Ambri

Batteries for clean energy

Liquid Metal Batteries for Large Scale Energy Storage

Executive Summary

Ambri's batteries are ideal for daily cycling, 4-24 hour duration energy storage applications

- Energy storage systems CapEx at 25% - 50% below 4-hour, Li-ion systems
- 20+ years lifespan with minimal fade
- Safe – no gas generated, no thermal runaway
- Uses commonly available materials

Commercialization Path

- Direct system sales to utilities, IPPs in grid scale energy storage market
- Plan to build, own and operate production of complete DC systems from 2024

Liquid Metal+ Battery

Company Background

- Spun out of MIT in 2010
- Investors include Bill Gates, Reliance New Energy Solar, Paulson & Co, Fortistar, GoRozen, Japan Energy Fund

Ambri Energy Storage Systems

Ambri cell, tray, tower configuration

Energy Storage + System

Ambri-based system

Insulated container with outer wall at ambient temperature

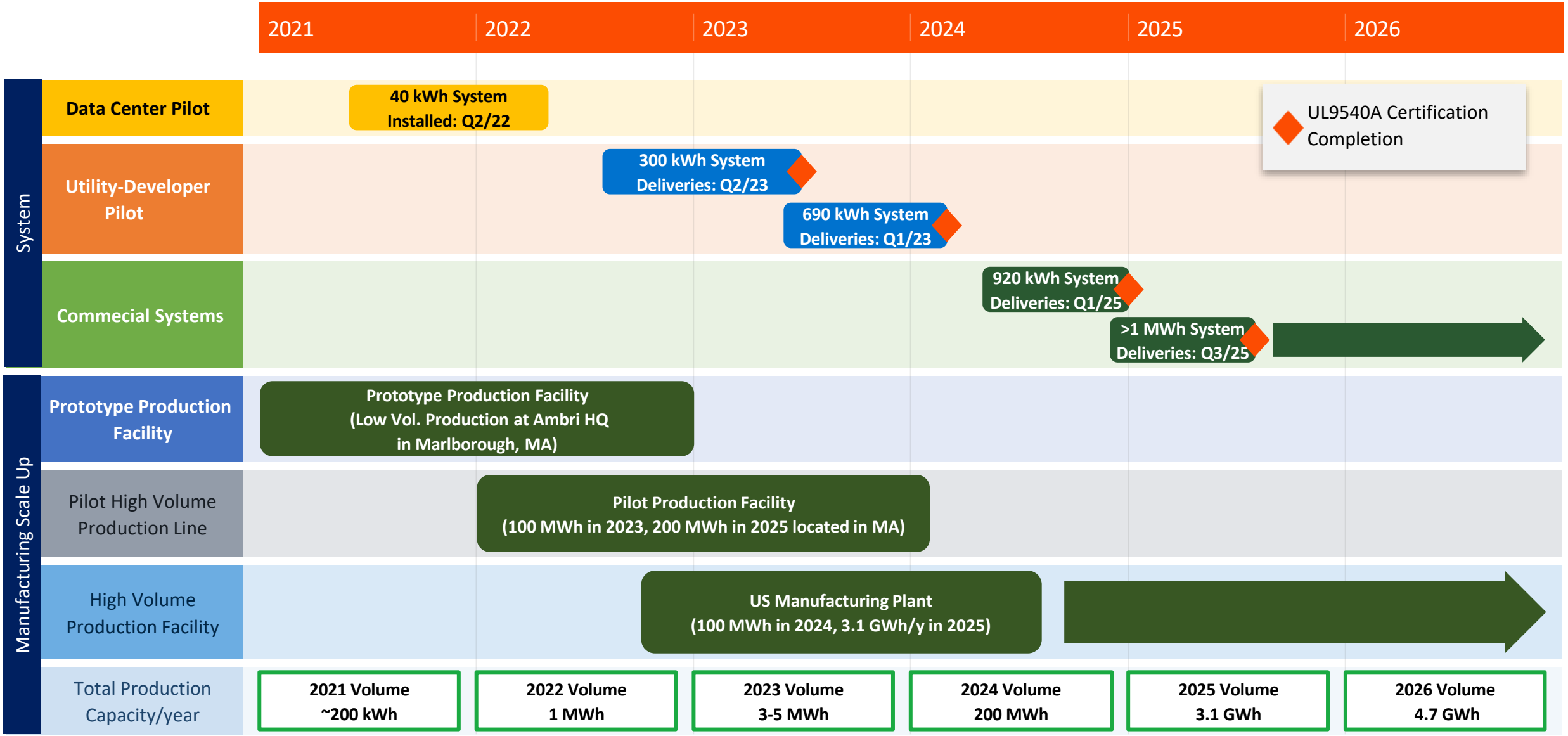
Liquid Metal Battery cell → Tray: 50+ cells → System: 10+ trays per 10' shipping container

