CONSORTIUM FOR BATTERY INNOVATION

The US Lead Battery Industry: Growth, ESS Examples, and Innovations

Military Power Conference
December 15, 2022

Presented by:
Matthew Raiford, Senior Technical Manager, Consortium for Battery Innovation

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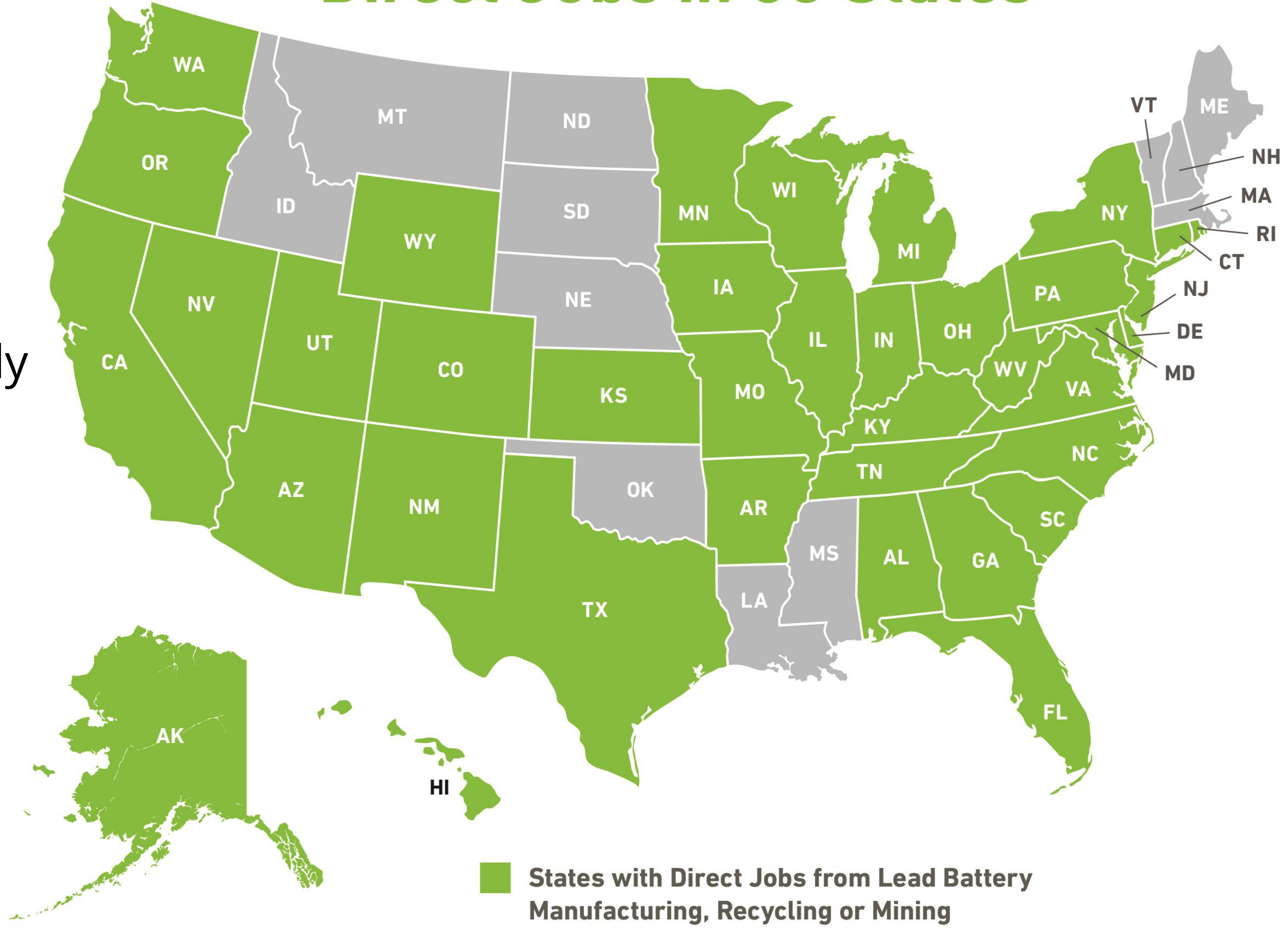
US Lead, Lead Battery Economic Impact

The industry provides a of total 92,200 jobs.

Beyond jobs, the U.S. lead battery industry annually supports:

- **$6.0 billion** in labor income,
- **$10.9 billion** in GDP
- **$26.3 billion** in output or overall economic impact
- **$2.4 billion** in government revenue.

Lead Battery Industry Provides Direct Jobs in 38 States



A Model for Circular Economy

The lead battery is the most recycled product in the world, brought on by the need to both steward Pb and create a stable and robust supply chain. <u>Sustainability requires a strong domestic manufacturing base…</u>


THE WALL STREET JOURNAL.

COMMODITIES

Lithium Prices Soar, Turbocharged By Electric-Vehicle Demand and Scant Supply

The lithium price surge is setting off a scramble for supply and fueling fears about long-term battery metals shortages

https://www.wsj.com/articles/lithium-prices-soar-turbocharged-by-electric-vehicle-demand-and-scant-supply-11639334956

November 15, 2021
7:00 PM CST
Last Updated a month ago

Energy

Column: United States adds nickel, zinc to critical minerals list: Andy Home

5 minute read

By Andy Home

https://www.reuters.com/business/energy/united-states-adds-nickel-zinc-critical-minerals-list-andy-home-2021-11-15/

