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Applied Natural Resource Management

Sustainable Resource Management

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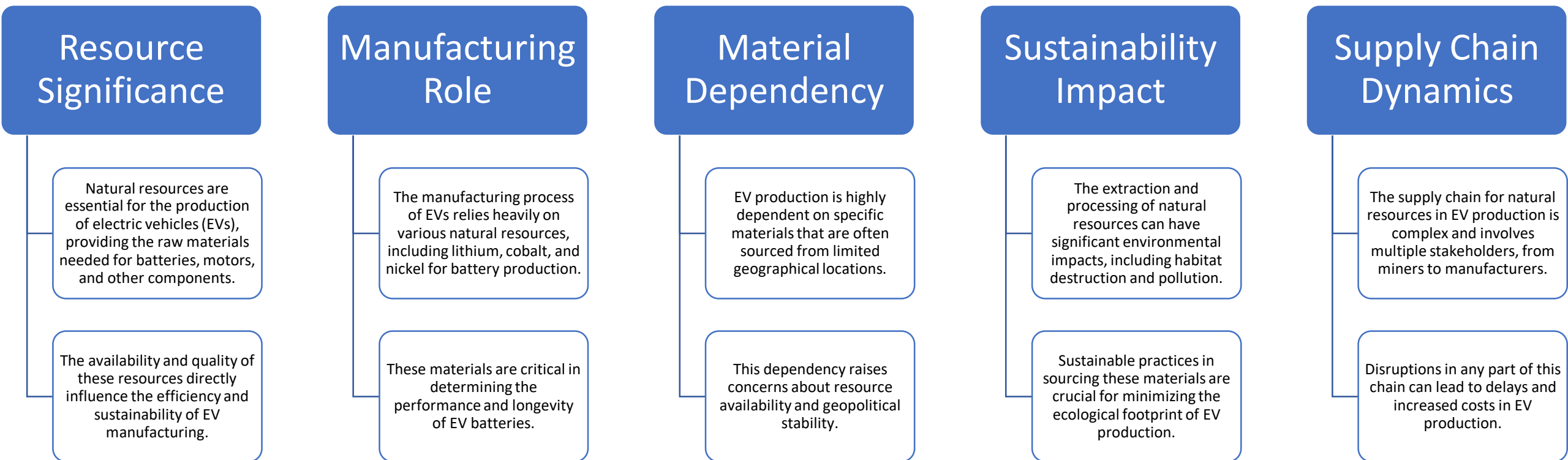
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**Partnership for Promotion and Popularization of Electrical Mobility through
Transformation and Modernization of WB HEIs Study Programs/PELMOB**

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Introduction to Natural Resources in EV Production



Key Natural Resources for EV Batteries

Lithium Importance

- Lithium is a key component in lithium-ion batteries, which are widely used in electric vehicles (EVs).
- It provides high energy density, allowing for longer driving ranges and faster charging times.

Cobalt Role

- Cobalt enhances the stability and longevity of lithium-ion batteries, preventing overheating and extending battery life.
- It plays a crucial role in maintaining the performance of batteries under high-stress conditions.

