

# Advanced Battery Technology Which Accelerates Battery Production Worldwide

*Keynote: Hungarian Battery Day 2024*

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# AGENDA

- Why was China so successful?
- Where is the money?
- Traditional Critical Minerals?
- Raw Mineral Harvesting
  - Impossible Metals
- Mineral Processing
  - ReElement
- Material Processing
  - Powall
- Manufacturing Technology
  - IKA
- Alternative Battery Technologies
  - LiNova
  - GMG
- Q&A



1. **Government Support: environmental concerns and difficulty of starting a new technical revolution**
  - Incentives
  - Tax assistance
2. **Technology**
  - Established over a decade of making consumer electronics battery
  - Developing supply chain from mining and processing to manufacturing cells
3. **Private Equity Investment**
  - Investors from all walks of life came to batteries for higher margins
4. **The M & M's: Man and Machines**
  - Educate and train people in all aspects of the operation
  - Design and Build machines capable of producing GWh volumes in ppb failure rates.

# A Perspective of the 4 Key Reasons of China's Success in Batteries

# Where is the money? How the Battery Industry Has Changed the Market

Market Cap comparison of mobility sector companies and battery manufacturers as of 9/6/2024

- \$735 B Tesla #11
- \$246 B Toyota #44
- **\$115 B CATL #131**
- \$115 B Airbus #132
- \$100 B Boeing #163
- **\$98 B BYD #174**
- **\$70 B LG Energy Sol #271**
- \$55 B Volkswagen #342
- \$54 B GM #349
- \$47 B Stellantis #414
- \$44 B Ford #454
- \$41 B Cummins #481
- **\$20 B Panasonic #956**
- **\$17 B Samsung SDI #1077**



# The Key Materials in an EV Battery

CELL PART: ● ANODE ● CURRENT COLLECTORS  
● CATHODE ● CELL CASING



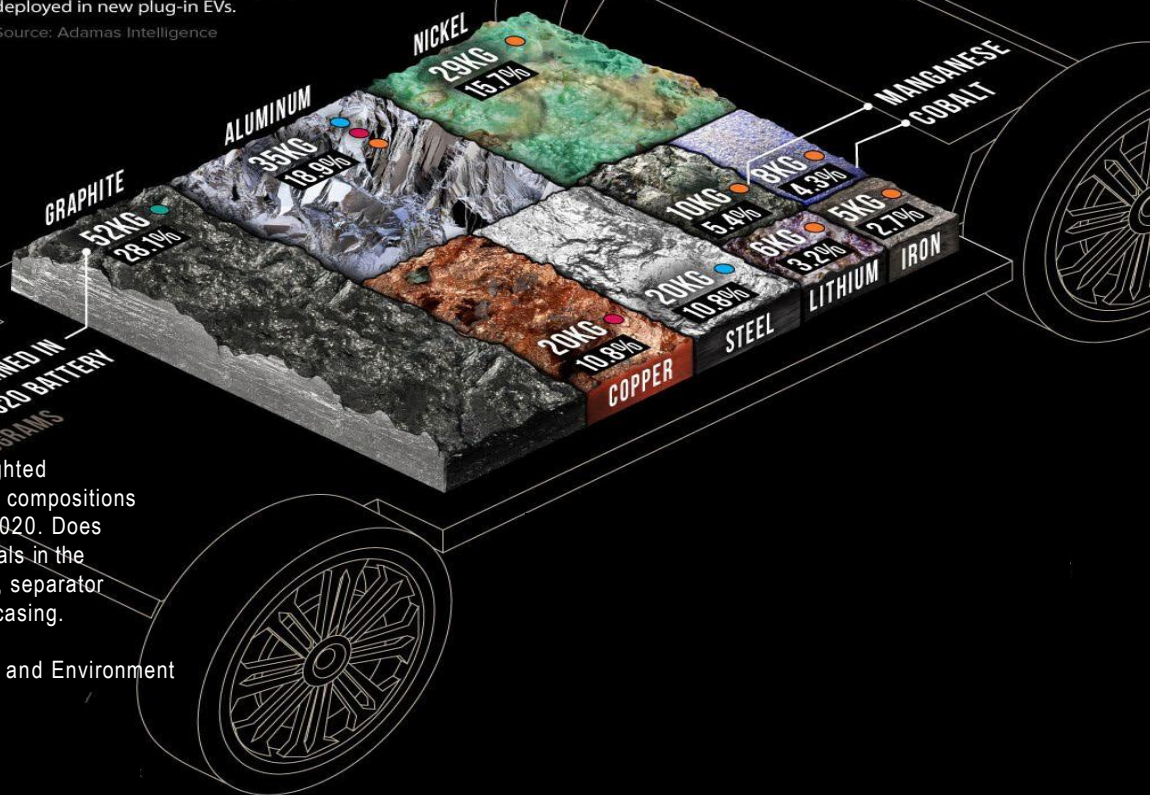
In 2021, **nickel-based** cathodes powered 80% of the battery capacity deployed in new plug-in EVs.

Source: Adamas Intelligence

AMOUNT CONTAINED IN THE AVG. 2020 BATTERY

Based on the weighted average of battery compositions on the market in 2020. Does not include materials in the electrolyte, binder, separator and battery pack casing.