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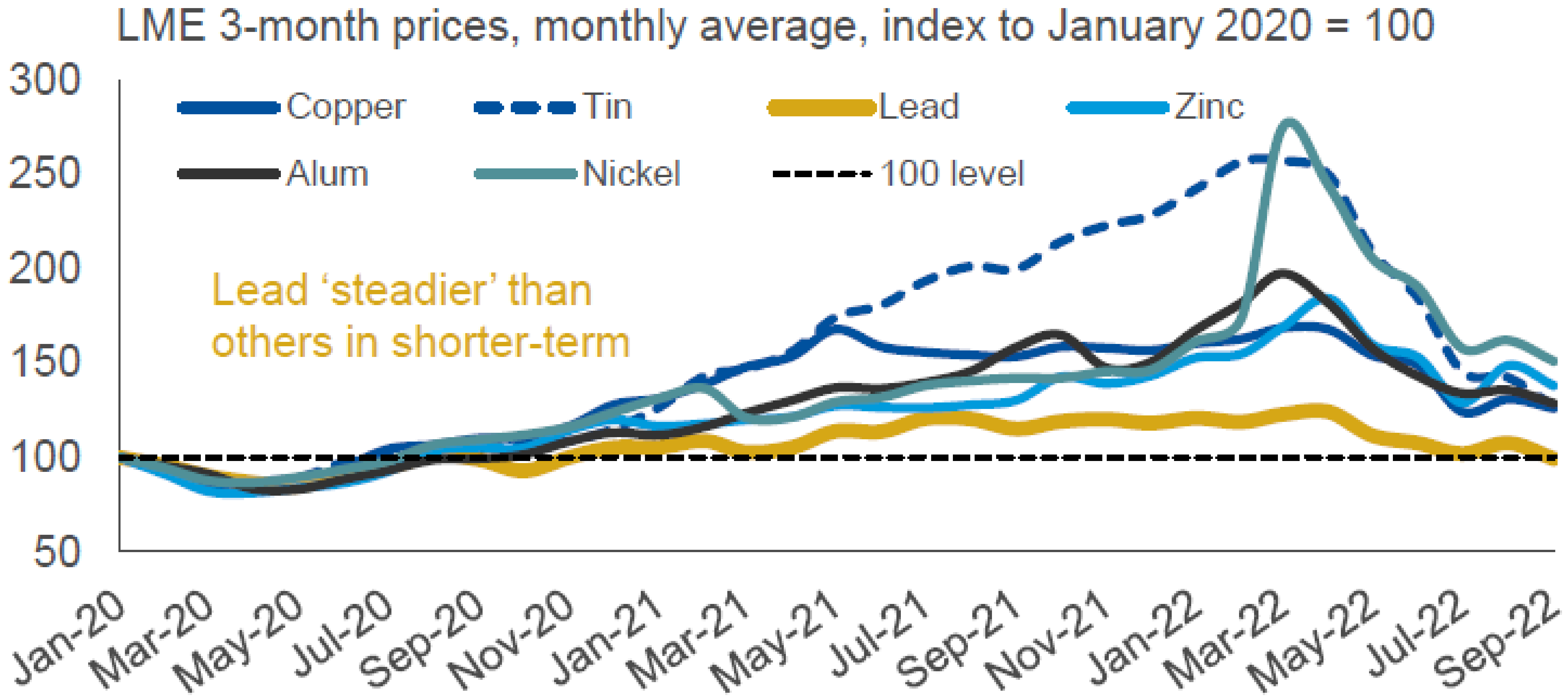
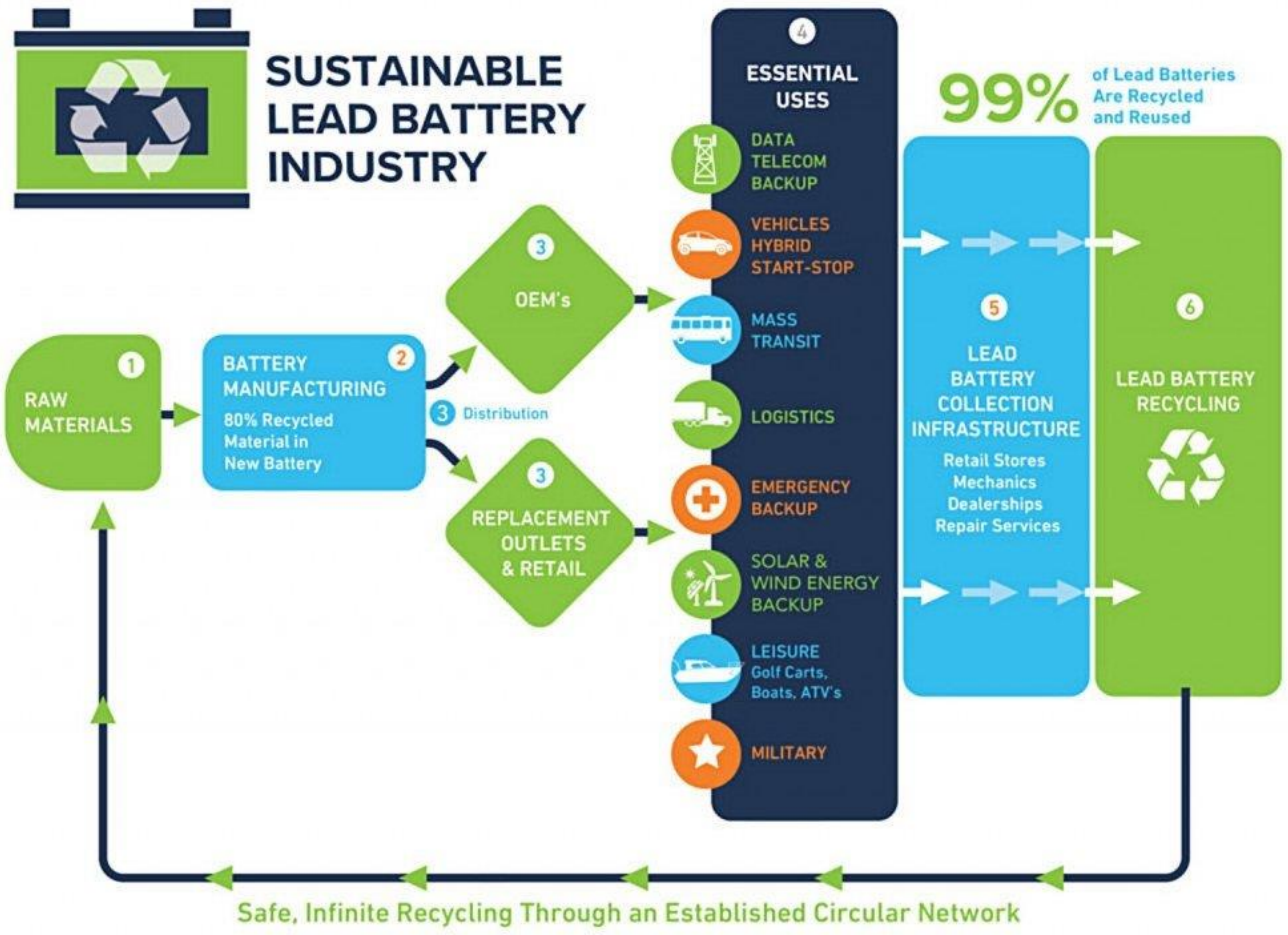


A Model for Circular Economy

10 recycling centers across the country handle over 3 billion lbs. of lead batteries per annum:

- Thousands of distribution centers
- Market driven scrap market
- Well developed logistics
- Domestic customer base (dozens of manufacturing facilities, many located near recycling centers)
- Transparent requirements, secondary specifications are well developed
- Mature regulations for:
  - Transport of scrap and batteries
  - Environmental controls
  - Materials Handling
  - Toxicity Levels



12 V Auxiliary Needs in Electric Vehicles

Key component for safe operation

Lead batteries are the go-to solution for 12 V batteries in vehicles, and in electric vehicles serve as the auxiliary safety battery.

