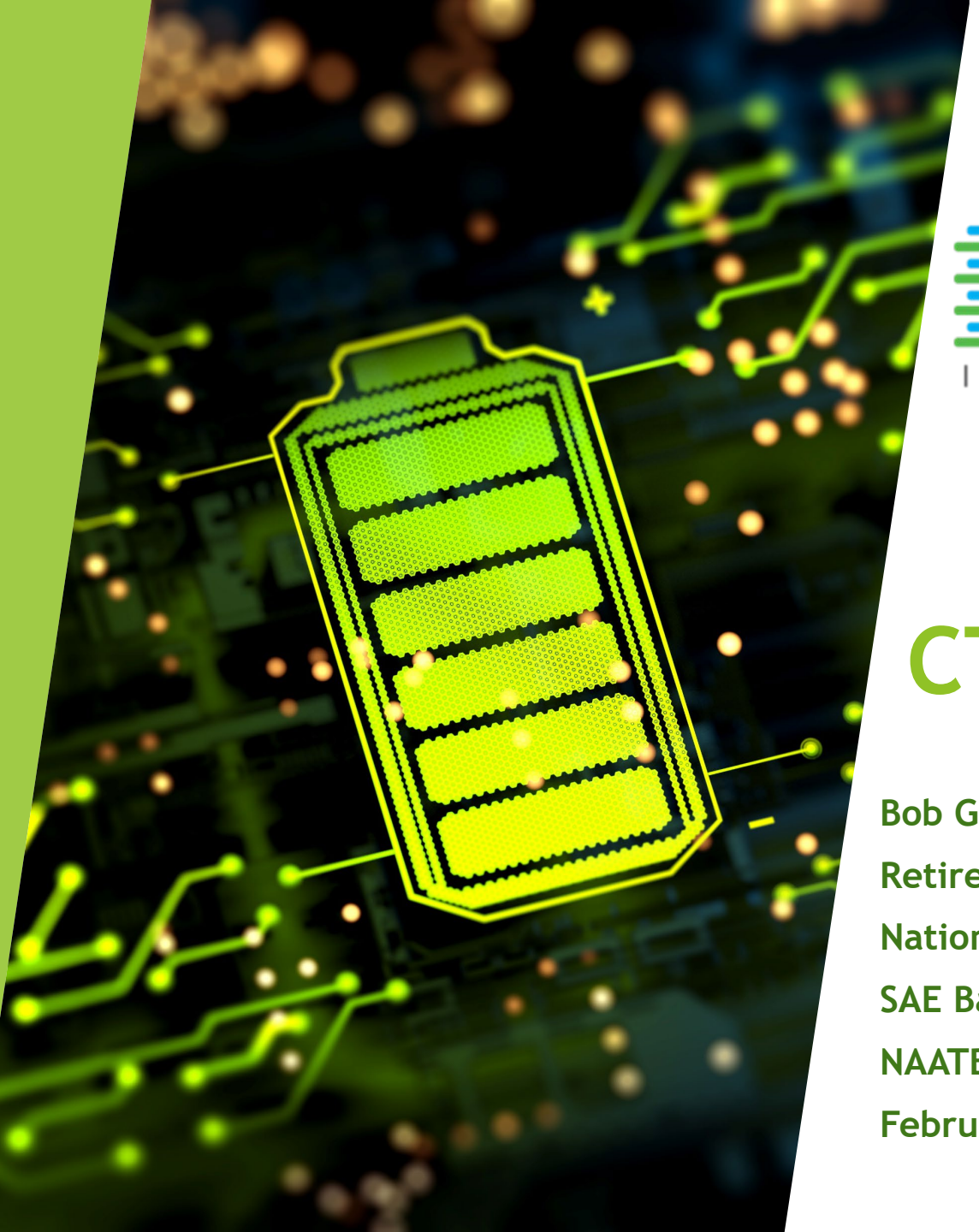


NAATBatt INTERNATIONAL

GALYEN ENERGY

NAATBatt Annual Meeting CTO's Address 2023

Bob Galyen

Retired CTO of CATL

National Distinguished Expert

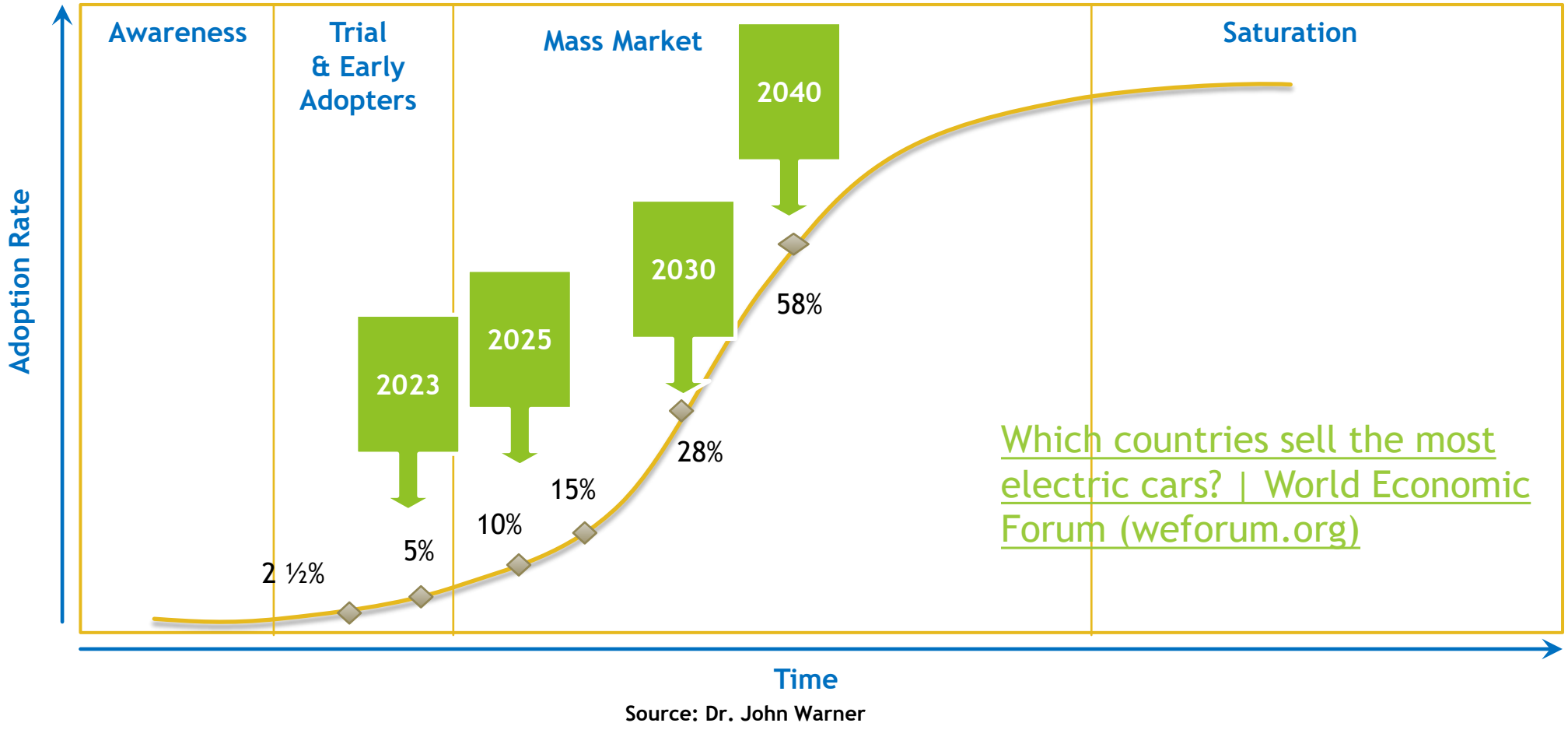
SAE Battery Standards Steering Committee Chairman

NAATBatt CTO and Chairman Emeritus

February 21, 2023 Phoenix, Arizona

Adoption of LIB's…..How Mature?

