MARKETSANDMARKETS™

RARE EARTH METALS RECYCLING MARKET

GLOBAL FORECAST TO 2026

BY APPLICATION (PERMANENT MAGNETS, ALLOYS, POLISHING MATERIALS, GLASS, CATALYST, PHOSPHOR, CERAMICS, HYDROGEN STORAGE ALLOYS), TECHNOLOGY (HYDROMETALLURGICAL, PYROMETALLURGICAL) AND REGION

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL FORM
APAC	Asia Pacific
CAGR	Compound Annual Growth Rate
EMEA	Europe, Middle East, and Africa
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
IMF	International Monitory Fund
MEA	Middle East & Africa
PPP	Public-private Partnerships
R&D	Research & Development
SME	Subject Matter Experts
FCC	Fluid Catalytic Cracking

1 INTRODUCTION

1.1 OBJECTIVES OF THE STUDY

- To estimate and forecast the rare earth metals recycling market in terms of value and volume
- To elaborate on the drivers, restraints, opportunities, and challenges in the market
- To define, describe, and forecast the market size based on application, source, technology, and region
- To forecast the market size in the key regions: North America, Europe, Asia Pacific, and the Rest of World, along with the key countries in these regions
- To strategically analyze micromarkets[1] with respect to individual growth trends, prospects, and their contribution to the total market
- To analyze growth opportunities in the market for stakeholders and provide details on the competitive landscape for the market leaders
- To strategically profile key players and comprehensively analyze their market shares and core competencies[2]
- To analyze competitive developments such as merger & acquisition, expansion & investment, agreement, partnership & joint venture, and new product development in the rare earth metals recycling market

1.2 MARKET DEFINITION

Rare earth elements are a group of 17 chemical elements that occur together. The group consists of yttrium and the 15 lanthanide elements (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium). Scandium is found in most rare earth element deposits and is sometimes classified as a rare earth element. The International Union of Pure and Applied Chemistry includes scandium in their rare earth element definition.

Rare earth elements are all metals, and the group is often referred to as "rare earth metals." These metals have many similar properties, which often causes them to be found together in geological deposits. They are also referred to as "rare earth oxides" because many of them are typically sold as oxide compounds.

Rare earth metals are important for modern technologies and are critical components in permanent magnets, electrical vehicles, and smartphones, among others. The elements occur naturally in ores; however, mining and separating the mineral ores is challenging. Further, these elements are limited in nature. Thus, recycling is an alternative to mining, but the cost of re-separation and purification of the elements is a challenge.

Recycling rare earth metals would result in steady use in multiple end uses, along with a reduction in waste. Currently, the recycling rate of rare earth metals is low from end-use products, with most of them landing up in waste.

1. Micromarkets are defined as the segments and subsegments of the global rare earth metals recycling market included in the report.

2. Core competencies of the companies are captured in terms of their key developments and key strategies adopted by them to sustain their position in the market.

1.3 INCLUSION AND EXCLUSION

TABLE 1 INCLUSION AND EXCLUSION

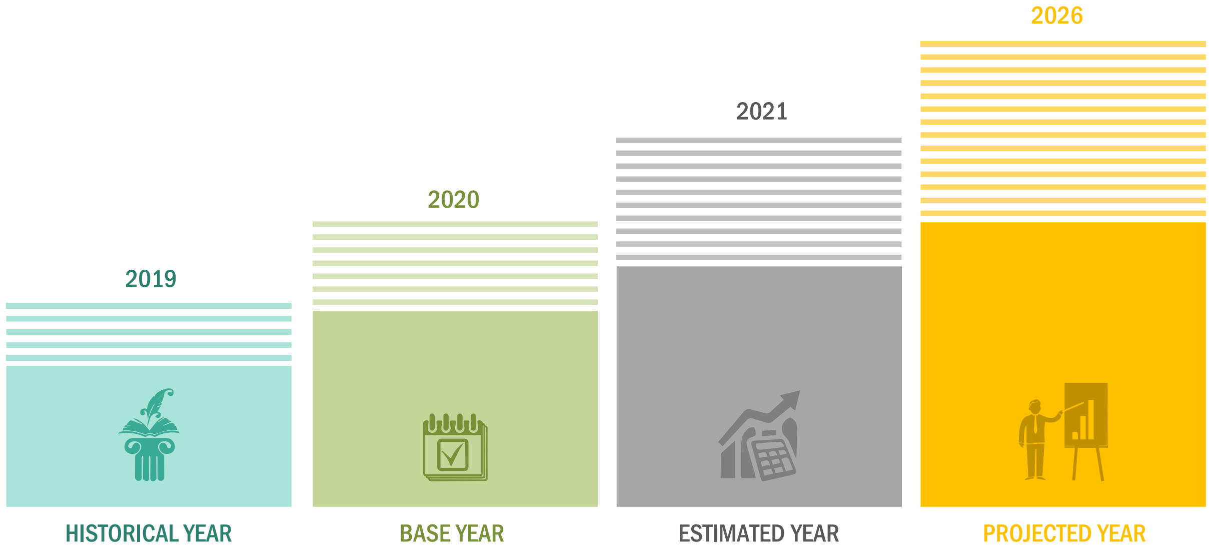
SEGMENT	INCLUSION	EXCLUSION
By Application	▪ Alloy ▪ Catalyst ▪ Permanent magnets ▪ Glass ▪ Ceramics ▪ Phosphor ▪ Polishing materials ▪ Hydrogen storage alloys	NA
By Source	▪ FCC ▪ Fluorescent lamps ▪ Magnets ▪ Batteries ▪ Industrial process	NA
By Technology	▪ Hydrometallurgical ▪ Pyrometallurgical	NA

1.4 MARKET SCOPE

This report covers the rare earth metals recycling market, which is segmented based on application, source, technology, and region.

FIGURE 1 RARE EARTH METALS RECYCLING MARKET SEGMENTATION

1.4.1 YEARS CONSIDERED



Note: The base year considered for most company profiles is 2020. In cases where the recent financial data was not available for the base year, data pertaining to 2019 was considered.

1.4.2 REGIONAL SCOPE

FIGURE 2 RARE EARTH METALS RECYCLING MARKET, BY REGION

Notes: Rest of Europe includes Italy, Russia, Spain, Belgium, Greece, Romania, and Switzerland.

Rest of Asia Pacific includes India, South Korea, Singapore, Indonesia, the Philippines, Vietnam, Taiwan, and Malaysia.

1.5 CURRENCY CONSIDERED

The base currency considered to denote the market size and company revenues in this report is United States dollars (USD); the unit used for representing the revenues and market size is USD million.

For companies reporting their revenues in USD, the data was taken from their annual reports.

For companies that reported their revenues in other currencies, the average annual currency conversion rate was taken from New Zealand Forex for that particular year to convert the values to USD.

1.6 UNIT CONSIDERED

The base unit used in the report to estimate the market size, in terms of volume, is metric ton.

1.7 STAKEHOLDERS

- Raw material suppliers and producers
- Regulatory bodies
- Rare earth metals recyclers
- End-use industries of rare earth metals
- Associations and industrial bodies
- Local governments
- Market research and consulting firms

1.8 LIMITATIONS

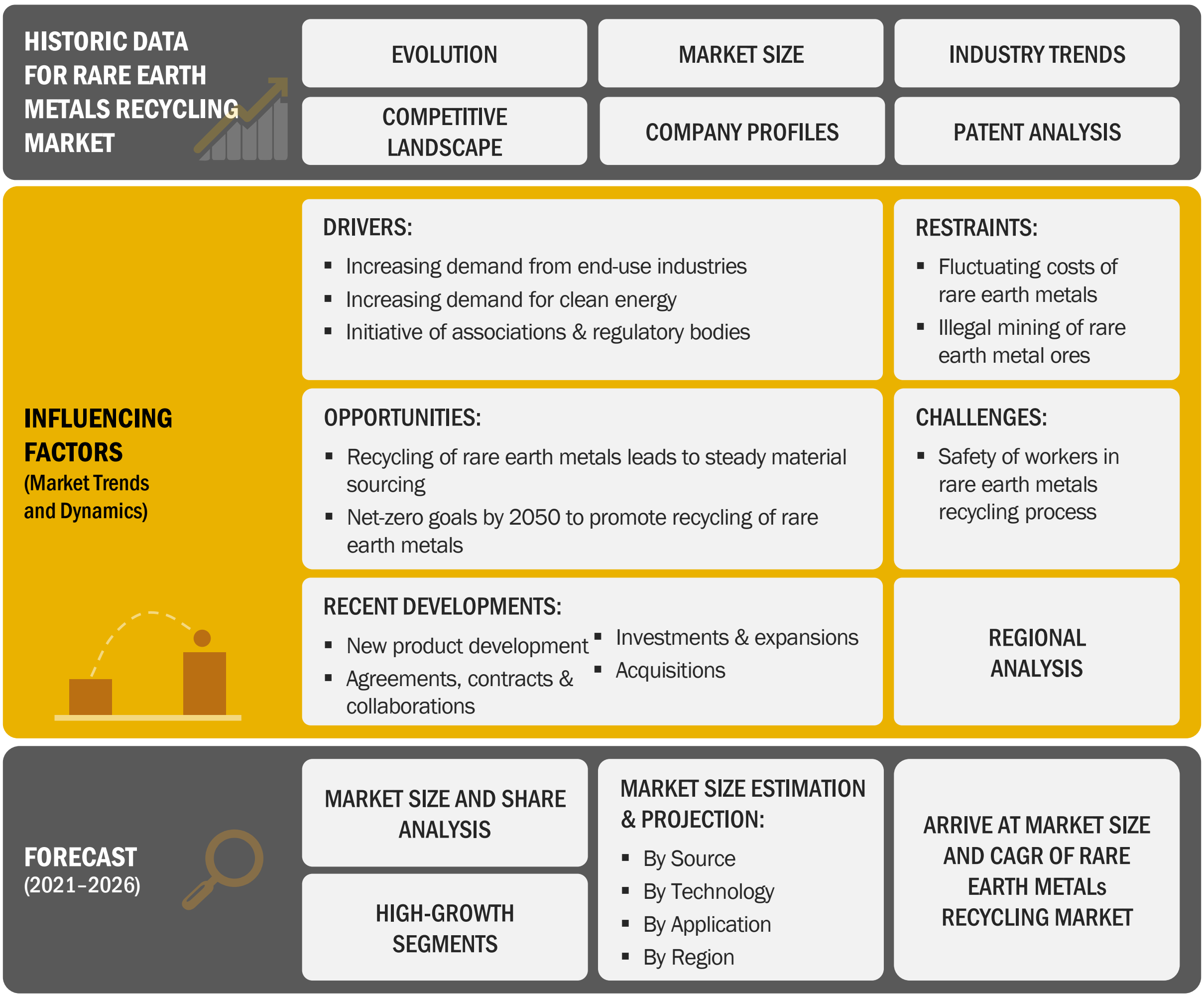
The quantitative information for certain market segments was kept confidential by some players. Hence, qualitative insights gathered during this study were used to arrive at the market size for some of the segments and sub-segments.

2 RESEARCH METHODOLOGY

2.1 RESEARCH DATA

This research study involved the usage of extensive primary as well as secondary sources for information. Primary sources consisted of several industry experts in the rare earth metals recycling market, related solutions and services providers, and academics & scientific research professionals. These sources have been interviewed to obtain and verify critical qualitative and quantitative information as well as to assess prospects. Secondary sources include press releases, investment reports, industry white papers, presentations, company annual reports, and other publicly available sources to collect information useful for this comprehensive, technical, market-oriented, and commercial study of the global rare earth metals recycling market.

FIGURE 3 RARE EARTH METALS RECYCLING MARKET: RESEARCH DESIGN



Source: Interviews with Experts, Secondary Research, and MarketsandMarkets Analysis

2.2 MARKET SIZE ESTIMATION

The market size estimation for the rare earth metals recycling market was calculated through the top-down approach. In order to estimate the global value of the market, the following were taken into account:

- The market size was estimated by triangulating the data obtained from the demand and supply side, MnM repository, and primary interviews.
- The rare earth metals recycling market size was also obtained directly from primary respondents.
- Regional split and country-level split assumptions have been made based on primary inputs, manufacturers' presence, association data, and demand for rare earth metals recycling by region.
- Based on all the primary sources, Asia Pacific is the largest market, accounting for approximately 65-70% of the global market, followed by North America and Europe at 12-15% and 10-12%, respectively.
- The market share of each rare earth metals recycling source has been considered based on primary inputs and the top ten manufacturers' product portfolios/type of product offering analysis.
- The market shares of the top manufacturers are analyzed through several parameters, including their revenue, geographical presence, product offerings, and the industry they cater to.

All the available data and information were validated through interviews with experts. The data on the regional share of the market was considered based on inputs from primary respondents and MnM repository.

The country-level market share was considered based on country-level manufacturers' inputs. In some countries where updated data and information were not available, MnM repository data was considered for calculation. All the available data and information were validated by manufacturers and other members of the supply chain.

2020 was considered as the base year for the calculation of the rare earth metals recycling market size. The following methodology was used for the calculation of the base market size.

2.2.1 SUPPLY-SIDE APPROACH

FIGURE 4 RARE EARTH METALS RECYCLING MARKET: SUPPLY-SIDE APPROACH

RARE EARTH METALS RECYCLING MARKET CALCULATION METHODOLOGY– BASE YEAR (2020) - SUPPLY SIDE

After calculating the global market volume, the production of rare earth metals from secondary sources on regional level has been calculated.

