Battery Market Development: Materials Requirements and Trends 2012-2025

Christophe PILLOT
Director, AVICENNE ENERGY
AGENDA

- The battery market in 2012 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 2012-2030
- Rechargeable battery market forecasts up to 2025
AVICENNE ENERGY: RENOWNED TO HAVE REALISTIC FORECASTS

HEV powered by Lithium ion battery forecasts from 2008 to 2012

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

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

Graph showing the worldwide battery market 1990-2010 with significant growth in Li-ion batteries from 1990 to 2010.
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)
THE WORLDWIDE BATTERY MARKET
1990-2012

50 BILLION US$ in 2012
5% AVERAGE GROWTH PER YEAR (1990-2012)
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)

Lead Acid Batteries
330 GWh for US $ 30 Billion

Industrial Batteries
54 GWh for US $ 10 Billion
The worldwide rechargeable battery market, in volume, MWh, 1995-2012

- Li-ion: +25% per year
- NiMH: +4% per year
- NiCd: -2% per year

2002-2012 (CAGR)
The worldwide rechargeable battery market, in value, M$, 1995-2012

- NiCd: -6% per year
- NiMH: +7% per year
- Li-ion: +14% per year

Note: Cell level
JAPANESE, CHINESE & KOREAN MARKET SHARE

Japanese market share (value) decreasing: from 82% of the market in 2001 to less than 45% in 2012
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,
M$, Worldwide, 2000-2012
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
BATTERY PRICE IS DECREASING DRASTICALLY

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

Average LIB cell price ($/Wh)

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

18650 oversupply ratio is increasing
LIB: THE BIGGEST PART OF THE COST IS RAW MATERIALS

RAW MATERIALS ACCOUNT FOR 50 TO 80% OF LIB CELLS BUSINESS
RAW MATERIAL COST IMPACT DRASTICALLY ON THE BATTERY MAKERS PROFIT

LIB Cost structure for Japanese, Chinese & Korean makers in 2012

Note: Average mix of cylindrical, prismatic & laminate cells
Lithium ion cell average cost
LI-ION VALUE CHAIN

For each component:
- Market in volume & value?
- Material used by application?
- Main suppliers / new comers?
- Material cost?
- Major trends?
- Technology roadmap

CATHODE SUPPLIERS
75 000 T in 2012
Revenues: 1,85 B$
CAGR 02/12: +16%

ANODE SUPPLIERS
38 000 T in 2012
Revenues: 0,6 B$
CAGR 02/12: 14%

ELECTROLYTE SUPPLIERS
29 000 T in 2012
Revenues: 0,46 B$
CAGR 02/12: 20%

SEPARATOR SUPPLIERS
490 M m² in 2012
Revenues: 0,9 B$
CAGR 02/12: 18%

BINDER SUPPLIERS
5 600 Tons in 2012
Revenues: 0,16 B$
CAGR 02/12: 16%

ANCILLARY
Revenues: 0,5 B$

CELL MANUFACTURERS
Revenues: > 11 B$
Gross margin: <10%

PACK MANUFACTURERS
Revenues: > 14 B$
Gross margin: <10%

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Strasbourg, FRANCE
CATHODE ACTIVE MATERIALS NEEDS BY CHEMISTRY

Cathode active materials for LIB in Tons, 2000-2012

LEADERS:

- Nichia
- Umicore
- Others
- Internal

NEW ENTRANTS ON THE FIELD:

- Clariant
- A123
- Formosa
- 3M
- LG Chem

LEADERS:

- Nichia
- Umicore
- Others
- Internal

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LEADERS:

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- Internal

NEW ENTRANTS ON THE FIELD:

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- Formosa
- 3M
- LG Chem
CATHODE ACTIVE MATERIAL FORECASTS 2000-2025

Cathode active materials 2000-2025 - Tons

- Portable devices: 2010-2025: +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
  - 1 M EV/year in 2020, 1.5 M/year in 2025
  - 100% LIB

Cathode active materials in 2012: 75 000 Tons

Cathode active materials in 2025: > 330 000 Tons
ANODE ACTIVE MATERIALS
38 000 TONS IN 2012

