e-ASIA Workshop

Electro-Acoustic Charging and Integrated Waste-to-Energy Approach for Enhancing Lead-Acid Batteries in Renewable Energy Storage

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2024.01.17

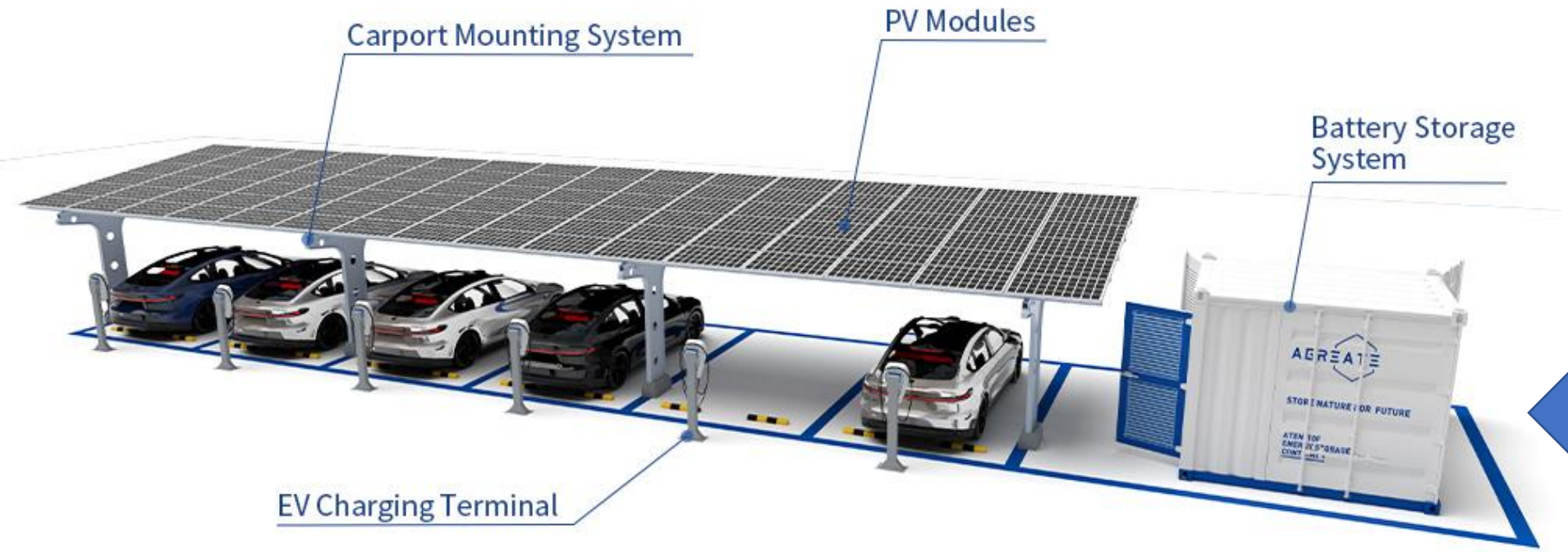
SCIENCE FOR CHANGE PROGRAM

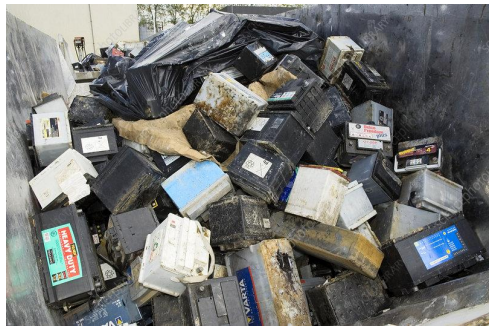
Rationale

Lead-Acid Battery

1.7 million metric tons toxic waste

