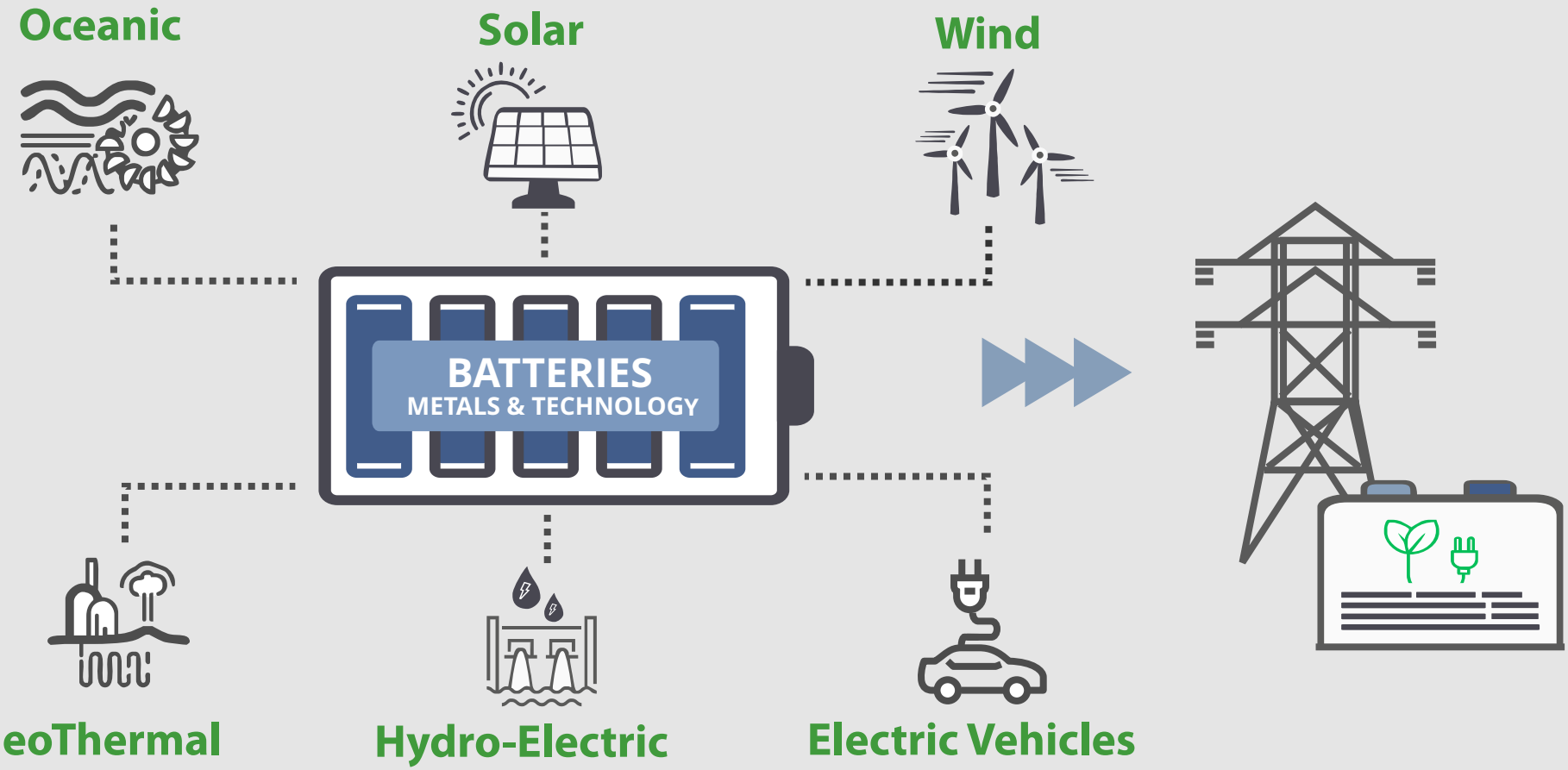
Invest in the Shared Core of Clean Energy

New clean energy sources require large-scale energy storage solutions.