Nickel Significance

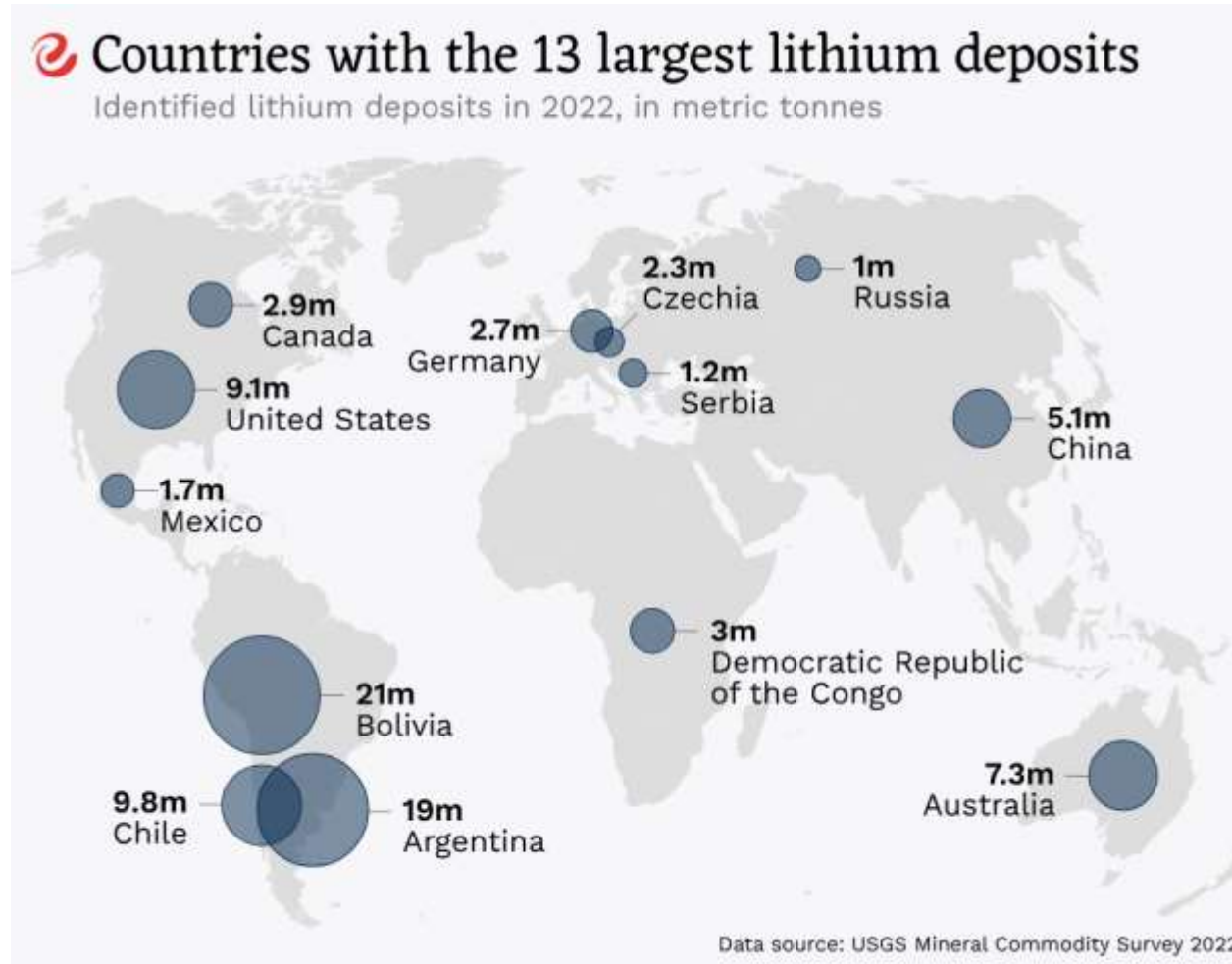
- Nickel is essential for increasing the energy capacity of batteries, enabling EVs to travel further on a single charge.
- It also helps reduce the overall cost of battery production by minimizing the amount of cobalt needed.

The world currently produces a little more than 100,000 tons of lithium a year. Under the base case scenario the researchers established, the United States alone would require 306,000 tons a year by 2050.

Lithium is critical to making EV batteries but is only produced at one mine in the United States — Silver Peak in Nevada run by Albemarle Corp. ([Greenwire](#), Oct. 14, 2022).

Australia, Chile, China and Argentina account for about 95 percent of the world's production

Globally, demand for lithium is expected to skyrocket by as much as six times the current level, requiring 50 new mines, the International Energy Agency concluded in a report last year.



Extraction of Lithium

Mining

- Lithium extraction begins with mining, where lithium-rich ores are extracted from the earth. The most common lithium ore is spodumene, which is processed to obtain lithium concentrate.

Brine Extraction

- In regions with high evaporation rates, lithium can be extracted from brine pools. This method involves pumping lithium-rich brine to the surface and allowing it to evaporate, concentrating the lithium.