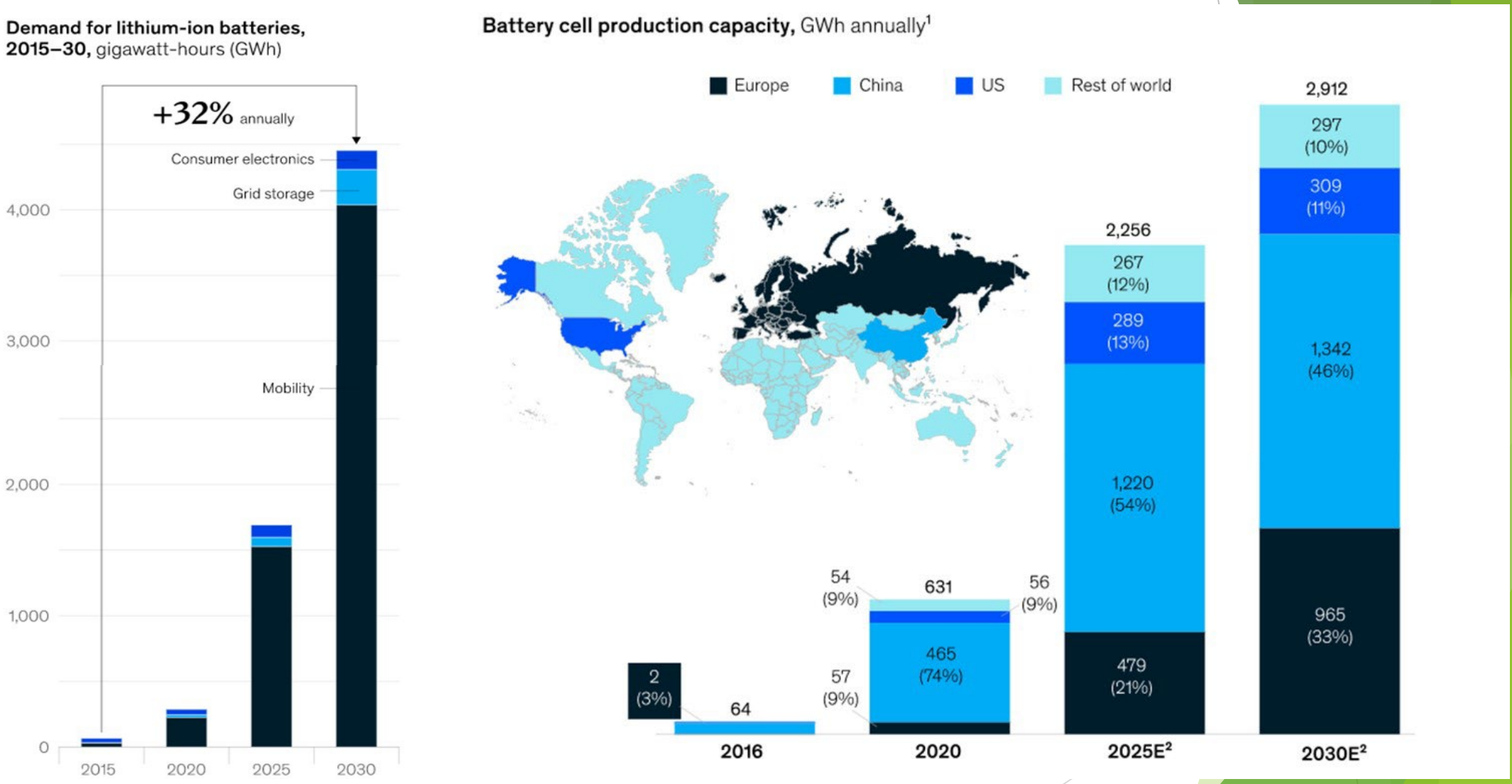
(We are just beginning the electrification revolution!)



Which countries sell the most electric cars? | World Economic Forum (weforum.org)

Source: Dr. John Warner

Demand and Supply Growth



Source: McKinsey & Company, October 2022

Moving Into the Terawatt Era:

Current state of Lithium-Ion Battery Manufacturers and EV market

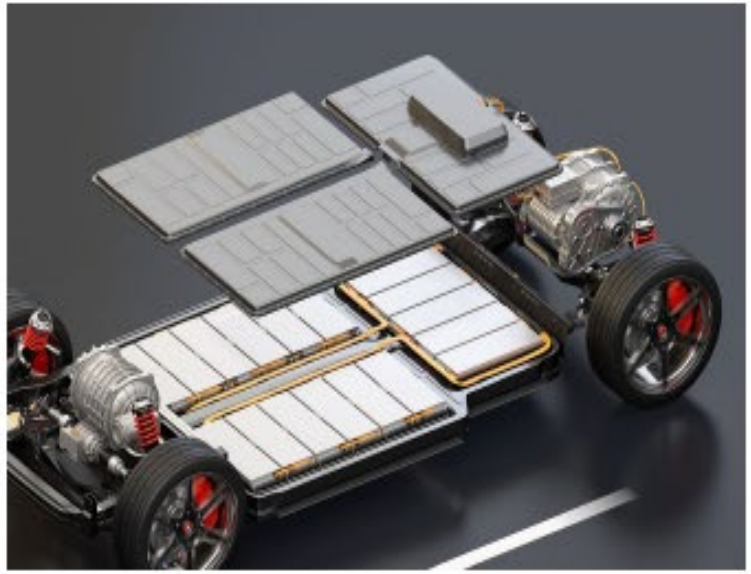
Market Cap comparison of battery manufacturers and vehicle manufacturers as of 1/15/2023

- $386.5 B Tesla #17
- $191.4 B Toyota #53
- $158.6 B CATL #69
- $106.9 BYD #132
- $90.0 B LG Energy Sol #156
- $78.9 B Volkswagen #177
- $51.8 B GM #304
- $49.5 B Stellantis #327
- $51,1 B Ford #308
- $35.6 B Cummins #494
- $33.5 B Samsung SDI #526
- $30.1 B Great Wall Motors #592
- $25.1 B SAIC Motor #696
- $19.5 B Panasonic #867

[Market capitalization (companiesmarketcap.com)]

Mobility Sector: Fully Integrated Battery Systems As Part of the Structure

Prismatic Cell – Structural Pack



Cylindrical Cell – Structural Pack

Pouch Cell – Structural Pack

Predominate Packaging Schemes in Mobility Sector

- First Generation: Module to Pack
- Second Generation: Cell to Pack
- Third Generation: Cell to Chassis (future)

Quality Control in the Terawatt-Hr Era

- Quality, Quality, Quality…..what does it take to be a parts per billion manufacturer?
- The story of a too big of lot size…..it can sink the ship!
- Over 3600 control points in making cells!
- Over 6400 control point in making battery packs!

Factory Carbon Neutrality

Facilities & Renewable Energy

PV power generation

47,654.7 MWh
in 2021

Intelligent BESS

Charging Station

E-Truck Pilot Project

560,000 km
in 10 months

Energy Conservation

351 energy conservation measures in 2021

609,630 t CO2 reduced

CFMS

CATL Facility Management System

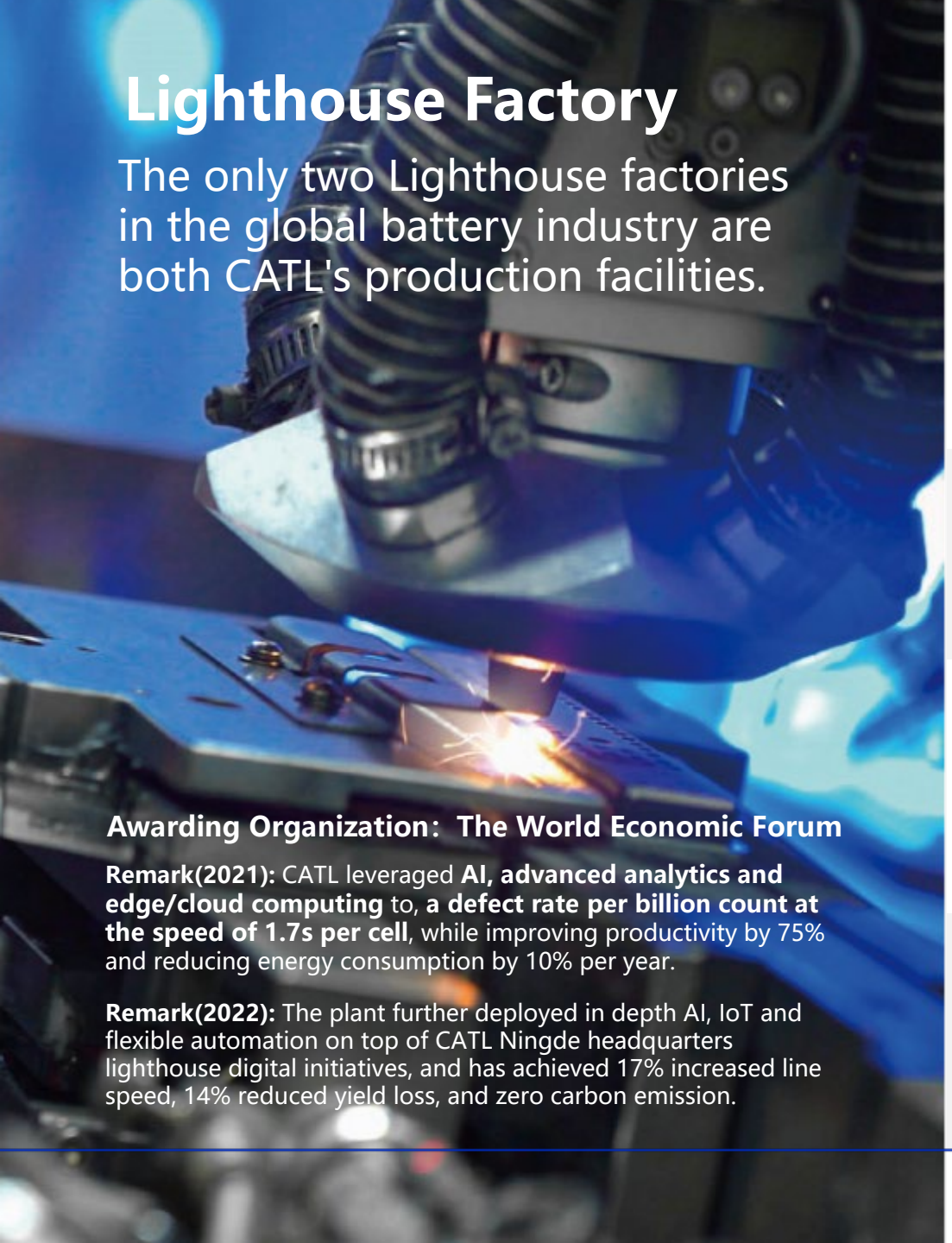
In 2021:

Ratio of Green Power Consumption

Increased to *22* %

Carbon Emissions per Unit Product

Reduced *10.33* %



Lighthouse Factory

The only two Lighthouse factories in the global battery industry are both CATL's production facilities.

