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ENERGY STORAGE: THE LINCHPIN TECHNOLOGY FOR ENERGY SECURITY



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Argonne National Laboratory is a
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managed by UChicago Argonne, LLC.



Energy Storage Provides Flexibility

We generate energy
in numerous ways



But we need to use energy
whenever we want it...



...And wherever we want it



Energy storage, often a battery, is the
key to make electrons dispatchable

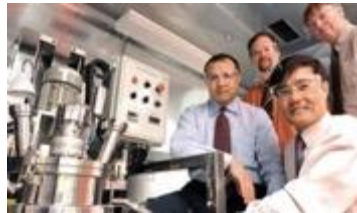
Storage Penetration Has Increased In The Past Decade

Pioneering research

Goodenough
Whittingham
Thackeray



Argonne's nickel-manganese-cobalt cathode



Starting with personal devices



- 60 MWh grid storage
- 12,500 US EVs



- 80,000 MWh grid storage
- 4M US EVs



1975-1983

2000

2007

2010

2012

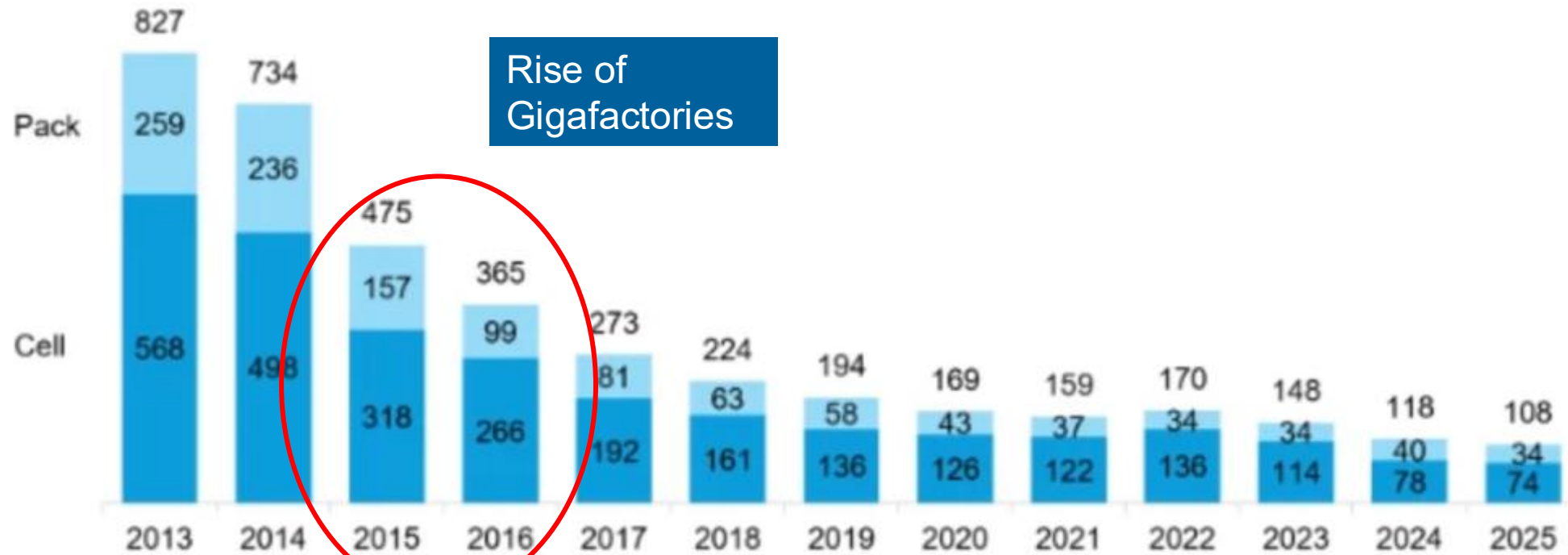
2024

2025

Reason: Rapid Cost Reduction Due To New Battery Materials Coupled With Mass Manufacturing