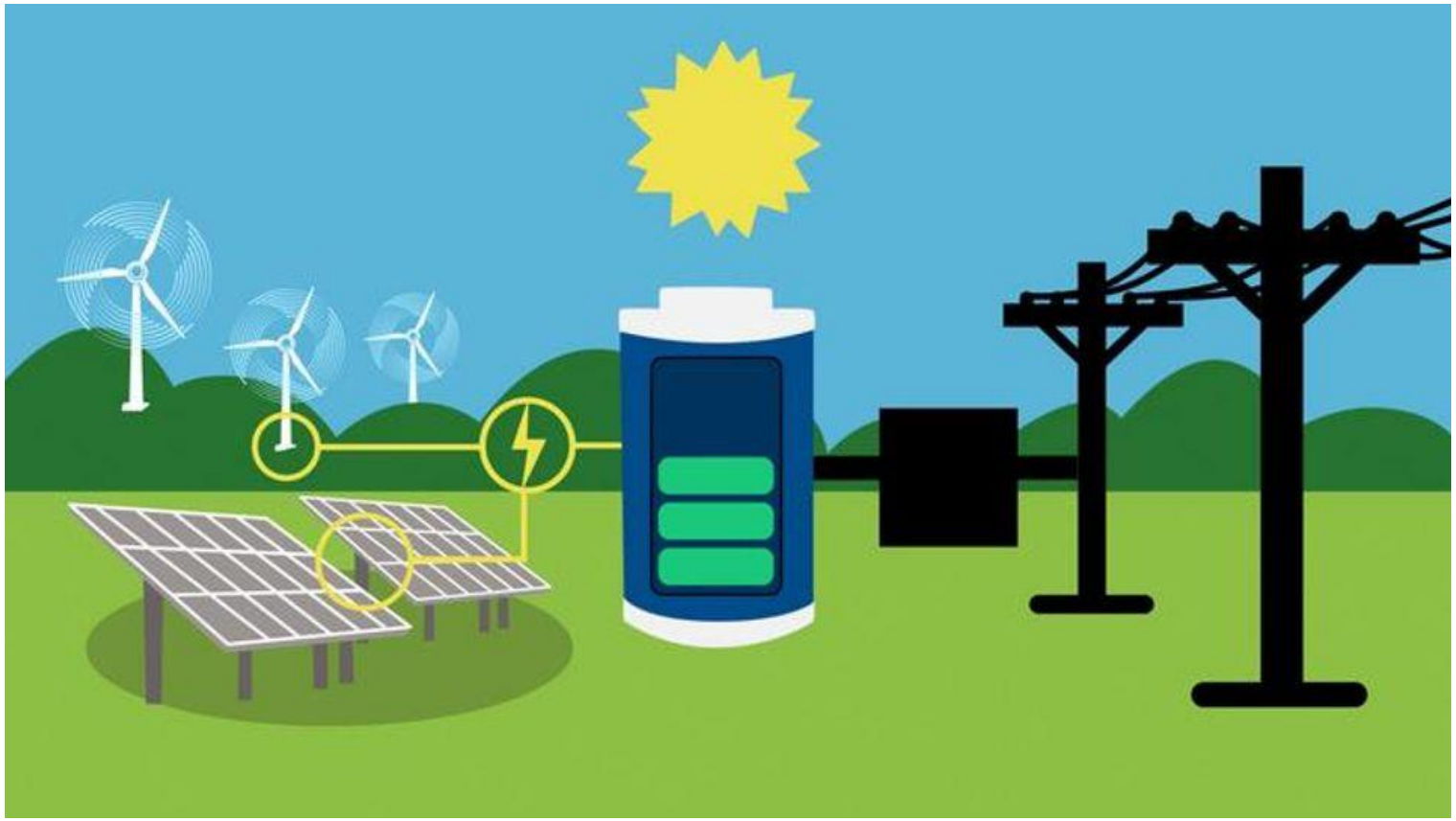
Introduction



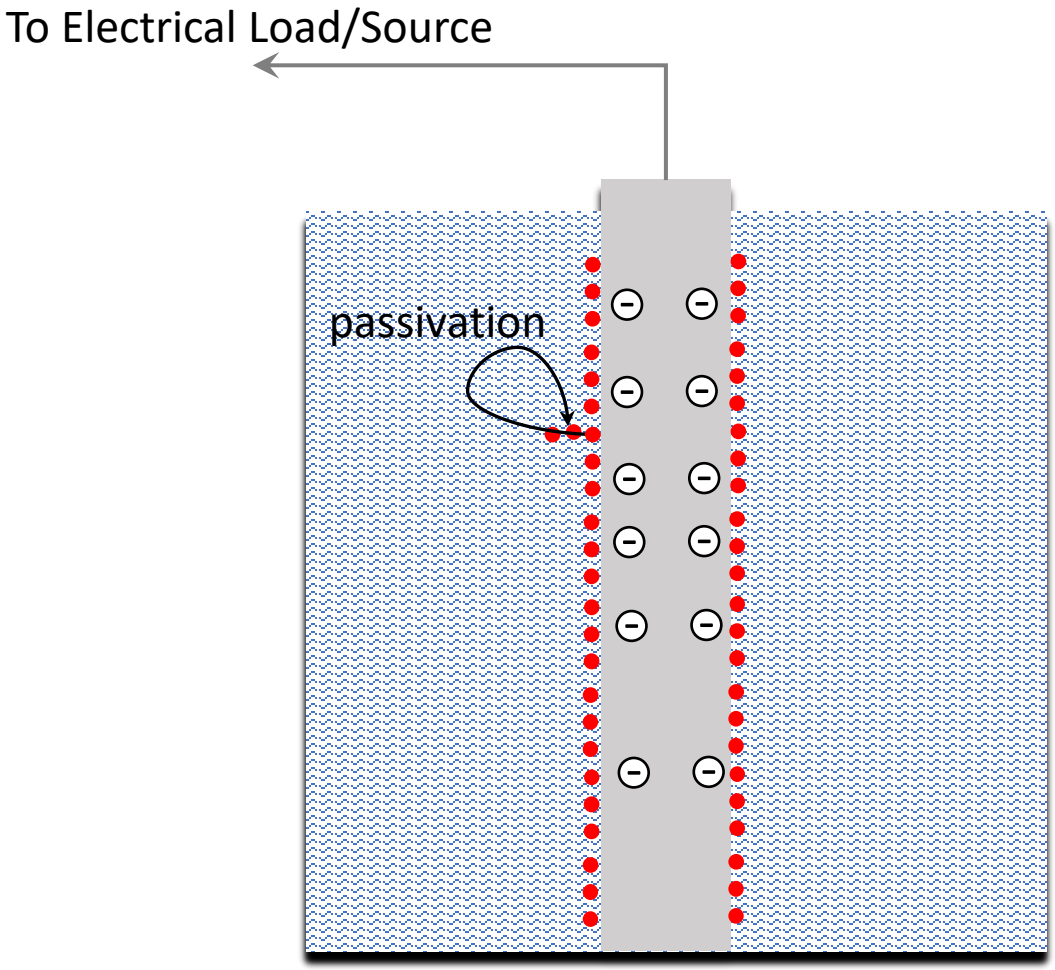


Problem

Intermittent renewable sources ***shorten*** battery life



Solution

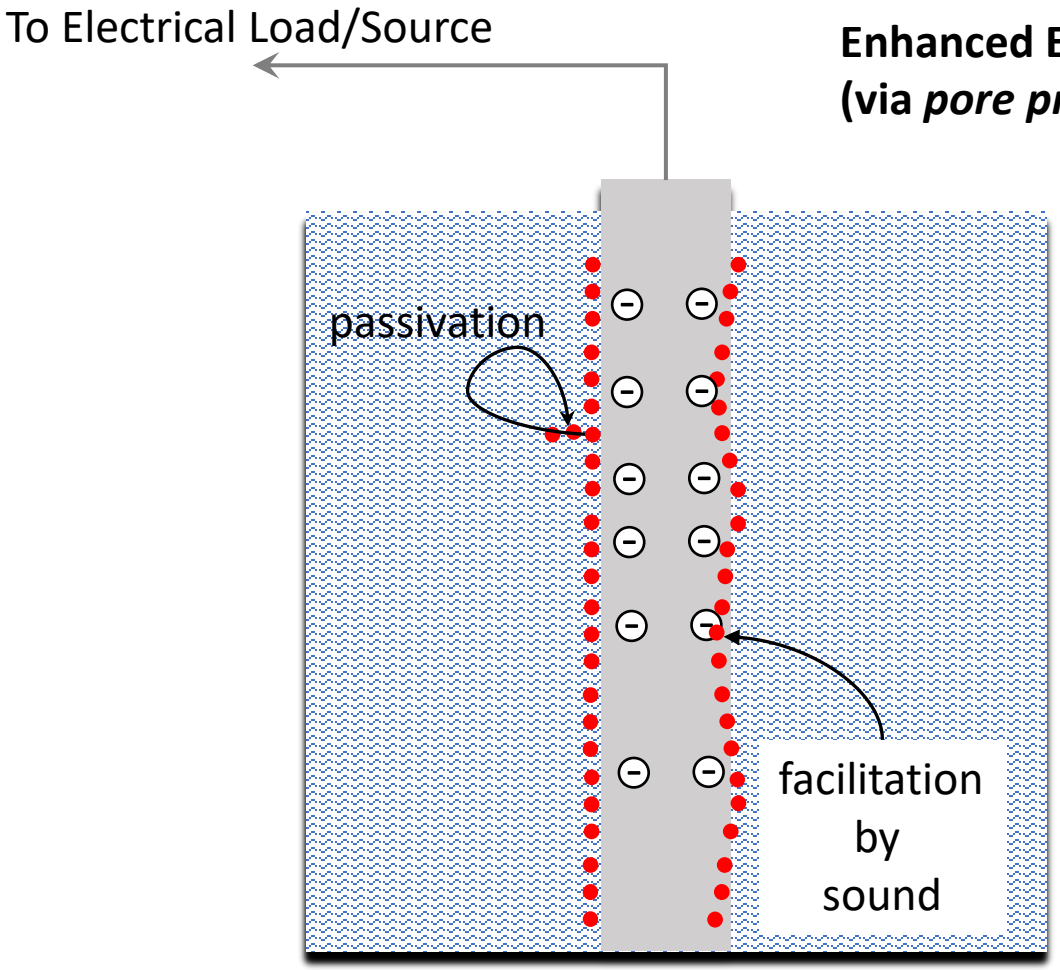


$$Pb^{2+} + SO_4^{2-} \xrightarrow{\text{yields}} PbSO_4$$

$$PbSO_4 + 2e^- \xrightarrow{\text{yields}} Pb + SO_4^{2-}$$

- lead sulfate ($PbSO_4$)
- ⊖ electrons ($2e^-$)
