FORGE NANO

On the Path Towards Domestic Production of Li-ion Batteries

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FORGE NANO

Li-BRIDGE

MPSC
MILITARY POWER SOURCES CONSORTIUM

NAATBatt INTERNATIONAL

SAE INTERNATIONAL®

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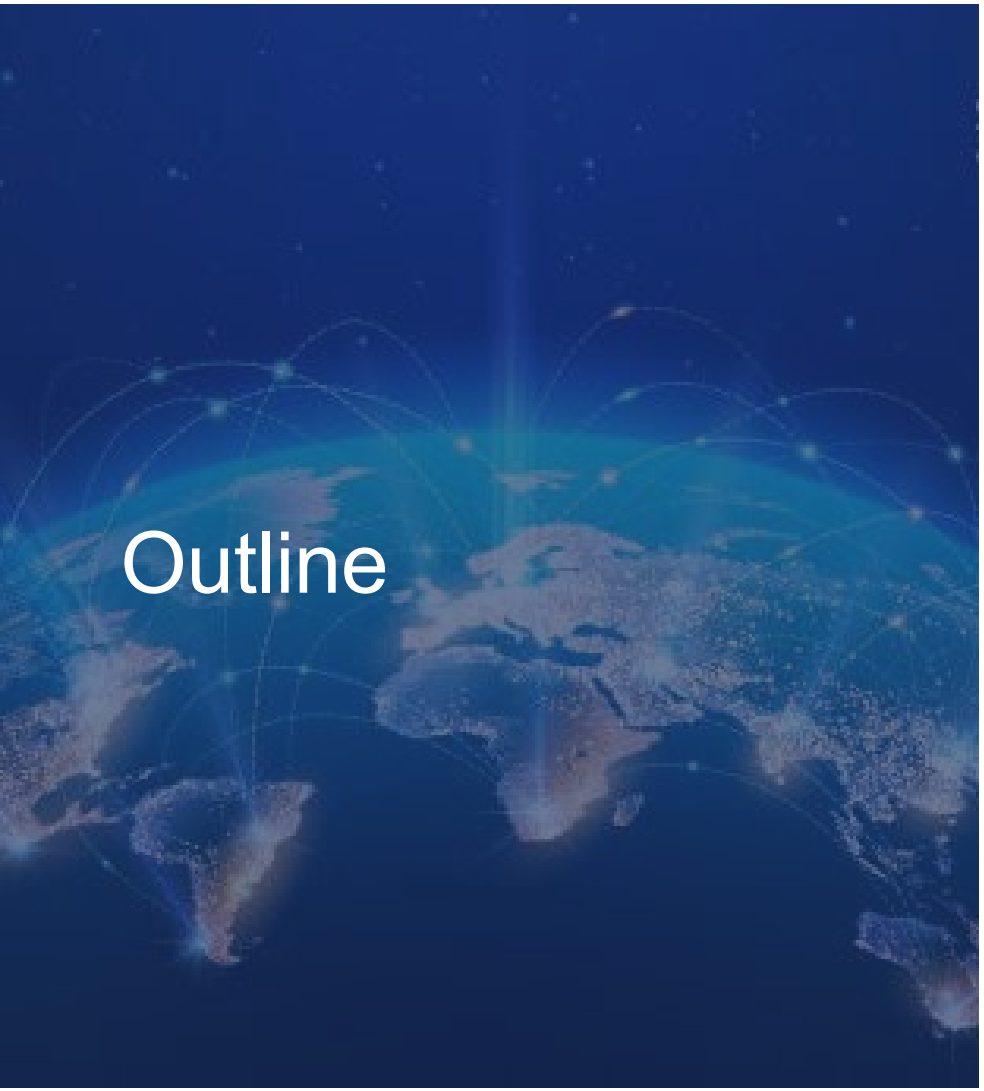
- Officer, MPSC
- Officer, NAATBatt
- Expert, SAE International

FORGE NANO	FORGE BATTERY • Global leader in specialty chemicals via nano-coatings • Technology improves Li-ion battery performance and safety, universally for any application (Additive, Magnetics, Propellants, Semiconductors, etc..) • On track to become a US cell supplier to specialty markets (1GWh+ in 2026)
Li-BRIDGE	• Public private partnership positioned as industry-side of the Federal Consortium of Advanced Batteries (FCAB) • 50+ companies addressing supply chain challenges for Li-ion batteries with ties to European Battery Alliance (EBA)
MPSC MILITARY POWER SOURCES CONSORTIUM	• Non-profit dedicated to supporting communication and effective collaboration between DoD and industry pertaining to energy and power • Data collection and networking aimed at providing recommendations for funding and policy
NAATBatt INTERNATIONAL	• Industry trade-group composed of leaders in the Li-ion battery industry • Promotes development and commercialization of energy storage technology
SAE INTERNATIONAL®	• World's leading authority in mobility standards development • Advanced Battery Concepts Committee developing standards, ratings, vocabulary, ect… Li-ion standardization

NDIS Strategic Priorities

- Resilient supply chains that can securely produce the products, services, and technologies needed now and in the future at speed, scale, and cost.
- Workforce readiness will provide for a sufficiently skilled, and staffed workforce that is diverse and representative of America.
- Flexible acquisition will lead to the development of strategies that strive for dynamic capabilities while balancing efficiency, maintainability, customization and standardization in defense platforms and support systems. Flexible acquisition strategies would result in reduced development times, reduced costs, and increased scalability.
- Economic deterrence will promote fair and effective market mechanisms that support a resilient defense industrial ecosystem among the U.S. and close international allies and partners and economic security and integrated deterrence. As a result of effective economic deterrence, fear of materially reduced access to U.S. markets, technologies, and innovations will sow doubt in the mind of potential aggressors.