Volume-weighted average lithium-ion battery pack and cell price split, 2013-2025

Real 2025 \$ per kilowatt-hour



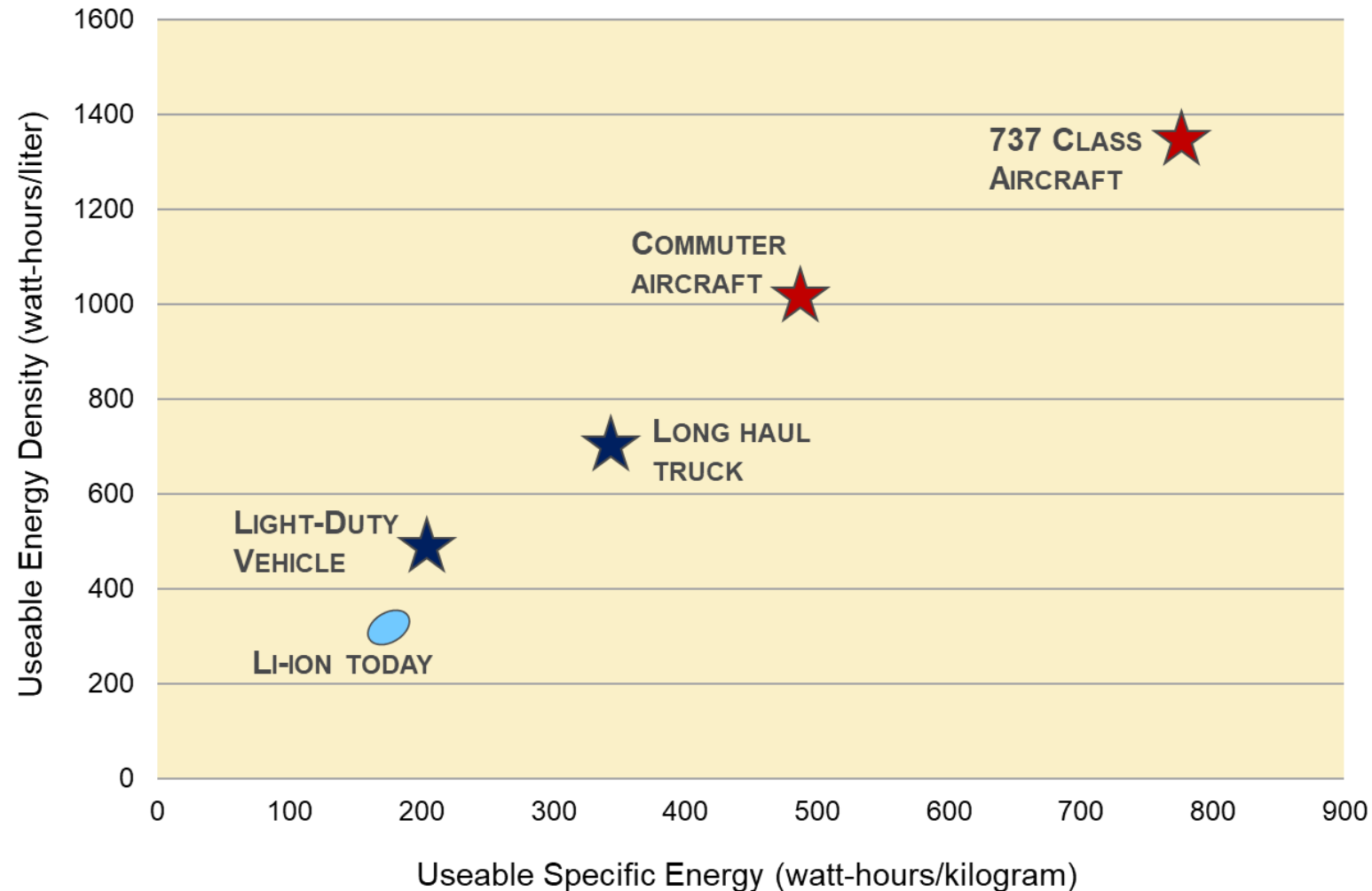
From Bloomberg BNEF

Storage Has Become Integral To Our Way Of Life

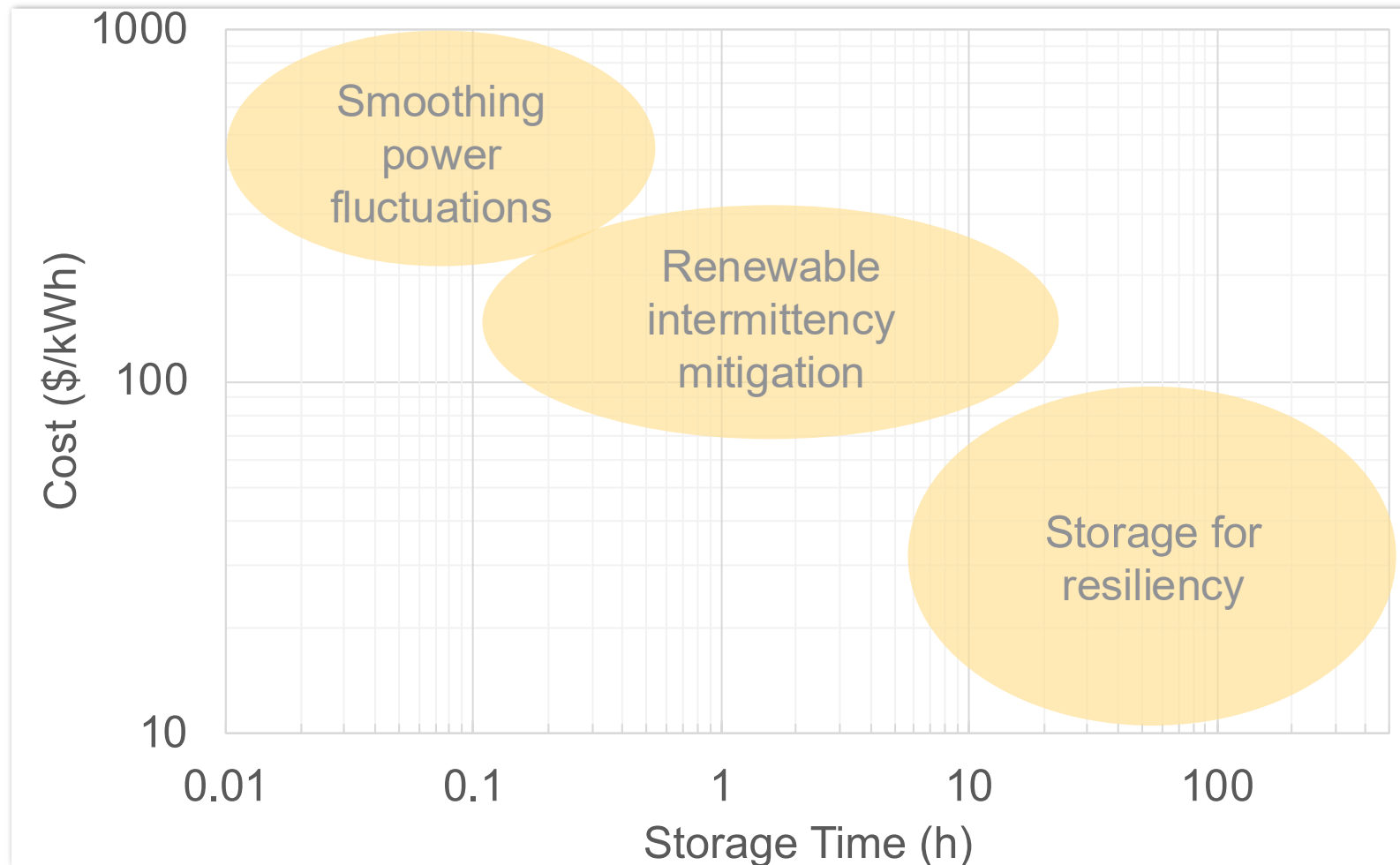


