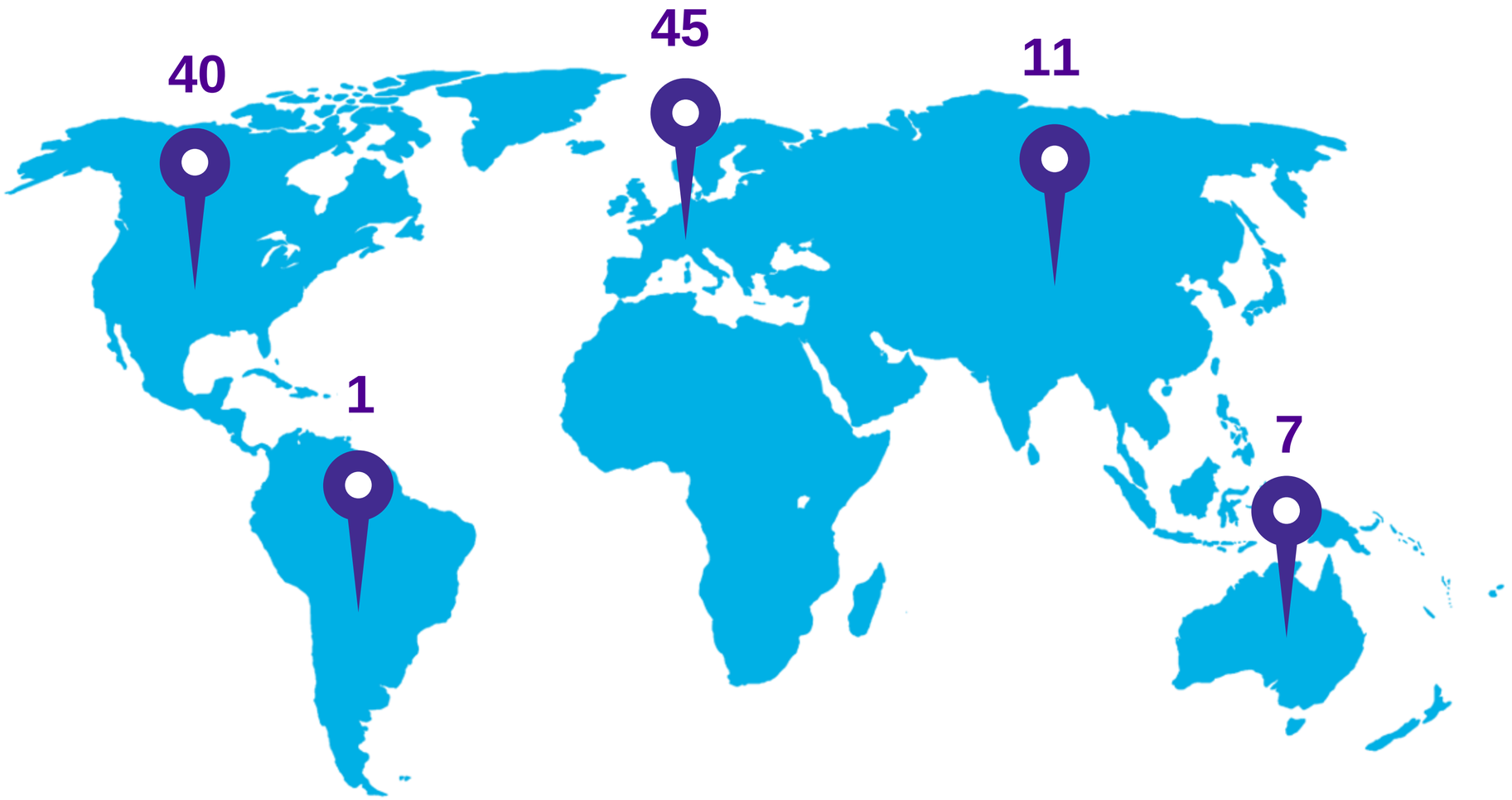
CONSORTIUM FOR
BATTERY
INNOVATION

Importance of Innovation for the Lead Battery Industry

14 October 2022

Presented by:
Dr Alistair Davidson, Director, Consortium for Battery Innovation

Map of Members and Partners



CBI member representation

- Battery manufacturers
- Industry suppliers
- Research & testing institutes, universities, end users
- Lead producers

CBI Members


ABERTAX® TECHNOLOGIES
ACE Green Recycling
Addenda Corporation
ADITYA BIRLA GROUP
Advanced Battery Concepts
Better Batteries, Better World©
AHLSTROM MUNKSJÖ
AMARA RAJA
Gotta be a better way
AMER-SIL
ArcActive
apg
ATOMIZED PRODUCTS GROUP, INC.
Aurubis
Metals for Progress
Banner Batterien
THE POWER COMPANY
battery energy
power solutions for tomorrow's world
BLACK DIAMOND STRUCTURES™
BOAB
METALS LIMITED
BOLIDEN
Metals for modern life
Borregaard LignoTech
C&D TECHNOLOGIES
CABOT
Campine
Ceylon Graphene Technologies
CLARIOS
CROWN BATTERY
DARAMIC
Digatron
power electronics
THE DOE RUN COMPANY
Electric Applications Incorporated
EASTPENN
EBL
Eichsfelder Batterielabor
ecobat
EnerSys
Power/Full Solutions
ENTEK
RAISING EXPECTATIONS. KEEPING THEM THERE.
enviro wales
EXIDE TECHNOLOGIES
FOCUS
FB FURUKAWA BATTERY
GLENCORE
GLOBAL LEAD
Technologies
Gopher Resource
GRAVITA
INDIA LIMITED
GRIDTENTIAL
Hakunas Lead Works Ltd.
HAMMOND
Hecla
MINING COMPANY
HYUNDAI
MOTOR GROUP
NIEHOFF
GRUPPE
HFSAB
HV
Hollingsworth & Vose
HOPPECKE
POWER FROM INNOVATION
inbatec
for a better production
KUSTAN
KCM 2000 GROUP
KGHM
POLSKA MIEDŹ
Korea Zinc
KOVOHUTĚ
Příbram
Livguard
lundin mining
METALLO
AURUBIS GROUP
MICROPOROUS
Proven. Partner. Focus.
MOLL
BATTERIEN
MONBAT
GROUP
moura
Batteries
MPI
reciklaža
narada
新春兴再生资源
NEW CHUNXING
orion
ENGINEERED CARBONS
OWENS CORNING
PENOX
RAMCAR TECHNOLOGY INC.
Rolls
BATTERY ENGINEERING
SORFIN YOSHIMURA
SOUTH32
STRYTEN ENERGY
SUPERIOR GRAPHITE
SUNLIGHT
POWER IS KNOWLEDGE
TBS
ENGINEERING
Teck
terrapure
The Graphene Council
TROJAN
BATTERY COMPANY
VILLANOVA
UNIVERSITY
WAVETECH
WIRTZ
GORE
Creative Technologies Worldwide
ZESAR
TECHNOLOGY FOR BATTERIES

CBI Partners

CBI Overview

RESEARCH

Better batteries

Facilitate improvements in battery and systems performance

- Market analysis
- Technical roadmap
- Core research program
- Government & other funded research
- Technical exchange