Purification

- Once lithium is extracted, it undergoes purification to remove impurities. This process typically involves chemical treatments that ensure the lithium is of high purity, suitable for battery production.

Battery-Grade Production

- The final step is producing battery-grade lithium, which is essential for electric vehicle batteries. This involves converting purified lithium into lithium carbonate or lithium hydroxide, meeting stringent quality standards.

Extraction of Cobalt

Mining

- Cobalt is primarily extracted from the earth through mining operations. This involves locating cobalt-rich ores, which are often found alongside nickel and copper deposits.

Preparation

- Once the ore is mined, it undergoes preparation to separate cobalt from other minerals. This process includes crushing and grinding the ore to liberate the cobalt particles.

Refining

- The prepared ore is then subjected to refining processes, which may include hydrometallurgical or pyrometallurgical methods. These techniques help to purify the cobalt and remove impurities.

Smelting

- After refining, the cobalt is smelted to produce a more concentrated form. This involves heating the refined material to high temperatures, allowing for the separation of cobalt from other elements.

Final Product

- The final product is cobalt metal or cobalt salts, which are used in various applications, including batteries and alloys. This step ensures that the cobalt meets industry standards for quality and purity.

Approximately 70% of the world's cobalt is mined in the Democratic Republic of Congo (DRC), a country known for its poverty, corruption, and human rights issues[1].

Cobalt mining, particularly in the DRC, relies on child labor and is accompanied by multiple violations, from dangerous operating conditions to the mistreatment of miners. As the electrification ecosystem strives to promote both social and environmental sustainability, low-cobalt (NMC — Lithium Nickel-Manganese-Cobalt, or NCA — Lithium Nickel-Cobalt-Aluminium) or even completely cobalt-free (LFP — Lithium Iron-Phosphate) battery chemistries are attracting increasing interest. Many manufacturers are very positive about this development. For example, Tesla plans to accelerate its transition to sustainable energy by manufacturing high-energy components with lower or no cobalt content[2].

Extraction of Nickel

Mining

- Nickel extraction begins with mining, where nickel ore is extracted from the earth's crust. This process involves the use of heavy machinery to dig and transport the ore to processing facilities.