State of the Li-ion Battery Industry

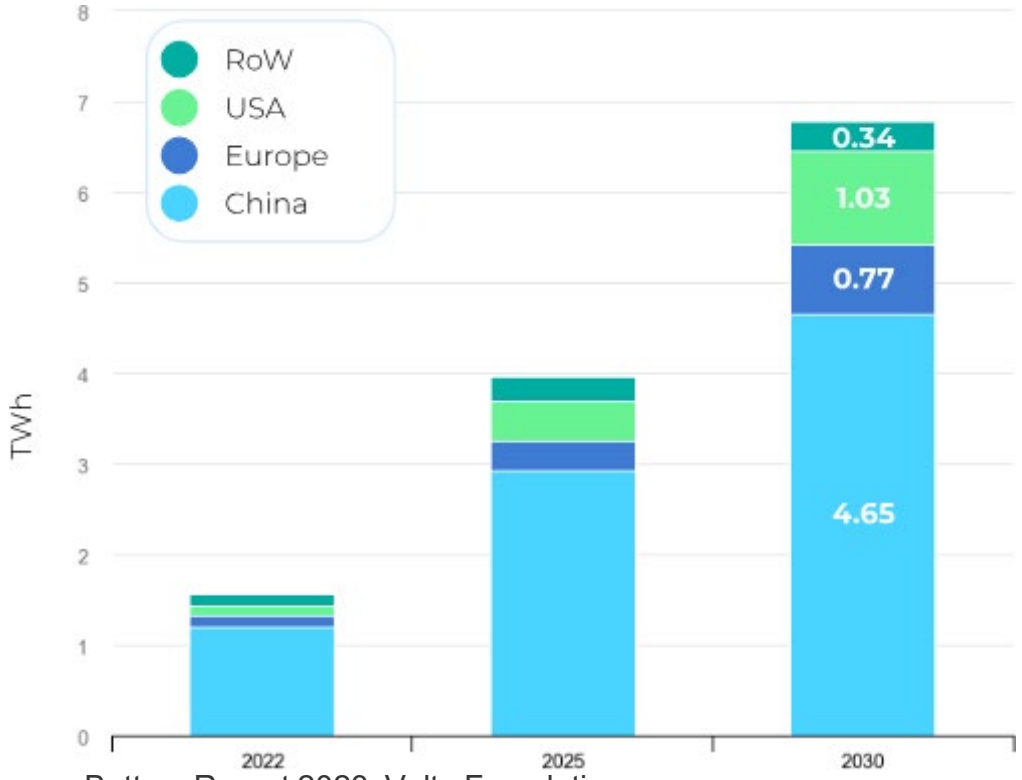
Challenges

More Challenges

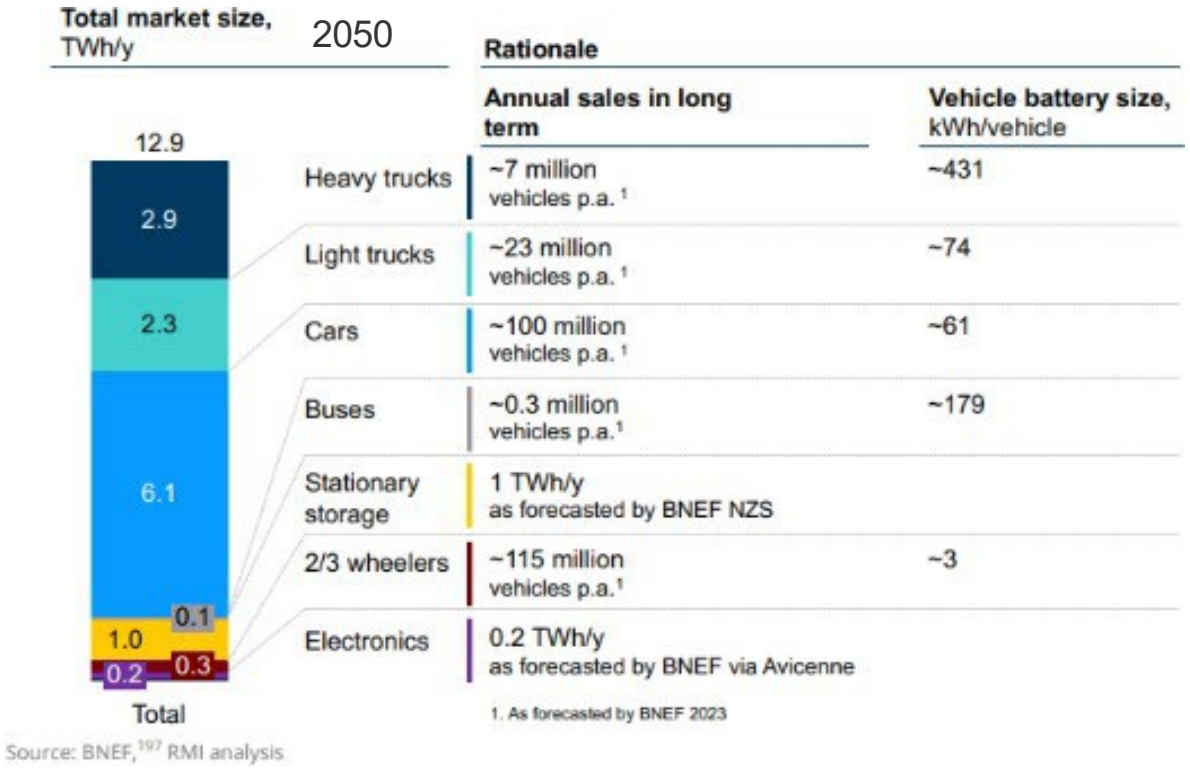
Progress Towards Domestic Production

Next Steps

Energy Storage in the US



Battery Report 2023, Volta Foundation.