- negative electrode
- electrolyte (liquid)

Solution



Enhanced Electron-Sulfate Interaction
(via *pore pressure reconfiguration*)

$$Pb^{2+} + SO_4^{2-} \xrightarrow{\text{yields}} PbSO_4$$

$$PbSO_4 + 2e^- \xrightarrow{\text{yields}} Pb + SO_4^{2-}$$

- lead sulfate ($PbSO_4$)
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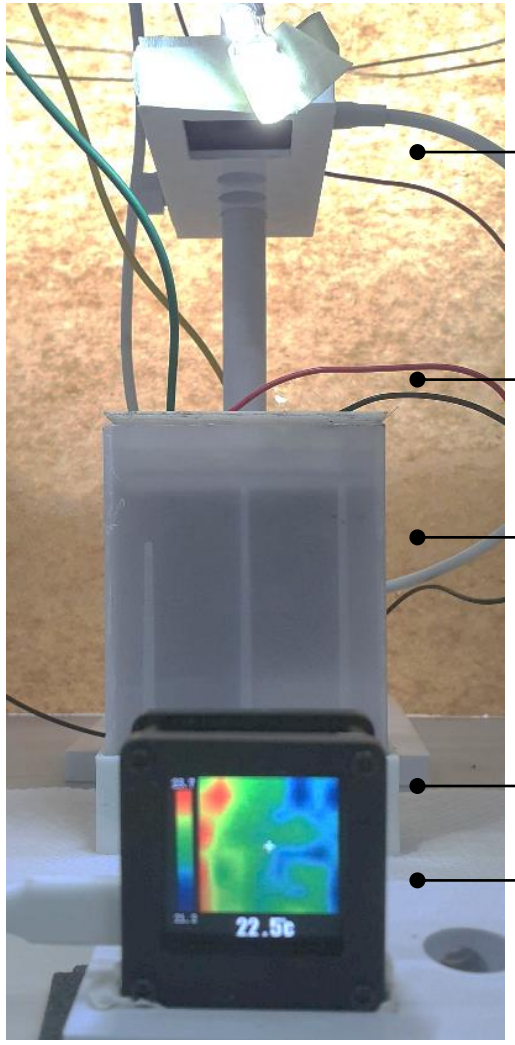
Experiments