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Source:
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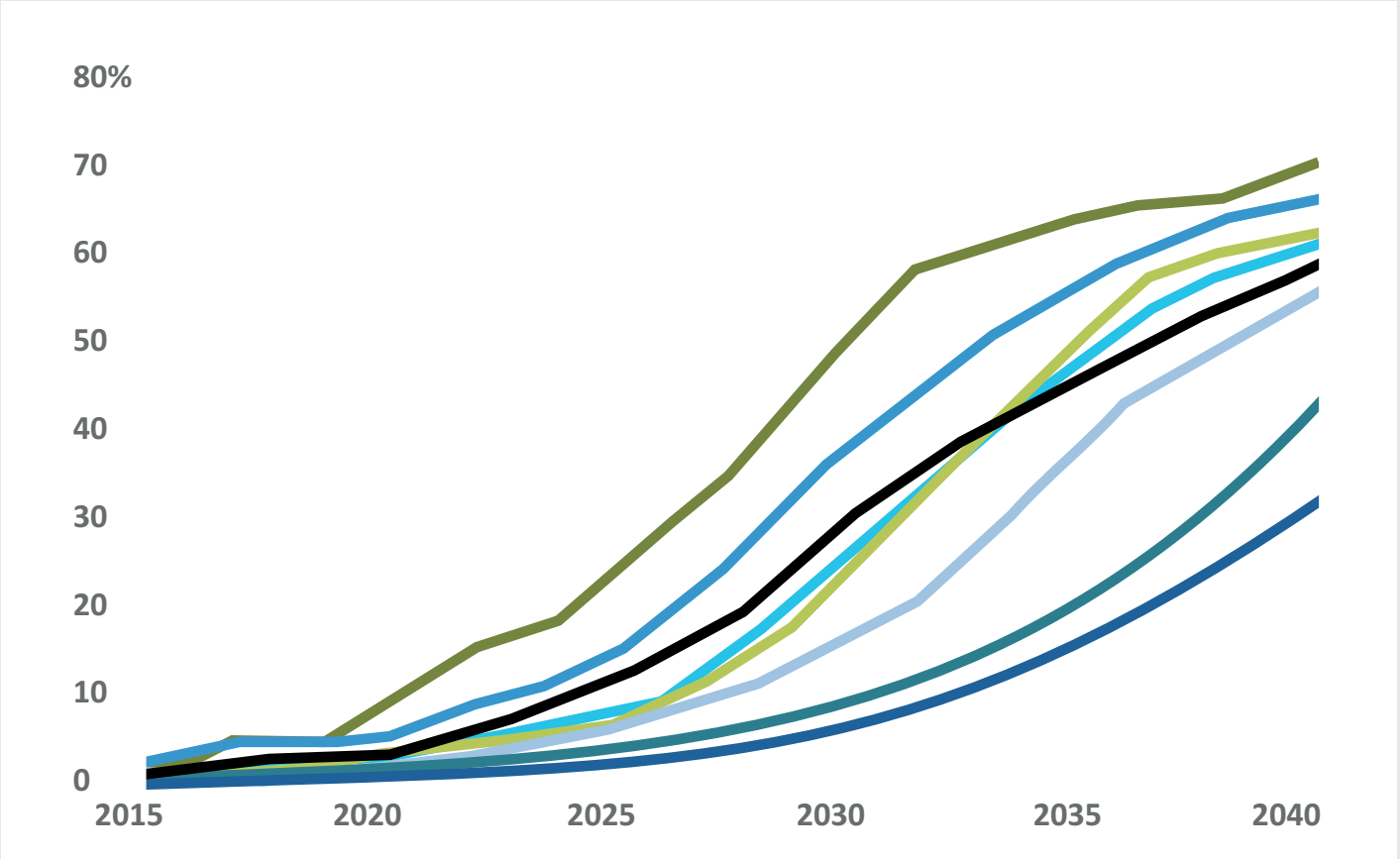
A Global Disruption in Transportation

In 2025, EVs will be 10% of global vehicle passenger sales, by rising to 28% in 2030 and 58% in 2040.



