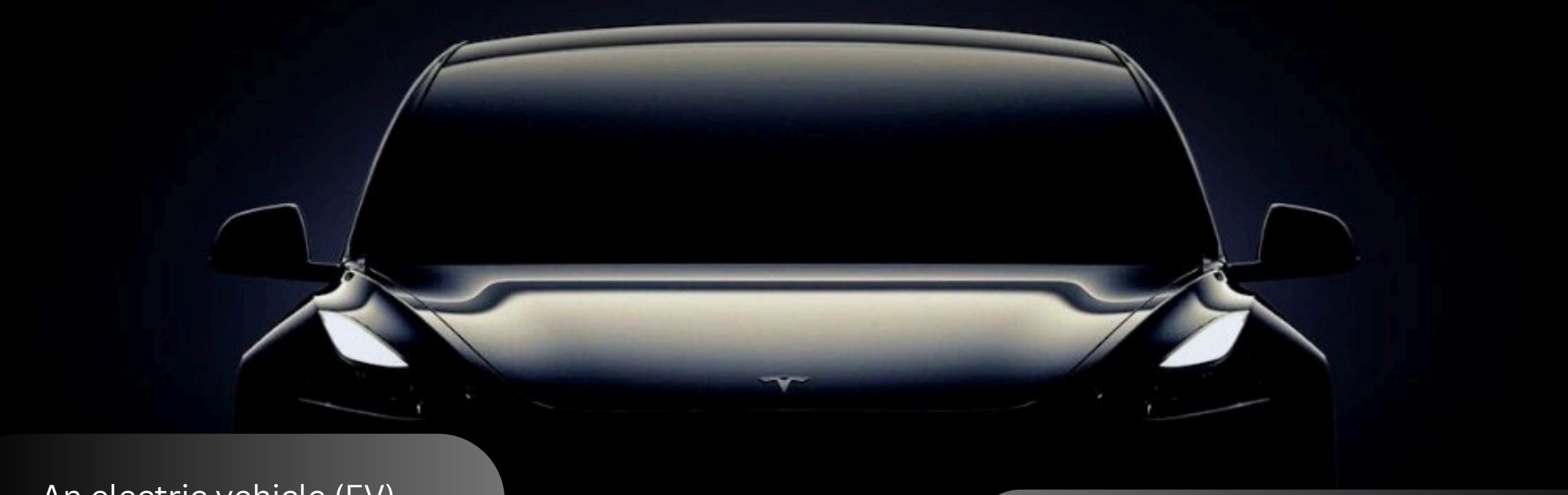
Society of Environmental Science and Engineering(SESE)
Indian Institute of Technology (Indian School of Mines) Dhanbad

ELECTRIC VEHICLES AND LITHIUM ION BATTERIES

Increasing Demand and the Problem of Recycling

SOURCE: *appleinsider.com*



An electric vehicle (EV) battery is a rechargeable battery that powers an EV's electric motor and electrical systems.

Electric vehicles (EVs) use a variety of battery types, most common type of EV battery is Lithium-ion battery. They have a high energy density, and use reversible systems, to charge and discharge.

DEMAND OF ELECTRIC VEHICLE BATTERIES:

AN INTRODUCTION TO ELECTRIC VEHICLE BATTERIES~

Simply put, electric vehicles (EV), as the name itself gives out, are electricity-driven, unlike the typical fuel-driven internal combustion engine (ICE) vehicles we all know of. This is done via a rechargeable battery that powers the vehicle's motor. Lithium-ion batteries (LIBs), are secondary batteries that have a high energy density, which is why they rank among the most commonly used EV batteries. Secondary batteries are reversible systems that turn their stored chemical energy into electricity to power an external circuit when discharging. While charging, the cell is connected to an external energy source, and the electrode processes are reversed. In particular, LIBs rely in lithium ions for these reactions involving the charging/ discharging processes.

THE NEED FOR RECYCLING LIBs~

The demand for EV batteries, driven by motivations to enhance grid stability, reduce reliance on fossil fuels, and support the integration of renewable energy sources, has significantly surged over the years. According to the International Energy Agency (IEA), just in 2022, EV battery demand soared to 550 GWh, a roughly 65% rise from the previous year. Lithium, cobalt and nickel are critical to the operation of LIBs, but they are also relatively scarce. By reclaiming materials from old LIBs, recyclers can contribute to a circular economy, repurposing resources and mitigating, if not compensating, the environmental impact of making new ones. This further calls for practices and governance strategies that ensure sustainability and circularity in the battery value chain. Some firms also hope to recover less-valuable materials, like copper or graphite.

