Battery Energy Storage: Key to Grid Transformation & EV Charging

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www.gridtential.com

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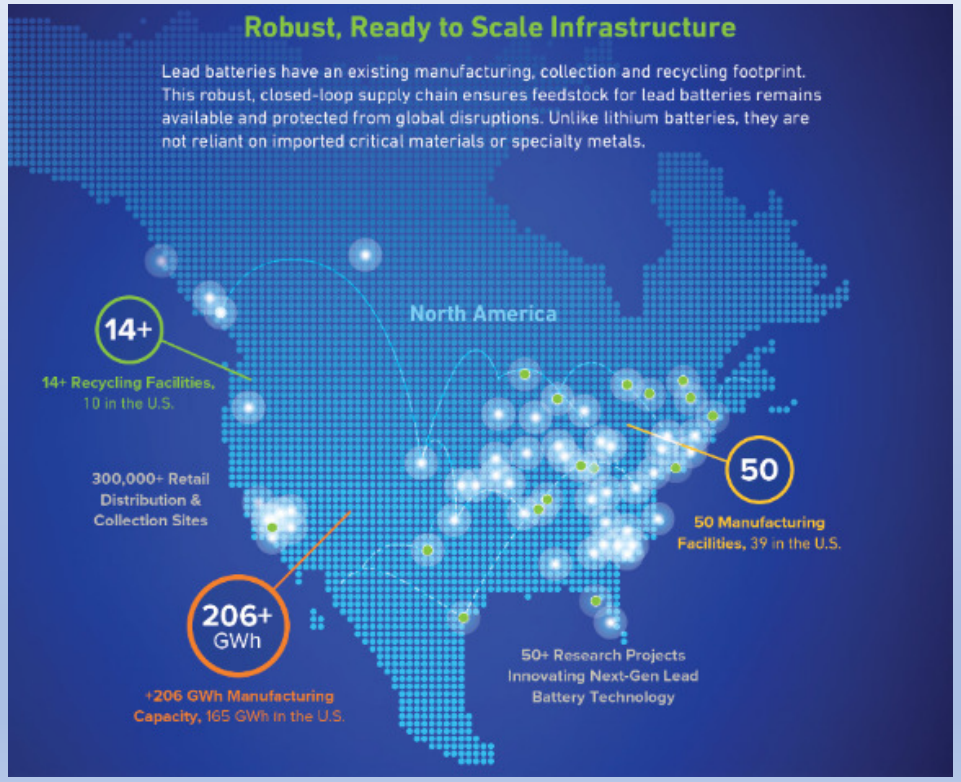

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Not if: Where & How Much Storage?

Front of the Meter (Centralized)		**Behind the Meter (Distributed)**
Long Duration Energy Storage		EV Charge Buffering
Firming		Demand Charge Reduction
Intermediary		Back-up Power
Peaking		Utility Demand Response w/wo PV
Frequency Regulation		Regulates/Smooth Supply to Grid

Batteries and Transmission

- Battery Storage critical to maximizing grid modernization
  - Alleviate thermal overload on transmission
  - Protect and support infrastructure
  - Leveling and absorbing demand vs. generation mismatch
- Utilities and transmission providers can look to batteries as an important tool in addressing ST/LT reliability

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Complementary Solutions for ESS

Lithium (Li)

- Where weight is critical
  - Consumer
  - EV Propulsion
- Other Advantages
  - Cycle Life Benefits
  - Volumetric Density
- Challenges for ESS
  - Safety
  - Cost
  - Recycling
  - Foreign Control
  - Preference for EVs
  - Demand Exceeding Supply

Funding & Developments Coming

Lead (Pb)

- Known Electrochemistry
  - Safety
  - Low Cost
- Truly Sustainable
  - Nearly 100% Recycled
  - Domestic Source / Production
  - Reused … infinitely
- Challenges for ESS
  - Cycle Life & E Efficiency
- Many Diverse Distributed Apps
  - Back-up Power
  - Commercial & Industrial
  - Matched with Solar
  - EV Charging Support

Innovation Pathways Clear

Flow

- LDES Potential
- Easily Scalable Systems
- Hybrid Systems
  - w/Lead for Black Start
- Challenges
  - Production Scaling
  - Cost Curve
  - Acceptance