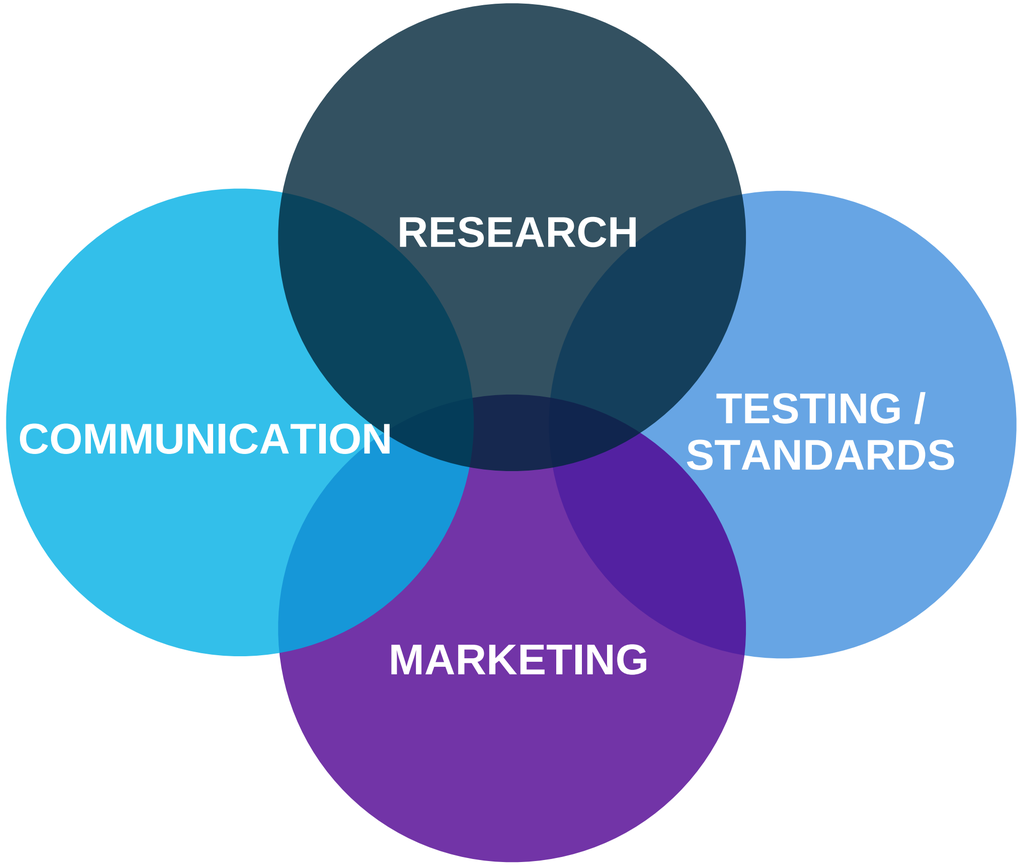
COMMUNICATION

Better recognition

(non-user stakeholders)

Communicating innovation in lead battery performance and applications

- Demonstrate lead batteries technology of future-change perception
- Direct stakeholder engagement (MEPs, Commission, DOE, Governments)
- Media Narrative (Social Media, articles, videos, PRs, blogs etc.)
- Lead battery information hub (website-technical data, market information etc.)



TESTING / STANDARDS

Better recognition

(industry/legislative standards)

Tests and standards that recognize lead battery benefits

- Test method development
- Technical exchange on testing
- Linking research to standards
- Coordination of industry input into standards committees

MARKETING

Better recognition

(end users)

Improve end user recognition of lead battery benefits

- Workshops
- Interactive Map
- Case studies and videos
- Battery Match
- Target industry media
- Demo projects
- Conferences and exhibitions
- Technical papers and publications
- Lead battery resource hub (website)

01.