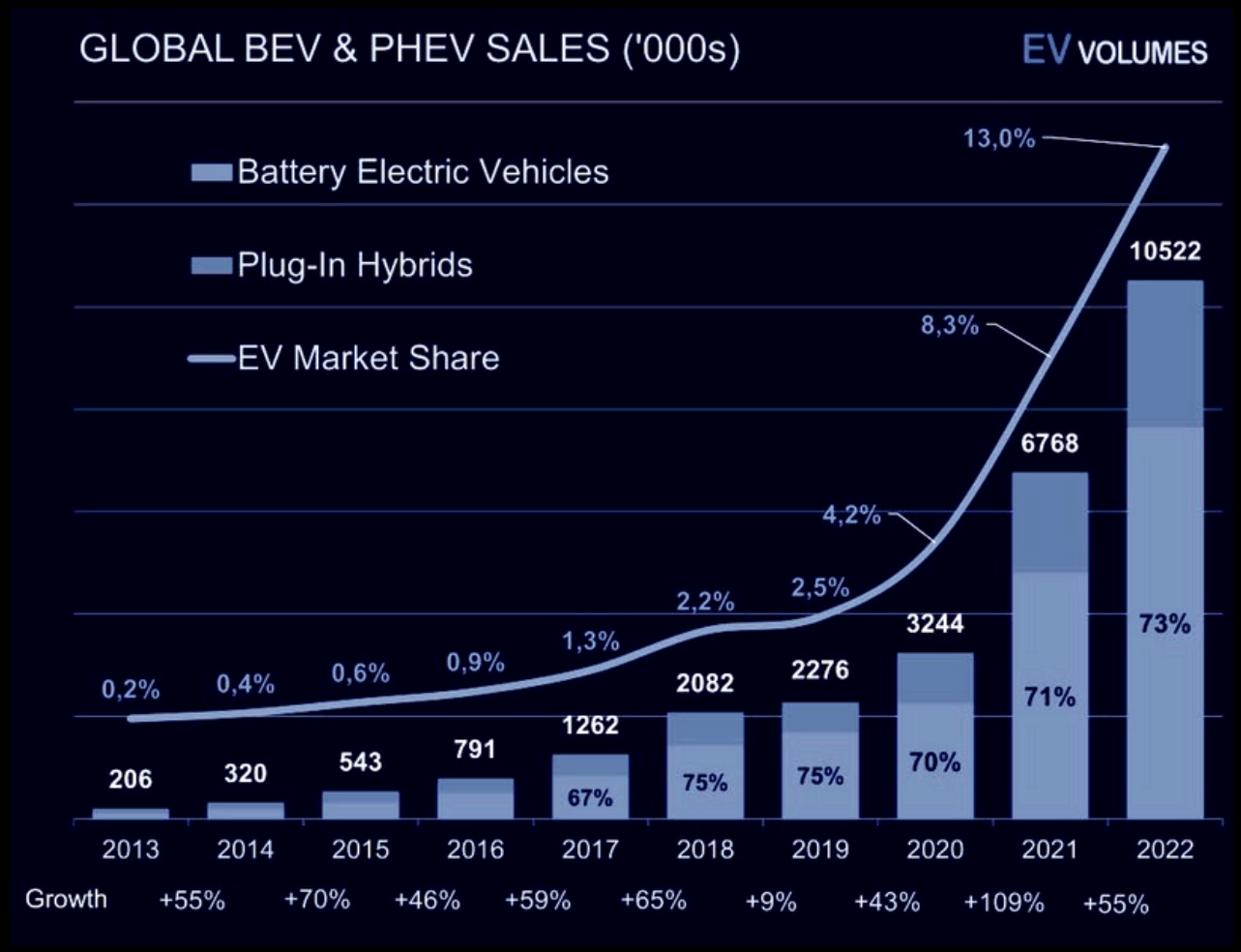


FIGURE 1:
Growth of the EV Market from 2013-22

SOURCE: International Energy Agency (IEA), 2022

CONSTRUCTION OF AN ELECTRIC VEHICLE BATTERY:

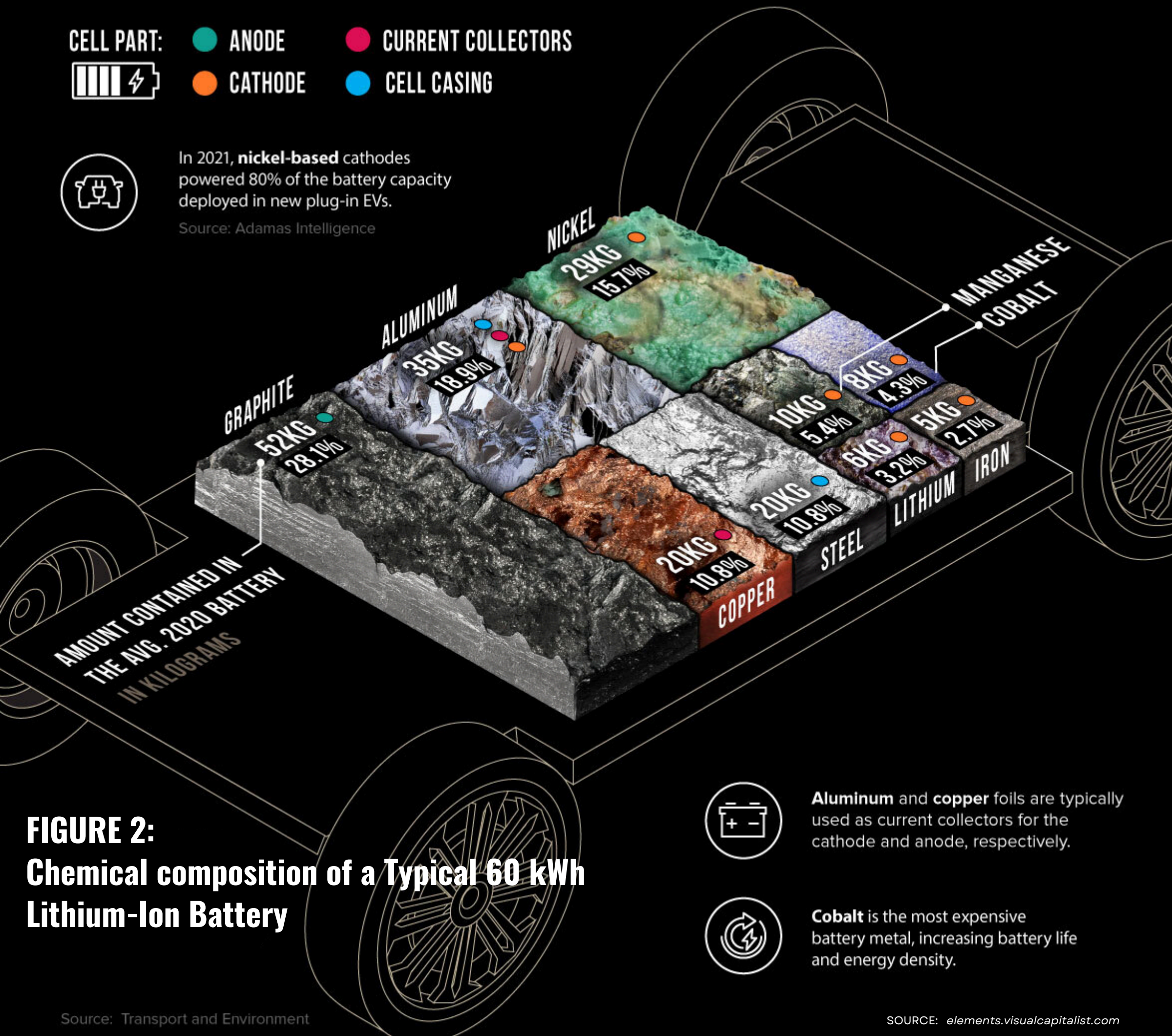


FIGURE 2:
Chemical composition of a Typical 60 kWh Lithium-Ion Battery

Aluminum and **copper** foils are typically used as current collectors for the cathode and anode, respectively.

Cobalt is the most expensive battery metal, increasing battery life and energy density.

Source: Transport and Environment

SOURCE: *elements.visualcapitalist.com*

THE RECYCLING OF A LITHIUM-ION BATTERY:

STEPS INVOLVED IN THE RECYCLING PROCESS~

The battery recycling value chain encompasses four key stages:

- ***Collection*** of batteries, followed by their evaluation and sorting;
- ***Discharging*** of batteries to eliminate any remaining charge;
- ***Shredding*** of batteries into the constituting components, generating streams like black mass, copper and aluminium foils, separators and electrolytes; and finally,
- ***Materials Recovery***, followed by further processing to extract and purify metals through either heat based smelting (pyrometallurgy) or liquid-based leaching (hydrometallurgy).