Concentration

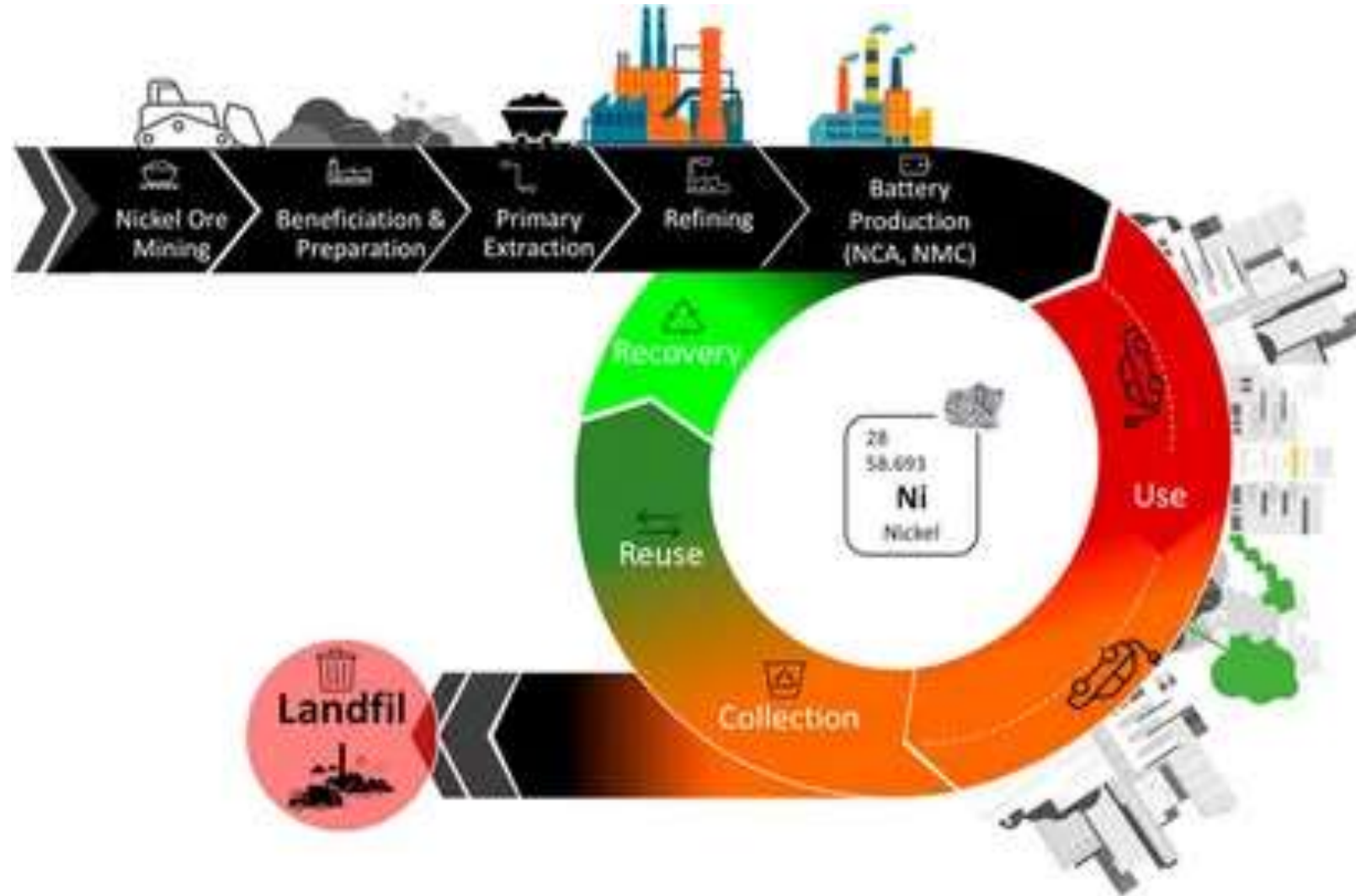
- Once the ore is mined, it undergoes concentration to separate nickel from other minerals. This is typically achieved through crushing, grinding, and flotation processes, which enhance the nickel content in the ore.

Smelting

- The concentrated nickel ore is then subjected to smelting, where it is heated in a furnace to extract the metal. During this process, impurities are removed, resulting in a nickel matte that contains a higher percentage of nickel.

Refining

- The final step is refining, where the nickel matte is further processed to produce pure nickel. This involves electrolysis or chemical methods to achieve a high level of purity, making the nickel suitable for various industrial applications.



References	Objective of study	Methodology	Supply chain stages				Environmental impact			Geographical scope
			Mining	Processing	Manufacturing	Recycling	Energy	Water	Emissions	
Eckelman, (2010)	Life cycle assessment of nickel production in stainless steel industries	LCA	X	X	X	X	X		X	Global
Mudd, (2010)	Assessing environmental issues in nickel mining	Data analysis	X	X			X		X	Global
Norgate and Jahanshahi, (2011)	Life cycle assessment of various nickel laterite processing method	LCA		X			X		X	Global
Bartzas and Komnitsas, (2015)	Life cycle assessment of ferronickel production	LCA and scenarios		X			X		X	Regional: Greece
Mistry et al., 2016	Life cycle assessment of nickel products	LCA	X	X	X		X		X	Global
Peters et al., 2016	Life cycle assessment of sodium-ion batteries	LCA			X				X	Regional: Europe
Khoo et al., 2017	Life cycle assessment of nickel laterite processing technologies	LCA and scenarios		X	X		X	X	X	Global
Kallitsis et al., 2020	Life cycle assessment of lithium-ion battery	LCA			X				X	Regional: China
Wei et al., 2020	Life cycle assessment of primary nickel production at mining stage	LCA	X	X			X		X	Regional: Australia, Indonesia and Colombia
Bai et al., 2022	Life cycle assessment of nickel production in urban mining	LCA	X	X			X		X	Regional: China
Current study	Global environmental impact of nickel supply chain focusing on lithium-ion battery	System dynamics modelling integrated with LCA and geometallurgical approach	X	X	X	X	X	X	X	Global

Introduction to Resource Usage Comparison

Resource Footprint

- The resource footprint of vehicles refers to the total amount of natural resources consumed throughout their lifecycle, from production to disposal. This includes raw materials, water, and land use.