Awarding Organization: The World Economic Forum

Remark(2021): CATL leveraged **AI, advanced analytics and edge/cloud computing** to, **a defect rate per billion count at the speed of 1.7s per cell**, while improving productivity by 75% and reducing energy consumption by 10% per year.

Remark(2022): The plant further deployed in depth AI, IoT and flexible automation on top of CATL Ningde headquarters lighthouse digital initiatives, and has achieved 17% increased line speed, 14% reduced yield loss, and zero carbon emission.

CATL 宁德时代

Extreme Manufacturing, Extreme Products

Self-learning Production Lines

We integrate cloud computing and artificial intelligence into the manufacturing processes, thus making the production lines self-learning

↑50%
takt time

Higher Quality

Our AI defect detection system has a higher consistency than humans

PPM → PPB
defect rate level

6σ → 9σ
safety performance control level

Greener Manufacturing Process

The smart energy management system optimizes the energy consumption of our equipment through real time monitoring of various energy data

↓57%
carbon emissions

↓10%
annual unit energy consumption

Full Lifecycle Data Tracing

Digital factory with high efficiency and high level of safety
Precise product optimization through tracking from raw material to recycling

1 trillion+
data assets accumulated

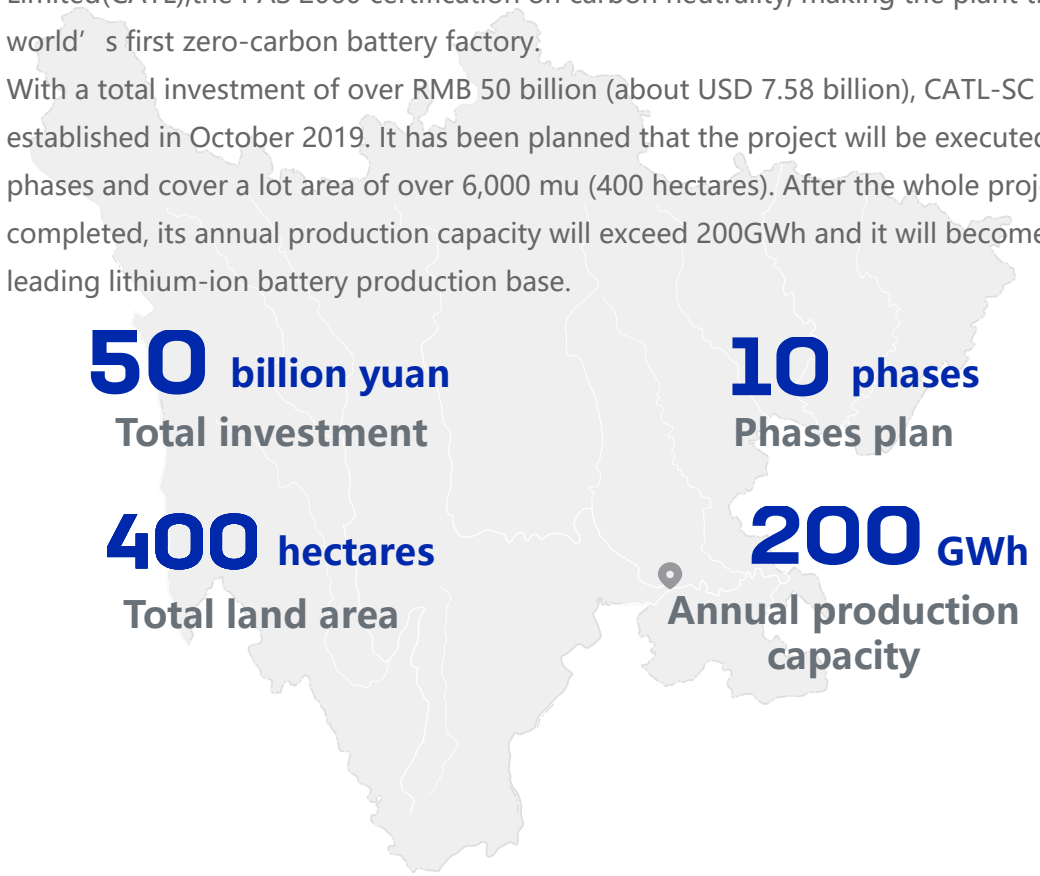
20 years
traceable big data

The World's First Zero-Carbon Battery Factory

Overview

In March 2022，SGS awarded Sichuan Contemporary Amperex Technology Limited (CATL-SC),a wholly-owned subsidiary of Contemporary Amperex Technology CO., Limited(CATL),the PAS 2060 certification on carbon neutrality, making the plant the world' s first zero-carbon battery factory.

With a total investment of over RMB 50 billion (about USD 7.58 billion), CATL-SC was established in October 2019. It has been planned that the project will be executed in 10 phases and cover a lot area of over 6,000 mu (400 hectares). After the whole project is completed, its annual production capacity will exceed 200GWh and it will become a world leading lithium-ion battery production base.



50 billion yuan
Total investment

10 phases
Phases plan

400 hectares
Total land area

200 GWh
Annual production capacity

Achieve Carbon Neutrality Through Comprehensive Measures of Carbon Reduction

Electricity	• Energy-saving technology reduces consumption • Introduce the CFMS intelligent system • Substitution with hydropower
Natural gas	• Thermal efficiency enhancement of boilers • Use of the efficient condensed water recovery system • Energy-saving technology of dehumidifiers • Energy-saving technology of coating machines • Net zero-carbon natural gas
Transportation	• Electrification of logistics vehicles • Electric mobility of employees
Others	• All-round electrification • Remaining emissions offset through carbon trading

SGS

Verification Statement of Achievement of Carbon Neutrality

The Operating activities at the organizational level of

Sichuan Contemporary Amperex Technology Co., Limited.

No.1, Industrial Avenue, Lingang Economic and Technological Development Zones, Yibin City, Sichuan Province, P. R. China.

has been verified in accordance with ISO 14064-3:2019, confirmed that has achieved carbon neutrality from 2021.01.01 to 2021.12.31 as meeting the requirements

PAS 2060:2014

Issue date: 2022.03.14
Version: 1

Authorized by:

SGS-CSTC Standard Technical Services Co., Ltd.
Country Headquarter: 6/F Century Fortune Mansion, No.73, Fuchang Road, Beijing, China 100042
Tel: +86 (10) 6845-6699 Fax: 6845-6121 www.sgs.com

This verification statement cannot be used on a single page, but must be used together with the verification scope, criteria, materiality and conclusion pages to be effective.

Page 1 of 3

CATL Leads High-Quality and Sustainable Manufacturing in Battery Industry

Ningde facility has been recognized by the World Economic Forum (WEF) as a global Lighthouse factory, the first battery manufacturing base joining WEF's Global Lighthouse Network (GLN).

CATL's Sichuan plant selected as Lighthouse factory by World Economic Forum

Sichuan Contemporary Amperex Technology Limited (CATL-SC), a wholly-owned subsidiary of CATL, has been added to the Global Lighthouse Network (GLN) by the World Economic Forum, making it CATL's second Lighthouse plant following its Ningde facility, So far there are only two Lighthouse factories in the battery industry globally, both of which are CATL's production facilities.

Bob’s Top 10 List

Top 10 List: 1 – Remarkable Growth!

- Battery Market: ~34% CAGR globally! Massive demand growth with over $300bn investment by 2030

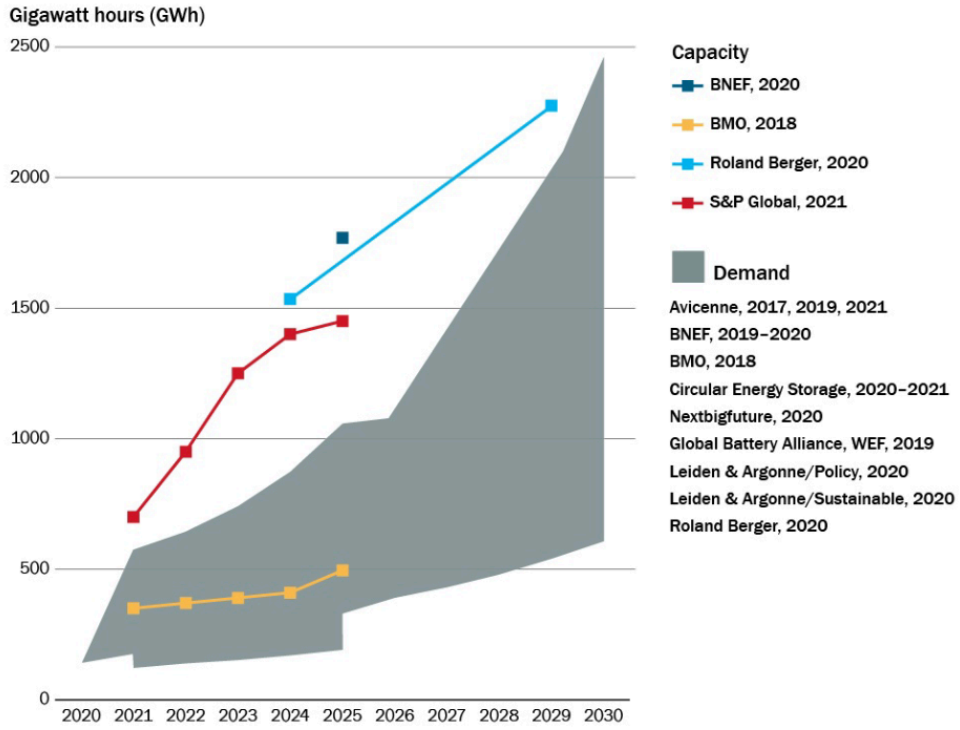


Figure 2. Global Li-ion EV Battery Demand Projections. Yan Zhou, David Gohlke, Luke Rush, Jarod Kelly, and Qiang Dai (2021) Lithium-Ion Battery Supply Chain for E-Drive Vehicles in the United States: 2010–2020.
Source: Argonne National Laboratory ANL/ESD-21/3.