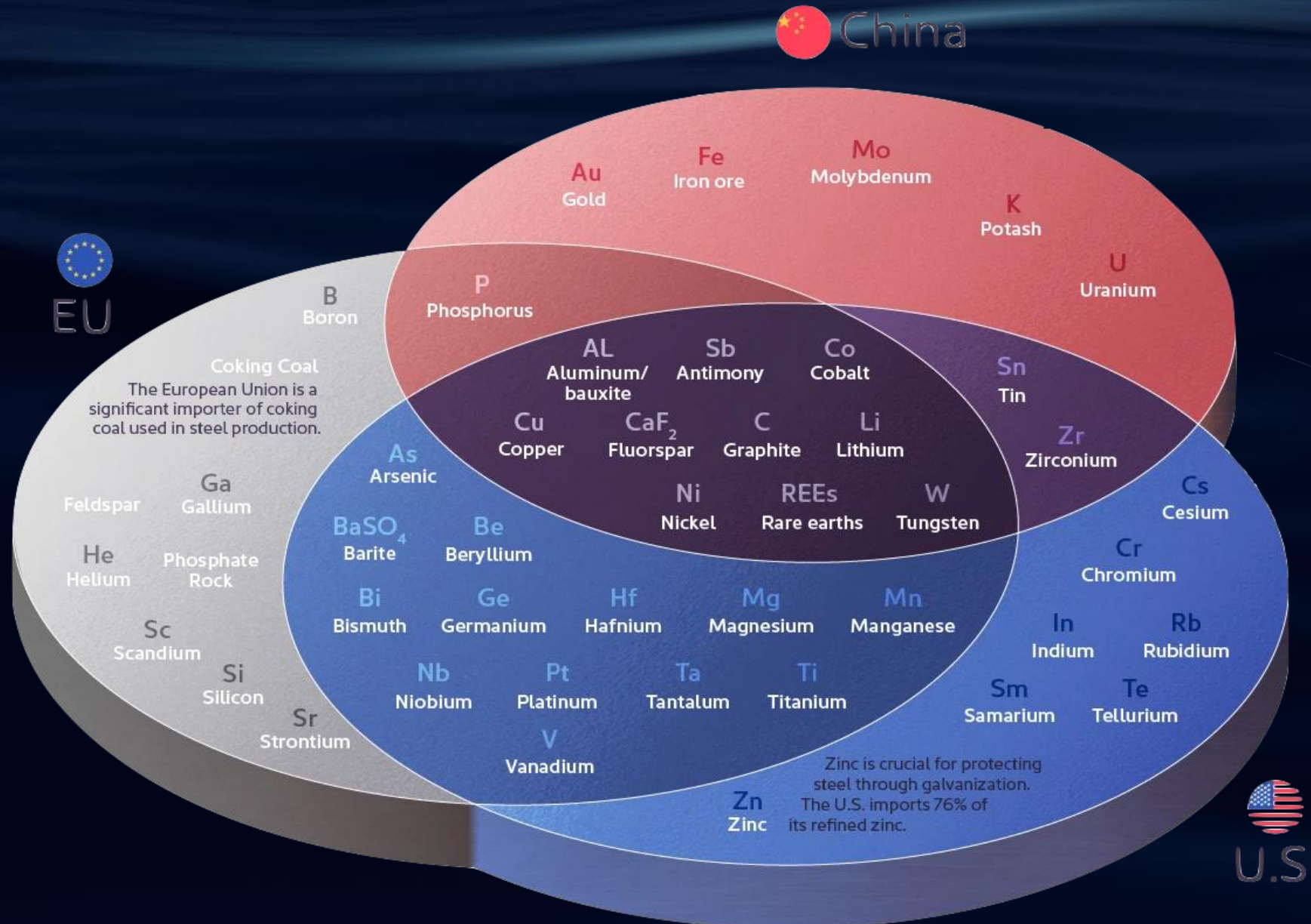
Source: Transport and Environment



Elements in a ~2020 vintage 60 kWh EV battery (various chemistry scenarios)

	NMC811 Nickel (80%) Manganese (10%) Cobalt (10%)	NMC523 Nickel (50%) Manganese (20%) Cobalt (30%)	NMC622 Nickel (60%) Manganese (20%) Cobalt (20%)	NCA+ Nickel Cobalt Aluminum Oxide	LFP Lithium iron phosphate
LITHIUM	5KG	7KG	6KG	6KG	6KG
COBALT	5KG	11KG	11KG	2KG	0KG
NICKEL	39KG	28KG	32KG	43KG	0KG
MANGANESE	5KG	16KG	10KG	0KG	0KG
GRAPHITE	45KG	53KG	50KG	44KG	66KG
ALUMINUM	30KG	35KG	33KG	30KG	44KG
COPPER	20KG	20KG	19KG	17KG	26KG
STEEL	20KG	20KG	19KG	17KG	26KG
IRON	0KG	0KG	0KG	0KG	41KG

# US, EU & China Critical Minerals



# IMPOSSIBLE

— METALS —

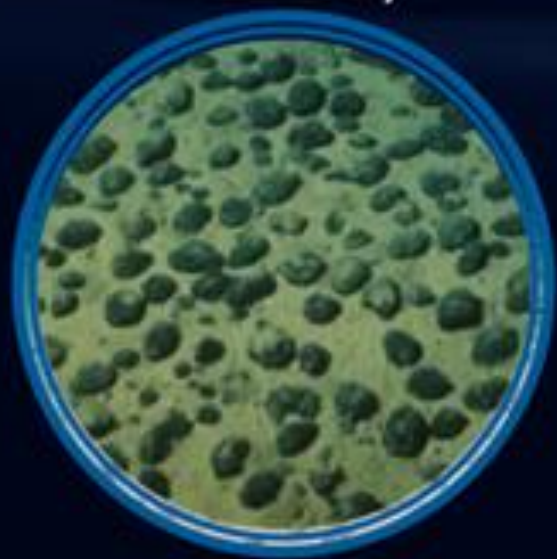
AI robots for sustainable critical metal harvesting from the seabed

Raw  
Minerals  
Harvesting



# Why Deep Sea Minerals?

- World's biggest reserves for critical metals (Ni, Co, Mn) due to 71% ocean
- Lowest cost to extract metals due to ore grade & shipping infrastructure
- Least ESG impacts due to lowest biomass and no human impacts
- Not controlled by China



Polymetallic Nodules  
(PMN) field

Co Ni Cu Mn Nd Pr



Polymetallic Nodule

**Dredge & Riser  
Based Systems  
(Tested in 1970s)**

**IMPOSSIBLE  
METALS**

**No Single point of failure  
Minimised Environmental Impacts**

**Port  
Transport**



**No ship-to-ship transfer  
required; a new ship arrives  
to continue operations**

**Vertical  
transport**

**Collection**



**Hovers over the  
seafloor, picking up  
nodules individually,  
avoiding macrofauna  
& minimizing sediment  
disturbance**



**Uses a fleet of AUVs, each  
transporting its own  
payload to the surface**

 [Click Here to  
Watch Now!](#)