- Back up for power steering.
- Back up for brake boosting.
- Powers also radio, sound, and peripheral electronics like back up cameras and side detectors.
- Designed to provide critical power in the event of an accident.
- Redundancy for ASIL level back up for automated driving.
- Integrated solutions optimized based on collaboration with sensor and automotive manufacturers.

WORLD ECONOMIC FORUM

How lead batteries could make EVs safer

Lead batteries are highly safe and reliable.

Image: Unsplash/ Andrew Roberts

This article was originally published by the

Consortium for Battery Innovation

09 Aug 2021

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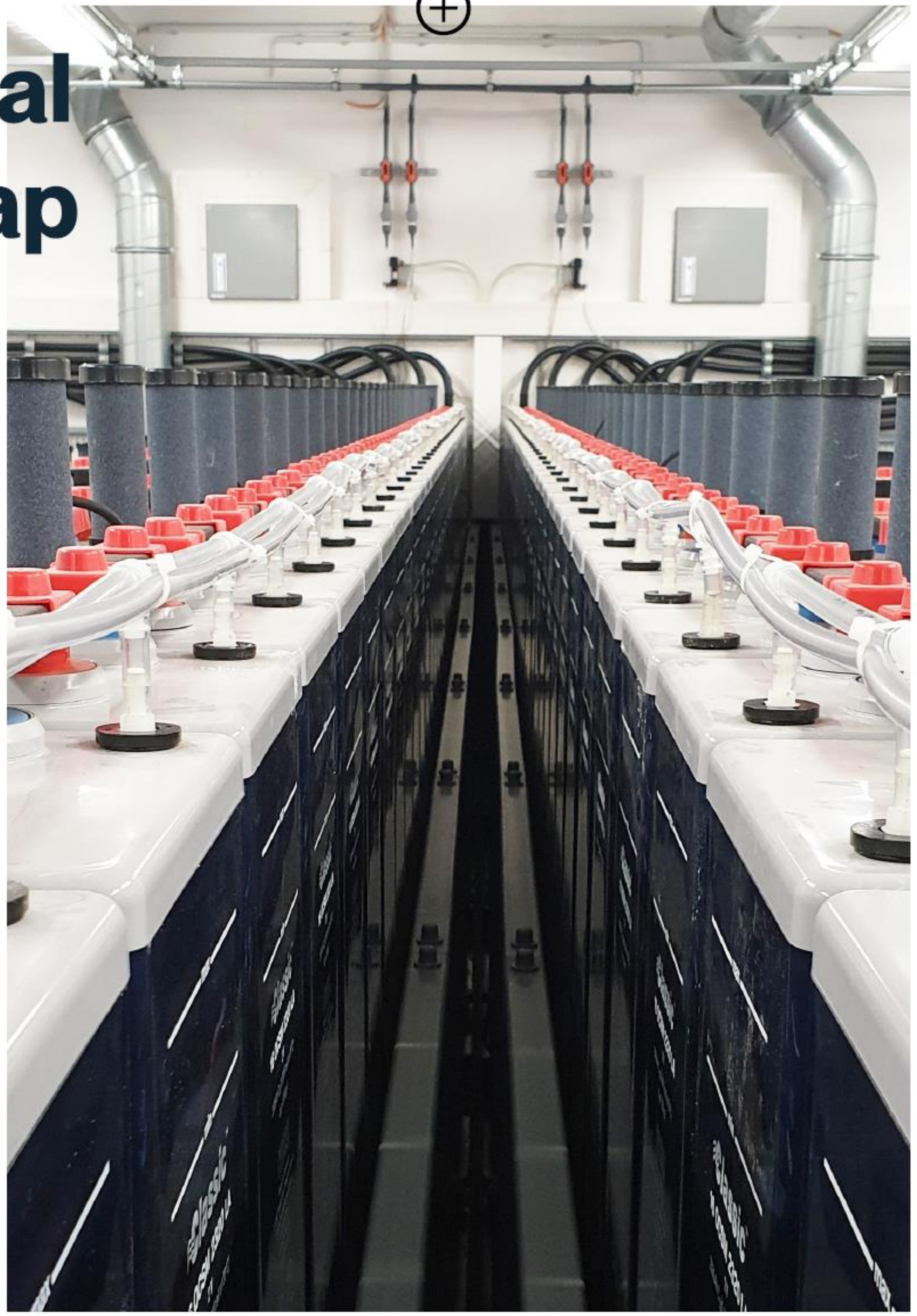
Chair of CBI and Vice President Industry and Governmental Relations EMEA, Clairos