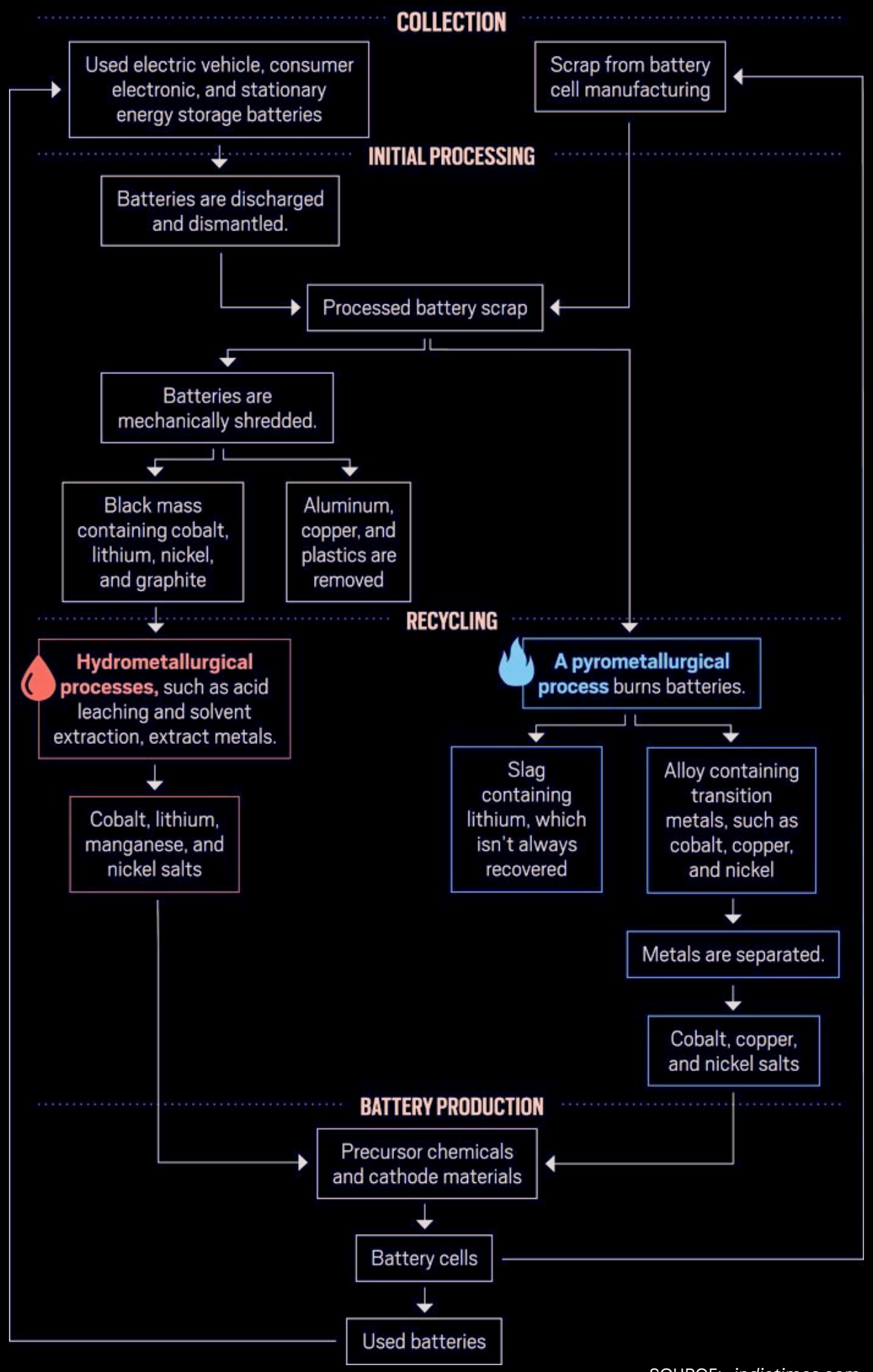


FIGURE 3:
A Flowchart showing the steps involved in LIB recycling

SOURCE: *indiatimes.com*

PROBLEMS IN THE EXISTING RECYCLING METHODS:

Environmental Risks:
The risks range from mining, and energy and water use to the hazards of discarded batteries. If deposited at dumps without proper caution,the wastes generated can leach toxic chemicals and even cause fires and explosions in waste management facilities and recycling centres. Processes like pyrometallurgy involve burning off the plastic separators before extraction of minerals from the batteries, which not only leads to the loss of some of the valuable minerals in it but also emits toxic gases and leads to wastage of energy.

