U.S. Department of ENERGY | Office of Manufacturing & Energy Supply Chains

IN PARTNERSHIP WITH THE

Modeling, Mapping, & Analysis Consortium (MMAC)

Supply Chain Readiness Level Preliminary Analysis: Batteries Summary

November 2024

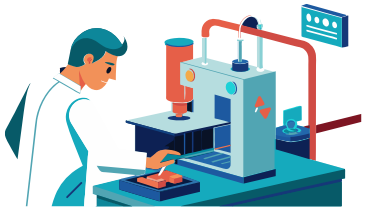
ABOUT MESC

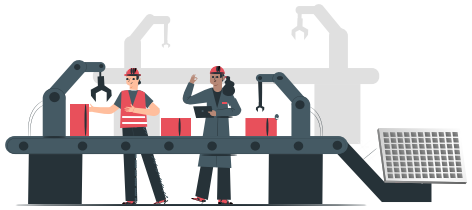
THE OFFICE OF MANUFACTURING & ENERGY SUPPLY CHAINS (MESC): DE-RISKING ENERGY SUPPLY CHAINS SINCE 2022

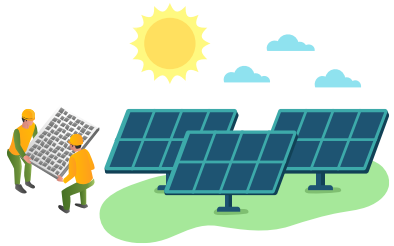
MESC's mission is to enhance economic and national security by **eliminating vulnerabilities** in the United States' energy supply chains.

MESC IS FOCUSED ON GOVERNMENT-ENABLED, PRIVATE SECTOR-LED ENERGY MANUFACTURING

Basic Research → **Development** → **Demonstration** → **Deployment**







Product Innovation

- Office of Science (SC)
- Office of Electricity (OE)
- Office of Fossil Energy & Carbon Management (FECM)
- Office of Energy Efficiency & Renewable Energy (EERE)
- Advanced Materials & Manufacturing Technologies Office
- Office of Nuclear Energy (NE)
- Advanced Research Projects Agency - Energy (ARPA-E)

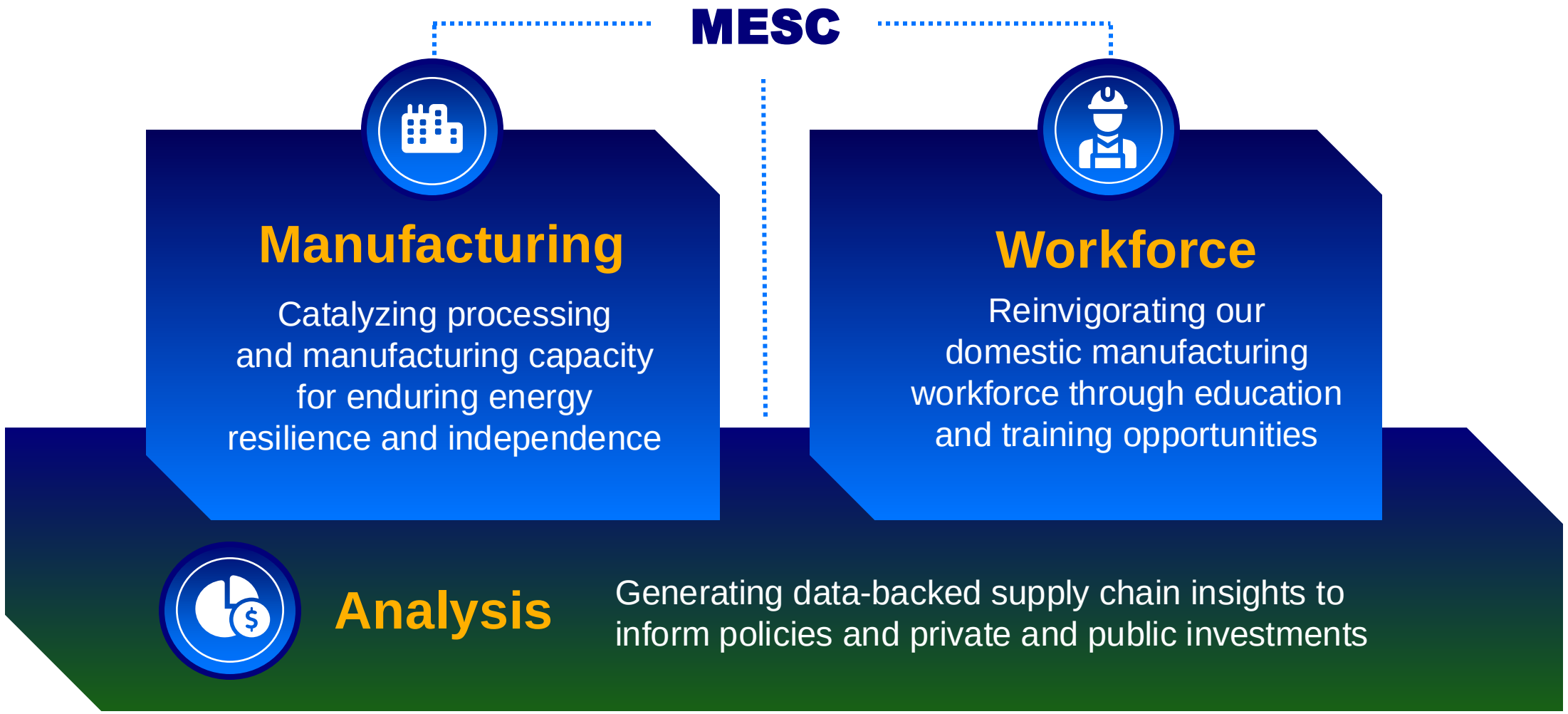
Product Installation

- Office of Clean Energy Demonstrations (OCED)
- Grid Deployment Office (GDO)
- Loan Program Office (LPO)