CONSORTIUM FOR BATTERY INNOVATION

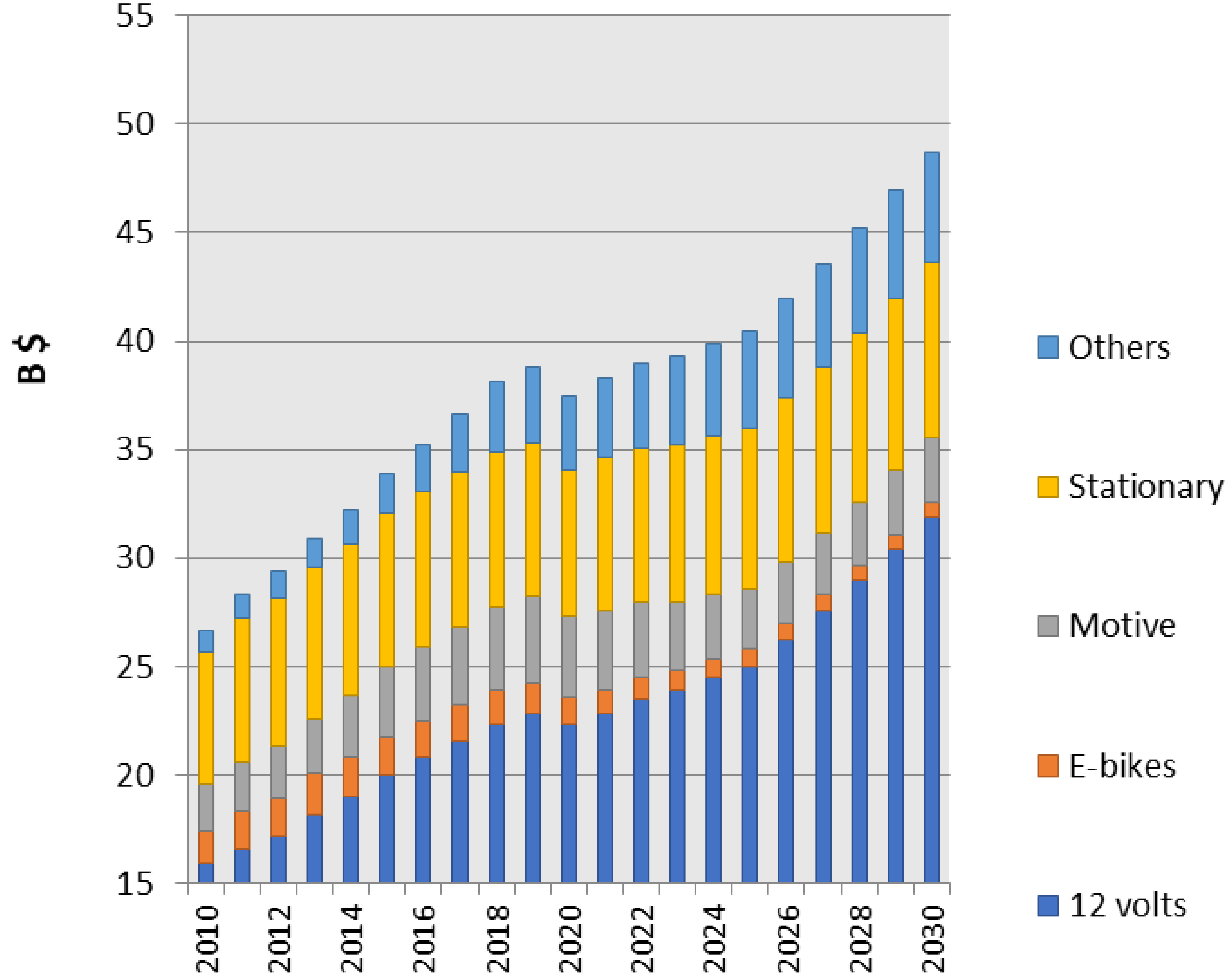
Technical Roadmap

Research and innovation pathways for next-generation advanced lead batteries

September 2021



Global lead-based battery sales, B $, 2010-2030



CONSORTIUM FOR BATTERY INNOVATION

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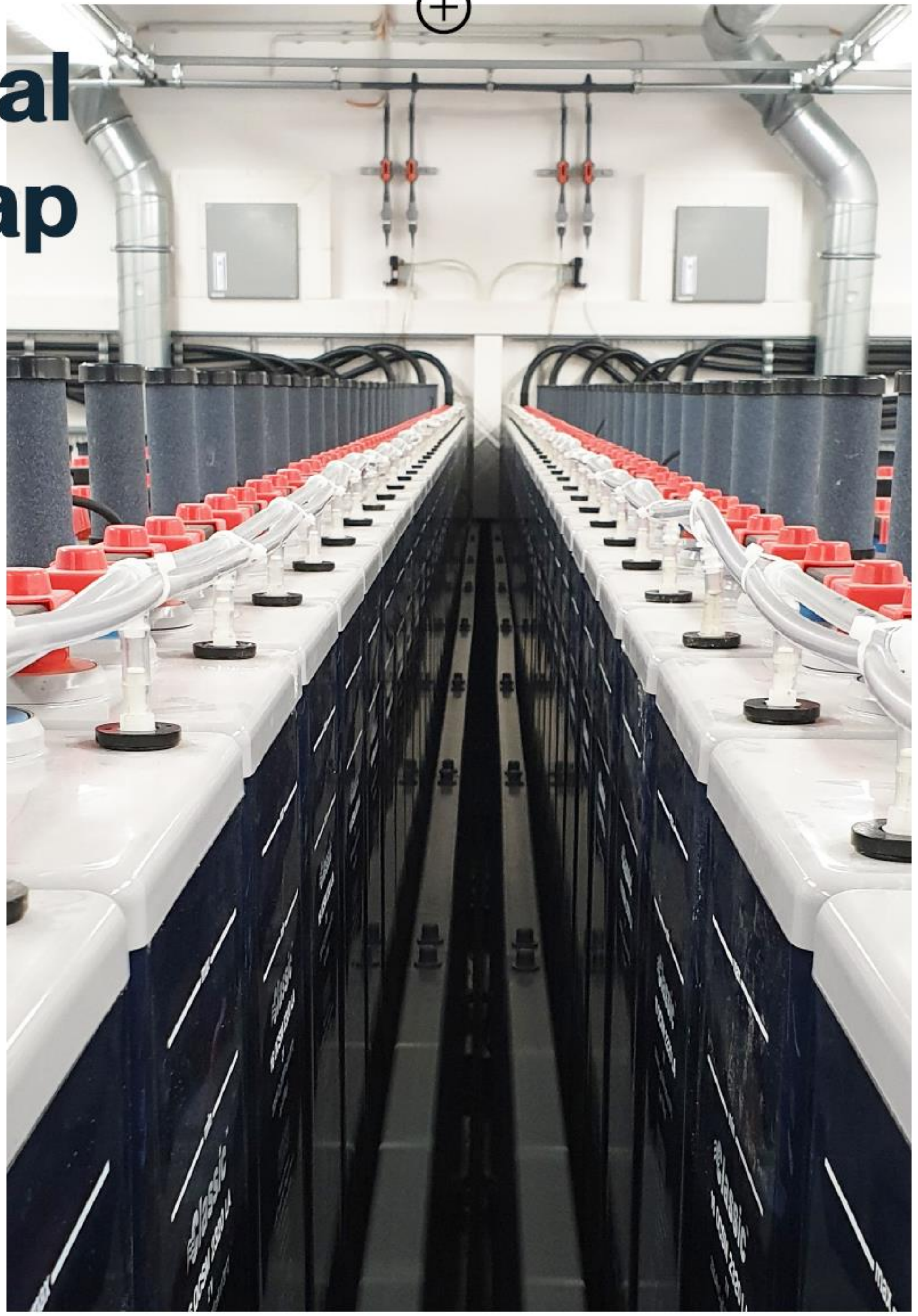


Automotive
(start-stop/micro-hybrid)

Ensure that recent improvements in Dynamic Charge Acceptance (DCA) are maintained, whilst improving high-temperature performance and ensuring no trade-offs in key parameters such as Cold Crank Amps (CCA) and water loss.

Automotive
(low-voltage EV)

Improve DCA and charge acceptance, whilst increasing charging efficiency and lifetime.

Energy Storage Systems

Improving cycle life, calendar life and round-trip efficiency whilst reducing acquisition and operating costs.

Industrial applications

Improving cycle and calendar life, whilst reducing battery costs.

Motive Power

Lowering TCO by increasing cycle life, recharge time, and producing maintenance-free batteries.