Current state of the ESS market

The key market for all energy storage moving forward

Battery Type	ESS Service Life (average)	ESS Service Life (with augmentation/ replacement)	Energy Density (Wh/kg)	Working State of Charge (SOC)	Approximate capital cost ($kWh) -10 MW 10 hr	Cycle life (based on 80% DOD)
Bi-pole (Pb)*	7+ years	25 years	70	10-100%	200	1500+
Thin Plate Pure Lead (12V)	7 years	25 years	45	30-90%	345	1500
Advanced AGM (2V)	10 years	25 years	35	20-90%	412	4000
LFP	10 years	25 years	120-150	20-100%	378	3600-4800
NMC	10 years	25 years	150-180	20-100%	428	3000-3600
VRFB (Vanadium Flow)*	25 years	No need	20	35-100%	408	Unlimited

The worldwide ESS market is predicted to need 585 GW of installed energy storage by 2030.
Massive opportunity across every level of the market, from residential to utility, especially for long duration.
No current technology fits the need for long duration, and currently lithium is the only major technology attempted as cost-effective solution.
Lead is a viable solution, if cycle life is increased.
Other technologies like flow need to lower cost, already allow for +25 years use (with some O&M of course).

Source: 2022 Grid Energy Storage Technology Cost and Performance Assessment
*Current state of in-development technologies.

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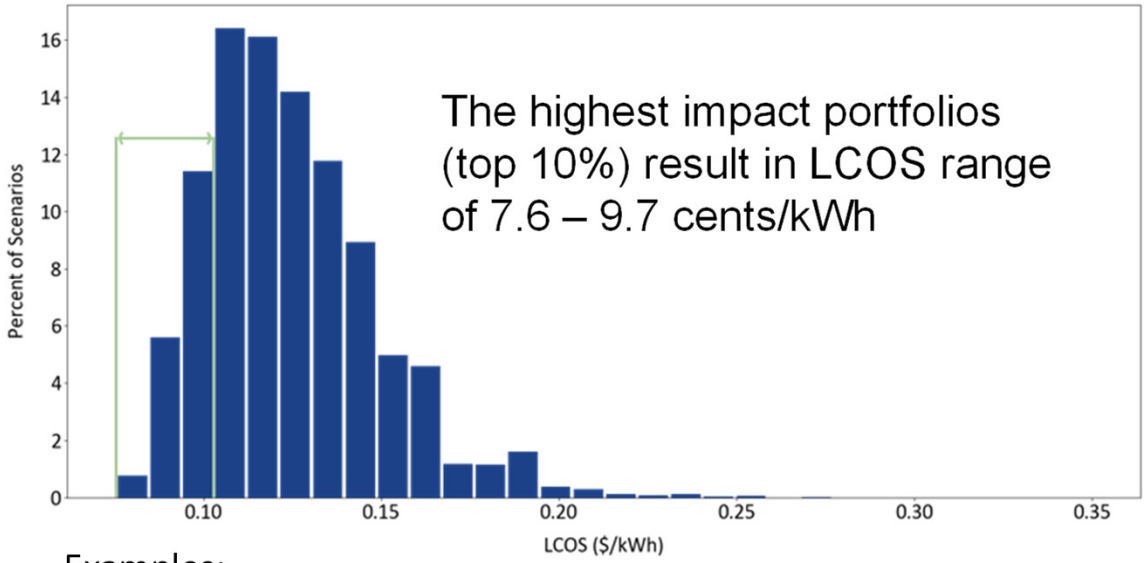
CBI Technology Roadmap for Lead Batteries for ESS+

Indicator	2021/2022	2025	2028	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

CBI – Consortium for Battery Innovation
Global Organization >100 members of lead battery industry's entire value chain