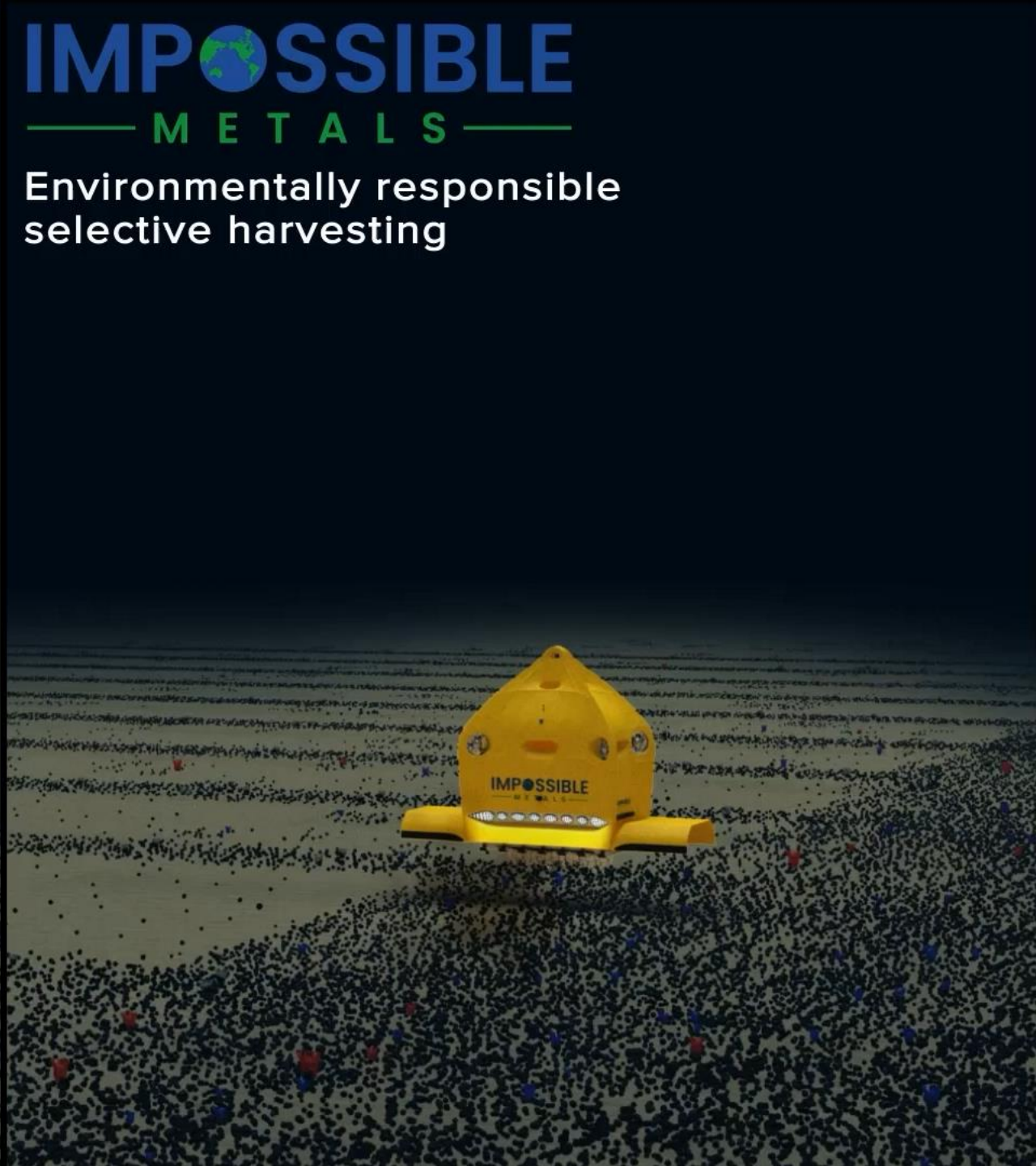
# COMPETING APPROACHES

Broad environmental destruction



# IMPOSSIBLE METALS

Environmentally responsible selective harvesting

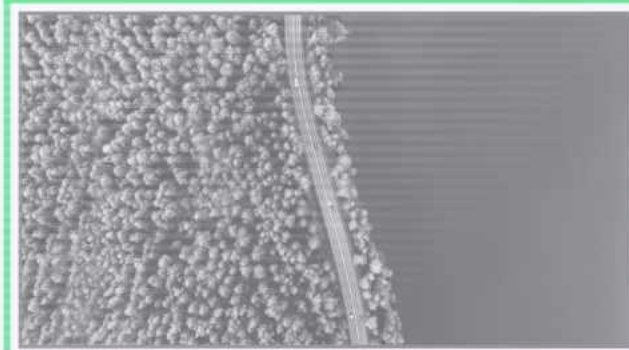
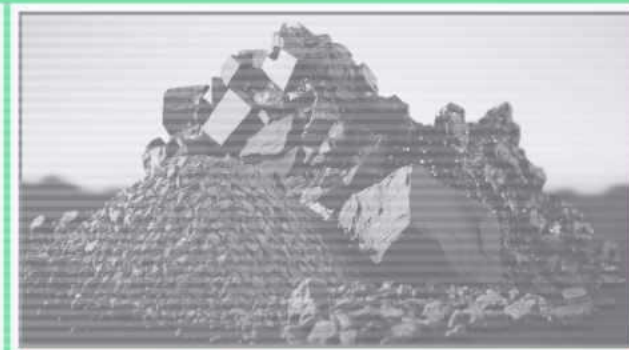
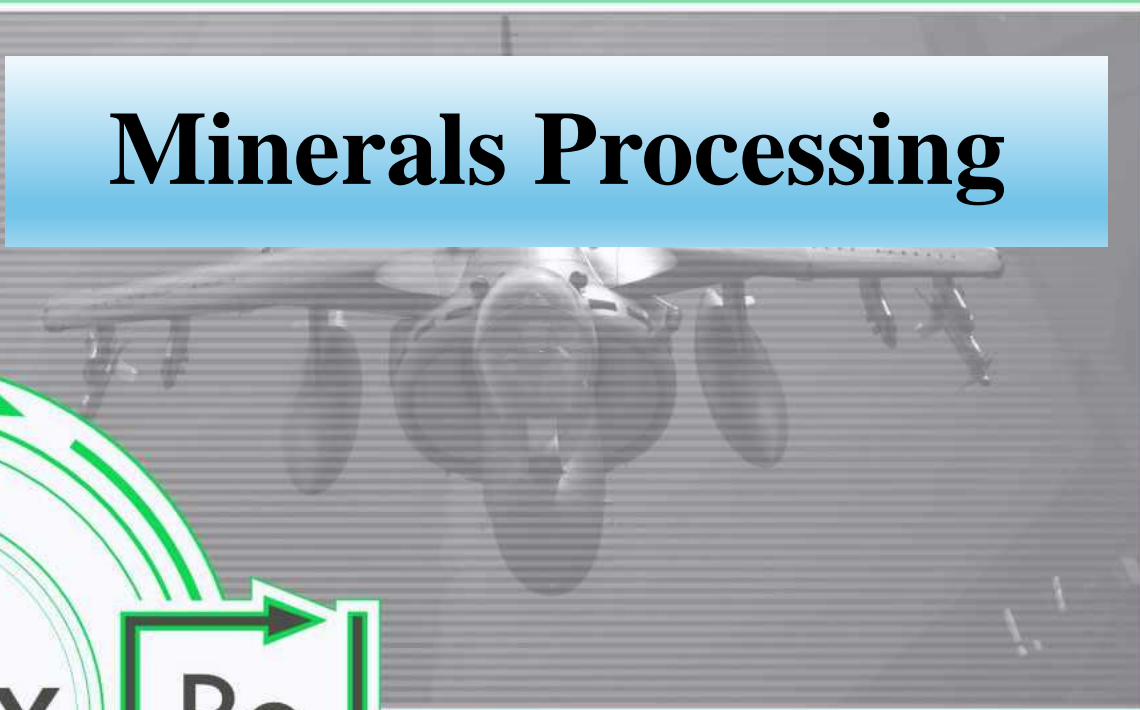
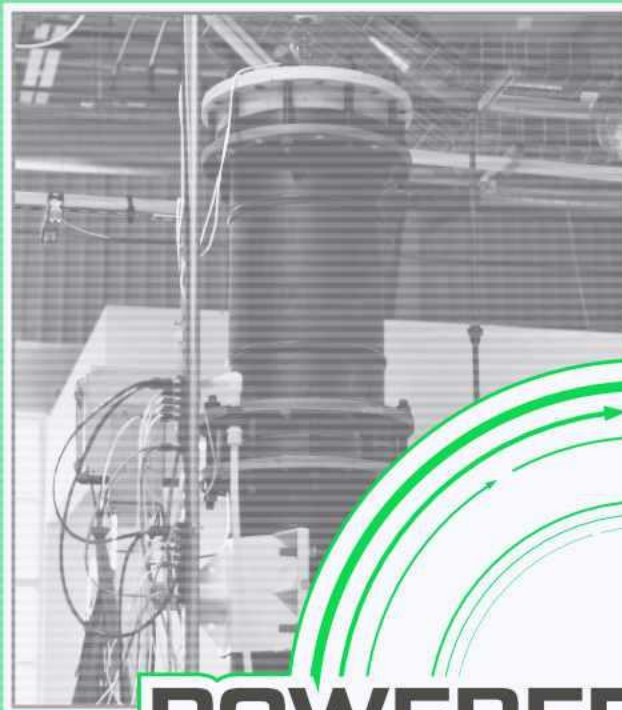


# Minerals Processing

**POWERED BY**

**Re**  
ELEMENT

**FINITE RESOURCES MADE INFINITE**



# Powered by ReElement: Feedstock Agnostic Refining

Engineered and Calibrated to Plug-and-Process all Magnet and Battery Feedstock Types & Chemistries



## NATURAL MINERAL FEEDSTOCKS

Mineral ores and brines include lithium containing spodumene and lepidolite deposits, lithium mineral brines along with rare earth element deposits in monazite sands and bastnasite deposits