Material Demand

- Electric vehicles (EVs) require specific materials such as lithium, cobalt, and nickel for their batteries, which can lead to significant mining impacts. In contrast, internal combustion engine (ICE) vehicles primarily rely on steel and aluminum, which also have environmental implications but differ in scale and type.

Energy Consumption

- The energy consumption of EVs is generally lower than that of ICE vehicles when considering the entire lifecycle, including manufacturing and operation. However, the source of electricity for EVs plays a crucial role in determining their overall energy efficiency.

Emissions Impact

- EVs produce zero tailpipe emissions, significantly reducing urban air pollution. However, emissions from battery production and electricity generation must be considered to assess their total environmental impact.

Sustainability Factors

- Sustainability in vehicle production involves assessing the renewable nature of materials and energy sources used. EVs have the potential for greater sustainability if powered by renewable energy and using recycled materials.

Resource Usage in EVs vs. ICE Vehicles

Material Differences

- Electric Vehicles (EVs) use lithium-ion batteries. These batteries require materials like lithium, cobalt, and nickel. Sourcing these materials can lead to environmental issues and ethical concerns.
- Internal Combustion Engine (ICE) vehicles are primarily made from steel and aluminum. They also use plastics and rubber, which have different environmental impacts compared to the materials used in EV batteries.

Quantity Disparities

- EVs require more raw materials because of their larger batteries. An EV can use up to six times more minerals than an ICE vehicle.
- ICE vehicles have a lower material demand per vehicle. However, their widespread use results in significant resource extraction over time, particularly for fossil fuels.

Critical Materials for EV Production

Rare Earth Elements

- Rare earth elements (REEs) are essential for the production of high-performance magnets used in electric motors.
- These elements enhance the efficiency and power output of EVs, making them crucial for modern electric vehicle technology.

Graphite

- Graphite is a key component in lithium-ion batteries, which power electric vehicles.
- It serves as the anode material, allowing for efficient energy storage and discharge, critical for EV performance.

Manganese

- Manganese is used in lithium-ion battery cathodes to improve energy density and stability.
- Its inclusion helps enhance the overall lifespan and safety of EV batteries, making it a vital material in EV production.

Obtaining Rare Earth Elements

Mining

- Rare earth elements (REEs) are extracted from the earth through mining operations, primarily from ores such as bastnäsite and monazite. This initial step involves locating deposits rich in these elements and extracting them using various mining techniques.



Separation

- Once mined, the ore undergoes a separation process to isolate the rare earth elements from other materials. This typically involves crushing the ore and using chemical processes to separate the REEs from impurities, ensuring a higher purity level for the next stage.



Refining

- The separated rare earth elements are then refined to produce individual REEs in a usable form. This process often includes additional chemical treatments and purification steps to achieve the desired quality and concentration of each element.



Application

- Finally, the refined rare earth elements are utilized in various applications, particularly in electric vehicles (EVs). They are essential for manufacturing powerful magnets, batteries, and other components that enhance the performance and efficiency of EVs.

Obtaining Graphite

Mining Process

- Graphite is extracted from the earth through mining, which can be done via open-pit or underground methods. The choice of method depends on the depth and quality of the graphite deposit.



Purification Method

- Once mined, the graphite undergoes purification to remove impurities. This is typically achieved through chemical processes, such as flotation or acid leaching, to ensure high purity levels suitable for industrial applications.



Shaping Techniques

- After purification, the graphite is shaped into desired forms using techniques like extrusion or molding. This step is crucial for preparing graphite for integration into various applications, including EV batteries.

Uses Of Graphite

- Writing Materials
- Lubricants
- Paint
- Refractory
- Nuclear Reactors
- Batteries
- Graphene Sheets



Obtaining Manganese

Mining

- Manganese is primarily extracted from open-pit mines, where large quantities of ore are removed from the earth's crust. This process involves drilling, blasting, and transporting the ore to processing facilities.