Top IR thermal imager

Wires to potentiostat

Cell compartment

Transducer attachment

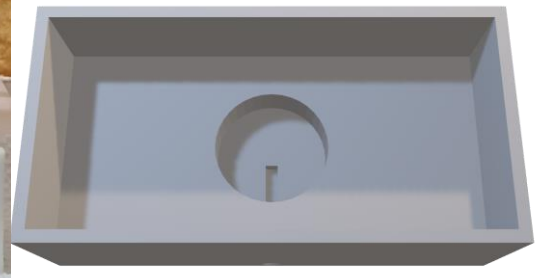
Front IR thermal imager

Nominal cell capacity: 2 Ah
Discharge current: 500 mA
Recharge current: 500 mA

Max voltage (0% depth): 2.40 V
Min voltage (100% depth): 1.75 V

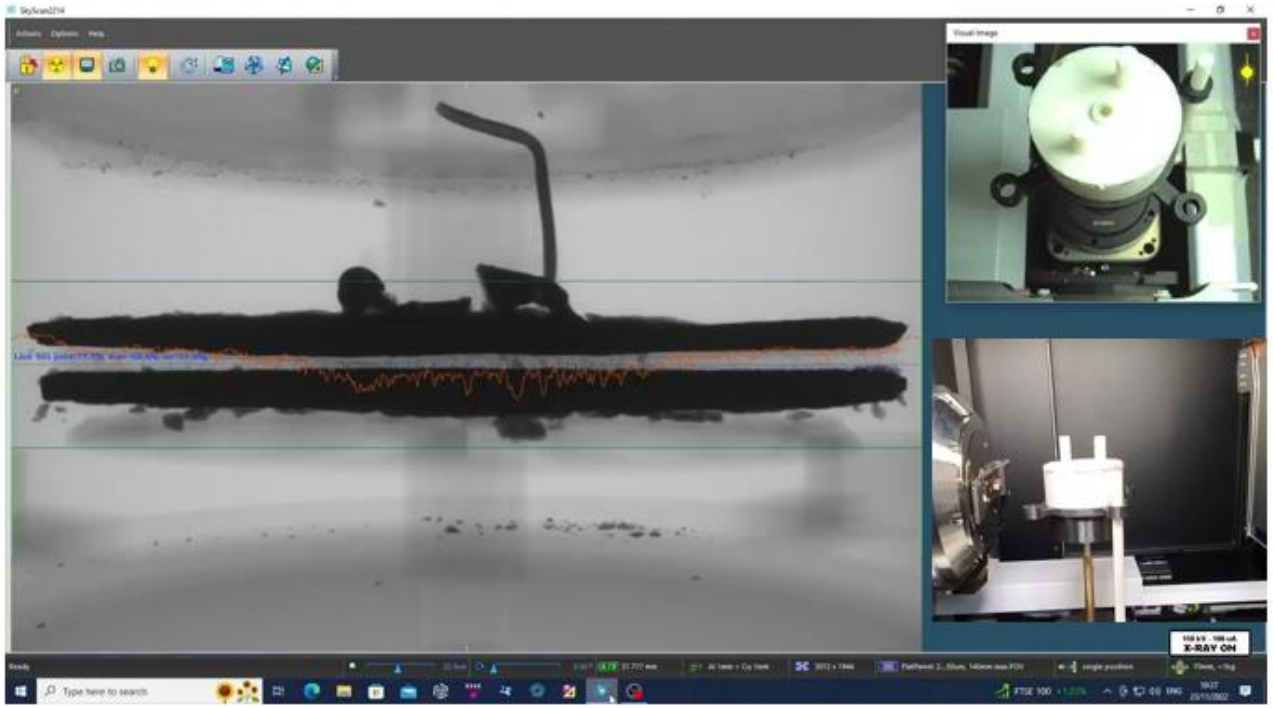
Cycle max duration: 4 h

Transducer module

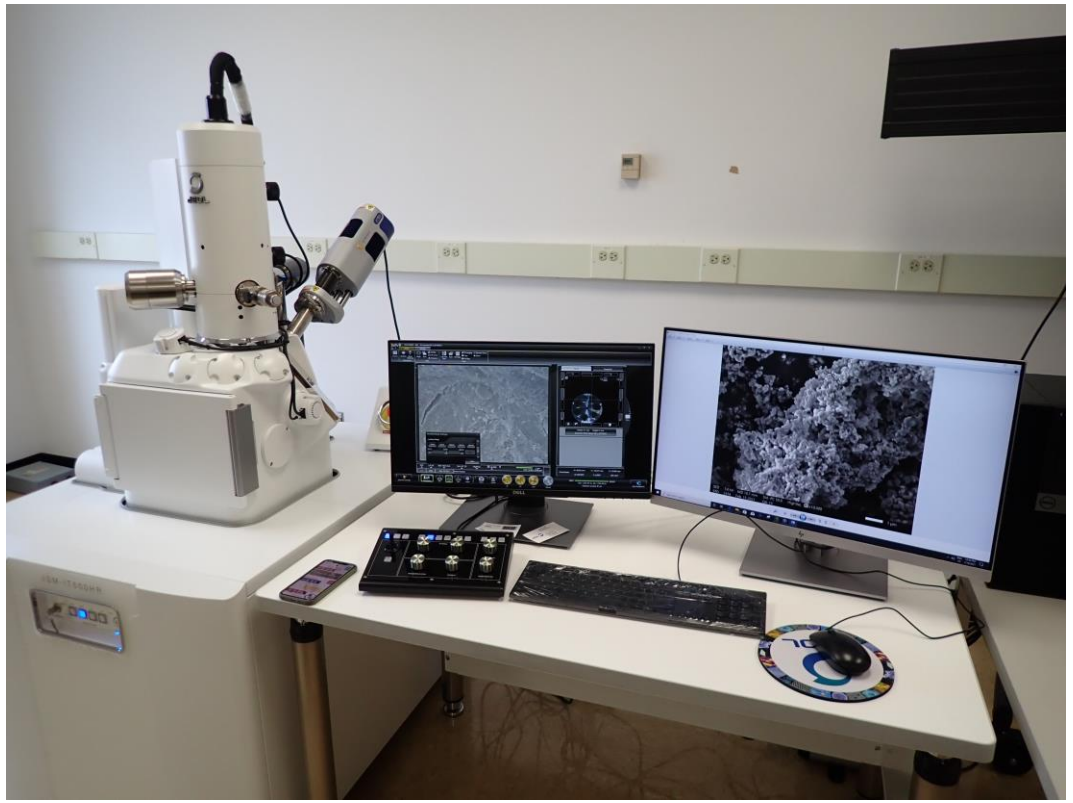


Diagnostics

X-ray nanotomography

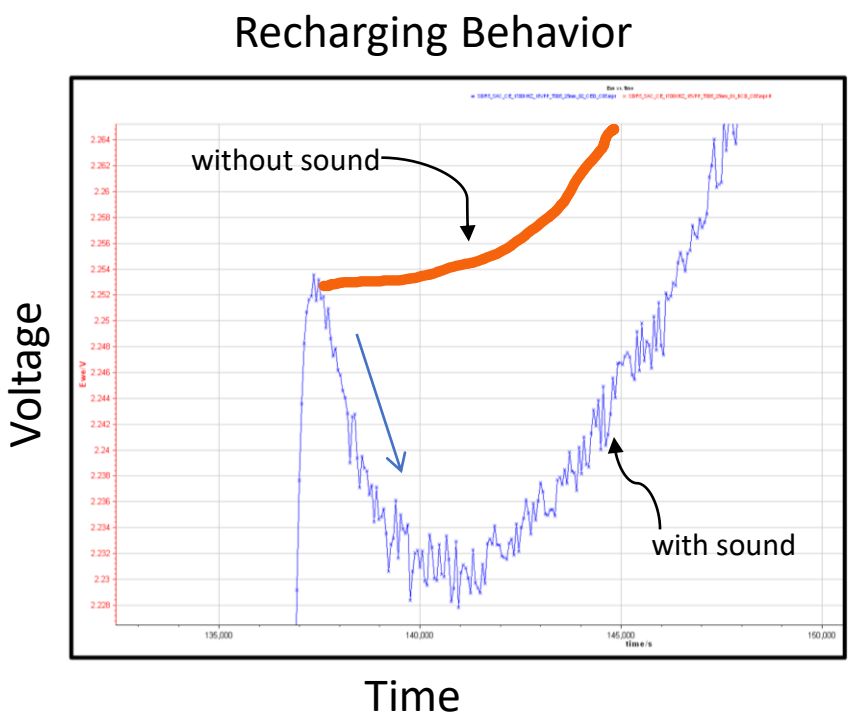


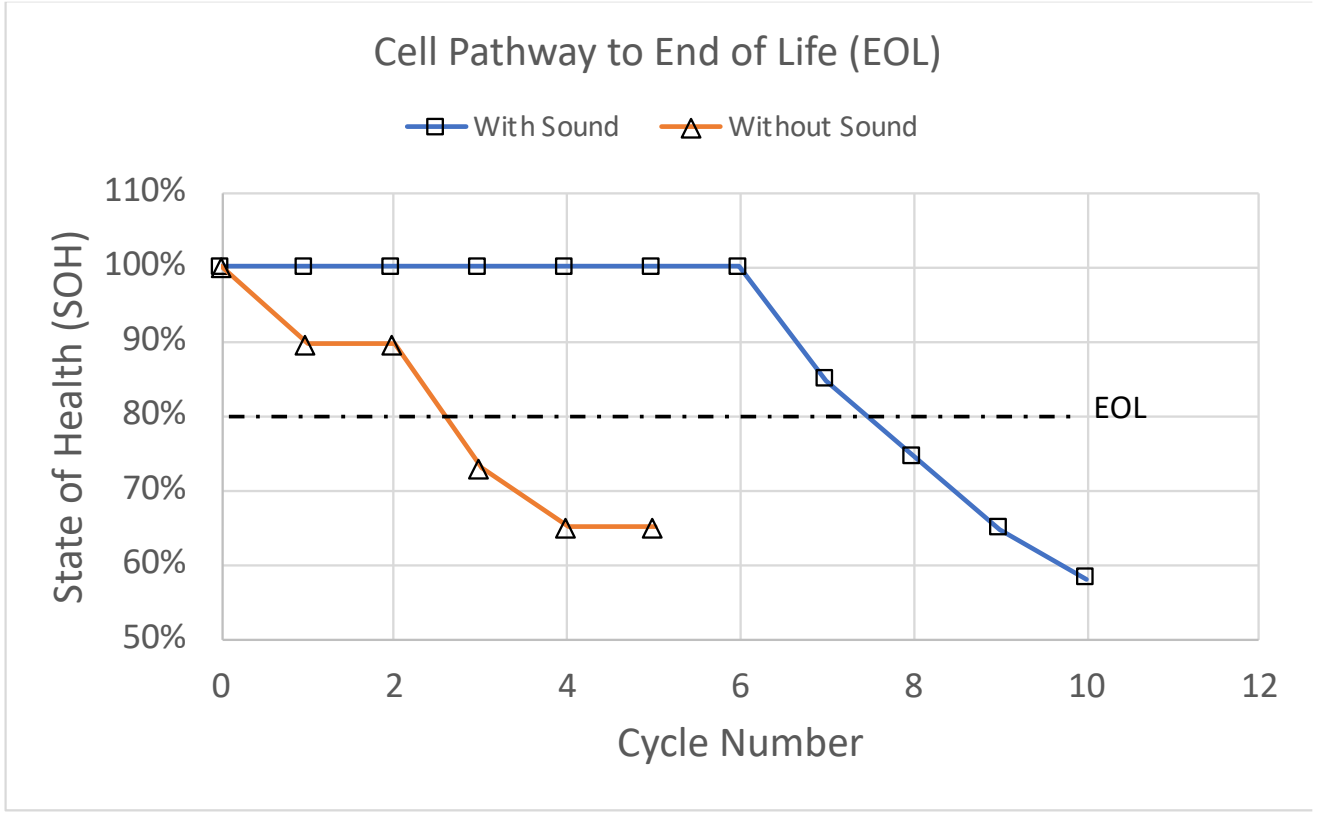
Scanning electron microscopy