US Li-ion energy storage needs are growing, led by transportation

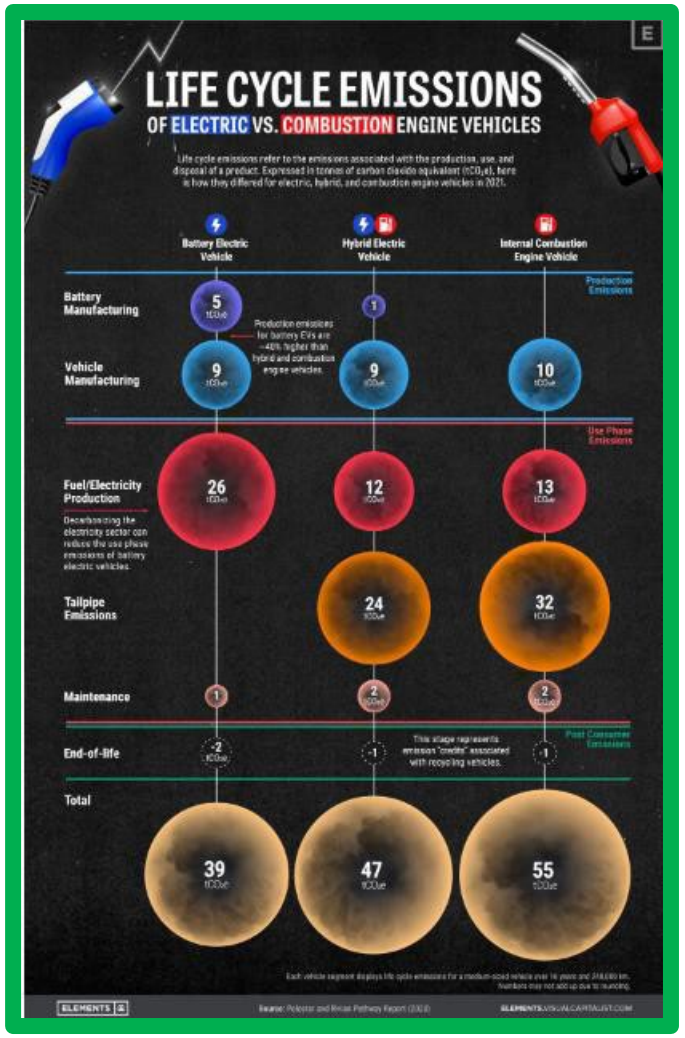
Pros and Cons of Li-ion

<u>Societal Improvements</u>

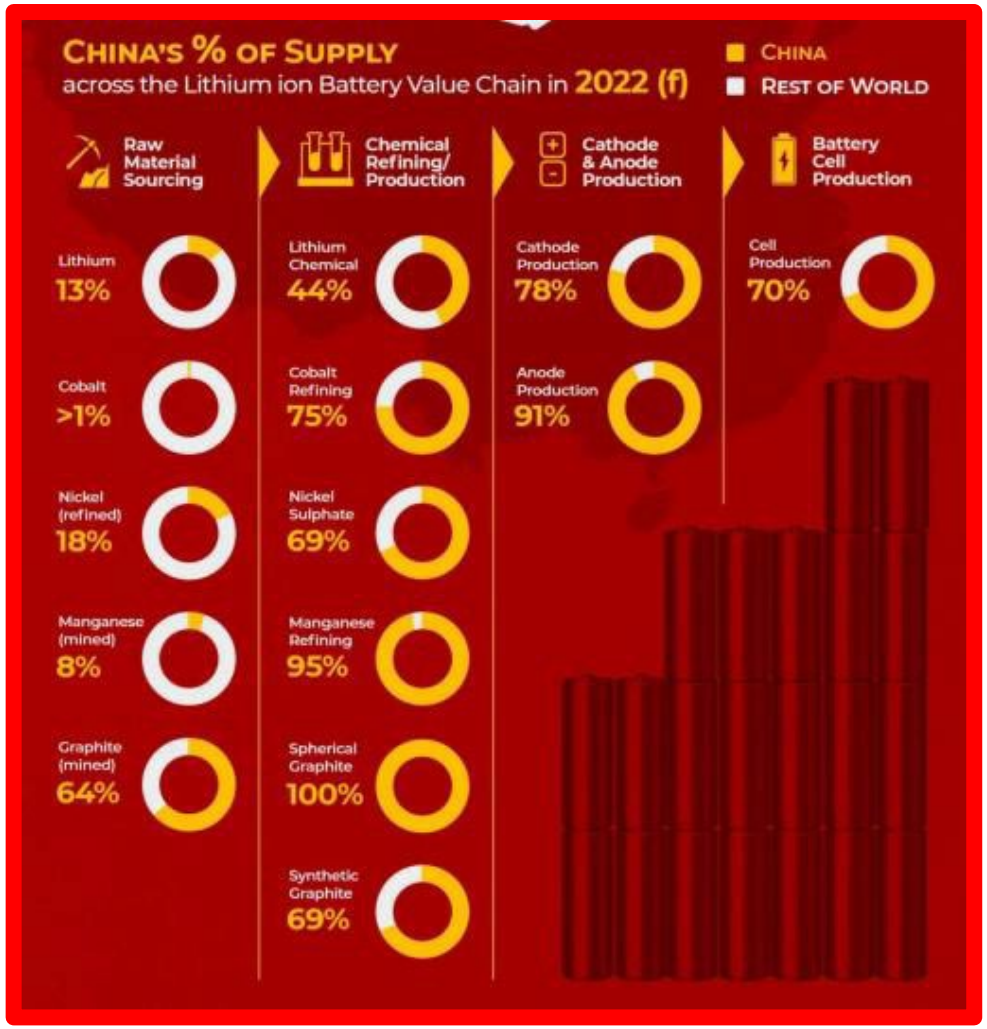
- Environmental improvements
- New Opportunities (drones)
- Consumer Savings (and fun!)

<u>Problem</u>

- US has created a supply chain dependency on China for Li-ion



Visual Capitalist, 2023.

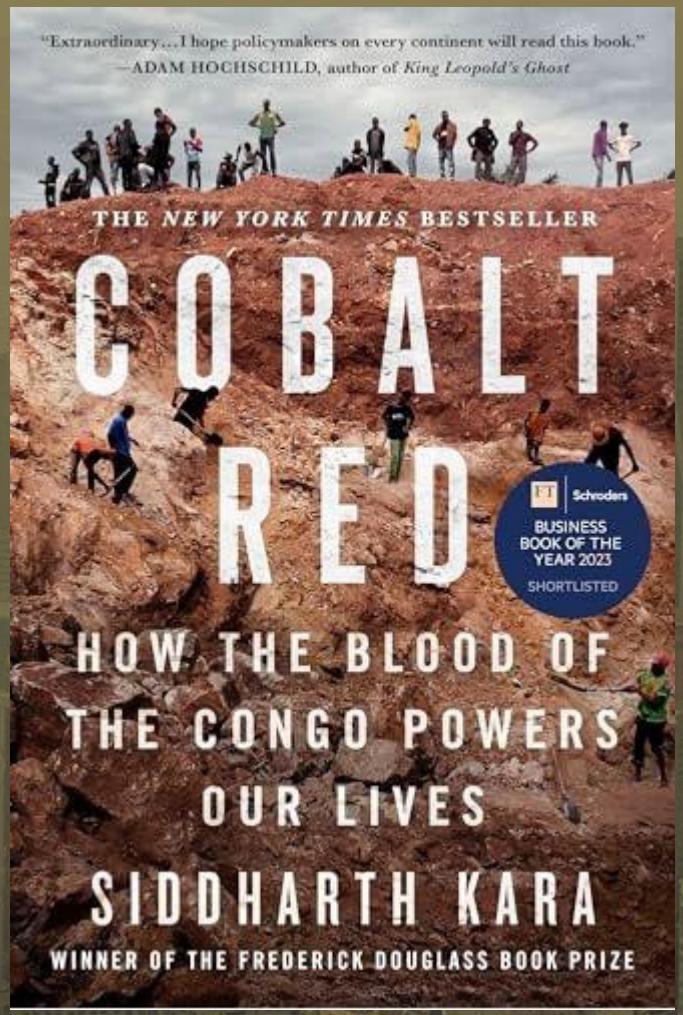


Benchmark Mineral Intelligence, 2022.

The US Has Stumbled Into A Significant Reliance Upon China For Lithium-ion Batteries Which is a <u>Resiliency Risk</u>

Why is a Chinese supply chain a problem?

