Minerals FOR CLIMATE ▷▷ ACTION

The world is rapidly transitioning to **low-carbon technologies** to combat climate change.

However, these technologies require large amounts of **minerals.** To meet this demand, more mining and mineral recycling will be needed.

Why will a low-carbon future be **more** mineral intensive?

The Clean Energy Transition

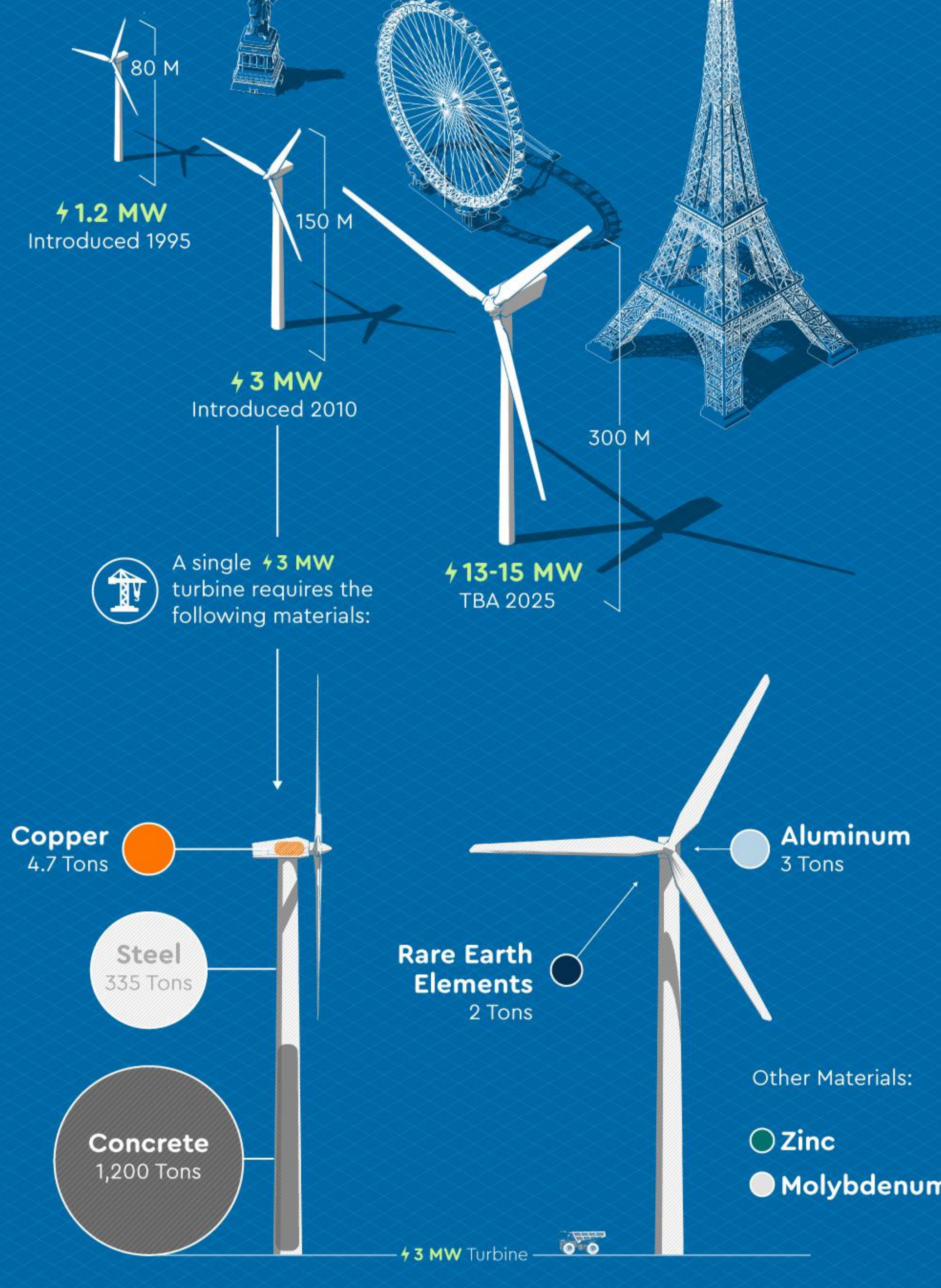Increasingly, the world is relying on **low-carbon technologies,** such as:

WIND | SOLAR | BATTERIES

Each of these technologies are mineral intensive, requiring large amounts of base and niche minerals.