We need different battery technologies for different applications

Energy Storage Targets: Some Easy...some Hard

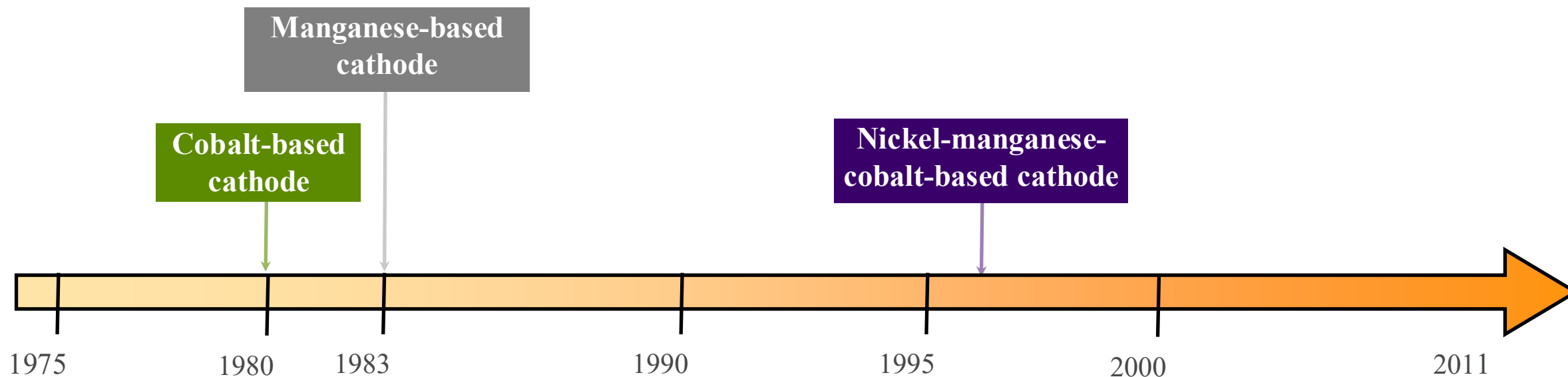


Grid Storage Removes The Weight/Volume Constraint

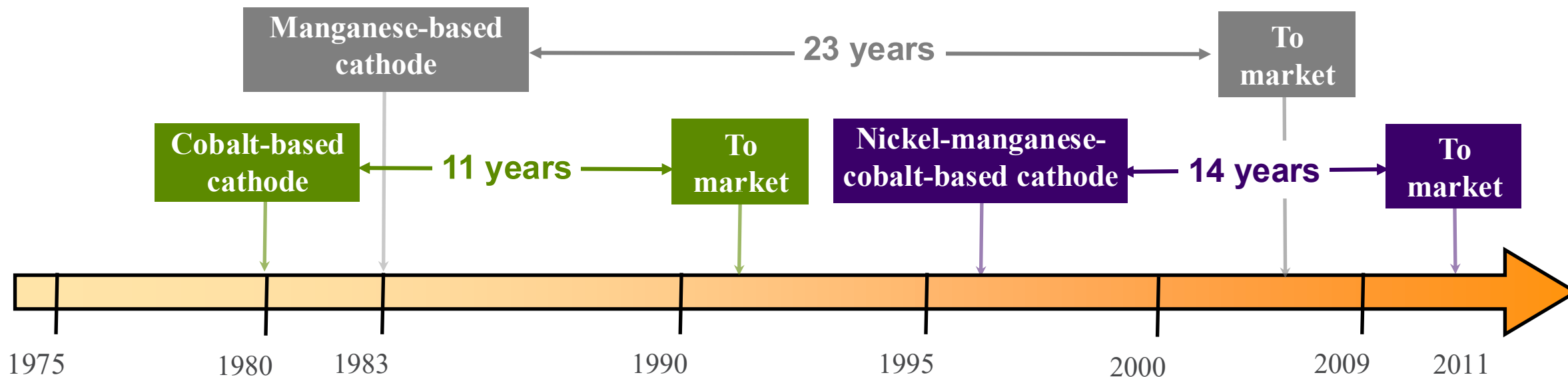


We need new forms of storage across the discharge time spectrum (mins to months)