Results

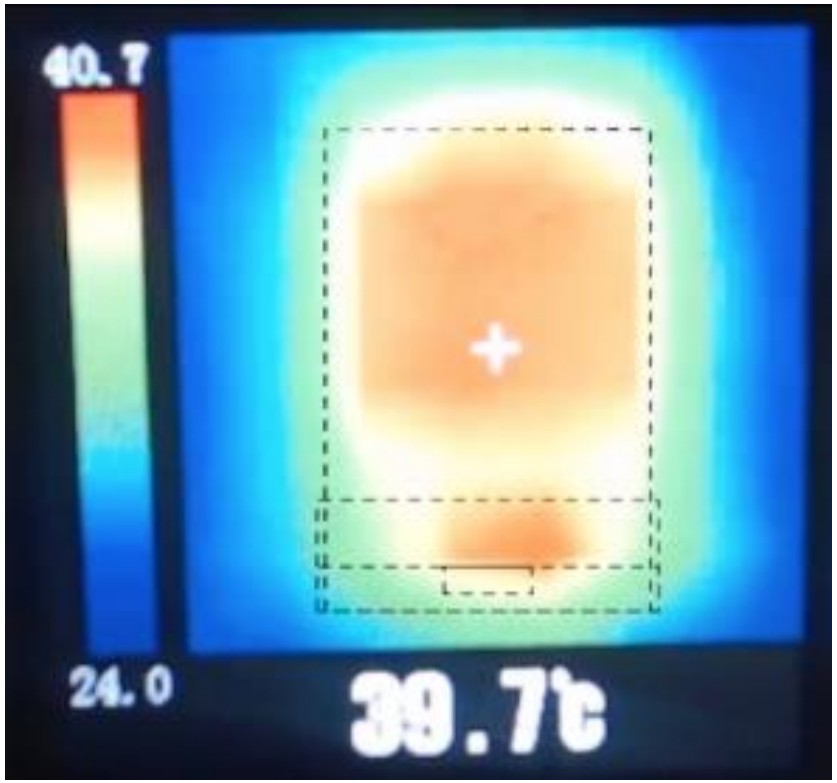
Enhanced electron-sulfate interactions reduce the electrode resistance while recharging



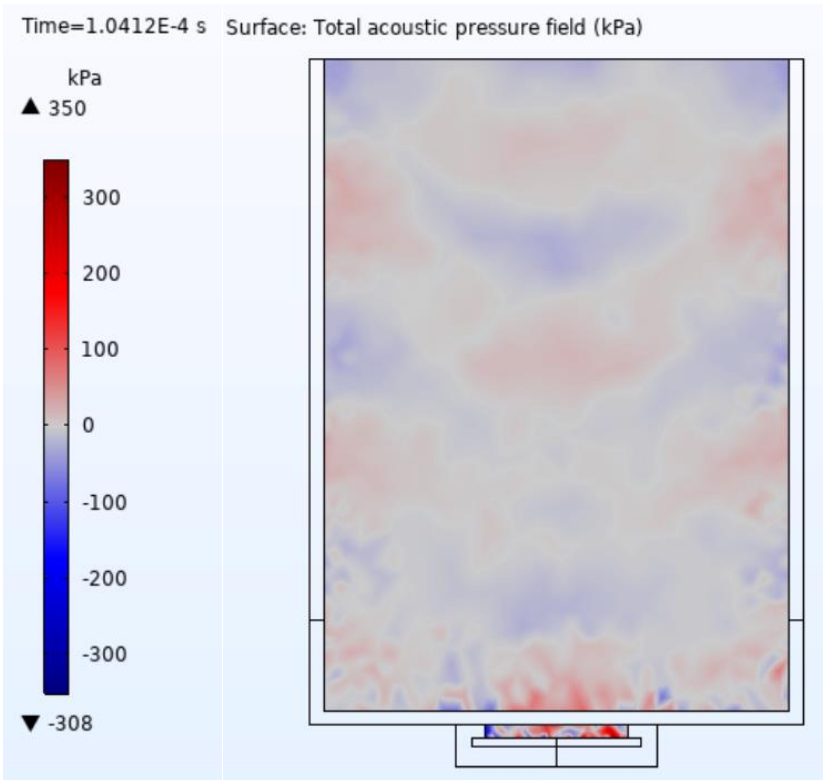


Results

Temperature and Pressure Measurements corroborate the pore pressure reconfiguration hypothesis