Refining

- Once the ore is mined, it undergoes refining to remove impurities and concentrate the manganese content. This is typically achieved through processes such as crushing, grinding, and chemical treatment.



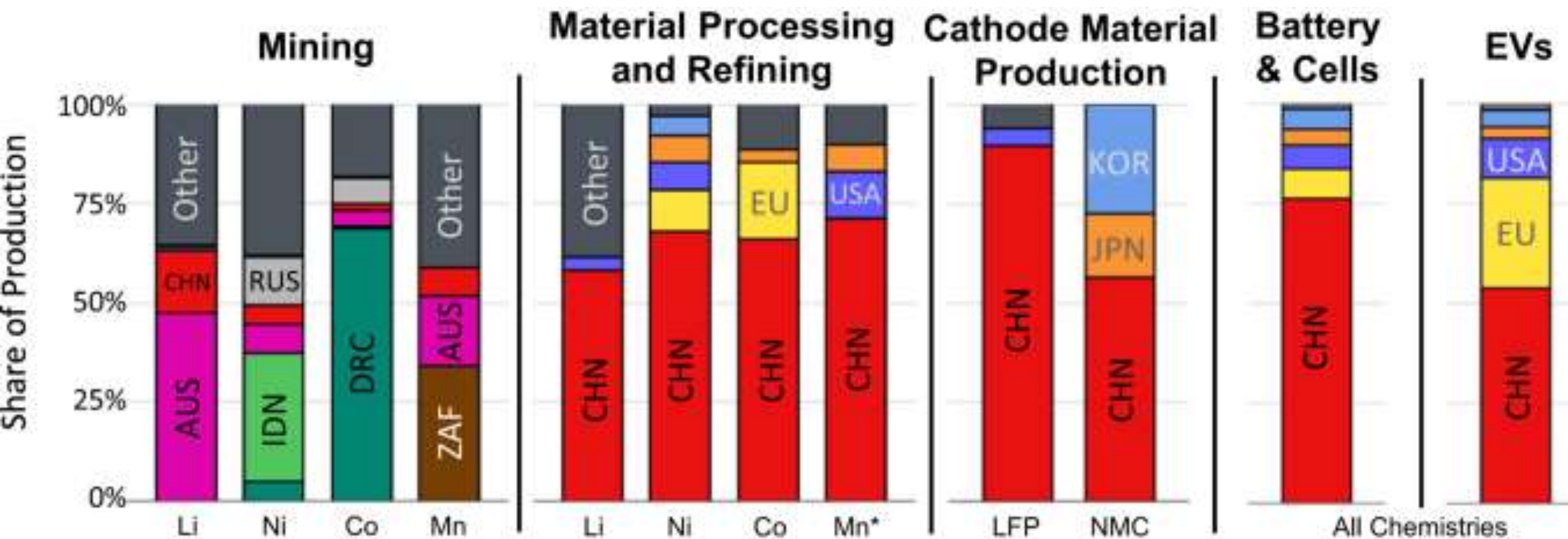
Alloying

- Refined manganese is then alloyed with other metals to enhance their properties. This step is crucial for producing high-strength steel and other alloys that require specific characteristics.

