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Metallurgy

# The State of Affairs of 'Rare Metal Industry' in Korea

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## ABSTRACT

This paper offers a thorough examination of South Korea's rare metal industry, delving into its definition, classification, supply and demand dynamics, international trade conflicts, and the government's strategic endeavors in this domain. It underscores the global significance of rare metals, spotlighting the challenges arising from their uneven distribution across the world. The paper emphasizes the pressing need for countries, including South Korea, to address these challenges through well-planned strategies. Additionally, the paper explores the legal and policy frameworks recently adopted in South Korea concerning rare metals. It places particular emphasis on the pivotal role played by the Korea Institute of Industrial Technology (KITECH) in fostering the growth and development of the rare metal industry within the nation. Furthermore, the paper provides insights into the current state of South Korea's rare metal industry, focusing on key sectors such as the utilization of rare earth metals in electric vehicles, refractory metals for semiconductors and displays, and cathode materials essential for secondary batteries. These areas of specialization illustrate the integral role that rare metals play in cutting-edge technologies, positioning South Korea as a leader in innovation. In its conclusion, the paper underscores the urgency of advancing technological capabilities, promoting recycling practices, and enhancing refining processes to establish a circular rare metal industrial economy. This approach not only guarantees a sustainable supply of rare metals but also aligns with global efforts for eco-friendly and resource-conserving industrial practices.

**Keywords:** Rare metals, South Korea, Global significance, Recycling and refining, International trade conflicts, Rare metal Industry

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## 1. Introduction

### 1.1 Background

The Ministry of Trade, Industry, and Energy (MOTIE), responsible for overseeing Korea's industry and trade, has unveiled the national policy on rare metals, first in 2009 and subsequently in 2021. This policy delineates the classification of rare metals, distinct from commonly mass-produced metals such as iron, copper, and aluminum.

Within the Korean context, rare metal elements encompass 35 out of 56 elements [[1], [2]]. These elements are characterized by both high industrial demand and the challenge of extraction due to their limited abundance in the earth's crust. The

dictionary definition of rare metals signifies metals with a low concentration of ore. From an economic standpoint, rare metals exhibit traits such as high price volatility and substantial demand. Additionally, a resource-security perspective underscores that these resources are not uniformly distributed and are concentrated in a select few countries [[1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11]].

### 1.2 Global Perspective

The United States designates fifty minerals as 'Critical Minerals,' while nineteen essential energy-related elements are classified as 'Critical Materials for Energy.' In Europe, 66 elements are identified as 'Critical Raw Materials,' and in Japan, 55 elements fall under the designation of 'Rare Metals.' These

classifications reflect international recognition of the strategic importance and unique characteristics of rare metals across different regions [[12], [13], [14], [15]].

## 2. Results and Discussion

### 2.1. Supply and Demand Dynamics

#### 2.1.1 Industrial Trends

Let's examine the current landscape of the rare metal industry, focusing on the dynamics of supply and demand. Over the past decade, the demand for rare metals has exhibited consistent growth, primarily driven by the expansion of the electric vehicle, secondary battery, and emerging new and renewable energy sectors. This surge is further intensified by the imperative of carbon-neutral initiatives, which, in addition to replacing fossil energy sources, are contributing to a heightened reliance on rare metals.

A notable illustration of this trend is the increased utilization of lithium nickel manganese cobalt in secondary batteries and rare earths in electric vehicle motors compared to a decade ago. This growth underscores the pivotal role rare metals play in advancing technologies aligned with environmental and sustainability goals.

#### 2.1.2 Market Stability and Resource Distribution

However, a potential concern arises from the concentration of rare metal production in specific regions, leading to a monopolistic resource distribution that can foster market instability and

impede the development of robust global supply chains. Noteworthy instances include China producing 63% of the world's rare earth metals, and an even more substantial 83% of tungsten. Additionally, Congo accounts for 70% of global cobalt production, while South Africa produces 55% of the platinum group [1].

This concentration of production in specific geographical locations raises critical questions about the resilience and sustainability of the rare metal supply chain, necessitating a careful examination of strategies to mitigate risks associated with monopolistic resource distribution.