But Market Impact Takes a Decade

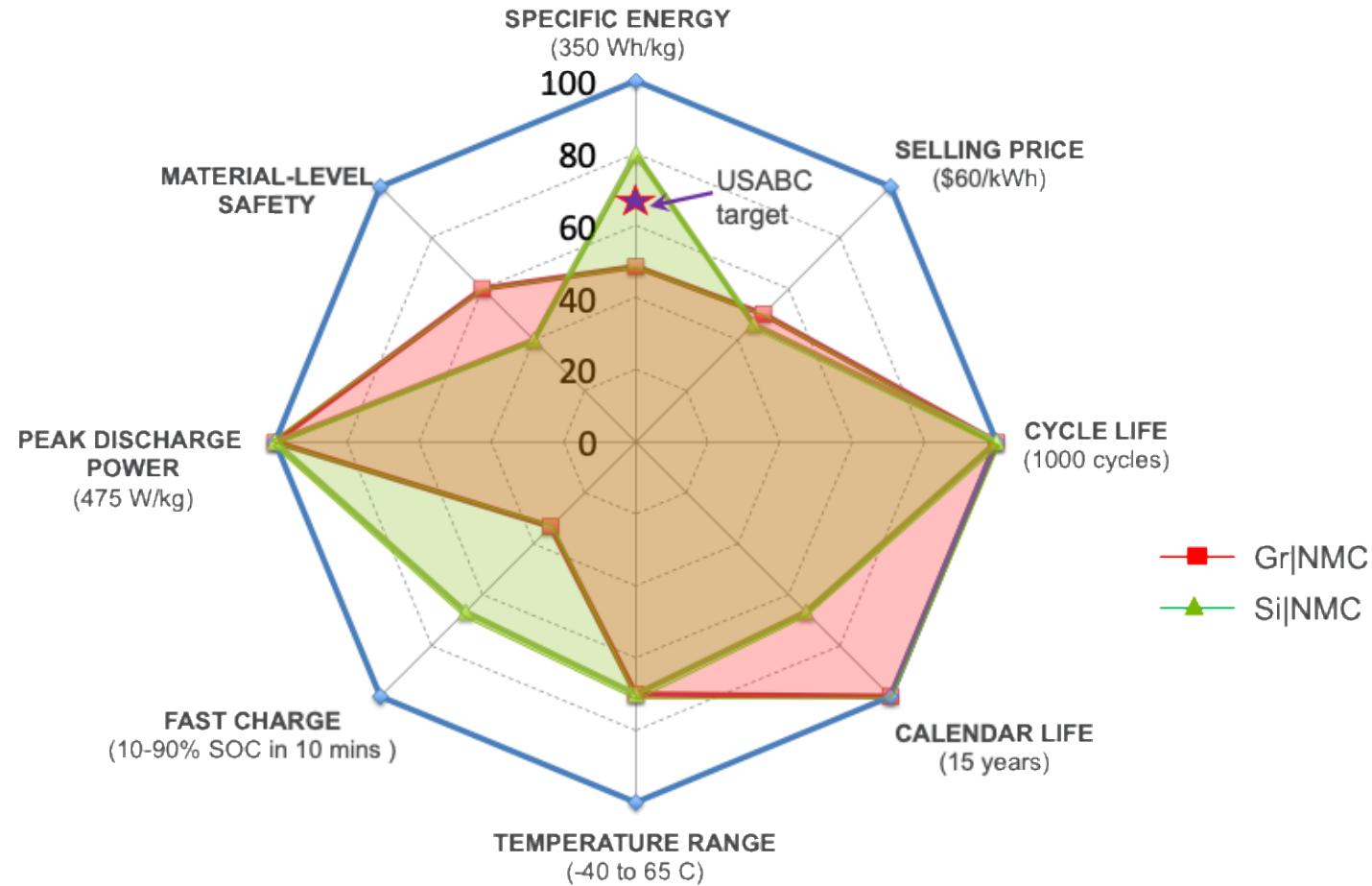


But Market Impact Takes a Decade



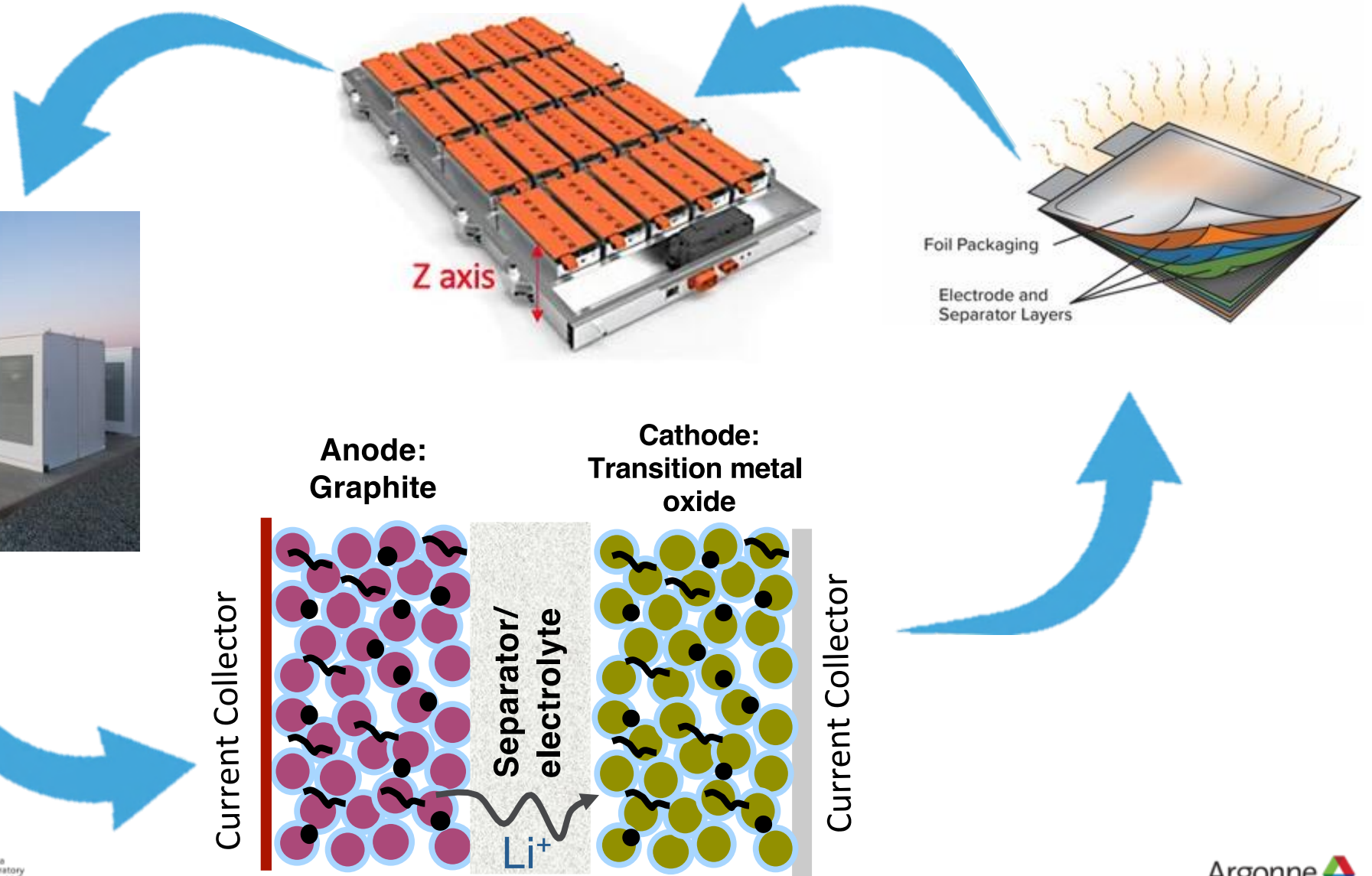
Argonne is changing the pace using artificial intelligence coupled with pilot manufacturing facilities

