



# The Battery Technology Race

ELBC, 18 September 2024, Milan

# EV RESET ⇒ BAD LITHIUM HANGOVER

	WHAT	COMPANIES
China	Excess in CARS & BATTERIES	<i>CATL &amp; BYD ok, investing Xiaomi, Huawei &amp; consolidation</i>
N. America & Europe	Car & Battery Plants Delayed Government initiatives continue	<i>Northvolt, VW, Ford, GM &amp; others adjusting</i>
Japan & Korea	Hybrids Lift Toyota & Honda Impact of Korea Fires?	<i>Panasonic, LG, Samsung, &amp; SK adjusting</i>
S. America Australia & Indonesia	Lithium & Nickel Excesses	<i>Albermarle, SQM, &amp; Vale adapting</i>

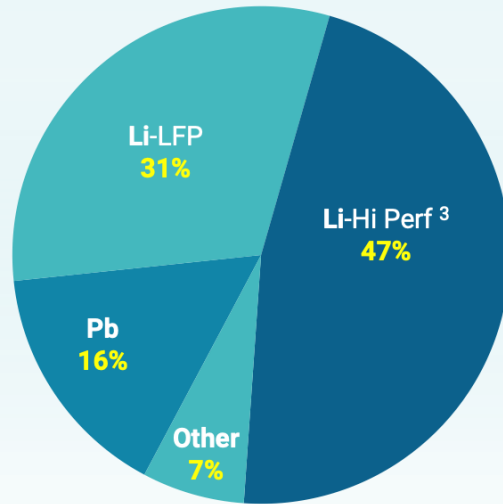
**>\$25 BILLION in investment deferrals and losses**  
**...2030 EV forecasts down ~6 million vehicles**