Other applications
(including e-bikes)

Improving gravimetric energy density, recharge capability and service life.

Automotive KPIs – Start-Stop/Micro-hybrid

- **Key Driver is DCA**
  - Reported values of 1.25 A/Ah in current products.
  - Preliminary cases of DCA above 2.0 A/Ah.
- **High Temperature Durability is an important OE metric.**
  - Lead batteries currently meet OE needs.
  - HTE test development in line with SAE J2801 performance.
- **Performance of other metrics must be sustained.**

Indicator (start-stop, micro/hybrid)	**2021/2022**	**2025**	**2030**
DCA (EN 50342-6, A/Ah)[a]	1.25	2.0	2.0
Ford Run-In Test B (A/Ah)	1.0	1.5	2.0
Durability: HTE (IEC/CENELEC draft)	16	20	20
Water Loss – EN/HTE (g/Ah)	<3	<3	<3
CCA, RC (comment)	Must not be compromised	Must not be compromised	Must not be compromised

ESS KPIs

- **The following KPIs are aggressive:**
  - Must be competitive with Li-ion.
  - Federal stakeholders and utilities have set up truly severe techno-economic drivers (US DOE and EU commission)
- **Operational cost and acquisition cost are vital.**
- Round Trip Efficiency primarily for renewable energy such as load following applications.
- **Productization is key** – configure and customize lead batteries to power conversion and control systems.
- The 2030 targets align with **many opportunities** from various governments for battery energy storage

Indicator	2021/2022	2025	2028	Stretch Target **2030**
Service life (years)	12-15	15-20	15-20	15-20
Cycle life (80% DOD) as an estimate for C10 or higher rates	4000	4500	5000	6000
Operational cost for low charge rate applications (above C10) – Grid scale, long duration	0.12 $/kWh/energy throughput	0.09 $/kWh/energy throughput	0.06 $/kWh/energy throughput	0.04 $/kWh/energy throughput
Operational cost for high charge rate applications (C10 or faster) - BTMS	0.25 $/kWh/energy throughput	0.20 $/kWh/energy throughput	0.15 $/kWh/energy throughput	0.10 $/kWh/energy throughput
Energy Storage efficiency (Wh in vs Wh out)(%)	75-90	80-90	85-90	88-92
Round Trip Efficiency (%)	85	88	90	92
Acquisition Cost (cell level) ($/kWh – 10 MW assumption)	175	140	100	75
Energy Density (Wh/l)	80-100	110	120	140
Acquisition cost, ESS level ($/kWh)	350	325	300	275
Safety	Maintain safety – deploy charging algorithms to control gassing			

Advanced lead battery research

US Synchrotron at ANL

Argonne National Laboratory

Site of lead battery research

IMPROVING UTILIZATION AND CYCLE LIFE

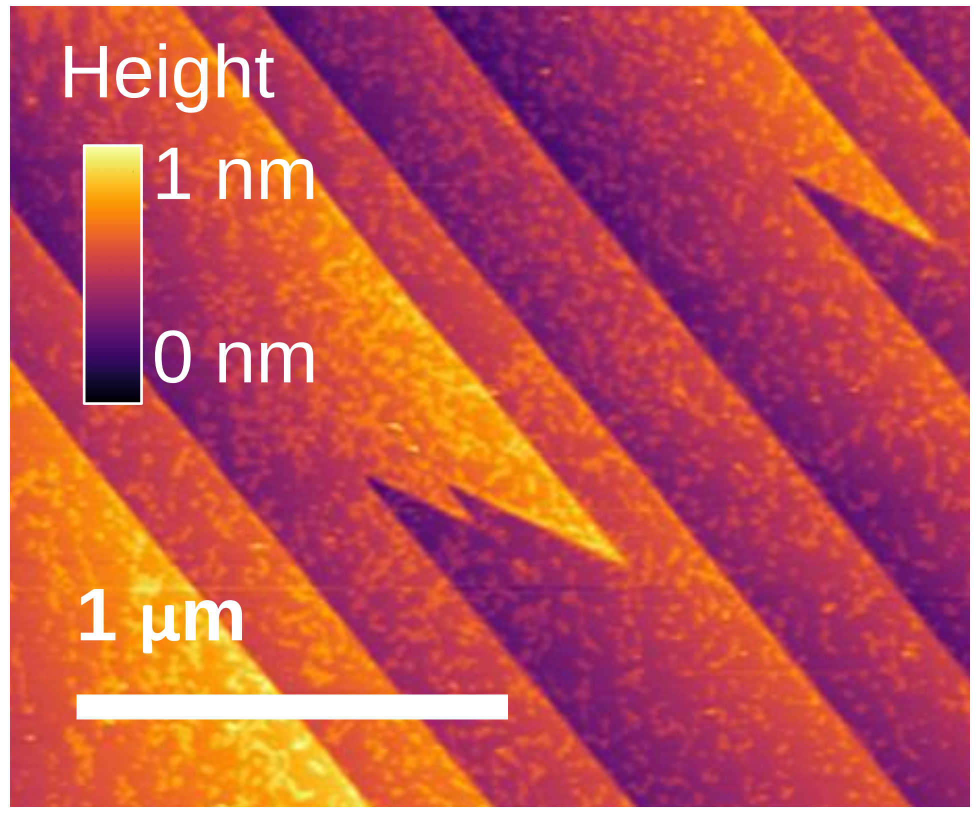
Issue = heterogeneity: a challenge over many length scales

Improving utilization and lifetime is inherently a multiscale problem:

- Atomic level issues: $PbSO_4$ nucleation, Pb^{2+} solvation, acid dissociation, additives/dopants
- Particle level issues: sulfation/pore clogging, diffusion/tortuosity limitations for e^- and SO_4^{2-}
- Cell level issues: electrolyte stratification, grid corrosion, paste shedding/softening
- Battery level issues: charge/discharge procedures, impedance, electrolyte management, grid design