Projected System Specifications

Power at rated energy	250 kW
Energy at Cp/4	1 MWh
Voltage	550 - 1150 VDC
External temperature range	-50°C to 100°C
DC-DC Efficiency	80% to 90% from C/4 to C/12
Internal operating temperature	485-525°C
Response time	Instantaneous
Dimensions	10' x 10' x 8' container
Design life	20 years

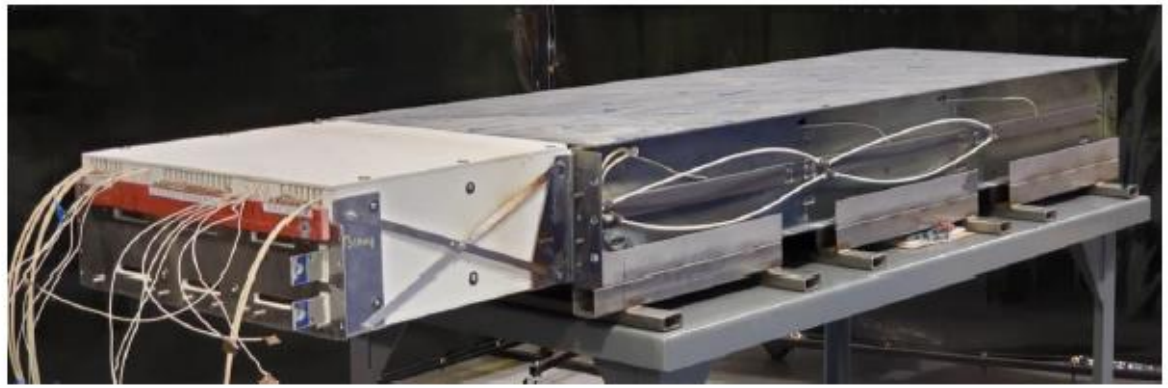
- **Modular design** – Fully populated containers to be combined for GWh-scale projects
- **Reliable** – No moving parts, always operating, redundant design
- **Scalable** – Global production capacity with commonly available materials
- **High performance in all environmental conditions** – no HVAC required in all ambient conditions

Ambri Product and Manufacturing Roadmap

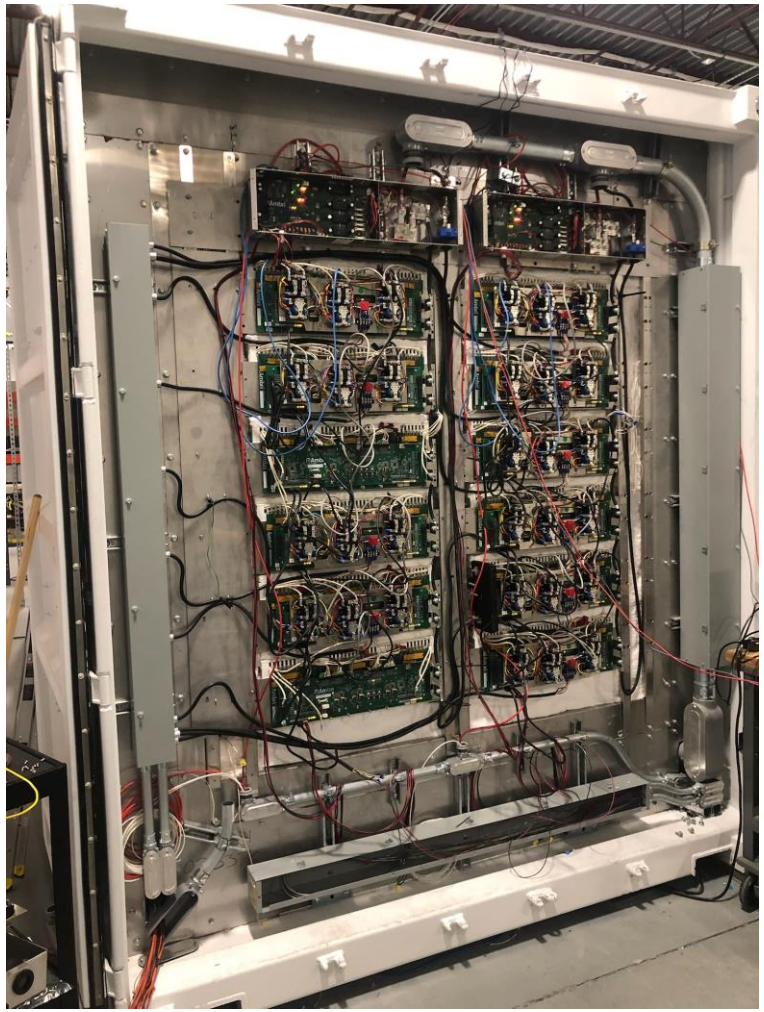


System Set-Up – Tray and System

Completed Tray



Assembled System



Ambri

Batteries for clean energy

Technology Overview

High Temperature Ambri Batteries

Ambri's batteries – a high temperature, Calcium || Antimony cell

- 500°C operating temperature inside insulated container
  - Self-heated from usage – no parasitic load

