Batteries for Automotive Applications– Market Outlook

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Johnson Controls
Part I: Introduction

Part II: Overview of current market

Part I: Introduction

Several battery technologies used to meet global targets for reduced CO$_2$ emissions from transport
Driving battery innovation

Main Drivers: CO2 Saving, Higher Fuel Economy

<table>
<thead>
<tr>
<th>CO₂ Targets</th>
<th>2012</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>154</td>
<td>130</td>
<td>95</td>
</tr>
<tr>
<td>United States</td>
<td>182</td>
<td>162</td>
<td>132</td>
</tr>
<tr>
<td>China</td>
<td>179</td>
<td>160</td>
<td>116</td>
</tr>
</tbody>
</table>

- **Europe**
  - -15% until 2015
  - -25% versus 2015 until 2021
- **United States**
  - -15% until 2016
  - 40+% Improved fuel efficiency until 2025
- **China**
  - Orientation to EU-regulations

grams CO₂/km
**Different levels of hybridisation and electrification**

**E-Mobility = Very fragmented market**

<table>
<thead>
<tr>
<th>Vehicle category</th>
<th>Micro HEV</th>
<th>Mild HEV</th>
<th>HEV</th>
<th>Plug-in Hybrid</th>
<th>EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start / Stop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regen. Brake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Power assist</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Drive</td>
<td></td>
<td></td>
<td>+/- 100m</td>
<td>+/- 10km</td>
<td>Up to 200km</td>
</tr>
</tbody>
</table>

**Electrical specifications**

<table>
<thead>
<tr>
<th>Operating Voltage</th>
<th>12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy level</td>
<td>0,3kWh</td>
</tr>
</tbody>
</table>
Different vehicle types require different battery technologies

<table>
<thead>
<tr>
<th>CLASS 1</th>
<th>CLASS 2</th>
<th>CLASS 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional ICE vehicles</td>
<td>Micro-hybrid vehicles (adv)</td>
<td>Plug-in hybrid electric vehicles (PHEVs)</td>
</tr>
<tr>
<td>Start-stop vehicles</td>
<td>Mild-hybrid vehicles</td>
<td>Full electric vehicles (EVs)</td>
</tr>
<tr>
<td>Micro-hybrid vehicles (basic)</td>
<td>Full-hybrid vehicles (HEVs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Lead-Based battery</strong></td>
<td><strong>Lead-based auxiliary battery</strong></td>
</tr>
<tr>
<td></td>
<td>(SLI, EFB or AGM)</td>
<td></td>
</tr>
<tr>
<td><strong>12 V</strong></td>
<td><strong>48-400 V</strong></td>
<td><strong>250V-600 V</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Mix of battery technologies</strong></td>
<td><strong>Lithium-ion battery</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Lead-based auxiliary battery</strong></td>
<td><em>(or NaNiCl2 battery for some heavy vehicles)</em></td>
</tr>
</tbody>
</table>
A Review of Battery Technologies in Automotive Applications

- **Joint Industry Report**, developed by EUROBAT, automotive industry associations (ACEA, JAMA, KAMA) and the International Lead Association.

- Evaluating the technical requirements placed on the battery system in different applications, from conventional vehicles up to full electric vehicles, and how this affects battery selection.

- **Overall conclusion**: *There would be a significant impact on the overall performance and cost of vehicles, plus an effect on targets for fuel efficiency and reduced CO₂ emissions, if established battery applications were to be replaced with alternative technologies.*
Part II: Overview of current market for batteries in automotive applications
Automotive 12V batteries

- 12V automotive batteries required in the 250m vehicles on European roads. Lead-based batteries are currently the only technology tested for the mass market that satisfy requirements.

- Since 2007, advanced lead-based batteries have been introduced to improve fuel efficiency in new European micro-hybrid vehicles.

- Start-stop and micro-hybrid systems improve fuel-efficiency by 5-10%, and contribute to 700-1600 kg of CO₂ savings across the vehicle lifecycle.
Market development:
European Sales of advanced lead-based automotive batteries (passenger cars)

- Significant increase in sales of advanced lead-based automotive batteries.
- Now comprising 20% of total automotive battery sales.