Office of Manufacturing & Energy Supply Chains (MESC)

Product Manufacturing

MESC IS SYSTEMATICALLY SECURING AMERICA'S ENERGY FOUNDATION



MESC IS SCALING U.S. MANUFACTURING AND CATALYZING U.S. ENERGY PRODUCTION

Batteries

Buildings & Energy Efficiency

Critical Materials & Recycling

Energy Generation & Fuels

Grid Equipment

Materials

Transport

ABOUT THE SUPPLY CHAIN READINESS LEVEL (SCRL) FRAMEWORK

SUPPLY CHAIN READINESS LEVEL (SCRL) ANALYSIS

THREE CORE OBJECTIVES

Assess readiness at two levels: overall technology (e.g., batteries) and individual supply chain segments (e.g., lithium)

Independently assess multiple risk factors, including sourcing concentration, commercial risks, and workforce availability

Enable dynamic analysis of supply chains over time

SCRL

Scalable, data-driven, and technology-agnostic framework to assess energy supply chain risks

MESC conducts the SCRL analyses in partnership with the DOE National Laboratories' **Modeling Mapping & Analysis Consortium (MMAC)**

SUPPLY CHAIN READINESS LEVEL EVALUATES SUPPLY RELIABILITY + U.S. COMMERCIAL COMPETITIVENESS

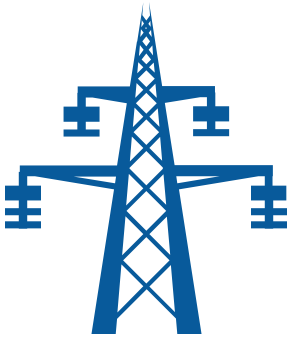
SCRL IS THE FIRST AND ONLY TOOL TO ASSESS ENERGY SUPPLY CHAIN NEEDS AND US CAPABILITIES TO MEET THOSE NEEDS

	RISK FACTORS	ASSESSMENT QUESTION
Supply Reliability Factors	Deployment Viability	Projected global demand relative to all known sources of supply
	Sourcing Risk Management	Projected US & partner demand relative to supply from reliable sources
Commercial Competitiveness Factors	Workforce Readiness	Availability of workers with sufficient skills
	Supplier Maturity	Availability of upstream materials/components from established, reliable sources
	Customer Maturity	Strength of demand at sufficient price levels to make US production viable
	Cost Competitiveness	US competitiveness relative to other global producers