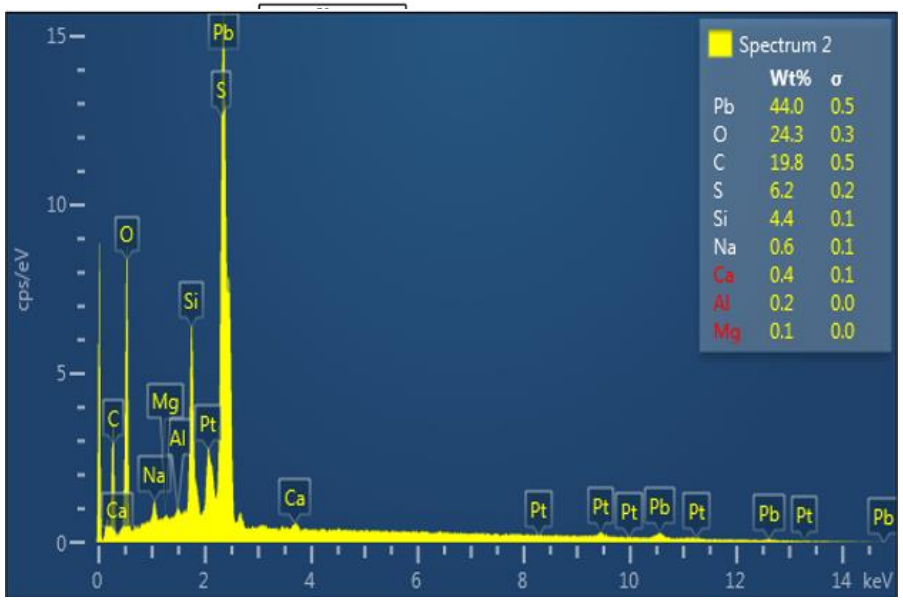
Measurement

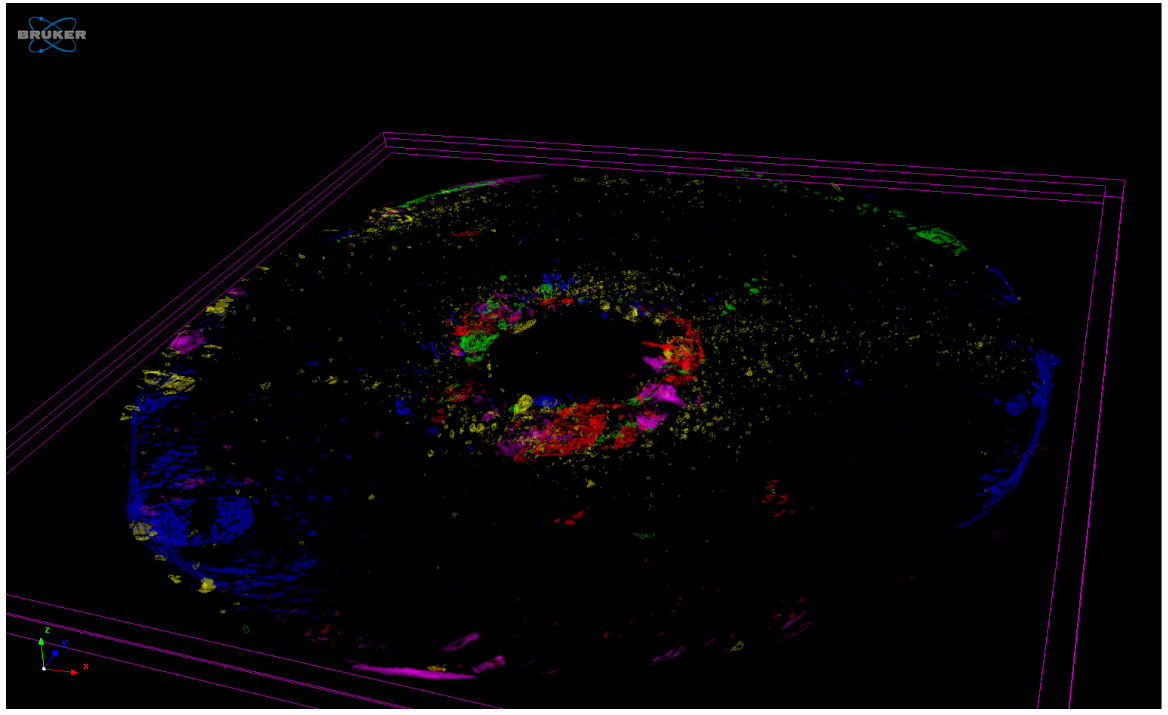


Multiphysics Simulations

Results

Diagnostics reveal fewer lead sulfates after four deep cycles when exposed to sound