WIND

Wind power technology is rapidly advancing to meet future energy demands, made possible with a large amount of materials.

80 M
+1.2 MW
Introduced 1995

150 M
+3 MW
Introduced 2010

300 M
+13-15 MW
TBA 2025

A single +3 MW turbine requires the following materials:

Copper 4.7 Tons

Steel 335 Tons

Concrete 1,200 Tons

Aluminum 3 Tons

Rare Earth Elements 2 Tons

Other Materials:
○ **Zinc**
● **Molybdenum**

+3 MW Turbine

With global wind power capacity expected to increase by **63% by 2023** the future demand for minerals will be significant.
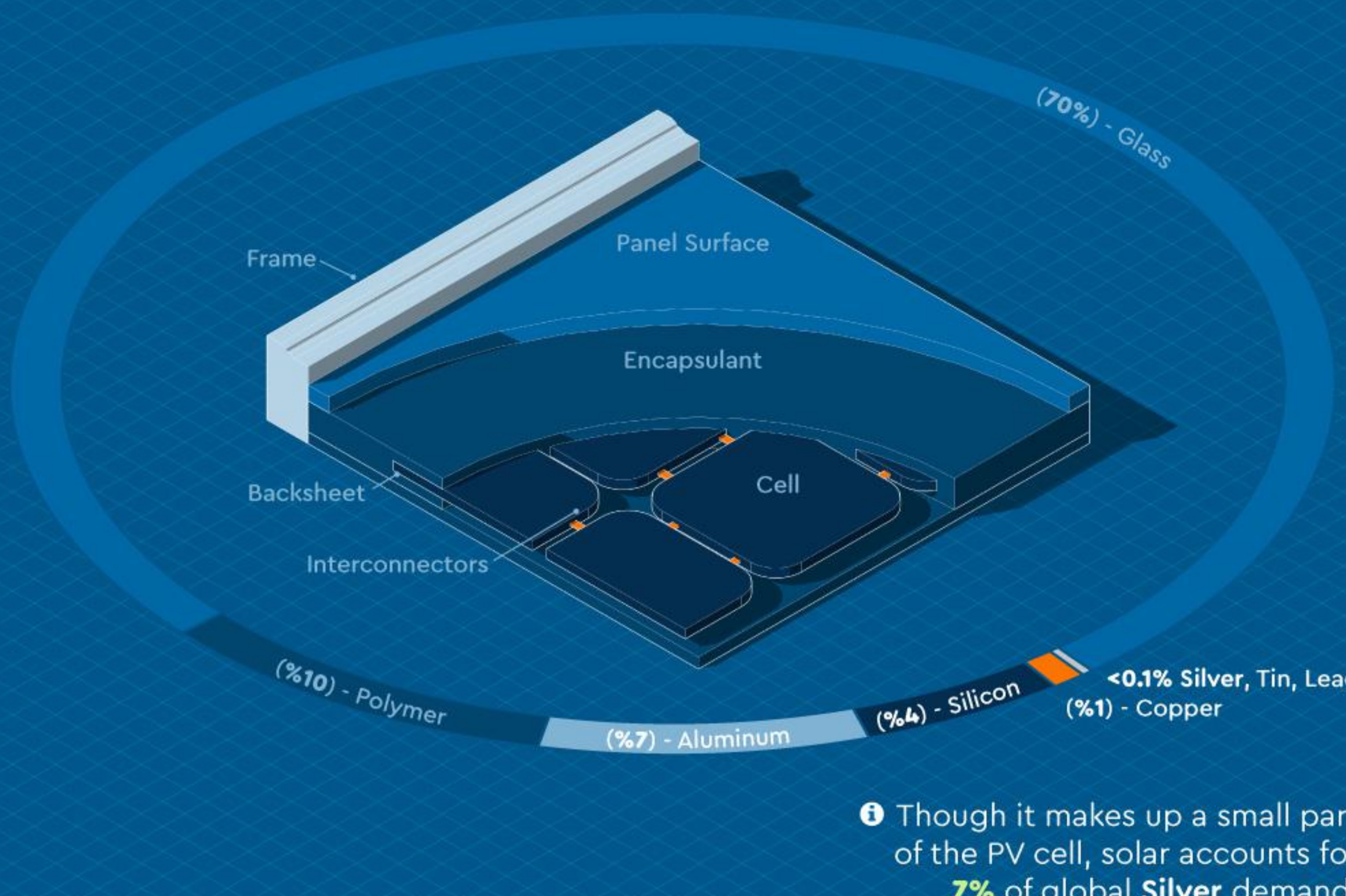
2017
+515 GW