Total Market (2020) – 4,692.4 Kiloton

Region	% Contribution	Kiloton
Asia Pacific	69.8%	3,275.3
North America	15.1%	708.6
Europe	11.9%	558.4
Rest of World	3.2%	150.2

From primaries and secondary sources, rare earth metals recycling in each region was calculated. The regional revenue mix of the leading supplier such Solvay SA, Hitachi Metals, Ltd., Umicore, OSRAM Licht AG, Energy Fuels Inc., and others was considered while deriving the regional level production.

2.2.2 DEMAND-SIDE APPROACH

FIGURE 5 RARE EARTH METALS RECYCLING MARKET: DEMAND-SIDE APPROACH

BASE NUMBER CALCULATION – APPROACH MARKET SIZE OF RARE EARTH METALS RECYCLING BASED ON GLOBAL RARE EARTH METALS CONSUMPTION		
Global rare earth metals market (Volume)	Global rare earth metals market (Volume) * percentage of rare earth metals recovered from secondary sources = Global rare earth metals recycling market	(Global rare earth metals recycling market (Volume) × ASP of rare earth metals recovered from secondary sources = Global rare earth metals recycling market (USD Million)
Global consumption of rare earth metals market was calculated through secondary sources	From the global rare earth metals market, the percentage share of rare-earth metals recovered from secondary sources was determined to arrive at the global rare earth metals recycling market in terms of consumption (volume)	The rare earth metals recovered from secondary sources (in terms of volume) was multiplied with the average selling price (ASP) of rare earth metals recovered from secondary sources for the year 2020 to arrive at the market size of rare earth metals recycling in USD million.

Source: Secondary Research, Primary Interviews, and MarketsandMarkets Analysis

2.3 MARKET ENGINEERING PROCESS

Both the top-down and bottom-up approaches were used to estimate and validate the size of the rare earth metals recycling market and various other dependent segments. The key players operating in the rare earth metals recycling market were identified through secondary research. Their annual capacity were identified at the global level through primary and secondary research. This procedure included the study of annual and financial reports of key market players and extensive interviews with industry leaders, such as Chief Executive Officers (CEOs), vice presidents, directors, and marketing executives of leading companies, to obtain key insights.

The recycling of rare earth metals of each country considered in the scope of research was calculated and summed up to arrive at the regional market numbers. The volume arrived at using the top-down and bottom-up approaches were multiplied by the ASP of rare earth metals recycling for the year 2020, at the global and country levels, to obtain the market size in terms of USD million.

All percentage shares, splits, and breakdowns were determined using secondary sources and verified through primary sources. All possible parameters that affect the markets covered in this research study were accounted for, viewed in extensive detail, verified through primary research, and analyzed to obtain the final quantitative and qualitative data on the rare earth metals recycling market.

2.3.1 TOP-DOWN APPROACH

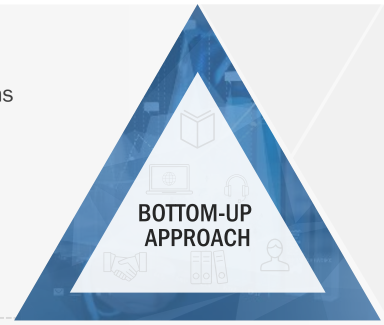
FIGURE 6 MARKET SIZE ESTIMATION: TOP-DOWN APPROACH

- Total market size in terms of volume (Kiloton)
- Percentage contribution of each individual segment to the overall market size
- Market split for application for each region
- Market split for each country for each segment

2.3.2 BOTTOM-UP APPROACH

FIGURE 7 MARKET SIZE ESTIMATION: BOTTOM-UP APPROACH

- Total market size (USD million)
- Calculation of global market size (by value) by summation (A x B) of all regions
- Average selling price (ASP) per region
- Regional market size (by volume) (A)
- Market share (by volume) of major countries estimated in each region



The bottom-up approach was used to arrive at the overall size of the rare earth metals recycling market by estimating the rare earth metals recycling at the country level. Based on this number, the consumption of recycled rare earth metals across each country was calculated. The market size for each country was multiplied by the ASP of recycled rare-earth for the year 2020 to determine the market size in terms of value (USD billion/million).

For the calculation of a specific market segment, the most appropriate and immediate parent market size was used to implement the top-down approach. The bottom-up approach was also implemented for the data extracted from secondary research to validate the market segment revenues obtained.

Sales of various companies were identified to calculate the share of these players in the rare earth metals recycling market. With the data triangulation procedure and validation of data through primaries, the exact values of the overall parent market were determined and confirmed.

2.4 MARKET BREAKDOWN AND DATA TRIANGULATION

After arriving at the total market size from the estimation process explained above, the overall market was split into several segments and subsegments. Data triangulation procedures were used, wherever applicable, to complete the overall market engineering process and arrive at the exact statistics for all segments and subsegments. The data was triangulated by studying various factors and trends from both the demand and supply sides. Subsequently, the market size was verified through primary interviews.

FIGURE 8 DATA TRIANGULATION

PRIMARY SOURCES

DEMAND SIDE

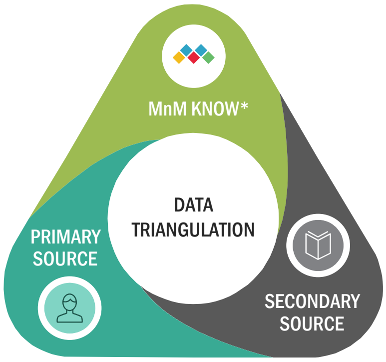
INTERVIEWS WITH:

- Rare Earth Metals Recyclers
- CEOs
- Purchase Managers
- Marketing and Business Development Managers

SUPPLY SIDE

INTERVIEWS WITH:

- CEOs
- Vice Presidents
- Managing Directors
- Technology & Innovation Directors
- Key Executives of Organizations Operating in the Rare Earth Metals Recycling Market



SECONDARY SOURCES

- The Rare Earth Industry Association (REIA)
- HSCodes.org
- British Metals Recycling Association (BMRA)
- Metal Bulletin
- European Metal Trade and Recycling Association
- Canadian Association of Recycling Industries)

Annual Reports, Presentations, Websites, and Press Releases News Articles, Journals, Paid Databases, and MnM KNOW*

INFORMATION SOURCED

Key Players	Competitive Landscape	Opportunities/ Challenges	Market Size and Share
Influencing Factors	Market Forecast	Regional Analysis	

*MnM KNOW stands for MarketsandMarkets' 'Knowledge Asset Management' framework. In this context, it stands for existing market research knowledge repository of over 5,000 granular markets, our flagship competitive intelligence and market research platform "Knowledge Store", subject matter experts, and independent consultants. MnM KNOW acts as an independent source that helps us validate information gathered from primary and secondary sources.

2.4.1 SECONDARY DATA

In the secondary research process, various sources were referred to identify and collect information for this study. Secondary sources included annual reports, rare earth metals recyclers association, press releases & investor presentations of companies, white papers, rare earth metals recycling magazines and associations, certified publications, and articles by recognized authors, authenticated directories, and databases.

Secondary research was mainly conducted to obtain key information about the supply chain of the industry, the monetary chain of the market, the total number of market players, market classification & segmentation according to industry trends to the bottom-most level, regional markets, and key developments from both market- and technology-oriented perspectives.

2.4.1.1 Key data from secondary sources

PARAMETER	SOURCE
MARKET SIZE	▪ Company Financials ▪ Magazines ▪ Journals ▪ Press Releases ▪ Paid Databases ▪ MarketsandMarkets Data Repository
REVENUE OF COMPANIES	▪ Annual Reports ▪ Company Websites ▪ Public Databases ▪ MarketsandMarkets Data Repository
QUALITATIVE INFORMATION (Market Dynamics and Trends)	▪ Company Websites ▪ Annual Reports ▪ Press Releases ▪ MarketsandMarkets Data Repository

2.4.2 PRIMARY DATA

In the primary research process, various sources from both the supply and demand sides were interviewed to obtain qualitative and quantitative information for this report. The primary sources from the supply side included industry experts such as Chief Executive Officers (CEOs), Vice Presidents (VPs), marketing directors, technology & innovation directors, consultants, and related key executives from major companies and organizations operating in the market. Primary sources from the demand side included researchers, technologists, and sales/purchase managers from the rare earth metals recycling industry.

After the complete market engineering (which includes calculations for market statistics, breakdowns, size estimations & forecast, and data triangulation), extensive primary research was conducted to gather information and verify and validate the critical numbers arrived at. Primary research was also conducted to identify the segmentation types, industry trends, Porter's Five Forces analysis, leading players, and key market dynamics such as drivers, restraints, opportunities, challenges, and strategies of key players.

As a part of the complete market engineering process, both the top-down and bottom-up approaches were extensively used along with the data triangulation method to estimate the size of the market and forecast all segments and subsegments listed in this report for the next five years (2021–2026). Extensive qualitative and quantitative data were analyzed to list key information/insights throughout the report. The methodology used for the projection of quantitative data from 2021 to 2026 involved the estimation of GDPs of particular countries based on which the CAGRs were calculated.

2.4.2.1 Key data from primary sources

TYPE	PARAMETER	KEY DATA
REGIONAL SPLIT	▪ Regional segmentation of rare earth metals recycling market ▪ CAGR of rare earth metals recycling market in each region during the forecast period (2021–2026)	▪ Rare earth metals recycling market, by region – Asia Pacific, Europe, North America, and Rest of World
GLOBAL MARKET SIZE	▪ Size of rare earth metals recycling market in 2020 ▪ CAGR of rare earth metals recycling market during the forecast period (2021–2026)	▪ Rare earth metals recycling market, by value (USD Million) and volume (Kiloton)
MARKET SPLIT	▪ By Source ▪ By Technology ▪ By Application	▪ By source - fluorescent lamps, magnets, batteries, fluid catalytic cracking, and industrial process ▪ By technology - hydrometallurgical and pyrometallurgical ▪ By application - alloy, catalyst, permanent magnets, glass, ceramics, phosphor, polishing materials, hydrogen storage alloys

2.4.2.2 Key industry insights

“

Rare earth metals recycling is less than 3% of the global demand for rare earth metals in 2020.

- CO-Founder & CEO
Rare Earth Metals Recycling Company

Lamp phosphor is the largest secondary source for rare earth metals recycling.

- Scientist and Technology office
Leading Rare Earth Metals Manufacturer

Asia Pacific is the largest and fastest-growing market, and China accounts for the largest share in the rare earth metals recycling market.

- General Manager
Global Rare Earth Association

Permanent magnets is the largest application segment in the market.

- Vice-President Magnets Division
Leading Magnets Manufacturer

”

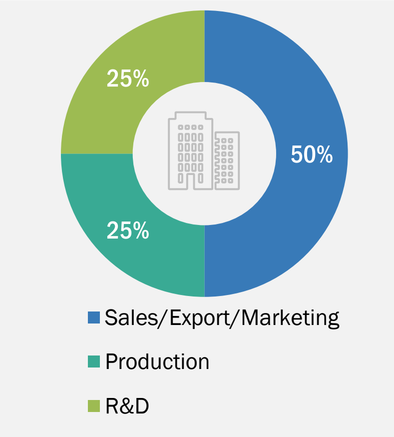
Source: Primary Interviews

TABLE 2 LIST OF STAKEHOLDERS INVOLVED

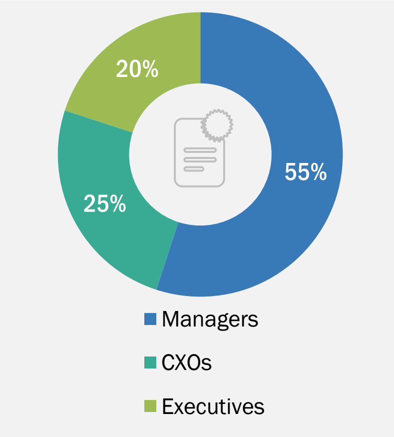
RARE EARTH METALS RECYCLERS	ASSOCIATION
Solvay SA	The Rare Earth Industry Association (REIA)
Hitachi Metals, Ltd.	British Metals Recycling Association (BMRA)
Umicore	European Metal Trade and Recycling Association
OSRAM Licht AG	Canadian Association of Recycling Industries)
Energy Fuels Inc.	Waste Electrical and Electronic Equipment Recycling (WEEE)

2.4.2.3 Breakdown of primary interviews

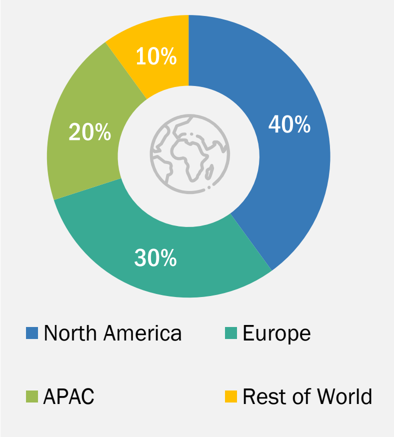
SHARE OF INTERVIEWS, BY DEPARTMENT



SHARE OF INTERVIEWS, BY DESIGNATION



SHARE OF INTERVIEWS, BY REGION



Notes: Tiers of companies are defined on the basis of their total revenues in 2020; Tier 1 = > USD 1 billion, Tier 2 = USD 500 million–USD 1 billion, and Tier 3 = <USD 500 million.

Other designations include sales, marketing, and product managers.

2.5 ASSUMPTIONS

PARAMETER	ASSUMPTION
ECONOMY	▪ Global economic conditions are assumed to remain favorable till the end of 2026. Inflation is considered for pricing and the price of rare earth metals recovered from secondary sources is expected to fluctuate during the forecast period. ▪ Effect of COVID-19 has been considered in the study.
POLITICAL STABILITY	▪ All regions are assumed to remain politically stable during the forecast period. ▪ The impact of political or economic instability was not considered for the study period.
EXCHANGE RATES	▪ Exchange rate fluctuations will not negatively impact the market forecast to a significant extent.