→ Use of low cost materials
  - Anode and electrolyte melt at high temp – "liquid metal battery"
  - Non-conductive solid metals at room temperature

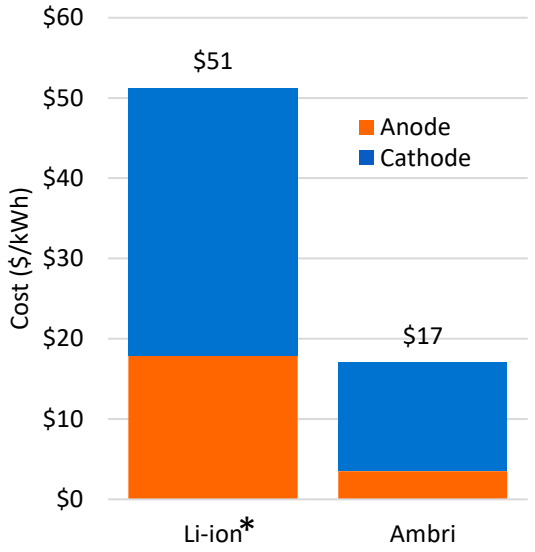
→ Minimal capacity degradation

→ Does not generate pressure or overheat under short, overcharge, over-discharge conditions

Targeted at Large Scale Energy Storage Market, 4 – 12 hour duration

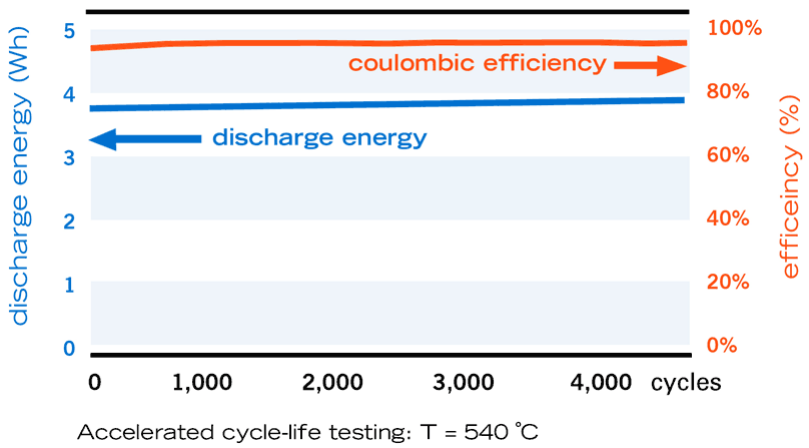
- Best suited for >10MWh, daily cycling applications
  - Solar + storage
  - Clean Peak
  - T & D deferrals

Li-ion electrodes cost 3x more than Ambri's



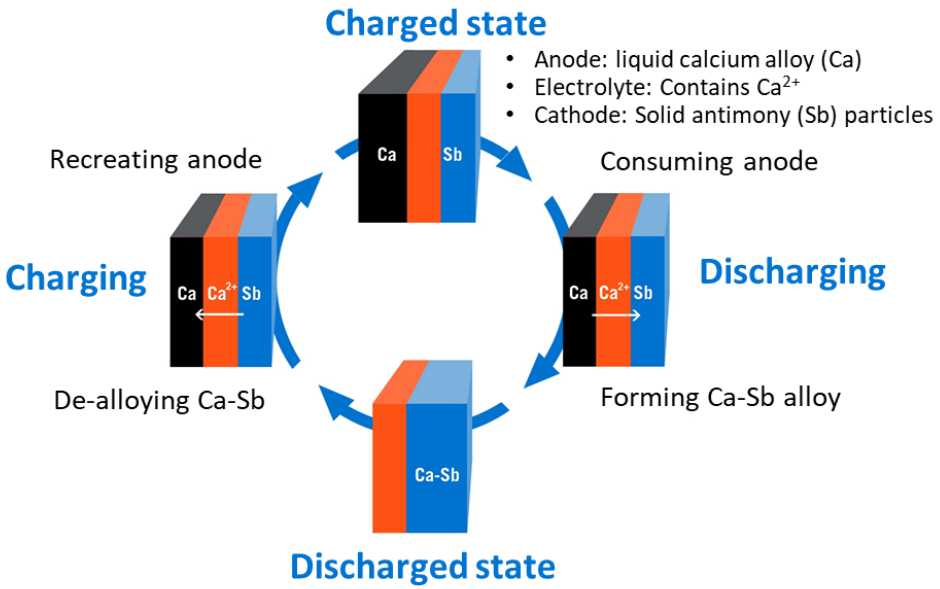
Source: Bloomberg NEF, based on Li-ion NMC chemistry