LIB Anode Materials

Source: A. Jossen, IRES 2007

LIB Anode market, (Tons)

Source: Hitachi Chemical

Source: Sanyo, March 2011
ANODE FOR LIB IN 2012

Natural graphite become a commodity

- **Artificial Graphite:** 28%
- **MCMB:** 6%
- **Amorphous:** 3%
- **LTO:** 1%
- **Si or Sn Type:** 1%
- **Natural Graphite:** 61%

**Note:** MCMB: Mesocarbon Microbeads

**Carbon for LIB anodes by type (2012):**
- **Others:** 0%
- **A123:** 5%
- **BAK:** 5%
- **ATL:** 5%
- **Maxell:** 5%
- **Lishen:** 5%
- **BYD:** 5%
- **LGC:** 5%
- **SDI:** 5%
- **PANASONIC:** 5%
- **SONY:** 5%
- **SANYO:** 5%

**Battery Market Development: Materials Requirements and Trends 2012-2025**

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**LEADERS:**
- **Hard Carbon**
  - Capacity (/g): 400 mAh/g
  - Capacity (/cc): ++
  - Power: ++
  - Stability: ++
  - Cyclability: ++
- **Soft Carbon**
  - Capacity (/g): 250 mAh/g
  - Capacity (/cc): 0
  - Power: +
  - Stability: +
  - Cyclability: +
- **Graphite**
  - Capacity (/g): 325-375 mAh/g
  - Capacity (/cc): +
  - Power: 0
  - Stability: 0
  - Cyclability: 0

<table>
<thead>
<tr>
<th>Precursors</th>
<th>Hard Carbon</th>
<th>Soft Carbon</th>
<th>Graphite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum Pitch, Resin, cellulose, wood, coconuts…</td>
<td>Petroleum coke</td>
<td>Natural or petroleum coke</td>
<td></td>
</tr>
</tbody>
</table>

**COST**
- **2012-2020**
  - Hard Carbon: 30 -> 25 $/kg
  - Soft Carbon: 25-20 $/kg
  - Graphite: 15-10 $/kg

**SUPPLIERS**
- **KUREHA**
- **HITACHI**
- **HITACHI BTR & many others**

**NEW ENTRANTS ON THE FIELD:**
- **LEADERS:**
  - **Hard Carbon**
  - **Soft Carbon**
  - **Graphite**
- **SUPPLIERS:**
  - **KUREHA**
  - **HITACHI**
  - **HITACHI BTR & many others**
LIB SEPARATOR MARKET 2012

LIB separator market, M$, CAGR 2002/2012: +18%

LIB Separator supplier, market share in 2012

LEADERS:
- Asahi Kasei
- Celgard
- Evonik
- LG Chem
- Mitsubishi

NEW ENTRANTS ON THE FIELD:
- TDK/Nitto Denko
- Foshan Jinhui Hi-Tech
- Shenzhen Senior Technology Material
- Xinxiang Green next Energy
- Dupont

Others: TDK/Nitto Denko, Foshan Jinhui Hi-Tech, Shenzhen Senior Technology Material, Xinxiang Green next Energy, Dupont, ...
**ELECTROLYTE SUPPLIERS/CUSTOMERS 29 000 TONS IN 2012**

LIB electrolyte market, Tons, CAGR 2002/2012: +20%

![Graph showing LIB electrolyte market growth from 2000 to 2012, with segments for Cellular, Portable PC, Tablets, Power tools, E-Bikes, Auto, and Others.]

LIB electrolyte supplier, market share in 2012

![Pie chart showing market share of LIB electrolyte suppliers, with PANAX-ETEC at 16%, Mitsubishi at 21%, Jinniu at 10%, Zhangjiagang Guotai-Huarong at 15%, others at 5%, and In-House, Tomiyama, and others at 3% each.]