Technical Program

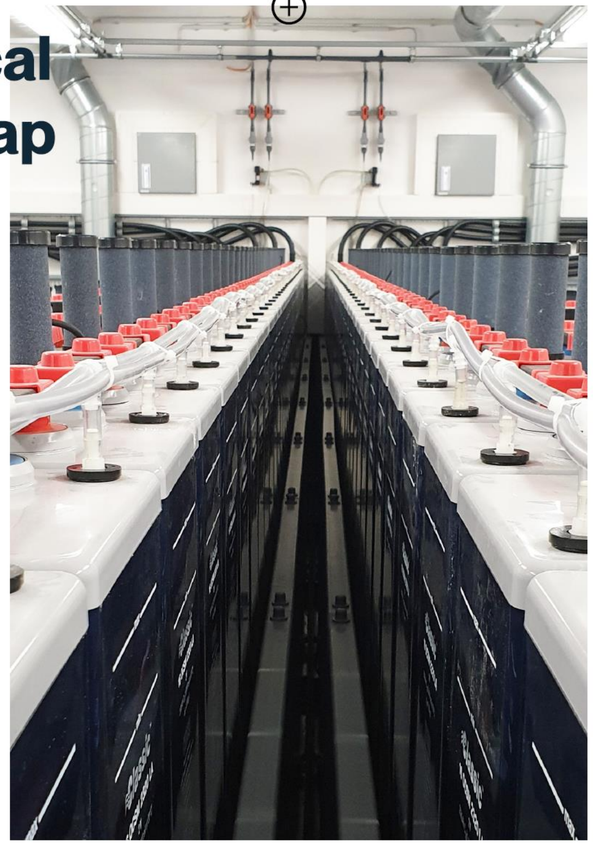

LEAD BATTERIES
CONSTANTLY INNOVATING

CONSORTIUM FOR
BATTERY
INNOVATION

Technical Roadmap

Research and innovation pathways for next-generation advanced lead batteries

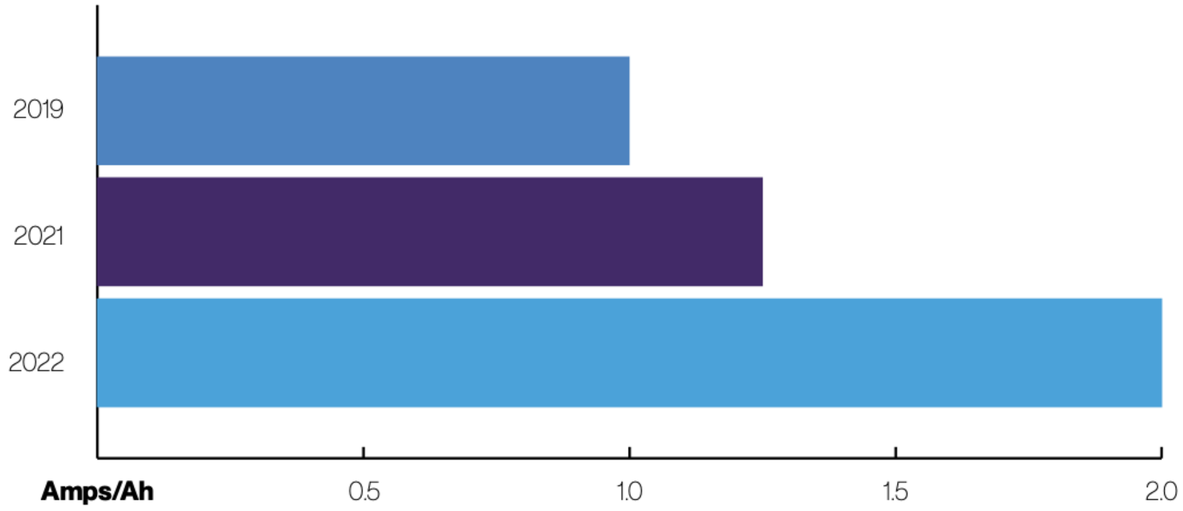
September 2021



Progress since last CBI’s 2019 Technical Roadmap

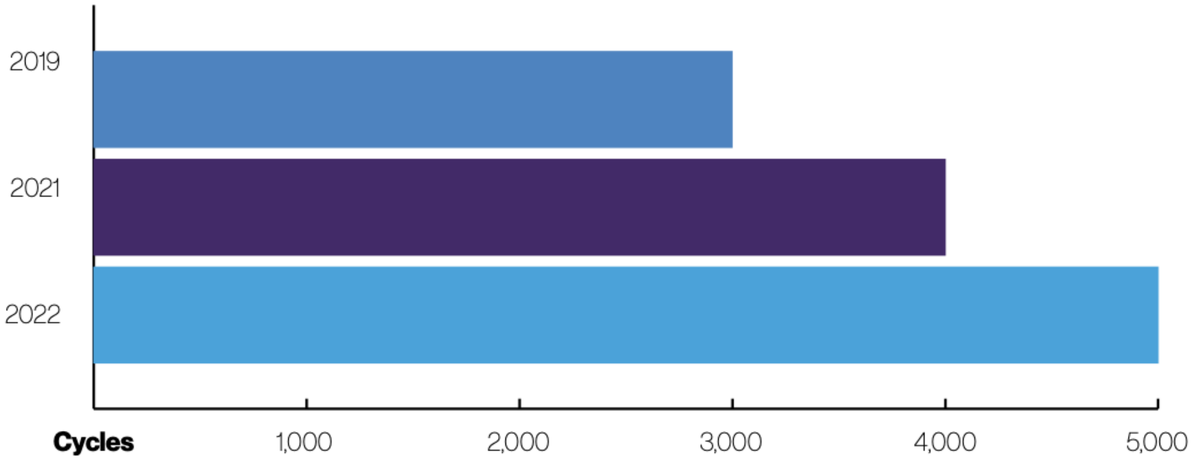
Auto

Dynamic Charge Acceptance



80% DOD

Cycle life



CBI 2021 Technical Roadmap

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

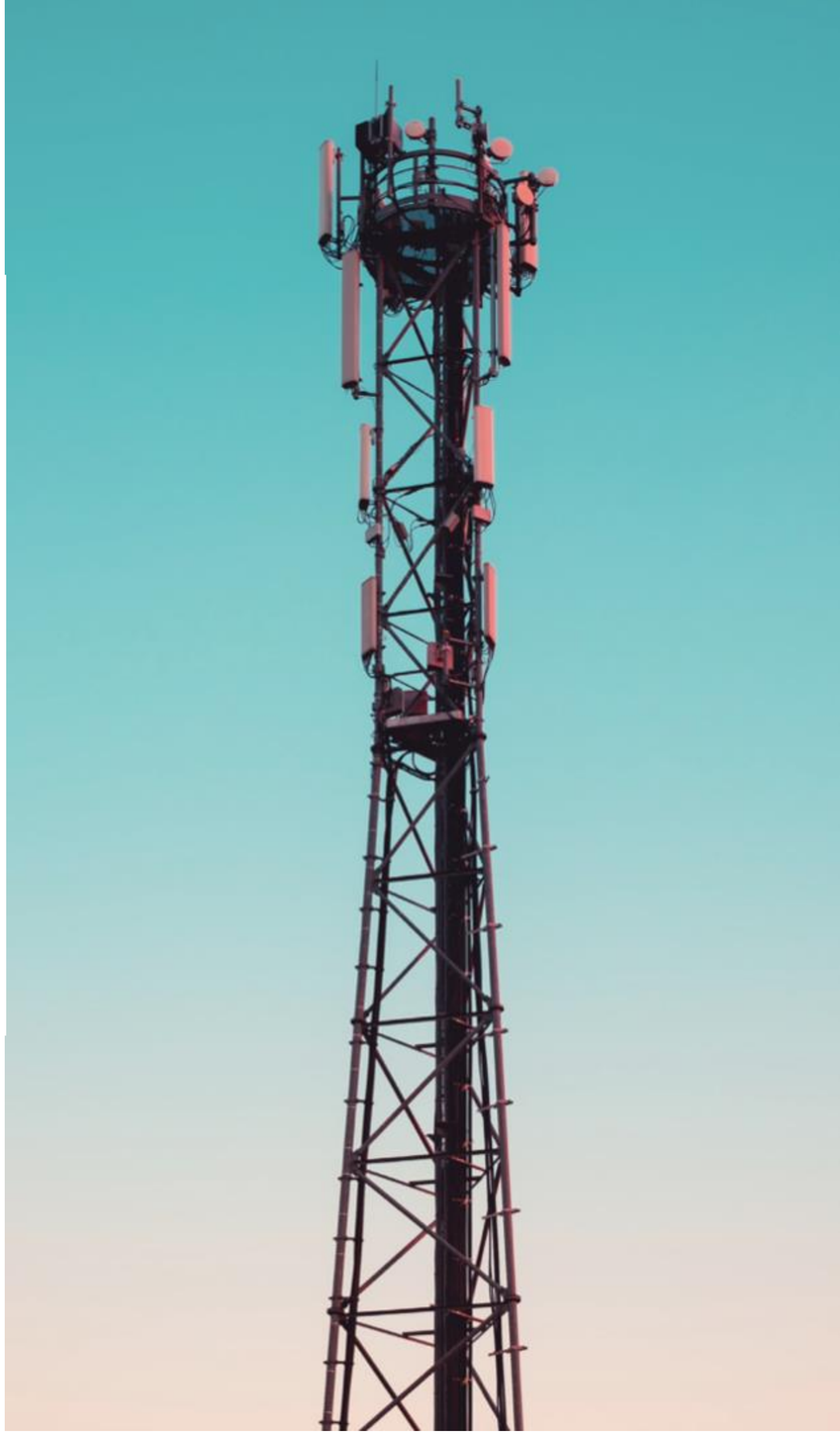
Improving cycle and calendar life, whilst reducing battery costs.

Motive Power

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

Other applications
(including e-bikes)

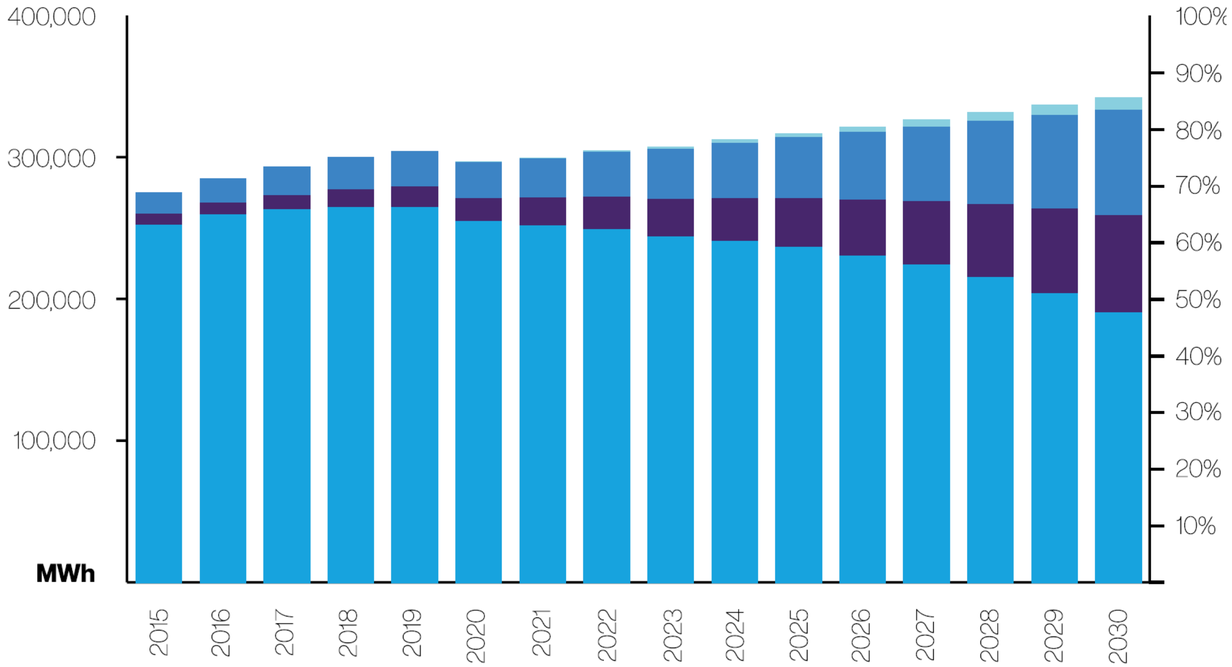
Improving gravimetric energy density, recharge capability and service life.