Stable cycling performance

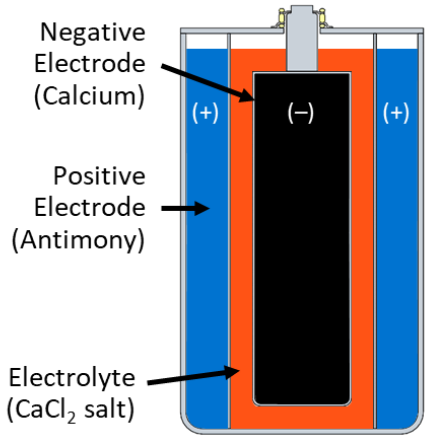


Accelerated cycle-life testing: T = 540 °C

The Liquid Metal Battery



Cell Cross Section



Novel Cell Technology

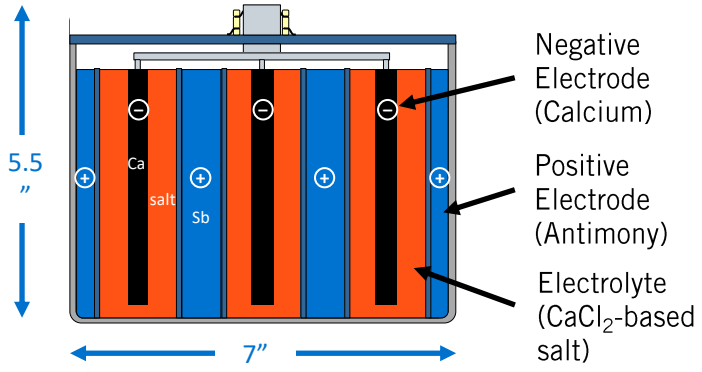
- Commonly available materials
  - Molten calcium alloy anode
  - Solid antimony cathode
  - Molten salt electrolyte
  - Stainless steel cans and anode plates
- Hermetic, welded prismatic construction

Cell Design

Key characteristics:

- **Multiple** vertical electrode plates
- **High-capacity** cells (500 → 1200 Ah)
- **"Lunch-box" sized** cells
  - *Allows for ~1000 cells in series per container, to reach required voltage vs. "one massive cell"*
- **Simple assembly**