Complexity and Profitability issues:
An electric vehicle battery is a very complex piece of technology with a lot of different components in it, which calls for complicated, and thus, expensive and labour-intensive recycling facilities. It is also challenging extract the minerals from the tight layers of inorganic and organic compounds. Due to this complex methods makes recycling less profitable.

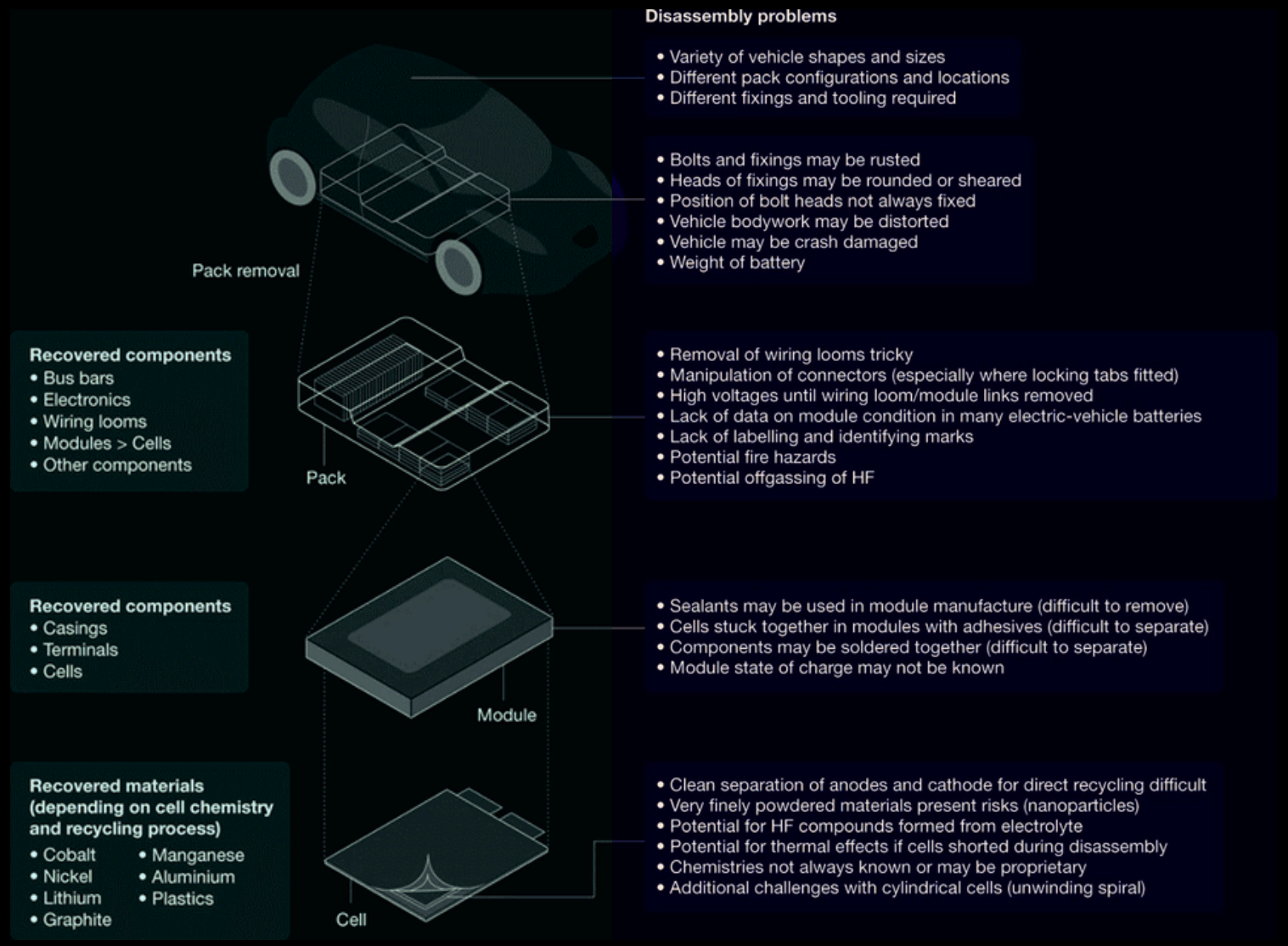


FIGURE 4:
Disassembly Problems encountered as different steps of EV Battery recycling