2.5.1 RISK ASSESSMENT

TABLE 3 RARE EARTH METALS RECYCLING MARKET: RISK ASSESSMENT

SEGMENT	COVERED	RISK
Rare earth metals recycling market, by source	All segments have been covered, including fluorescent lamps, magnets, batteries, fluid catalytic cracking, and industrial process.	NA
Rare earth metals recycling market, by technology	All segments have been covered, including hydrometallurgical and pyrometallurgical.	NA
Rare earth metals recycling market, by application	All segments have been covered, including alloy, catalyst, permanent magnets, glass, ceramics, phosphor, polishing materials, and hydrogen storage alloys.	NA
Rare earth metals recycling market, by country	Country-wise market size is provided by source, by technology, and by application.	NA

TABLE 4 RISK ANALYSIS

DESCRIPTION	RISK ANALYSIS
Assumptions have been made for some countries where data or information is not available.	Low
Growth rate for each segment is based on historical data and information along with primary inputs and some assumptions. Due to the impact of COVID-19, the possibility of slow growth has been considered.	Long term: High Short term: Low

2.6 LIMITATIONS

PARAMETER	DESCRIPTION
Methodology-related Limitations	▪ The market size estimation from the supply side has been done based on approximations of the market share of major vendors. ▪ The market size of the overall market has been arrived at using a holistic and systematic approach.
Scope-related Limitations	▪ The quantitative information for market sub-segments has been kept confidential by market players. Hence, qualitative insights have been provided.

2.7 GROWTH RATE ASSUMPTIONS/GROWTH FORECAST

The growth forecast model was defined based on the assessment of qualitative and quantitative factors affecting the market growth. These mainly include:

- Historic revenue growth trends of leading players in the market
- Demand-side factor assessment, including indicative estimates of R&D spending
- Impact assessment of historic competitive trends driving market growth, which include product launches, strategic growth initiatives, innovation trends, and R&D initiatives
- Impact assessment of regulatory guidelines/mandates on market growth over the forecast period

The impact of the underlying drivers on the rare earth metals recycling market is quantified in the table below. Growth contributions to the existing growth rates were derived majorly from primary research, and the impact of growth drivers was analyzed for 2- and 5-year forecasts. Quantifications can vary significantly with each individual primary participant, and hence, percentages were provided in ranges. Cumulative growth drivers were calculated simply by adding the individual parameters contributing to growth.

FIGURE 9 MARKET GROWTH PROJECTIONS: DRIVERS AND OPPORTUNITIES

DRIVERS	2 YEARS	5 YEARS	REASON	CONTRIBUTION TOWARD GROWTH
Increasing demand from end-use industries	●	●	Rare earth metals, owing to their various properties, find applications in a wide range of industries. The hybrid electric vehicle (HEV) market is expected to drive growth for rare earth magnets as they use more rare earth magnets per vehicle compared to conventional automobiles. The application of rare earth magnets in wind turbines, consumer & industrial electronic, and catalyst systems is expected to be another major driver in the long term.	(+) 11%–12%
Increasing demand for clean energy	●	●	The green energy market is witnessing a significant boost as increasing new legislations are passed by different regulatory bodies across the world. These legislations are banning the use of conventional mediums in industries, and they require the use of green technologies, such as wind turbines, hybrid electric vehicles, and compact fluorescent lighting.	(+) 9%–10%
			CUMULATIVE GROWTH FROM DRIVERS	(+) 10%–12%

IMPACT LEVEL : ● HIGH ● MEDIUM ● LOW ● VERY LOW

Source: Secondary Research, Primary Interviews, and MarketsandMarkets Analysis

3 EXECUTIVE SUMMARY

Rare earth elements are a group of 17 chemical elements that occur together. The group comprises yttrium and the 15 lanthanide elements (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium). Scandium is found in most rare earth element deposits and is sometimes classified as a rare earth element. The International Union of Pure and Applied Chemistry includes scandium in its rare earth element definition.

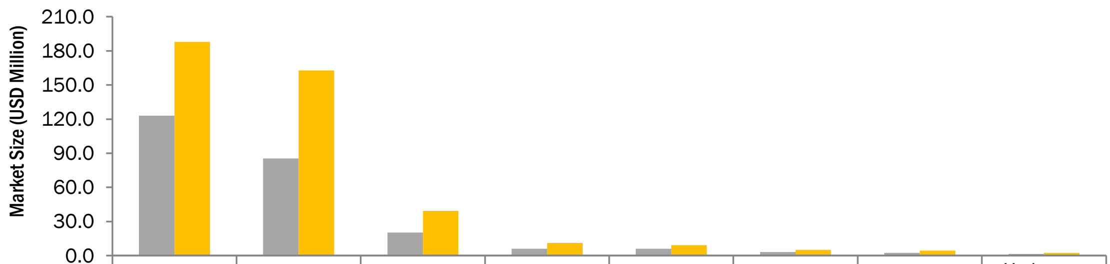
Rare earth elements are all metals, and the group is often referred to as "rare earth metals." These metals have many similar properties, often causing them to be found together in geological deposits. They are also referred to as "rare earth oxides," as many of them are typically sold as oxide compounds.

Rare earth metals are available in various forms, such as lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium, scandium. These oxides are widely used in permanent magnets, metal alloys, glass polishing, glass, additives, catalysts, phosphors, ceramics, and other applications. Other emerging end users of rare earth metals are the aerospace & defense and medical sectors.

The rare earth metals recycling market was valued at USD 248.2 million in 2021 and is projected to reach USD 422.3 million by 2026, at a CAGR of 11.2% during the forecast period.

Increasing demand for rare earth metals from various end-use industries, especially in the Asia Pacific region, is expected to drive the demand for rare earth metals in the near future. Rare earth metals are considered key elements in developing technologies in the communications, electronics, automotive, and military weapon sectors. The demand for these elements is expected to increase in the near future as these are key components in emerging applications, such as green technology and electric and hybrid vehicles.

FIGURE 10 **GLASS APPLICATION TO DOMINATE RARE EARTH METALS RECYCLING MARKET BY 2026**



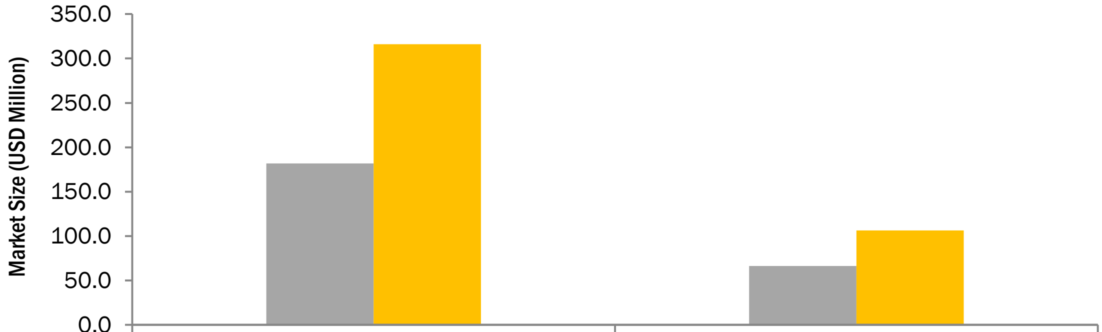
	Glass	Permanent Magnets	Phosphor	Ceramics	Alloy	Catalyst	Polishing Materials	Hydrogen Storage Alloys
2021	123.1	85.5	20.3	6.1	5.9	3.2	2.4	1.4
2026	188.0	162.8	39.3	11.0	9.2	5.1	4.3	2.5
CAGR (2021-2026)	8.8%	13.8%	14.1%	12.4%	9.2%	9.6%	12.2%	11.8%

Source: Secondary Literature, Expert Interviews, and MarketsandMarkets Analysis

Erbium, ytterbium, and neodymium are the most widely used rare earth metals in glass. Optical communication uses erbium-doped silica fiber, engineering materials processing uses ytterbium-doped silica fiber, and glass lasers used for inertial confinement fusion apply neodymium-doped. The ability to change the fluorescent properties of glass is one of the most important uses of rare earth metals in glass.

Rare earth is used as clarifier, additive, decolorizer, colorant, and polishing powder in the glass industry and plays an irreplaceable role in other elements. By using the characteristics of high refraction and low dispersion of some rare earth elements, optical glass can be produced, which can be used to make good lenses for cameras, telescopes, and other good optical instruments.

FIGURE 11 HYDROMETALLURGICAL TECHNOLOGY TO DOMINATE RARE EARTH METALS RECYCLING MARKET, 2021-2026

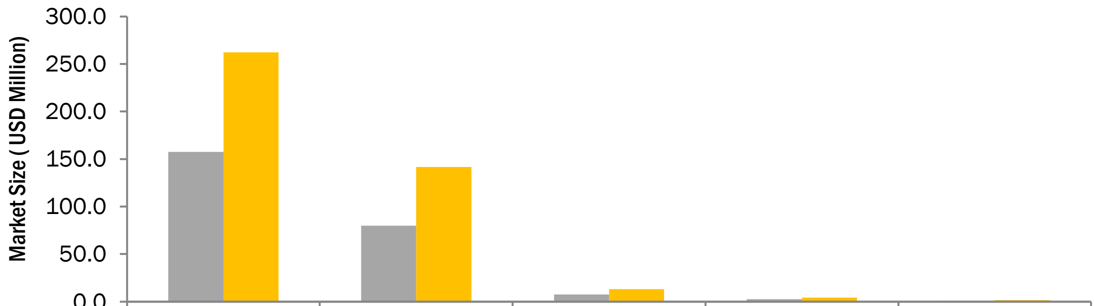


	Hydrometallurgical	Pyrometallurgical
2021	181.9	66.3
2026	316.2	106.2
CAGR (2021-2026)	11.7%	9.9%

Source: Secondary Literature, Expert Interviews, and MarketsandMarkets Analysis

Rare earth metals bearing deposits are limited, and hence, secondary sources of rare earth metals such as wastes are becoming the potential sources. Hydrometallurgical processing technology methodologies routed through leaching, solvent extraction, and precipitation is often preferred as a prominent technique for recovering rare earth metals from secondary wastes such as batteries, spent magnets, e-wastes, and others. The technology has a number of advantages over the pyro-metallurgical route. The favorable features of this technique are low production costs, small amount of waste generation, and low levels of noxious gases emission, which prevent environmental contamination and enable a clean separation of targeted rare earth metals.

FIGURE 12 FLUORESCENT LAMPS TO BE LARGEST SOURCE OF RARE EARTH METALS, 2021-2026

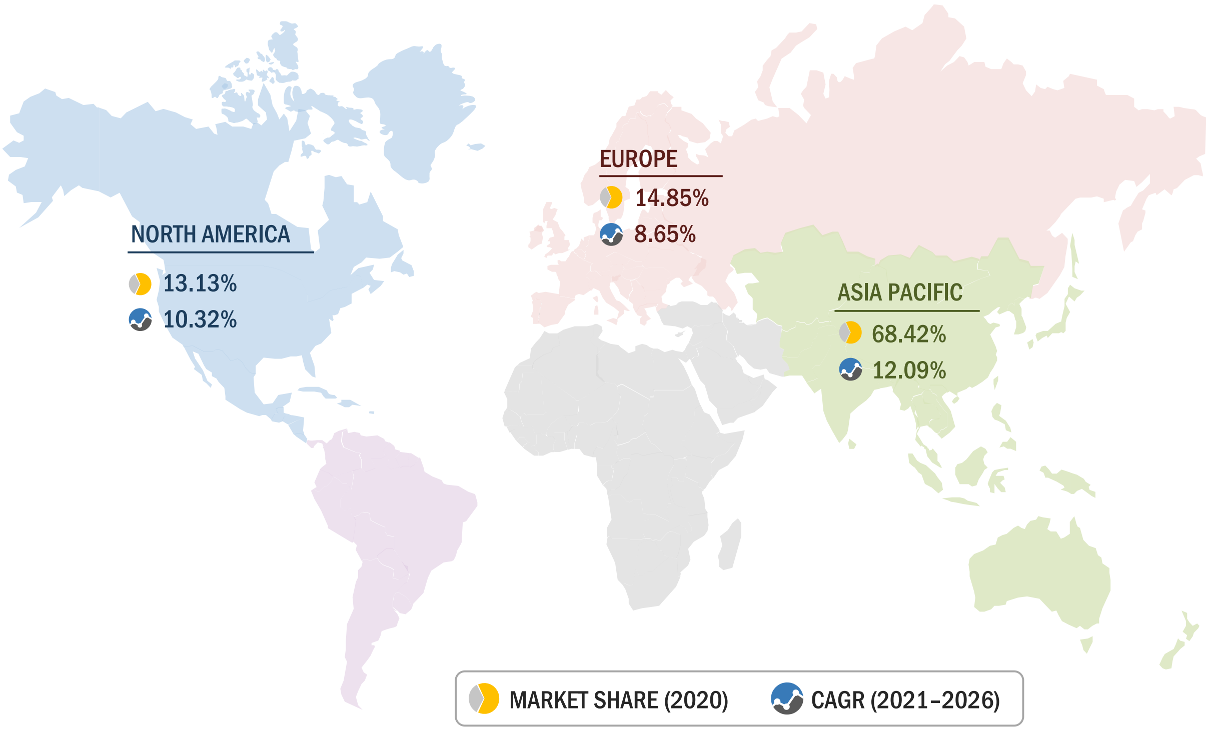


	Fluorescent Lamps	Magnets	Batteries	Industrial Process	FCC
2021	157.6	79.8	7.4	2.4	0.9
2026	262.0	141.6	13.0	4.2	1.5
CAGR (2021-2026)	10.7%	12.2%	12.0%	11.7%	9.6%

Source: Secondary Literature, Expert Interviews, and MarketsandMarkets Analysis

The inner lining of fluorescent tubes is coated with phosphors, which absorb the ultraviolet light from electrically charged mercury vapor and re-emit visible light based on a mix of blue, green, and red emitters. While the adoption of LED lighting technology is growing rapidly, there are still about 2.3 billion fluorescent light sockets in the US, which will probably continue to be widely used in the foreseeable future. Europium (Eu) and yttrium (Y) are two rare earth metals that are commonly used in sustainable technology and high-tech applications. As these metals are difficult to mine, there is a great scope for recycling them. They can be recovered from red lamp phosphor, a powder that is used in fluorescent lamps such as neon tubes.