2023
+839 GW

SOLAR

Solar power technology has improved vastly in recent years.

Global renewable capacity is expected to grow by over 1 TW from 2016 to 2023, a **46%** increase. Solar photovoltaic (PV) accounts for more than half of this growth.

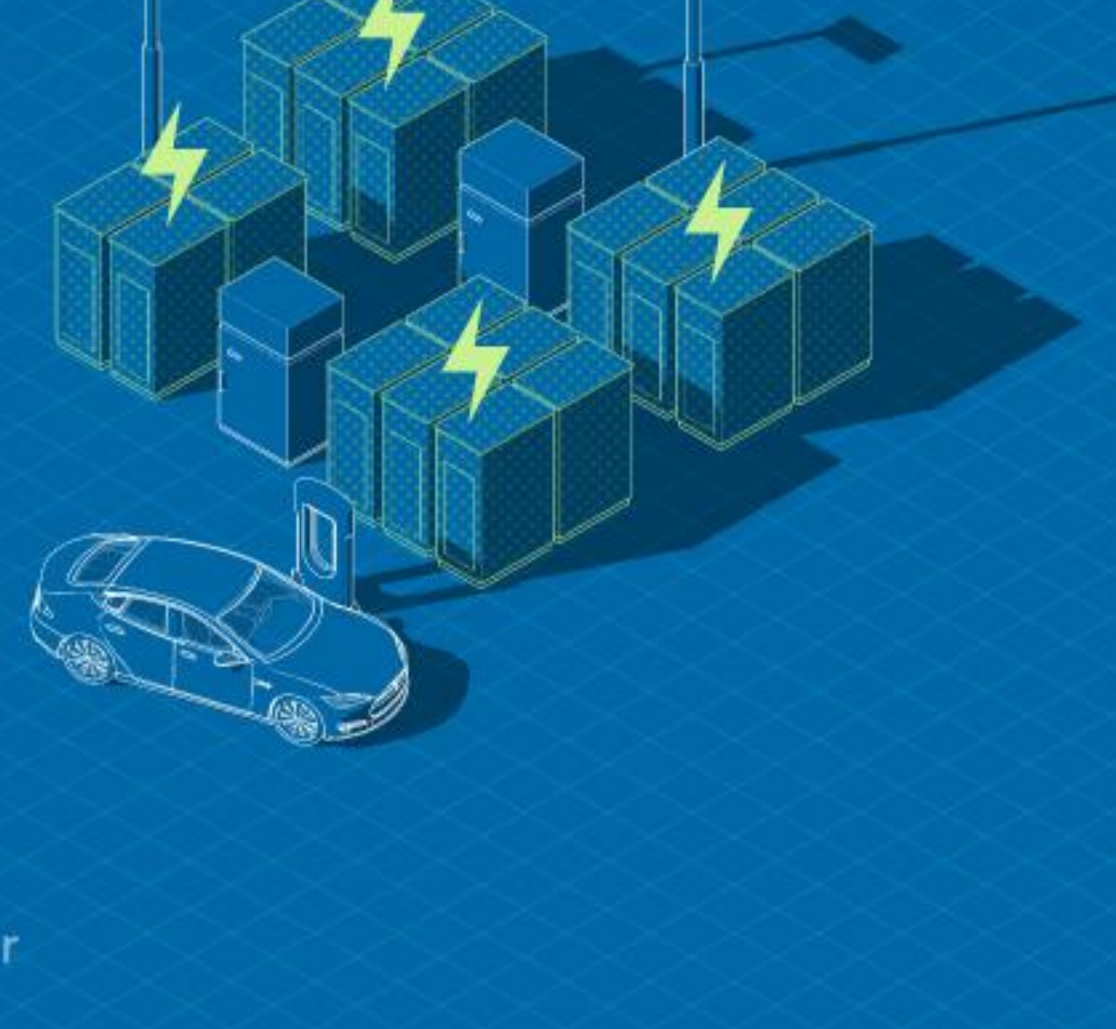Existing and future PV cell technology will require a number of minerals:

Total Renewable Capacity Additions

1 TW

178 GW
☀ 97.5 GW Solar (54.5%)
2017

575 GW
☀ 575 GW Solar (57.5%)
2023

Frame | Panel Surface | Encapsulant
Backsheet | Cell
Interconnects

(%AI) - Polymer | +Silicon | +0.3% Silver, Tin, Lead
(%Si) - Copper

ⓘ Though it makes up a small part of the PV cell, solar accounts for **7%** of global **Silver** demand.
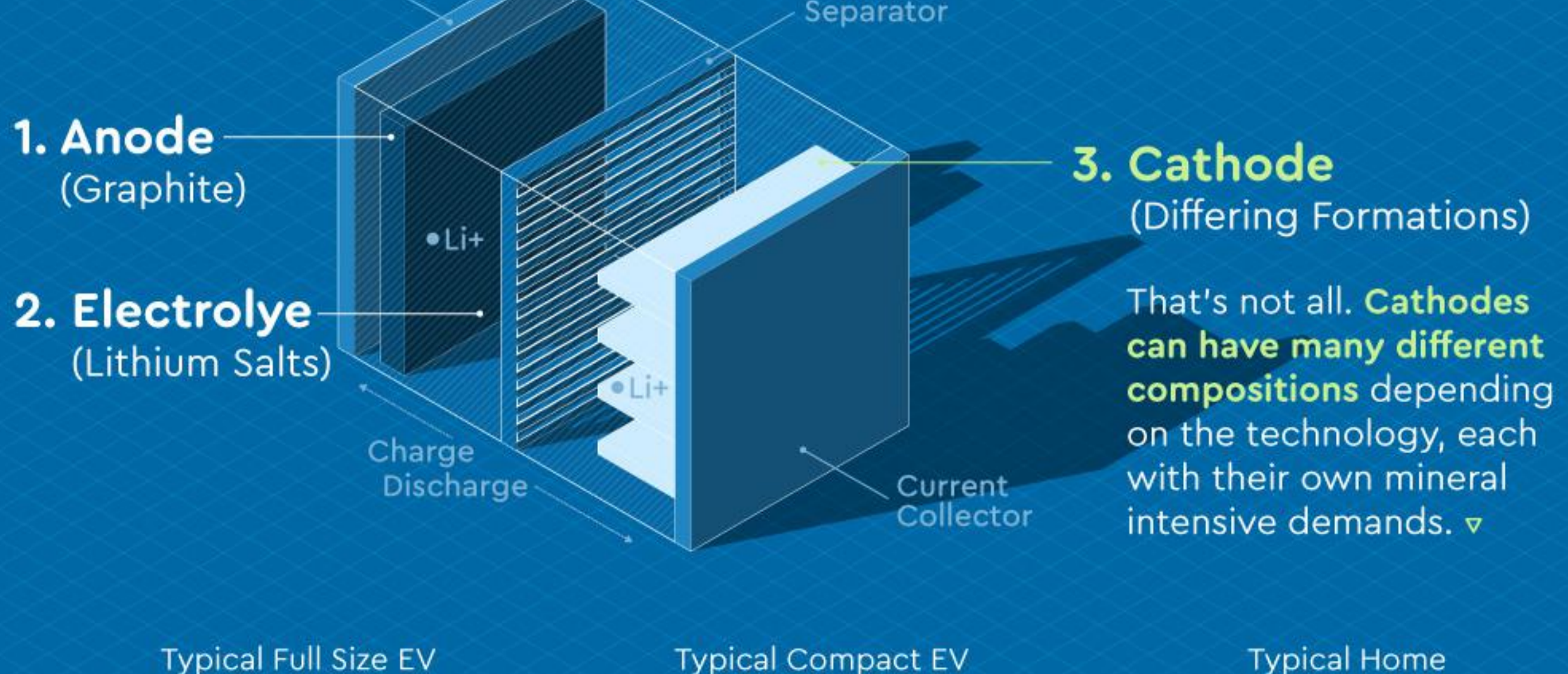
BATTERIES