12 V Automotive Battery Market

CBI market report 2021, Avicenne

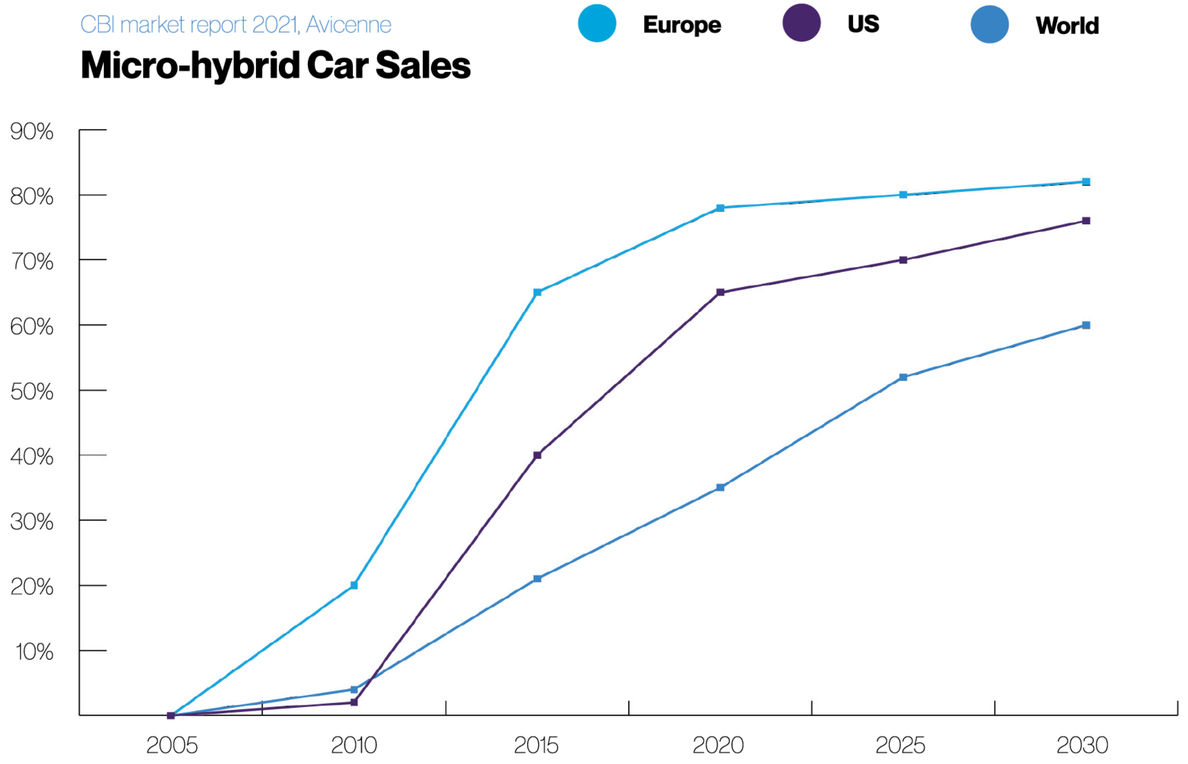
Battery Market for SLI



Flooded
EFB
AGM
LIB

CBI market report 2021, Avicenne

Micro-hybrid Car Sales



Micro-hybrid vehicles continue to grow as a significant market for the global automotive battery sector. By 2030, 60% of global sales will be micro-hybrids, with Europe leading the way with an expected 82% of sales by 2030, and the US close behind with 75%.

Automotive KPIs – ISS/Micro-hybrid

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.

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

EN 50342-6:2015 (M1, M2, M3 classification) should be used for cycle life requirements
Maintain 15 weeks of SAE J2801

[a] DCA testing from EN 50342 – 6 : 2015 theoretically only allows a DCA value up to 1.67 A/Ah (33*I20). DCRss discharge rate may be too low. An adjustment of the EN DCA protocol would be necessary.

Automotive KPIs – Low Voltage EV (Auxiliary)

- **DCA and CA are important metrics to consider in auxiliary batteries.**
- **The actual use of auxiliary by OEs and the consumer alike is unpredictable, and further test development is likely needed.**
- **Float charging may be a concern – accurate testing of this use case is underway within IEC.**

Automotive
(low-voltage EV)

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

ESS Growth

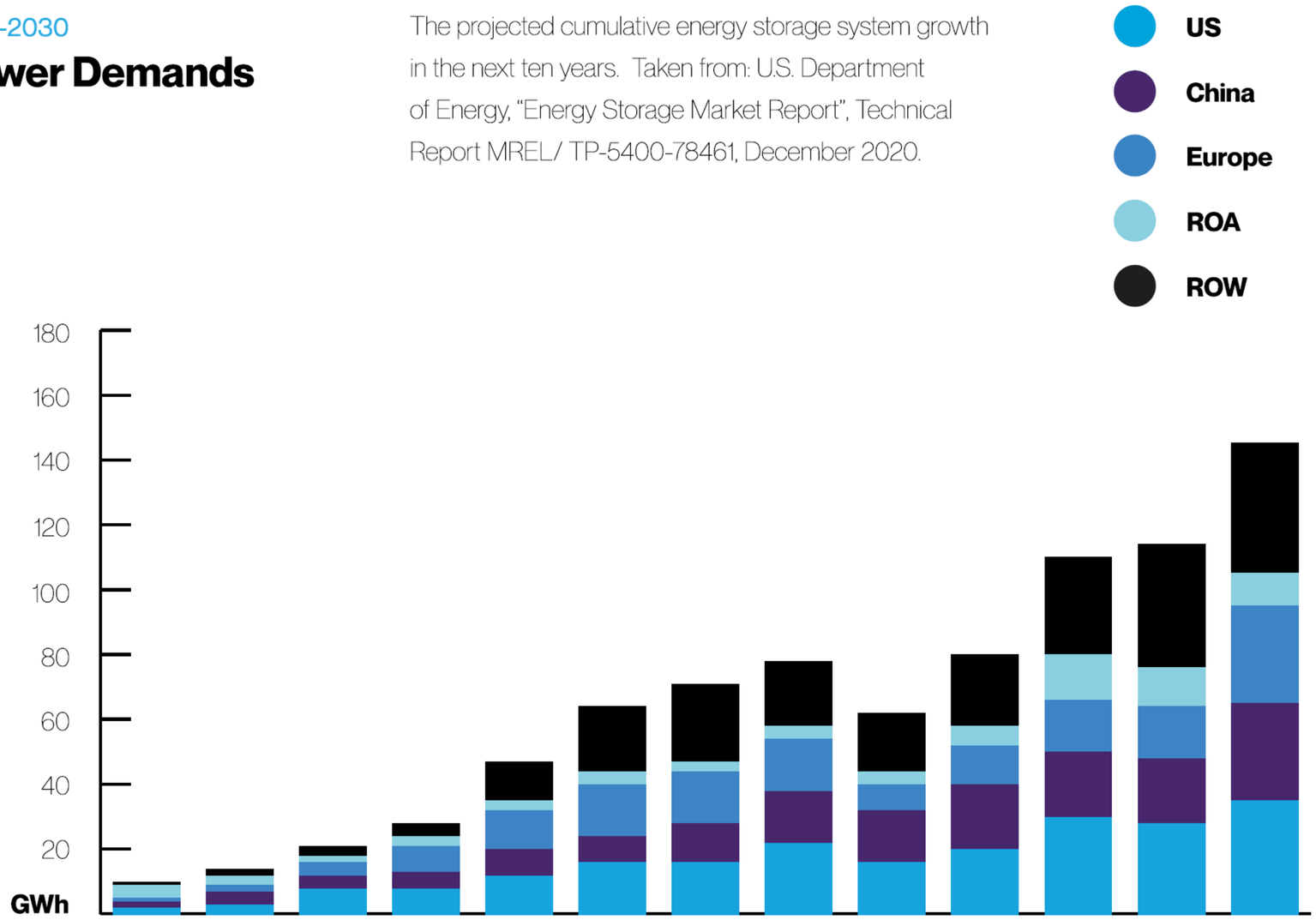
- **Conservative reporting predicts massive growth**
  - Strong growth in all areas.
  - 100’s of billions of dollars of government moneys directed toward this sector.