## RECYCLED MAGNETS & BATTERIES

After physical and chemical preprocessing is complete, the chromatography columns can accept any recycled material regardless of battery or permanent magnet chemistry to produce battery or magnet-grade materials



## BATTERY BLACK MASS

The processing columns are battery-chemistry agnostic and have proven effective recovering all cathode active material battery elements at high-yield, high-purity and scale. LFP is the most common black mass we refine to battery-grade purity

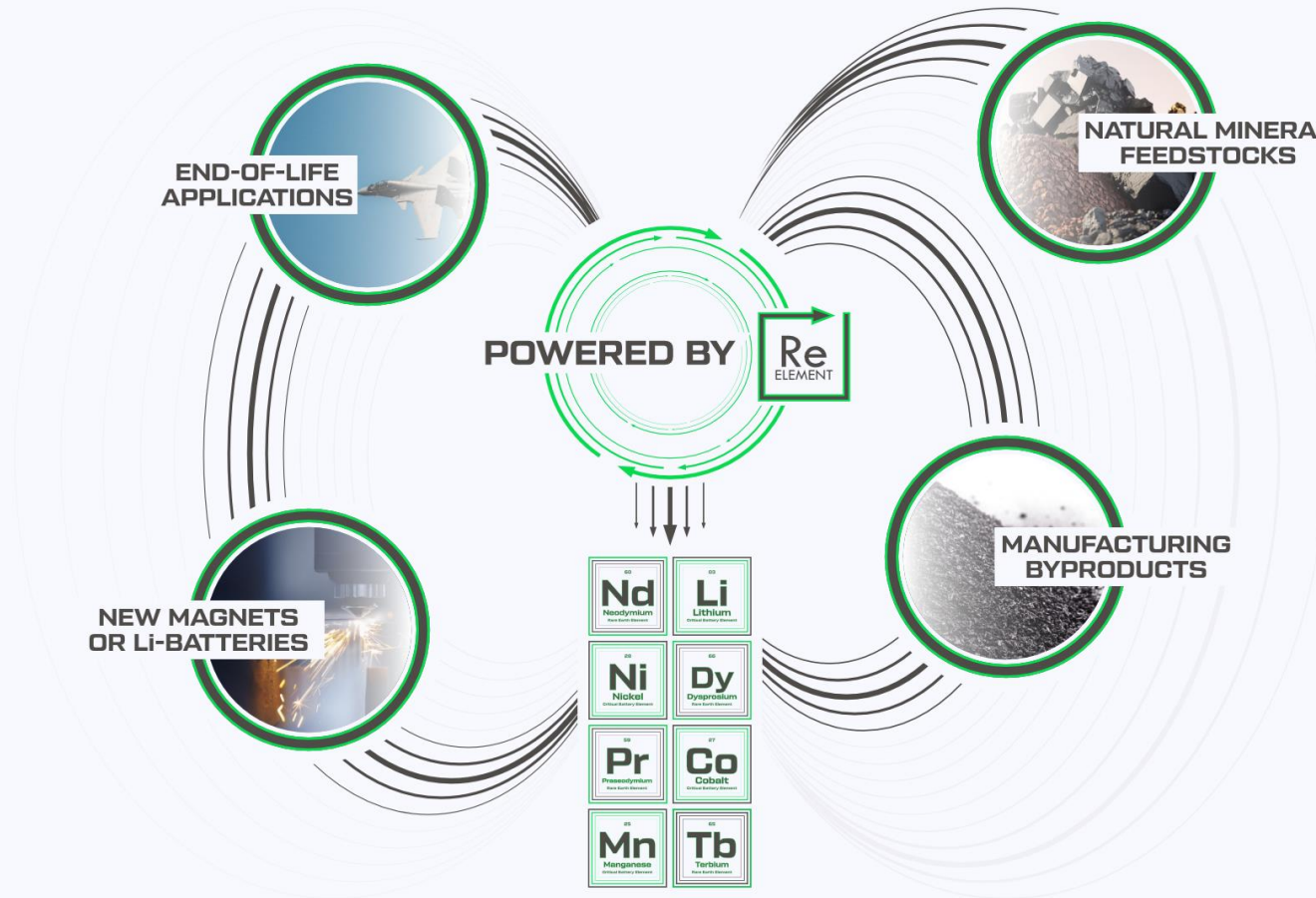


## BATTERY & MAGNET MANUFACTURING WASTE

Battery and magnet manufacturing loses ~20% of critical minerals to production waste. Our platform integrates and continuously recovers and purifies waste streams

# Powered by ReElement: Refining-as-a-Service

High-Yield, High-Purity, Low-Cost Critical Mineral Refining for All Possible Feedstock Types & Chemistries



Eliminating the refining bottleneck by offering superior quality minerals at the lowest OPEX and CAPEX prices

# Powered by ReElement: Decentralizing & Localizing Logistics

Deliverable, Deployable, Co-locatable Refining Platform without Large Capital Investment

