BlueSolutions by Bolloré

Solid State Battery Technology

WORLD BANK – ESMAP Stakeholders Meeting

Pretoria, South Africa

January 21, 2020

WHY SOLID STATE TECHNOLOGY ?

1. ***Cost Reduction*** in the long run compared to current technologies
   - Savings on the anode and separator elements
2. ***Higher Energy Density***
   - Longer duration stationary applications; longer range for mobility
3. ***Safety***

PRINCIPLES OF SOLID-STATE BATTERY TECHNOLOGY

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1. There is no liquid or gel
   - The liquid or gel electrolyte is replaced by a ‘solid-state’ layer
   - Electrolyte could be ceramic, glass, or plastic-like polymer
2. Solid electrolyte allows for ***higher density***
   - More energy contained in smaller space/area
3. Traditionally challenging to manufacture
4. Growing installation footprint today → ***Big potential for hot climates, high tolerance to ambient heat without need of cooling systems***

MAIN CHALLENGES OF TOMORROW'S BATTERY

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1) Cost

- Raw material costs (re-use via recycling)
- Continuous Process
- Suppression of formation of migrating ions (SEI)
- **Scaling**

2) Safety

- 0 risk of fire
- 0 risk of explosion
- 0 risk of leakage
- 0 risk of gas emissions

3) Density

- **Long energy delivery**
- Autonomy/range required for electro mobility

4) Service Life

- Calendar life > 15 years
- Cyclability depending on applications (**> 4000 for daily use;** > 1500 for EV)
- Constant performance: no loss of capacity

5) Traceability / Ethical Sourcing

- Responsible extraction
- Full material traceability

6) Life Cycle

- 100% recyclable
- Close loop material reuse

An R&D priority shared by all manufacturers: the solid battery

SOLID STATE TECHNOLOGY

Anode : Lithium foil

Electrolyte : PEO + Lithium salts

Cathode: $LiFePO_4$

$\leftrightarrow$

$Li_{1-x}FePO_4 + xLi^+ + x\ e^-$

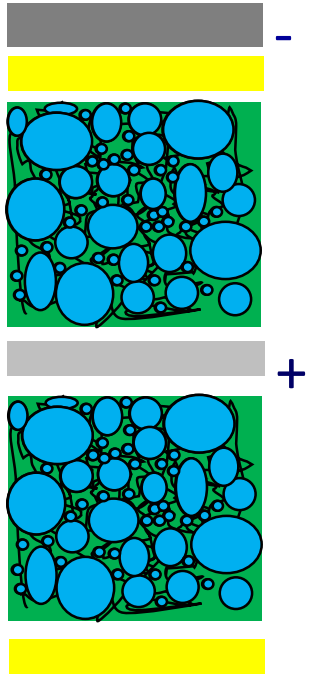
Current collector : Aluminum foil

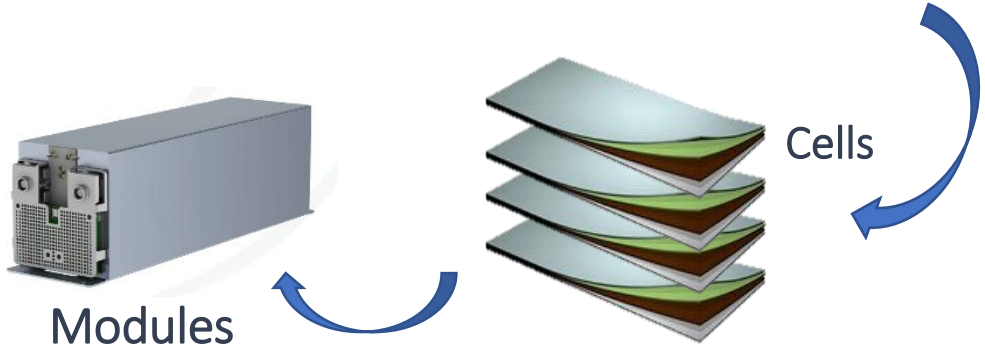
Cathode: $LiFePO_4$

$\leftrightarrow$

$Li_{1-x}FePO_4 + xLi^+ + x\ e^-$

Electrolyte : PEO + Lithium salts





BENEFITS

SAFETY

- No thermal runaway

ROBUST

- Suitable for hot climates
  → *Africa, South Asia, Tropical Islands*
- No cooling needed