FIGURE 13 ASIA PACIFIC DOMINATED RARE EARTH METALS RECYCLING MARKET IN 2020



Note: The CAGRs in the above figure are provided in terms of value.

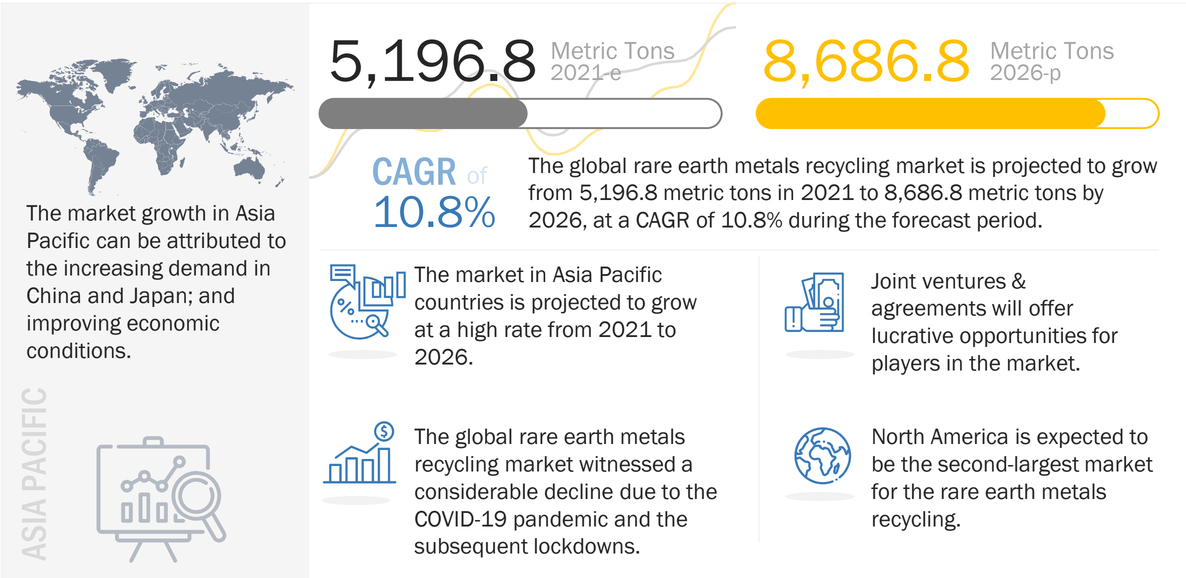
Source: Research Journals, Related Publications, Expert Interviews, and MarketsandMarkets Analysis

Asia Pacific has witnessed tremendous growth in the past few years, driven by the growing population, favorable investment policies, growing economies, and government initiatives directed at promoting electronics and automobile industries in the region. The region is the largest consumer of rare earth materials due to the rapidly increasing demand in China, which accounts for the maximum consumption of rare earth metals globally. The estimated market revenue of China in 2020 was over USD 153 million.

4 PREMIUM INSIGHTS

4.1 EMERGING ECONOMIES TO WITNESS RELATIVELY HIGHER DEMAND FOR RARE EARTH METALS RECYCLING

FIGURE 14 DEVELOPING COUNTRIES OFFER ATTRACTIVE OPPORTUNITIES IN RARE EARTH METALS RECYCLING MARKET

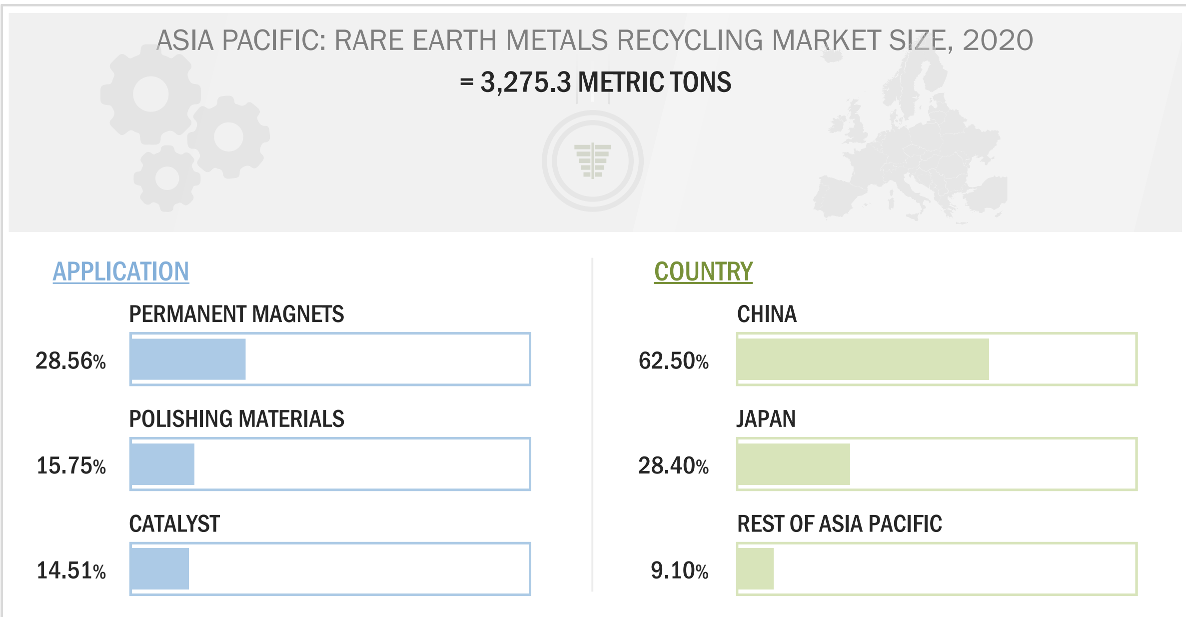


e - Estimated; p - Projected

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

4.2 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET, BY APPLICATION AND COUNTRY

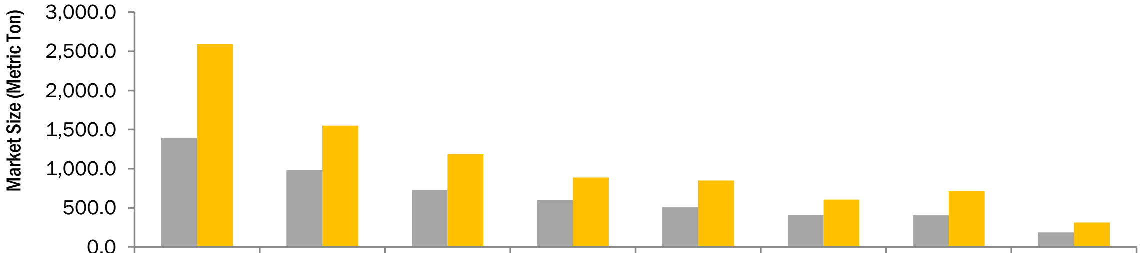
FIGURE 15 CHINA WAS LARGEST MARKET FOR RARE EARTH METALS RECYCLING IN 2020



Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

4.3 RARE EARTH METALS RECYCLING MARKET, BY APPLICATION

FIGURE 16 PERMANENT MAGNETS SEGMENT TO LEAD RARE EARTH METALS RECYCLING MARKET DURING FORECAST PERIOD



	Permanent Magnets	Catalyst	Polishing Materials	Alloy	Ceramics	Glass	Phosphor	Hydrogen Storage Alloys
2021	1,395.1	980.9	725.0	597.9	505.8	405.7	402.0	184.4
2026	2,591.0	1,549.6	1,185.0	886.7	846.6	605.2	712.0	310.2
CAGR (2021-2026)	13.2%	9.6%	10.3%	8.2%	10.9%	8.3%	12.1%	11.0%

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

4.4 RARE EARTH METALS RECYCLING MARKET, BY TECHNOLOGY

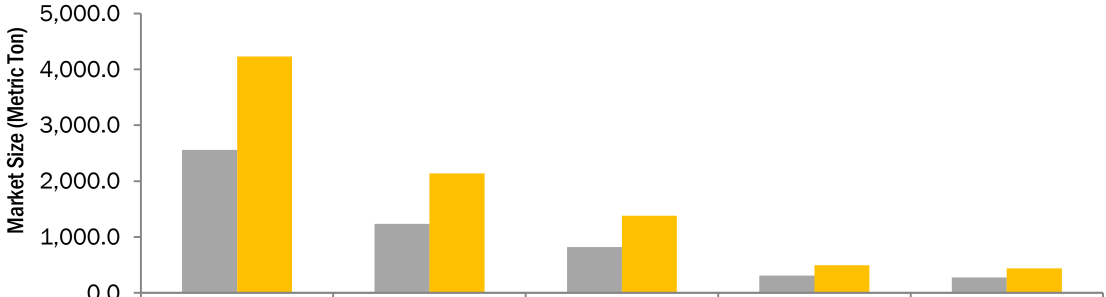
FIGURE 17 HYDROMETALLURGICAL TECHNOLOGY TO LEAD RARE EARTH METALS RECYCLING MARKET DURING FORECAST PERIOD

	Hydrometallurgical	Pyrometallurgical
2021	3,816.2	1,380.6
2026	6,516.8	2,169.4
CAGR (2021-2026)	11.3%	9.5%

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

4.5 RARE EARTH METALS RECYCLING MARKET, BY SOURCE

FIGURE 18 FLUORESCENT LAMPS TO BE LARGEST SOURCE FOR RARE EARTH METALS RECYCLING DURING FORECAST PERIOD

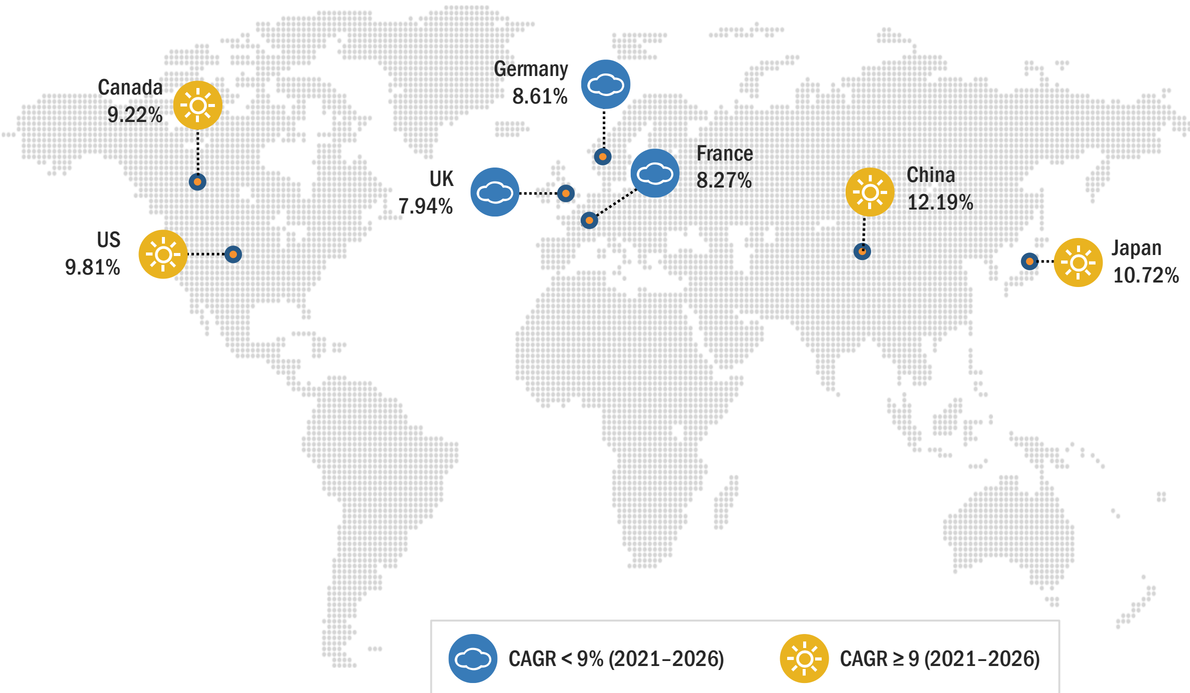


	Fluorescent Lamps	Magnets	Batteries	Industrial Process	FCC
2021	2,560.3	1,235.0	817.7	307.5	276.4
2026	4,231.4	2,138.3	1,383.1	496.8	436.6
CAGR (2021-2026)	10.6%	11.6%	11.1%	10.1%	9.6%

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

4.6 RARE EARTH METALS RECYCLING MARKET, BY COUNTRY

FIGURE 19 CHINA PROJECTED TO WITNESS HIGHEST CAGR FROM 2021 TO 2026



Note: The CAGRs have been calculated in terms of volume.

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

5 MARKET OVERVIEW

5.1 INTRODUCTION

Rare earth metals or rare earth elements are a relatively abundant group of seventeen elements found in the periodic table. Out of the seventeen, fifteen elements comprise the lanthanide series found between atomic numbers 57 and 71. The elements scandium and yttrium are also considered rare earth elements as they are found in the same ore as other rare earth elements and have similar chemical properties. Rare earth metals are considered key elements in developing technologies in the communications, electronics, automotive, and military weapon industries. The demand for these elements is expected to increase in the near future as these are key components in emerging applications, such as green technology for electric and hybrid vehicles. The demand for rare earth metal commodities is a derived demand, which differs from consumer goods demand. The rare earth metals recycling market is driven by factors such as increasing demand for clean energy and initiatives taken by governments and associations.