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Sources: Bloomberg, New Energy Finance, Electric Vehicle Outlook 2020, EQM Indexes LLC.

History of Lithium-Ion Batteries

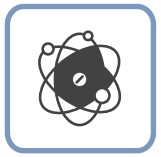
POWERING the FUTURE

Lithium [Li^3] is ideal for batteries because of its lowest density and atomic weight. This small size speeds its diffusion and ability to flow energy. Early Lithium-Ion (Li-ion) cells had serious safety issues, however the development in the 1990s and 2000s focused on safer electrolytes, separators and additives. This has resulted in an innovation cycle with dramatic growth in applications and market demand.

1912

American chemist Gilbert Newton Lewis began experimenting with lithium batteries.

1970s



Lithium batteries were first proposed by British chemist M. Stanley Whittingham while working for Exxon.

1973

Adam Heller invents the lithium-thionyl chloride battery, which is still used in implantable medical devices and defense systems due to its 20-year shelf life, high energy density and extreme operating temperatures.

1979-1980

Working as separate teams, Ned Godshall and John Goodenough of Stanford University, as well as Koichi Mizushima of Oxford University demonstrated rechargeable lithium cells using lithium cobalt oxide (LiCo02) cathodes.

1982

French-Moroccan scientist Rachid Yazami, working at the University of Grenoble, discovered the graphite anode used in today's lithium-ion battery chemistry.

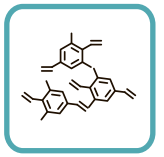
1991

Sony introduced the first commercial lithium-ion battery based on earlier research by Japan-based Asahi Chemical.

1996

Scientists succeeded in using lithium manganese oxide as a cathode material allowing for the world's first rechargable battery. NEC applied this new battery technology to mobile phones and motorized bicycles.

1997



Early lithium-ion batteries made by Sony were not thermally stable and prone to catch fire. John Goodenough, considered the "father of the lithium-ion battery," developed a nano technology that enabled a more stable polymer-based solution.

2002

Scientists developed the first laminated lithium-ion batteries, making them ideal for small, portable devices like mobile phones, cameras, laptops and tablets.

2000s+

Lithium-ion batteries continue to become smarter, cleaner, safer and lighter. This has created a product-innovation cycle that has increased dramatically as the batteries are now commonly used in electric vehicles, drones and energy storage. They also have many industrial uses for small and large capacity requirements.

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Sources: Wikipedia, Battery University, UPSBatteryCenter.com, Phys.org - History and Development of Batteries, EQM Indexes LLC.

POWERING the FUTURE

The Underlying Metals for Lithium-ion Batteries

Atomic Number **3** Alkali Metal — Atomic Mass 6.94

Lithium [Li]

A soft, silvery-white alkali metal. Lithium is the lightest of all metals, has the greatest electrochemical potential, and provides the largest specific energy per weight.

BATTERY USE
[LCO - LMO - LFP - NMC - NCA]

Atomic Number **27** Transitional Metal — Atomic Mass 58.93

Cobalt [Co]

Hard, lustrous silver-gray metal extracted as a by-product when mining nickel and copper. Used as a cathode material in Li-ion batteries, but is very expensive.

BATTERY USE
[LCO - NMC - NCA]

Atomic Number **28** Transitional Metal — Atomic Mass 58.68

Nickel [Ni]

A silvery-white lustrous metal with a slight gold tinge that can be traced back to 3500 B.C. Found in large nickel-iron meteorites on earth and found in combination with iron.

BATTERY USE
[NMC - NCA]

Atomic Number **25** Transitional Metal — Atomic Mass 54.94

Manganese [Mn]

Produced by mining iron and other minerals, it is relatively abundant. Steel manufacturing uses roughly 90% of manganese production. Also used as a cathode material.

BATTERY USE
[LCO - NMC]

Atomic Number **6** Metalliod — Atomic Mass 12.01

Graphite [C]

Graphite is an allotrope and stable form of carbon. Used as an anode, it is heat-resistant, electrically and thermally conductive, chemically passive, and lighter than aluminum.