# MARKETS BY 2030

## ENERGY CONTENT

~~4,500 GWh~~

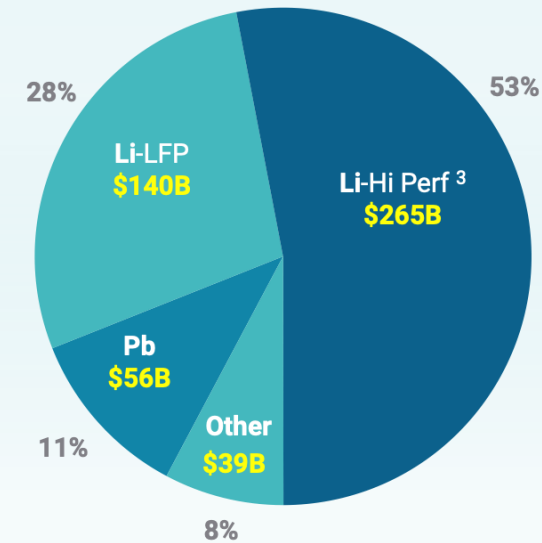
↓ 7% to 4.2 TWh



## VALUE

~~\$500 Billion~~

↓ 16% to \$420 B



*Still \$420 Billion, and \$1 Trillion by 2040*

NOTES: <sup>1</sup> Estimates by speaker from diverse industry sources and model

<sup>2</sup> Excludes portable consumer apps

<sup>3</sup> Li Hi Perf includes all Li variants except LFP

# HORSES FOR COURSES – 3 RACES

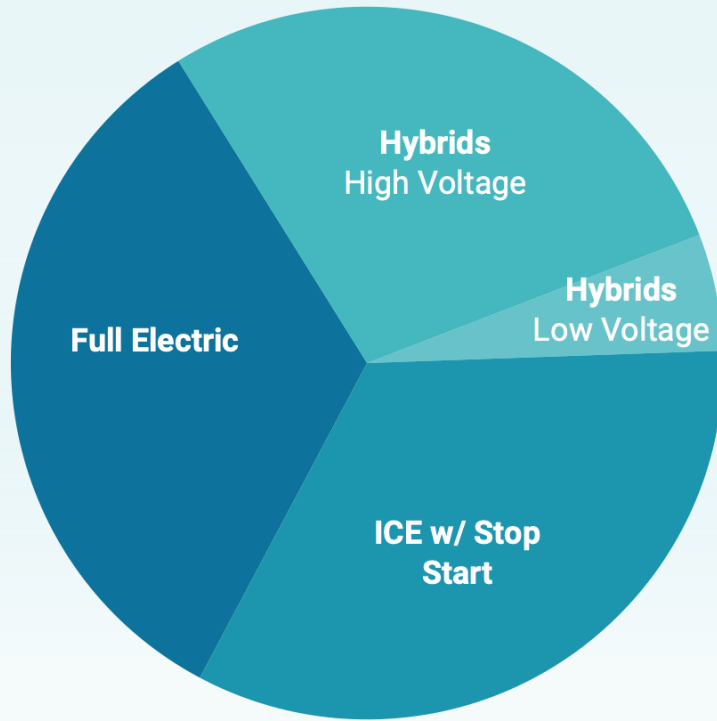
		PURSE BY 2030	FAVORITES
RACE 1	BEV Propulsion	<b>\$210B</b> 2.2TWh @ \$95/kWh CAGR	<b>NCM811, LFP/LMFP</b> <i>...maybe Solid-State, Li-Sulfur</i>
RACE 2	ESS, Material Handling, LSEVs <sup>1</sup>	<b>\$100B</b>	<b>LFP/LMFP, Pb</b> <i>...maybe Na, Fe, Zn, VRFB</i>
RACE 3	Hybrids, Stop/Start, SLI, Back-up <sup>2</sup>	<b>\$110B</b>	<b>Diverse Li, Pb</b> <i>..still NMH, maybe Na</i>

# HANDICAPPING THE RACES

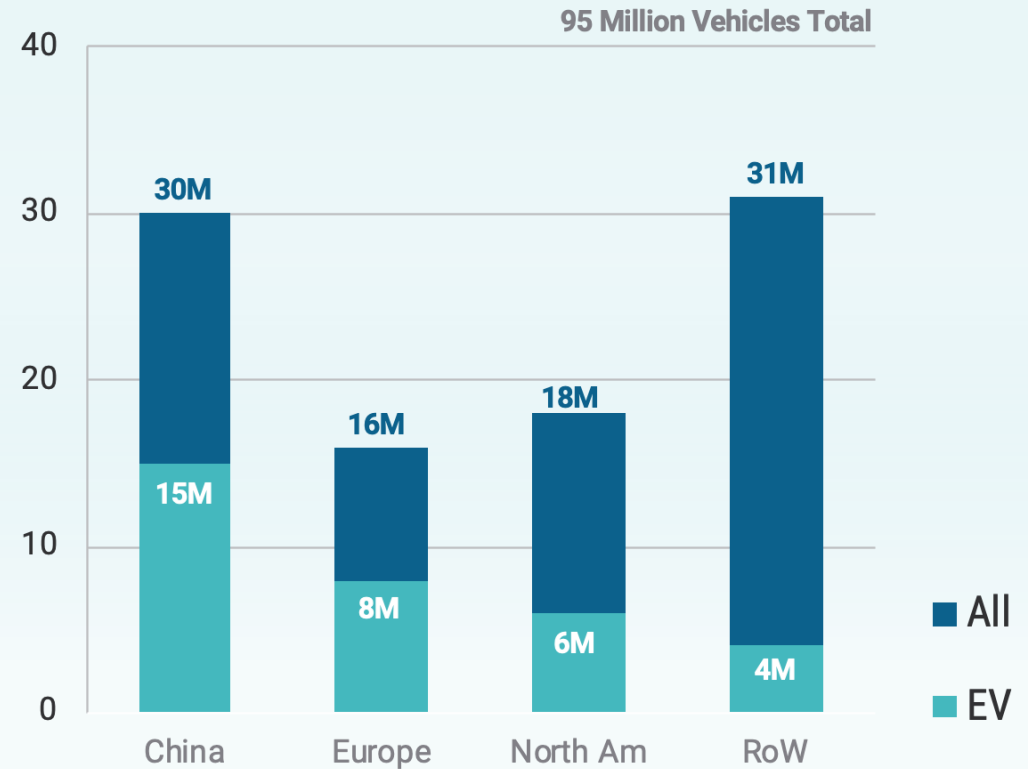
	HORSES	BATTERY TECH
Recent Form	Last 3 races	Last 3 years progress
Competition	Class of race	Position & Resources
Leadership & Risk Tolerance	Trainer, Jockey	CEO, CTO, CFO