5.2 MARKET DYNAMICS

FIGURE 20 RARE EARTH METALS RECYCLING MARKET DYNAMICS

DRIVERS	▪ Increasing demand from end-use industries ▪ Increasing demand for clean energy ▪ Initiative of associations & regulatory bodies
RESTRAINTS	▪ Fluctuating costs of rare earth metals ▪ Illegal mining of rare earth metal ores
OPPORTUNITIES	▪ Recycling of rare earth metals leads to steady material sourcing ▪ Net zero goals by 2050 to promote recycling of rare earth metals
CHALLENGES	▪ Safety of workers in rare earth metals recycling process

Source: Related Industry Publications, Industry Journals, and MarketsandMarkets Analysis

5.2.1 DRIVERS

5.2.1.1 Increasing demand from end-use industries

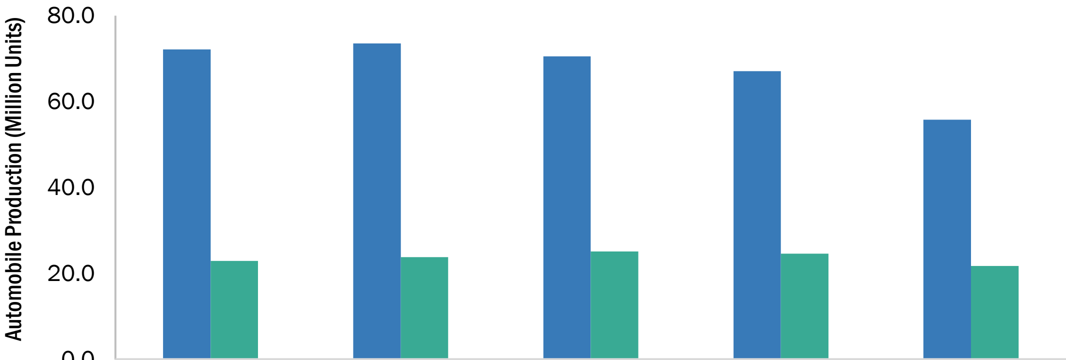
Rare earth metals, owing to their various properties, find applications in a wide range of industries. These applications include permanent magnets, metal alloys, phosphors, catalysts, polishing, and glass additives. Rare earth permanent magnets are expected to be the prime growth market over the next five to ten years. The major rare earth elements that are used in the permanent magnet application are neodymium, praseodymium, dysprosium, terbium, and yttrium. These metals possess special properties, such as remanence and high coercivity, which keep permanent magnets from losing their magnetivity even after long periods. These magnets find major applications in the automotive market, and their demand is dependent on this market. Rare earth permanent magnets find use in both conventional automotive as well as hybrid vehicles. In fact, the hybrid electric vehicle (HEV) market is expected to drive strong growth for rare earth magnets soon as they use more rare earth magnets per vehicle compared to conventional automotive. Generally, a hybrid car contains 650 grams or 1,000 grams of neodymium.

The application of rare earth magnets in wind turbines is expected to be another major growth market over the long term. The latest offering of direct drive wind turbines, where the use of rare earth magnets allows the gearbox to be removed from the turbine, has greatly decreased weight and maintenance issues.

Along with the above applications, rare earth magnets are widely used in major consumer and industrial electronic applications, such as smartphones, acoustic speakers, and hard disk drives, due to their high performance to size ratio and high magnetic strength. The usage of rare earth metals in permanent magnets is expected to grow by 12% to 14% in the next five to ten years.

Rare earth metals are also widely used in catalyst systems. Their main contribution to a catalyst system is to absorb, store, and release oxygen and stabilize the environments in which they operate. Rare earth metals which are widely used in catalyst systems are lanthanum and cerium. They are mainly applied as catalysts in automotive catalytic converters for cars and other vehicles and fluid cracking catalysts (FCCs) used in oil refineries. Apart from growth in worldwide unit sales, the demand for auto-catalysts is further complemented by increasingly demanding legislation around the world governing vehicle emissions. It is expected that the demand for rare earth metals in auto-catalysts has the potential to continue to grow by about 6% per annum.

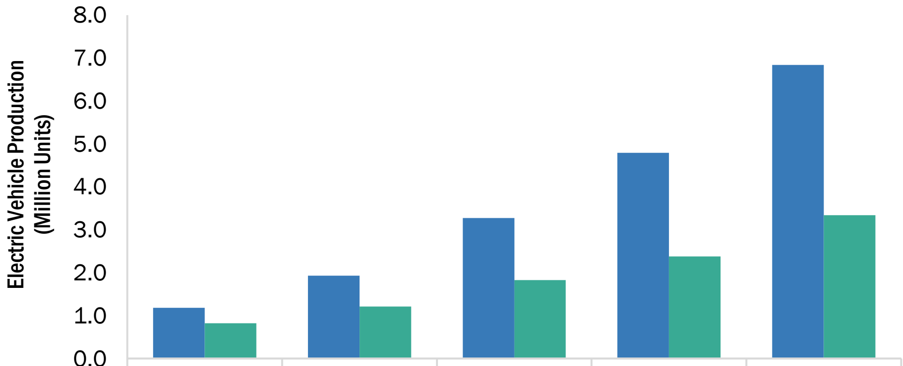
FIGURE 21 GLOBAL AUTOMOBILE PRODUCTION DATA, 2016–2020



	2016	2017	2018	2019	2020
Passenger Vehicles	72.1	73.5	70.5	67.1	55.8
Commercial Vehicles	22.9	23.8	25.1	24.6	21.7

Source: OICA

FIGURE 22 GLOBAL ELECTRIC VEHICLE PRODUCTION DATA, 2016-2020



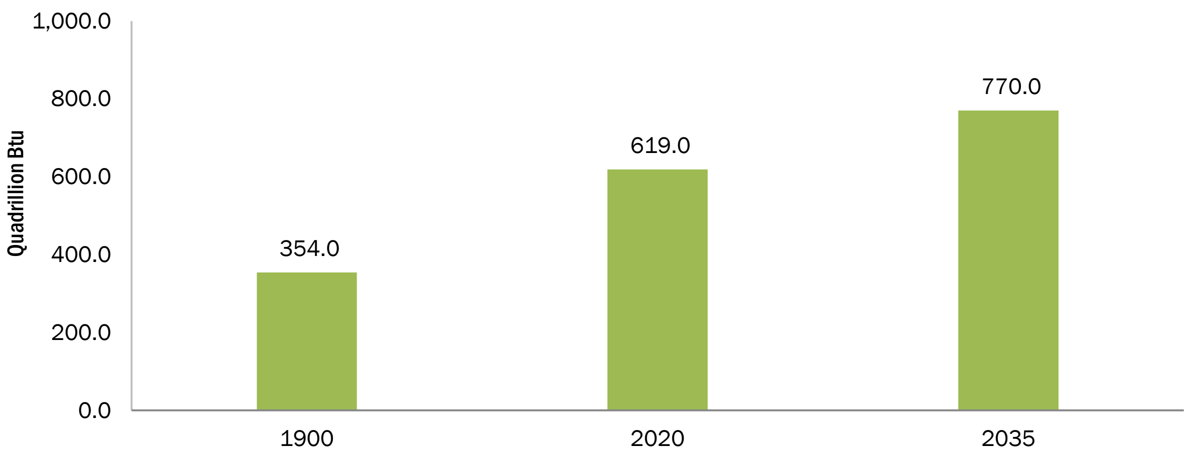
	2016	2017	2018	2019	2020
BEV (Battery Electric Vehicles)	1.18	1.93	3.27	4.79	6.84
PHEV (Plug-in Hybrid Electric Vehicles)	0.82	1.21	1.83	2.38	3.34

Source: International Energy Agency

5.2.1.2 Increasing demand for clean energy

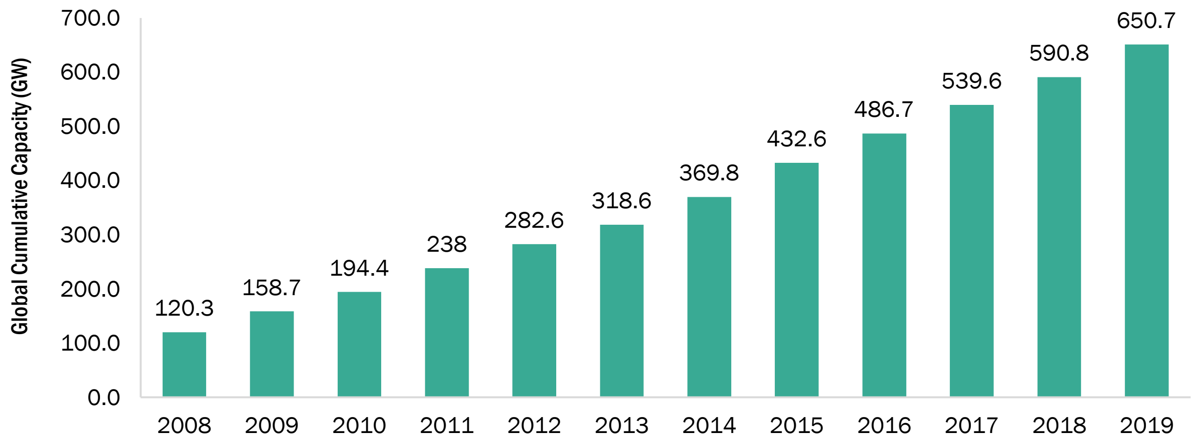
The green energy market is witnessing a significant boost as new legislations are passed by different regulatory bodies across the world. These legislations ban the use of conventional mediums in industries, and they require the use of green technologies, such as wind turbines, hybrid electric vehicles, and compact fluorescent lighting. Wind turbines have started using direct drive permanent magnets, wherein the use of rare earth metals, such as neodymium, praseodymium, dysprosium, europium, and terbium, is extensive. The increasing drive for environmental protections leads to the development of clean energy sources, for instance, wind energy. The wind turbines and water turbine markets offer another growth opportunity for permanent magnets. Direct-drive (DD) generators for wind turbines use about 650 kg of permanent magnets per megawatt (MW) of power output. The chart mentioned below shows the installation of wind power systems in the past 16 years. This makes the usage of permanent magnets relatively economical and enables companies to be environmentally responsible, thereby making the technology sustainable. All these growing sectors that have significant usage of permanent magnets offer a huge impetus for the growth of this market.

FIGURE 23 GLOBAL ENERGY DEMAND



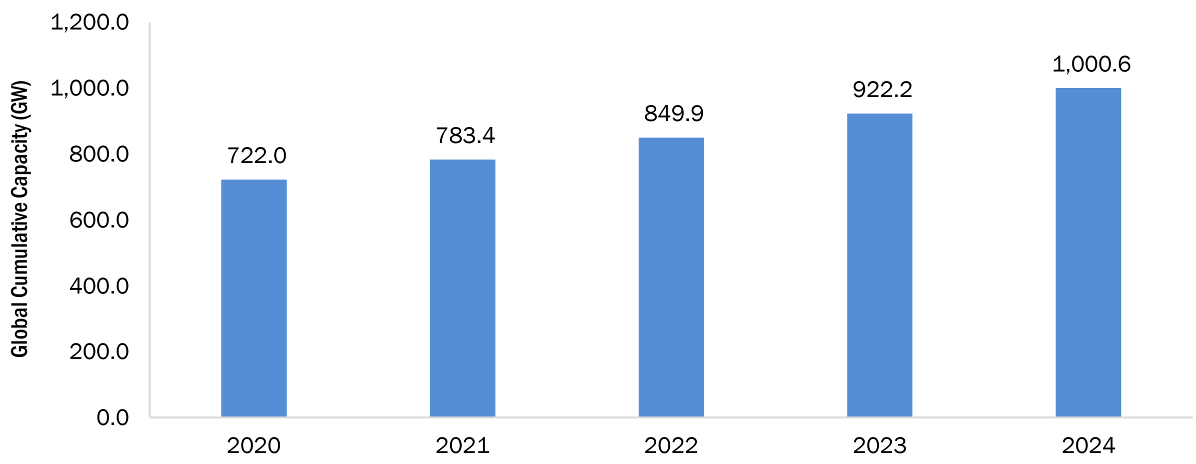
Source: US Department of Energy

FIGURE 24 GLOBAL WIND POWER CUMULATIVE CAPACITY



Source: Global Wind Energy Council

FIGURE 25 GLOBAL WIND POWER CUMULATIVE CAPACITY PROJECTION, 2020-2024



Source: Global Wind Energy Council

The technology of nickel metal hydride (NiMH) battery, which is being used widely in hybrid vehicles of Toyota and Honda, is slated to be the technology of the future. A NiMH battery for a hybrid vehicle, such as Toyota Prius, for example, uses between 12 kg and 20 kg of rare earth metals, primarily lanthanum and cerium, with some neodymium and praseodymium, in its overall construction.