### 2.2. National Policies and Strategies

Table 1 outlines the trends in the rare metals industry across major countries.

Due to the impact of rare metal resource challenges, countries across the globe are developing tailored policies to tackle industry-specific issues and strengthen their security measures. Remarkably, although China boasts the largest production of rare earths, they are limiting their mining and smelting capabilities.

Australia currently holds the leading position in global lithium production, whereas Indonesia is the top nickel producer and the second-largest tin producer worldwide. Myanmar has recently established a rare earth smelting industry that can produce up to 22,000 tons annually. This resource imbalance has prompted resource-dependent nations to draft special policies for rare metals that align with their unique industrial landscapes and geopolitical settings.

**Table 1** - The trends in the rare metals industry across major countries

Category	Country	Contents
Supply	CHINA	The world's largest producer countries of rare metals
	AU	Lithium No. 1 producer countries
	ID	Nickel, the world's No. 1 and Tin No. 2 producer countries
	MY	Possession of rare earth processing industry
Demand	US	Reducing excessive dependence on supply chains and facilitating the expansion of alliance-centered cooperation
	EU	Announced of a plan to stabilize the supply and demand of key raw materials
	JPN	The promotion of a new International Resources Strategy with an Energy Strategy that Includes Rare Metals

For example, the United States is actively reducing its dependence on China for rare earths through initiatives such as REEshore, which was implemented in 2022. Efforts are underway to enhance collaboration with allied nations. Europe has revealed detailed schemes to guarantee a steady supply and demand of primary rare metal raw materials. The proposals consist of four overarching goals and ten actionable initiatives. Japan has also commenced a fresh international resource strategy for 2022 in conjunction with a material strategy aimed at backing its energy industry objectives. These efforts highlight the worldwide acknowledgment of the vital significance of uncommon metals and the need for bespoke policies to navigate the intricate terrain of their production and use.

### 2.3. International Trade Conflict

Presently, the global scenario surrounding rare metals is entangled in international trade conflicts, where disputes between nations impede the free flow of resources in accordance with their respective interests. This has been exacerbated by the recent global upheaval caused by the COVID-19 pandemic, which has disrupted the intricacies of the global supply chain, leading to adverse consequences for industries in each affected country due to decreased production at importers.

During the era of the COVID-19 pandemic, South Korea encountered substantial challenges in securing a stable raw materials supply. The pandemic-induced reduction in production in China significantly impacted the productivity of major industries in Korea, a reality underscored by the memorable urea water crisis experienced by the nation. Given this intricate backdrop, it becomes imperative for South Korea to formulate strategic countermeasures for establishing a virtuous cycle within the rare metals' industrial ecosystem. Additionally, proactive measures need to be taken to mitigate the risks associated with the supply of rare metals, ensuring resilience in the face of unforeseen challenges in the global supply chain.

## 2.4. Korea's Rare Metal Industry Development

### 2.4.1 'Strategy of Rare Metal Industry Development 2.0'

Against the backdrop of the current international landscape, the Korean government introduced the 'Strategy of Rare Metal Industry Development 2.0' in 2021, signifying a pivotal

initiative. This strategic framework is underpinned by three overarching policy objectives: 'Nurturing Core Companies,' 'Establishment of a Stable Rare Metal Supply Chain,' and 'Securing Resources.' To effectively realize these goals, the Korean government has embarked on a multifaceted approach encompassing the establishment of a resilient resource supply system, active support for rare metal companies, and the creation of a robust industrial development promotion system at the governmental level.

Fig. 1 shows the detailed strategy for 'Strategy of Rare Metal Industry Development 2.0' The strategic imperative of nurturing core companies underscores the government's commitment to fostering the growth and sustainability of key enterprises within the rare metal sector. Simultaneously, the focus on the establishment of a stable rare metal supply chain reflects a strategic orientation toward mitigating risks associated with global disruptions and ensuring a reliable and consistent flow of rare metals critical to various industries.