From electric vehicles (EV) to power grids, battery technology will be ubiquitous and require significant amounts of minerals.
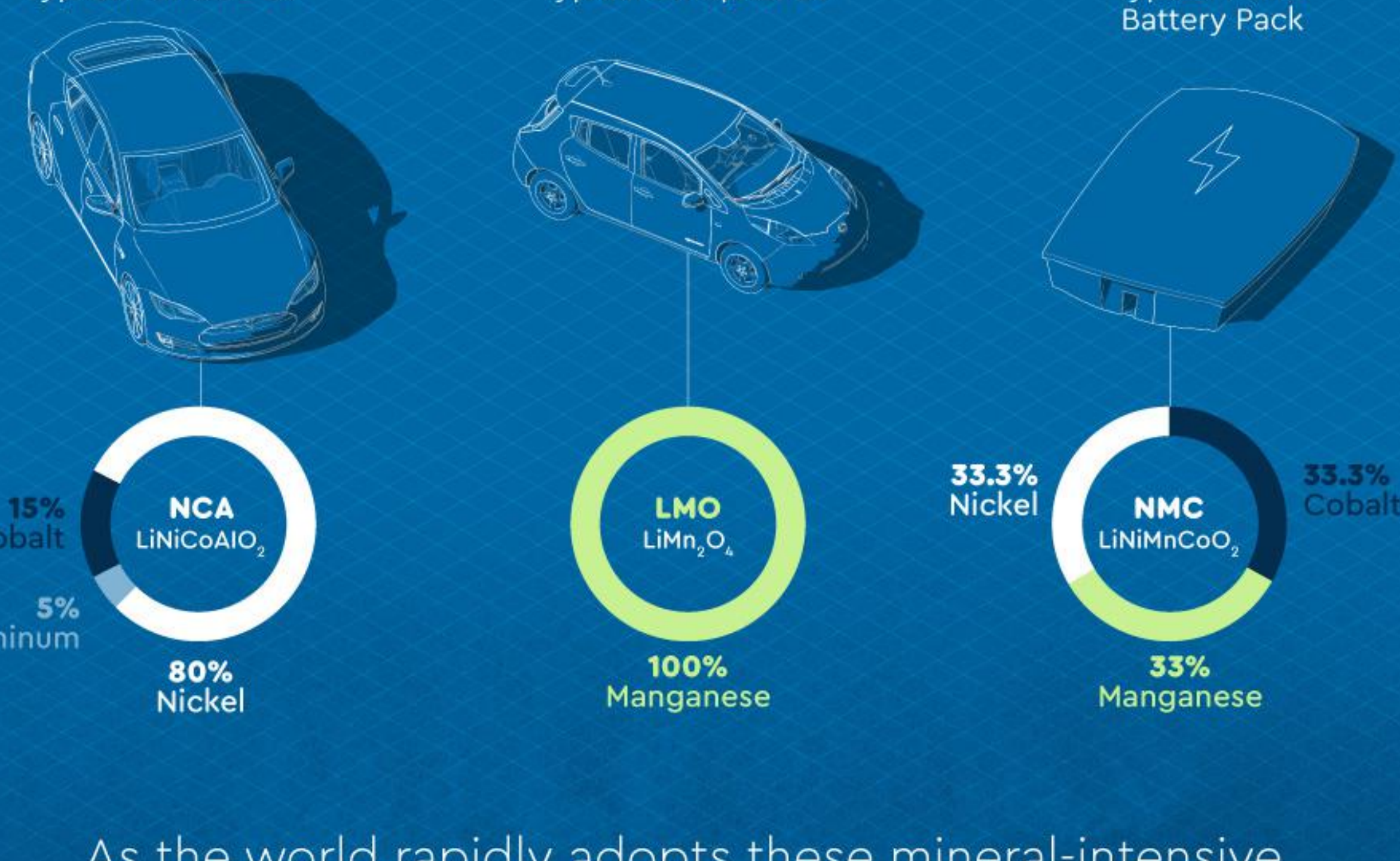
The lithium-ion cell has **three** components and each relies on key minerals such as lithium, nickel, and cobalt.