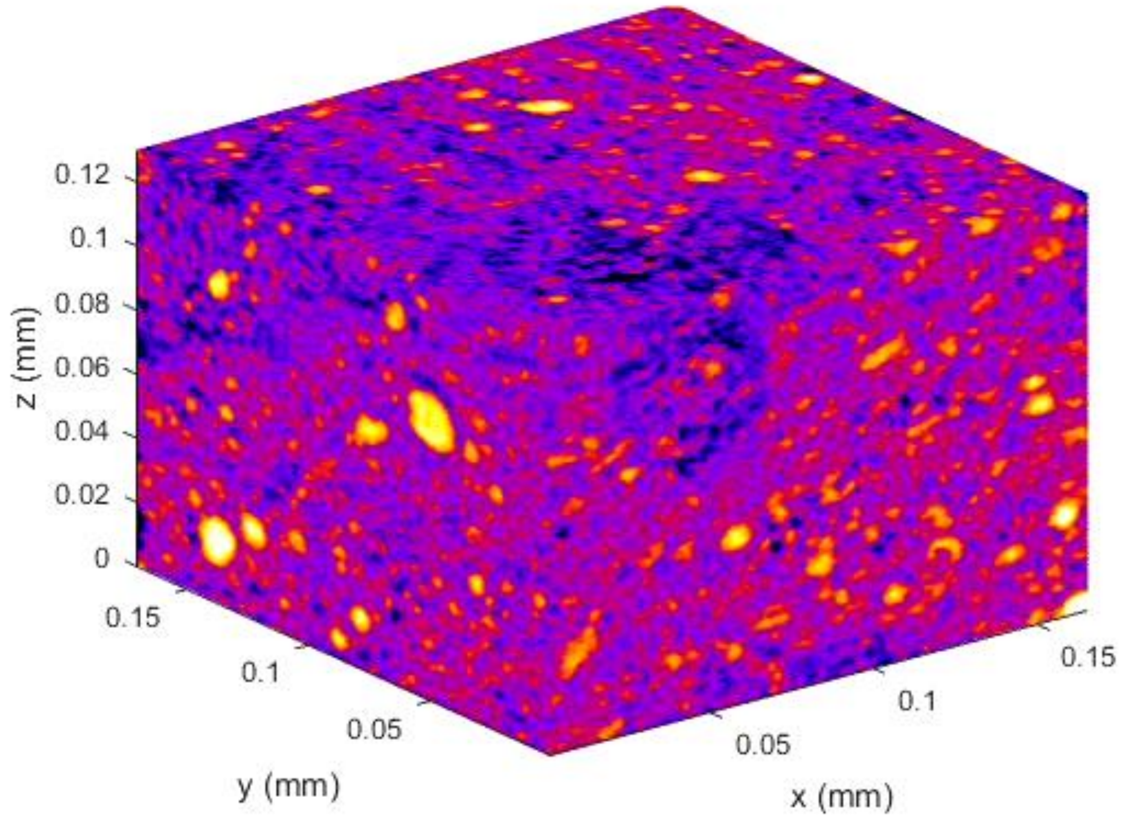
Atomic level (~nm, nAh)

Example: monolayer growth of $PbSO_4$ on barite 001.



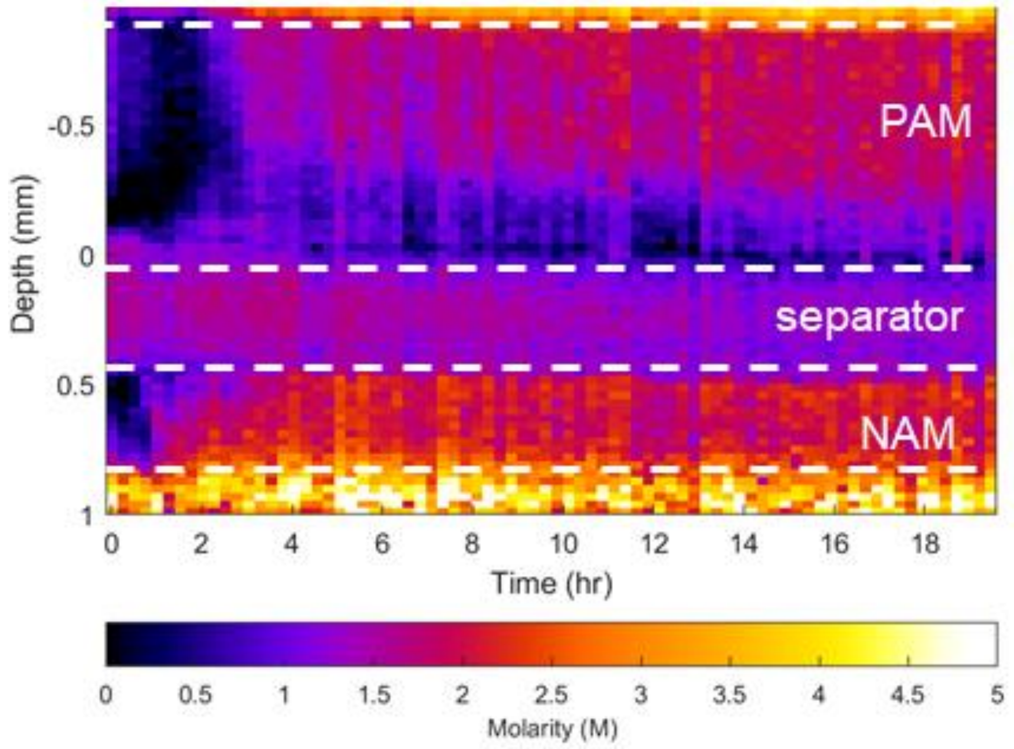
Particle level (~µm, µAh)

Example: Reconstructed volume from CT scan of a paste electrode (color = density)