In addition, the prioritization of resource security highlights an acknowledgment of the geopolitical obstacles and potential vulnerabilities in the supply of valuable minerals. The government's plan involves taking proactive measures to secure and broaden channels of resources, guaranteeing resilience against any external disruptions.

In the pursuit of these objectives, the Korean government is actively implementing a suite of strategies that collectively contribute to the realization of a dynamic and self-sustaining rare metal industry. These encompass the establishment of a robust resource supply system, targeted support mechanisms for rare metal enterprises, and the creation of a conducive environment for industrial development through comprehensive governmental initiatives.

### 2.4.2. Legal Framework

In 2023, a landmark legislative initiative was introduced by the Korean government in collaboration with the Korea Institute of Industrial Technology, marking the inaugural legislation aimed at fostering the rare metal industry in Korea. This legislative endeavor aligns with the overarching goal of advancing the competitiveness of the Materials-Parts-Equipment system and fortifying the stability of the rare metal supply chain.

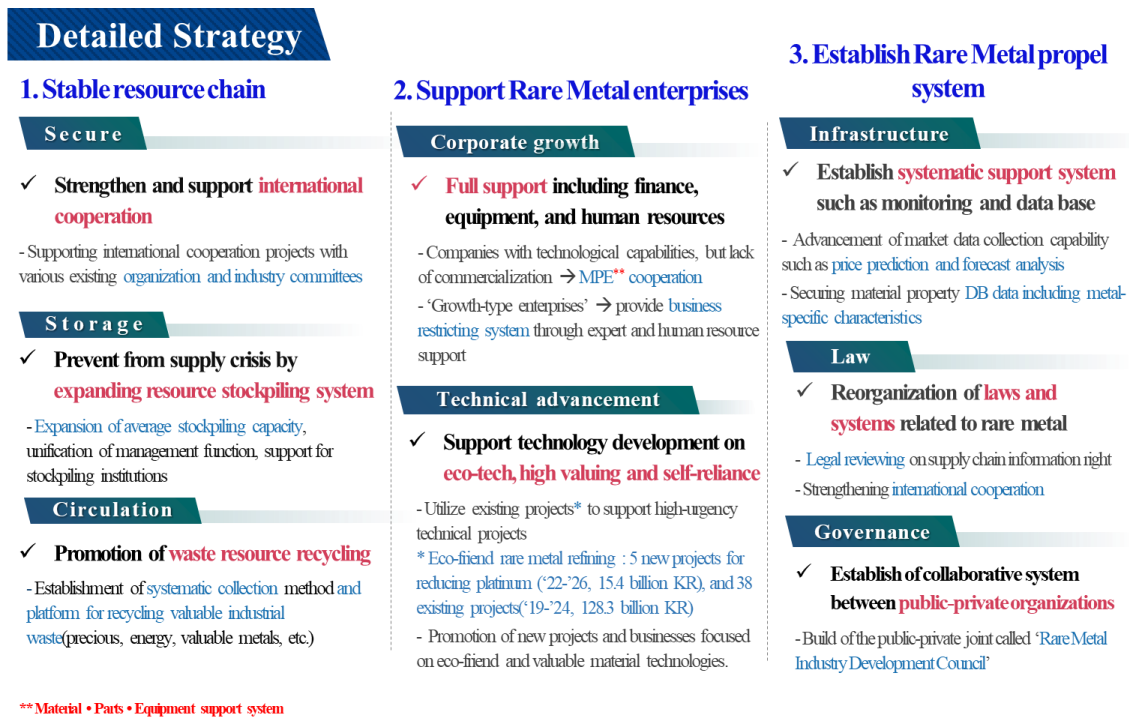


Figure 1 - Strategy of Rare Metal Industry Development 2.0

Recently instituted Actionable Commitments (ACTs) underpin efforts to propel the development of the rare metal industry, focusing on strategic measures to elevate the competitiveness of the Materials-Parts-Equipment system and ensure resilience in the rare metal supply chain. Specific details, including promulgation dates and identification numbers, elucidate the nuances of these commitments.