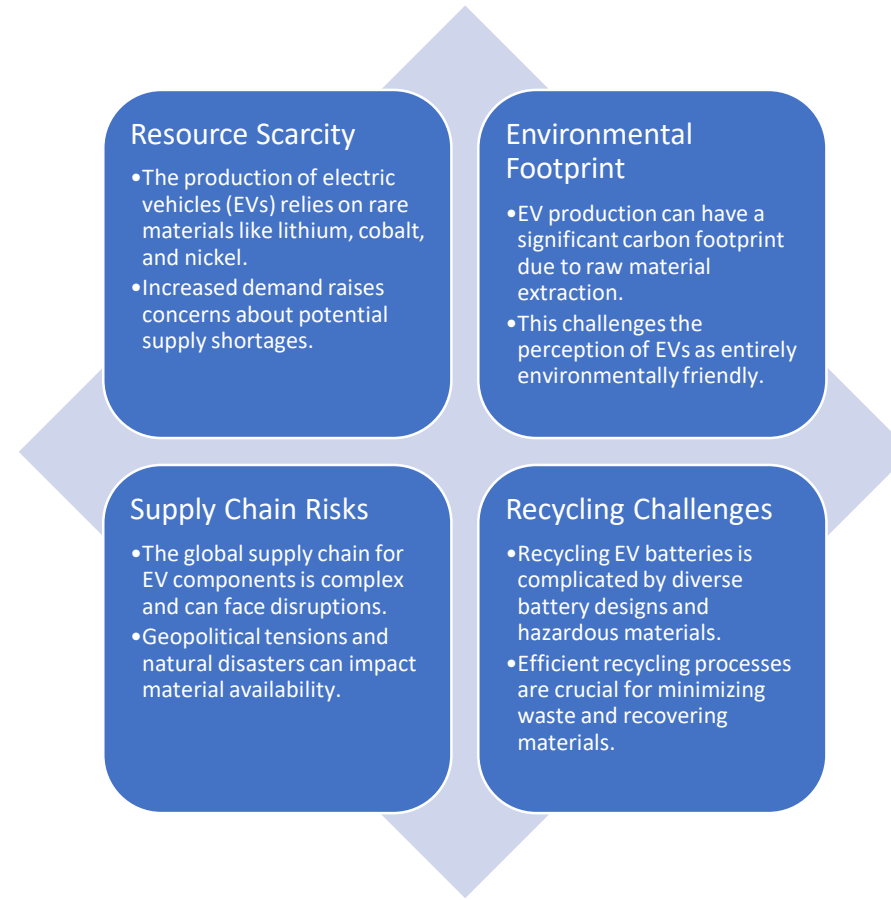


EV Components

- Finally, manganese plays a vital role in the production of electric vehicle (EV) components, particularly in batteries. Its inclusion improves energy density and overall performance, making it essential for modern EV technology.



Introduction to Production Concerns



Critical Parts at End of Life for EVs

- Batteries are the most critical component of electric vehicles (EVs) at the end of their life cycle. They contain valuable materials that can be recycled, but improper disposal can lead to environmental hazards.

Batteries

- Electric motors are essential for the propulsion of EVs. At the end of their life, they can be refurbished or recycled to recover metals and other materials, reducing waste.

Motors

- Electronic components, including control units and sensors, play a vital role in the operation of EVs. These components can often be reused or recycled, contributing to a circular economy.

Electronic Components

Introduction to Recycling Resources

Sustainable Practices

Sustainable practices in recycling resources focus on minimizing waste and maximizing the reuse of materials. This approach not only conserves natural resources but also reduces environmental pollution.

Resource Recovery

Resource recovery involves extracting valuable materials from waste products, particularly from electric vehicles (EVs). This process helps in reclaiming metals, plastics, and other components that can be reused in manufacturing.

EV Lifecycle

The lifecycle of an electric vehicle includes production, usage, and end-of-life phases. Understanding this lifecycle is crucial for implementing effective recycling strategies that enhance sustainability.

Environmental Impact

Recycling resources from EVs significantly lowers the environmental impact associated with mining and manufacturing new materials. It contributes to reducing greenhouse gas emissions and conserving energy.

Circular Economy

The concept of a circular economy promotes the continuous use of resources by creating closed-loop systems. In the context of EVs, this means designing vehicles for easier disassembly and recycling at the end of their life.

Recycling EV Batteries

Collection

- The first step in recycling EV batteries is the collection of used batteries from various sources, including dealerships, repair shops, and recycling centers.
- Proper collection ensures that batteries are safely transported to recycling facilities, minimizing environmental risks.



Disassembly

- Once collected, the batteries undergo disassembly to separate the different components, such as the casing, electrodes, and electrolyte.
- This step is crucial for identifying reusable parts and hazardous materials that need special handling.