* Combined annual data for AGM and EFB battery sales (passenger car), in EU-28 Member States (+ NO and CH)
All data has been collected privately from member companies and aggregated confidentially by the EUROBAT Secretariat, in respect of competition law. Data comprises 90-95% of overall EU market for automotive batteries.
Market development:
Total European Sales of Automotive Batteries (passenger cars)

- Overall European automotive battery market has increased by 9% since 2011 low point.
- Advanced lead-based batteries have gained progressive market share due to roll-out of micro-hybrid vehicles.
Current Market: Snapshot of e-Mobility battery sales

- Although markets are increasing, HEV, PHEVs and EVs still represent a very **small percentage of all vehicle sales**:

  - **Over 6 million full hybrid vehicles** now on the road globally (ZSW, 2014). Currently, nickel-metal hydride batteries provide recuperation of braking energy and electric propulsion.

  - **Over 405,000 plug-in hybrid and electric vehicles** on the road globally (ZSW, 2014). Currently, lithium-ion batteries provide a significant level of zero-emission driving.

- Vehicle competitiveness will be improved through cost reductions and energy density increases for lithium-ion and other battery technologies.
Market Outlook: Passenger cars

- Further mass-market rollout of **micro-hybrid vehicles** expected over the next decade, predominantly using advanced lead-based batteries.

- Share of **full hybrid, plug-in hybrid and electric vehicles** will increase steadily from now until 2020. Market share of Lithium-ion batteries will increase, especially in hybrid segments.

Avicienne (2013)
1. Vehicle typology
   - Buses and public transportation vehicles
   - Commercial trucks
   - Industrial and Special vehicles

2. Two types of business case
   - Switch from traditional ICE to Hybrid or EV
   - Substitute lead-acid traction batteries by li-ion and sodium-nickel chloride when business case makes sense

3. Commercial Truck market example
   - Strong growth driven by more transportation need
   - HEVs for long distance, delivery between cities
   - EVs for short distance, delivery inside/around cities
2015-2025 vision: Advanced Lead-based batteries

- Further improvements expected to AGM and EFB battery performance:
  - Cycle life
  - Power density
  - Charge recoverability

- This will be achieved through:
  - Carbon nanotechnologies
  - High surface area doping materials
  - Low-cost catalysts
  - Light-weighting solutions

- **Consequence**: Higher performance in partial state of charge conditions, and ability to provide a greater range of services in micro-hybrid applications.
2015-2025 outlook: Lithium-ion batteries

Over the next 5Y
- Automotive/Industrial are the major driver of Li-ion growth
- Consumer remains an important driver as well

Over the next 10Y
- Industrial/Other Li-ion to become main market segment by value in 2025
- Automotive is 2nd
- Consumer is 3rd
## 2015-2025 Vision

### Lithium-ion batteries

#### 2015-2025 Vision

<table>
<thead>
<tr>
<th>R&amp;D topic</th>
<th>Feature</th>
<th>Benefit</th>
</tr>
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<tbody>
<tr>
<td><strong>Cell</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High energy material</td>
<td>- Improve energy</td>
<td>- Reduce battery volume &amp; weight</td>
</tr>
<tr>
<td>High voltage material</td>
<td>- Improve power</td>
<td>- Allow fast charge, opportunity charge (reduce battery size)</td>
</tr>
<tr>
<td>High power material</td>
<td>- Decrease cost</td>
<td>- Use of lower voltage engine</td>
</tr>
<tr>
<td>New separator &amp; electrolyte</td>
<td>- Improve component stability</td>
<td>- Increase market penetration</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Components for high voltage / high current</td>
<td>- Improve high power</td>
<td>- More demanding application</td>
</tr>
<tr>
<td>Cooling system</td>
<td>- Improve cooling efficiency</td>
<td>- Improve battery life</td>
</tr>
<tr>
<td>ESS interface</td>
<td>- Decrease cost</td>
<td>- Increase market penetration</td>
</tr>
</tbody>
</table>
- Thank You -

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