Top 10 List: 2 – Government Engagement

- Governments: Scrambling on what to do! What model to follow? Lack of knowledge in decisions!

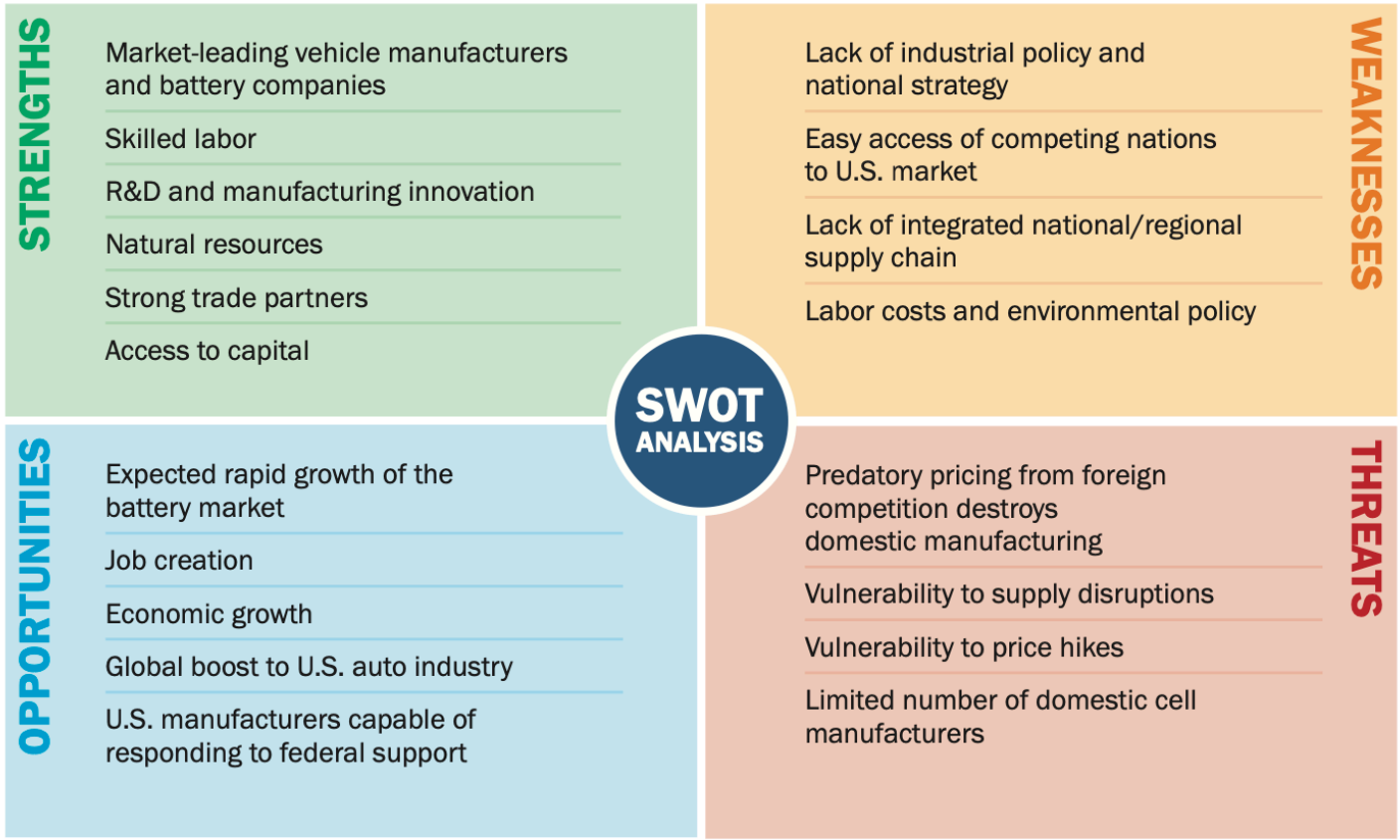
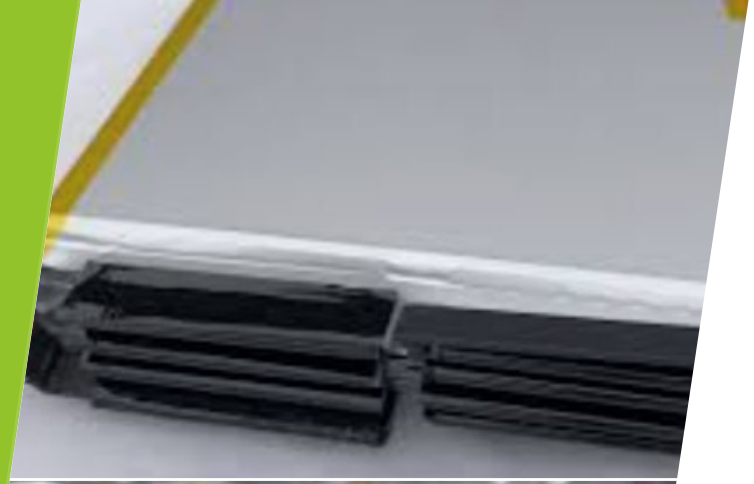


FIGURE 4. Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis of the U.S. position in global battery manufacturing.

SOURCE: FEDERAL CONSORTIUM FOR ADVANCED BATTERIES

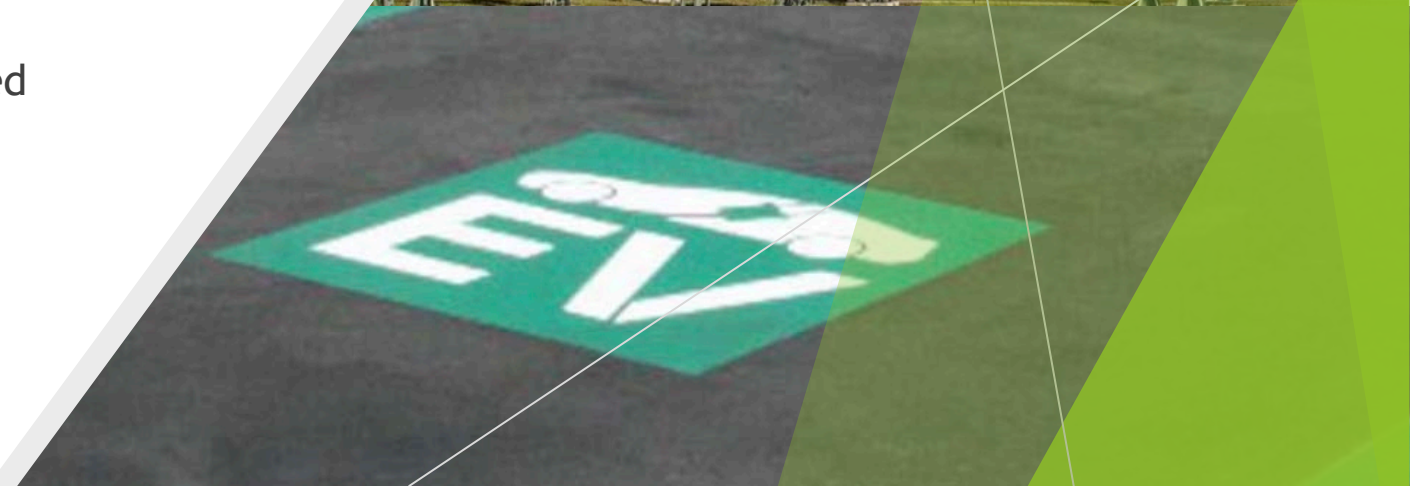


Top 10 List: 3 – Key Decision Making

- Technology: What Chemistry to use? NMC/LFP/other……
- Packaging: What Form Factor to use? Cylindrical/Pouch/Prismatic

Top 10 List: 4 – Infrastructure Required?