Problem Is The Need To Simultaneously Improve Many Metrics. Example: Electric Vehicles

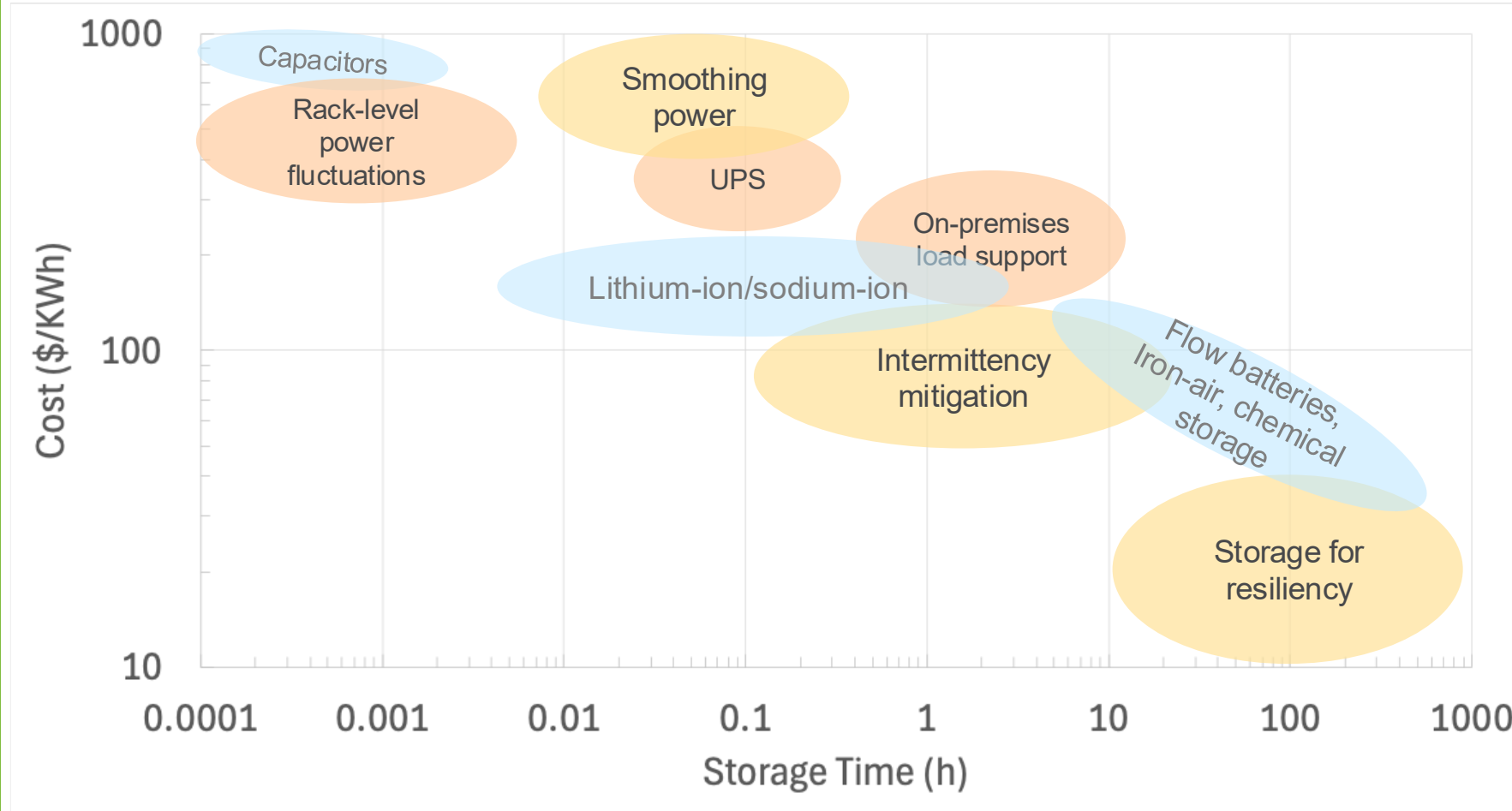


Every new battery technology has a different set of compromises

Battery Innovation Is Rooted In New Materials And Associated Manufacturing Methods