- **Key growth area for lead battery industry.**
  - Productization is vital.
  - Residential (Safe, advanced batteries)
  - 1-10 MW industrial (Multiple technology approach
  - Long duration, shallow cycling (Lead battery chemistry excels in this duty cycle).

2018-2030

Power Demands

The projected cumulative energy storage system growth in the next ten years. Taken from: U.S. Department of Energy, “Energy Storage Market Report”, Technical Report MREL/ TP-5400-78461, December 2020.



ESS Battery KPIs

Energy Storage Systems

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

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

ESS Battery KPIs

Energy Storage Systems

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

Indicator	2021/2022	2025	2028	Stretch Target 2030
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			

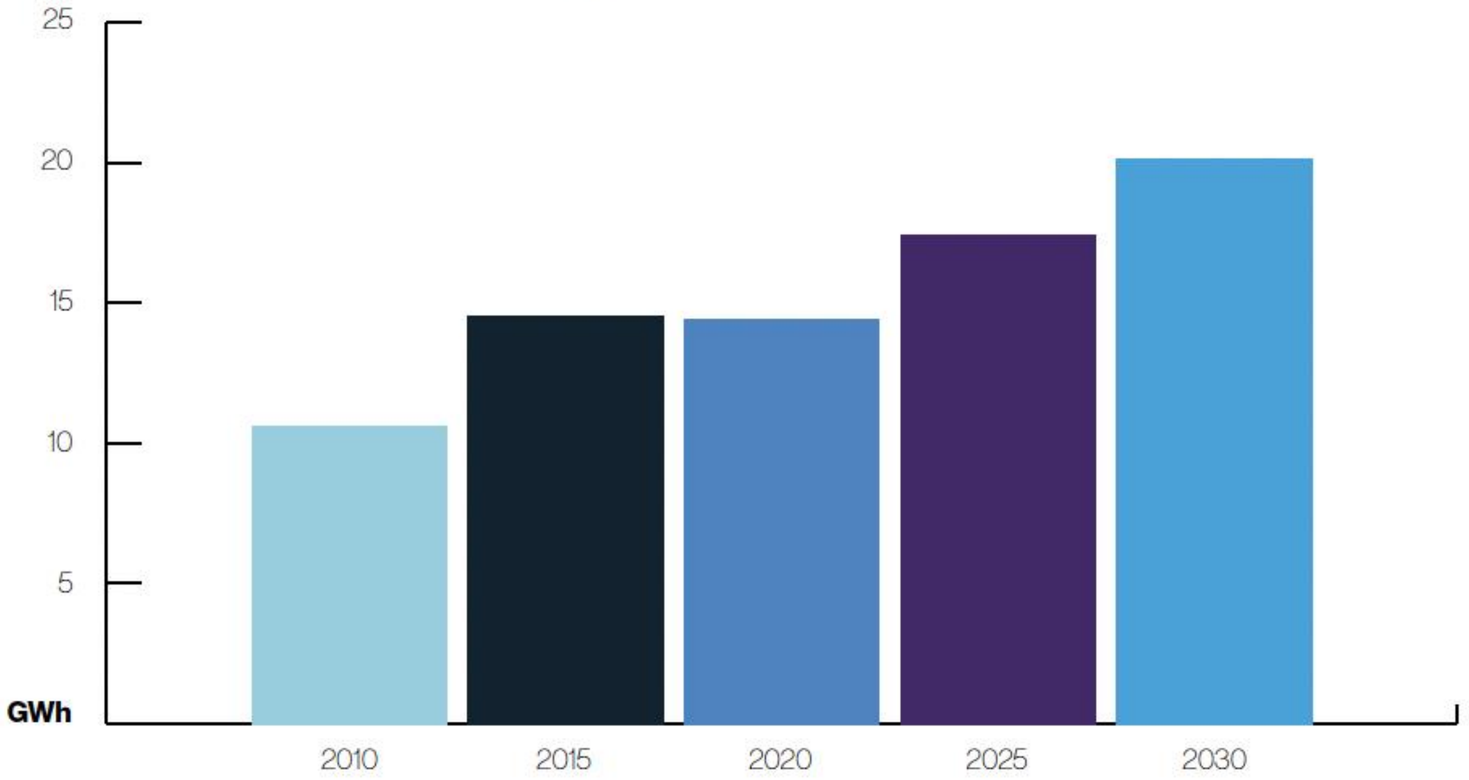
Telecom Market and Drivers

- **Strong market growth beyond current reports.**
  - H&V market information gathering has indicated ~23% growth in market to April 2021.
  - 5G deployments combined with deferred orders during 2020 (due to COVID).
  - Demand is very strong.
- **Healthy CAGR ~4-6% over next decade.**
- **5.6 GWh predicted.**

CBI market report 2021, Avicenne

Telecom Market

Lead batteries remain the dominant technology for telecom, back-up and UPS applications. For telecoms and back-up they provide an invaluable resource in keeping the power on in blackout events, with a growth of 5.6 GWh predicted between 2015 and 2030.



Lead Battery KPIs for Telecom Applications

Industrial applications

Improving cycle and calendar life, whilst reducing battery costs.

