Energy Storage Solutions Panorama for Telecom Stand-By applications

ETSI – 2015 Energy Workshop

By Claude Campion
3C Projects
3C Projects founded in 2011 by Claude Campion coming from large battery industry, is a unipersonal independent company located in Clichy nearby Paris.

Main Activities are:
- Technical support: Test lab or field investigation, storage energy solutions selection analysis, training course, test or maintenance procedure update, battery monitoring specifications
- Marketing support: Promotion of R&D license for use in industry, Specific Technology and Market development surveys

Main References are:
- Orange; EDF (French Utility); SNCF (French Railways); Electrabel (Belgium); BAE (Germany); ForseePower (France); Albioma (France)...

More information at [www.3cprojects.eu](http://www.3cprojects.eu)
Batteries & Energy Storage Solutions

Long Storage (day to year)  Medium Storage (sec to week)  Short Storage (µs to min)

Telecom Opportunities

3C Projects

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Electrical Energy Storage

Mechanical
- Pump Hydro
- Compressed Air
- Flywheels

Electro-Magnetic
- Supercapacitor
- SMES DSMES

Chemical
- Hydrogen
- SNG

Electro-Chemical
- Flow Batteries
- Rechargeable Batteries

Thermal
- Sensible Heat
- Latent Heat
- PHES

Classification according IEC ESS WP 12/2011

- Long Storage (day to year)
- Medium Storage (sec to week)
- Short Storage (µs to min)

Telecom Opportunities
# Lead Acid Batteries Flooded

| Strengths                                                                 | Mature Technology - Cell Cost of 80 € - 150 €/kWh  
|                                                                         | Good extreme temperature acceptance - Convenient cycling performance for tubular variant |
| Weaknesses                                                              | Limited cycle life for flat plate variant - Water topping up  
|                                                                         | Efficiency of 80-85% |
| Opportunities                                                           | Large global production capacities  
|                                                                         | Large capacities range from 10Ah to 4000 Ah |
| Threats                                                                 | Competition with Li-Ion |

**Main Technologies**
- PbSb (flat or tubular) ; PbCa (Flat) ; Plante ; PbC

**Telecom Opportunities**
- Large central office back-up  
- Wireless outdoor and Off-Grid BTS (PbSb Tubular)  
- Starting Engine (PbSb or PbCa flat)  
- Microwave Antenna
# Lead Acid Batteries AGM

| Strengths | Mature Technology - Cell Cost of 100 - 130 €/kWh  
Good Power Performances - Balancing and Maintenance free |
|-----------|--------------------------------------------------|
| Weaknesses | Limited cycle life  
Reduced life operation at high temperature |
| Opportunities | Large global production capacities  
Standard format |
| Threats | Competition with Li-Ion |

### Main Technologies
- PbCa (flat thin / thick) ; Pure Lead

### Telecom Opportunities
- UPS – Data Center
- Large or district office back-up
- Wireless outdoor or indoor BTS
- Starting Engine
- Microwave Antenna – PABX - DSL

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## Lead Acid Batteries Gel

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td>Mature Technology - Cell Cost of 120 - 180 €/kWh - Good cycling ability</td>
</tr>
<tr>
<td></td>
<td>Balancing and Maintenance free</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td>Poor Power Performance</td>
</tr>
<tr>
<td></td>
<td>Life time affected at high temperature operation</td>
</tr>
<tr>
<td><strong>Opportunities</strong></td>
<td>Large global production capacities</td>
</tr>
<tr>
<td></td>
<td>High reliability and safety reputation</td>
</tr>
<tr>
<td><strong>Threats</strong></td>
<td>Competition with Li-Ion</td>
</tr>
</tbody>
</table>

**Main Technologies**
- PbCa (flat or tubular)

**Telecom Opportunities**
- Large or district central office back-up
- Wireless outdoor, indoor and off-grid BTS
- Microwave Antenna – PABX - DSL

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Large Differences in Term of Battery Choice

- kWh Cost varies from 1 to 3 according types
- Life operation can be from 3 years to 25 years according type and temperature operation
- Cycling performances are quite different from type to type

- Today Lead Acid battery is the largest player for stand-by applications
- IEC/EN 60896-1 & 2 ruled the type test performances (float & cycling)
- IEC/EN 61427 provides recommendations for PV applications

Performances Cycles. 20°C
Indicative values issued from 3C Projects analysis for Orange Telecom
# NiCd Batteries

## Strengths
- Mature Technology - Extreme low temperature performances
- Robust reliability - Good energy density

## Weaknesses
- Cost around 400 €/kWh
- Recycling process of Cadmium

## Opportunities
- Engine starting at low temperature
- On board rail application & extreme temperature PV applications

## Threats
- Competition with Li-Ion - Cadmium ban

### Main Technologies
- Pocket plates (flooded or sealed) & Sintered plates

### Telecom Opportunities
- Wireless outdoor and off-grid BTS
- Microwave Antenna
- Engine starting

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## NiMH Batteries

| Strengths                                                                 | Mature Technology - Extreme low temperature performances  
|                                                                         | Robust reliability - Good energy density - |
| Weaknesses                                                             | Cost around 450 €/kWh |
| Opportunities                                                          | Hybrid Vehicle (Toyota Prius)  
|                                                                         | Portable applications |
| Threats                                                                | Competition with Li-Ion |