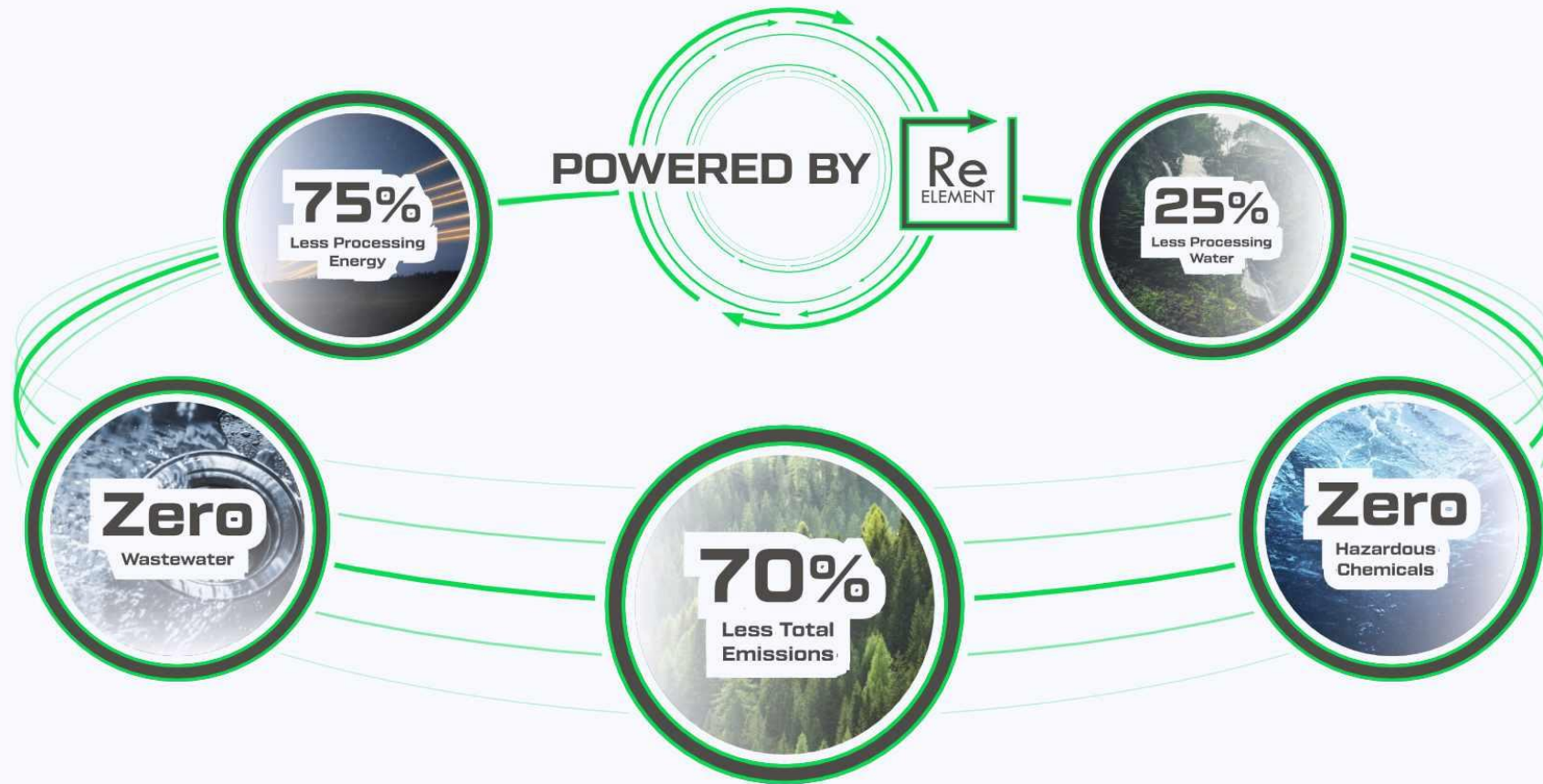


Powered by ReElement: easy-to-transport, on-site refining-as-a-service platform

Decentralizing and localizing the logistics to greatly improve refining economics

# Powered by ReElement: Near-Zero Waste Refining

The Most Environmentally Sustainable Refining Technology Operational Today Compared to Current Industry Standards



# Let Powall help you enhance your battery materials, now at scale !



Dry gas-phase post treatment for nanocoating of cathode materials e.g. NMC, NCA, LMNO, LFP  
Cheaper than wet-, better than dry-coating

## Impact

**1 nm** Powall Nanocoating

Improved materials

Better batteries

Better materials

Less critical material

Cheaper and more durable

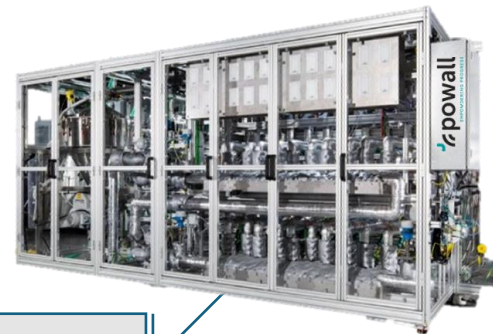
## Offering

### Coating Equipment

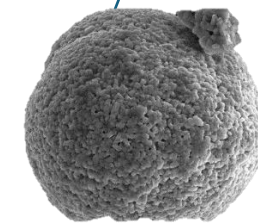
- Unit 10kg/h, 100kg/h or 1000kg/h
- Tailored to your needs (add-on)
- Full installation support and extensive training possible
- Various Service & Maintenance options

### Coating Services

- Proof of Concept
- Nanocoating & Process development
- On-demand nanocoating



Coating equipment 100 kg/hr



Nanocoated particle



Contact : [info@powall.com](mailto:info@powall.com)

# Materials Processing

# IKA

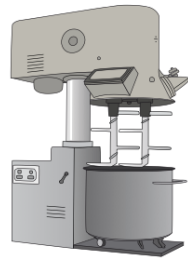
**BREYER**   
*extrusion lines*

 **Mühlbauer**  
High Tech International

# Manufacturing Technology

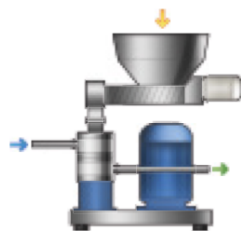


## Inline mixing vs. conventional technologies (wet slurry mixing)



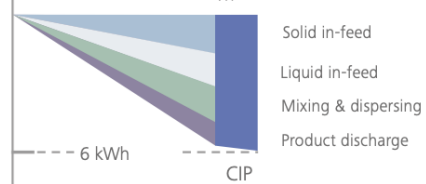
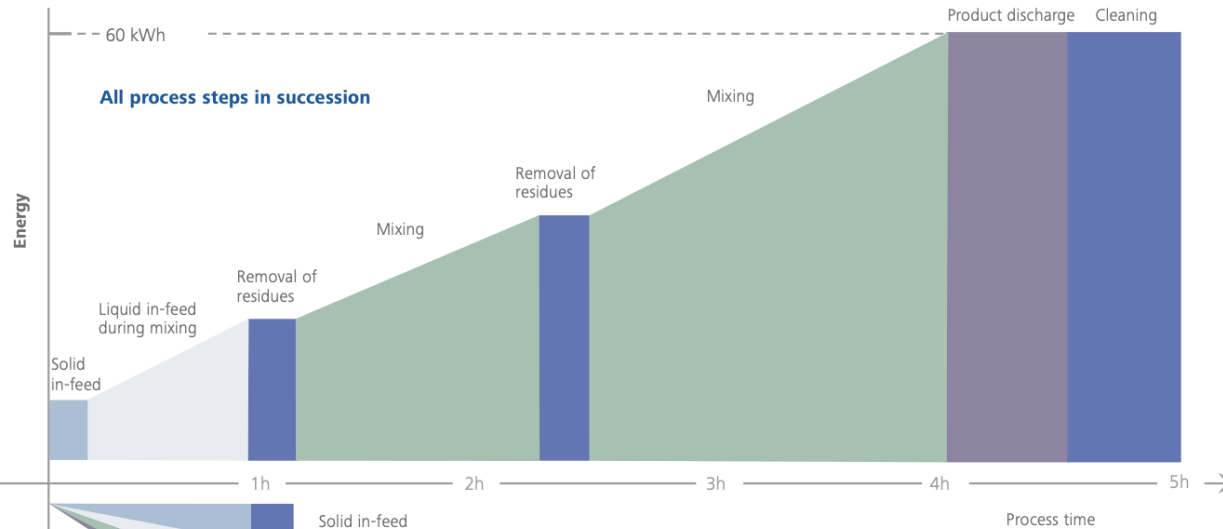
### Planetary mixer

- 15 kW motor output
- 400 l capacity
- Batch process



### MHD 2000/05 in-line mixer

- 5.5 kW motor output
- 400 l/h throughput
- In-line process



**Time and energy required to produce 400 kg of battery slurry**



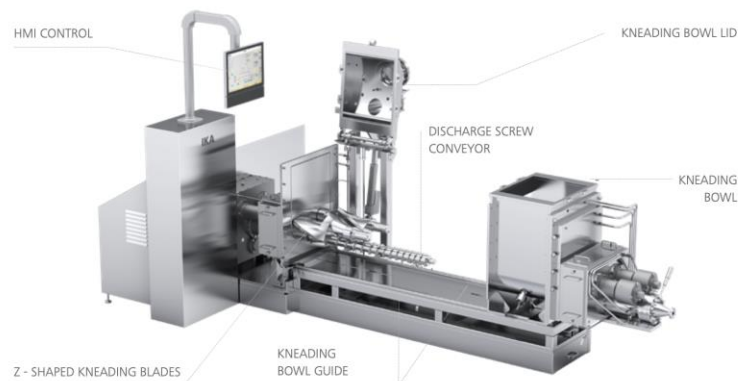
**The in-line process is 5x quicker and requires just 10% of the energy**



designed to work perfectly

## Kneading as dry electrode mixing technology

- › High process stability & reproducibility
- › Compact design
- › Flexible process options (batch & continuous)
- › Scalable solutions
- › Continuous dry mixing, fibrillation and pre-shaping all-in-one