*Also for batteries: Government Policies, Safety, & Sustainability*

# RACE 1: PROPULSION MIX BY 2030



*~33% each*



*...still half EVs in China/Europe*

# SOLID-STATE Li – DIVERSE VIEWS

Life &  
Manufacturing  
Costs??



**Tech Roadmap is clear and credible**

- *On Niche vehicles starting in 2027?*



**Says tough to manufacture** pushing out expectations

- *Market leaders often do that, High Chinese support*



**Committed to first production** after multiple delays

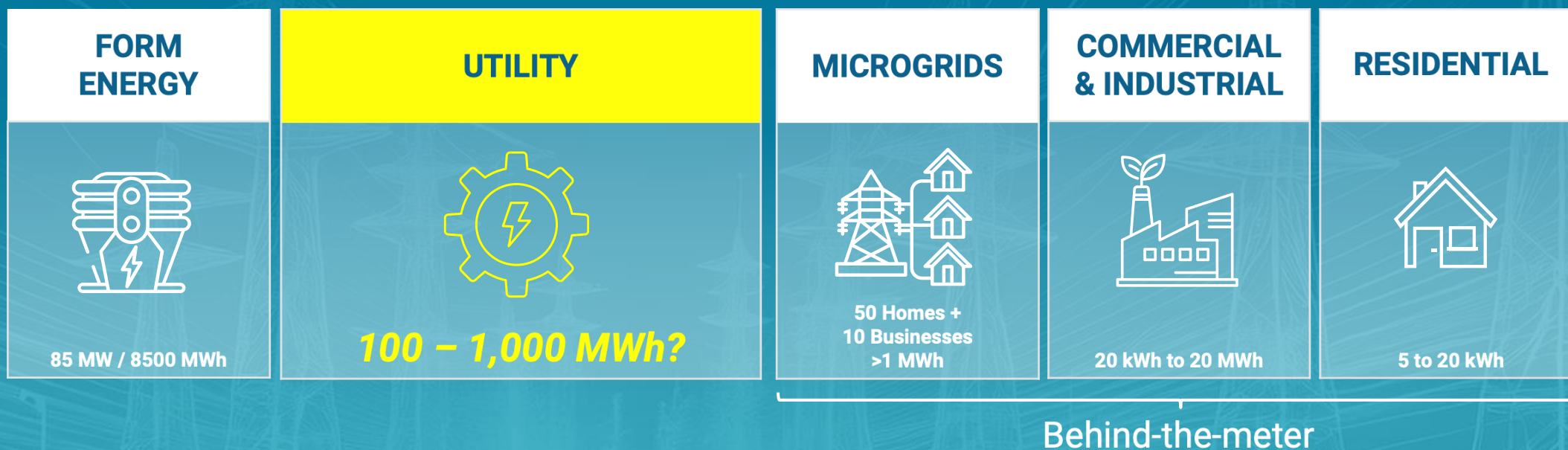


**Small cells are real** and many other claims

*Clear winner if density 2x to 500 Wh/kg*






## RACE 2: ENERGY STORAGE SYSTEMS (ESS)



***Support Less Stable Grid – Save Money***



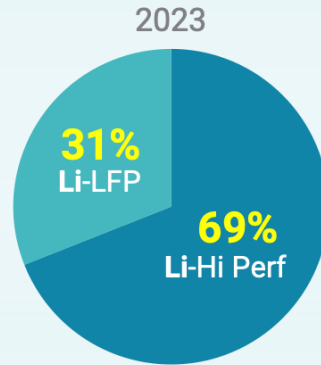
## RACE 2: OTHER DEEP CYCLE APPS

	Material Handling w/ AGVs & Drayage	LSEVs 2, 3, & 4 wheel	Diverse <sup>(1)</sup>
			
<b>Global Market '24</b>	<b>&gt;\$10 B</b>	<b>&gt;\$11 B</b>	<b>&gt;\$4 B</b>
<b>Li share at OEs in 2030</b>	10-67%	10% to 95%+	0 to 33%
<b>Global \$ Growth CAGR % to 2030</b>	>4%	>5%	>5%