- FEOC in control of the on/off switch for Lithium-ion Batteries is a national security risk
- US usage of FEOC fuels it, loosing value capture, new technology opportunities, and jobs
- China puts zero value on worker safety, responsible sourcing, and pollution



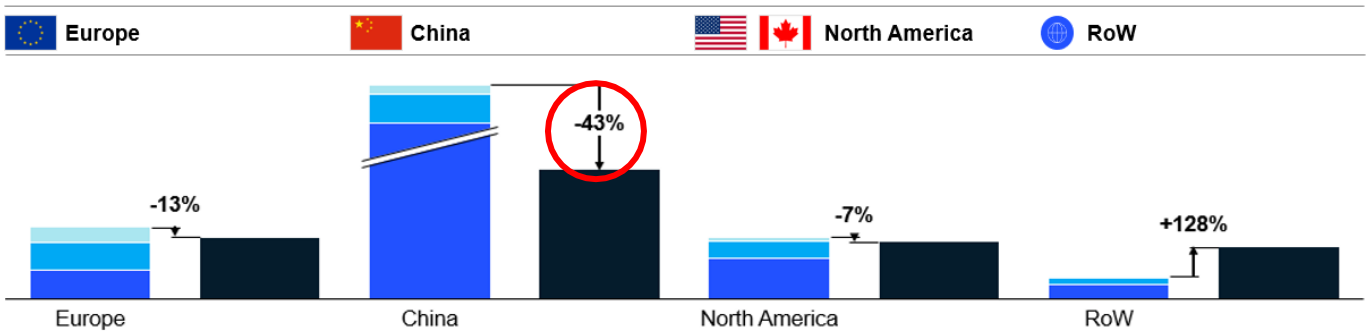
A Chinese-dominant supply chain creates national security risk and supports an unethical supply chain

What is the US doing to course correct?

- Government Reports
  - EO14017, 100-day, National Blueprint, NDIS
- Alignment with Industry
  - Li-Bridge, MPSC, NAATBatt, Companies
- Long Term Strategy
  - BIL, IRA, Title III

- **US has a long way to go to address all the challenges**

Adjusted supply and Demand of Li-ion battery cells, GWh, 2030



McKinsey at NAATBatt, 2024.

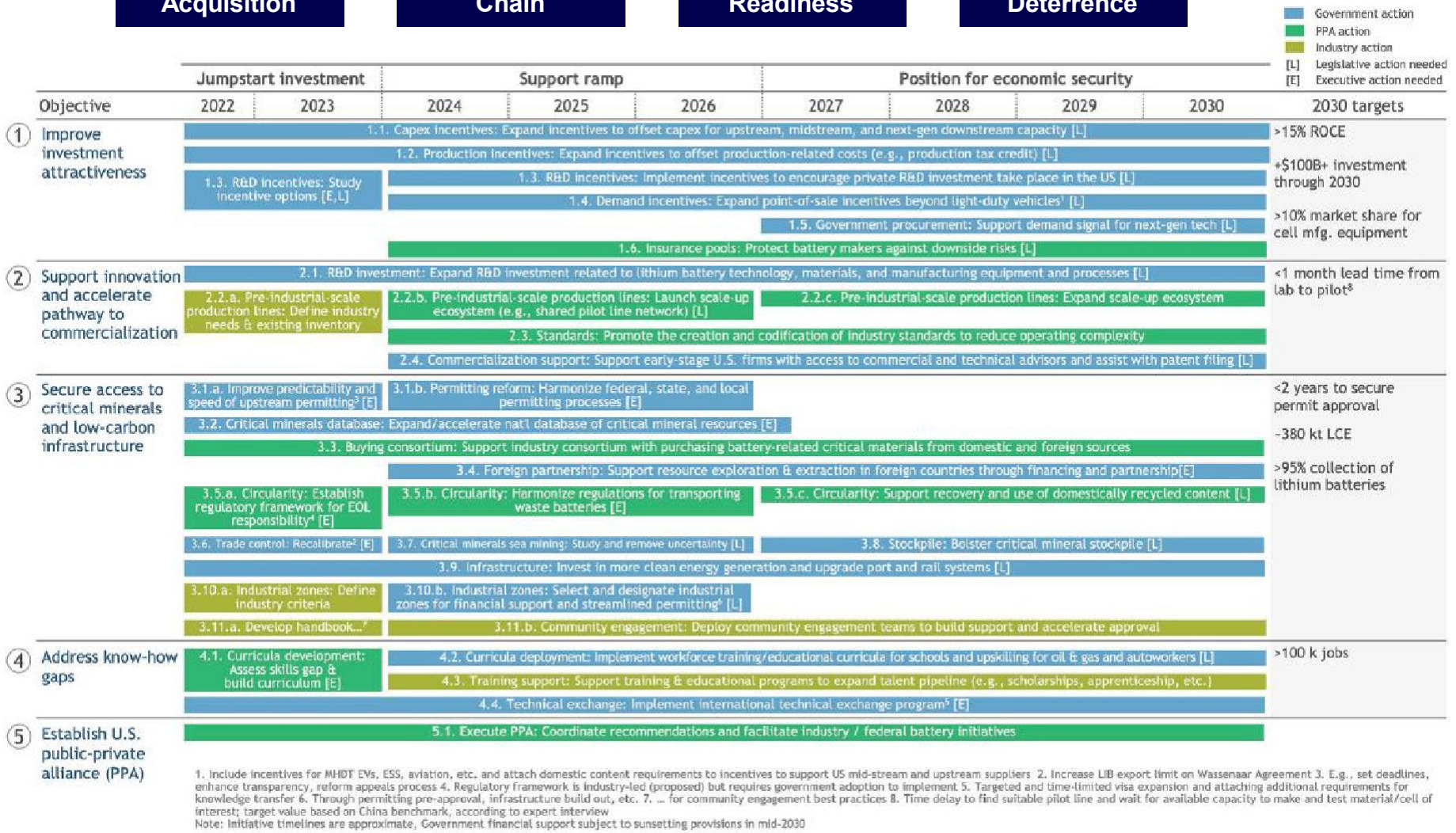
The US is doing a great job gaining alignment between government and industry, but has a long way to go

Challenges

Flexible Acquisition | **Resilient Supply Chain** | **Workforce Readiness** | **Economic Deterrence**

Primary Challenges

- Capital Investment (Risk)
- Permitting
- Workforce
- Government Industry alignment
  - Difficult because industry doesn't have a consistent voice
- **Getting off the ground in the wake of global over-supply**

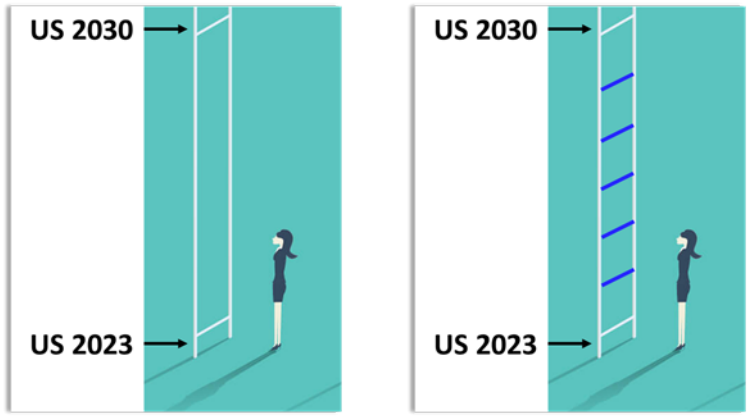


The US must define and achieve a wholistic solution and prepare for some 'pain' in order to 'gain'