5.2.1.3 Initiative of associations & regulatory bodies

Governments across the world are introducing numerous legislations supporting the use of green technologies and banning the use of conventional and inefficient practices. Many associations and government authorities are taking the initiative for further research & development (R&D) of rare earth metals, especially in the permanent magnet sector, to expand the technological know-how and applications of permanent magnets. For example, IEEE Magnetics (US) focuses on the basic development, designs, and applications of magnetic devices. The National Institute of Standards and Technology (NIST) (US) focuses on the development of measurements, standards, and technology to improve the quality of permanent magnets. In 2019, the Global Rare Earth Industry Association was founded in Belgium by 12 organizations. The founding members represent the entire rare earth metals supply chain, from mining to finished products and research. The initiative is funded by the EU independent body – the European Innovation and Technology Raw Materials Fund. The Japanese government is cooperating with the US and

Australia on investing in processing facilities for rare earth metals, which will ease the reliance on imports from China. Japan is discussing a cooperation deal with the US and Australia. Smelting facilities under construction in the US State of Texas that will be operated by Australian rare earths miner Lynas are a probable investment target. That site is scheduled to come online in the middle of the decade. Also, the US and Australia have agreed to work together on securing rare earth element resources and support private industries. The US has signed a similar agreement with Canada.

As the market for green technology is driven by government regulations and policies worldwide, the demand for these metals is also increasing. The policies are not restricted to wind turbines, solar cells, incandescent lighting, and hybrid electric vehicles. They include other industries such as automotive to use light metals to comply with modern emission standards. Cerium-containing converters have been used to lower vehicle emissions. This would have a positive impact on the demand for recycling rare earth metals to maintain the material supply.

5.2.2 RESTRAINTS

5.2.2.1 Fluctuating costs of rare earth metals

The global recession of 2008-09 had several negative implications on a number of markets, and the rare earth metals market was not an exception. Rare earth metal prices increased suddenly in 2011 after China introduced a 40% cut on its export quotas, citing environmental reasons. The cost of dysprosium oxide, used in magnets, lasers, and nuclear reactors, rose to about USD 1,470 a kilogram from USD 700 to USD 740, buoyed by demand and concerns over future availability. These fluctuations in prices coupled with rising energy costs are destabilizing the supply chains of rare earth elements. This factor makes it difficult for manufacturers to deliver quality products at a profit.

As the prices of raw materials fluctuate, it depends on the manufacturers to either absorb additional costs or increase the prices of the products. Price fluctuations leave no room for error when planning a project's budget and have quite a few manufacturers walking a thin line between success and operating at a loss.

When the price of raw materials increases suddenly, a few manufacturers search for new suppliers that allow them to maintain revenue targets. This often means sourcing materials from lower-cost economies. Switching to a different source of raw materials carries a high risk of disrupting the supply chain. Rare earth elements are not traded in any exchange in the way other precious or nonferrous metals are. They are rather sold in the private market, which makes their prices tricky to track and monitor. The elements are not usually sold in their pure form, but distributed in mixtures of varying purity, for example, 99% neodymium metal. In any case, pricing can vary based on the quantity and quality required by the end-use applications.

5.2.2.2 Illegal mining of rare earth metal ores

China's rare earth element extraction is mainly concentrated in the Bayan Obo iron-niobium-rare earth metal deposits in Inner Mongolia. This deposit is the source of almost half of China's rare earth metals and almost half of global rare earth metals extraction. This abundance has posed a problem of plenty and has created a lot of unwanted situations. The problem of illegal mining and artisanal mining using basic technologies, including pumping acid into the ground, has posed a major environmental threat. These kinds of practices are very hard to track and monitor and, thus, also affect the profitability of the industry.

Illegal mining of rare earth metal ores causes two major problems. Firstly, it poses a great environmental problem. Illegal mining of rare earth metals is often done with the help of basic facilities, sometimes to the extent of throwing acid on the raw ores. These methods are potentially dangerous as they can sometimes expose hazardous radioactive tailings of thorium or uranium in the ore and release them into the water supply. In May 2010, China announced a major five-month operation to check illegal mining in South China. The smaller and unsophisticated mines in these regions are prone to exposing radioactive wastes to the water supply. The Bukit Merah mine in Malaysia underwent a USD 100 million clean-up, which started in 2011. Secondly, illegal mining poses a serious economic problem. Illegal mining and smuggling in the recent past possibly might have accounted for about 20% of the total exported rare-earth metals from China. This has opened up a grey market where the transactions of the metals are difficult to track and monitor. This creates discrepancies in estimating production values of rare earth metals. In 2019, China stepped up efforts to eliminate illegal mining, production, and smuggling of rare earth metals, while at the same time encourage more high-end processing. The Ministry of Industry and Information Technology (MIIT) stepped up efforts to prohibit illegal mining and recycling of rare earth materials and ensure that unauthorized facilities are completely eliminated.

It established a “traceability system” to stop buyers from using illegal materials and ensure that producers do not exceed the output target, and also suspend licenses of law-breaking companies. The rare earth metals industry has contaminated large amounts of land and water in major producing regions, such as Inner Mongolia and Jiangxi, and the ministry has vowed to provide more support to clean up the industry and reduce waste discharges.

5.2.3 OPPORTUNITIES

5.2.3.1 Recycling of rare earth metals leads to steady material sourcing

Production of many minerals that are vital for energy transitions is concentrated in a few geographical areas. For instance, the top three rare earth metals producers dominate more than half of the global production. China holds a significant position in the rare earth value chain, where it is responsible for more than 70% of the processing operations associated with rare earth metal mining. This has resulted in concern for companies that manufacture solar panels, batteries, and wind turbines, amongst others, as this can affect their supply chains due to trade barriers, regulatory changes, and political instability. Furthermore, current extraction practices of rare earth metals are inefficient, unsafe, and generate pollution. Rare earth metal processing requires a large amount of harmful chemicals and produces high volumes of solid waste and wastewater, which are sometimes handled inappropriately. These pose challenges for stable sourcing of minerals in light of the growing social and environmental concerns.

Recycling provides an opportunity to maintain the steady sourcing of rare earth metals. For this, it is important that the importing countries strengthen the management of products and components which have reached their end of life. This would promote recycling and retrieval of valuable minerals. Research and development efforts by research institutions would result in large-scale recycling of rare earth metals and would generate environmental and security benefits, along with a reduction in dependency on foreign countries for material sourcing.

5.2.3.2 Net-zero goals by 2050 to promote recycling of rare earth metals

A major part of the climate challenge is energy challenge. Energy produces three-quarters of global emissions. Many countries such as Germany, Japan, France, the UK, Canada, South Korea, Hungary, New Zealand, and Ireland have announced that they aim to bring their emissions down to net zero by the year 2050 or soon after. The growing climate ambitions augment the significant momentum behind the production of clean energy. However, long-term targets alone would not result in net zero by the mid-century. Transformation of our energy infrastructure would be required. There is a need for better mechanisms to coordinate support for emerging and developing economies. A global approach would be required for the energy security challenges, along with technological integration, to ensure sufficient supplies of rare earth metals.

5.2.4 CHALLENGES

5.2.4.1 Safety of workers in rare earth metals recycling process

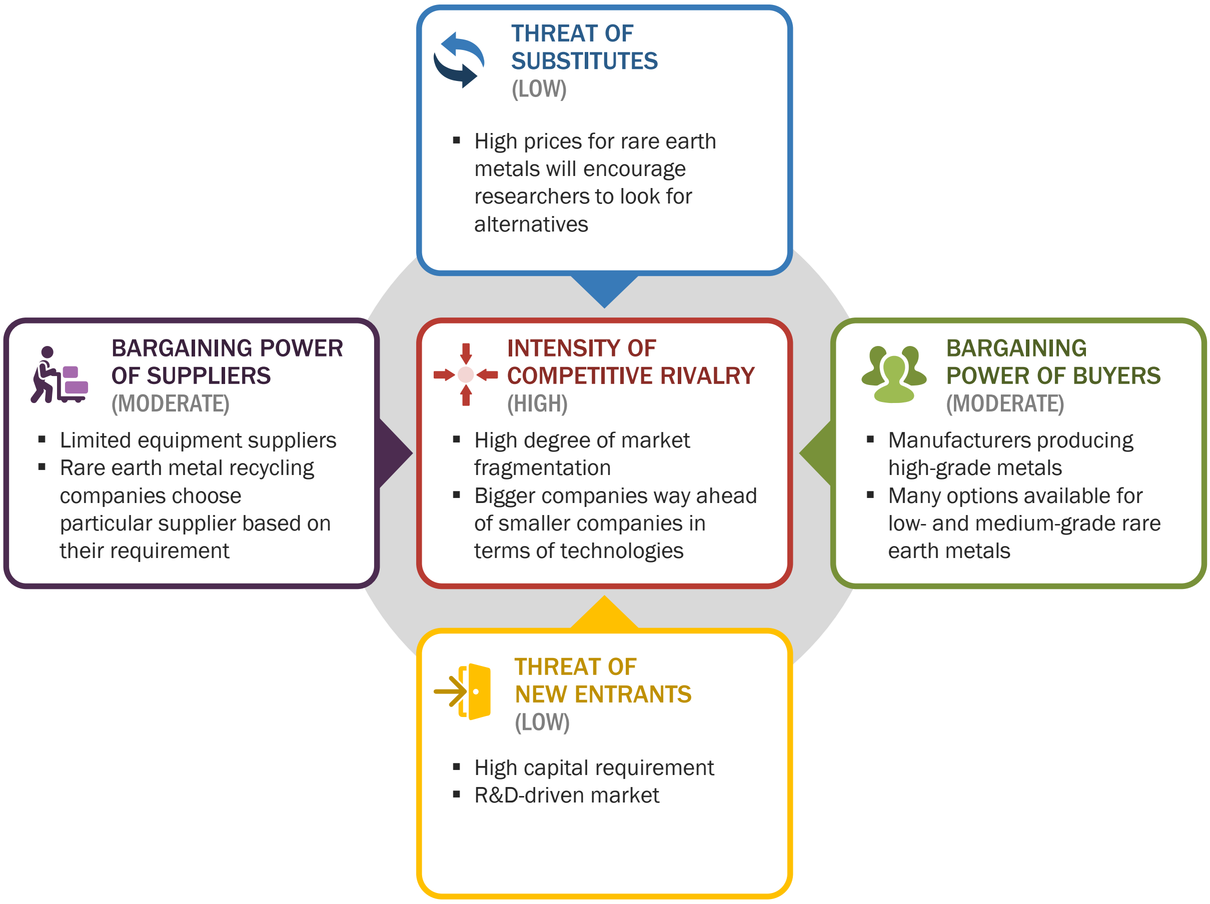
Recycling of rare earth metals is considered to solve the problem of supply and demand for rare earth metals. However, caution is required for rare earth metals recycling process due to hazardous chemicals which should be treated properly. The United Nations Environment Programme (UNEP) classified hazardous substance emissions in the rare earth metals recycling into three categories. The first is primary, where the emissions include lead, mercury, arsenic, polychlorinated biphenyls, sulfides, and ozone-depleting substances which are obtained from electronic waste. The secondary emission includes dioxins and furans, amongst others, which are generated from reactions due to inappropriate treatment of plastics. The tertiary emissions include harmful substances and reagents such as cyanide and leaching agents that are exposed due to inappropriate management. This is becoming a challenge in developing countries where inappropriate recycling systems are prevalent. Thus, it is vital to have a verified monitoring system for the recycling of rare earth metals to eradicate the potential threat to humans and the environment. To ensure safety in the workplace, it is necessary to have appropriate protective gear, management of hazardous substances, and regular safety education.

6 INDUSTRY TRENDS

6.1 PORTER'S FIVE FORCES ANALYSIS

The Porter's five forces analysis is a framework that determines the competitive intensity in the rare earth metals recycling market and, therefore, its attractiveness. It helps with decision-making regarding the entry or exit from the market. This section analyzes the market from five different perspectives: the intensity of competitive rivalry within the industry, the threat of new entrants, the bargaining power of suppliers, the bargaining power of buyers, and the threat of substitutes.

FIGURE 26 RARE EARTH METALS RECYCLING MARKET: PORTER'S FIVE FORCES ANALYSIS



Source: Expert Interviews and MarketsandMarkets Analysis

TABLE 5 RARE EARTH METALS RECYCLING MARKET: PORTER'S FIVE FORCES ANALYSIS

PORTER'S FIVE FORCES	IMPACT
Threat of New Entrants	Low
Threat of Substitutes	Low
Bargaining Power of Suppliers	Moderate
Bargaining Power of Buyers	Moderate
Rivalry Among Existing Competitors	High

Source: Secondary Literature, Expert Interviews, and MarketsandMarkets Analysis

6.1.1 BARGAINING POWER OF SUPPLIERS

The suppliers in this market are the companies providing equipment to the rare earth metal recyclers. There are limited equipment suppliers in this market. These equipment are expensive but have a long life span. Although there are limited equipment suppliers, rare earth metal recycling companies can choose a particular supplier based on their requirements.

Therefore, the bargaining power of suppliers is moderate.

6.1.2 THREAT OF NEW ENTRANTS

The rare earth metal industry is both capital- and technology-intensive. The companies have to adhere to many norms and regulations in all the stages, right from waste collection to the recycling of rare earth metals. These stages require a lot of expert attention as mishandling can lead to hazardous pollution. Also, the collection of products and their separation is a major responsibility for the companies. Moreover, the customers of certain big companies are loyal and are wary of the switching costs. Therefore, there is minimal threat of new entrants in this industry.

Thus, the threat of new entrants is low.

6.1.3 THREAT OF SUBSTITUTES

Rare earth metals have traditionally been used in various applications such as catalysts, phosphors, and glass additives. This has resulted in the rise in consumption of these elements at a steady growth rate over the years. Recently, these elements have been used in various emerging green technologies, such as wind turbines and hybrid electric cars. This has resulted in high growth as they have become the key components in these emerging applications. The only downside with these elements is their high price. There are no substitutes available for rare earth metals in the market. However, the high prices and the limited quantity of metals will encourage R&D for other products and substitutes.

Thus, the threat of substitutes is low.