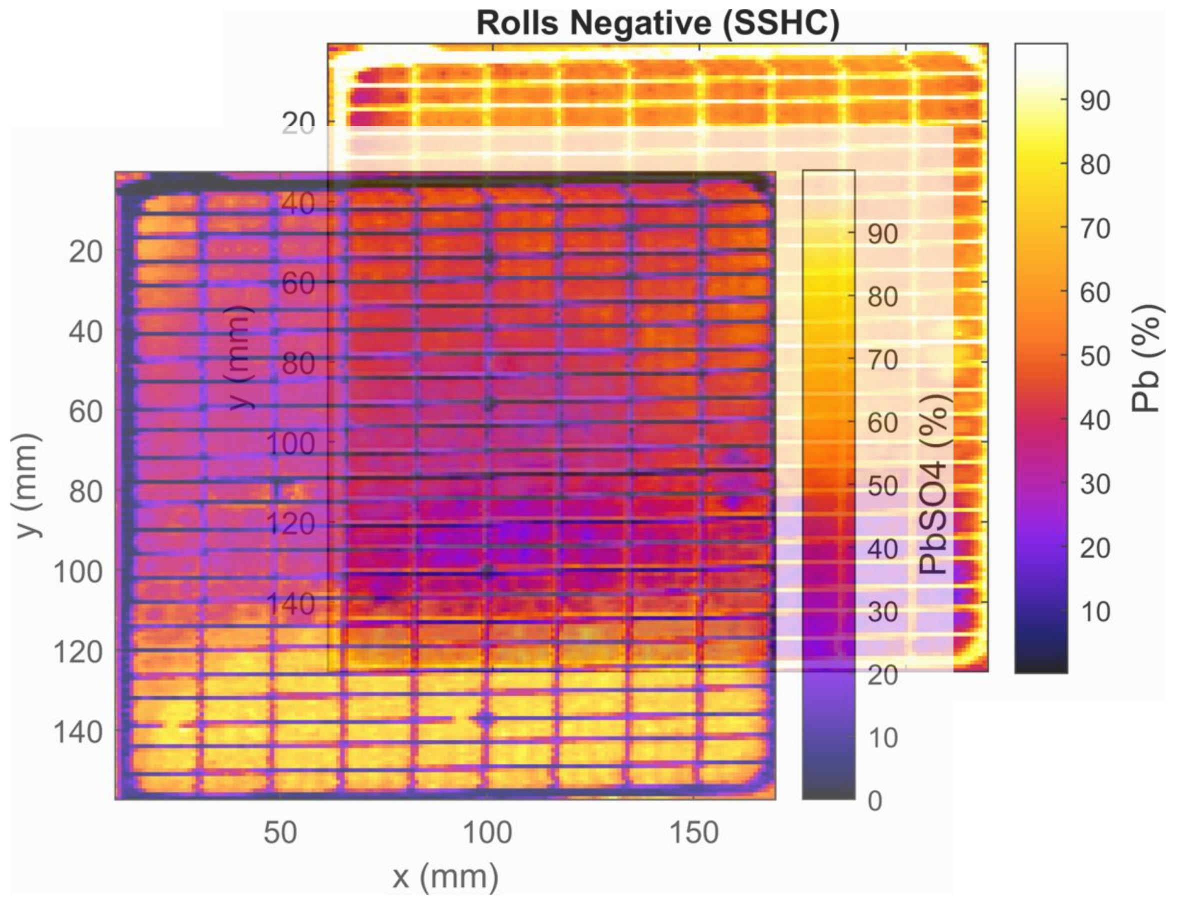
Cell level (~mm, mAh-Ah)

Example: Electrolyte mapping during formation (OE data used for LBSRP!)



Battery level (~100 Ah)

Example: cycling at PNNL and XRD from EOF battery plates



LoCEL-H2 – European Funding Project

European Commission

LoCEL-H2
Sustainable Electricity and Hydrogen for Remote Communities

HOPPECKE
POWER FROM INNOVATION

cea

Loughborough University

UNIVERSITE DE GABES جامعة قابس

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A Not-for-Profit University

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SUNKOFA ENERGY

EO – 14017: Resilience Needs

- ...identifying risks in the supply chain for high-capacity batteries, including electric-vehicle batteries, and policy recommendation to address these risks.

- Energy storage demand, especially for lithium-ion (Li-ion), has created potential national security issues.

- ESS systems provide a unique solution for the military to make operational centers independent of outside resources, such as gas or petroleum.

US Military Microgrid Project

US Army Corps of Engineers®
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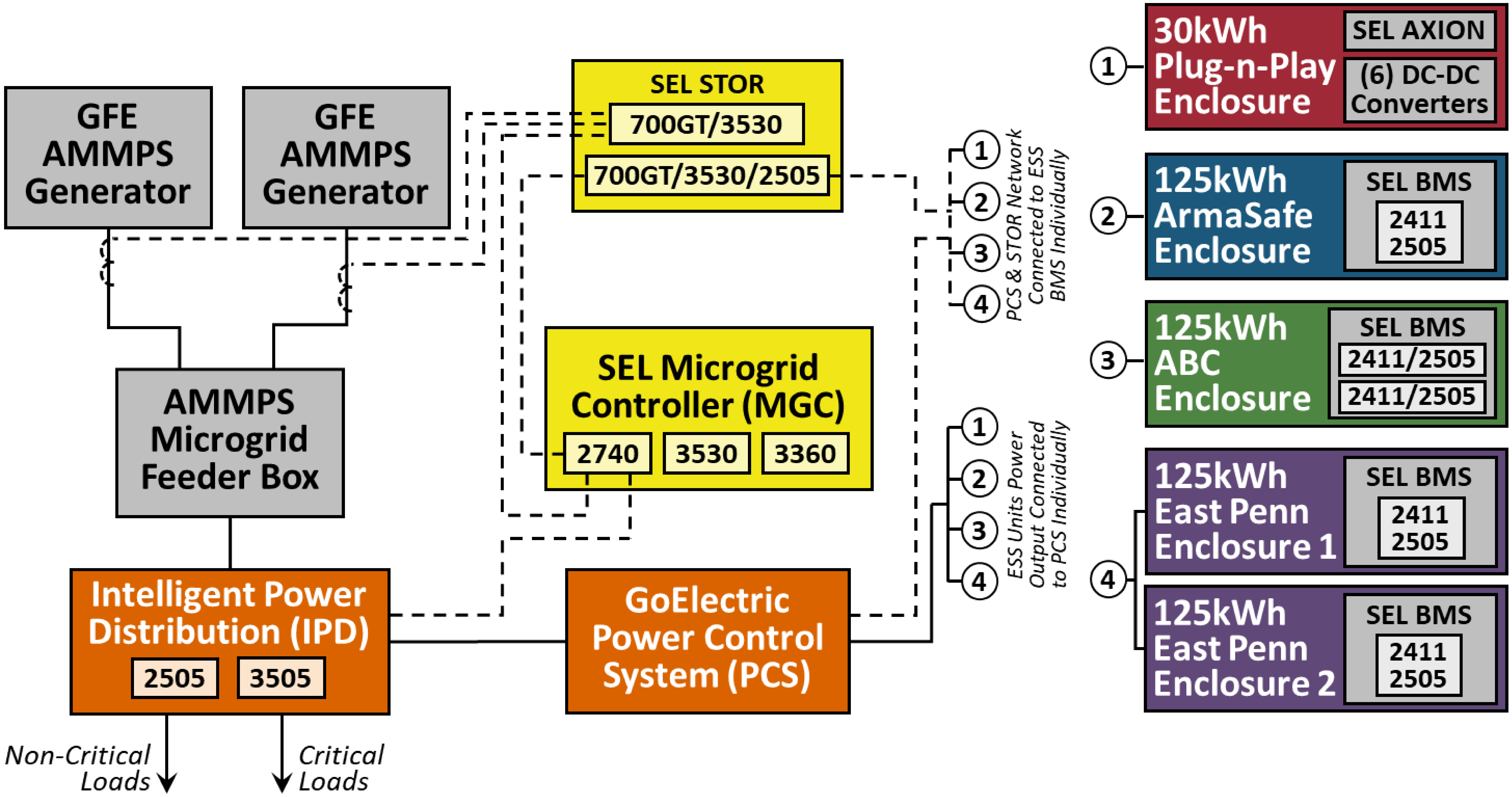
EASTPENN
Electric Applications Incorporated
EAI