- Infrastructure: Charging capacity deficiencies?
  - Lack of Charge Stations
  - Concern of Overrunning the Grid
  - How to Bill the Consumer on Energy Charged or Road Taxes

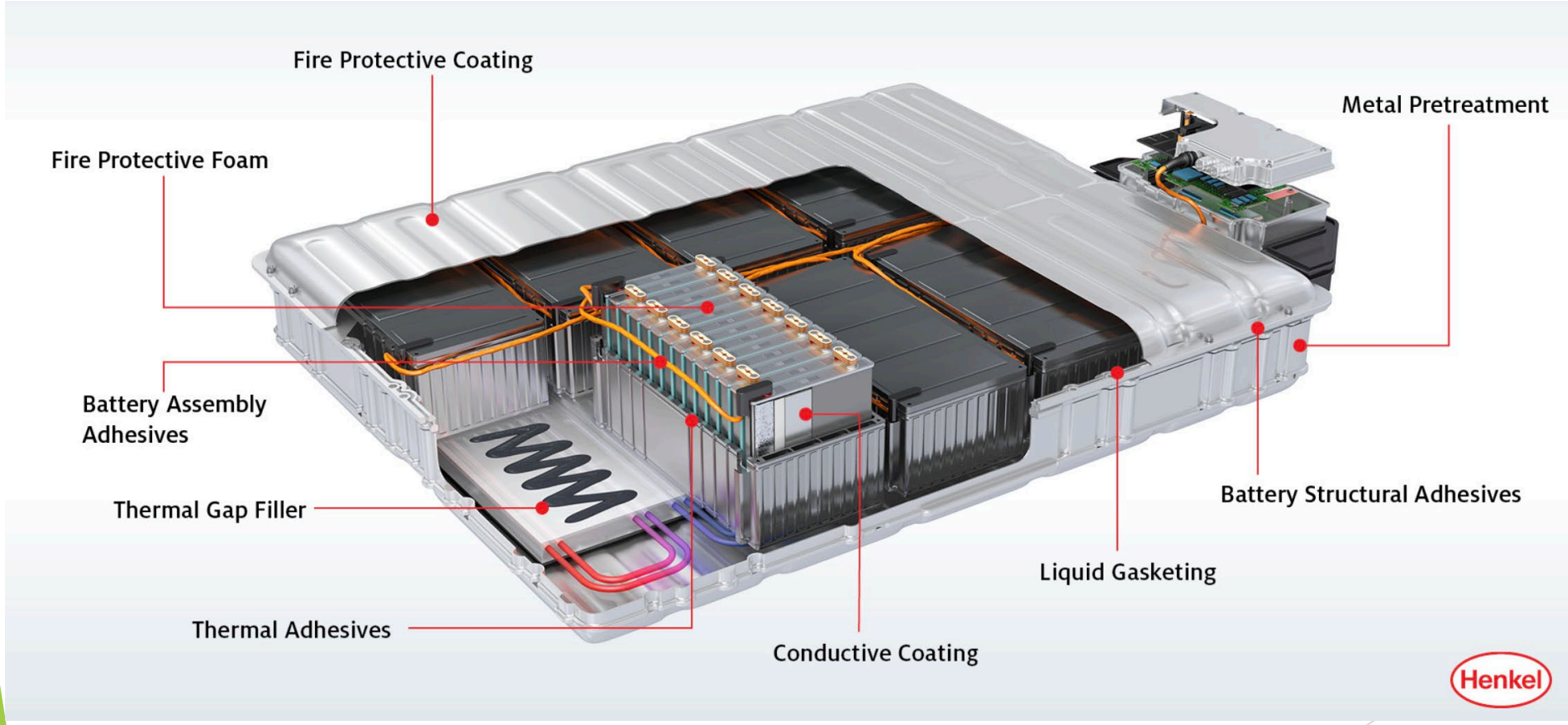


Top 10 List: 5 - Industrialization

- Industrialization: Building materials availability?
- Steel
- Lean up concrete
- Roofing

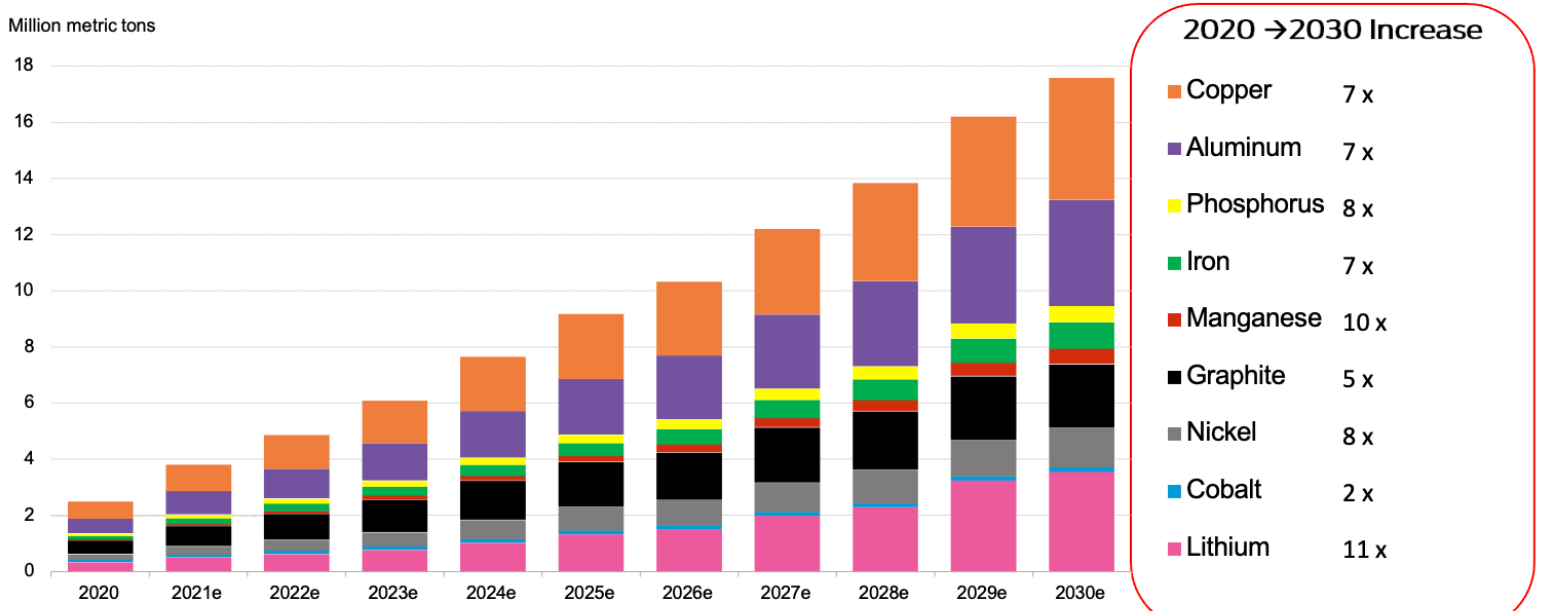
Top 10 List: 6 – Fire Concerns

- Fire propagation and prevention: massive efforts



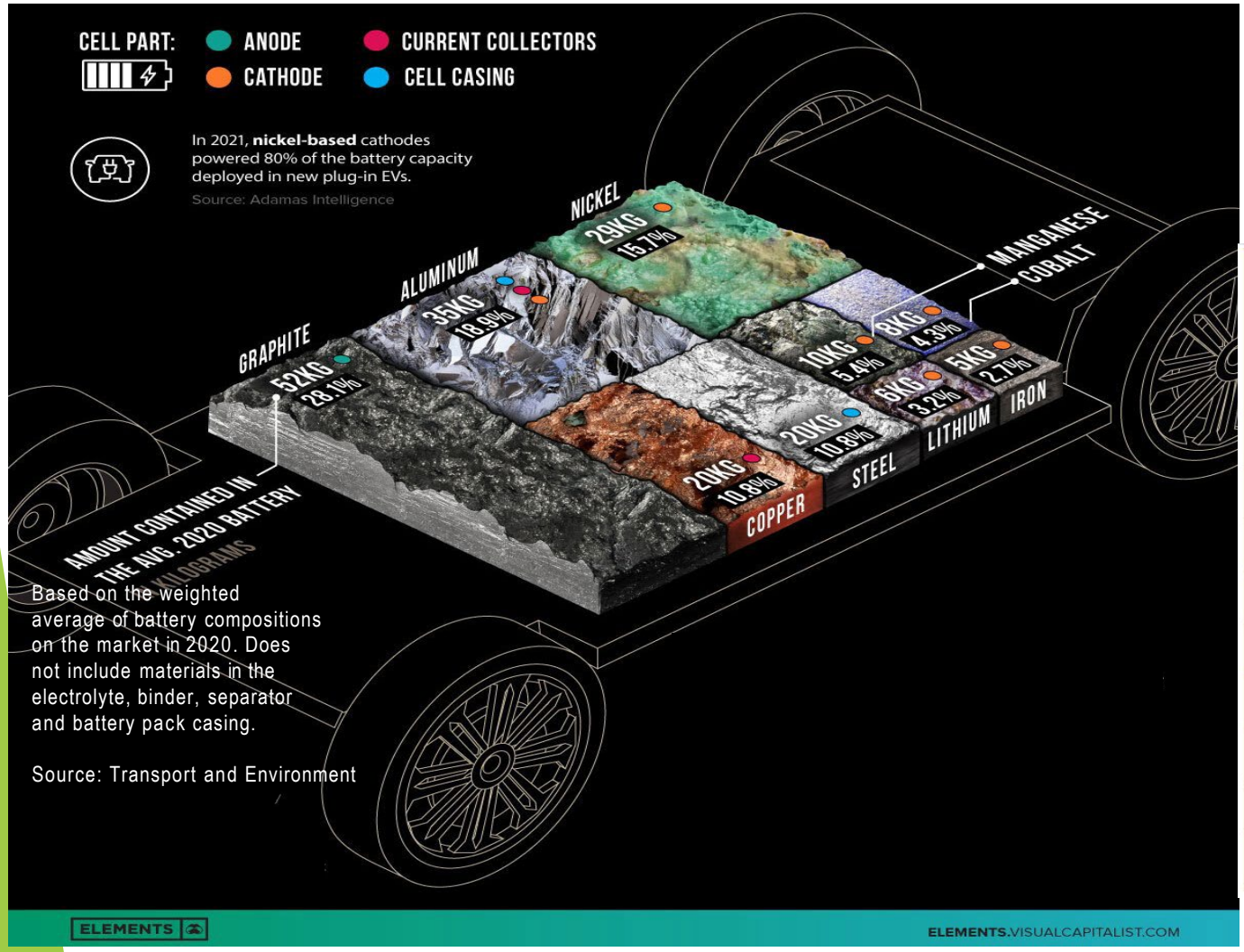
Top 10 List: 7 - Materials

- Supply Chain: Raw material supply-demand
  - Deficits at cell level (Li, Ni, Co, Mn, Graphite)
  - Lack of mining, 10 years est. to open new mines
  - Lack of processing capacity