6.1.4 BARGAINING POWER OF BUYERS

The rare earth metals market has a few big players, such as Baotou and China Minmetals in China and Lynas Corp. outside China. The buyers can buy it from the companies which mine and extract these rare earth metals or can buy it from the companies which recycle rare earth metals. The buyers of these metals are the companies that use them in several applications, such as auto-catalysts, permanent magnets, phosphors, polishing, and ceramics. The bargaining power of buyers is low if only the high-grade rare earth metals are considered as they are generally produced by the big players. On the contrary, some of the applications do not require such high-grade metals, so the companies that use these metals have a lot of options available.

Therefore, the overall bargaining power of the buyers is moderate.

6.1.5 INTENSITY OF COMPETITIVE RIVALRY

The rare earth metals industry has been dominated by Chinese companies for a long time. China accounted for 85% of the total production of rare earth metals in 2011. But with the country introducing production quotas on the companies due to environmental issues, its dominance has faded slightly. Recyclers of rare earth metals are also catering to the needs of rare earth metals in various end-use industries. There is a huge opportunity for the recycling companies to enter the market, which would lessen the dependence of these metals on China, which will result in increased competition among companies in the industry to fill the void left by Chinese companies. Companies mostly based in the US, Australia, and Canada will try to capture their respective local markets.

Therefore, the degree of competition in the market is high.

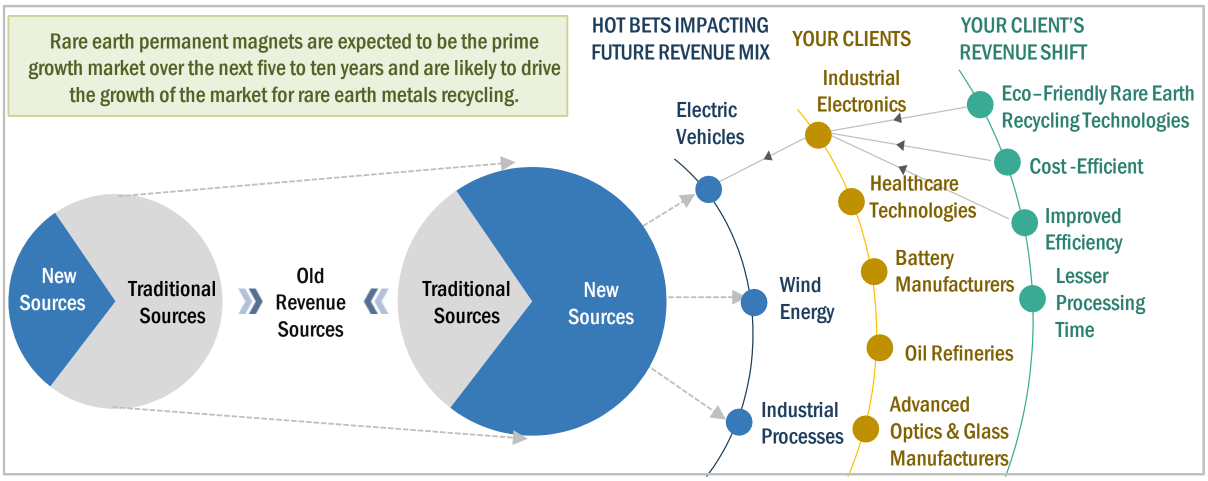
6.2 YC-YCC DRIVERS

MarketsandMarkets has witnessed a rapid ecosystem change in the rare earth metals recycling market. Changing demand for rare earth permanent magnets is expected to be the prime growth driver of the market over the next five to ten years. The revenue streams of rare earth metal recycling companies are impacted by the automotive, glass & ceramic, and defense sectors.

The players operating in the rare earth metal recycling market aim to offer low-cost rare earth metals and environment-friendly processing of rare-earth oxides to end-use industries, such as industrial electronics, automotive, oil refineries, and glass manufacturing. New environment-friendly technologies promise to be game-changers in this field and enable the major countries to create a more stable and reliable domestic source of these essential metals. Owing to several new environment-friendly processing technologies, many companies across the world do not even consider extracting rare-earth elements due to the damages caused to the environment by acid-based separation and purification of these elements.

Recycling is gaining traction to solve the supply-demand issues, which decreases the criticality of the metals and provides a secondary source of supply for the key metals. Recycling will not only provide a secondary source of supply but will also have a positive impact on the environment with decreased mining. It will also minimize the impact of waste and toxins entering water sources.

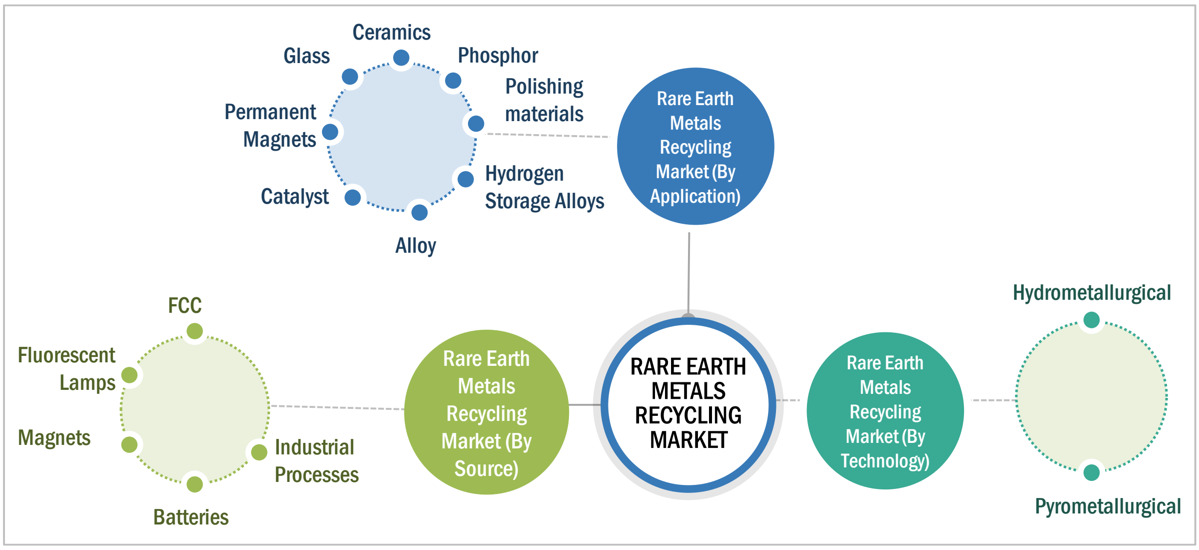
FIGURE 27 YC-YCC DRIVERS



Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

6.3 MARKET MAPPING/ECOSYSTEM MAP

FIGURE 28 ECOSYSTEM MAP



Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

6.4 VALUE CHAIN ANALYSIS

The value chain for the rare earth metals market covers all the stages of production and supply, starting from raw material mining (mining of ores and their refining) to their respective applications in end-use industries. The value chain for the rare earth metals market is explained below in the figure.

FIGURE 29 RARE EARTH METALS VALUE CHAIN

Mining & Rare Earth Mineral Ore Production	Rare Earth Ore Separation to form Oxides	Refining of Oxides to form Metals	Applications	End-use Industries
▪ From the ground ore to the crushed ore	▪ Hydro-metallurgy process ▪ Separation of the ore from oxides	▪ The rare earth oxides are then refined to their respective metal forms	▪ Permanent magnets ▪ Metal Alloys ▪ Glass Additives ▪ Catalysts ▪ Phosphorous ▪ Others	▪ Healthcare Technologies ▪ Hybrid and Electric vehicles ▪ Consumer Electronics ▪ Oil Refining ▪ Glass Products ▪ Defense Technologies

Source: Parliament of Canada Website

6.4.1 MINING & RARE EARTH ORE PRODUCTION

The value chain of rare earth metals starts with its mining and ore production. Rare earth elements frequently occur with other elements, such as gold, copper, uranium, phosphates, and iron. Thus, they are often mined as a by-product of other minerals. Most of the rare earth elements throughout the world are found in deposits of bastnaesite and monazite. China has the largest concentrations of rare earth elements in its bastnaesite deposits, while the monazite deposits in Australia, China, Brazil, India, and South Africa account for the second-largest concentrations of rare earth elements. Lighter rare earth elements, such as lanthanum, cerium, praseodymium, and neodymium, are more abundant and concentrated and usually account for about 80%-99% of a total deposit. The mineral deposit is identified, mined, and then compressed to crushed ore for further processing.

6.4.2 SEPARATION OF RARE EARTH ORE TO FORM RARE EARTH OXIDES

Rare earth ore in its crushed form needs to be purified as the rare earth elements are present in compound form with other minerals. The separation of rare earth metals is usually preceded by two simultaneous processes: milling and hydrometallurgy.

Milling of the mined ore means compressing the ore in the gravel to be further grounded into smaller particles. These particles are sorted and sifted by flotation and electromagnetic separation to take out usable material and remove the waste products called tailings. The above process is followed by a complicated yet inexpensive and quick process of hydrometallurgy. Separation of rare earth oxides is a broad term that basically involves the process of isolating the rare earth elements safely. This process gives out usable rare earth oxides. Finally, the rare earth metals are separated through the process of solvent extraction that relies on different solubilities of two rare earth compounds, which are separated with the help of two immiscible liquids.

6.4.3 REFINING OF RARE EARTH OXIDES

The separation of rare earth metals is carried out by using specific chemicals, which break down the specific components within a substance. The components which are soluble break down more readily. This produces rare earth metals specific to a given application. Rare earth oxides are converted into high purity metals or rare earth alloys. Electrolysis or metallothermic reaction and calcinations are the common rare earth metal refining processes.

Metallothermic reduction or catalysis uses heat and chemicals to yield metal from rare earth oxides. Calcination is a thermal technique wherein the chemically combined components are removed by melting the metal compounds to a point where they are volatile.

6.4.4 APPLICATION

Rare earth elements are important for green and high-end technologies. They are used in magnets, automotive, industrial catalysts, energy-efficient lighting, batteries for e-mobility, metal alloys, glass additives, electronics, ceramics, and polishing materials. Rare earth metals are used in various direct applications, such as permanent magnets, catalysts, phosphors, glass additives, polishing, and X-rays.

Rare earth metals such as neodymium, praseodymium, dysprosium, europium, and yttrium are used in permanent magnets. The automotive (hybrid electric vehicles) and the green technology (wind turbines) markets are the major consumers of rare earth metals in the permanent magnet application.

Rare earth metals are used in catalyst systems as they help to provide a stable environment by absorbing, storing, and releasing oxygen. Among the rare earth metals, lanthanum and cerium are used extensively in this application. The two major sectors using these elements are automotive and petroleum. The automotive industry uses environmentally friendly catalysts, whereas the petroleum industry uses petroleum cracking catalysts.

6.4.5 END-USE INDUSTRIES

Rare earth metals are indirectly used in a wide range of industries. The demand for rare earth elements in industries such as automotive, defense, and energy is different from that of consumer goods. Rare earth metals are used in permanent magnets, metal alloys, phosphors, polishing, and glass additives in the automotive, green energy, and glass industries.

Green technology is a major end-use industry that uses rare earth metals. The main rare earth metals that are used in this industry are neodymium, praseodymium, dysprosium, and holmium. The main application for these metals is permanent magnets, which are further used in green technologies, such as wind turbines and hybrid electric vehicles.

Another major application for rare earth metals is in the automotive industry. Rare earth permanent magnets are used in hybrid electric vehicles. These metals are used to reduce corrosions in the engine. Cerium present in automotive lubricants reduces the toxicity of the carbon monoxide produced in the engine.

6.4.6 RARE EARTH METALS RECYCLING

Recycling processes of rare earth metals can be mainly divided into four key steps - collection, dismantling, separation (pre-processing), and processing.

Collection as the first step can be performed by various methods, such as transporting expired products to a designated place or a collection area near the manufacturing factory. In the case of Japan, which is an advanced recycling country, the collection routes for rare earth metal-containing wastes are systematically established with the development of the urban mining project. Dismantling and separation are mostly performed by manual and mechanical processes, and the specific methods are applied depending on the type of the waste products. Hitachi developed a process using a rotating drum for disassembling hard disk drives, and the National Institute for Materials Science (NIMS) developed a small-scale electronic crushing device and three-dimensional ball mill, resulting in sharply shortened work time. Processing generally consists of pyrometallurgy, hydrometallurgy, electrochemical process, and materialization technology, and recently, these methods have been combined.

Currently, the application areas of rare earth metals are limited to permanent magnets, polishing agents, batteries, and lamps. Many countries are continuously trying to develop rare earth metal recycling technologies.

The recycling methods for magnets are mainly divided into three types: extracting/recovering rare earth metals by smelting process, recycling as a magnetic alloy material, and reuse of collected magnets for other uses. Hydrometallurgy is a simple method for rare earth metals recycling using a strong acid.

6.5 RARE EARTH METALS RECYCLING MARKET PATENT ANALYSIS

6.5.1 METHODOLOGY

This patent analysis offers crucial insights into patent filing, business interests, and patenting activities year-wise and country-wise. The developing trends of a product or technology can be identified by analyzing patent information. Patents analysis is a technique to research the knowledge contained in patents. This study defines patents claiming inventions linked to “Rare Earth Metals Recycling.” For the purpose of this study, a well-planned strategy was devised. The patents were categorized and analyzed using the keywords "alloy recycling," "catalyst recycling," "glass recycling," "ceramics recycling," "magnets recycling," "phosphor recycling," and "hydrogen storage alloys recycling," which are in in the title of the patents. The source used for this analysis is Patentscope, Espacenet, and The Lens - Patent and Scholarly Search.

6.5.2 DOCUMENT TYPE

This section presents an analysis of "Rare Earth Metals Recycling" patents registered from 2011 to 2021. During this period, approximately 2,493 patents were observed.