Storage Innovations (Pb)
…high R&D payback prospects toward DOE Goals

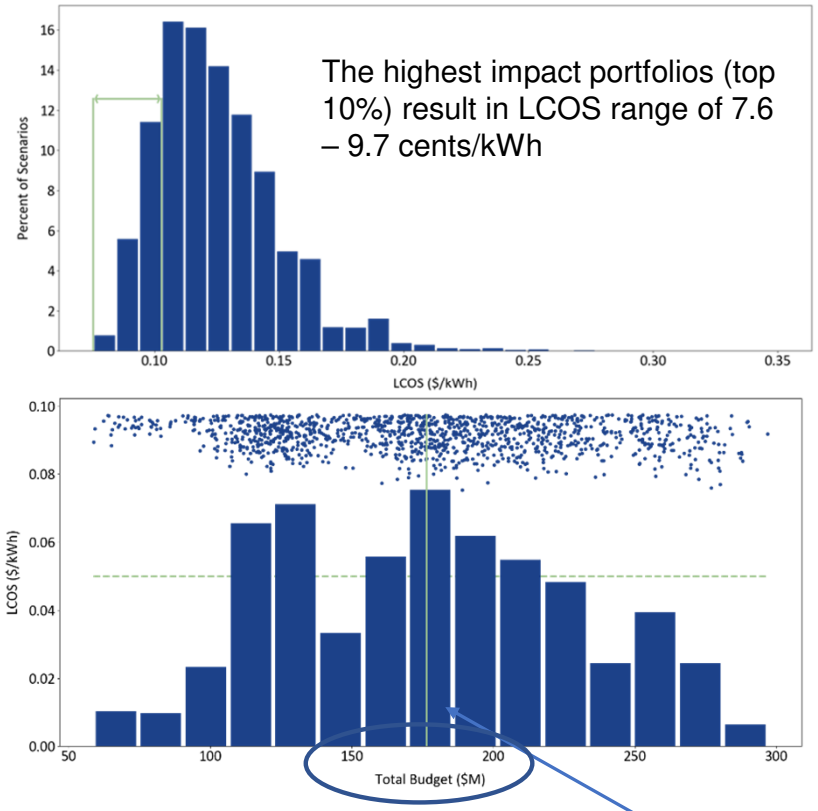


Examples:
Redesign of Current Collectors
Novel active material and additives
Scaling and Managing the ES System

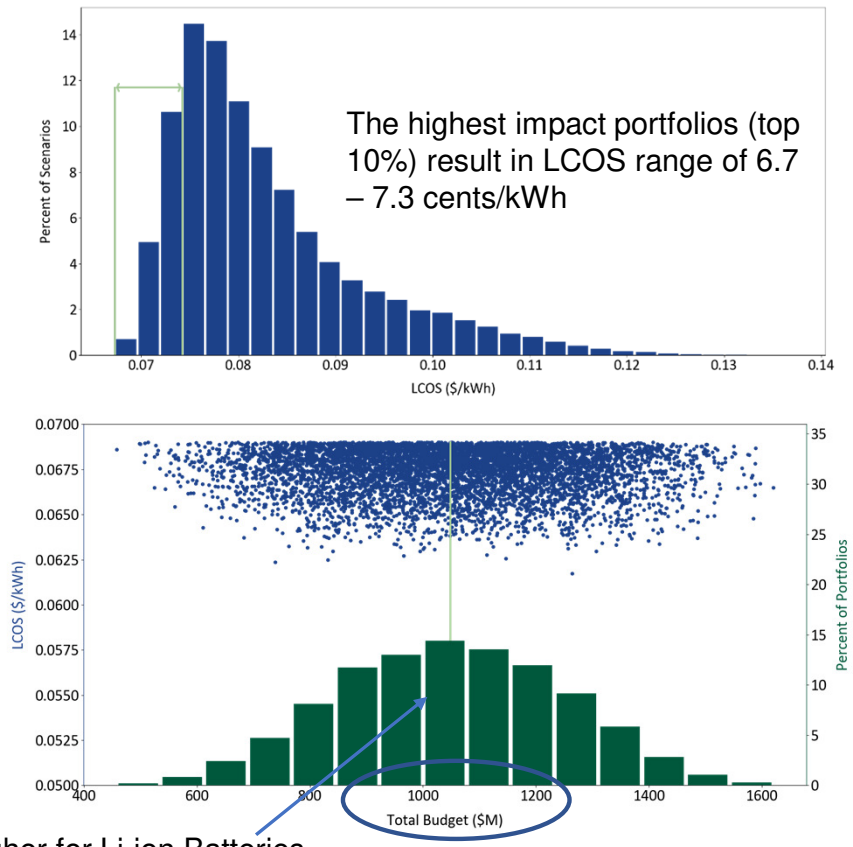
Excerpt: Storage Innovations 2020 by Patrick Balducci, Argonne National Laboratory