The legislative landscape witnessed a notable expansion with the introduction of new articles, namely Articles 37-2 and 37-3, complemented by their associated Enforcement Decree and Enforcement Rule. The motivation behind this legislative enactment is rooted in the commitment to periodically formulate policies every five years, fostering an environment conducive to nurturing and supporting companies integral to the rare metal industry.

Article 37-2 specifically addresses the formulation of policies designed to bolster the competitiveness of the rare metal industry, while Article 37-3 focuses on the establishment and operation of the National Rare Metal Center. Designated as the most fitting national research institute, the Korea Institute of Industrial Technology (KITECH) assumes the pivotal role in these legislative provisions. The Ministry of Trade, Industry, and Energy (MOTIE) officially designates KITECH as the National Rare Metal Center, reflecting its strategic significance.

In conformity with this legislative development announced last June, plans are underway for a signboard ceremony at the Korea Institute of Industrial Technology in December of the same year, formally designating it as the National Rare Metal Center. This legislative framework serves as a comprehensive strategy to cultivate and sustain the rare metal industry, addressing the evolving needs of both domestic and global industrial landscapes.

**2.5. Overview of Korea’s Rare Metal Industry**

Figure 2 provides an overview of Korea's rare metal industry, focusing on three key categories that have recently garnered attention due to supply and demand dynamics in the country. This exposition delves into three critical categories of rare metals that have recently gained prominence due to evolving supply and demand dynamics in Korea. The focal areas include rare earth metals pivotal for electric vehicles, refractory metals crucial for semiconductors/displays, and cathode materials essential for secondary batteries.

Commencing with the rare earth category, noteworthy Korean enterprises such as Hyundai and Kia have successfully commercialized motor parts for electric vehicles. Despite these accomplishments, a prevailing challenge lies in the lack of localized production for rare earth alloys and magnetic materials, integral components for electric vehicle motors [[16], [17], [18], [19], [20]]. Consequently, Korea has initiated research endeavors to produce

rare earth metals and their alloys, either sourced from imported rare earth oxides or domestically generated scraps.

Transitioning to the domain of high-melting-point metals, conventionally employed as structural alloys or additives for steel materials, these metals have found extensive application in the semiconductor industry. Korea currently relies entirely on imports of ultra-high-purity metals, sourcing from companies like Mitsui in Japan, Honeywell in the US, and KFMI in China. To enhance self-sufficiency, collaborative efforts between KITECH and industry partners are underway to develop technology for the commercialization of ultra-high-purity metal manufacturing. Recent achievements include the successful production of commercial-grade ultra-high-purity metal, with subsequent technology transfer to domestic companies.

The third category concerns secondary batteries, with LG Energy Solutions and Samsung SDI being prominent contributors to 35% of the world's annual manufacturing capacity. Nevertheless, Korea only possesses a paltry 0.5% of corresponding precursor manufacturing capacity. Despite domestic lithium, cobalt, or nickel deposits being absent, Korea has a substantial amount of scraps and process by-products, presenting a feasible opportunity for recycling. Sungil Hitech, based in Korea, is acknowledged for its world-leading technology in the recycling of secondary batteries, and is actively expanding its production. However, the current recycling capacity amounts to only a fraction - approximately 1/10 - of the imported raw materials necessary for secondary batteries in Korea, highlighting the need for more recycling companies to meet demand.