### Main Technologies
- Flat or Cylindrical

### Telecom Opportunities
- Handy terminal
- PABX

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# NiZn Batteries

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td>Cycling performance - Wide temperature range operation -</td>
</tr>
<tr>
<td></td>
<td>No electronic balancing - Recyclability - Energy density</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td>No long field experience feedback</td>
</tr>
<tr>
<td><strong>Opportunities</strong></td>
<td>Abondance of material New jocker for extreme temperature cycling operation</td>
</tr>
<tr>
<td><strong>Threats</strong></td>
<td>Competition with Li-Ion &amp; Lead Acid</td>
</tr>
</tbody>
</table>

**Main Technologies**
- SCPS License or Powergenix License

**Telecom Opportunities**
- Wireless outdoor and off-grid BTS
- Microwave antenna
- Engine starting

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# NiFe Batteries

## Strengths
- Mature technology - Very long life operation up to 25 years
- No electronic balancing - Recyclability

## Weaknesses
- High maintenance cost due to high rate of water consumption

## Opportunities
- Abondance of material

## Threats
- Competition with Li-Ion & Lead Acid

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## Main Technologies
- Edison type

## Telecom Opportunities
- Wireless outdoor and off-grid BTS
- Microwave Antenna
Niche Applications and New Players

- Nickel Cadmium keeps strong positions on railways and cold starting engine due to safety maturity
- NiMH keeps market shares in HEV and portable tools due to its safety operation, maturity, as well as good energy density
- NiZn is a new player and can afford right opportunities for cycling operations at extreme temperature operations with expected reasonable cost
- NiFe is coming back and field experiences are looking with great attention
- Competition with lithium based batteries is tough (Battle is lost for portable except for power-tool)
- IEC/EN 61434, 60623, 62259, 60622, 61951 provides major information for type test performances
- IEC/EN 61427 is the reference for PV applications
### Lithium LiFePo4 Batteries

| Strengths | High Cycling Performances - Partial State of Charge Capability  
|           | Good safety operation |
| Weaknesses | Cell cost about 320 €/kWh & Pack cost around 450 €/kWh  
|           | Need electronic pack balancing - Low & High temp. operation |
| Opportunities | Renewable energy storage applications  
|              | Bus & Commercial EV |
| Threats | Competition with Li-Ion Titanate anode batteries & Flow batteries |

**Main Technologies**
- Cylindrical, Pouch (Polymer), Large prismatic

**Telecom Opportunities**
- Wireless outdoor and off-grid BTS
- Microwave antenna

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## Lithium Ion Batteries (LCO, LMO, NCA, NMC)

| Strengths | High Cycling Performance - Partial State of Charge Capability  
|           | High Energy & Power Density  
| Weaknesses | Cell cost from 250 €/kWh to 600 €/kWh  
|           | Need electronic pack balancing - Limited low & high temp. operation  
| Opportunities | Portable equipment - EV Batteries  
|             | Grid support  
| Threats | Limited supply in Lithium  

### Main Technologies
- Cylindrical – Prismatic Pouch (Polymer)

### Telecom Opportunities
- Terminal (Phone, Tablets, Laptop...)
- NCA, NMC, LMO can play for off-grid applications, Antenna and BTS equipment
# Lithium Ion Batteries (LTO anode)

| Strengths       | Very High Cycling operation > 10,000 Cycles  
|                 | Good safety operation and good charging suitability at low temp. |
| Weaknesses      | Cell cost over 450 €/kWh - Lower energy density  
|                 | Need electronic balancing - Limited high temp. operation |
| Opportunities   | Renewable energy storage Grid support - UPS short backup |
| Threats         | Limited supply in Lithium  
|                 | Few suppliers |

**Main Technologies**
- Prismatic & Pouch

**Telecom Opportunities**
- Wireless outdoor and off-grid BTS
- UPS Short Backup
# Lithium Metal Polymer Batteries (LMP)

## Strengths
- Very High Cycling Performance > 5000 Cycles
- Can work at extreme temperature

## Weaknesses
- Pack cost over 700 €/kWh - lower efficiency
- Need electronic cell balancing and thermal management

## Opportunities
- Renewable energy storage
- EV batteries

## Threats
- Limited supply in Lithium
- Limited supplier

## Main Technologies
- Prismatic Pack

## Telecom Opportunities
- Wireless outdoor and off-grid Antenna or BTS

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Lithium based Batteries Summary

Large difference in term of battery choice

- Cycling performances vary from 1 to 30 according, shape, size, cathode and anode material as well as supplier manufacturing process.