R&D Funding Need 5 - 6x Higher for Li-ion than Pb

Lead Batteries



Li-ion Batteries



Budget requirement much higher for Li-ion Batteries

Source: Storage Innovations Report, Balducci, Argonne National Laboratory, 2023

Collaboration & Investment

Industry

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ESSENTIAL ENERGY EVERYDAY

CONSORTIUM FOR BATTERY INNOVATION

Lead Battery Science Research Program - LBSRP
Electric Applications Inc. (Administrator)

American Battery Research Group

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U.S. DEPARTMENT OF ENERGY

ENERGY STORAGE GRAND CHALLENGE
U.S. DEPARTMENT OF ENERGY

Pacific Northwest NATIONAL LABORATORY

Argonne NATIONAL LABORATORY

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Sandia National Laboratories

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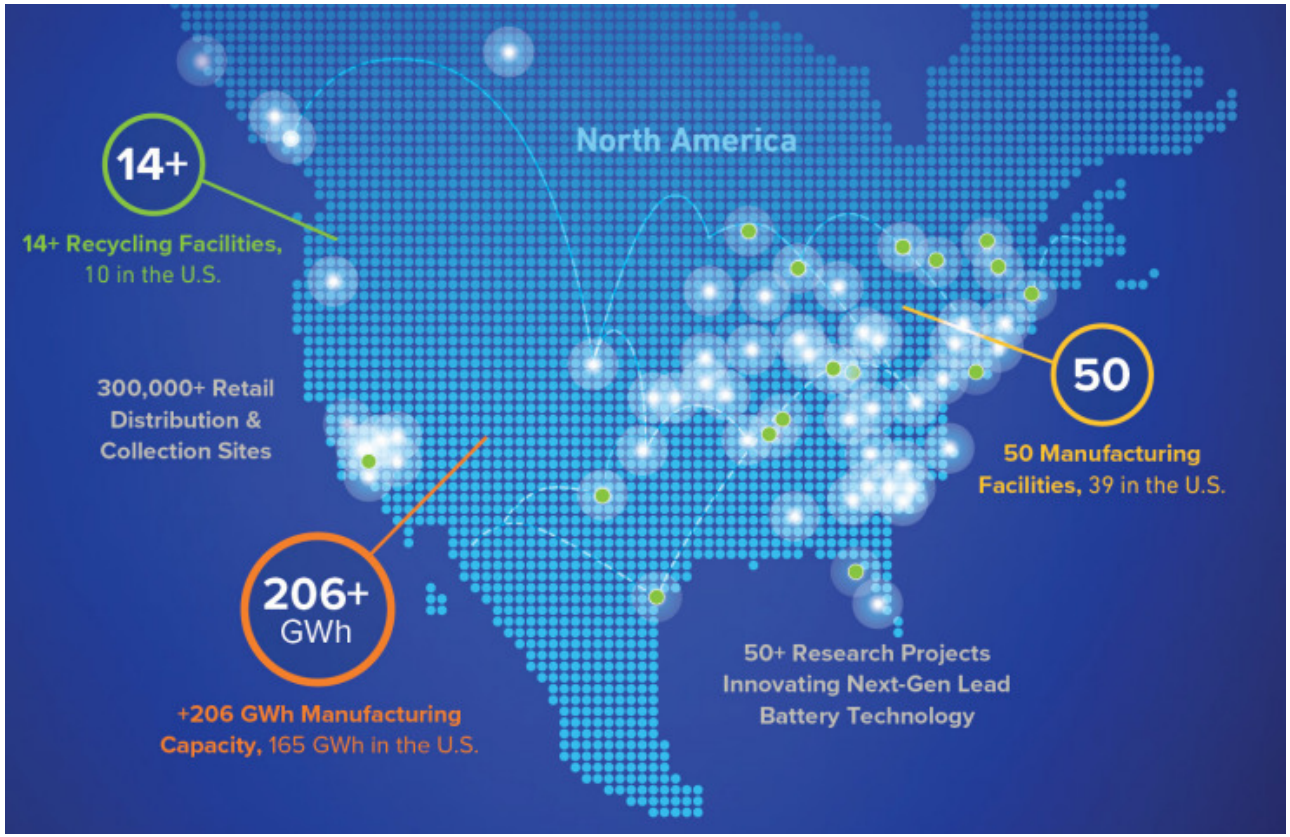
Unlocking Real Potential in Advanced Lead Batteries