*Race for convenience, cost, and safety*

# LFP STILL GAINING & IMPROVING

## RECENT



Up from <10%

**COST** < \$100 kWh  
**SAFETY** Better than NCM  
**CYCLE LIFE** > 3,000

## NEAR FUTURE

**CHEMISTRY**  
*LMFP lifts Wh/kg*



**ARCHITECTURE**  
*Bi-Pole for Hybrids*



**PACKAGING**  
*Prismatics & skateboards for density and safety*

*Supply Chain?? Current Excesses / Virtually all from China*

# SODIUM (Na) ENTRY & PROSPECTS

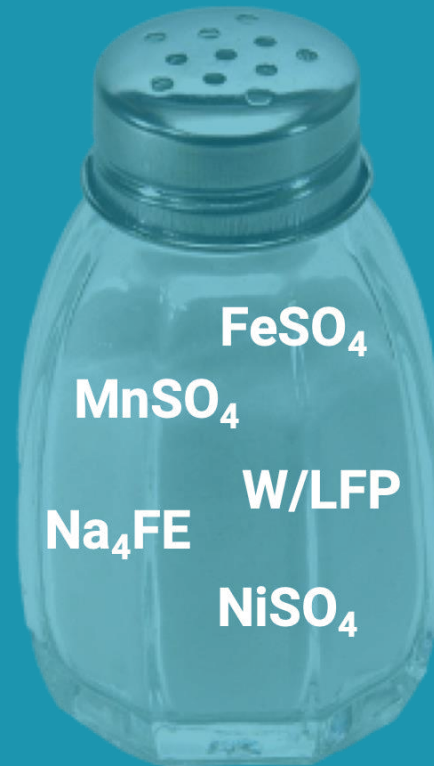
## CLAIMS

**"Low Costs"**  
< \$100 kWh

**"Long Cycle Life"**  
> 2,000

**INITIAL APPS**  
China EVs  
Possibly ESS & LSEV

## WHAT'S INSIDE



## WHO



## RACE 3: DRIVERS FOR VALUABLE STORAGE

### FEAR

3x Electricity Growth  
Shift to Intermittent Generation  
Lag in Transmission Upgrades

### GROWTH






Electricity cost increases  
Weather extremes & Geo-Politics  
EVs: *Redundant Auxiliary,  
EV Charge Buffering*  
Smart Hybrid solutions  
Safe & Secure Networks  
Data Centers/AI, Edge

### SOLUTIONS

Match Distinct Uses  
Life and Redundancy  
Resiliency/Safety  
Competitiveness  
Smarter systems  
Sustainability