SCRL ANALYSIS PRELIMINARY FINDINGS: BATTERIES

BATTERY STORAGE IS CRITICAL TO OUR ENERGY AND TRANSPORTATION FUTURE

EMERGING GRID, DEFENSE AND TRANSPORTATION NEEDS DEPEND ON SUFFICIENT AND AFFORDABLE BATTERY STORAGE

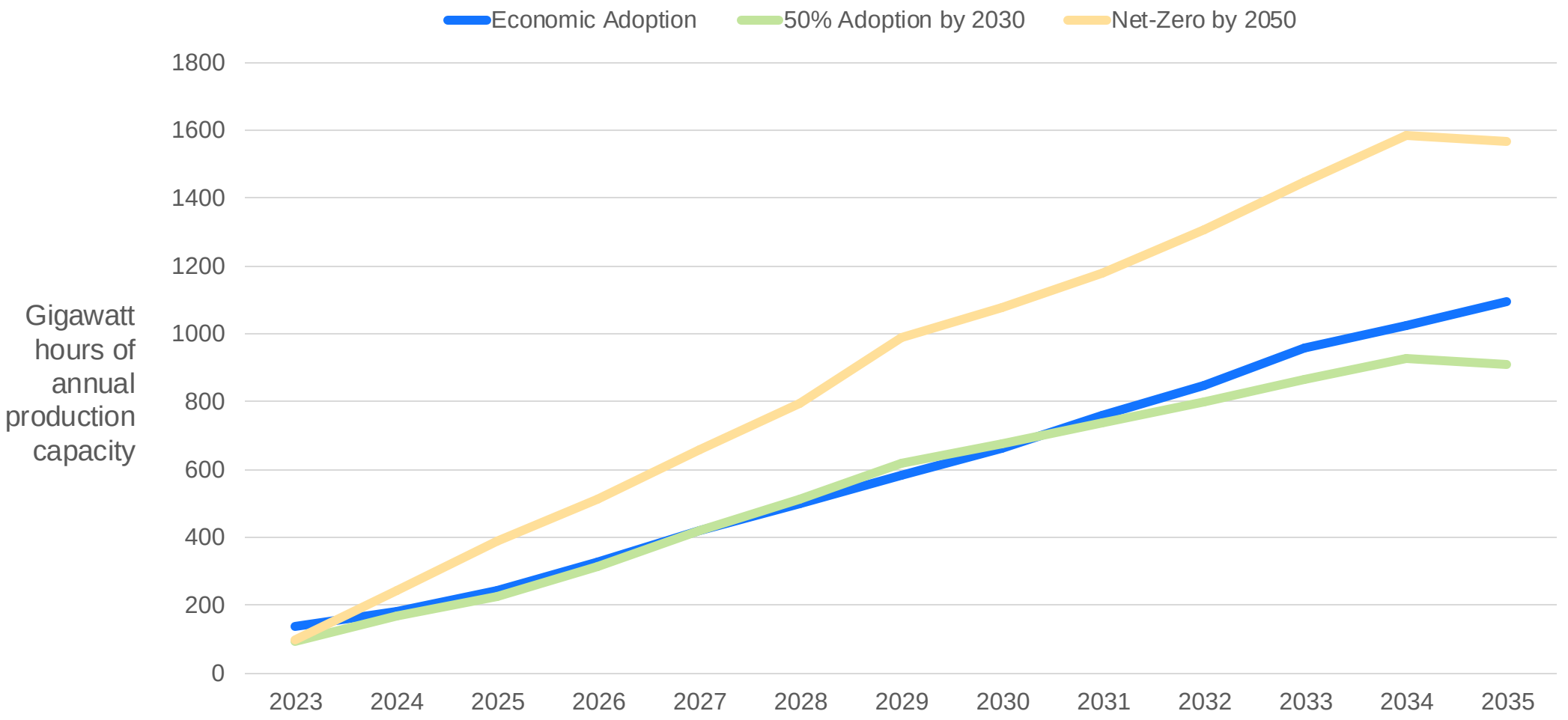


Battery storage will be increasingly essential to maintain system and price stability, bridging energy supply and demand differentials

Batteries provide reliable, portable power essential for military operations, from powering equipment and vehicles to ensuring resilient energy supply in remote and combat environments

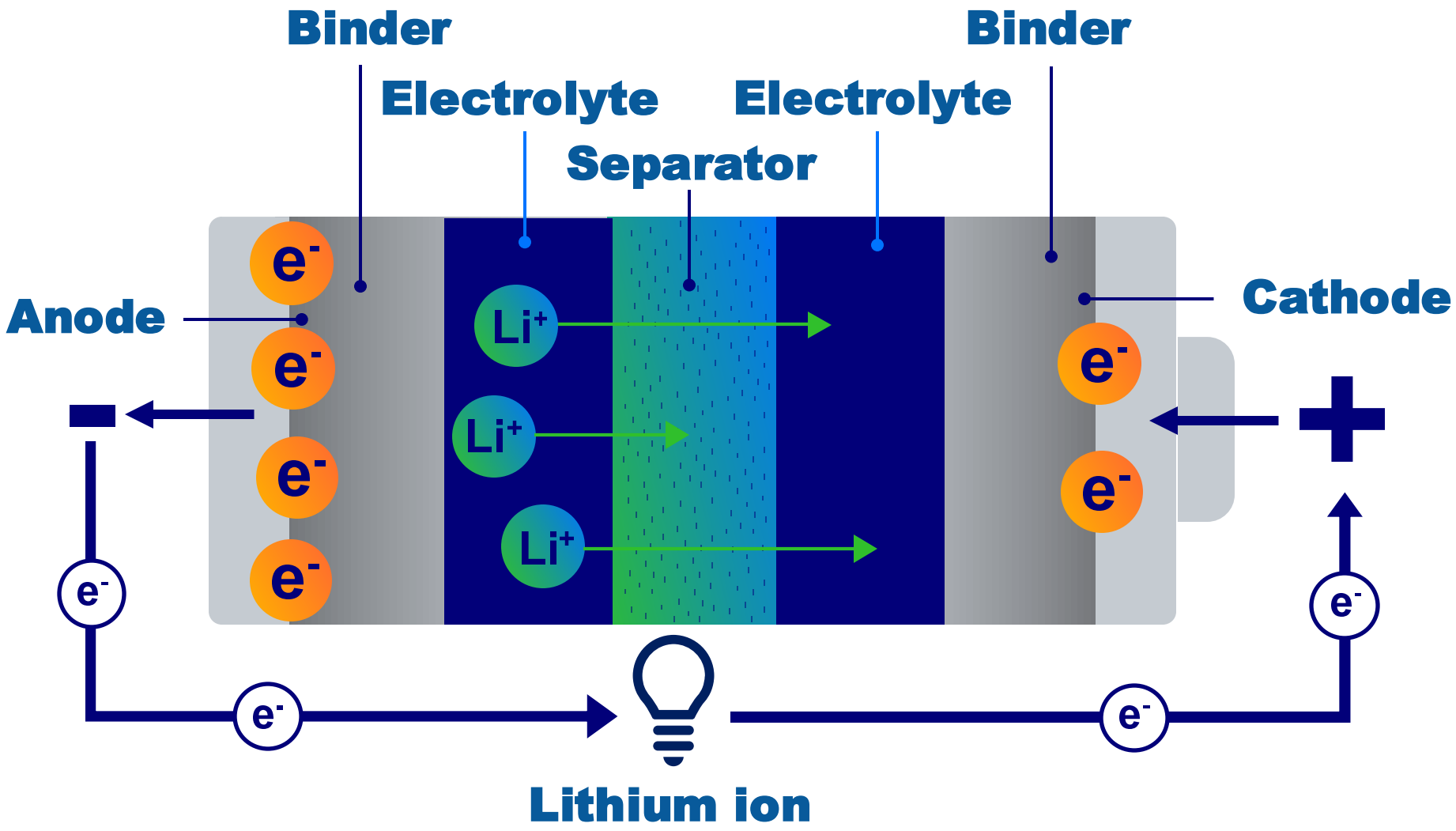
Battery cell and pack manufacturing are key to American OEM competitiveness as other nations seek to dominate the growing electric and hybrid transportation market