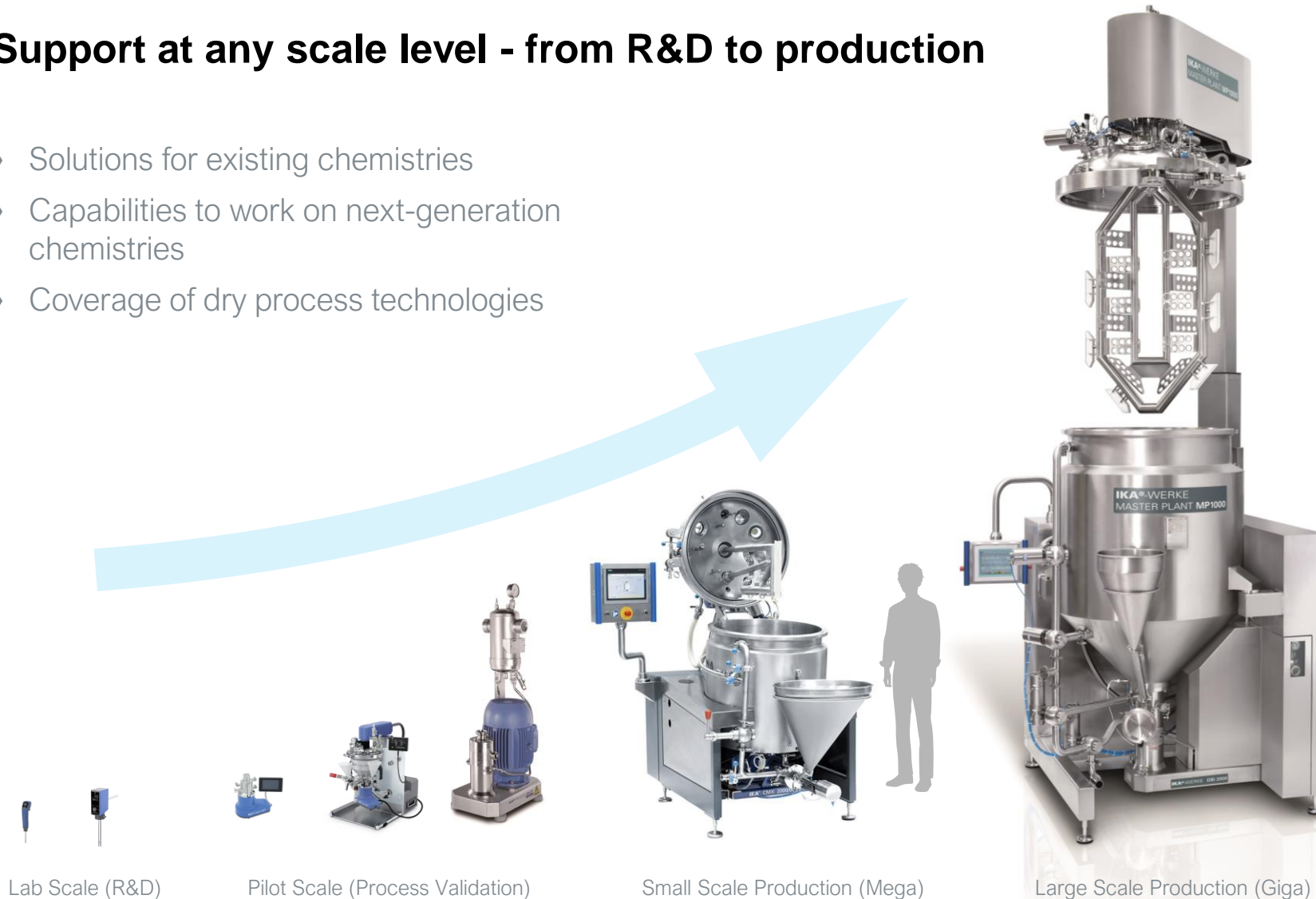




designed to work perfectly

## Support at any scale level - from R&D to production

- › Solutions for existing chemistries
- › Capabilities to work on next-generation chemistries
- › Coverage of dry process technologies





Alternative Battery  
Technologies

**LINOVA**  
Energy

**High Energy Polymer Cathode Battery**

**September 2024**

# Metal-Free Polymer Cathodes

LiNova Energy is developing ultra-high-energy batteries utilizing a Polymer Cathode for the EV, Energy Storage and Aerospace (JDA with SAFT for aerospace) industries.



## ENERGY DENSE

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Significantly higher energy than NMC

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## LOW COST

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1/10<sup>th</sup> the cost of NMC.

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## SAFE

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Intrinsically stable with no chance of thermal runaway.

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## SUSTAINABLE

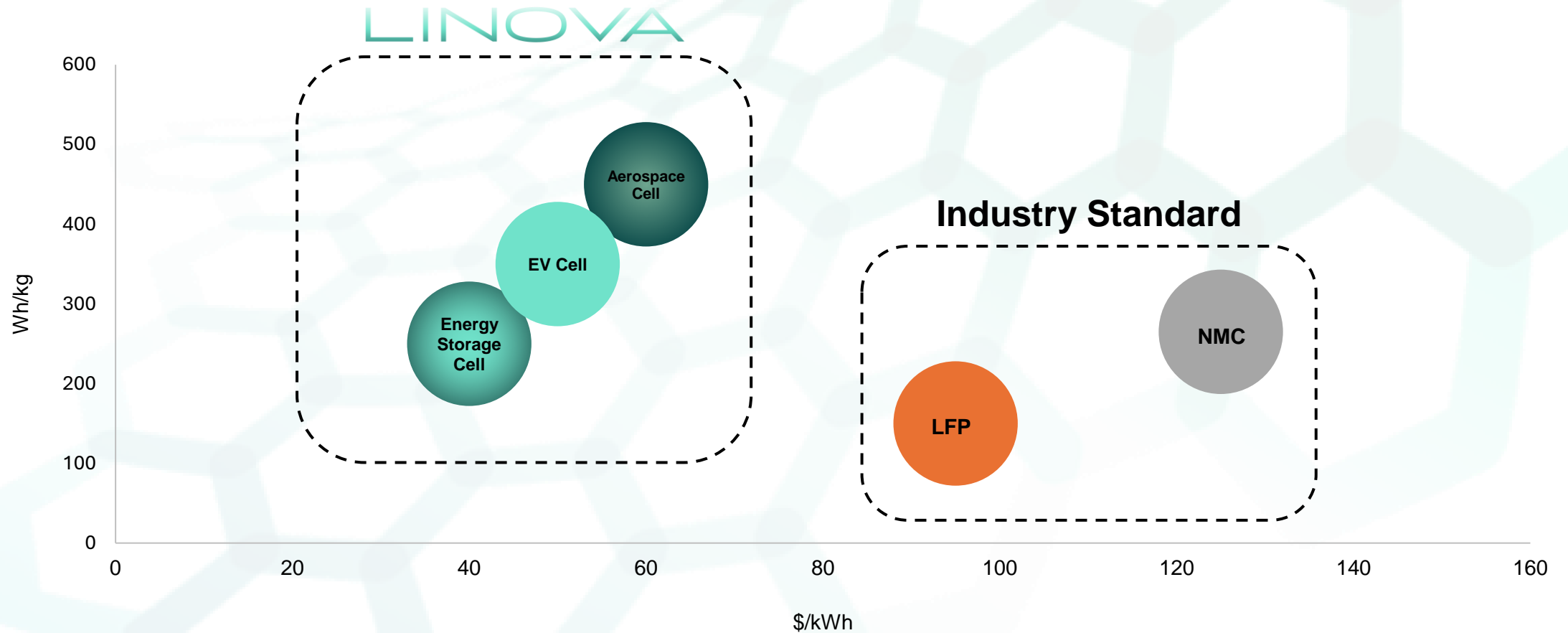
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No transition metals. Polymers sourced locally around the world.