DENSITY

- **230 Wh/kg**
- **360 Wh/L**

PERFORMANCE

- Service Life ***> 12 years***
- Cyclability **> 4000 cycles**
- Constant Capacity
- **Long Duration** (>C/2)

SUSTAINABILITY

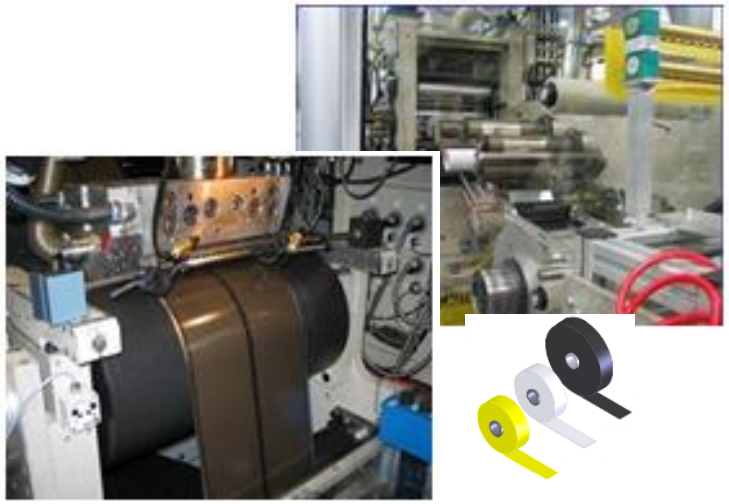
- No Cobalt / Nickel
- No Rare Earths
- No Solvents

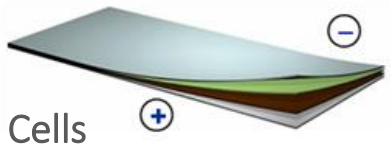
LIMITATIONS

- Not suitable for power applications (nominal discharge C/2)
- Electrolyte conductivity from 60 °C

LITHIUM METAL POLYMER - LMP® TECHNOLOGY

MANUFACTURING PROCESS





1

Extrusion of ultra thin films used as anodes, electrolytes and cathodes

2

Manufacturing of cells by stacking of films to create modules

3

Assembly of modules to create packs (electromobility) or a set of DC cabinets for stationary applications

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Thank you!