Sustainable Capacity… Already Here

- 206+ GW hrs of Pb Battery Manufacturing
- 1.5 Million tons of battery recycling
- Most recycled consumer product
- $32 Billion in economic activity



Source: Battery Council International, U.S. EPA

Containerized Lead Battery ESS for EV Charging Station

1.5MWh EV Charging station with Mid-West Electric Utility Co.

Operational Mode Targets:

- Islanding
- Demand Charge Management
- Demand Response Management
- Optimal EV Charger Dispatch (EV fleets)

GS YUASA

NUVATION ENERGY
ACCELERATING ENERGY STORAGE

GREENTECH -RENEWABLES-

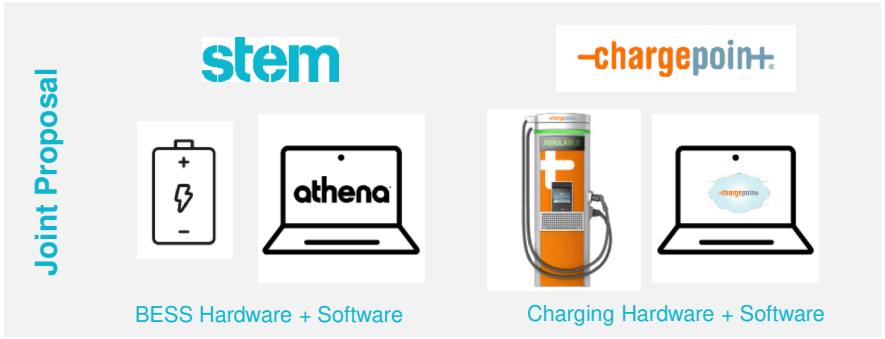
epcpower

Module Solutions

Enabling Technology: ***Advanced Nanocarbon Lead Battery*** → 5000 cycles, 10 yrs+

Lead Batteries are critical components of the energy storage portfolio for the US electrical grid.

EV Charging + Battery Storage Accelerates eMobility



Barriers to High Power Charging Deployment

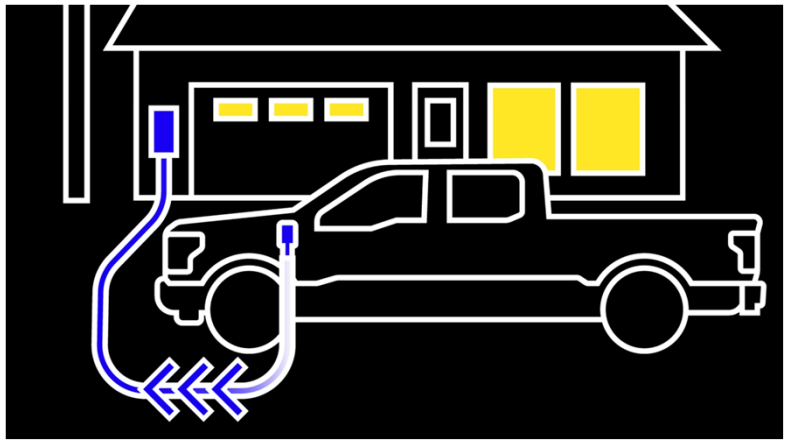
+ Low-powered infrastructure & long utility upgrade processes
+ Expensive demand charges create high OPEX
+ Low utilization today, ramping quickly
+ Mixed electricity sources
+ Resiliency and reliability

ChargePoint & Stem's joint solution enables

+ Faster deployment
+ Reduced demand charges
+ Maximized grid services
+ Use locally stored onsite solar energy or clean energy from the grid for cleaner charging
+ Increase charger uptime by continuing EV charging during outages

