Solid State Battery Technology

WORLD BANK – ESMAP Stakeholders Meeting
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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**
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

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$_4$

\[
\text{Li}_1-x\text{FePO}_4 + x\text{Li}^+ + x\text{e}^- 
\]

**Current collector:** Aluminum foil

**Cathode:** LiFePO$_4$

\[
\text{Li}_{1-x}\text{FePO}_4 + x\text{Li}^+ + x\text{e}^- 
\]

**Electrolyte:** PEO + Lithium salts

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**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

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**PERFORMANCE**

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

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

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**LIMITATIONS**
- Not suitable for power applications (nominal discharge C/2)
- Electrolyte conductivity from 60 °C
Extrusion of ultra thin films used as anodes, electrolytes and cathodes

Manufacturing of cells by stacking of films to create modules

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

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Additional Notes
MICROGRIDS USING SOLID-STATE BATTERY TECHNOLOGY

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

4. **CELL**
   - Mastery of significantly different manufacturing process
   - Continuous Manufacturing Process
   - Absence of Solvents
Solid-State Cells Manufacturing