Research targets

KPIs for lead batteries in telecom applications

Indicator	2021/2022	2028
Calendar Life on float	15 y at 20°C	7-10 y at 40°C 20 y at 20°C
Cycle life (Testing should follow IEC 60896-21/22)	300 at 80% DoD	500 at 80% DoD
Cost	$175/kWh	$150/kWh

Maintain Safety and Recyclability, Maintain Shelf life

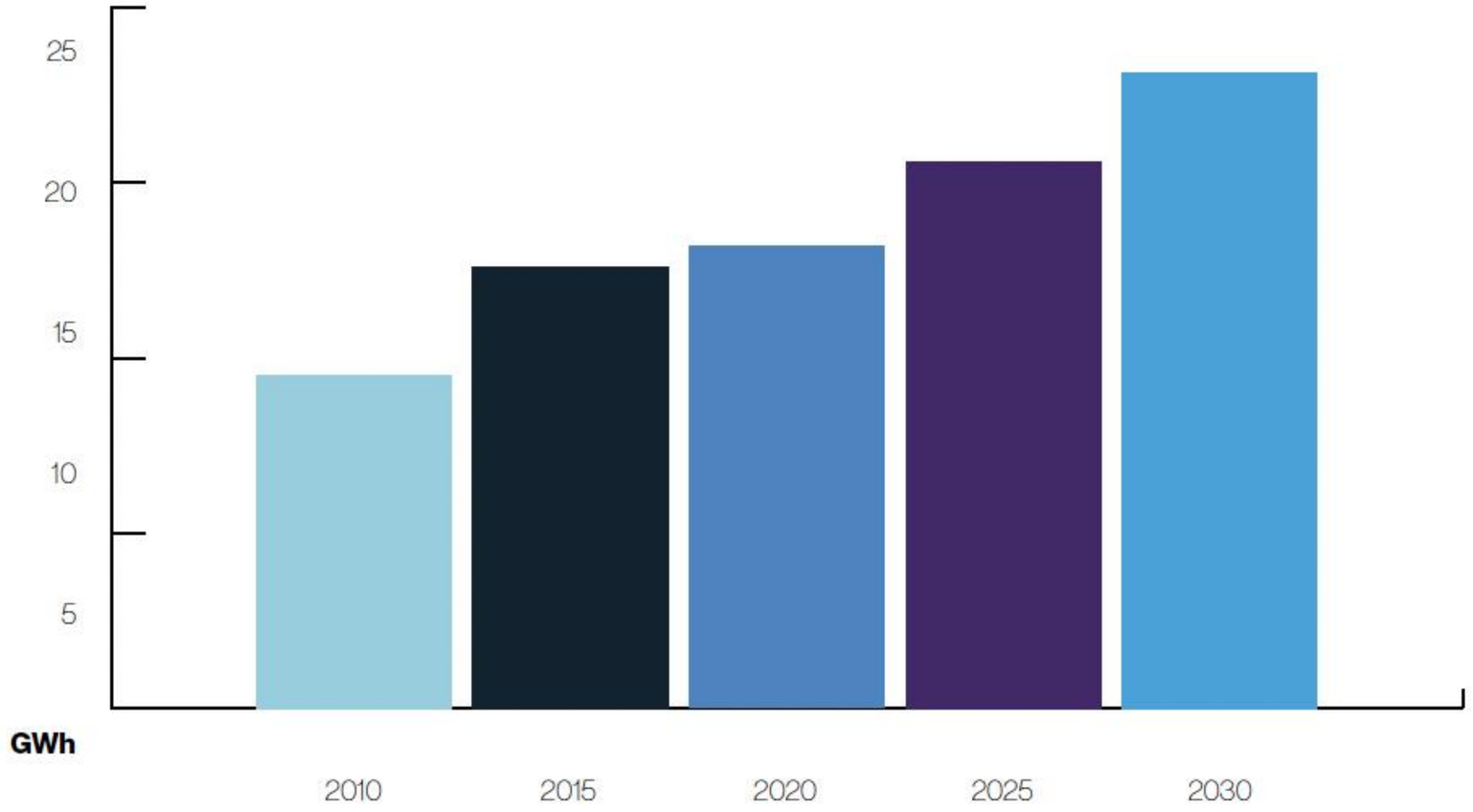
UPS Market and Drivers

- **Data center growth has pushed this market to new plateaus.**
  - Lead batteries enjoy a small footprint due to current IFC/NFPA standards.
- **Similar to Telecom market, approximately 5.5 GWh growth from 2020.**
- **Also similar to telecom, unprecedented market growth (~17%) due to back orders and investment in data center growth.**

CBI market report 2021, Avicenne

UPS Battery Demand

By enhancing the cycle life and charging efficiency of lead batteries, whilst lowering total cost of ownership (TCO) future opportunities for lead battery technology in this market are substantial.



Lead Battery KPIs for UPS Market

Industrial applications

Improving cycle and calendar life, whilst reducing battery costs.

Research targets

KPIs for lead batteries in UPS applications

Indicator	2021/2022	2028
Calendar Life on float	10 y at 20°C	15 y at 20°C
Peukert Capacity (15-minute vs. 10-hour capacity)	65-80%	85-90%
Cycle life Testing should follow IEC 60896-21/22	1000 at 50% DoD 6000 at 10% DoD	5000 at 50% DoD 12000 at 10% DoD
Cost	$175/kWh	$150/kWh

Maintain Safety and Recyclability, Maintain Shelf life

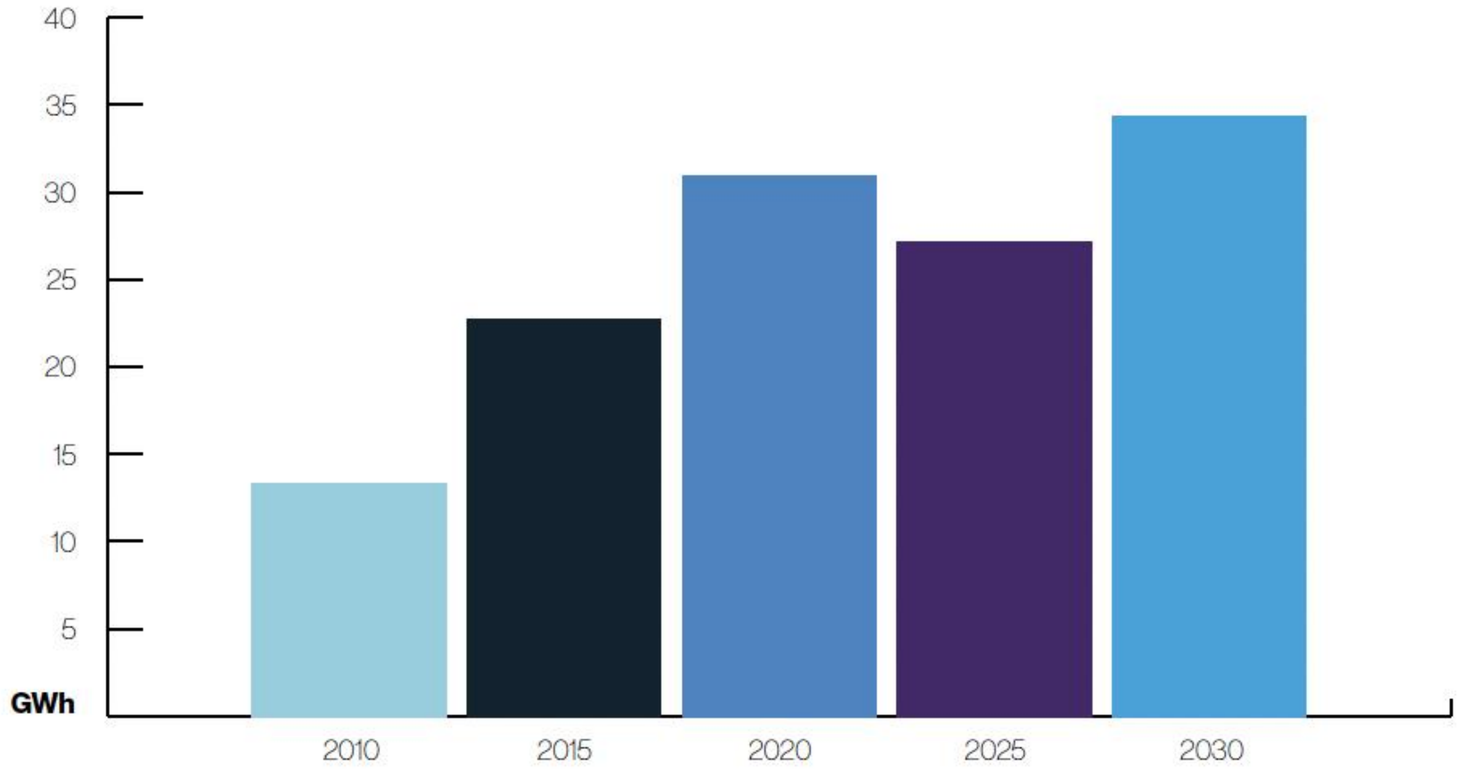
Motive Power Market (Forklift/Lift Trucks)