Francisco DaSilva Passos
francisco.dasilvapassos@blue-solutions.com

Adrian Tylim
adrian.tylim@blue-solutions.com

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Additional Notes

MICROGRIDS USING SOLID-STATE BATTERY TECHNOLOGY

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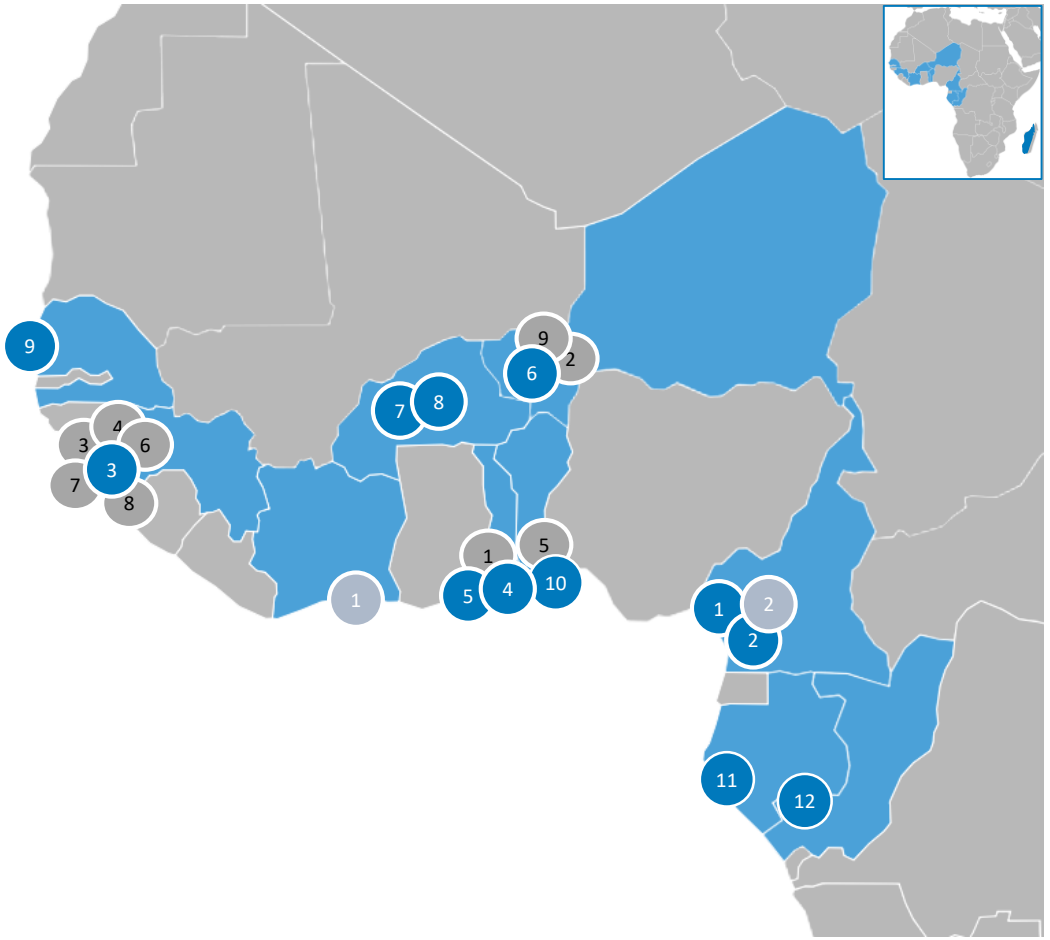
LMP IS THE #1 OF STORAGE TECHNOLOGY IN AFRICA WITH MORE THAN 7 MWH ALREADY OPERATIONAL AND MORE THAN 9 MWH UNDER DEVELOPMENT



Bluezone

1. Togo – Cacavelli
   145 kWp - 360 kWh
2. Niger – Dosso
   70 kWp - 180 kWh
3. Guinea – Kaloum
   145 kWp - 360 kWh
4. Guinea – Dixinn
   145 kWp - 360 kWh
5. Benin – Cotonou
   145 kWp - 360 kWh
6. Guinea – Yataya
   50 kWp - 90 kWh
7. Guinea – Sonfonia
   50 kWp - 90 kWh
8. Guinea – Kagbelen
   50 kWp - 90 kWh
9. Niger – Niamey
   70 kWp - 180 kWh

Bluebus

1. Ivory Coast – Abidjan
   70 kWp - 180kWh
2. **Cameroon** – Yaoundé
   70 kWp - 180kWh

Canal Olympia

1. Cameroon – Yaoundé
   145 kWp - 400 kWh
2. **Cameroon** – Douala
   145 kWp - 400 kWh
3. Guinea – Conakry
   145 kWp - 400 kWh
4. Togo – Lomé
   145 kWp - 400 kWh
5. **Togo – Lomé**
   145 kWp - 400 kWh
6. Niger – Niamey
   145 kWp - 400 kWh
7. Burkina – Ouagadougou
   145 kWp - 400 kWh
8. **Burkina – Ouagadougou**
   145 kWp - 400 kWh
9. Senegal – Dakar
   145 kWp - 400 kWh
10. Benin – Cotonou
    145 kWp - 400 kWh
11. Gabon – Port Gentil
    145 kWp - 400 kWh
12. Congo – Brazzaville
    145 kWp - 400 kWh
13. Madagascar – Antananarivo
    145 kWp - 400 kWh