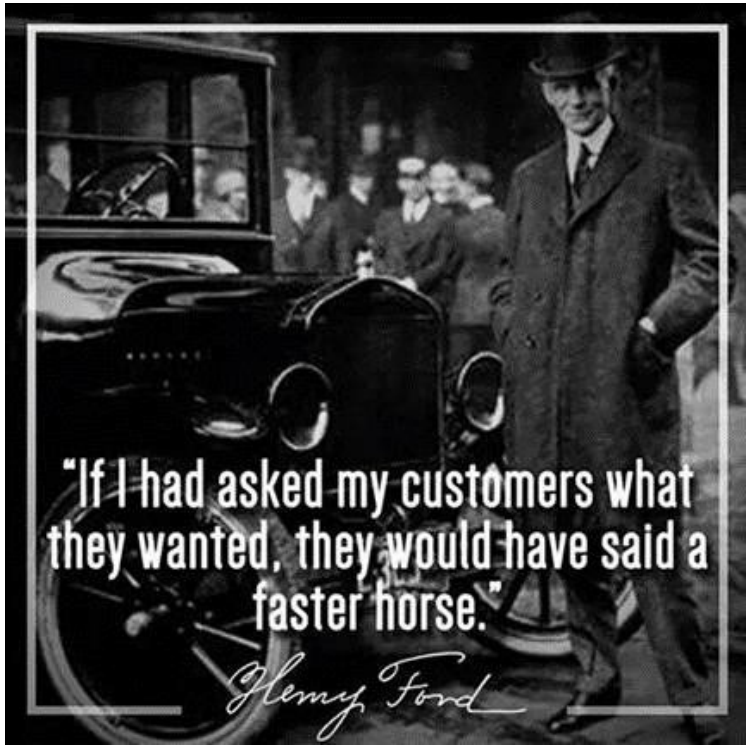
Challenges Continued

- **The US can't 'lead' by copy/pasting (leadership undefined still)**
- **Only way to lead is to innovate, or, "leapfrog"**
- **55% of innovators in Li-ion space are looking to offshore partners due to lacking US infrastructure to properly demonstrate scaling success**
  - **Li-Bridge Pilot Line Focus**

Achieving US leadership



The US is lacking the underlying infrastructure necessary to keep and utilize new innovations in energy storage.



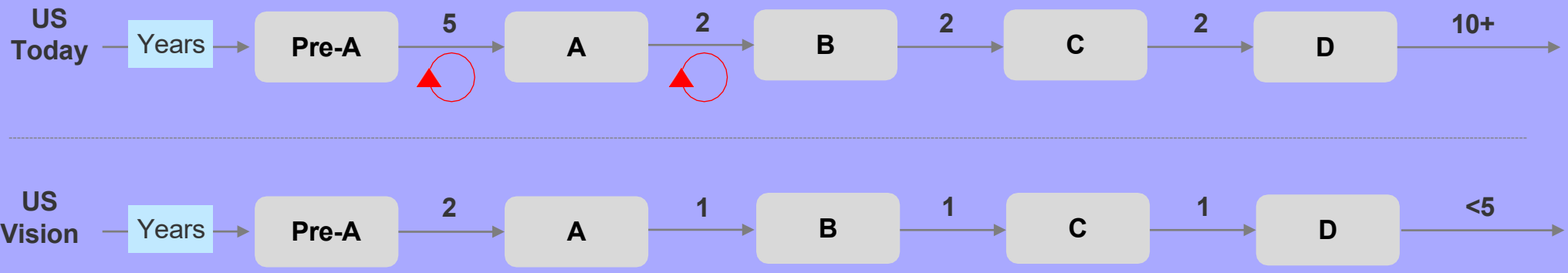
55% Innovation Leakage

Beyond the industry-government alignment issues, the US needs to build a framework for success

A Key Issue Under the Radar: Noise

Class	Stage	Cell form factor	Scale	Note
Pre-A	Demo	Any	10's	Basic R&D, TRL 1-3
A	Concept validation	Close/Final	100's	Pilot R&D, TRL 3-4
B	Design validation	Final	1000's	Pilot Manufacturing, TRL 5-6
C	Production validation	Final	10's MWh+	Lite Manufacturing, TRL 6-8
D	High volume manufacturing	Final	10's GWh+	Large Scale Manufacturing, TRL 9

Goal to keep and implement US innovation faster to achieve global leadership

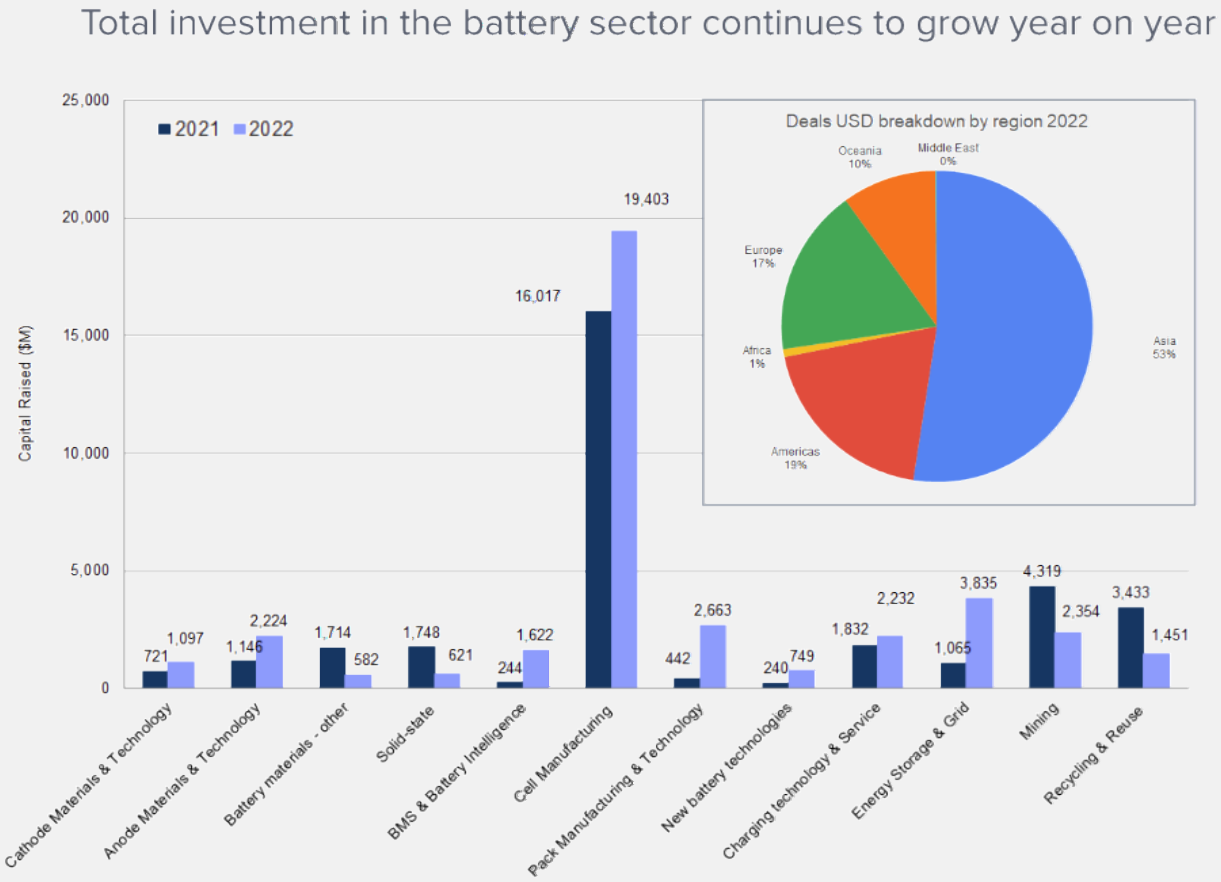


Noise is causing high risk and government-industry misalignment

Where to Focus?