Multi-plate vertical electrode cell configuration, Schematic Cross-Section



Cell can assembly from key supplier

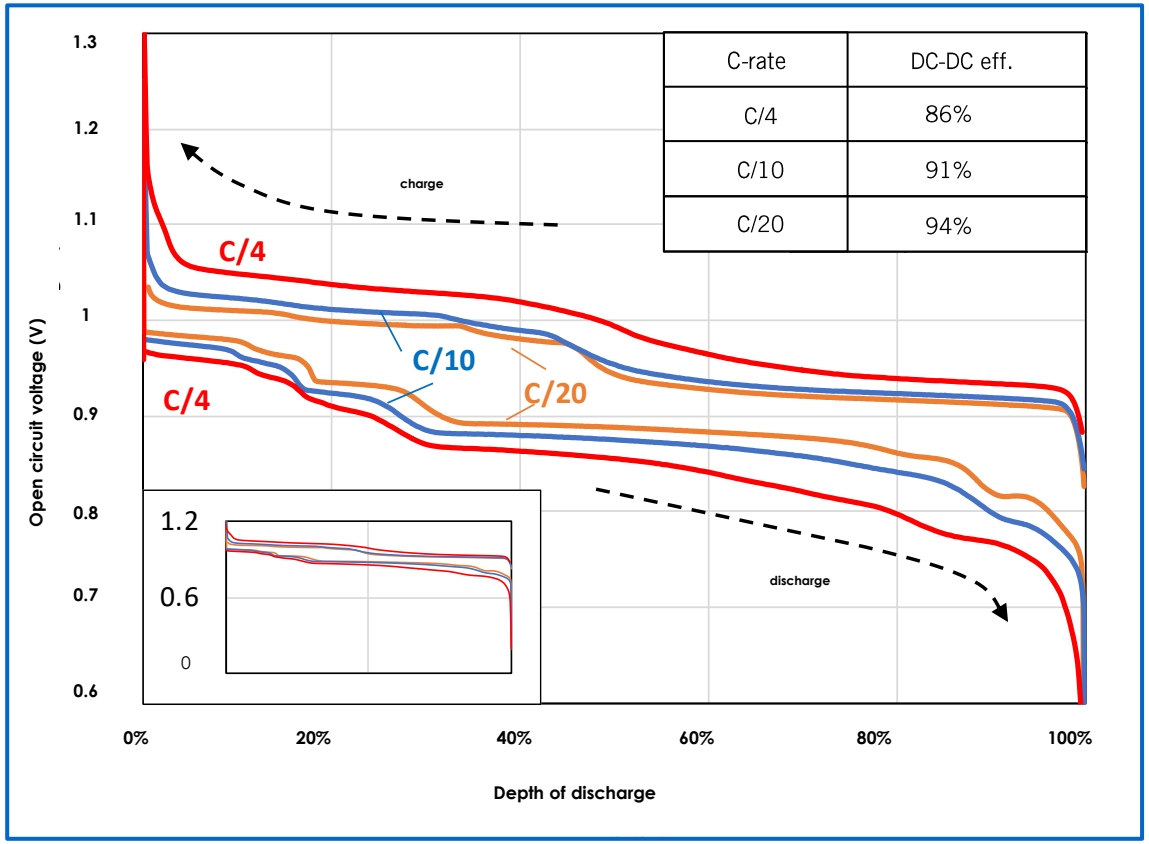
Final cell assembly

Good Cell Efficiency

80 – 90% Efficiency in Daily Cycling

- R&D cells with 86-94% round-trip DC-DC efficiency
- Commercial cells targeting 80-90% at 4 hr cycling rate
- → ***Performance confirmed by independent third-party testing group in 2021***