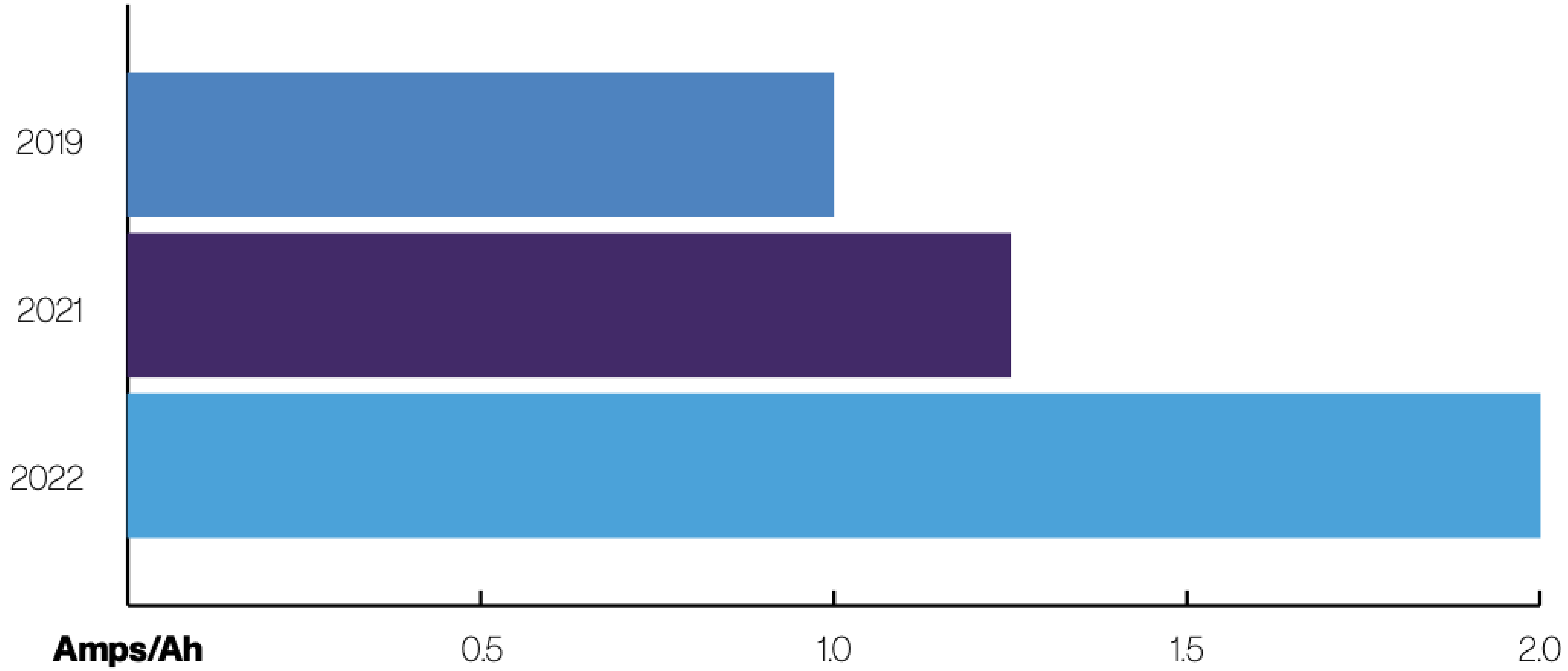
Military Microgrid Overview



Progress since 2019

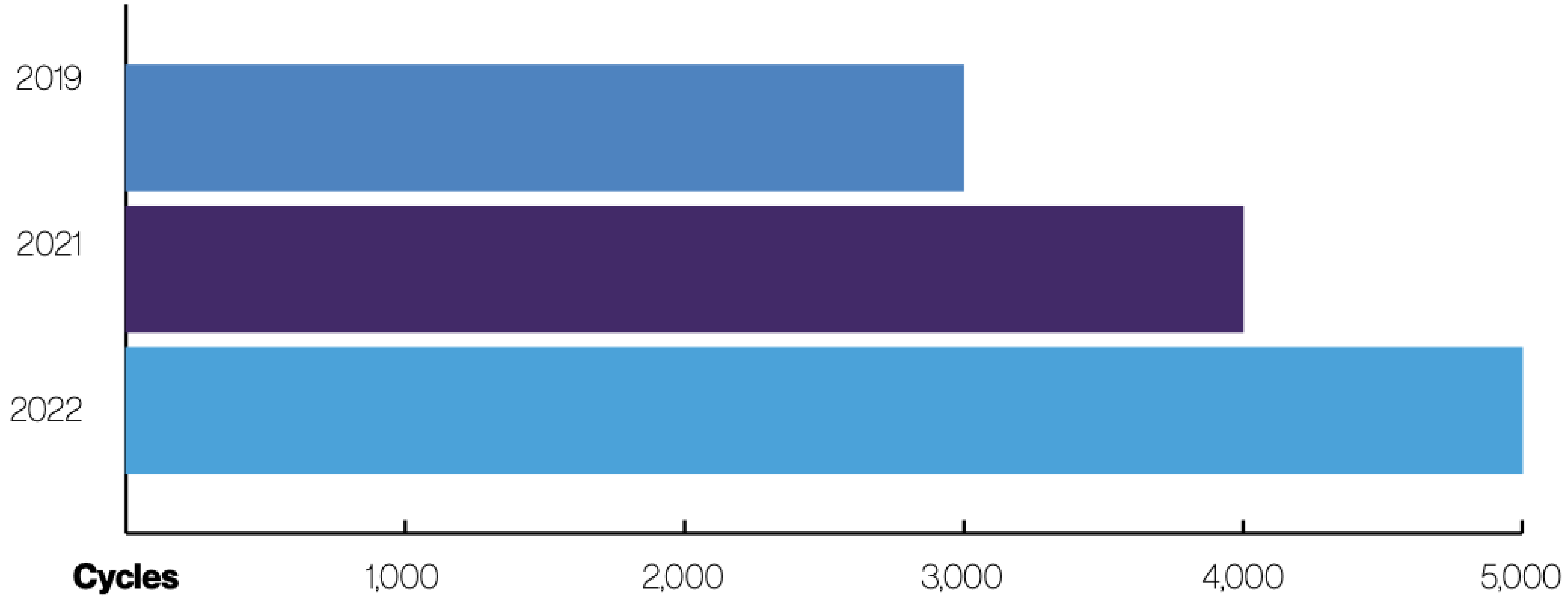
Auto

Dynamic Charge Acceptance



80% DOD

Cycle life



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Thank you!

Further questions:

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