITZ

MILD HEV
- GM Saturn Vue
- GM AURA
- GM MALIBU
- HONDA ACCORD

MEDIUM HEV
- HONDA CIVIC
- INSIGHT
- MERCEDES S400

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

Fuel saving Vs. Cost

EV Drive
- EV

Motor-assist
- P-HEV

Regenerative braking
- HEV

0% 20% 40% 60% 80% 100%
0 $ 5 000 $ 10 000 $ 15 000 $
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
HEV WORLDWIDE IN 2012
BY CAR SUPPLIER

Total HEV Vehicles
+1,5 M in 2012

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

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 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
HEV WORLDWIDE IN 2012
BY COUNTRY

Total HEV Vehicles
1,5 M in 2012

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

USA 29%
EUROPE 10%
JAPAN 54%
OTHERS 7%

Total HEV Vehicles
1,5 M in 2012

HEV, P-HEV and EV market 2011-2025
Battery is the Key

Micro hybrid not included
HEV FORECASTS 2012-2020

HEV MARKET: +2 Million units in 2015 & +4 M Units in 2020

Micro hybrid not included
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 2012

Micro hybrid not included
LI-ION PENETRATION IN VARIOUS DEVICES: AVICENNE & OTHER ANALYSTS FORECAST

Li-ion penetration in electronic devices & HEV

HEV powered by LIB forecasts from 2008 to 2011


Micro hybrid not included
LIB BUSINESS
RECALL SLASH BATTERY PROFIT

- More & more incidents & accidents
- All the battery makers and the OEM are concerned
- Recall cost impact drastically the battery business and the profitability

RECALL SLASH BATTERY PROFIT

Operating profit/Revenue

- Sanyo
- MBI
- BYD
- SGS
- Sony
- NEC
- Maxell
- LGC
- SDI
- Average

2002 2003 2004 2005 2006 2007 2008 2009 2010

-30% -20% -10% 0% 10% 20% 30%
TIME TO MARKET FOR NEW MATERIALS IN LIB INDUSTRY

The research and development in this industry is very long and time consuming.

Time to market to commercialize a new material is long. Remember that the first Li-ion battery was launched by Sony in 1991 with LCO cathode, graphite, LiPF6 electrolyte & polyolefin membrane. It was 20 years ago.

LTO was invented by Matsushita in 1993 (19 years ago)

Lithium iron phosphate was invented in 1995 (15 years ago).

So, it takes between 10 & 20 years to commercialize a new material in the battery industry.
LIB MANUFACTURING INVESTMENTS 2009-2015

10-12 B$ WORLDWIDE
>50 GWh in 2015

Total Investment (M$) made for LIB manufacturing

- LI Tec GmbH
- Panasonic EV
- SK Energy
- Mitsubishi H.I.
- NEC Tokin (Electrodes)
- AESC Japon
- Hitachi Vehicle Energy
- SAFT
- SAFT US
- BAK
- Lishen
- Nissan-Renault (Port)
- Blue Energy
- Toshiba
- Nissan - Renault (UK)
- LG Chem - Compact...
- Rusnano-Thunder Sky
- Lithium Energy Japan
- Hitachi Vehicle Energy
- SB Limotive
- GS YUASA
- Dow Kokam (KD ABG MI)
- Nissan-Renault (Fr)
- Ener1
- Sanyo
- A123
- JCI
- LG Chem
- BYD
- Sony
- NISSAN Motor US
- PANASONIC

Average Investments: 250 $ / kWh

A123 Michigan Plant - Photo courtesy of A123 Systems

Liotech Plant, Novosibirsk – 1,5 GWh production capacity
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 2011
$/kWh

<table>
<thead>
<tr>
<th>LIB</th>
<th>LIB EV</th>
<th>LIB pack for EV</th>
<th>LIB HEV</th>
<th>LIB pack for HEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>18650 cell</td>
<td>EV Cell</td>
<td>pack for EV</td>
<td>HEV cell</td>
<td>pack for HEV</td>
</tr>
</tbody>
</table>

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LI-ION BATTERY COST
2011-2020

LIB cell average cost
(EV design ; NMC cathode)

LI-ION BATTERY PACK COST
FOR EV

* For Production > 100 000 packs/year
EV FORECASTS 2011-2020

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

EV impact on the LIB & raw material market is HUGE

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
TOTAL BATTERY DEMAND
2011-2020

EV, HEV & P-HEV Battery needs (M Wh) 2005 – 2020

Total battery demand (MWh) 2000 – 2025
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

<table>
<thead>
<tr>
<th></th>
<th>Micro-hybrid</th>
<th>Full HEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery</td>
<td>Advanced lead acid</td>
<td>NiMH or LIB</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>300</td>
<td>3000</td>
</tr>
<tr>
<td>Fuel saving</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td>Million Vehicle sold per year in 2020</td>
<td>35 - 55</td>
<td>4</td>
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</table>
HEV, P-HEV AND EV REALITY OF THE MARKET WILL BOOST MICRO HYBRID AND ADVANCED LEAD ACID BATTERIES

HEV, P-HEV and EV market 2011-2025

Battery is the Key

Hev, P-Hev and EV reality of the Market Will Boost Micro Hybrid and Advanced Lead Acid Batteries

Standard Lead Acid Batteries

STANDARD CAR 88.5%

2010

Mild HEV 0.5%

Full HEV 1%

Advanced Lead Acid (+ EDLC)

STANDARD CAR 88.5%

Li-ion Batteries

STANDARD CAR 54%

2015

Advanced Lead Acid

NiMH

Full HEV 2%

STANDARD CAR 54%

Li-air, Li-S, Fuel Cells

2020

Standard Lead Acid Batteries

Micro Hybrid 40%

Full HEV 4%

Micro Hybrid 10%

Mild HEV 0.5%

Micro Hybrid 1%

After

Ultra Battery

Li-ion

Li-air, Li-S, Fuel Cells
TAKEAWAYS

Battery Market 2010-2020
CAGR = +8%

- Li-ion battery is driven today by Portable PCs & electronic devices
- For HEV, the battery technology is today the NiMH
- LIB begin really to compete in 2012
- P-HEV & EV will be powered by Li-ion: 5 B$ market in 2015 & 9 B$ in 2020
- 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 40%
- Lead acid battery will be the first market in 2020 in volume & value
THANK YOU

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