Material Recovery

- After disassembly, the next step is material recovery, where valuable materials like lithium, cobalt, and nickel are extracted from the battery components.
- This process not only recycles these materials but also reduces the need for new mining, which can be environmentally damaging.



Reuse

- The final step involves reusing the recovered materials to manufacture new batteries or other products, closing the loop in the battery lifecycle.
- By reusing materials, we contribute to a more sustainable economy and reduce waste.

Recycling Electric Motors

Removal

- The first step in recycling electric motors is the removal of the motor from its original equipment. This involves safely disconnecting the motor from power sources and any mechanical connections. Proper safety protocols must be followed to prevent accidents during this process.



Dismantling

- Once the motor is removed, the next step is dismantling it into its individual components. This includes taking apart the housing, rotor, and stator. Careful dismantling is crucial to avoid damaging reusable parts and to facilitate the next step of material separation.



Material Separation

- After dismantling, the components are sorted into different materials such as copper, aluminum, and steel. This separation is essential for effective recycling, as each material has its own recycling process. Proper material separation maximizes the recovery of valuable resources and minimizes waste.

Recycling Electronic Components

Collection

- The first step in recycling electronic components from electric vehicles (EVs) is collection. This involves gathering discarded or end-of-life EVs from various sources, including dealerships, recycling centers, and consumer drop-off locations. Proper collection ensures that valuable materials are not lost and can be processed efficiently.



Sorting

- Once collected, the next step is sorting the electronic components. This process involves categorizing the components based on their type, material, and potential for recovery. Effective sorting is crucial as it determines the efficiency of the subsequent recycling processes and maximizes material recovery.



Material Recovery

- After sorting, the material recovery phase begins. This step involves extracting valuable materials such as metals, plastics, and rare earth elements from the electronic components. Advanced technologies, including shredding and chemical processes, are often employed to ensure that as much material as possible is recovered for reuse.



Repurposing

- The final step is repurposing the recovered materials. This involves transforming the extracted materials into new products or components, thereby reducing the need for virgin resources. Repurposing not only contributes to sustainability but also supports the circular economy by giving new life to materials that would otherwise be wasted.

Summary of Natural Resources in EV Production

Critical Materials

- Key materials for EV production include lithium, cobalt, and nickel, which are essential for battery manufacturing. These materials are crucial for enhancing battery performance and longevity.

Extraction Processes

- The extraction of critical materials often involves mining and refining processes that can be environmentally damaging. Sustainable practices are increasingly being sought to minimize the ecological footprint of these operations.

Sustainability Concerns

- The demand for critical materials raises concerns about resource depletion and environmental impact. Efforts are being made to develop recycling methods and alternative materials to ensure a sustainable future for EV production.

Resource Usage Comparison

EV Resource Demand

- Electric vehicles (EVs) require lithium, cobalt, and nickel for their batteries. The mining of these materials can lead to significant environmental issues, including habitat destruction and pollution.

ICE Resource Demand

- Internal combustion engine (ICE) vehicles rely on fossil fuels such as gasoline and diesel. The extraction and processing of these fuels contribute to greenhouse gas emissions and environmental degradation.

Conclusion

Sustainable Production

- Sustainable production methods are essential for reducing the environmental footprint of electric vehicles (EVs). By utilizing renewable resources and minimizing waste, manufacturers can create a more eco-friendly production process.

End-of-Life Practices

- Implementing effective end-of-life practices ensures that EVs are disposed of responsibly. Recycling components and repurposing materials can significantly reduce landfill waste and promote a circular economy.

Environmental Impact

- The environmental impact of EVs extends beyond their operation; it includes the entire lifecycle from production to disposal. Understanding and mitigating these impacts is crucial for achieving true sustainability.

Future Innovations

- Future innovations in sustainable technologies will play a pivotal role in enhancing the eco-friendliness of EVs. Research into new materials and processes can lead to more efficient and less harmful production methods.

Consumer Responsibility

- Consumers play a vital role in promoting sustainability by making informed choices. Supporting brands that prioritize sustainable practices can drive change in the industry and encourage more responsible production methods.