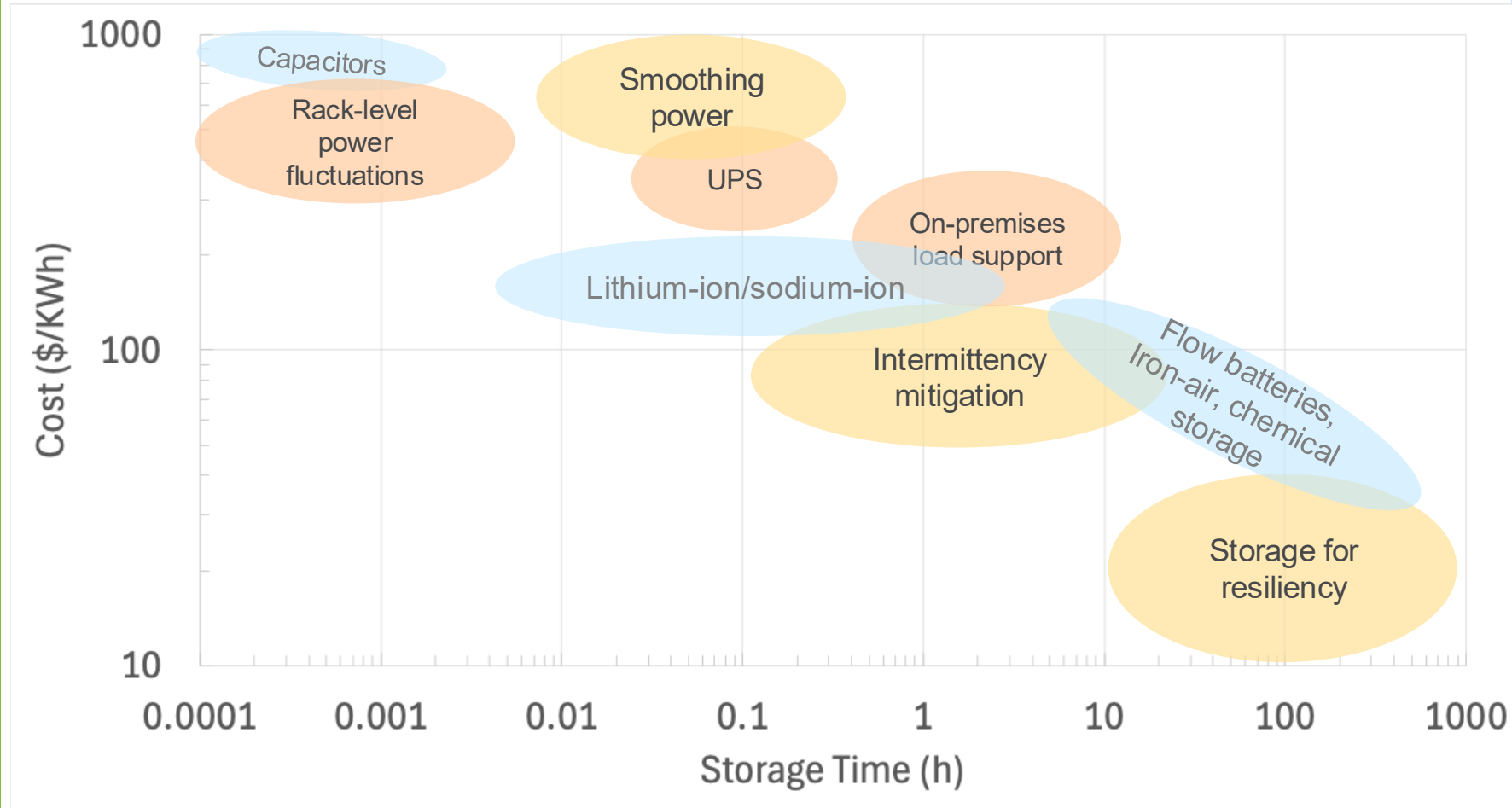
Rapid Rise Of AI Data Centers Scrambling Use Cases For Energy Storage



Requirements for data center use case:

- High power pulses
- High energy (low footprint)
- Cycle life >10k cycles
- Supply chain
- **Safety**
- Low thermal load
- Energy efficiency
- Cost

R&D Focus Areas



1. System designs co-optimizing economics and reliability

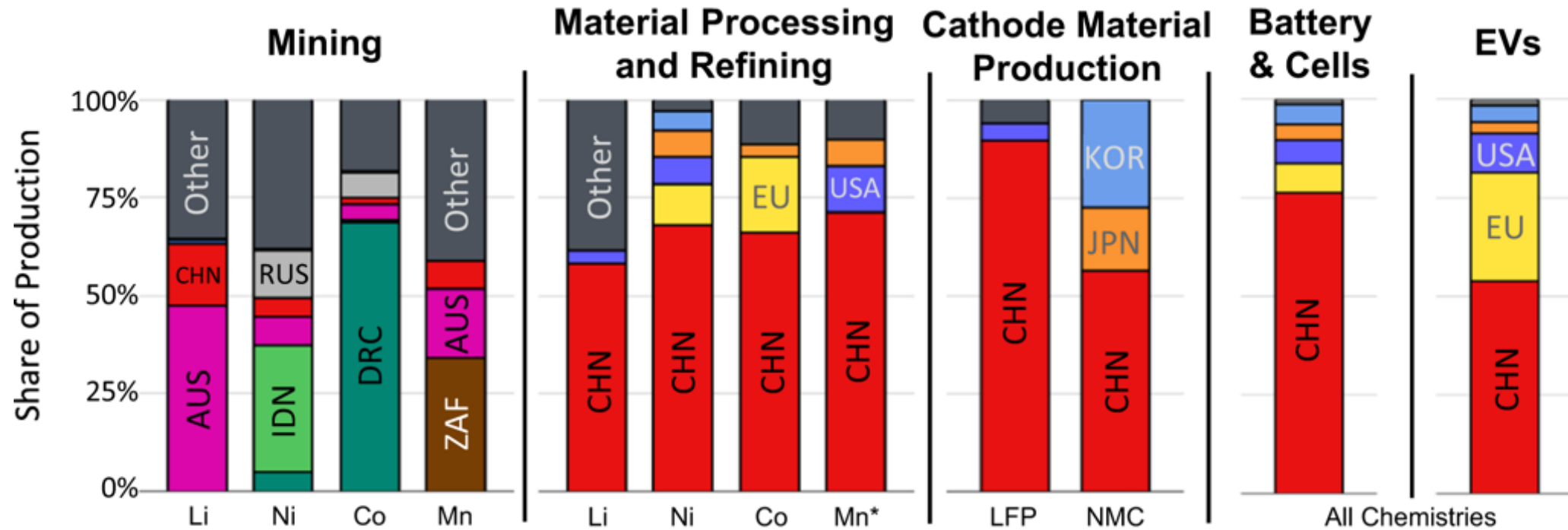
2. Predict/extend battery life: Second life and new business models