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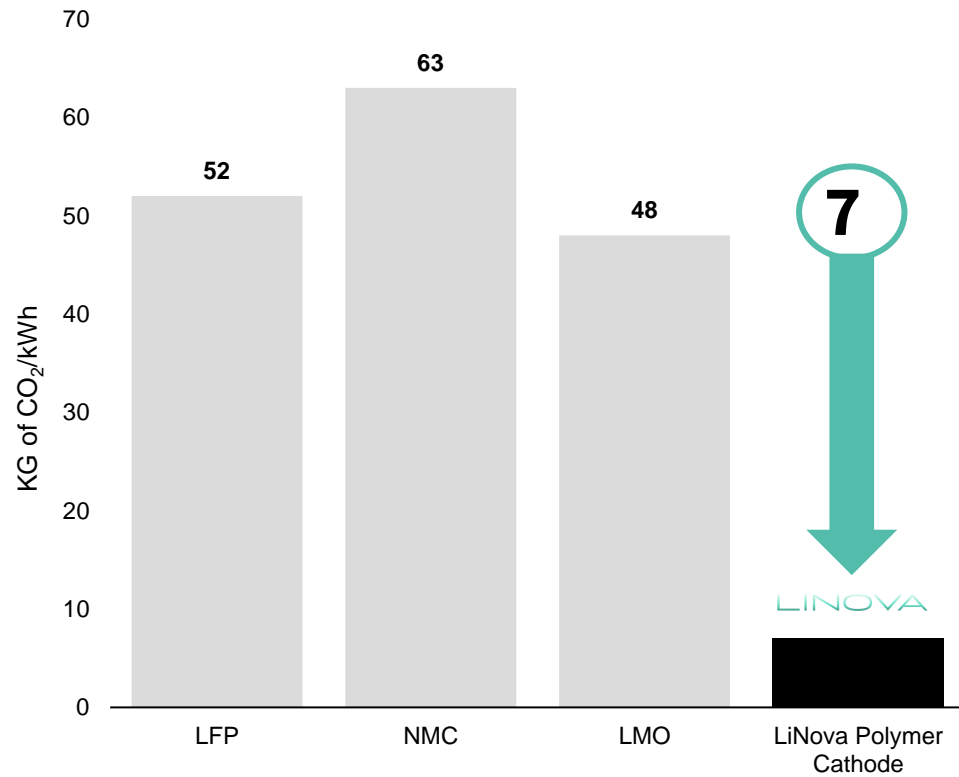
# Energy and Cost Advantages

LiNova's polymer battery offers a significant cost advantage over the LFP and Li-Ion NMC cathode competitors, while offering a higher energy density. The Company's polymers are abundant and readily available throughout North America and around the world.

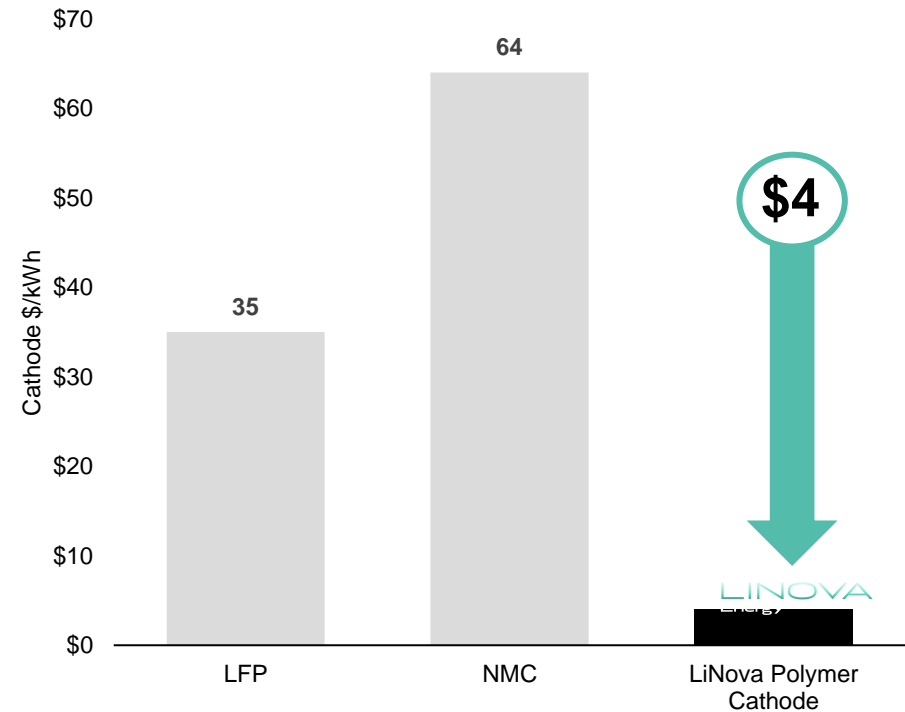


# Significant CO<sub>2</sub> and Cost Reduction

## Cathode manufacturing GHG's (KG of CO<sub>2</sub>/kWh)



## Cathode cost \$/kWh



# LiNova Polymers are Scalable

- LiNova has scaled up Poly-M to 100 kg batches using a 3<sup>rd</sup> party Toll Chemical manufacturing company.
- Infrastructure currently in place within the US can scale LiNova's polymer cathode to 100's of GWh/year.



**4 kg batch**  
LiNova Facility



**100 kg batch**  
LiNova's 3rd party toll manufacturer



**100's GWh/year**  
Industrial scale manufacturing  
available in NA, Europe and Asia

## 1 Revolutionary critical mineral technology:

Enabled by graphene, GMG is a clean-technology company providing revolutionary energy saving and storage solutions.

## 2 Founded by former Shell Executive, Craig Nicol:

Bringing over 20 years of experience in delivering large scale innovation, including leading multi-billion-dollar gas and LNG value chains in Australia and Asia Pacific.

## 3 A proud Queensland company:

GMG'S state-of-the-art facility is located in Brisbane, with future plans underway to establish a major battery manufacturing plant in Queensland.

## 4 Major partnerships in place

GMG enjoys significant partnerships with Rio Tinto, the University of Queensland and the Queensland Government.

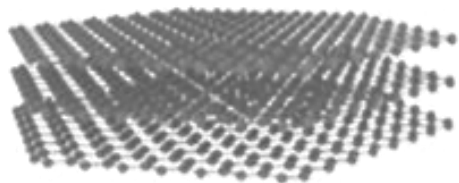


Minister for Industry and Science, Hon Ed Husic MP, visits GMG's HQ.

# UQ BATTERY NANOTECHNOLOGY SCIENCE

## Nanotechnology

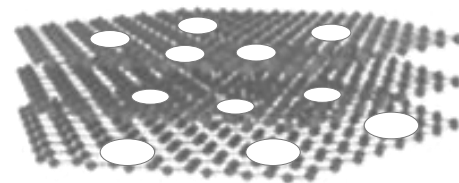
UQ design uses nanotechnology to insert Aluminium-Ions (atoms without some electrons) inside tiny perforations in GMG Graphene platelets.