- **Significant penetration from Li-ion**
- **“Lift all ships” currently happening in market.**
  - Heavy demand for trucks and replacement batteries.
  - Lead battery demand is up 6% relative to 2019.
- **High volatility in market predictions.**
- **CARB initiative in California is an example of electrification efforts posing a great opportunity.**
  - Similar initiatives are possible NY and parts of EU.

CBI market report 2021, Avicenne

Motive Battery Demand

With the market predicted to grow to 34.3 GWh by 2030, this is a significant sector for lead batteries.



Motive Power Battery KPIs

Motive Power

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

Research targets

KPIs for lead batteries in motive power applications

Indicator	2021/2022	2025	2028
Service life	5	5-6	6-7
Energy throughput	1200 equivalent cycles	1400 equivalent cycles	1600 equivalent cycles
Cycle life IEC 60254	2400 (50% DOD)	2800 (50% DOD) 1750 (80% DOD)	3000 (50% DOD) 2000 (80% DOD)
Energy density (specific to charge efficiency)	35 Wh/kg	40 Wh/ kg [c]	42-45 Wh/kg [c]
Charge time to 30 – 80% Opportunity Charging (Highly dependent on charger/charge current)	Less than 2 hrs	1 – 1.5 hrs	1 hr or less
Technology requirements	- Maintenance free present - Management of the battery [a] - Harmonization with Chargers [b] - Few products capable of opportunity charging	- Maintenance free more common - Management and monitoring of the battery [a] - Harmonization with Chargers - Capable of opportunity charging	- Maintenance free typical. - Management and monitoring of the battery [a] - Harmonization with Chargers - Capable of opportunity charging

2019-2020 Technical Program

Project ongoings…

Exide/ICMA –In-operando” Neutron Diffraction analysis of the Charge/Discharge Processes inside the Positive Active Mass

Fraunhofer ISC/WUST – “Investigations on the Effect of Carbon Surface Functional Groups on Electrochemical Behavior of Lead Carbon Electrodes

UCLA - “Visualizing the Dynamics of Carbon – Enhanced Negative Electrodes in Lead Batteries”

EAI – “Grid Energy Storage Performance Improvement Using Controlled Overcharge”

Borregard Lignotech, East Penn, Cabot, Hammond – “Investigation into the Combined Influence of Carbon Black and Organic Expander to Improve Micro-Hybrid Service of Enhanced Flooded Batteries”

Fraunhofer ISC/TUB/Ford/Moll – “Improving Dynamic Charge Acceptance and High-Temperature Durability in Automotive Lead Batteries”

New additions

…

Exide/ICMA – “In-operando Neutron Scattering Analysis of the Charge/Discharge Processes inside the Battery Electrodes – ESS focus” – 24 month project

Hammond Group, Inc./East Penn – “Examination of the Effects of Surfactant Coatings & Particle Size of Barium Sulfate on the Structure Changes and Overall Performance of NAM in Energy Storage Systems (ESS) Application” – 27 month project

University of Warwick/Loughborough University - “HALO-SMART-ESS-LAB: Health And Lifespan Optimization with Smart Management Algorithms & Recuperative Testing of ESS of Lead Acid Batteries”

Gridtential/EAI – “Bipolar Lead Batteries for Energy Storage Systems Applications”

Key Results from Technical Program

DCA-40% improvement

- **Optimization of additives**
- **Bipolar designs**
- **Novel techniques for understanding battery fundamentals**

Cycle life-on target to deliver 5,000 cycles

- **New understanding on failure modes**
- **Controlled overcharging**
- **Novel techniques for understanding battery fundamentals**

02.

Government funding work

Worldwide funding for batteries

U.S. Government Pledges $45 Million to Develop Better EV Batteries

The Department of Energy has set up a new program that will fund the domestic development of batteries for electric vehicles that can charge faster and last longer.

US Department of Energy announces $45Mn in battery funding

State aid: Commission approves €3.2 billion public support by seven Member States for a pan-European research and innovation project in all segments of the battery value chain

ENERGY STORAGE

EU boosts battery R&D funding

US government announces $3.1 billion of funding for battery manufacturing, processing, recycling

Brussels approves €2.9 billion investment into battery innovation

LoCEL-H2 – European Funding Project

European Commission

LoCEL-H2
Sustainable Electricity and Hydrogen for Remote Communities

HOPPECKE
POWER FROM INNOVATION

cea

Loughborough University

Université de Gabès
جامعة قابس

RHYDE
RÉSEAUX HYDROGÈNE DÉCARBONÉ

LUMS
A Not-for-Profit University

Hollingsworth & Vose® Creating a Cleaner World™

SUNKOFA ENERGY

US Military Microgrid Project

US Army Corps of Engineers®

CONSORTIUM FOR BATTERY INNOVATION

PARAGON SOLUTIONS, INC.