U.S. BATTERY DEMAND IS EXPECTED TO GROW NEARLY 7X



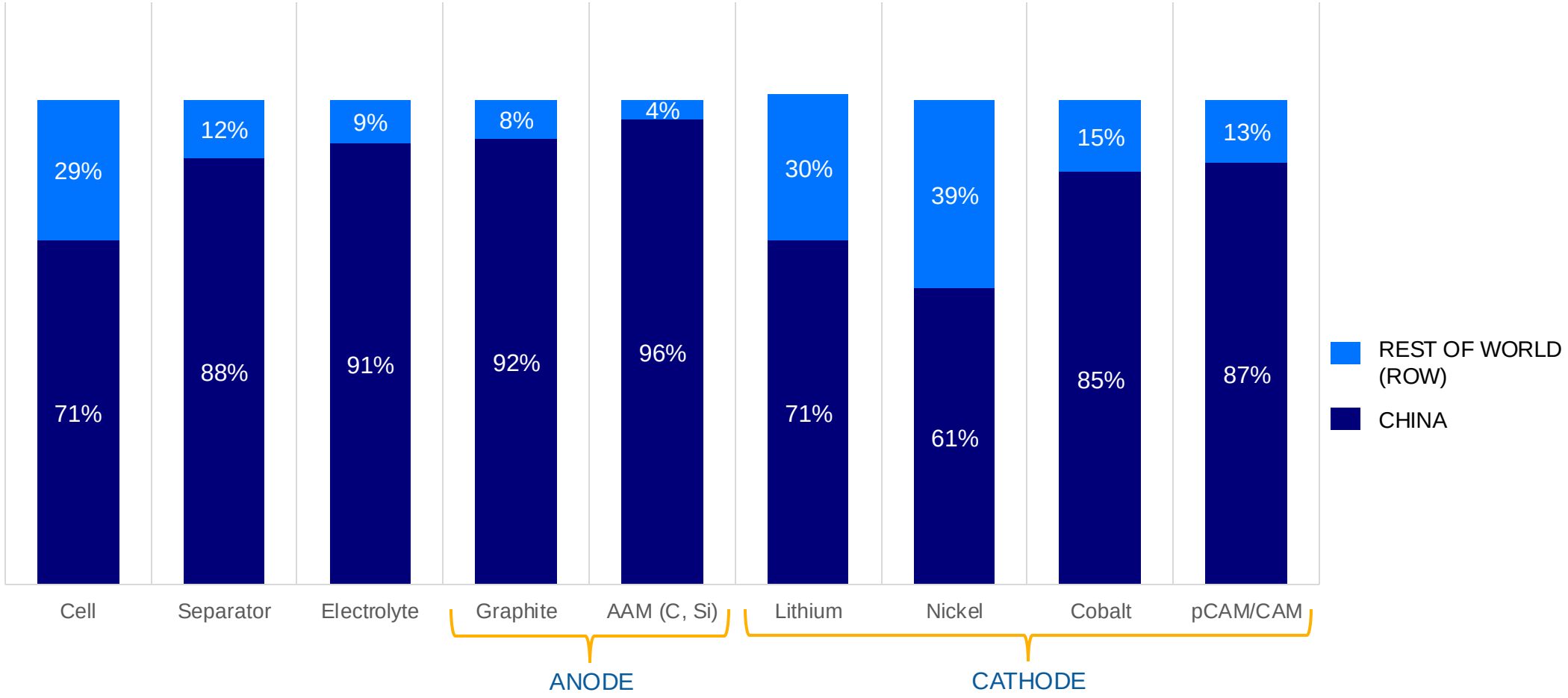
MMAC compilation of data sources

WHAT'S IN A BATTERY CELL?



CHINESE PRODUCTION DOMINATES GLOBAL BATTERY SUPPLY CHAINS

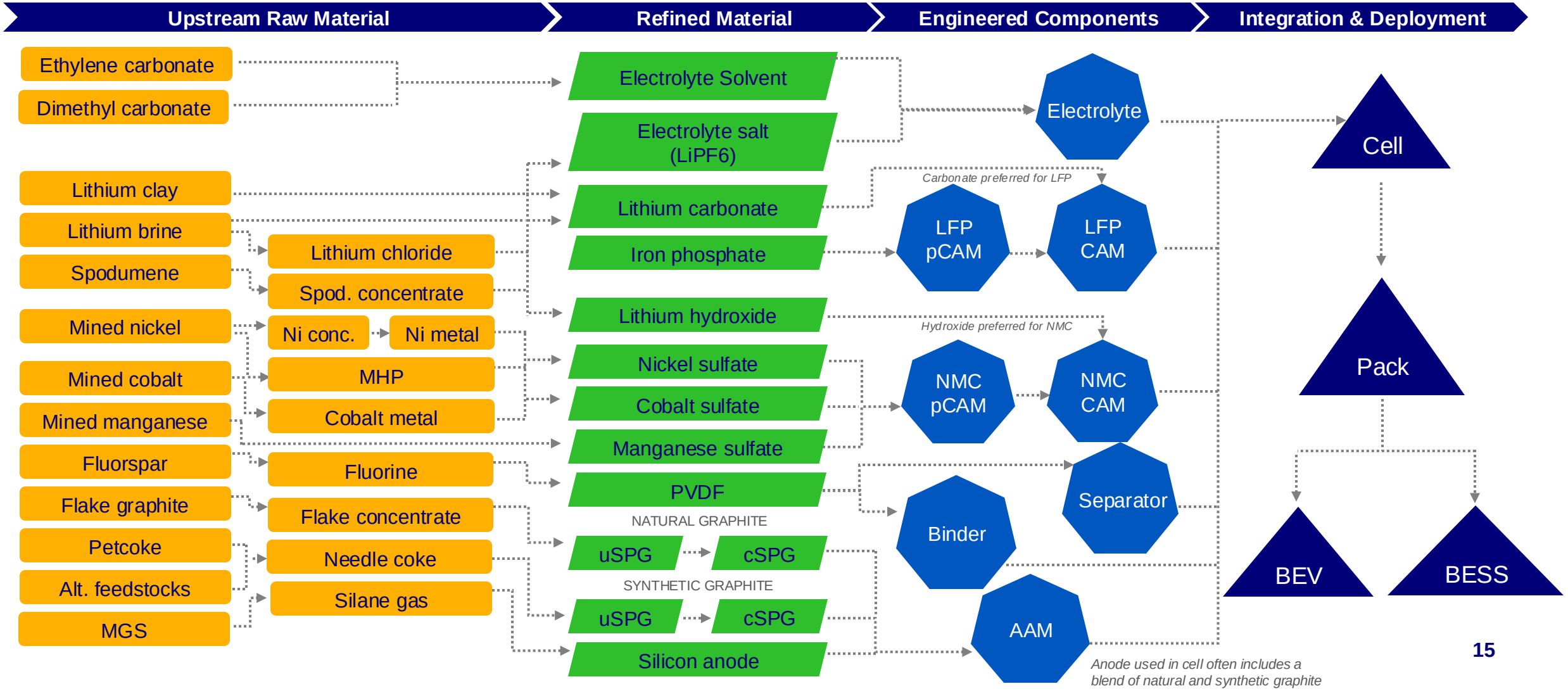
CHINA HAS >60-90% MARKET SHARE OF CRITICAL MIDSTREAM PRODUCTION, POSING ENERGY SECURITY RISKS