Lithium-ion Cells

Current Collector | Separator

1. Anode (Graphite)

2. Electrolye (Lithium Salts)

3. Cathode (Differing Formations)

+Li+

Charge
Discharge

Current Collector

That's not all. **Cathodes** can have many different **compositions** depending on the technology, each with their own mineral intensive needs.

Typical Full Size EV

Typical Compact EV

Typical Home Battery Cell

NCA LiNiCoAlO₂
15% Cobalt
5% Aluminum
80% Nickel

LMO LiMn₂O₄
100% Manganese

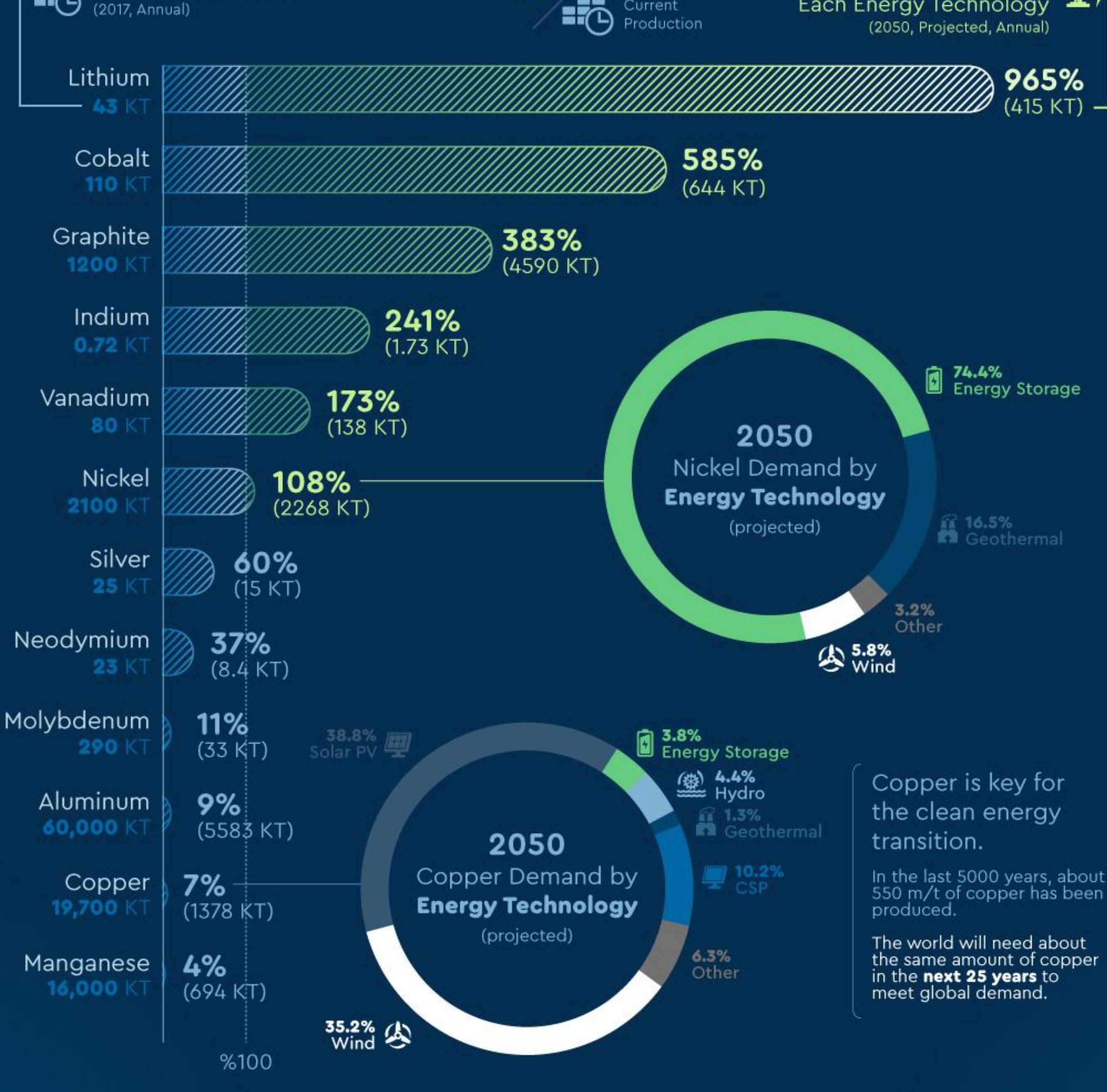**NMC** LiNiMnCoO₂
33.3% Nickel
33.3% Cobalt
33% Manganese