BATTERY USE
[LCO - LMO - LFP - NMC - NCA]

BATTERY TYPE: LCO - Lithium Cobalt Oxide / LMO - Lithium Cobalt Oxide / LFP – Lithium Iron Phosphate / NMC – Lithium Nickel Manganese Cobalt Oxide / NCA – Lithium Nickel Cobalt Aluminum Oxide

SOARING DEMAND, LIMITED SUPPLY

The growing market for lithium-ion batteries is being driven by continued demand for mobile devices, the accelerating pace of global electric vehicle adoption, and the rising need for grid energy storage solutions. This growth trend creates significant opportunities for investment in the underlying elements contained within lithium-ion batteries.

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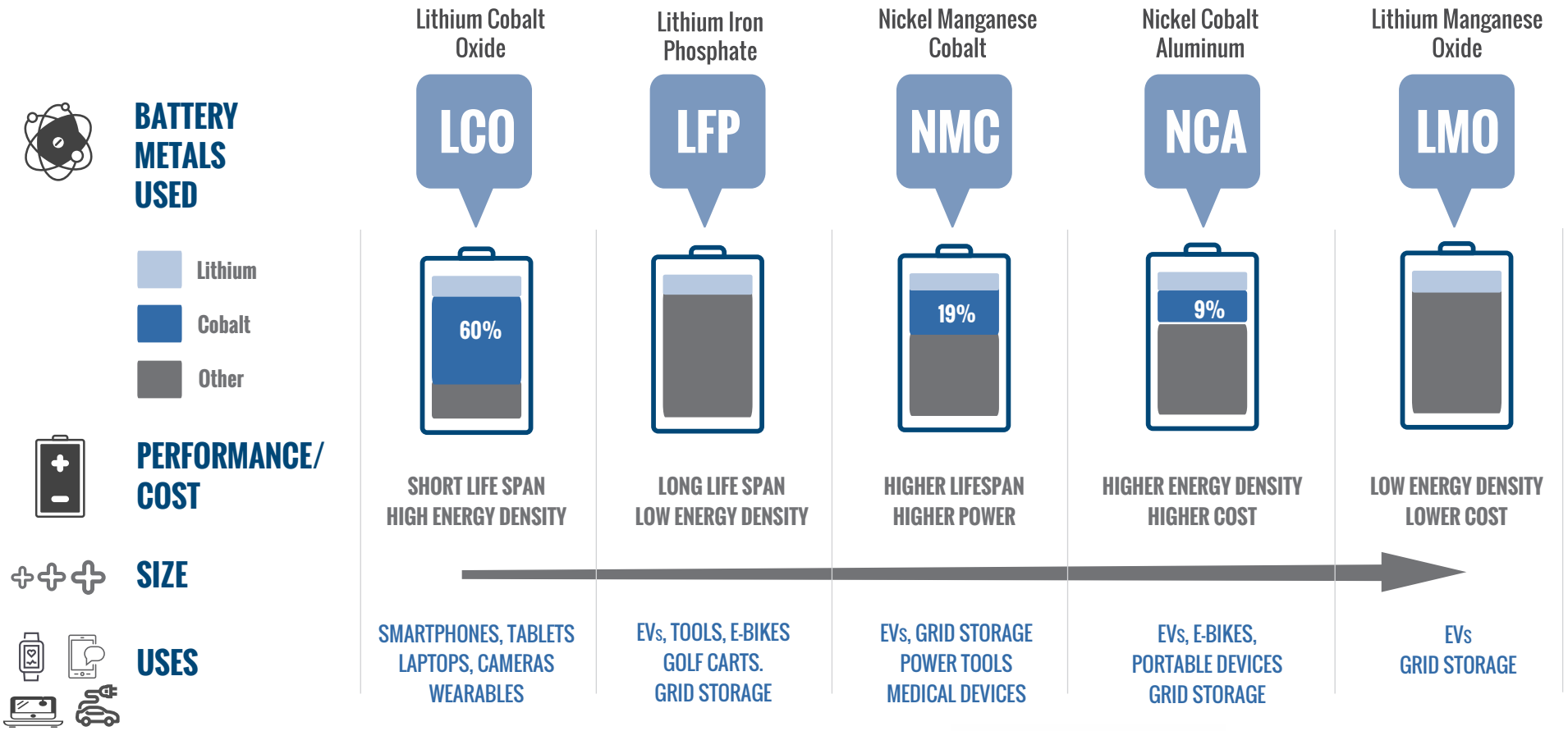
Sources: Wikipedia, Battery University, EQM Indexes LLC.