**... much more *DISTRIBUTED* Energy Storage**

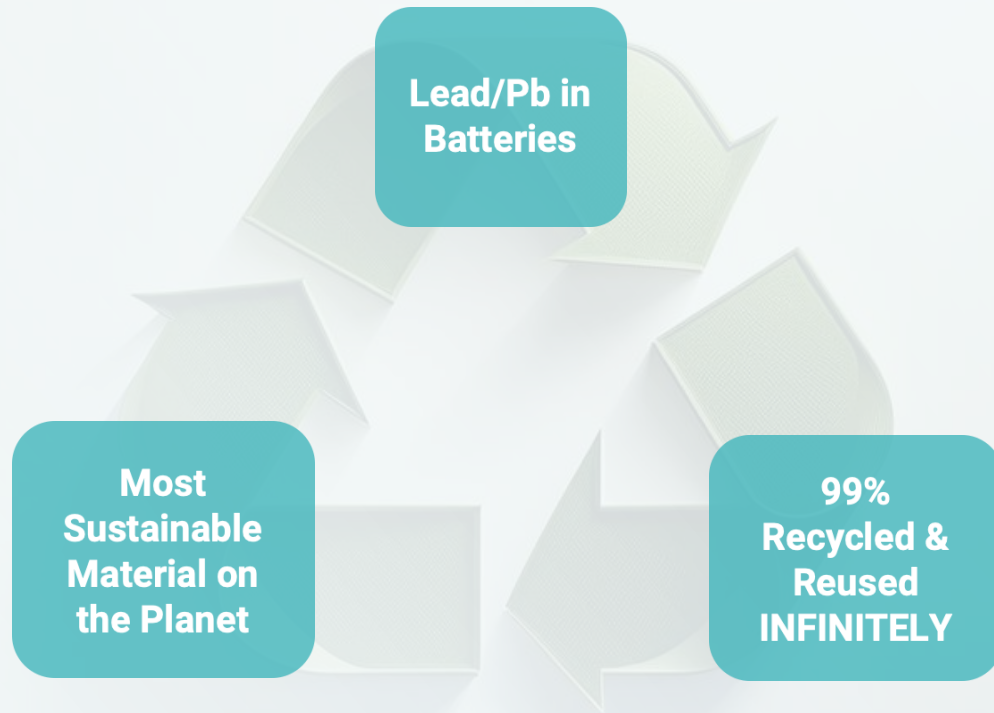
# MORE THAN BACKUP POWER

	<i>Different Needs = Different Value Solutions</i>				
	 <b>DATA CENTERS</b>	 <b>TELECOM &amp; BROADBAND</b>	 <b>EV LOW VOLTAGE</b>	 <b>EV CHARGE BUFFERING</b>	 <b>COMMERCIAL &amp; INDUSTRIAL</b>
<b>Run time</b>	3-10 minutes	2-12 hours	minutes	< 30 minutes	< 1min – 4 hrs
<b>Voltage</b>	220 – 440V	36-48V	12-48V	150W / 220 - 440V	High
<b>Use intensity</b>	Low	Low	Constant	Intermittent	High
<b>Service life</b>	7-10 years	5-10 years	8 years 100,000 miles	7-10 years	7-10 years

***Also Cost, Safety, Redundancy, Temperature tolerance, & Sustainability***



# LEAD (Pb) \$100 Billion by 2030?



**PLUS: High Power, Low Cost & Safe  
While improving**

*Cycle Life to 3,000+  
Cost: LCOS <\$.07  
Charge Acceptance*

Markets & Share	Today	2030	Keys
SLI Stop/Start	99%	> 95%	<i>Life</i>
LV EV auxiliary	> 90%	> 75%	<i>Redundancy</i>
Material Handling	> 75%	50%	<i>Convenience</i>
LSEV-2,3 & 4 wheel	> 67%		<i>Cycle life</i>
Diverse Backup	80%		<i>Life &amp; Safety</i>
ESS BTM	< 5%	10-25%	<i>Cycle life &amp; Safety</i>
EV Charging	NM	> 25%	<i>Power&amp; Safety</i>