Graphene Platelets

## Spare Electrons

Aluminium atoms have 3 spare electrons vs Lithium atoms with 1 spare electron.



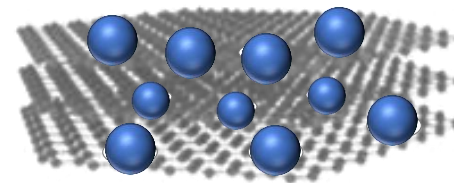
Surface Perforation

## Energy Density

Aluminium-Ion batteries have up to 3 times the energy density of Lithium-Ion batteries.

## Graphene Storage

Graphene is used to store the Aluminium-Ions (atoms without spare electrons).



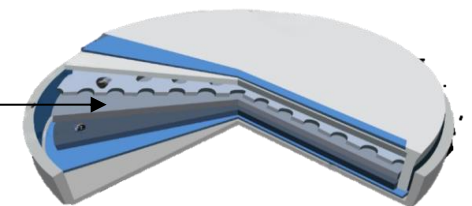
Al-Ions inserted between Graphene Platelets

## Supercapacitor

Extremely fast charging and discharging – called a hybrid **supercapacitor battery**.

## Construction Simplicity

Simpler construction than Lithium-Ion batteries, predominantly Graphene and Aluminium.



Coin Cell Mechanism  
Cathode = Perforated Graphene

# GRAPHENE ALUMINIUM-ION BATTERY

## NEXT GENERATION BATTERY

### Indications So Far

### The University of Queensland

### Intellectual Property Licence

- Graphene and Aluminium
- No Lithium – less complicated supply.
- Rechargeable
- Greener & Safer
- Up to 3x More Battery Life
- Interchangeable (at 3+ volts)
- Up to 60 Times Faster-charging
- Ongoing IP collaboration between UQ & GMG.

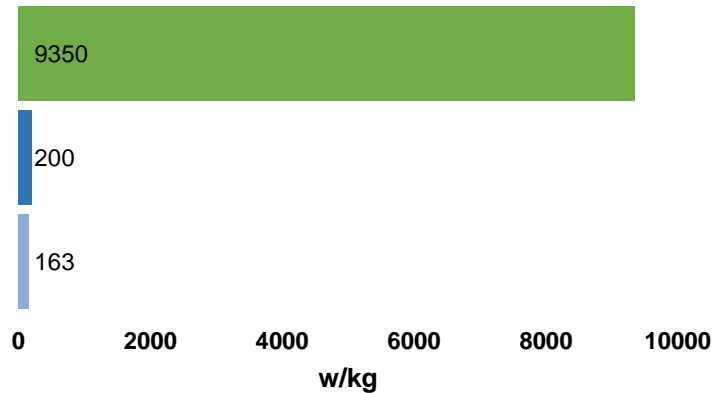
2021 | GMG entered into a research and exclusive commercialisation agreement with UQ to develop Graphene Aluminum-Ion batteries.

GMG was granted an exclusive licence for The UQ patent-pending technology for battery cathodes.

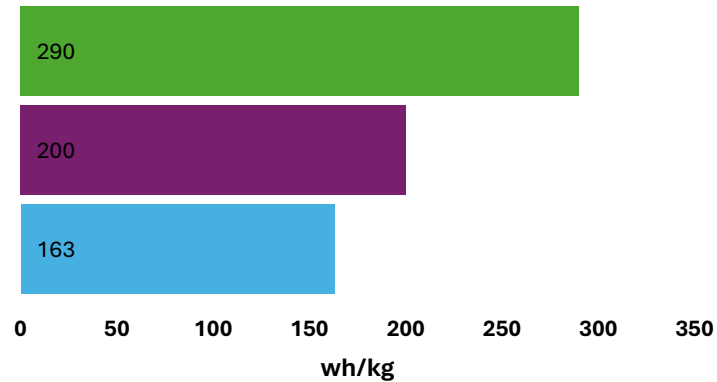


# Next generation battery technology

## Power Density (W/kg)



## Energy Density (Wh/kg)



- GMG + UQ Graphene Aluminium Ion\*
- Lithium Manganese Nickel Cobalt Ion (NCM) @ 1C#
- Lithium Iron Phosphate (LFP)\$

Pouch cell performance data could be significantly different and will be published once 1000 mAh+ capacity pouch cells are developed and tested.

Source:

\*University of Queensland validated GMG testing data based on industry standard estimate methodology from coin cells using a reducing factor of 2.3.

#CATL 3.7V 65Ah NCM Lithium Battery Cell - LiFePO4 Battery (lifepo4-battery.com) on 29/09/22 7

\$ CATL 3.2V 150Ah LiFePO4 Battery Cell - LiFePO4 Battery (lifepo4-battery.com) on 29/09/22

## Graphene Aluminium-Ion Potential Benefits:

- Aluminium is 1000 times more available & ~10 times cheaper than Lithium
- No Lithium needed – lower cost & less complicated supply.
- Cathode: Graphene coated metal foil
- Anode: No coating - aluminium foil only - lower cost & less complicated to manufacture
- Up to 60 Times Faster-charging\*
- Safer (no risk of electrochemical fires)
- Up to 3 x More Battery Life (tested up to 3000 cycles)\*

# What is GMG graphene's competitive advantage?

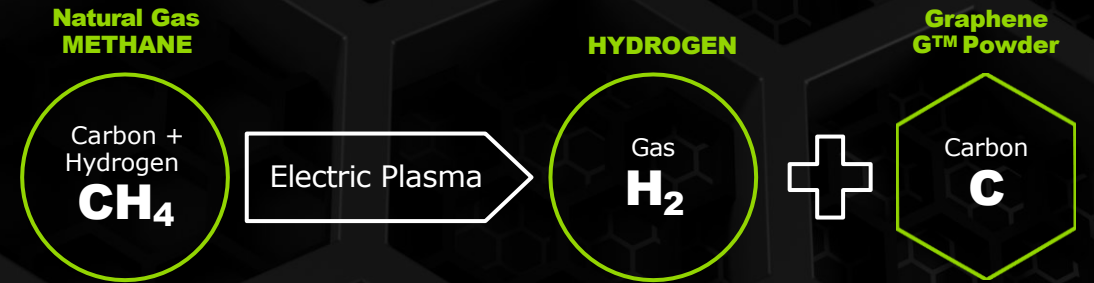
## 1 Made from limited and existing natural gas:

GMG is the only company in the world making high-quality green graphene from only natural gas. This process produces high quality, low cost, scalable, 'tuneable' and low/no contaminant graphene suitable for use in clean-technology and other applications.

## 2 Other types of graphene production are more complex and less commercially viable:

Other graphene producers mine graphite and chemically process it in order to extract graphene. This makes it more expensive and less environmentally friendly.

## GMG GRAPHENE PRODUCTION



- Instantaneous & Continuous
- Low-Cost Inputs and Setup
- Unconstrained Fast Scalability (after validating quality)
- Controlled Definability
- High-Quality Grade Graphene (*University Verified*)
- Cogeneration Capabilities
- Low environmental footprint

## OTHER GRAPHENE PRODUCTION



- Mining Constraints & Gestation
- High-Cost Inputs and Setup
- Constrained Scalability
- Variable Definability
- Impurities form Graphene Oxide
- Environmental Footprint



**Thank You!**

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