As the world rapidly adopts these mineral-intensive technologies, there will be implications for mineral-rich **developing countries and emerging economies.**

Growing Demand

By 2050, low-carbon technologies will demand a higher percentage of the world's mineral production. To meet this demand, sustainable and reliable production will need to keep up.

Current Production (2017, Annual)   Future Demand   Current Production   2050 Demand in Supplying Each Energy Technology (2050, Projected, Annual)

Mineral	Increase	(Amount)
Lithium 43 KT	965%	(415 KT)
Cobalt 110 KT	585%	(644 KT)
Graphite 1200 KT	383%	(4590 KT)
Indium 0.75 KT	241%	(1.73 KT)
Vanadium 66 KT	173%	(138 KT)
Nickel 2100 KT	108%	(2268 KT)
Silver 25 KT	60%	(15 KT)
Neodymium 23 KT	37%	(8.4 KT)
Molybdenum 290 KT	11%	(33 KT)
Aluminum 60,000 KT	9%	(5583 KT)
Copper 19,700 KT	7%	(1378 KT)
Manganese 16,000 KT	4%	(694 KT)

%100

2050 Nickel Demand by Energy Technology (projected)

- 74.4% Energy Storage
- 16.0% Geothermal
- 5.8% Wind
- 3.8% Solar PV

2050 Copper Demand by Energy Technology (projected)

- 35.2% Wind
- 6.5% Other
- 3.1% CSP
- 4.4% Geothermal
- 5.8% Energy Storage

Copper is key for the clean energy transition.

In the last 5000 years, about 550 m/t of copper have been produced.

The world will need about the same amount of copper in the next 25 years to meet global demand.

Where will all the minerals come from? The shift to a low-carbon future will produce opportunities for **developing countries and emerging economies** with a rich supply of minerals that are crucial to the world's green transition.

Colombia   Guinea   India   Peru   Gabon   Mongolia   Chile   DR Congo   Indonesia   Brazil   Mozambique   China   Madagascar

65%   The Democratic Republic of Congo (DRC) currently supplies over **65% of cobalt** in the global market and is expected to supply more than 73% by 2023.

However, while mining is crucial to the clean energy transition, it also accounts for **up to 11% of global energy use.**

To benefit from the increase in mineral demand, developing countries and emerging economies must adopt mining practices that minimize carbon and material footprints.

These countries will need **good governance, knowledge, capacity** and **strategy** to do so.

They will need Climate **Smart** Mining.

What is "Climate **Smart** Mining"?

Climate **Smart** Mining supports the sustainable extraction and processing of minerals and metals to secure supply for clean energy technologies while minimizing the climate and material footprint throughout the value chain.

The Building Blocks of Climate **Smart** Mining:

CLIMATE CHANGE MITIGATION
- Use of Renewable Energy
- Innovation in Extractive Practices
- Energy Efficiency

CLIMATE CHANGE ADAPTATION
- Forest Smart Mining
- Resource Efficiency
- Innovative Tailings Solutions

REDUCING MATERIAL IMPACTS
- Adoption of a Circular Economy
- Recycling of Strategic Minerals
- Strategic Mineral Supply Chain Management

CREATING MARKET OPPORTUNITIES
- De-risking Investments
- Enabling Carbon Markets
- Robust Geological Data

Climate **Smart** Mining

These building blocks will help mining companies and downstream users of minerals contribute to the Sustainable Development Goals.

Investors

Public and **Private** sector actors will need to work together to implement Climate **Smart** Mining to contribute to the low-carbon future.

Clean Tech Companies   Miners   Consumers