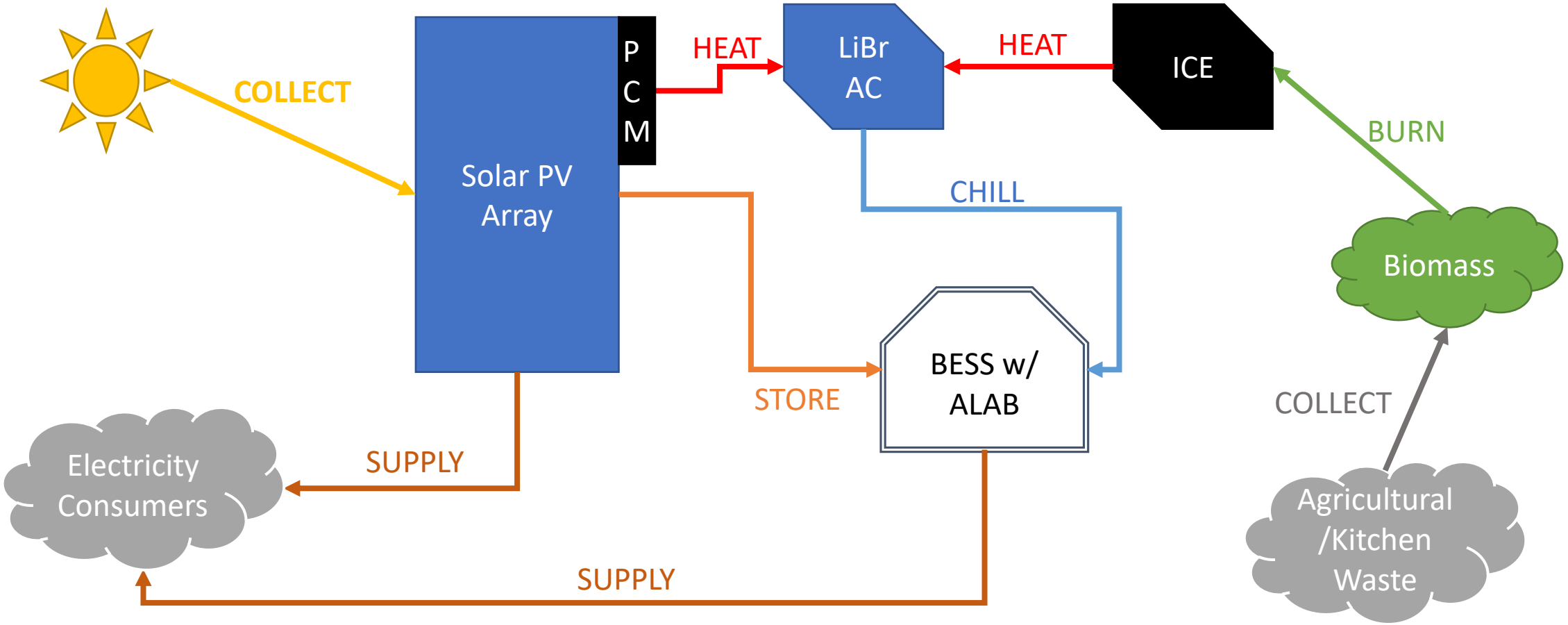




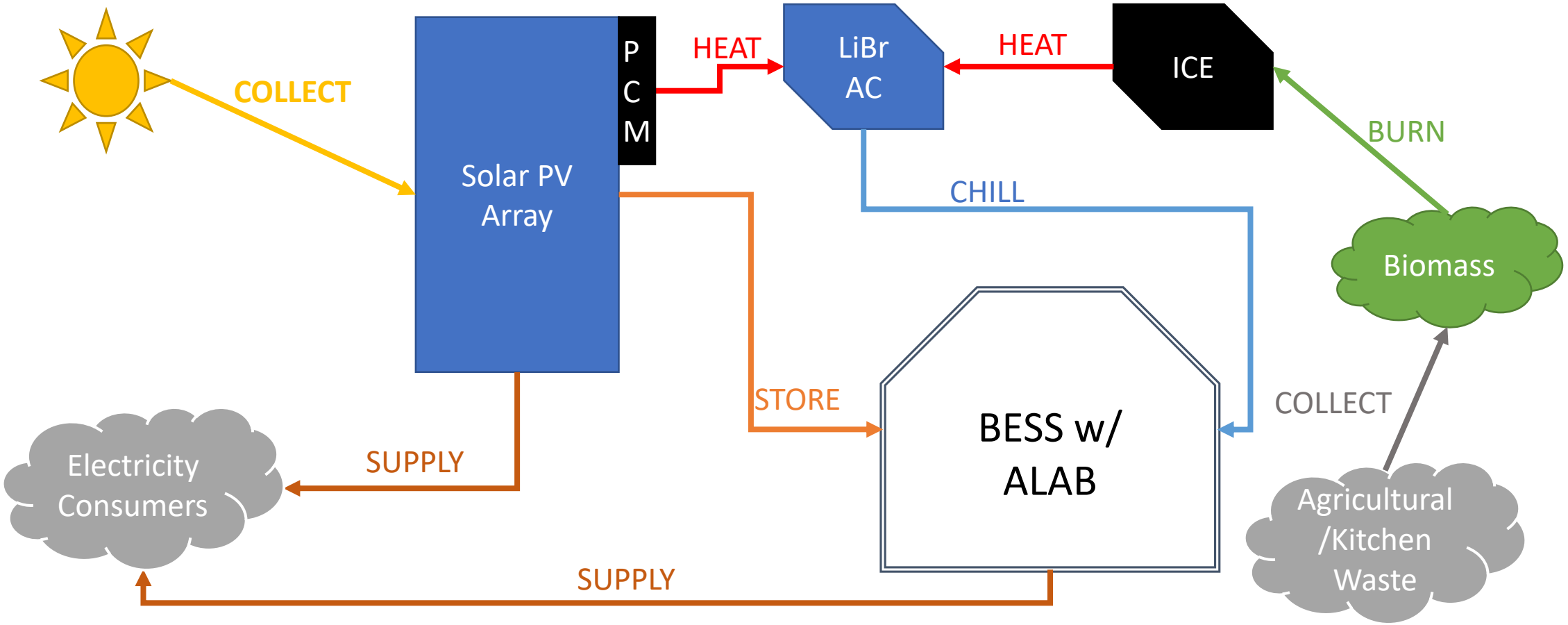
	☑	Volume	%	Color	Cut/clip
1	☑	SDR T3	20		None
2	☑	SDR T4	20		None
3	☑	SDR T5	20		None
4	☑	CTRL T2	20		None
5	☑	CTRL T1	20		None

DESIGNATION	Object Volume Total (Slice 330 - 351)	Notes
CTRL T1	9.14250631	4 cycles
CTRL T2	7.42798098	4 cycles
SDR T3	5.76600422	4 cycles
SDR T4	3.90009895	4 cycles
SDR T5	3.89692542	4 cycles

Integrated Waste-to-Energy



Integrated Waste-to-Energy



Conclusion and Recommendations

- Recharging with electricity and sound decreased electrode resistance
- Lower resistance due to enhanced electron-sulfate interaction
- Temperature and pressure consistent with *pore pressure* hypothesis
- Diagnostics: fewer leftover sulfates from electro-acoustic charging

- Scaling up will require engineering in sound injection
- Field tests in battery energy storage, including integration with waste-to-energy approach