Voltage Profiles & Efficiencies of R&D Cells

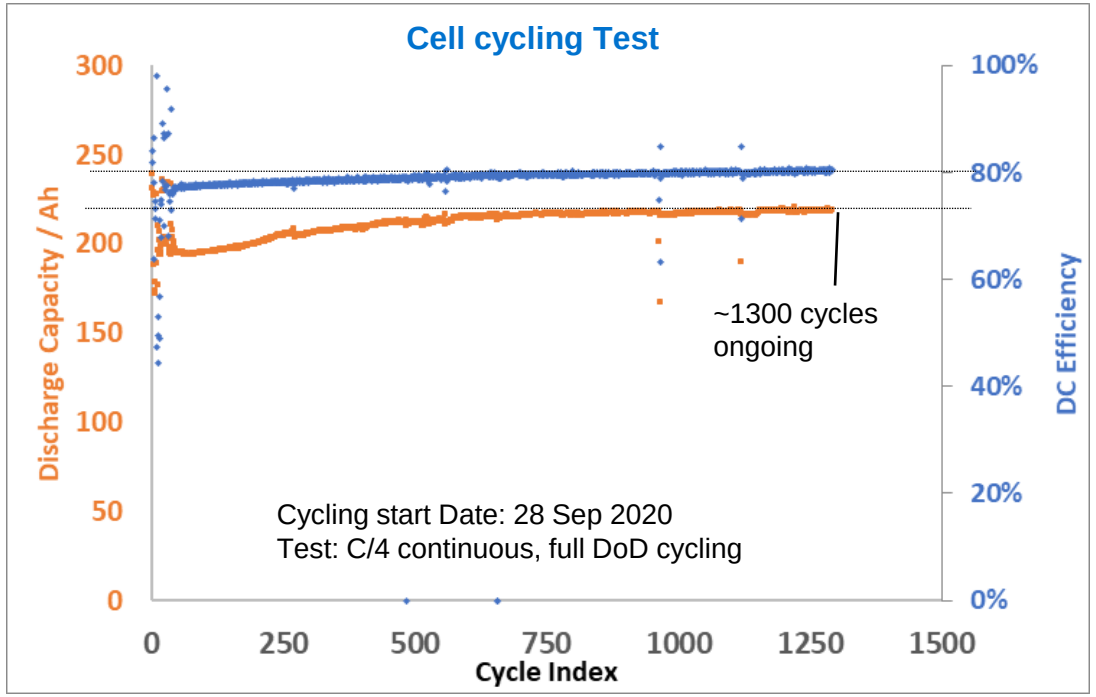


C-rate	DC-DC eff.
C/4	86%
C/10	91%
C/20	94%

Ambri

Cell Development Update

18 Months of Repeated Cell Production



No capacity degradation during ongoing testing of production cells

Fundamental Waste Advantages

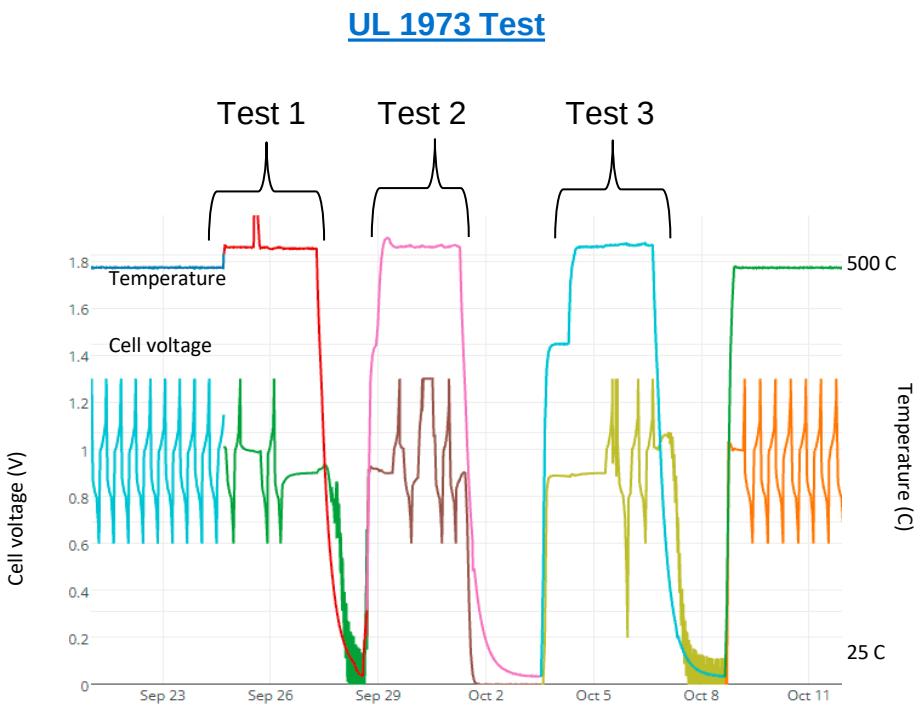
- Recycling and disposal
  - Stainless steel and Sb easily collected and recyclable
  - $35,000 value for these materials per container
  - Suggests positive decommissioning value at end of life

Cell materials are safety handled and processed

Safety Testing: UL1973

UL 1973 Safety Certification Complete

- Temperature excursion, high voltage float, short circuit
- No safety issues, ran successfully thereafter



Cell used to perform UL1973 testing on a "cycled cell". Cell not only completed the test without failure but returned cycling with no performance impact. In fact, the capacity grew 3-4% during the testing (Cell: C5-50252).

Safety Testing: UN38.3 Transportation

Ambri's cells tested by 3rd party for transportation safety; passed all tests

AMBRI INC
UN38.3 TRANSPORTATION TESTING

SCOPE OF WORK
Model Number: CC-08.01

REPORT NUMBER
104670244DET-001

ISSUE DATE
20-September-2021

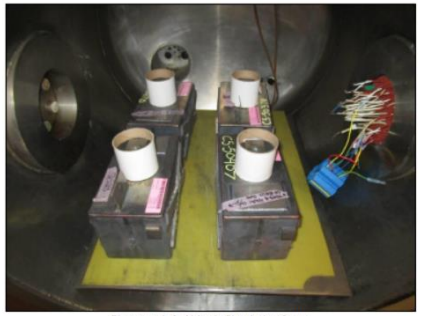
PAGES
58

DOCUMENT CONTROL NUMBER
RT-L-AMER-DET-003

Ambri Inc.
September 20, 2021
Client P.O. No.: E02654

Report No.: 104670244DI
Page 1

APPENDIX A – PHOTOGRAPHS
T1 – Altitude Simulation



Photograph 1: Altitude Simulation Setup

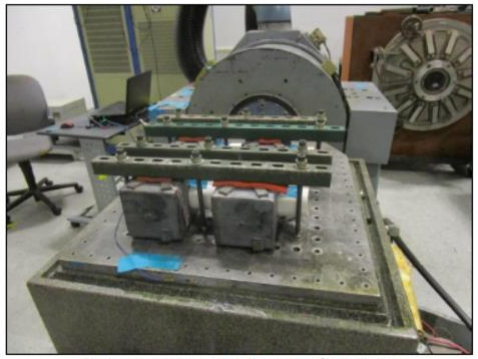
Ambri Inc.
September 20, 2021
Client P.O. No.: E02654

Report No.: 10467024
Pag

APPENDIX A – PHOTOGRAPHS (cont'd)
T2 – Thermal Test

Photograph 2: Thermal Test Setup

APPENDIX A – PHOTOGRAPHS (cont'd)
T3 – Vibration



Photograph 3: Vibration Test Setup – Fore/Aft Direction

RESULT SUMMARY: The tested samples met the test requirements. See below breakout for tests performed.