# CBI BLUEPRINT PROJECT

## Lead battery ESS to back up EV fast charging



Using advanced lead batteries from



Supported by

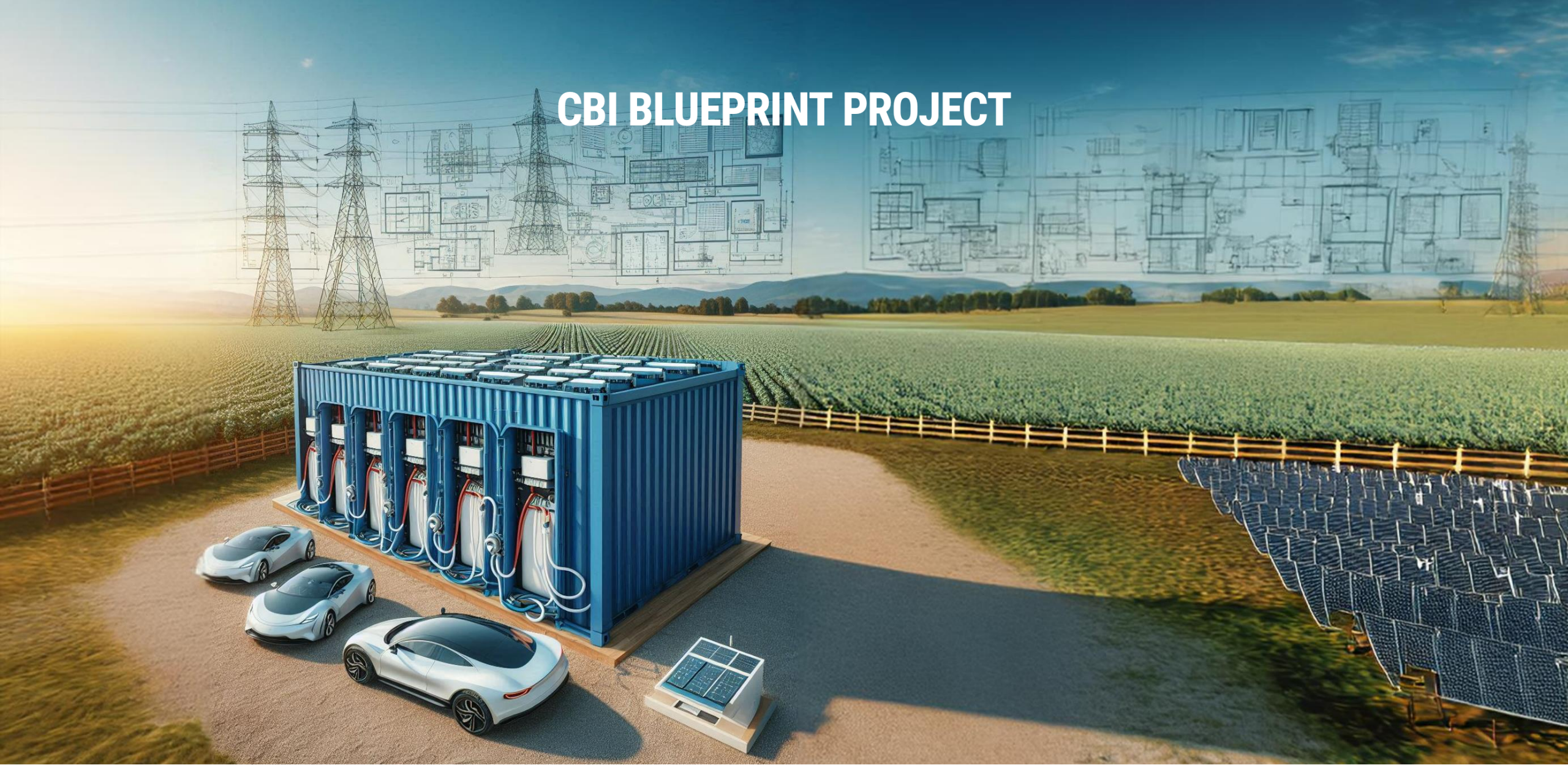


In partnership with





# CBI BLUEPRINT PROJECT





## RACE 1: EV PROPULSION BY 2030

<b>WINNER</b>	<b>NCM811</b>	<i>In Higher Performance/Range Also Si enriched anodes Semi-solid state for better safety</i>
<b>PLACE</b>	<b>LF(M)P</b>	<i>2nd is still a big payout Vehicles w/ lower Cost/Range appeal China dominance here a constraint</i>
<b>SHOW</b>	<b>Li Solid State</b>	<i>Enters at 3rd in premium vehicles True disrupter from 2030-2040</i>

