HEV, P-HEV, and EV market 2011-2020

Impact on the battery Business

Christophe PILLOT
Director, AVICENNE ENERGY
AVICENNE PROFILE

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

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THE BATTERY SHOW
DETOIT, MICHIGAN, USA
13-15 NOVEMBER 2012

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METHODOLOGY: EXTENSIVE FIELD RESEARCH TO RETRIEVE & CROSS CHECK INFORMATION

Top management contacts network > 17 000 contacts

Conferences & Exhibitions

In Depth analysis Of applications

Cross Check Analysis

Battery Makers

Battery Users, OEM

Substitution technologies: SuperCap, Fuel cells

Raw materials suppliers

Environment & recycling

Safety
## MORE THAN 180 REFERENCES WORLDWIDE

| A123       | AIR LIQUIDE | AIR PRODUCT | AHI LSTROM | ALCATEL | AMPEREX (ATL) | APPLIED MATERIALS | AROS SECURITIES | ARC | ASHLAND | ATOFINA - ARKEMA | AT KEARNEY | AXEON | BAIN | BASF | BATTERY R&D ASSOCIATION OF KOREA | B&D | BHP BILLITON | BRAND LICENCING PARTNERS (BLP) | BOURNS | BOSCH | BUHLER GMBH | BYD | 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 | DCN | DELTA | DGA | DIALOG SEMICONDUCTOR | DOW CHEMICAL | DOW CORNING | DUPONT | DURACELL | EDF | ELECTRO ENERGY | ENER 1 | ENERGIZER | EOLITE | EP COS OHG | ERAMET | ETC AB | FACOM | FALCON BRIDGE | FAIRSilD SEMICONDUCTOR | FAMEART | FIST | FLORIDIENNE DE CHIMIE | FMC | FORTU POWER CELL | FRANCE TELECOM | FULTON INNOVATION | GAIA | GIL IMPORT BATTERIES LTD. | GS MELCOTEC | HC STARCK (BAYER) | HILTI | HITACHI MAXELL | HOLLINGSWORTH & VOSE CIE | HONEYWELL | HPL (HIGH POWER LITHIUM) | HUTCHINSON | IER | IGL EXPORT. | INTERNATIONAL COMPONENT CORP. | INTERNATIONAL RECTIFIER | INTEK | INTEL | INTERSIL | INCO | ITRI | ITS | JBC | JETRO | JOHNSON CONTROLS | KODAK | KRUGER | LAZARD | LECLANCHÉ | LEGRAND | LG CHEMICAL | LION CELLS | LITTLE FUSE | LILIPUCIAN | LYNAS CORP | MATSU SITA | MICROSOFT | MTI MICRO FUEL CELLS | MOLTECH | MOLYCORP | MOMENTIVE | MOTOROLA | MUNSTER UNIVERSITY | NANOCYL | NCCP - RUSSIA | NITECH | NNKPC | NORILSK NICKEL | NOVALED | NTK POWERDEX | OMG INC | PANASONIC | PHILIPS | PHOTON | PK & WISE | POWER GENIX | PRAYON | PRISMARK | PSA | RAYOVAC | RECHARGE | RENAULT | RHODIA | ROLAND BERGER | SAFT | SAGENTIA | SAINT GOBAIN | SAKTI | SAMSUNG SDI | SANIK | SCHRODER VENTURE | SCOTENT ENTREPRISE | SFPZ | SHENZHEN HIGH POWER TECHNOLOGY | SCHOTT AG | SKC | SVE - DASSAULT | SOLVAY | SONY | STIBAT | STORCK | STRATEGY ANALYSIS | TERRAROSSA CAPITAL | TIGER GLOBAL | TODA KOGYO | TOTAL | TOTAL WIRELESS SOLUTION | TOYO | TOYOTA | TYCO | UMICORE | UNIROSS | URALELEMENT | US NAVY | VARTA | VOLTRACK | WARBURG PINCUS | WORLD INDUSTRIAL INFORMATION CENTER | WR GRACE & CIE | YASLAMEN | ZEBRA | ZPOWER |

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AVICENNE ENERGY: RENOWNED TO HAVE REALISTIC FORECASTS

HEV powered by Lithium ion battery forecasts from 2008 to 2011

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

OUTLINE

THE RECHARGEABLE BATTERY MARKET IN 2011/2012

THE HEV, P-HEV & EV MARKET IN 2011/2012

2020 FORECASTS

IMPACT ON THE BATTERY BUSINESS

CONCLUSIONS
THE BATTERY MARKET IS REALLY DYNAMIC

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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

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

- 2000
- 2011

HEV, P-HEV and EV market 2011-2025
Impact on the battery business
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)

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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

Cellular Phones
Portable PCs
Others

Automotives
Tablets
Camcorders
Digital camera
MP3
Games
E-Bikes
Others
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:** http://www.eia.doe.gov/emeu/steo/pub/contents.html

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

HEV, P-HEV and EV market 2011-2025
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Fuel saving Vs. Cost

EV

P-HEV

HEV
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

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

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

USA
EUROPE
JAPAN
OTHERS

Micro hybrid not included

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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

(1)AVICENNE HEV Forecasts, march 09, Relevant scenario
(2)AVICENNE HEV Forecasts, march 09, Li-ion Optimistic scenario
(3)IIT, TAKESHITA, March 08, THE 25th INTERNATIONAL BATTERY SEMINAR & EXHIBIT, Slide 8 & March 2009, 26th Battery Seminar,
(4)AAB, Menahem ANDERMAN, Ph.D, Tampa, Florida, May 2009


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

![Graph showing operating profit/Revenue for different battery makers from 2002 to 2010](image.png)

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

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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 launch 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 take between 10 & 20 years to commercialized 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

- LiTec 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
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
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

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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

<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</td>
<td>3.5</td>
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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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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

RECHARGEABLE BATTERY MARKET WORLDWIDE
2000-2020

- MWh

- Lead Acid
- NiCd
- NiMH
- LIB
- Others
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