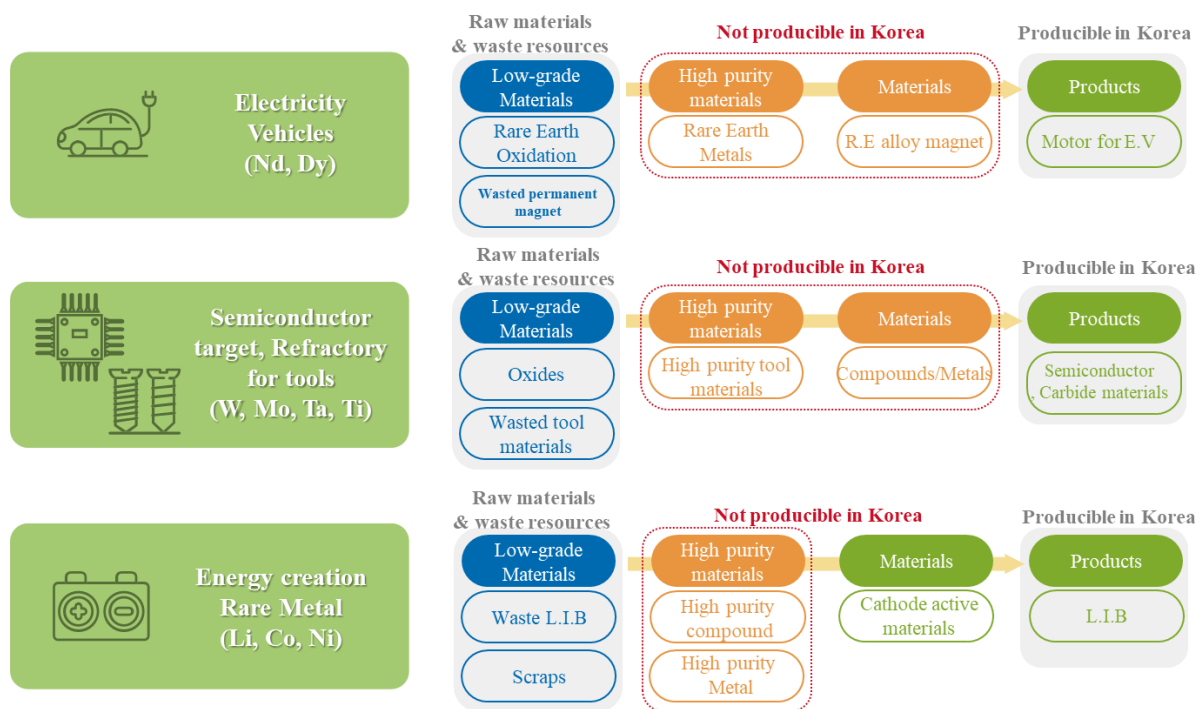


Figure 2 - Overview of Korea's rare metal industry

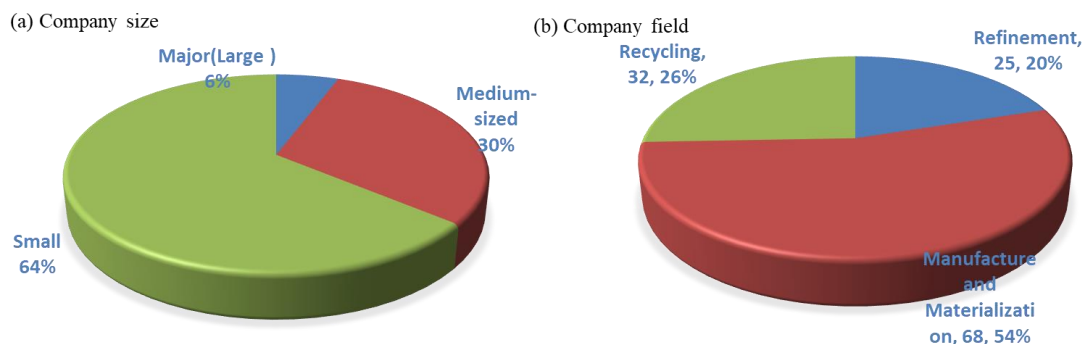


Figure 3 - Current survey results of 125 companies related to rare metal



Figure 3 illustrates a graph that surveys the size and fields of Korean companies in the rare metal industry. The study, which focuses on the rare metal sector, provides valuable insights into 125 companies operating in Korea. These entities are actively involved in rare metal-related activities, either by directly producing rare metals or by developing intermediate goods in this field. It is essential to highlight the significance of rare metals in the Korean economy, as these metals are critical components in various high-tech products.

Notably, of the 125 surveyed companies, 64% are small enterprises that may have difficulty meeting the demands of larger entities such as Samsung and LG. In light of this situation, the government has formulated policies with the objective of advancing and bolstering small-scale businesses. It is significant to note that KITECH assumes a critical position in directing its backing towards these smaller firms, conforming to state initiatives.