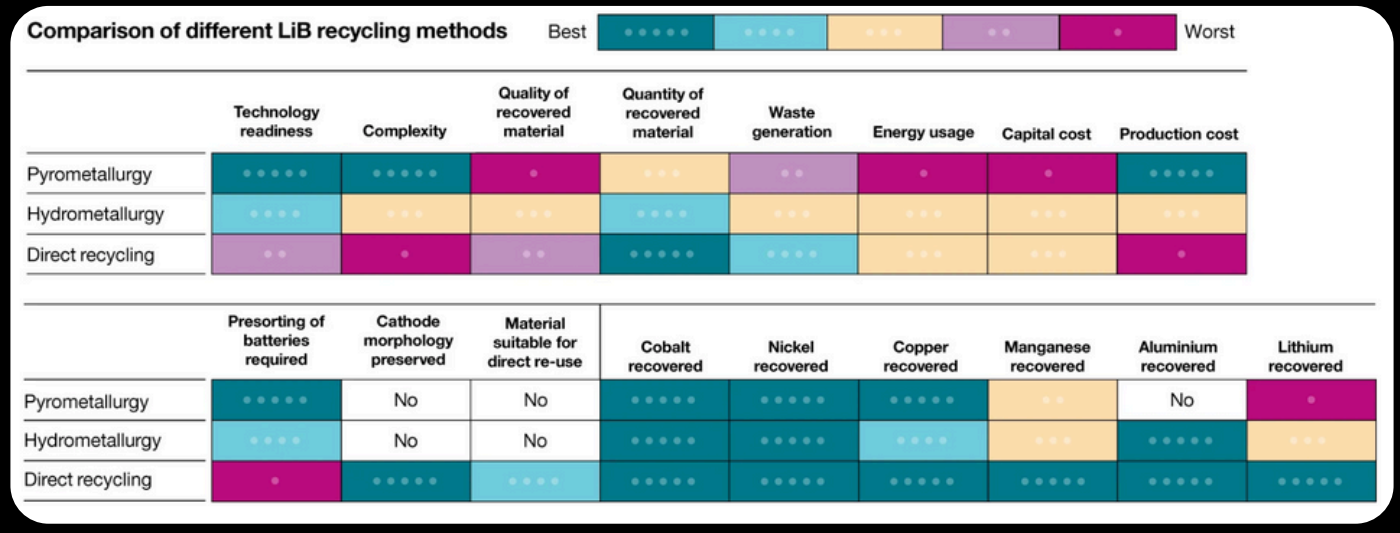
SOURCE: *Nature* journal

INNOVATIONS IN RECYCLING TECHNOLOGY:

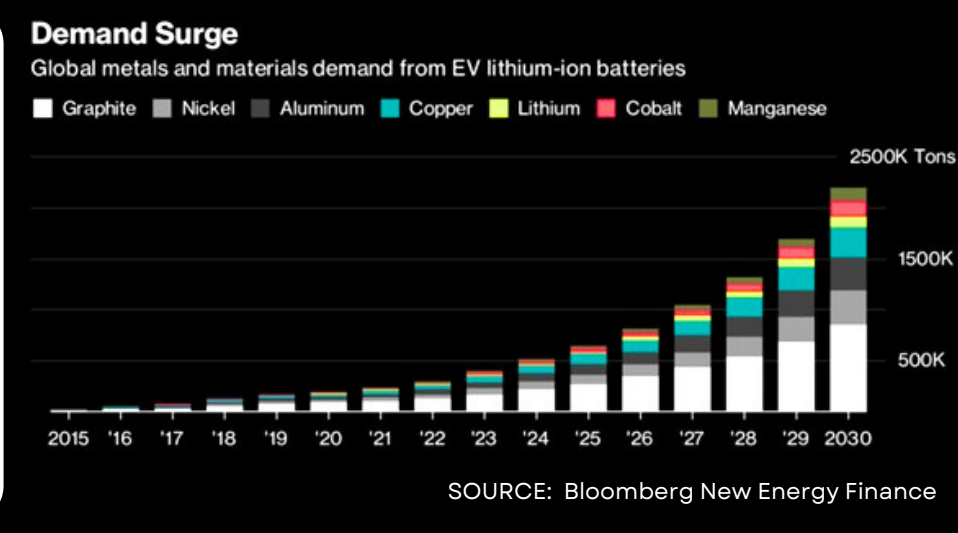
Pyrometallurgy:
Pyrometallurgical processes burn batteries in a furnace to produce a slag containing lithium, which isn't usually recovered, and an alloy of other metals, like cobalt, copper, and nickel. Those metals are then separated and converted into chemicals for battery production.