Mobile Storage for Diverse Applications

- Emergency “on the road charging”
  - Emergency boost preferable to a tow truck
- Battery swapping (NIO)
  - Very different use-case and infrastructure needs
- Vehicle as Backup Power (F150)
  - Generator alternative to overcome short grid outages
- Most other applications proposed are not cost or CO_2 effective
  - Extended power outages will require generation not storage

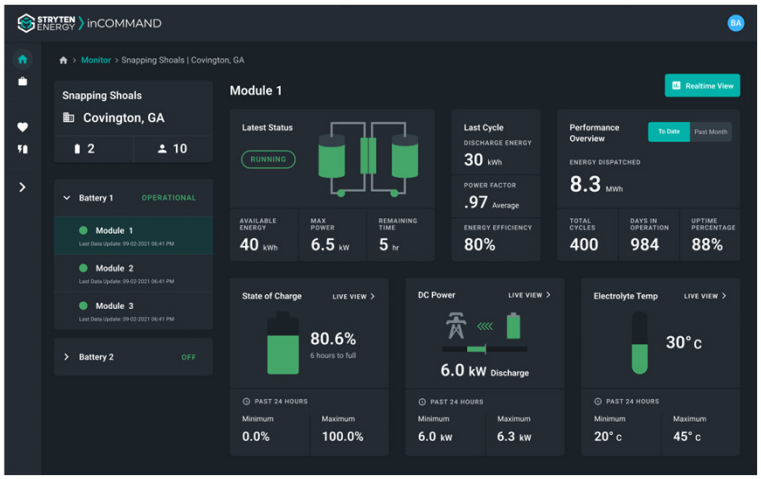


Hybrid Flow and Lead Solutions Benefit All

Hybrid Solutions:

- Provide both technical and commercial benefits
- Flow is low OpEx while lead is low CapEx
- Lead is mature technology and highly reliable
- Flow is excellent for deep cycling and long durations
- Lead is excellent for passive, black start, high in-rush currents
- Both are near 100% recycle ready

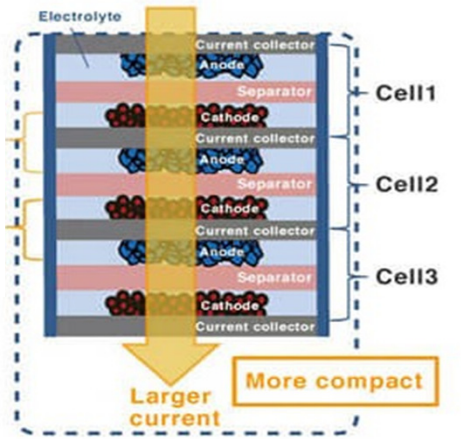
STRYTEN ENERGY



Better Performance with Bi-Pole Architecture …

Nickel based

TOYOTA

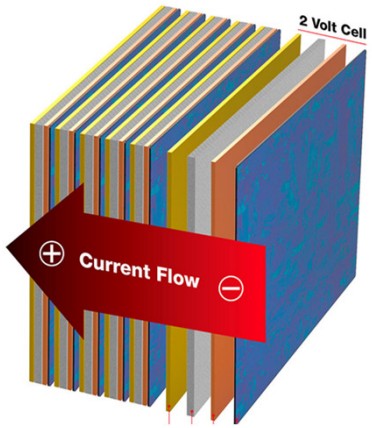


"…. the new battery realizes approximately twice the output"

https://hydrogen-central.com/toyota-new-aqua-first-ev-high-output-bipolar-nickel-hydrogen-battery-electric-drive/

Silicon + Lead

GRIDTENTIAL



Increases life and performance 2 – 3x

SILICON JOULE

Advanced Pb Solutions Require Stakeholder Buy-In

Better Recognition of Lead Batteries Role & Potential

- All storage needs cannot be met with lithium
- Pb battery production and recycling capacity on-shore and expandable
- Perfect example of a sustainable circular economy
- Cost, safety, and core electro-chemistry proven and known
- Density, cycle life, and efficiency can significantly increase
- With support, DOE's LCOS goals are within reach

More Support Needed

- Funded access to the experts, analytics, and equipment at National Labs
  - Current small projects already unlocking groundbreaking improvement pathways
- Proper share of the $$$ focused on clean energy
  - Prioritize US projects to accelerate product and production innovation for advanced lead batteries