Source: BNEF July 2022

The Key Materials in an EV Battery



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

Source: ELEMENTS.VISUAL CAPITALIST.COM

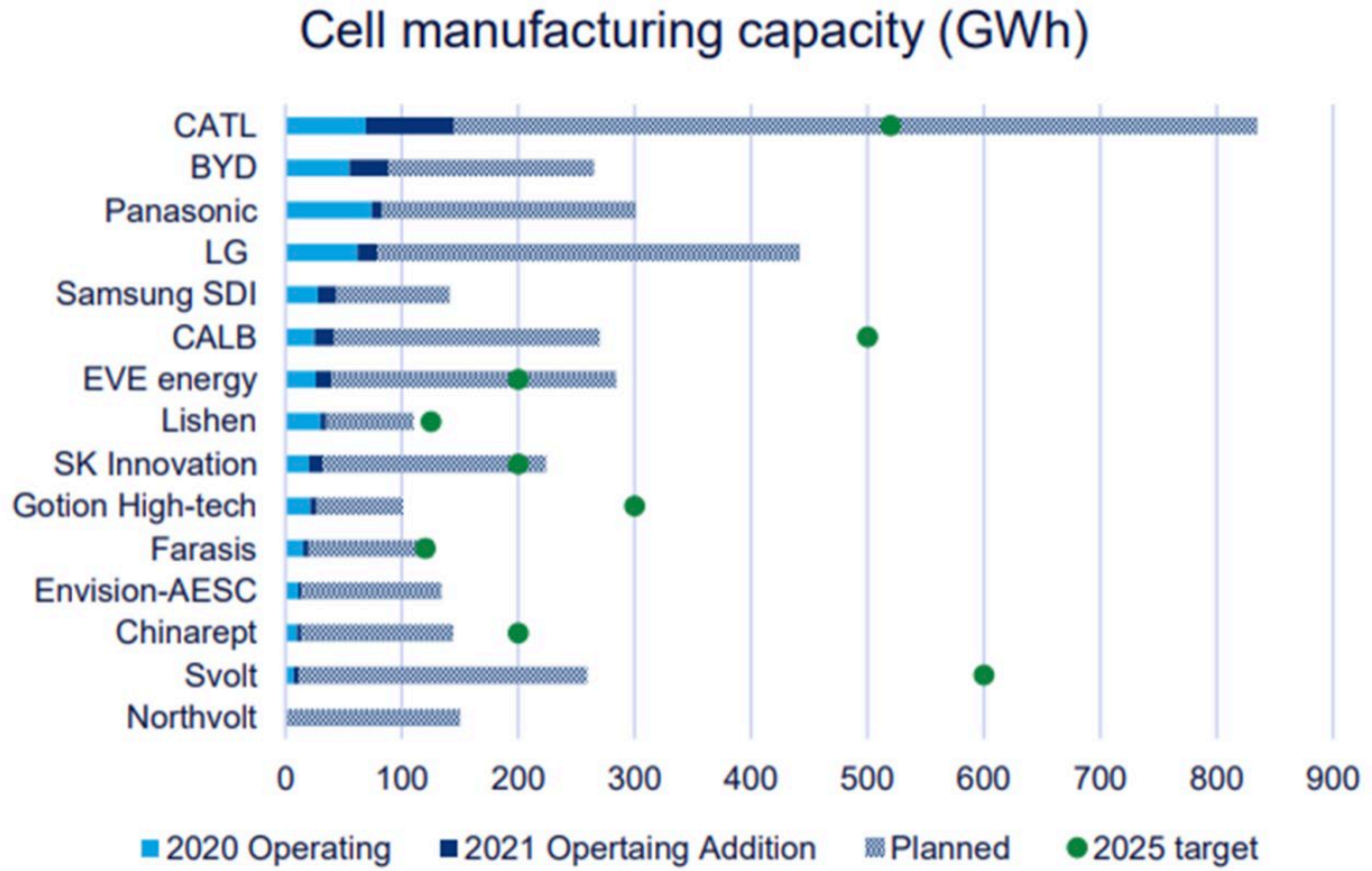
Top 10 List: 8 – Recycling (A major effort to reconstitute precious & commodity materials)

PHOTO: RECELL

- Recycling:
  - Collection
  - Shipping
  - Disassembly
  - Separation
  - Shredding
  - Chemistry
  - Reformation

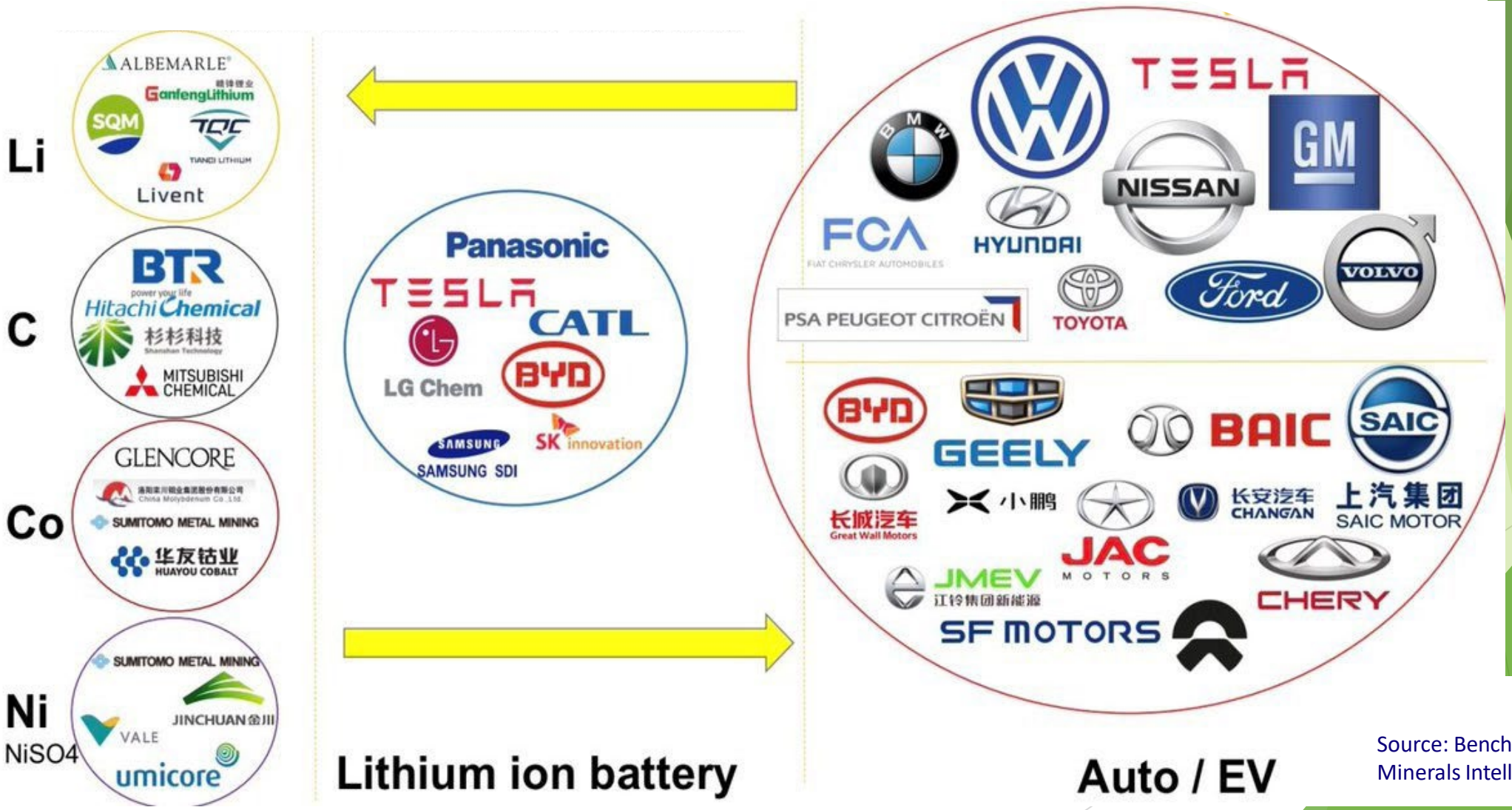
Top 10 List: 9 – Corporate Structure

- Corporate structuring: JV's, partnerships, etc.