**NEW ENTRANTS ON THE FIELD:**

- **Zhangjiagang Guotai-Huarong**
- **JINNIU**

**LEADERS:**

- **MITSUBISHI**
- **UBE**
- **SHANSHANTECH**
- **PANAX-ETEC**
- **LG Chem**
- **BASF**
- **Dow**
- **DuPont**
- **DAIKIN**

**CONTACT**

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LIB ELECTROLYTE MARKET 2012

Electrolyte Battery makers & suppliers relation in 2012

Electrolyte maker sales 2005-2012

Note: ¹ former Samsung Chiel
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, LiPF$_6$ 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.
LI-ION RAW MATERIALS ROADMAP

Source: Kai-Christian Möller, Fraunhofer – 2013, AVICENNE ENERGY Analyses
PORTABLE ELECTRONIC DEVICES FORECASTS 2012-2025

Cellular phones demand (M Units) CAGR 2012-2025: +6%

Cellular Phones market Drivers
- Emergent market
- Renewal ratio increase
- Smartphone penetration increase

LIB cells demand 2012-2025
Polymer penetration: 30% -> 75%

LIB cells for cellular phones trends
- Laminates ratio increase
- Increase of Thickness
- Increase of >1400 mAh capacity
PORTABLE ELECTRONIC DEVICES FORECASTS 2012-2025

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

![Graph showing Portable PCs demand from 2010 to 2025 with Emerging and Mature markets]

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\(^{(2)}\) in 2013)
- 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%

![Graph showing LIB cells demand from 2010 to 2025]

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
2025 LIB FORECASTS EXCEPT AUTOMOBILE

LIB market, MWh, by application (except Auto) - CARG 2012-2025: 12%

2000-2025 LIB market, M cells, by form factor (Except Auto)

(1) Source: Battery Japan 2012 BJ-1 conference – Slide p 10
HEV FORECASTS
2012-2025

HEV MARKET: 2.5 Million units in 2015 – 5 M in 2020

Micro hybrid not included
LI-ION BATTERY DEVELOPMENTS FOR HEV, P-HEV & EV

LIB >>> NiMH but
SAFETY & COST ISSUES

<table>
<thead>
<tr>
<th>PRIUS III NiMH</th>
<th>PRIUS x - Li-ion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volts</td>
<td>201.6</td>
</tr>
<tr>
<td>Cells</td>
<td>168 (28*6)</td>
</tr>
<tr>
<td>Capacity</td>
<td>6.5 Ah</td>
</tr>
<tr>
<td>Energy</td>
<td>1310 Wh</td>
</tr>
<tr>
<td>Weight</td>
<td>38 kg</td>
</tr>
<tr>
<td>T°C Range</td>
<td>+</td>
</tr>
<tr>
<td>Cyclability</td>
<td>+</td>
</tr>
<tr>
<td>Safety</td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td></td>
</tr>
</tbody>
</table>

Recall slash battery profit

Operating profit/Revenue

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# SAFETY ISSUES

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

<table>
<thead>
<tr>
<th>Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td>- <strong>CONSEQUENCES</strong>: Except BOLLORE, all the companies developing Li metal batteries cancelled their projects</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li-ion batteries for mobile devices mostly used a Lithium Cobalt Oxide Cathode and liquid electrolyte.</td>
</tr>
<tr>
<td>In case of overcharging or short-circuit (contact between anode &amp; cathode) a chain reaction starts -&gt; heating &amp; gasing -&gt; fire (&quot;Thermal runaway&quot;)</td>
</tr>
<tr>
<td><strong>CONSEQUENCES</strong>: In 2006, SONY had to recall millions of portable PCs for total costs of 400 million USD, more than there profit-to-date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Automotive</th>
</tr>
</thead>
<tbody>
<tr>
<td>With new cathode chemistry, most of the automotive today on the markets experienced safety concerns:</td>
</tr>
<tr>
<td>(1) BYD Taxi in China with a lithium iron phosphate cathode</td>
</tr>
<tr>
<td>(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 !)</td>
</tr>
<tr>
<td>(3) PRIUS P-HEV in the US with a Panasonic battery using NMC, NCA cathodes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aircraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
<tr>
<td><strong>CONSEQUENCES</strong>: All the 787 worldwide are grounded. Considerable losses for Boing.</td>
</tr>
</tbody>
</table>
SAFETY IS A SINE-QUA-NON SELECTION CRITERIA FOR BATTERY TECHNOLOGIES