Driven By Demand

Lithium-Ion Battery Chemistry (Usage By Battery Size)



Cobalt Demand - 2021

34% of Cobalt demand is driven by Electric Vehicles. / **75 %** of all lithium batteries contain Cobalt.

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EQM Battery Metals and Mining Index

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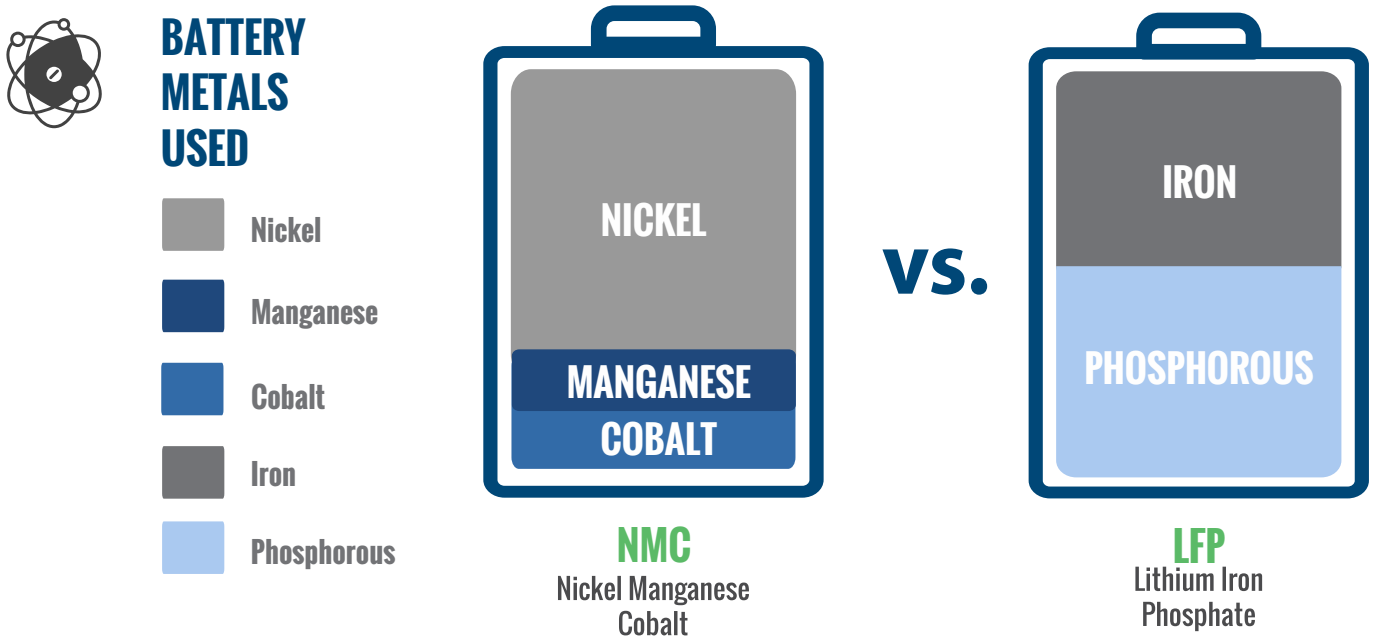
Sources: Battery University, CRU, Cobalt 27, History and Development of Batteries EQM Indexes LLC.

Competing Battery Chemistries

Battle of Cost vs Performance. Currently there are two main battery chemistries competing for market share: low cost LFP and high-performance (high nickel) NMC.

LFP vs NMC: Cost vs. Energy Density



Source: Nickel Institute

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