3. Non-flammable batteries for safety

4. Develop low-cost long-duration storage

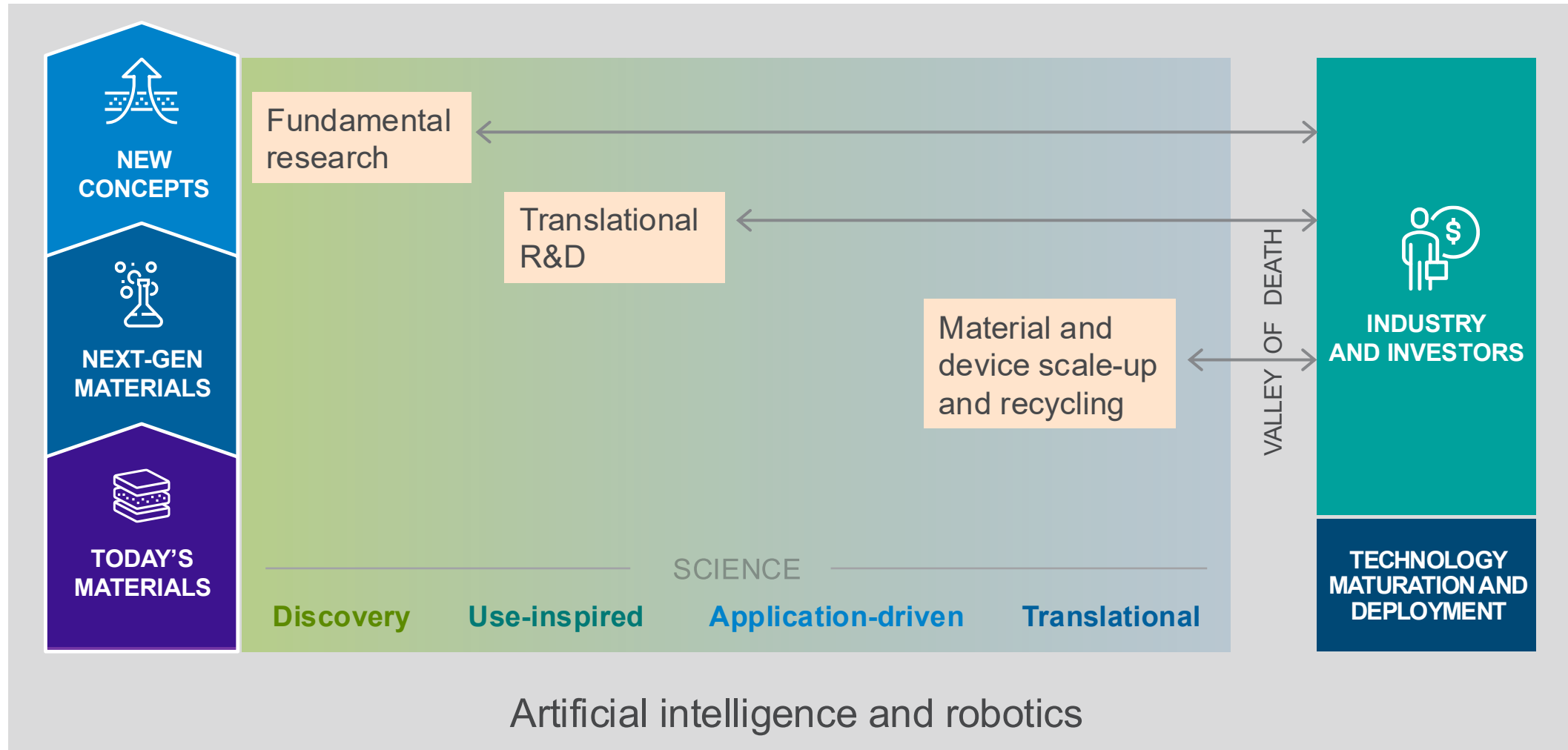
Challenge: PRC Controls Lithium Battery Supply Chain And Is Doubling Down

R&D funding *at least* 10x more in PRC than in the US



There is a desperate need to grow the domestic supply chain

Argonne's Capabilities Can Be Leveraged By Industry To Build A Domestic Supply Chain