- Cell Pilot Lines
  - Cells are the pinch point even though entire supply chain needs attention
- Workforce
- Recycling

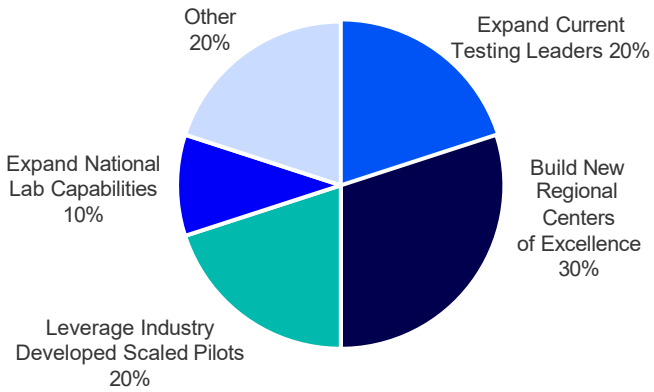
Initial focus on pilot line processing, workforce, and recycling



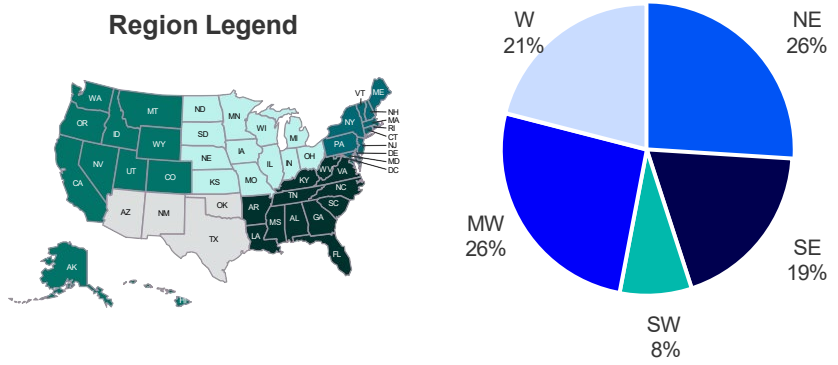
Key Insights from Recent Li-Bridge Study

1. Support for expanding current providers and regional COEs
2. Distribution of demand throughout US (**but quality first and foremost**)
3. Focus on final-format cylindrical and prismatic cell formats
4. Diverse chemistry interest, but focus still on Li-ion & Li metal

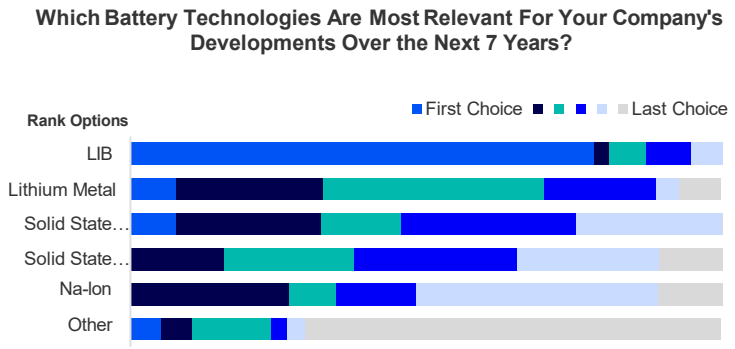
What does success look like?



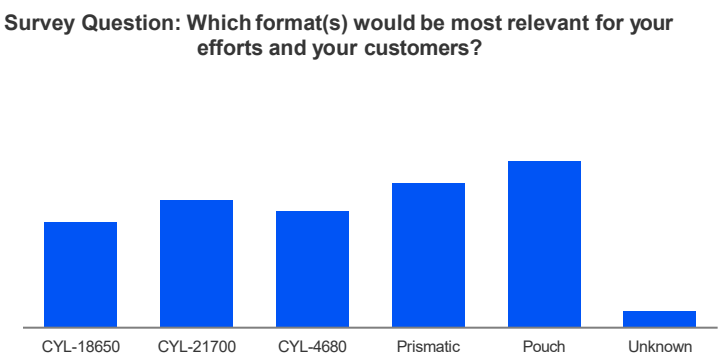
Capability to be spread over ecosystem



Capabilities should expand across the US



Focus on Li-ion and Li-metal battery types



Focus on cylindrical and prismatic cell types

Survey results indicate lowest-risk pathway to leadership, Li-ion, high quality, and final format processing

Workforce: Skill Gaps

INDUSTRY-WIDE GAPS

Electrochemistry / Battery Chemistry

Manufacturing

Battery management systems (BMS)

Product & system design

Safety

Battery Recycling

UPSTREAM GAPS

Chemistry/ Chem. Engineering,

Extraction / Mining,

Metallurgical/ Mineral Processing

DOWNSTREAM GAPS

Electrochemistry/ Battery Chemistry

Battery Materials

(Chem. Eng. & Materials science)

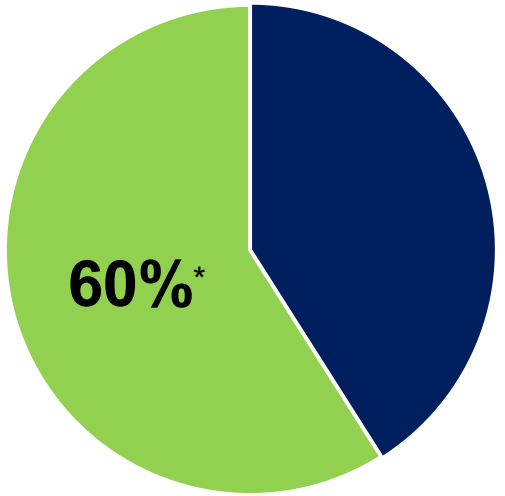
Battery Management (BMS)