SOURCE: WOOD MACKENZIE

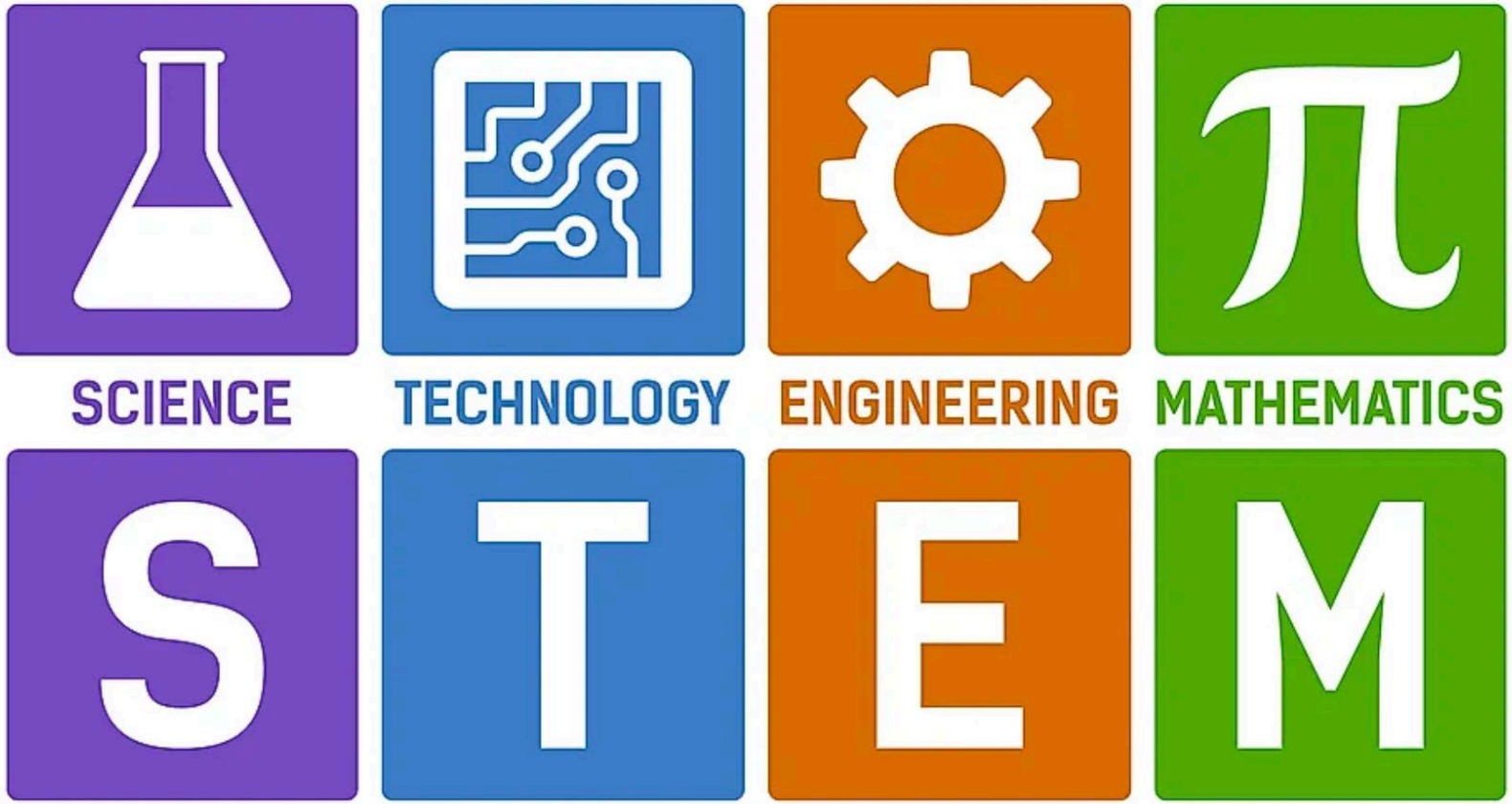
New Era of Vertical Integration and Strategic Partnerships



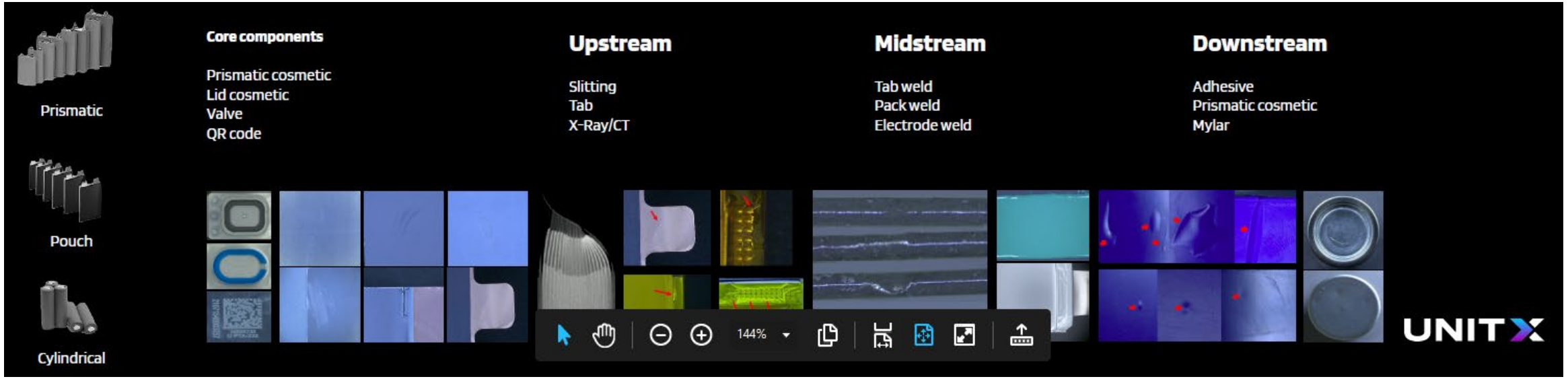
Source: Benchmark Minerals Intelligence

Top 10 List: 10 – Education & Training

- Current workforce, scientist, engineers, lawyers, laborer's, academicians, college, high school, grade school



New Technologies on the Horizon



UnitX AI vision inspection has deployed 250+ units in world's top EV plants

- Designed by engineers from **Stanford, MIT**
- Deployed in world's **top 2** EV, **top 3** Li battery, **top 5** automotive component plants

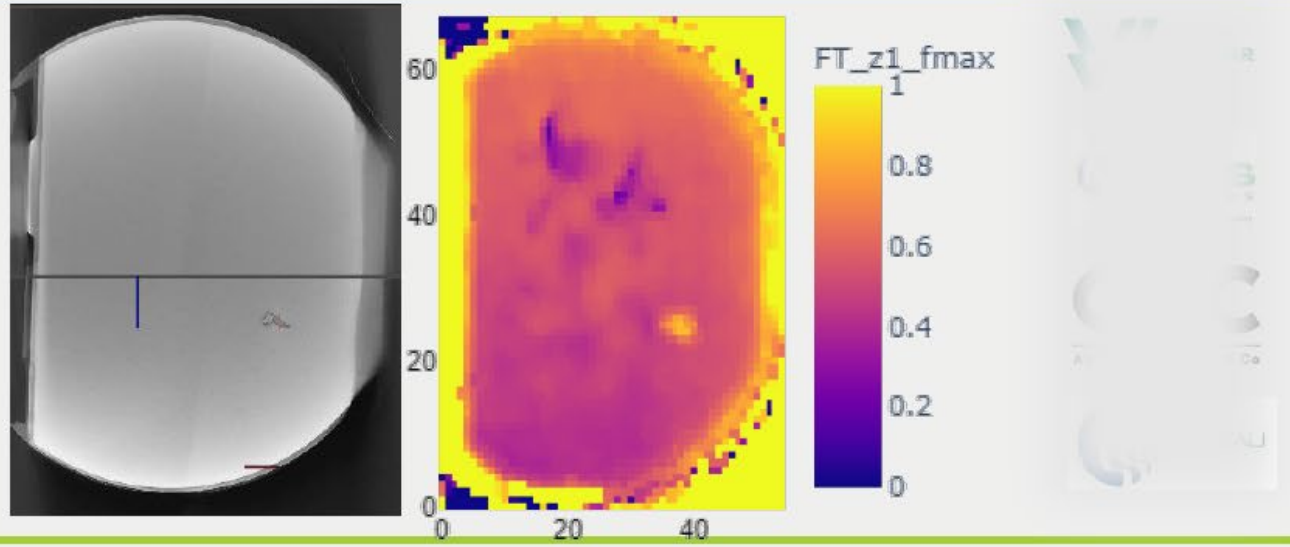
Quality Control – TitanAES (1)