Advanced Battery Concepts
Better Batteries, Better World®

EnerSys®
Power/Full Solutions

EASTPENN

Electric Applications Incorporated

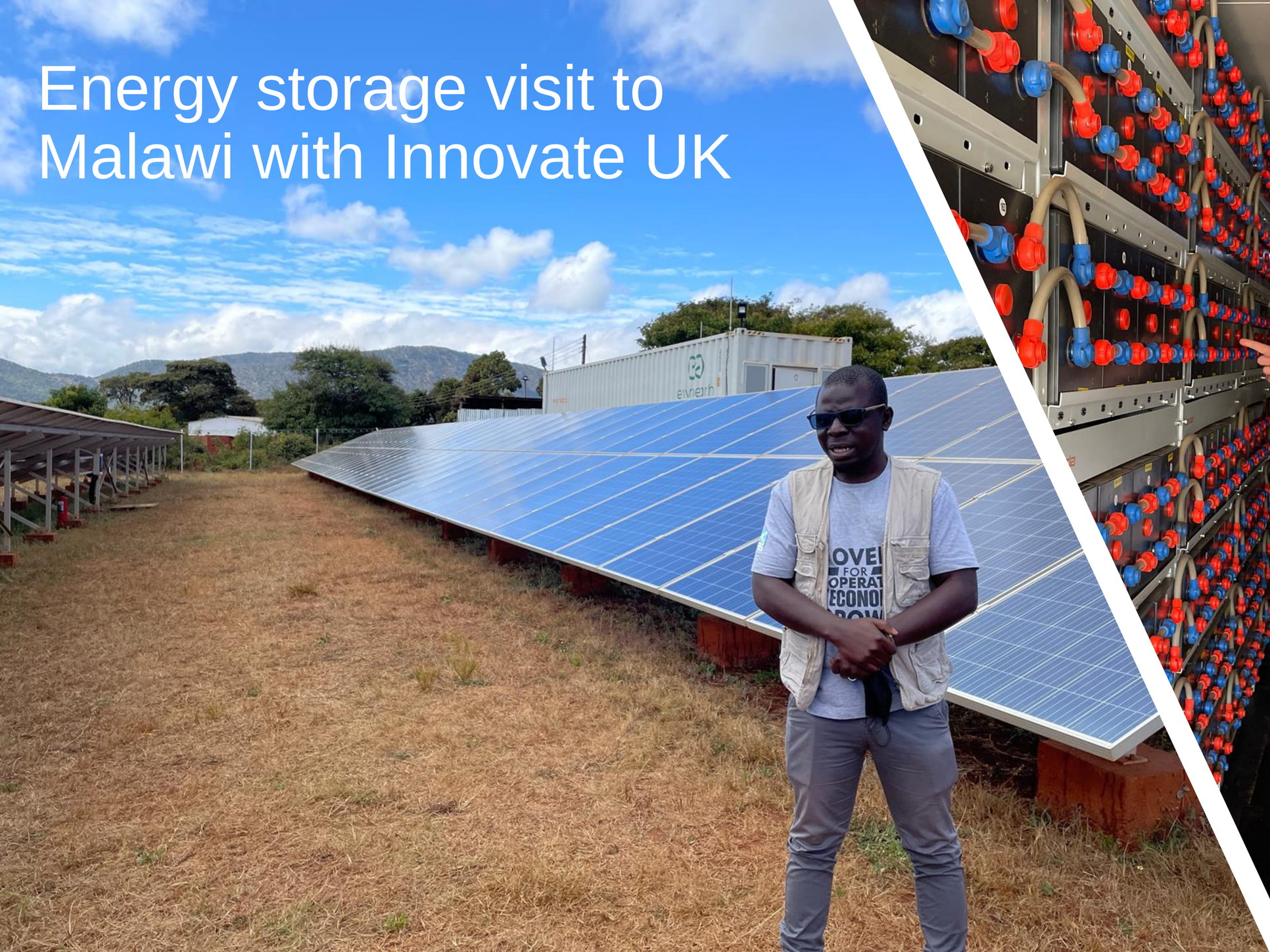
Advanced lead battery research

US Synchrotron at ANL

Argonne National Laboratory

Site of lead battery research

Energy storage visit to Malawi with Innovate UK



02.

Energy Storage Opportunities

ESS Growth

2018-2030

Power Demands

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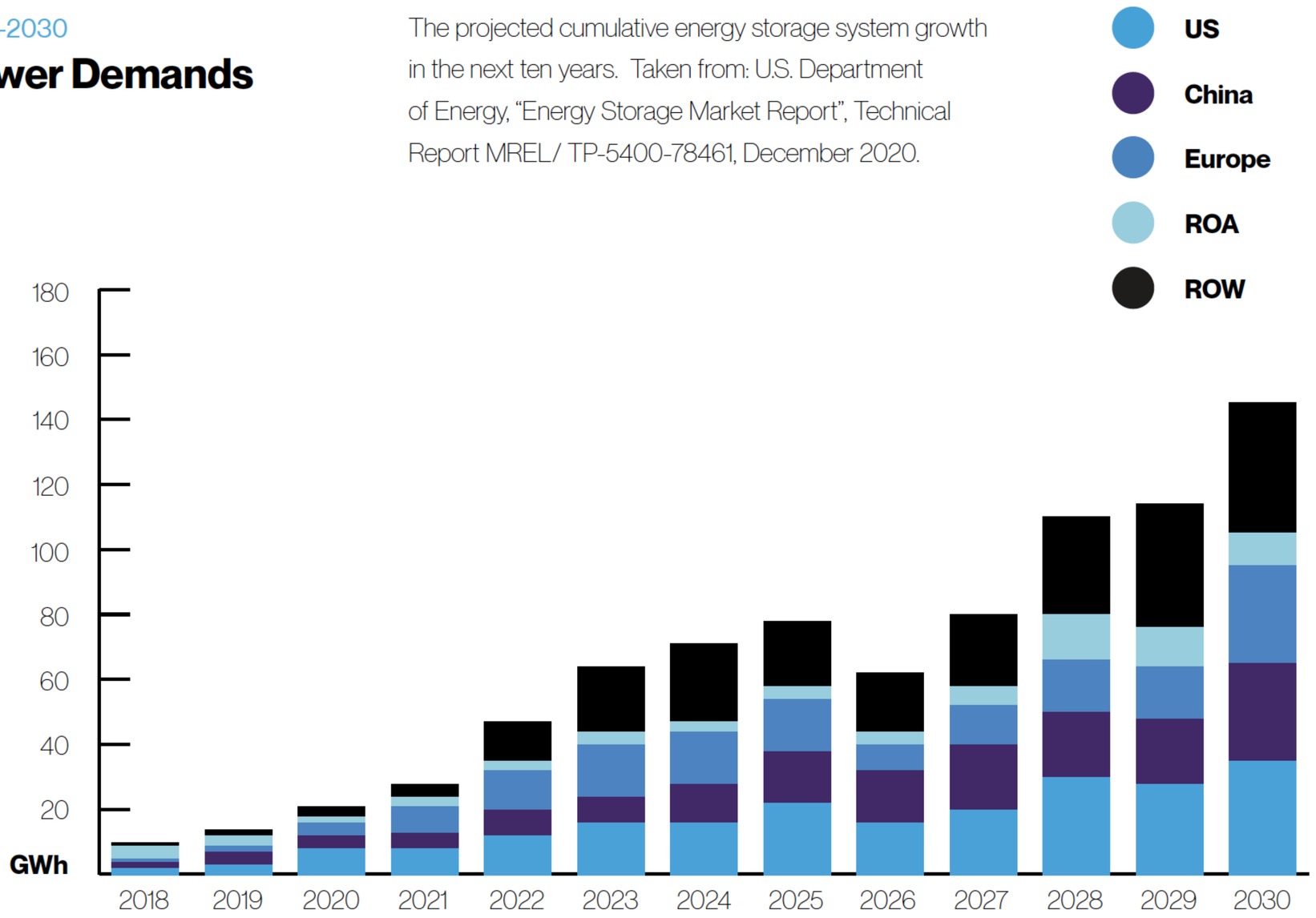

PERFORMANCE

PRODUCTISATION

GOVERNMENT FUNDING

COMMUNICATIONS

Marketing Program

04.

Communications Program

Expansion of Battery video series

All you need to know about lead batteries

- Ongoing project to cover all the key topics around lead batteries:
  - Definitions
  - Applications
  - Markets
- Seven videos currently live, with 10+ finalized for release over coming months
- Great engagement on social media:
  - 3000+ impressions on LinkedIn and 17 shares since launch
- Feedback from our audience to cover other topics such as traction batteries and the motive power markets
- Expanding to include versions in Chinese and other regions especially on important topics for the Asian market e.g. e-bikes

Thank you!

For information, please contact

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