Building on existing policies and legislative frameworks, KITECH seeks to enhance the presence of recycling and refining firms in the rare metal industry. The primary aim is to promote the development of technologies that are essential for these companies, promoting sustainable growth and innovation within the rare metal sector in Korea.

In recent times, the international landscape has undergone significant transformations marked by events like Japan's export restrictions, the US-China

trade war, and the global impact of COVID-19. Within this dynamic environment, South Korea encountered fluctuations in supply and demand, underscoring the critical importance of securing raw materials for the nation.

Recognizing the imperative of a stable resource supply foundation and the expansion of technological capacities in the Rare Metal industry, there is a pressing need to enhance recycling and refining technologies. This strategic endeavor aims not only to fortify the resilience of the industry but also to contribute to the establishment of a circular rare metal industrial economy. By fostering a circular structure, Korea seeks to ensure the sustainable utilization and circulation of rare metals, mitigating supply chain vulnerabilities and enhancing its position in the global rare metal landscape.

### 3. Conclusions

This paper sheds light on the current state of Korea's rare metal industry, highlighting its global context, supply and demand dynamics, and government strategies. It emphasizes the importance of international cooperation, policy adjustments, and technological advancements to ensure a sustainable and secure rare metal supply chain.

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## Кореядағы «Сирек металдар өнеркәсібінің» жағдайы

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### ТҮЙІНДЕМЕ

Бұл жұмыс Кореядағы сирек металдар өнеркәсібін терең зерттеп, оның сипаттамасын, жіктелуін, сұраныс пен ұсыныс динамикасын, халықаралық сауда мәселерін және үкіметтің стратегиялық бастамаларын қарастырады. Зерттеу сирек металдардың жаһандық маңыздылығын, олардың біркелкі емес таралуынан туындайтын қиындықтарды және елдердің, соның ішінде Кореяның осы проблемаларды стратегиялық тұрғыдан шешуге міндетті екенін көрсетеді. Сондай-ақ мақалада Кореяның соңғы заңнамалық және саяси негіздері зерттеліп, Кореяның өнеркәсіптік технологиялар институтының (KITECH) сирек металл өнеркәсібін дамытудағы рөлі атап өтіледі. Сонымен қатар, мақалада электр көліктеріне арналған сирек жер металдары, жартылай өткізгіштер/дисплейлер үшін отқа төзімді металдар және екінші реттік батареяларға арналған катодты материалдар сияқты негізгі салаларға тоқталып, Кореяның сирек металдар өнеркәсібінің қазіргі жағдайы талқыланады. Қорытынды бөлімде сирек металдардың қалдықсыз өнеркәсіптік экономикасын құру үшін қажетті технологиялық жетістіктерге, қайта өңдеуге баса назар аударылады.

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	<b>Түйін сөздер:</b> сирек металдар, отқа төзімді металдар, жартылай өткізгіш/дисплей және катодты материалдар, экономика, өнеркәсіп.
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## Состояние дел в «индустрии редких металлов» в Корее

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	<b>АННОТАЦИЯ</b> В этой статье представлено углубленное исследование индустрии редких металлов в Корею, рассматривается ее определение, классификация, динамика спроса и предложения, международные торговые проблемы и стратегические инициативы правительства. Исследование подчеркивает глобальное значение редких металлов, проблемы, связанные с их неравномерным распределением, а также необходимость для стран, включая Корею, решать эти проблемы стратегически. В документе также подробно рассматривается недавняя правовая и политическая база Кореи, подчеркивающая роль Корейского института промышленных технологий (KITECH) в развитии промышленности редких металлов. Кроме того, в нем обсуждается текущее состояние индустрии редких металлов в Корею, освещаются такие ключевые области, как редкоземельные металлы для электромобилей, тугоплавкие металлы для полупроводников/дисплеев и катодные материалы для аккумуляторных батарей. В заключительном разделе подчеркивается необходимость технологических достижений, переработки и переработки для создания безотходной промышленной экономики редких металлов. <b>Ключевые слова:</b> металлы, тугоплавкие металлы, полупроводниковые/дисплейные и катодные материалы, экономика, промышленность.
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