Hydrometallurgy:
In this process batteries are dissolved in acids. Liquid solvents are then used to extract the minerals. If done properly, this method can be better, while being cost-efficient at the same time, than processes like pyrometallurgy.

Direct Recycling:
This method aims to recapture the cathode material without melting or dissolving the whole battery. It aims at chemically recovering cathode powder which can then be rejuvenated by adding fresh lithium and rejuvenating its charging capacity.

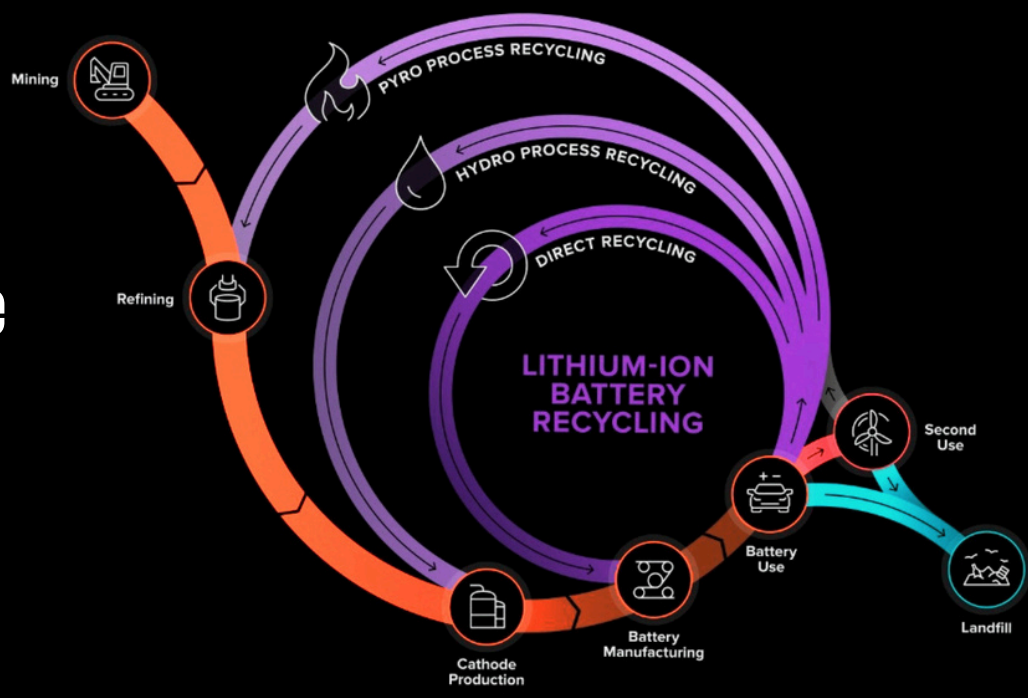


SOURCE: *Nature* journal



SOURCE: Bloomberg New Energy Finance

FIGURE 5:
Recycling Technologies and a qualitative comparison between them



SOURCE: *americanbatterytechnology.com*

CONCLUSION- A FUTURE OUTLOOK:

The rapid expansion of the electric vehicle market underscores the critical need for effective and sustainable lithium-ion battery recycling. For the future of battery recycling to be sustainable, it will need to balance technological innovation with cost-effectiveness, ensuring that recycled materials can compete with virgin resources in the market. Furthermore, public awareness and proper disposal practices must be improved to support the recycling infrastructure. Without proper recycling, the significant growing in the production of lithium-based materials will not only lead to the depletion of the natural resources, but also a whole plethora of environmental issues associated with the mining and mineral processing activities. It is estimated that recycling can save up to 51% of the extracted natural resources, including the reduction in the use of fossil fuels and nuclear energy necessary in the extraction and production processes.