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

<table>
<thead>
<tr>
<th>Anode</th>
<th>Graphite</th>
<th>Hard Carbon</th>
<th>Soft Carbon</th>
<th>LTO</th>
<th>SiC</th>
<th>Li Metal</th>
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<tr>
<td>SAFETY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xEV?</td>
<td>Yes</td>
<td>Yes</td>
<td>No (1)</td>
<td>?</td>
<td>?</td>
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</table>

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Liquid</th>
<th>Additive</th>
<th>Gel Polymer</th>
<th>5V</th>
<th>Polymer membrane</th>
<th>Solid</th>
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<tr>
<td>SAFETY</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>xEV?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>YES</td>
<td>&gt; 2025</td>
</tr>
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<table>
<thead>
<tr>
<th>Cathode</th>
<th>LCO</th>
<th>NMC</th>
<th>LMO</th>
<th>LFP</th>
<th>High V</th>
<th>Sulfur</th>
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<tbody>
<tr>
<td>SAFETY</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>xEV?</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

**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.
LIB FOR AUTOMOTIVE VALUE CHAIN

Battery Market Development: Materials Requirements and Trends 2012-2025

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<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>Component</th>
<th>Cell mfg</th>
<th>Tiers 1</th>
<th>OEM</th>
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<tbody>
<tr>
<td>Li Salts</td>
<td>CATHODE</td>
<td>SAMSUNG</td>
<td>DENPHI</td>
<td>BMW</td>
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<tr>
<td></td>
<td>ANODE</td>
<td>Panasonic</td>
<td>DANA</td>
<td>VOLKSWAGEN</td>
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<tr>
<td>Additives</td>
<td>ELECTROLYTE</td>
<td>DELPHI</td>
<td>MAGNA</td>
<td>FORD</td>
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<tr>
<td>Lithium</td>
<td>SEPARATORS</td>
<td>BOSCH</td>
<td>JOHNSON CONTROLS</td>
<td>HYUNDAI</td>
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<tr>
<td>Rockwood Lithium</td>
<td>BINDER</td>
<td>SK INNOVATION</td>
<td>CONTINENTAL</td>
<td>DAIMLER</td>
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<tr>
<td>Solvents</td>
<td>BINDER 2</td>
<td>NEC</td>
<td>BOSCH</td>
<td>DAIMLER</td>
</tr>
<tr>
<td></td>
<td>BINDER 1</td>
<td>גף</td>
<td>BOSCH</td>
<td>DAIMLER</td>
</tr>
<tr>
<td></td>
<td>NEW ENTRANTS</td>
<td>BOSCH</td>
<td>BOSCH</td>
<td>DAIMLER</td>
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<tr>
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<td>CATHODE</td>
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<td>DAIMLER</td>
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<td>ELECTROLYTE</td>
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**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.
LIB MANUFACTURING INVESTMENTS
2009-2015

10-12 B$ WORLDWIDE
>50 GWh in 2015

Total Investment (M$) made for LIB manufacturing

- A123 Michigan Plant - Photo courtesy of A123 Systems
- Liotech Plant, Novosibirsk – 1.5 GWh production capacity

Average Investments: 250 $ / kWh
### Battery Market Development: Materials Requirements and Trends 2012-2025

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**BATTERY & POWER ELEC. COST IN EV**

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### Power Elec Pack Manufacturing
- BMS
- Thermal Mgmt + packaging
- Cell manu
- Cell

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<table>
<thead>
<tr>
<th>Calculated Cost Range (€)</th>
<th>HV batt. Pack for EV</th>
<th>HV batt. CELL for EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>€ 8,250 - € 18,100</td>
<td>€ 8,150 - € 15,100</td>
<td></td>
</tr>
<tr>
<td>€ 5,500 - € 8,000</td>
<td>€ 50 - € 300</td>
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<tr>
<td>€ 100 - € 400</td>
<td>€ 150 - € 350</td>
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</tr>
<tr>
<td>€ 50 - € 2,500</td>
<td>€ 300 - € 500</td>
<td></td>
</tr>
<tr>
<td>€ 1,000 - € 3,000</td>
<td>€ 900 - € 1,250</td>
<td></td>
</tr>
</tbody>
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### HV battery Pack for EV
- Charger
- Inverter
- Rectifier
- Generator

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### HV battery
- Pack Manufacturing
- Cooling Syst
- Batt. Magt Syst
- Batt. Packaging Manuf.