Under development

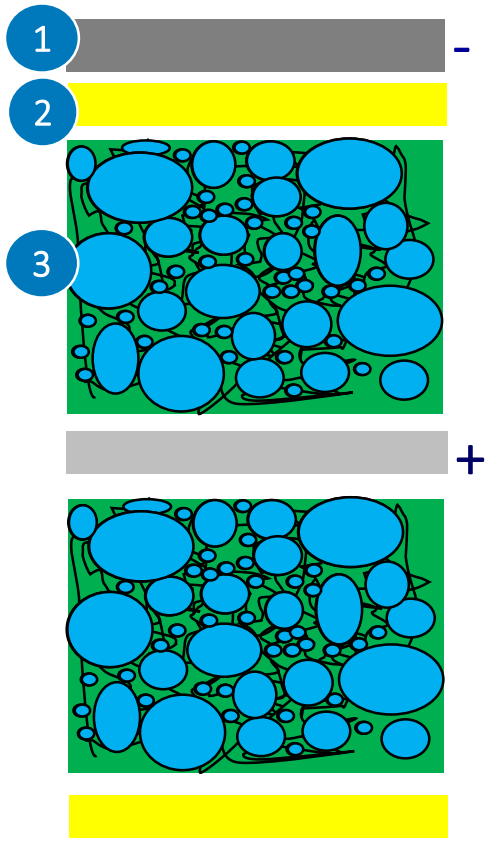
CanalOlympia

- Guinea – Tombolia
  145 kWp - 400 kWh
- Congo – Pointe Noire
  145 kWp - 400 kWh
- Congo – Oyo
  145 kWp - 400 kWh
- Nigeria
  300 kWp - 800 kWh
- Rwanda – Kigali
  145 kWp - 400 kWh
- + 10 other countries

Mini-Grids

- Tanzania – Kigali
  100 kWh
- Benin
  3,5 MWp - 4 MWh
- Madagascar – North
  645 kWp - 1000 kWh
- Sierra Leone – North
  155 kWp - 400 kWh
- Guinea
  155 kWp - 400 kWh

TECHNICAL CHALLENGES IN SOLID STATE TECHNOLOGY



1 ANODE

Mastery of manufacturing processes for Lithium Metal films:

- Homogeneous thickness of only a few µm
- Smooth surface
- Purity
- Interface compatibility with electrolyte

2 ELECTROLYTE

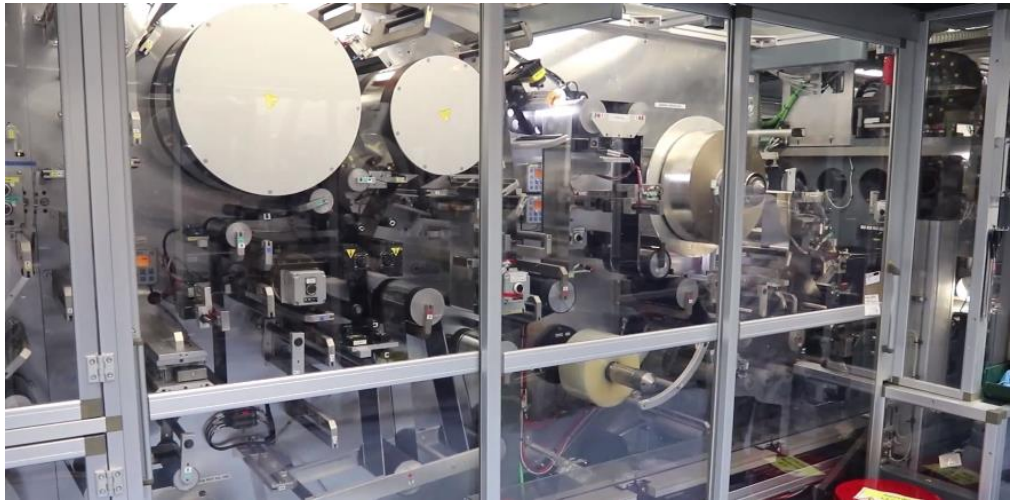
- Solid membrane w/ high mechanical resistance
- Prevention of dendrite formation
- Good conductivity
- Cost Control and density aspects compared to a liquid electrolyte
- Capacity to withstand voltage

3 CATHODE

- Use of high potential materials
- Interface compatibility with electrolyte

CELL

- Mastery of significantly different manufacturing process
- Continuous Manufacturing Process
- Absence of Solvents



Solid-State Cells Manufacturing