ADVANCED MANUFACTURING

Materials science,

Chemistry/ Electrochemistry,

Managing / operating automated tools



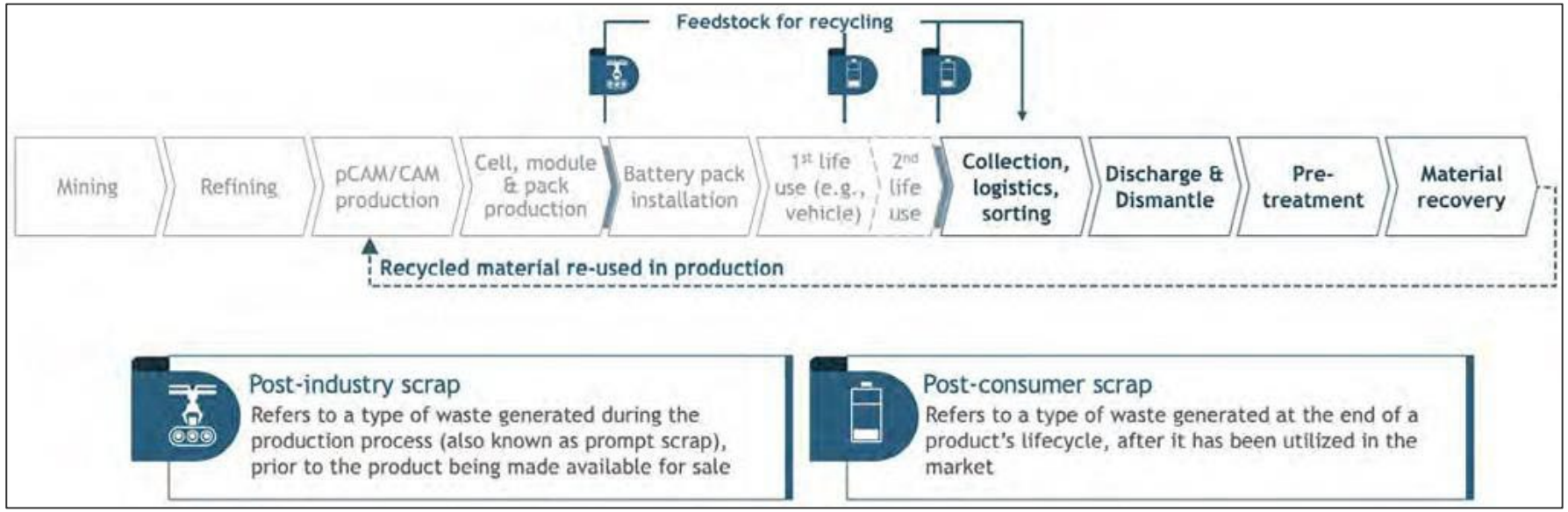
**Percent reporting 25-100% of employees with outdated skills*

https://nabwc.org/

All sectors of workforce need support, need on-the-job training and long-term education

Key End-of-Life Burdens

- **High processing costs** relative to the intrinsic value of certain battery chemistries and cell components
- **Nascent pathways to recycle batteries in sufficiently large volumes** for a fully domestic circular economy
- **High labor intensity** in collection, sorting, and disassembly
- **Lack of customized classification** frameworks for lithium-based battery storage and transport
- **Lack of knowledge of occupational and environmental health risks** and the absence of occupational health and safety best practices



https://www.anl.gov/access/reference/bridging-the-us-lithium-battery-supply-chain-gap-forum-on-liion-battery-recycling-and-endoflife

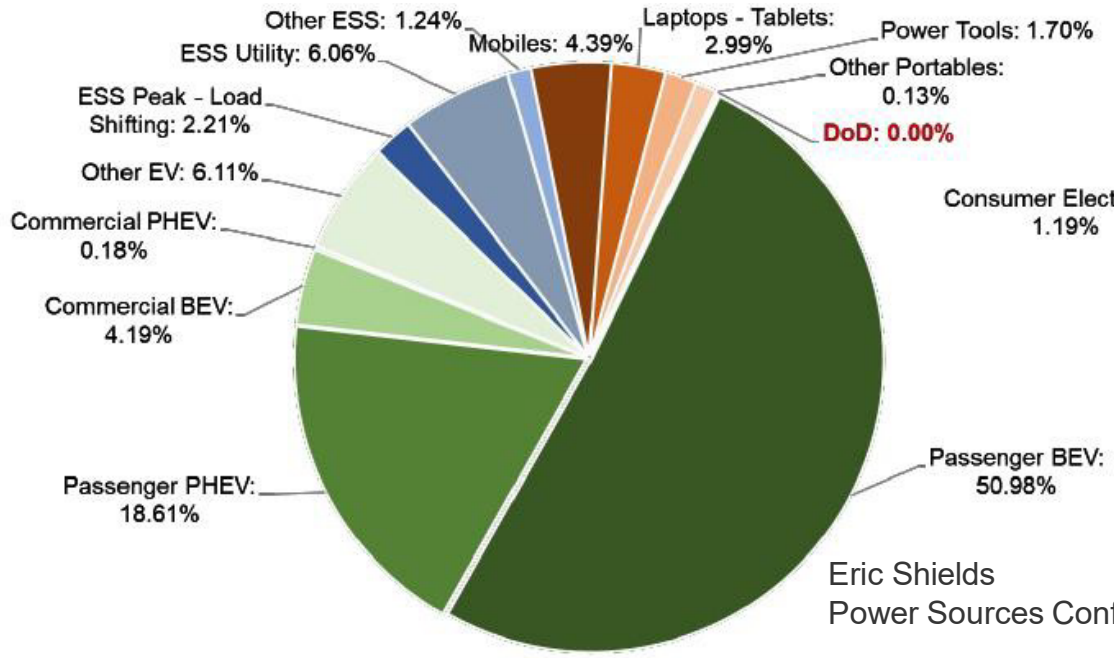
What about the DOD?

Challenges

- Small demand in grand scheme
- Bad customer
- Want to feed off industry but have dissimilar needs (18650 as best-case)
- Primes

Opportunities

- Positioned well to catalyze early scaling efforts (the pilot line network) with low-volume demand
- Existing funding vehicles can accelerate future developments on the pilot line network



Eric Shields
Power Sources Conference 2023.