MMAC compilation of data sources

SUPPLY CHAIN READINESS LEVELS ASSESS RISKS AT EVERY SUPPLY CHAIN SEGMENT

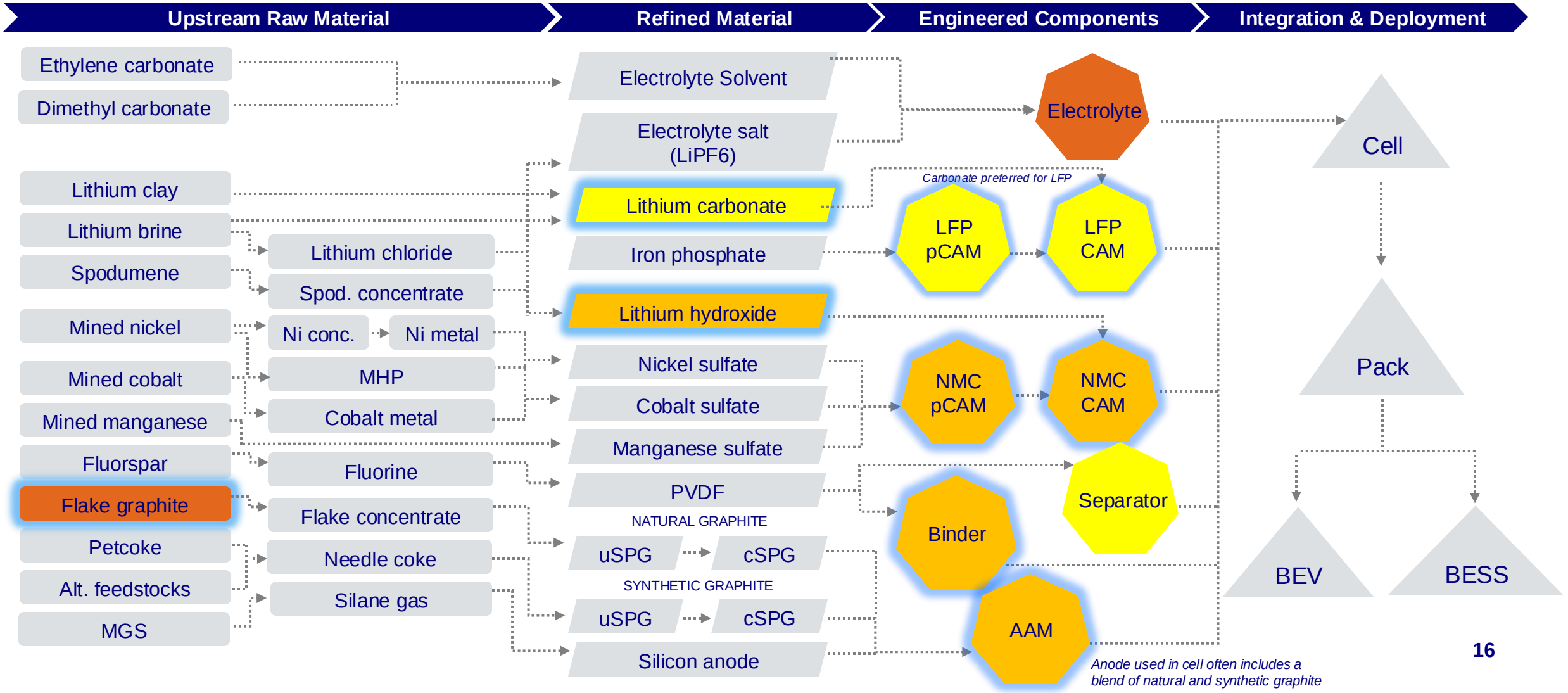
REPRESENTATIVE VIEW OF THE LITHIUM IRON PHOSPHATE (LFP) AND NICKEL MANGANESE COBALT (NMC) BATTERY SUPPLY CHAINS



SUPPLY CHAIN READINESS LEVELS ASSESS RISKS AT EVERY SUPPLY CHAIN SEGMENT

READINESS KEY — LOW | LIMITED | MODERATE | HIGH

REPRESENTATIVE SEGMENT READINESS RATINGS IN THE LITHIUM IRON PHOSPHATE (LFP) AND NICKEL MANGANESE COBALT (NMC) BATTERY SUPPLY CHAINS



U.S. STRATEGIC INVESTMENTS IN DOMESTIC BATTERY SUPPLY CHAINS

DOE's battery supply chain investments de-risked and unleashed private investment, enhancing energy security and decreasing reliance on China.