Specification Section	Test Description	Results
T1	Altitude Simulation	Conforms
T2	Thermal Test	Conforms
T3	Vibration	Conforms
T4	Shock	Conforms
T5	External Short Circuit	Not Applicable
T6	Impact/Crush	Conforms
T7	Overcharge	Not Applicable
T8	Forced Discharge	Not Applicable

*Tests T5, T7, and T8 were not applicable as the battery cells are not electrochemically active at ambient temperatures below approximately 500°C.

Results – Ambri's initial commercial-sized passed UN38.3 Transportation testing, not safety issues to report.

Ambri Building Block of Energy and Power

Building block of energy and power:

- 8 MW / 8.34 MVA / 32 MWh

Similar footprint density to the best Li-ion

300 MW, 1,200 MWh Layout

Site Layout:

38 power blocks

317 MVA total

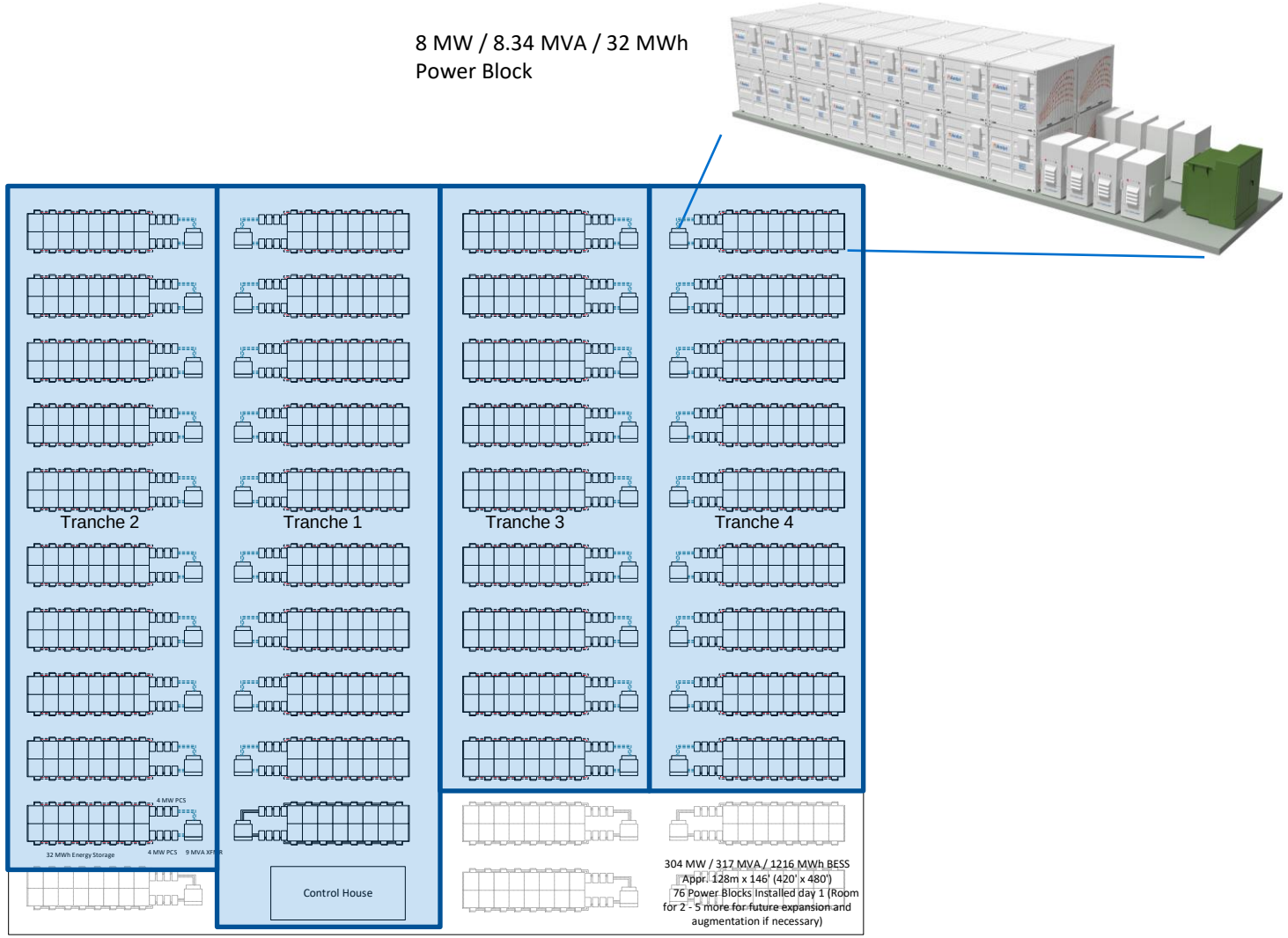
304 MW total

1216 MWh

128m x 146m (4.6 Acres)