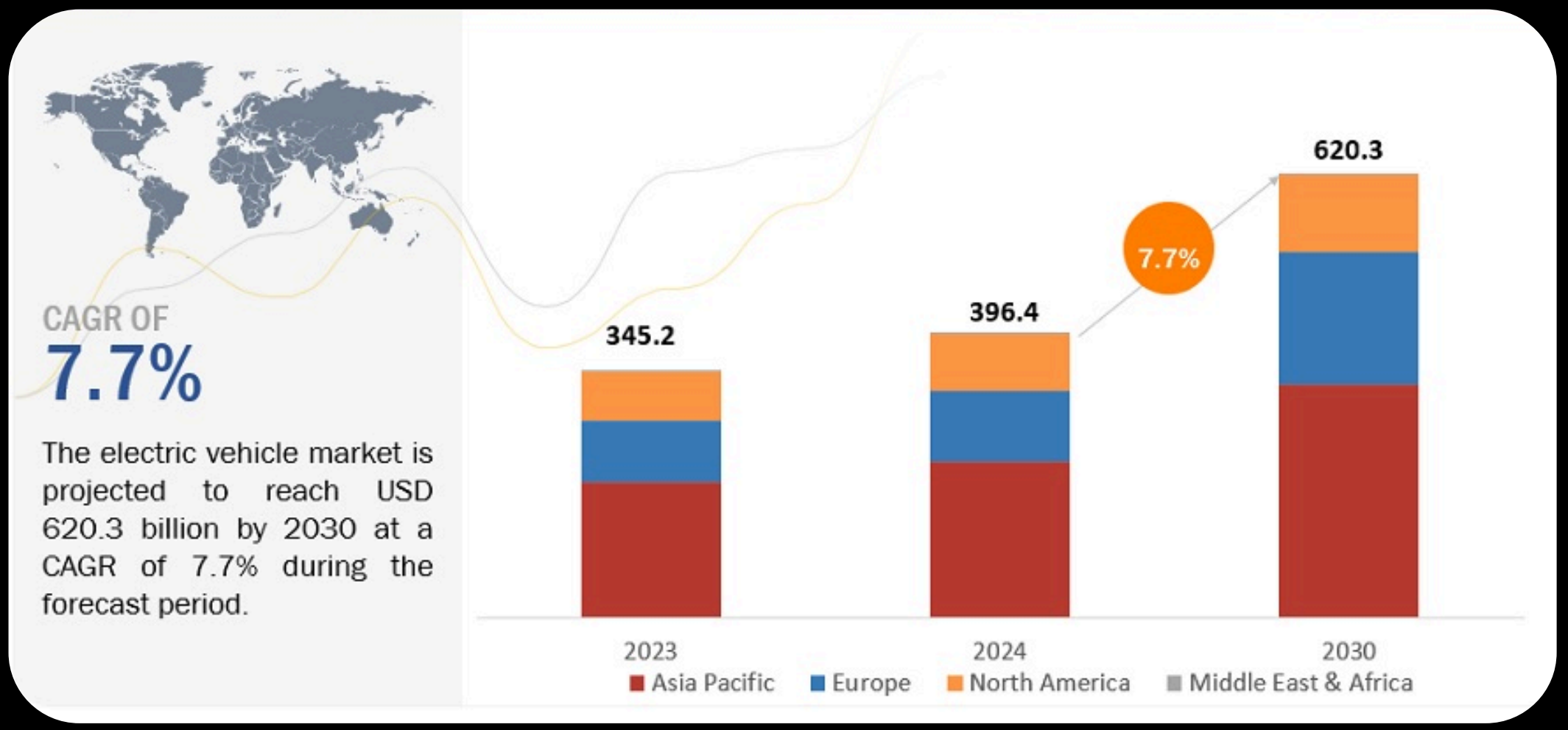


FIGURE 6: Global Forecast of the EV Market to 2030

SOURCE: *marketsandmarkets.com*

REFERENCES:

1. *Recycling lithium-ion batteries from electric vehicles* : Nature journal, et. al. Gavin Harper, Nov. 2019.
2. *Recycling and environmental issues of lithium-ion batteries* : *Advances, challenges and opportunities,* Elsevier, et. al. C. M. Costa, May 2021.
3. *What will it take to recycle millions of worn-out EV batteries* : Knowable magazine, by Ula Chrobak, Sept. 2022.
4. *Lithium-ion battery recycling goes large* : C&EN, by Mark Peplow, Nov. 2023.
5. *Electric Vehicles Battery Recycling Market* : Markets and Markets, Feb. 2024

SOURCE: *telegrafi.com*