$120B

Total public and private investment in battery and EV supply chains: 80% of total cleantech manufacturing investment

$33B

U.S. government investment share from MESC battery grants program, LPO loans, and the 48C tax credit

>154K

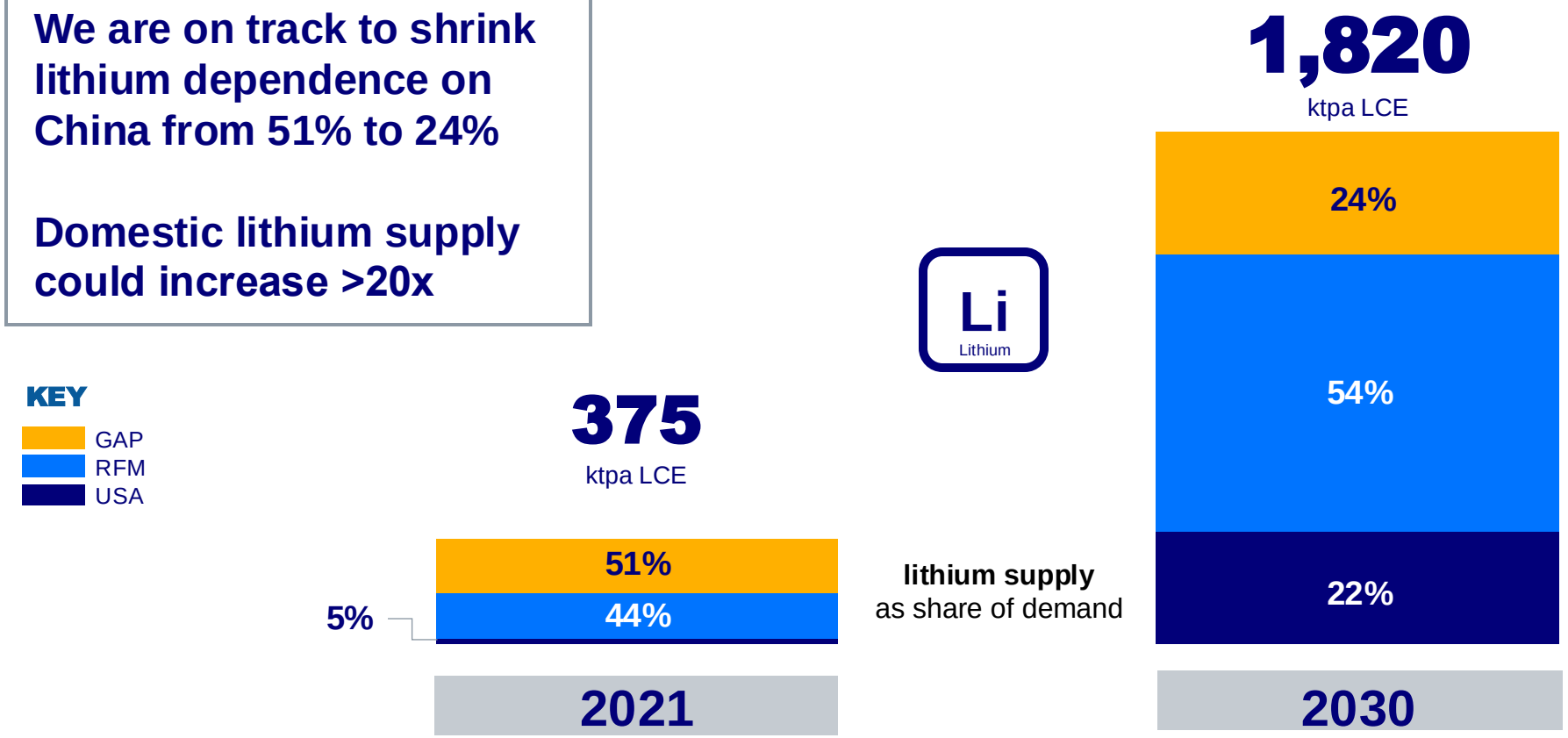
Manufacturing jobs being created across the country