(5 spare spaces for future augmentation if necessary)

65 kWh/m^2



Simple Cell Design Allows For Low-Cost Manufacturing Plants

- Ambri planning to build/own/operate GWh cell and system manufacturing plants
- 3-4 total facilities would serve regional markets
  - US, Europe, SEA/Australia, and/or MEA
  - JV partners to be considered in some cases

$56M for Ambri GWh factory vs. $114-142M for Li-ion*

* "Gigafactory", Tesla, https://www.tesla.com/sites/default/files/blog_attachments/gigafactory.pdf

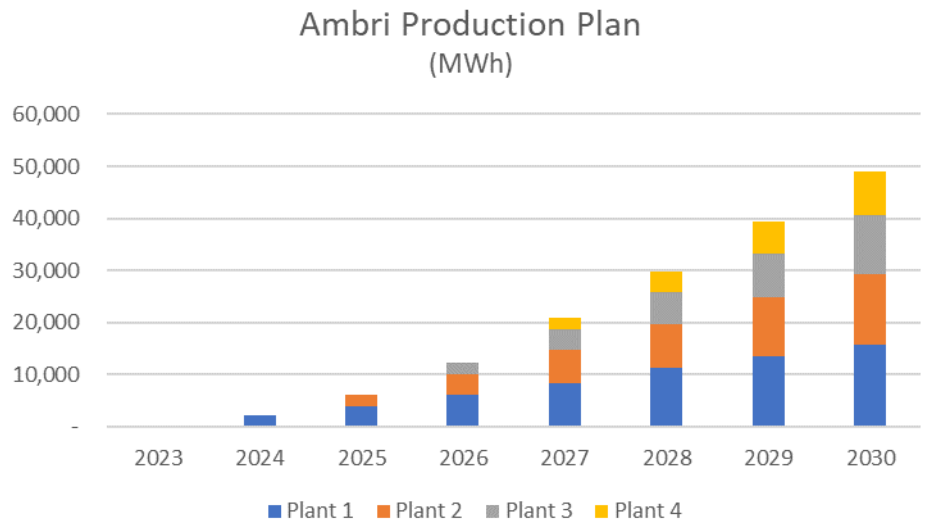
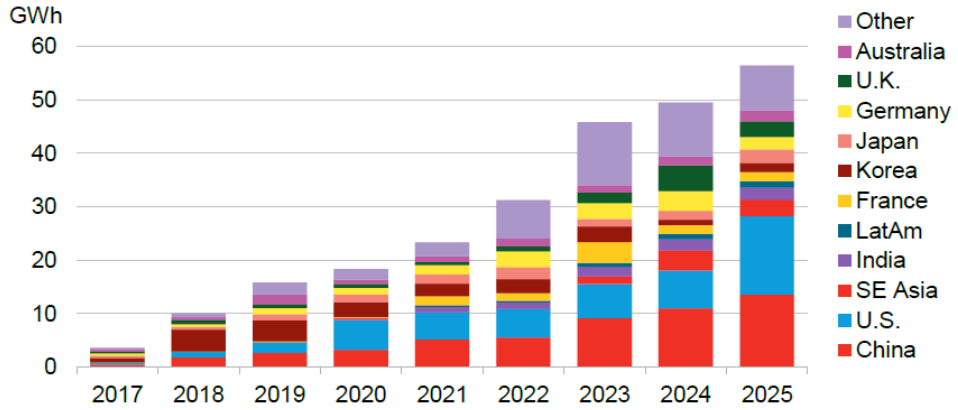


Figure 10: Global annual deployments by country based on energy capacity



Source: Bloomberg NEF

Two thirds of the market is to be installed in China, the U.S., India, Japan, Germany, France, Australia, Korea and the U.K

Thank you for your interest

For more information, contact:

Adam Briggs
Chief Commercial Officer
abriggs@ambri.com
732-403-7285

Doug Alderton
Vice President of Global Sales & Business Development
dalderton@ambri.com
603-391-2817