BAQA a Revolution in Quality Inspection

TITAN

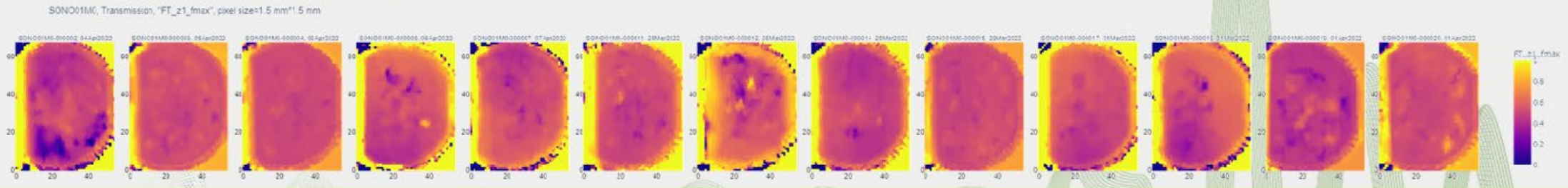
CT vs Ultrasound scans

- Ultrasound detected tear inside one of the cell layers (yellow spot) and confirmed using CT scan
- Ultrasound found material property variations (purple shadowing), which were almost imperceivable in CT scan
  - Inspector missed it in CT data



Inter-cell variation

- Found significant variations between cells due to a range of manufacturing anomalies



We provide CT scan quality in-line for a fraction of a cost

Success in Isolation & Purification of Battery Materials

Isolation and Purification of Battery Metals to > 99.9% Purity from End-of-Life Lithium-Ion Batteries from EVs

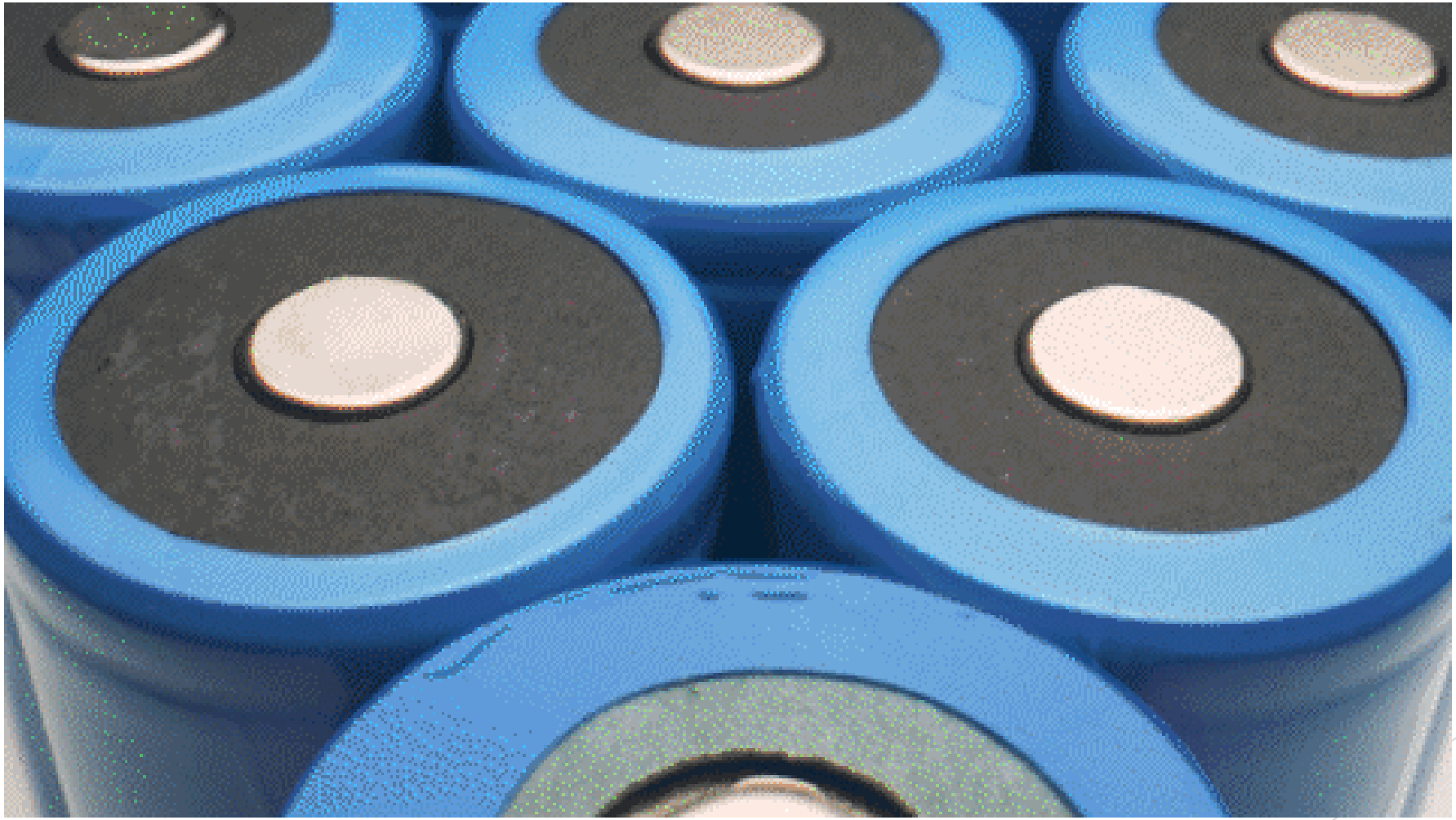
Waste Lithium-Ion Battery from EV

Black Mass

Multi-Mode Chromatographic Separation & Purification

Isolated and Purified Battery Elements

The LiNova Cell

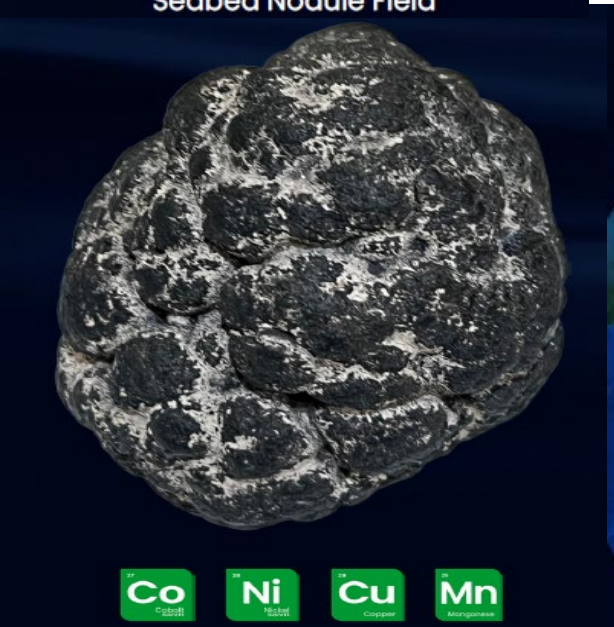


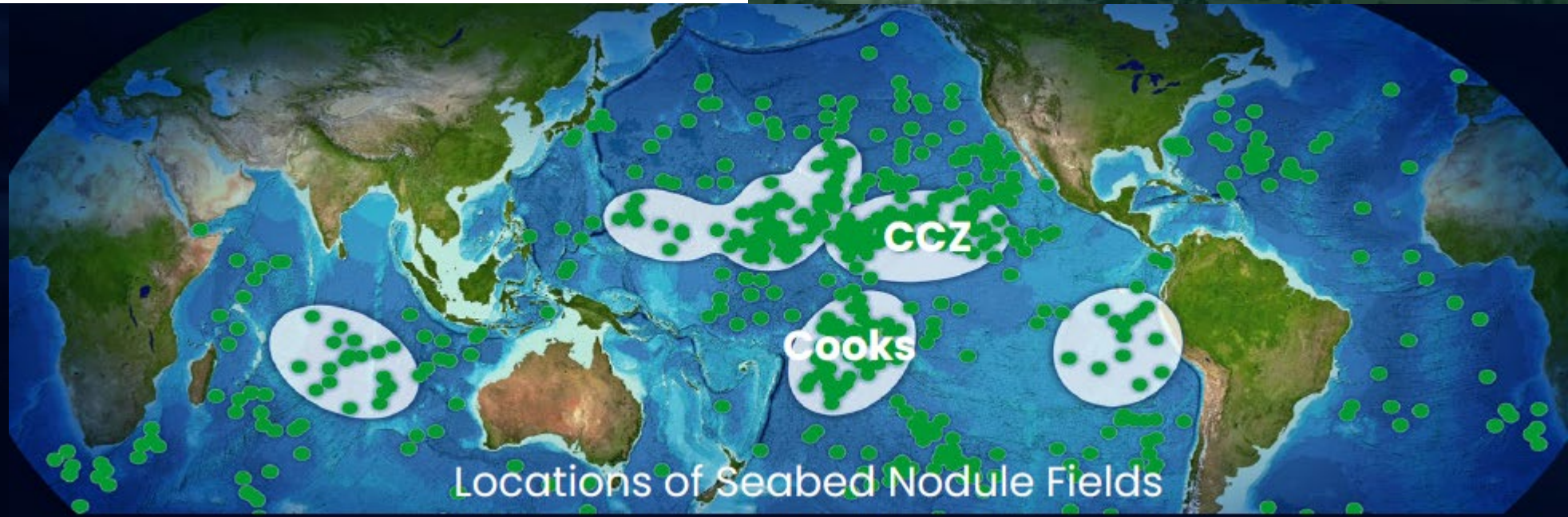
LiNova

Materials – Impossible Metals: Polymetallic Nodules on Ocean Floor


Seabed Nodule Field

- Headquarters in Los Angeles Basin
- First generation robot proven concept works
- Anticipated first operations 2025-6
- Seeking strategic partnerships





Thank You!

bob@galyenenergy.com

+1 (317) 716-9326