DOE INVESTMENT IS DRIVING U.S. STRENGTH IN THE GLOBAL BATTERY SUPPLY CHAIN

CHINA DOMINATES TODAY'S BATTERY SUPPLY CHAIN, RISKING OUR ENERGY SECURITY

We are on track to shrink lithium dependence on China from 51% to 24%

Domestic lithium supply could increase >20x



Rest of Free Market (RFM) excludes Covered Nations

FLIPPING THE SCRIPT: ON TRACK FOR A RESILIENT SUPPLY FOR BATTERY CELLS

DOE DOWN PAYMENTS ARE CROWDING IN PRIVATE SECTOR INVESTMENT AND TURNING THE TIDE FOR BATTERY CELL MANUFACTURING

We are on track for 100% independence from China for battery cells by 2030

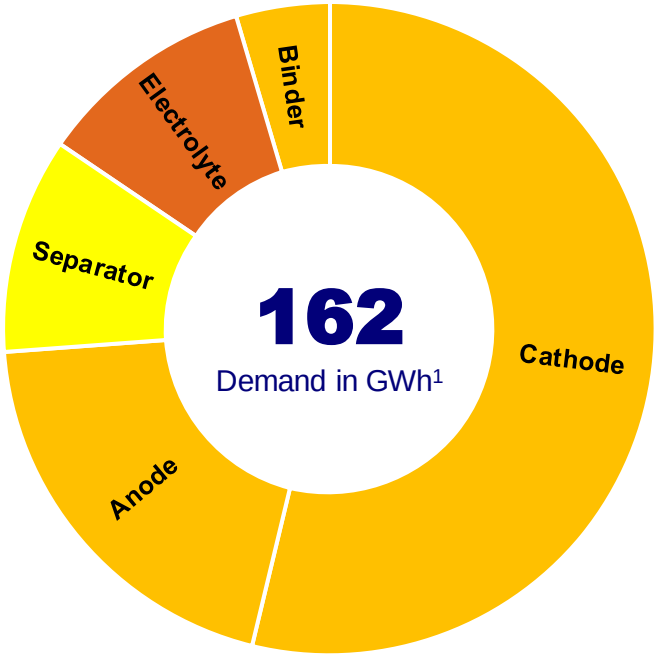
U.S. production to increase > 18x

Rest of Free Market (RFM) excludes Covered Nations

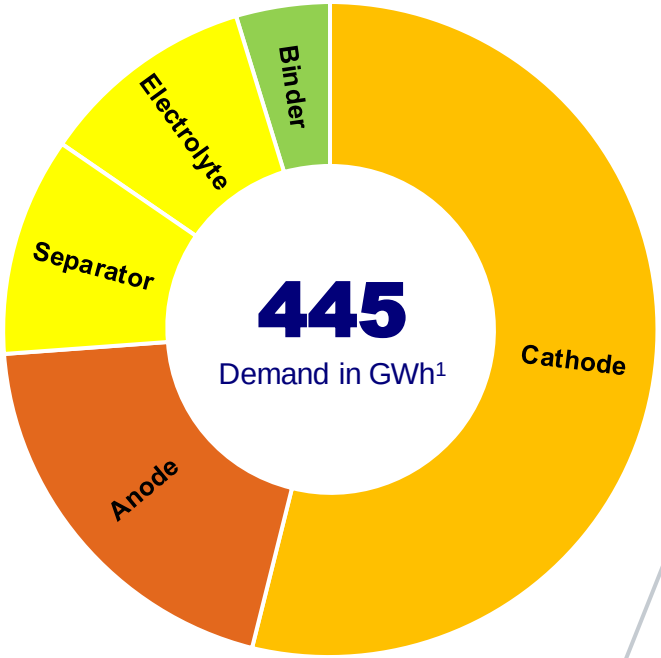
NMC-GRAPHITE BATTERY READINESS EXPECTED TO IMPROVE BY 2030

EXCEPTION: ANODE READINESS DECREASES DUE TO DEMAND OUTPACING FORECAST OF SUPPLY BUILD OUT

2023 READINESS



2030 READINESS



DEMAND FOR THIS BATTERY TYPE IS SET TO INCREASE NEARLY 3X BY 2030

READINESS KEY LOW | LIMITED | MODERATE | HIGH

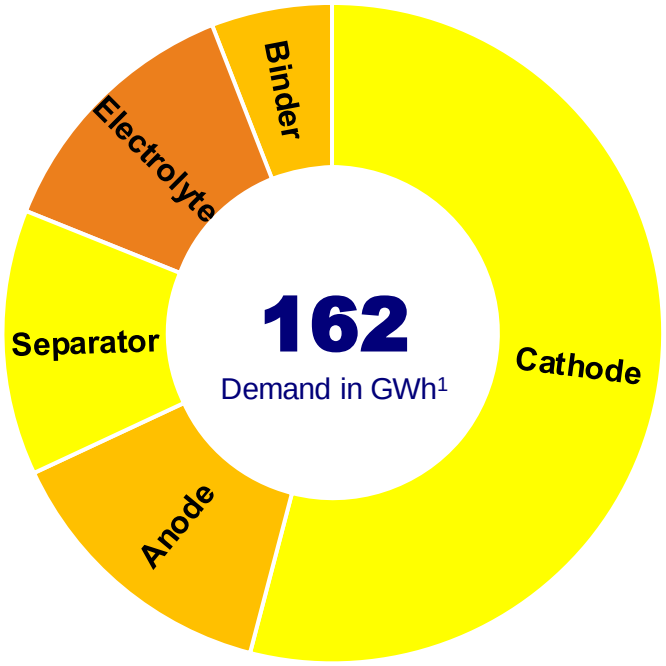
U.S. Department of ENERGY | Office of Manufacturing & Energy Supply Chains

1. Demand for US, Korea, Japan, and Europe. Source: BNEF Battery Demand Outlook for passenger electric vehicles . Includes NMC 111, NMC 532, NMC 622, NMC 721, NMC 811, NMC 955, NMC (96Ni), NMCA chemistries.

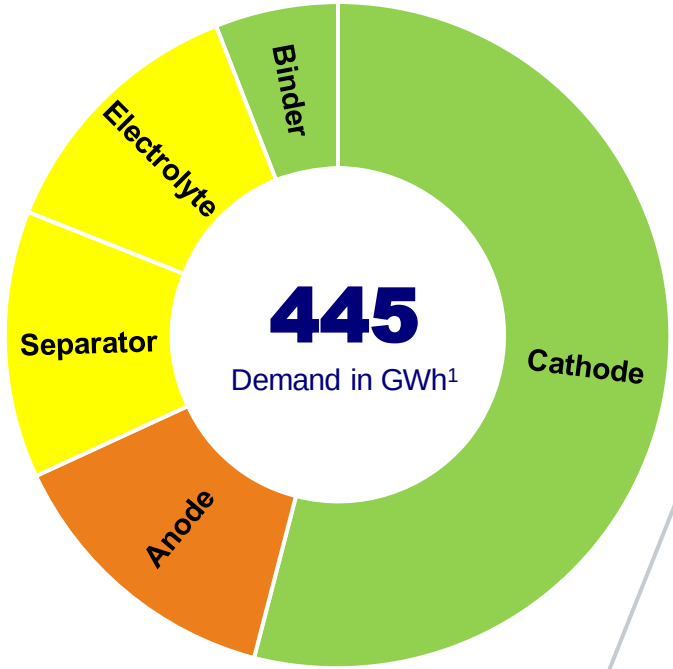
LFP-GRAPHITE BATTERY SUPPLY CHAIN SHOWS GREATER NEAR-TERM READINESS WITH IMPROVEMENT TO 2030