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### HV Cables & Connectors
- HV battery pack
- Packaging material
- LV battery

---

### Active Hybrid 5, Volt, Bluecar, Leaf
- HEV
- P-HEV
- EV

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**AVICENNE ENERGY - CONFIDENTIAL INFORMATION**
LIB CELL BILL OF MATERIALS

NISSAN LEAF

BOLLORE BLUE CAR

GM VOLT

BMW ACTIVE HYBRID 5

AVICENNE ENERGY - CONFIDENTIAL INFORMATION
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 2025 FORECASTS

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

Total battery demand (MWh)
CAGR 2012-2025: +12%
RECHARGEABLE BATTERY MARKET
2000 – 2025

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

Rechargeable battery market, M$, 2000-2025 (cell level)
Micro-hybrids car market 2010-2020

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 address the micro-hybrid market

Advantages of micro-hybrid compared 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

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

2010

STANDARD CAR
88.5%

MICRO HYBRIDS
10%

MILD HEV
0.5%

FULL HEV
1%

2015

Advanced Lead acid

STANDARD CAR
44%

2020

STANDARD CAR
44%

MICRO HYBRID
50%

FULL HEV
4%

2025

STANDARD CAR
44%

MICRO HYBRID
50%

FULL HEV
4%

AFTER

ULTRA BATTERY

Li-ion

Li-Air, Li-S, Fuel Cells
TAKEAWAYS

Battery Market 2010-2025
CAGR = +8%

- 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

RECHARGEABLE BATTERY MARKET WORLDWIDE
2000-2025

Note: Excluding Energy Storage batteries
THANK YOU

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About
AVICENNE ENERGY
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

AABC EUROPE
June 24-28
Strasbourg, FRANCE

Battery Market
Development: Materials
Requirements and Trends
2012-2025

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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

2013
- 22nd Edition of “The rechargeable battery market worldwide 2012-2025
- 15th Edition of BATTERIES CONGRESS
OUR METHODOLOGY

INFORMATION COLLECTION

<table>
<thead>
<tr>
<th>PRIMARY RESEARCH</th>
<th>SECONDARY RESEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Interviews</td>
<td>Company News &amp; Financials</td>
</tr>
<tr>
<td>Vendor Briefings</td>
<td>Technology &amp; Product Specs</td>
</tr>
<tr>
<td>Product Demos and Tours</td>
<td>Government Data</td>
</tr>
<tr>
<td></td>
<td>Economic, Demographic Data</td>
</tr>
<tr>
<td>Consumer Surveys</td>
<td>Case Studies</td>
</tr>
<tr>
<td>Business Leader Surveys</td>
<td>Reference Customers</td>
</tr>
</tbody>
</table>

MARKET & STRATEGIC ANALYSIS

<table>
<thead>
<tr>
<th>QUALITATIVE</th>
<th>QUANTITATIVE</th>
<th>STRATEGIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Models &amp; Trends</td>
<td>Company News &amp; Financials</td>
<td>SWOT Analysis</td>
</tr>
<tr>
<td>Technology Issues</td>
<td>Technology &amp; Product Specs</td>
<td>Gap Analysis</td>
</tr>
<tr>
<td>Policy &amp; Regulatory Factors</td>
<td>Government Data</td>
<td>Business Plan</td>
</tr>
<tr>
<td>Competitive Landscape</td>
<td>Economic, Demographic Data</td>
<td>Value Proposition</td>
</tr>
<tr>
<td>Profiles of Key Players</td>
<td></td>
<td>Due Diligence</td>
</tr>
</tbody>
</table>