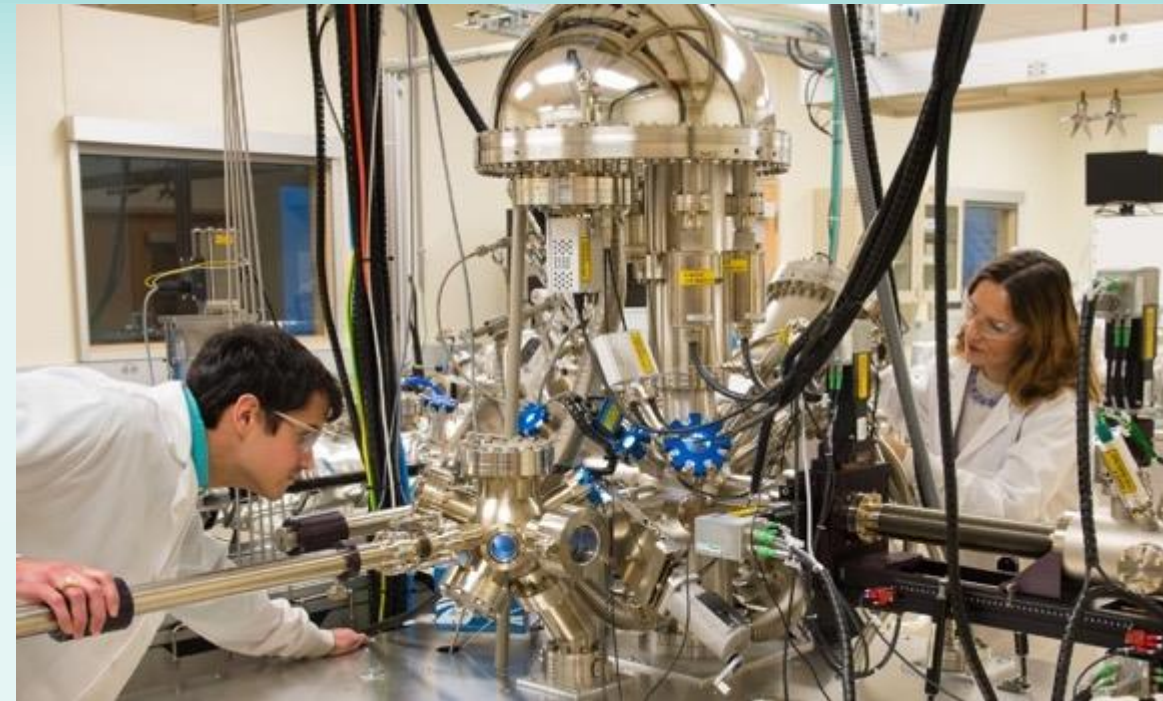
THANK YOU



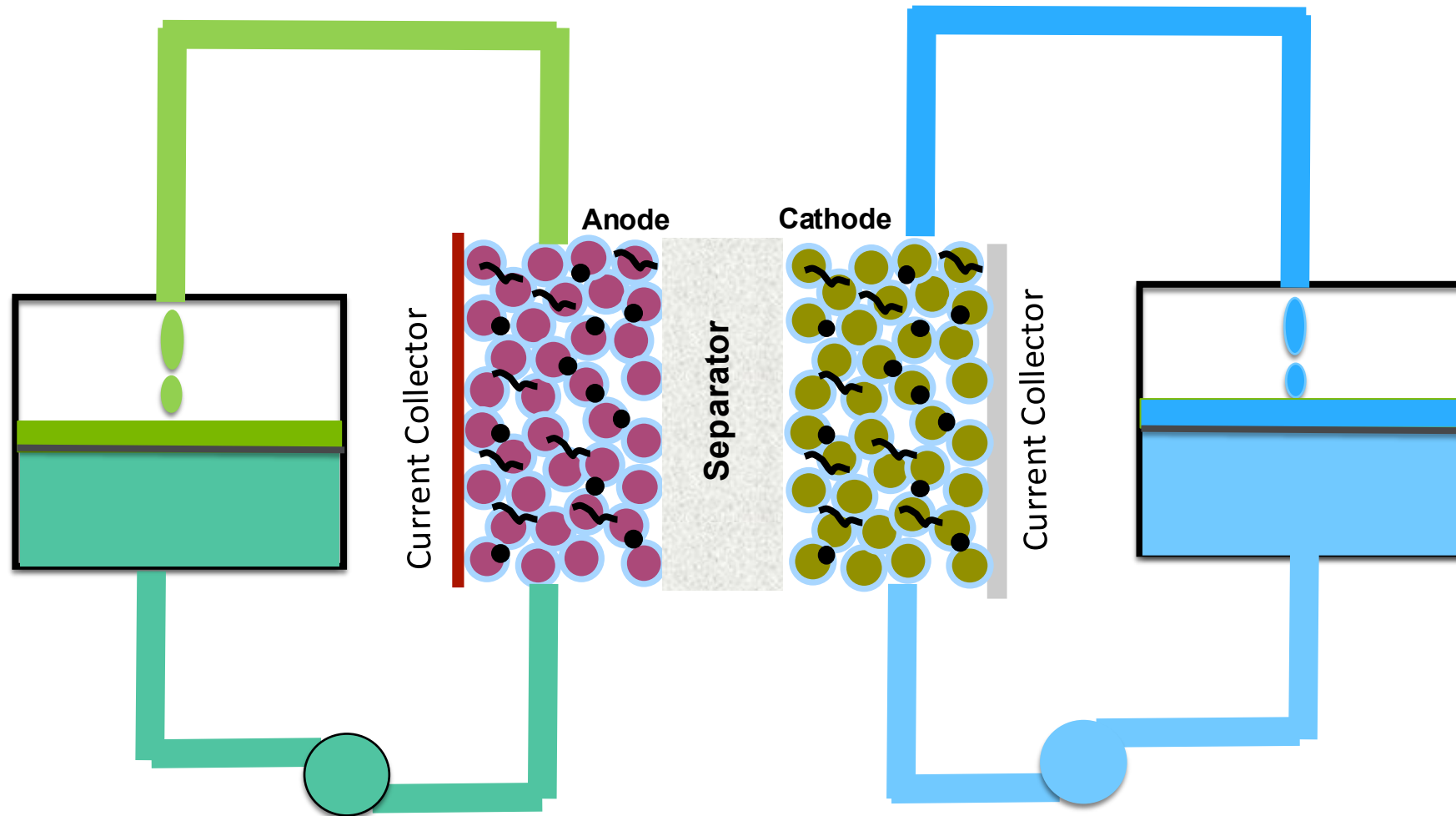
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Innovation needs to occur at many levels in both container and flow cells



Four levels of innovation: (i) materials (ii) cell/pack design (iii) manufacturing process and (iv) overall system