EXCEPTION: ANODE READINESS DECREASES DUE TO DEMAND OUTPACING FORECAST SUPPLY BUILD-OUT

2023 READINESS



2030 READINESS

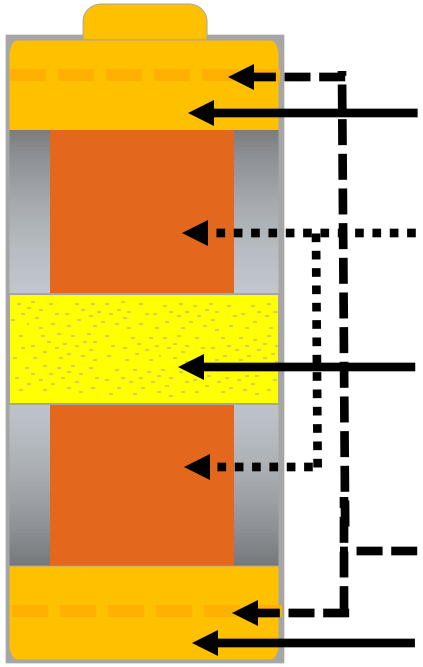


DEMAND FOR THIS BATTERY TYPE IS SET TO INCREASE 12X BY 2030

READINESS KEY LOW LIMITED MODERATE HIGH

1. Demand for US, Korea, Japan, and Europe. Source: BNEF Battery Demand Outlook for passenger electric vehicles. Includes LFP, LMFP chemistries

DOMESTIC PRODUCTION IS RAMPING UP
2023 U.S. NMC-GR BATTERY SCRL IS "LIMITED"

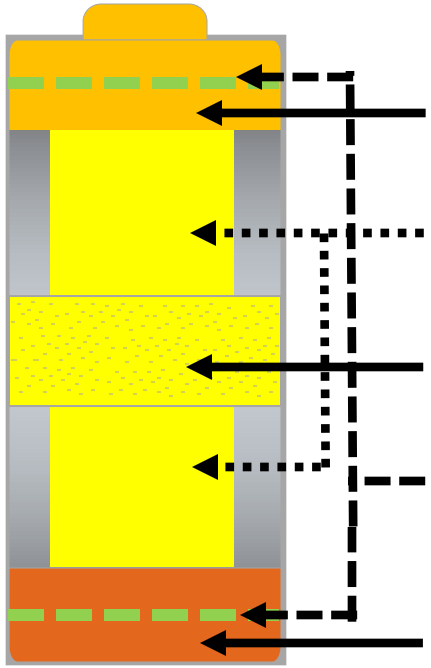


NMC-Gr Battery

CATHODE	**Limited.** Significant reliance on China for processing key cathode inputs, including lithium, nickel, and cobalt.
ELECTROLYTE	**Low.** Heavy reliance on China for electrolyte inputs. China's production costs are extremely low relative to peers.
SEPARATOR	**Moderate.** Japan and South Korea offer substantial production capacity, improving readiness.
BINDER	**Limited.** US production costs are comparatively high relative to current major producers.
ANODE	**Limited.** Graphite processing capacity and cost competitiveness represent primary risks.

READINESS KEY — LOW | LIMITED | MODERATE | HIGH

DOMESTIC PRODUCTION IMPACT INCREASING BUT NOT AT MARKET PACE; 2030 U.S. NMC-GR SCRL IS "MODERATE"



NMC-Gr Battery

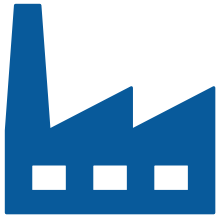
CATHODE	**Limited.** US capacity for lithium processing and recycling improves readiness; nickel and cobalt challenges remain relative to demand.
ELECTROLYTE	**Moderate.** US electrolyte production capacity increasing substantially due to recent DOE grants.
SEPARATOR	**Moderate.** US separator production capacity increasing substantially due to recent DOE grants.
BINDER	**High.** Announced US capacity increases and robust battery cell manufacturing improves readiness.
ANODE	**Low.** US and allied investments in graphite processing have been substantial, but demand is scaling faster than supply.

READINESS KEY — LOW | LIMITED | MODERATE | HIGH

BATTERY SCRL ASSESSMENTS REVEAL KEY INSIGHTS

Raw Materials

- Readiness improves as lithium projects reach full-scale commercial production
- Processing and refining remain bottlenecks for other minerals



Manufacturing

- Cost competitiveness improvements are key to long-term viability
- Demand outpaces projected supply across multiple manufactured components

Workforce

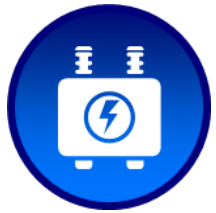
- Demand for workers likely to exceed supply in 2030
- Battery supply chain faces comparatively greater hiring difficulty (limited electrical assemblers and testers familiar with batteries manufacturing)

THE SCRL FRAMEWORK: UPCOMING ANALYSES

THE SCRL FRAMEWORK SPOTLIGHTS VULNERABILITIES ACROSS OUR ENERGY SUPPLY CHAINS

Grid: Transformers, Conductors & Other Key Grid Components

Nuclear: Fuel Supply, Existing Fleet, and Advanced Reactors



Electrolyzers: Proton Exchange Membrane (PEM), Liquid Alkaline, & Solid Oxide Electrolysis Cells (SOECs)

Solar: Polysilicon, Ingots/Wafers, Solar Glass, & Next-Generation Solar Technologies

WANT TO LEARN MORE ABOUT SUPPLY CHAIN SECURITY?

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