*Na misses a payout, yet starts in select China local and export sales*

## RACE 2: ESS & DEEP CYCLE PROSPECTS BY 2030

DIFFERENT <b>WINNERS</b> BY APP	FTM ESS	BTM ESS	DEEP CYCLE
	<p><b>Li in 5 MWh+ Apps</b> continues with 80%+, Fe</p> <p><b>Contenders</b> Na + Pb up to 5MWh Flow in LDES Fe in Large multi-day</p>	<p>Li still leading with LF(M)P, China concerns?</p> <p>Pb takes 25%+ share: Cost, Sustainability, and 3x Cycle life</p> <p>Na growth maturing, Zn also possible</p>	<p><b>Dead Heat/Tie for Pb &amp; Li</b></p> <p>Across Material Handling, LSEVs, Lifting, et al</p> <p>Cost, Cycle life, and Recycling economics all big factors</p>

*Distributed Energy Storage Emerges with Highest Growth*



## RACE 3: POWER & ENERGY SOLUTIONS

### WINNING ATTRIBUTES

1. Cost always key, yet some high value apps
2. Charge/Discharge rate matters
3. Safety and Consistency across Life
4. Temperature tolerance and weight savings

#### SLI & Stop Start

*Likely still Pb, mostly AGM at OE by 2030*

#### Hybrids

*Ni & Li share, Pb Bi-Pole credible for 48v*

#### EV LV Auxiliary

*Pb leading, Li challenging; Diagnostics & redundancy needed*

#### Data Center/BU

*Li gaining notably, yet Pb can sustain with cost, safety & added life*

#### EV Charge Buffer

*Power, Safety & Cost of Pb is credible alternative to any eChemistry*

#### Other BU<sup>1</sup>

*Known Safety & Cost sustains Pb's lead, but Li, possibly Ni challenges*

*Varying Performance & Cost Values*

## ▶ BIG WINS ARE POSSIBLE

### ▶ Powerful Global Electrification Trend Continues

- ▶ **EV Reset** *has heightened storage competition*
- ▶ **Storage Growth** *to \$420B by 2030 & \$1 Trillion by 2040*

### ▶ Technology Races

- ▶ **BEV Propulsion**  
*Better NCM & LFP share, yet solid-state coming*
- ▶ **ESS/Deep Cycle**  
*Adv Lead maybe Na+, will challenge Li*
- ▶ **Power/Energy**  
*Major shares for Pb & Li  
Na, Ni, Fe, & Zn for niches*

### ▶ Challenge

- ▶ **A tough race is on for PROFITS in the GOLDEN decade for Energy Storage...**  
... invest NOW for the breakthroughs in Advanced Lead for your future

# SILICON JOULE ESS/DEEP CYCLE PLATFORM



**48V GC2+**  
1.3 kWh

## KEY METRICS

- ✓ **Cycle Life**  
at 80% DoD  
**Gen 1 2,000+**  
**Gen 2 3,000+**
- ✓ **Cost**  
BOM *Equivalent to AGM*  
LCOS *<50% of AGM*
- ✓ **Heat Tolerance** *very high*
- ✓ **>40% Lighter** *than AGM*
- ✓ **Safe & Recyclable**

## TARGET APPLICATIONS

- ✓ **ESS**  
BTM (*now*)  
C&I  
Residential
- ✓ **Mat/I Handling**  
24/36V Packs
- ✓ **LSEVs**  
2, 3, & 4 wheel
- ✓ **Back-up**  
Telco 48V  
Broadband 36V

## TECHNOLOGY ROADMAP

- Pb** Larger Blocks, Diverse Back-up & EV Aux., hybrid & SLI s/s
- Beyond Pb** LFP, Zn, Na, Ni all possible with Silicon Bi-Pole & Gridtential packaging

# SOURCES & THANK YOU

The opinions and forecasts herein are those of the presenter, yet reflect the synthesis of the many fine reports, plus the technical and financial releases of 100+ companies, many referred to herein.

*Reports referenced  
include*

**US Dept. of Energy Office of Electricity**  
**Volta Foundation**  
**Consortium for Battery Innovation**  
**Roland Berger**  
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