INFORMATION COLLECTION

Track valuable Information's

Strategic Analysis

Presentation of the results

Q&A with customers

Customer Evaluation

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Battery Market Development: Materials Requirements and Trends 2012-2025

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INFORMATION FOR GROWTH
METHODOLOGY: EXTENSIVE FIELD RESEARCH TO RETRIEVE & CROSS CHECK INFORMATION

Top management contact network > 19 000 contacts

Conferences & Exhibitions

In Depth analysis Of applications

Cross Check Analysis

- Battery Makers
- OEM
- Substitution technologies
- BMS Electronics
- Raw materials suppliers
- Environment & recycling

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CUSTOMIZED & MULTICLIENT SURVEY FOR ALL THE VALUE CHAIN

RAW MATERIALS | MATERIALS | CELLS | PACK | OEM
---|---|---|---|---

Source: Photo from BASF

Battery Market Development: Materials Requirements and Trends 2012-2025

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MORE THAN 180 REFERENCES WORLDWIDE

- A123
- AIR LIQUIDE
- AIR PRODUCT
- AHLSTROM
- ALCATEL
- AMPEREX (ATL)
- APPLIED MATERIALS
- AROS SECURITIES
- ARC
- ARKEMA
- ASHLAND
- ATOFINA
- AT KEARNEY
- AXEON
- BAIN
- BASF
- BATTERY R&D ASSOCIATION OF KOREA
- B&G
- BHP BILLITON
- BRAND LICENCING PARTNERS (BLP)
- BOURNS
- BOSCH
- BUEHLER 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
- EPCOS OHG
- ERAMET
- ETCAB
- FACOM
- FALCON BRIDGE
- FAIRCHILD SEMICONDUCTOR
- FAMEART
- FIST
- FLORIDENNE 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
- LECLANCHE
- LEGRAND
- LG CHEMICAL
- LION CELLS
- LITTLE FUSE
- LILIPUCIAN
- LYNAS CORP
- MATSUSHITA
- MICROSOFT
- MIT MICRO FUEL CELLS
- MOLTECH
- MOLYCORP
- MOMENTIVE
- MOTOROLA
- MUNSTER UNIVERSITY
- NANOYL
- NCCP - RUSSIA
- NITECH
- NKKPC
- NORILSK NICKEL
- NOVALED
- NTK POWERDEX
- OLIVER WYMAN
- OMG INC
- OSKR
- 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
- SOLAY
- 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
- WACKER CHEMIE AG
- WARBURGPIBCUS
- WORLD INDUSTRIAL INFORMATION CENTER
- WR GRACE & CIE
- YASLAMEN
- ZEBRA
- ZPOWER

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More than 180 references worldwide
SPEAKER, CHAIRMAN OR WORKSHOP MODERATOR

Tens of INTERNATIONAL CONFERENCES per year

  Owner, chairman & speaker
  “The battery market 2010-2025”

- INTERNATIONAL Li-ion BATTERY SUMMIT – Dec 2011, Shenzhen, China
  “The Li-ion battery raw materials market 2010-2020”

- AABC Europe, Mainz (2012)
  “The Lithium ion raw material battery market 2010-2020”

- THE 28th INTERNATIONAL BATTERY SEMINAR - FLORIDA
  Fort Lauderdale, Florida, March 2012
  “HEV, PHEV & EV market 2010-2020 ; Battery is the key” (From 2004 to 2010)

- EVER 2009, MONACO
  “Challenges for EV market in Europe”

- EVS 20011,
  “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, Frankfort, 2009-2010
  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
  “The Chinese battery Industry”

- ...
BATTERIES 2013
OCTOBER 14TH-16TH
www.batteriesevent.com

- 3 days congress in France (Nice)
- 500 attendees
- 40 Booths
  Battery makers, raw materials suppliers, IC & BMS suppliers, tests, machining, coating,
- 80 international experts:
  Researchers, industrial process, marketing, financials,
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

Knowledge

Methodology

Expert Network

Flexibility