Need standards for form factor, quality, and/or performance

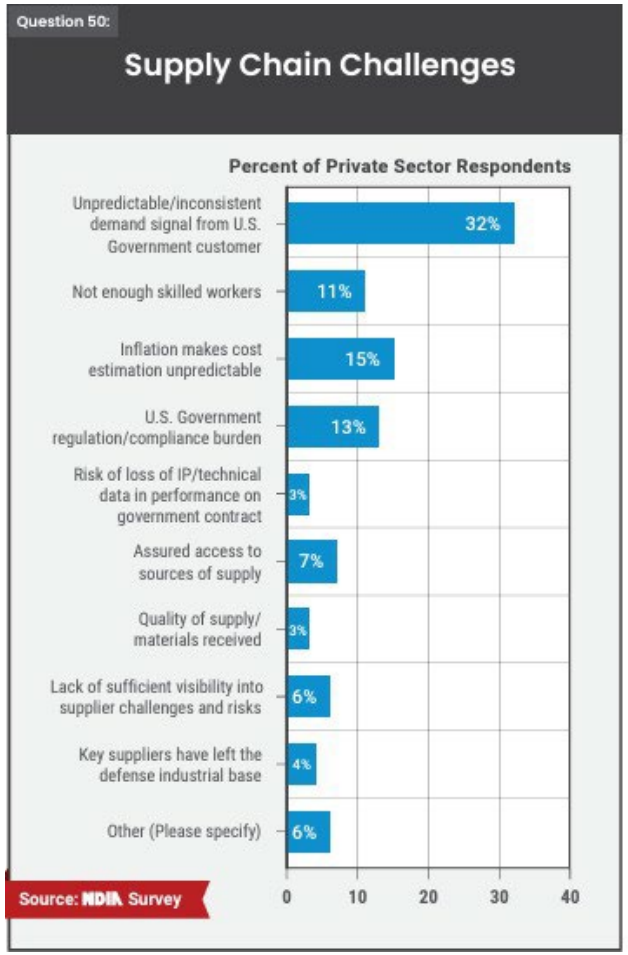
Need a clear demand signal *(cells or investment)*

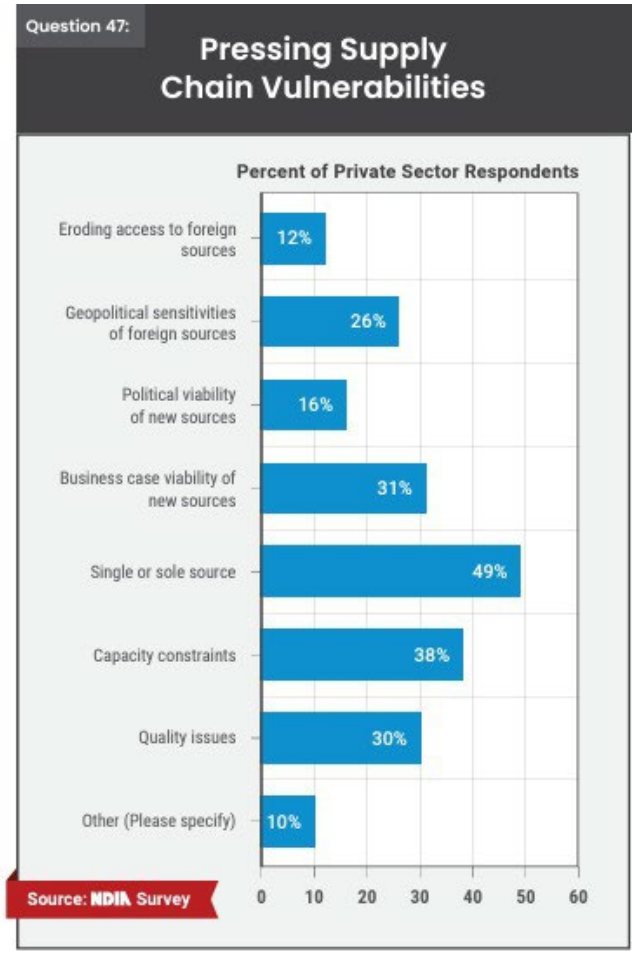
Need immediate access/capability for next-gen performance

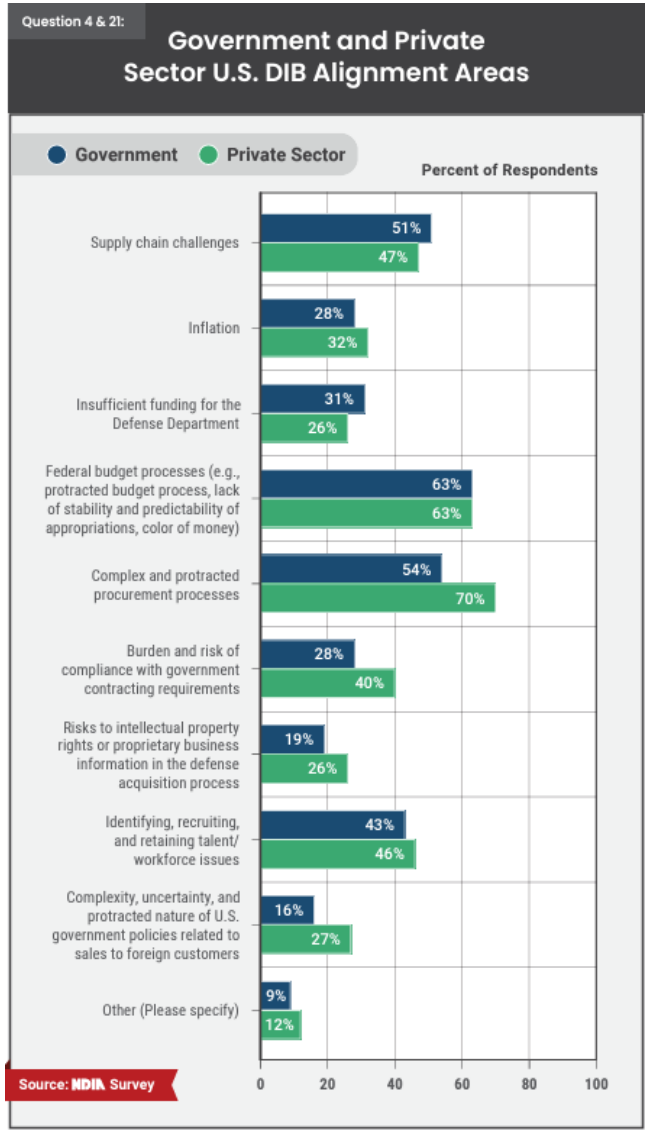
Need a network of cell providers

The DOD has some unique challenges but is well positioned to support US leadership long-term

Familiar?







Is the US government its own biggest enemy?

NDIA Vital Signs shows consistency of issues outside of Li-ion (US much-needed return to manufacturing)

Next Steps to Address Li-ion as Part of Maturing US Manufacturing

- Government-Industry Alignment is Critical
  - Policy to Prevent Mindful Oversupply (need to overcome procurement managers)
  - Identifying and Capitalizing on Strengths of Government Services and Industry Organizations
  - Early Focus on Specialty Markets (thanks BIL)
- Support of Supply Chain Localization and Partnerships
  - Maximize value capture while reducing risk and cost
- Supporting a Framework for Success
  - Cell-Focused Complete Pilot Line Network
    - Reduced Risk
    - Workforce Training Pipeline
    - Investment Attractiveness
    - New Technology Investment and Retention

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The US is making great progress but must continue working towards long-term alignment to be successful

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Food for Thought

- When factoring in population estimates for 2030 the TWh per person for China and US are nearly equivalent (~3 TWh/Billion).
- Has China already achieved the US 2030 goal (~$50/kWh)? Or is it a shell/marketing game (example, solid-state)?
- Can we bear the pain to turn China's strength into a weakness?
- Is there an acceptable amount/type of risk when it comes to China? Is it physical goods only, or all-encompassing?