Example of announced performances: (Here below extract from Lishen datasheets)

<table>
<thead>
<tr>
<th>P/N</th>
<th>Cathode</th>
<th>Capacity (mAh)</th>
<th>Life Cycles</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>LR1865BI</td>
<td>NMC</td>
<td>1500</td>
<td>300/75%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LR1865LA</td>
<td>NMC</td>
<td>2000</td>
<td>300/75%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LR1865SK</td>
<td>LCO/NCM</td>
<td>2600</td>
<td>300/80%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LR1865SA</td>
<td>LCO</td>
<td>2800</td>
<td>300/80%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LR1865SC</td>
<td>LCO</td>
<td>3000</td>
<td>300/80%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LR1015AB</td>
<td>LCO</td>
<td>60</td>
<td>500/80%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LR1865SD</td>
<td>LCO/NCM</td>
<td>2200</td>
<td>1000/80%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LR1865EC</td>
<td>LFP</td>
<td>1350</td>
<td>1000/80%</td>
<td>Cyl.</td>
</tr>
<tr>
<td>LP2714897</td>
<td>LFP</td>
<td>20000</td>
<td>2000/80%</td>
<td>Prism.</td>
</tr>
</tbody>
</table>

- Up to now very few long period field experiences, project sizing and economics are mainly based on data-sheet.

- Standards for safety are fixed, concerning stand-by type test the standard processes are on going.
### Sodium Batteries (NaNiCl - NaS)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High Cycling Performances</td>
<td>Pack cost over 700 €/kWh</td>
</tr>
<tr>
<td>5 000 - 10 000 Cycles</td>
<td>Need thermal management - Thermal losses - Low efficiency</td>
</tr>
<tr>
<td>Can work at extreme temperature</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energy storage</td>
<td>Lack of safety confidence - Competition with lithium</td>
</tr>
<tr>
<td>Grid support</td>
<td></td>
</tr>
</tbody>
</table>

### Main Technologies
- Fiamm, GE for NaNiCl & NGK for NaS

### Telecom Opportunities
- Wireless outdoor and off-grid BTS at extreme temperature with NaNiCl

### Standards
- No specific type test standard up to now
## Redox-Flow Batteries

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Energy and Power are Independently scalable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cyclic lifetime &gt; 10 000 Cycles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weaknesses</th>
<th>Low efficiency of 60 - 74%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lack of long field experience. Cost still at about 500 € / kWh at scale</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Expiration of patent protection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cheap raw materials are available</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Threats</th>
<th>Only few manufacturers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wrong field experiments results</td>
</tr>
</tbody>
</table>

### Main Technologies

- VFRB (Vanadium) – ZnBr – FeCr – H₂Br

### Telecom Opportunities

- Large central office connected to Renewable Energy supply source and operating at extreme temperature
## TES – Thermal Energy Storage (Hot or Cold)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td>Scalable Size. Mature</td>
</tr>
<tr>
<td></td>
<td>Cyclic lifetime &gt; 10 000 Cycles</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td>Low efficiency of 60 - 70 %</td>
</tr>
<tr>
<td></td>
<td>Not adapted for electricity recovery</td>
</tr>
<tr>
<td><strong>Opportunities</strong></td>
<td>Extreme temperature operation</td>
</tr>
<tr>
<td></td>
<td>micro-grid systems</td>
</tr>
<tr>
<td><strong>Threats</strong></td>
<td>Not considered as inovative</td>
</tr>
</tbody>
</table>

### Telecom Opportunities

As an improvement of renewable energy integration Cold TES can be part of energy efficiency approach for systems and Hot TES with associated applications can be explore.
# Hydrogen and Regenerative Fuel Cell (RFC)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Autonomous concept</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Excellent cycling performance</td>
</tr>
<tr>
<td></td>
<td>Scalable</td>
</tr>
<tr>
<td>Weaknesses</td>
<td>Low efficiency around 50% total</td>
</tr>
<tr>
<td></td>
<td>Lack of long field experience.</td>
</tr>
<tr>
<td></td>
<td>CAPEX Cost 600 € - 1000 €/kWh</td>
</tr>
<tr>
<td>Opportunities</td>
<td>Seasonal storage for Renewable Energy</td>
</tr>
<tr>
<td></td>
<td>Combination with EV propulsion</td>
</tr>
<tr>
<td>Threats</td>
<td>Safety regulation</td>
</tr>
<tr>
<td></td>
<td>Electrolyser and fuel cell membrane reliability</td>
</tr>
</tbody>
</table>

## Technologies
- Electrolyser PEM + Fuel Cell + Solid, Liquid or Compressed Hydrogen Storage

## Telecom Opportunities
- Seasonal storage for antenna or off-grid BTS

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Energy storage solutions are multiple

Operation conditions have to be well set to ensure the right choice

LCOE (Life Cost of Energy) linked to CAPEX, OPEX and service life is a good approach to set the cost effective choice

Dual or Hybrid solutions are more and more considered:
- Power + Energy or Cycling + Floating
  - Lithium + Lead
  - Lithium NMC + Lithium LTO
  - Supercapacitor + lead
  - Supercapacitor + lithium
  - Electrochemical + Thermal
  - Electrochemical + Chemical

New developments are on the way:
- LiS: Lithium Sulfur
- Metal Air: Zn-Air, Li-Air,
No one energy storage solution is predominant

each one has its adapted fitment

Thank You