AllCell Technologies, LLC

Cool by Design™

PCC Extends Battery Cycle Life
PCC Value Proposition

- **PCC:**
  - Prevents thermal propagation
  - Distributes and manages the temperature to improve cell life
  - Enables use of higher energy cells at a higher power through improved thermal management
  - Independently validated by:
    - Major eScooter customer validated life cycle testing
    - NREL (thermal testing and modeling)
    - UL (94-V0 certification)
    - Intertek (UN38.3)

- **IP Portfolio:**
  - Issued patents: 6 US, 1 EPO (France and Germany), 1 South Korea (2 new patents extend IP to ~2034)
  - Applications: 2 US, (filing in India, China, EU)
Integrated PCC + iBTM Solution

Power Grid → Renewable Energy

ESS Buffering → Charging Station

PCC+iBTM Battery Enabled Energy Storage System

E-Aircraft → Material Handling → Robots

iBTM System Diagram

SoC

Thermal SoC

Cell Balancing

Monitoring Sensors

Optimal Charging/Dis-Charging Current Command

Thermal Control

cool by design

Battery Pack with PCC

PCC Material Li-ion Cells

ESS Buffering

Renewable Energy

Charging Station

Melting Point

Temperature Remains Constant During Melting

Temperature With No PCC

Temperature with PCC

Time

Temperature

Melting Point

ESS

Buffering

Renewable Energy

PCC Material

Li-ion Cells
How Does AllCell’s patented PCC Work?

AllCells Phase Change Composite (PCC) consists of a patented and proprietary engineered graphite matrix designed for rapid heat dispersion, and an encapsulated wax, to provide optimum heat absorption.

Wax absorbs heat as it melts

$$Q_{\text{absorbed}} = f(L_{\text{wax}}, m_{\text{wax}}, k_{\text{graphite}})$$

Graphite distributes heat evenly – temperature gradient reduced by 50%, peak temperature reduced by 8°C
Impact of Higher Temperatures on Cell Life

Calendar aging of Li-Ion cells at different temperatures

Keeping a cell 10°C cooler doubles life

Source: NREL, ECS 2018
AllCell solution significantly extends cycle life

Customer testing demonstrated that cycle life to 14% capacity fade (86% of original capacity) increased from 500 cycles to 875 cycles (75% increase). Accounting for the testing discontinuity* it is estimated that the battery would have reached 1000 cycles.

* Customer test to demonstrate 1000 cycle capability at which point test was terminated. Discontinuity is the result of customer interrupting testing. State of charge and other key data was not available to AllCell for this interruption.
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