The granted patents are important for individual inventors and business community and the economy at large. The granted patent encourages development and new ideas. They make new inventions available to the public.

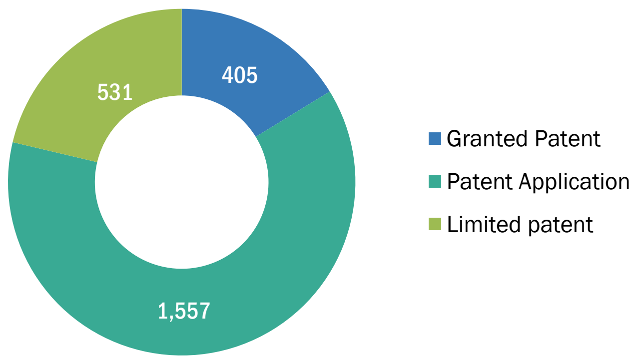
The granted patents account for 16 % of the total count in the last ten years.

TABLE 6 TOTAL NUMBER OF PATENTS FOR RARE EARTH METALS RECYCLING MARKET

Granted Patent	405
Patent Application	1,557
Limited Patent	531
Total	**2493**

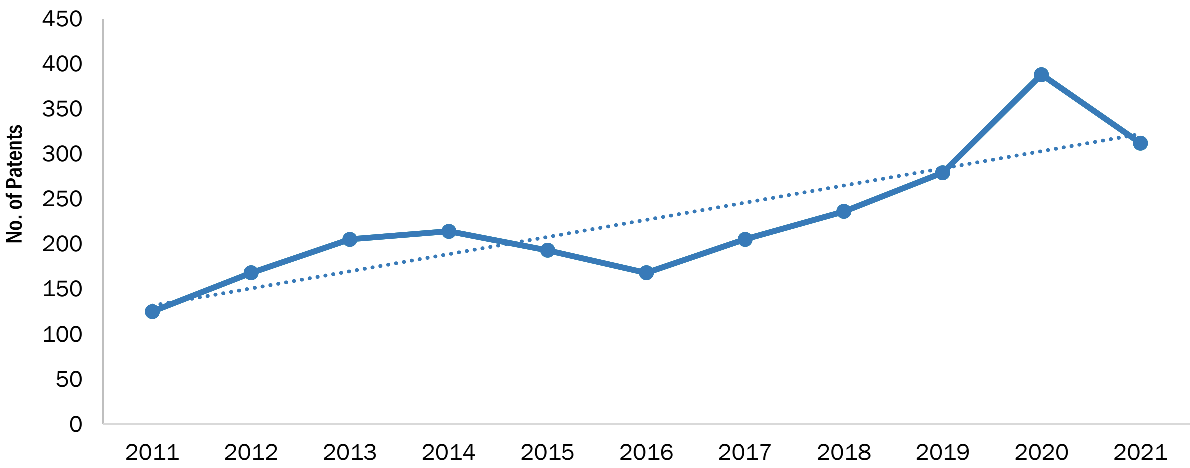
Source: The Lens - Patent and Scholarly Search, and MarketsandMarkets Analysis

FIGURE 30 RARE EARTH METALS RECYCLING MARKET: GRANTED PATENT, LIMITED PATENT, AND PATENT APPLICATION



Source: The Lens - Patent and Scholarly Search, and MarketsandMarkets Analysis

FIGURE 31 PUBLICATION TRENDS - LAST 10 YEARS



Source: The Lens - Patent and Scholarly Search, and MarketsandMarkets Analysis

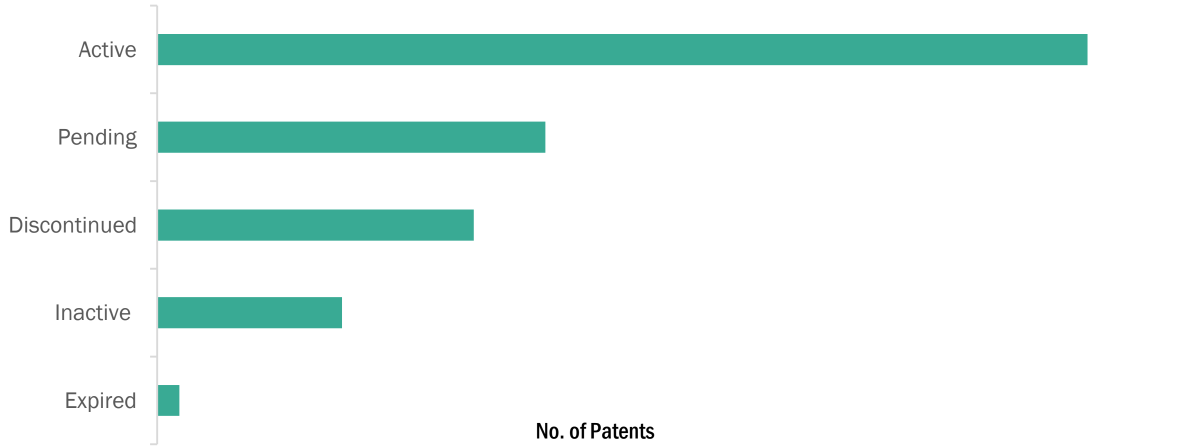
6.5.3 INSIGHT

The study was conducted to monitor the trend of patenting activity of “Rare Earth Metals Recycling” from 2011 to 2021 based on 2493 patents. Global patenting trend analysis demonstrates overall steady up trend in patent activity year by year from 2011 to 2021. There has been good patent activity observed around this area throughout the last few years, but the real surge in the activity around this technology happened from 2016 to 2020. The highest rise was observed in 2020 with 388 patents, and the lowest count was observed in 2011 at 125 patents.

6.5.4 LEGAL STATUS OF PATENTS

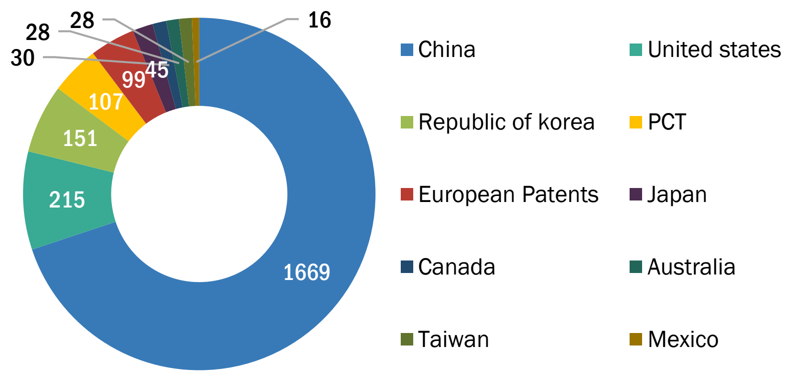
The legal status search is used to identify one or more patents based on their current legal status. The legal status of a patent can be used to determine if the patent is active, inactive, or abandoned.

FIGURE 32 LEGAL STATUS OF PATENTS



Source: The Lens - Patent and Scholarly Search, and MarketsandMarkets Analysis

FIGURE 33 JURISDICTION ANALYSIS



Patents are valid only in the jurisdiction that grants them. This implies that regardless of the strength of statutory patent protection, the same invention may be patent protected in one jurisdiction but not in another.

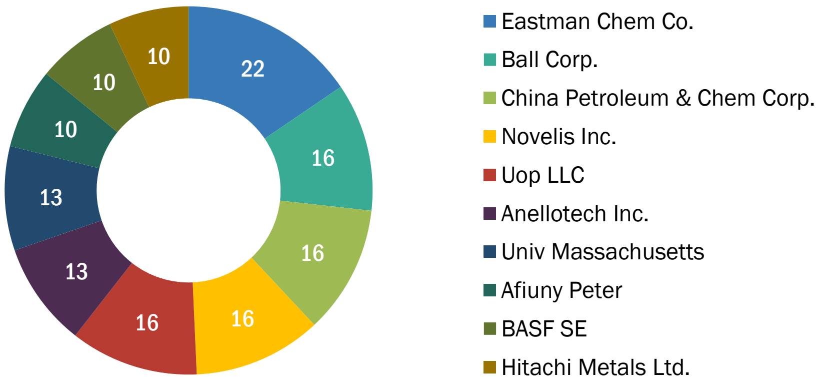
Jurisdiction analysis is performed to have a better understanding of the “Rare Earth Metals Recycling” interests of different Jurisdictions between 2011 to 2021. In the last ten years, major patenting activity was observed for the Jurisdiction of China, the US, the Republic of Korea, PCT, and European Patents.

As shown in the above chart, the Jurisdiction of China has the maximum number of patents at 1,669, which comes to 70 % of the total patents. The second and third-highest count was 215 and 151 for the US and the Republic of Korea, respectively. There is little patenting activity observed in Mexico.

6.5.5 TOP COMPANIES/ APPLICANTS

The top applicant's analysis helps in knowing which organization possesses the most patents related to "Rare Earth Metals Recycling" inventions. This will help to assess the collaborators to identify the inventor and vice versa for joint development of products.

FIGURE 34 TOP APPLICANTS OF RARE EARTH METALS RECYCLING PATENTS



Source: The Lens - Patent and Scholarly Search, and MarketsandMarkets Analysis

Eastman is a global advanced materials and specialty additives company that produces a broad range of products found in items people use every day.

TABLE 7 LIST OF PATENTS BY EASTMAN CHEM CO.

PATENT TITLE	PATENT PUBLICATION NUMBER	YEAR
Chemical Recycling of Waste Plastic Materials with Improved Solvolysis Catalyst	WO 2021/211506 A1	2021
Catalyst Systems for Crystallizable Reactor Grade Resins with Recycled Content	WO 2021/072020 A1	2021
Method of Extracting and Sending for Recycling Ruthenium Homogeneous Catalysts	RU 2582615 C2	2016
Process for Recovering and Recycling an Acid Catalyst	EP 2618903 B1	2016
Method for Recovery and Recycle of Ruthenium Homogeneous Catalysts	US 8829248 B2	2014

Source: Related Industry Publications, Industry Journals, and MarketsandMarkets Analysis

China Petroleum & Chemical Corporation or Sinopec is a Chinese oil and gas enterprise based in Beijing. It is listed in Hong Kong.

TABLE 8 LIST OF PATENTS BY CHINA PETROLEUM & CHEM CORP.

PATENT TITLE	PATENT PUBLICATION NUMBER	YEAR
Process Method for Synthesizing Lactide from Lactic Acid and Convenient for Recycling Catalyst	CN 112745293 A	2021
Method for Treating and Recycling Polyolefin Catalyst Production Waste Liquid	CN 112723430 A	2021
Waste Hydrogenation Catalyst Recycling Method	CN 112619658 A	2021
Method for Recycling Waste Hydrogenation Catalyst	CN 112439462 A	2021
Method for Separating and Recycling Catalyst	CN 110627663 A	2019
MTO (methanol to olefins) Catalyst Spray-Drying Waste Recycling Method	CN 109746023 A	2019
Recycling Method of Polyolefin Catalyst Carrier, Solid Catalyst Carrier and Application thereof	CN 109678989 A	2019
Recycling Method of Hydrotreating Catalyst	CN 108067245 A	2018
Heat Recycling System for Spray Drying Tail Gas of Catalytic Cracking Catalyst and Method of Heat Recycling System	CN 108020104 A	2018
Treatment Process for Realizing Zero Emission and Resource Recycling of Catalyst Wastewater	CN 107235590 A	2017

Source: Related Industry Publications, Industry Journals, and MarketsandMarkets Analysis

Novelis Inc. is an American industrial aluminum company headquartered in Atlanta, Georgia, US. It is a subsidiary of Indian aluminum and copper manufacturing company Hindalco Industries. Novelis is a leading producer of rolled aluminum and a global leader in beverage can recycling.

TABLE 9 LIST OF PATENTS BY NOVELIS INC.

PATENT TITLE	PATENT PUBLICATION NUMBER	YEAR
High Performance Aluminum Alloys Having High Amounts of Recycled Material and Methods of Making the Same	US 11180838 B2	2021
Aluminum Alloys Produced from Recycled Aluminum Alloy Scrap	WO 2021/211696 A1	2021
Techniques for Producing Aluminum Alloy Products Having Improved Formability and Recyclability	WO 2021/150610 A1	2021
Highly Formable, Recycled Aluminum Alloys and Methods of Making the Same	EP 3827108 A1	2021
High-Speed Blow Forming Process to Shape Aluminum Containers Using 3xxx Alloys with High Recycled Content	CA 2985088 C	2020

Source: Related Industry Publications, Industry Journals, and MarketsandMarkets Analysis

TABLE 10 LIST OF TOP 10 PATENT OWNERS (US) IN LAST 10 YEARS

SR. NO.	TOP 10 PATENT OWNERS (US)	NUMBER OF PATENTS
1	Uop LLC	9
2	Eastman Chemical Company	8
3	General Electric Company	7
4	House of Metals Company Limited	6
5	Ball Corporation	5
6	Constellium Issoire	5
7	Hitachi Metals Ltd.	5
8	University of Massachusetts	5
9	Apple INC.	4
10	Honeywell International Inc.	4

Source: Related Industry Publications, Industry Journals, and MarketsandMarkets Analysis

Disclaimer: The main purpose of this chapter is to provide basic information on patent activity. The criteria supported by different search services may vary. According to it, individual results also may vary.

6.6 REGULATORY LANDSCAPE

Rare earth element mining, processing, and exploitation are large-scale industries that use a wide range of chemical substances and generate significant quantities of waste. In addition, the ores contain variable amounts of impurities, such as non-target toxic metals, fluorine, and radionuclides, that may be released from the ore during processing into the product or waste streams and/or pose safety risks to the workers. Rare-earth element mining and processing in the past has led to significant environmental impact in several countries, including Brazil, China, and the US (EPA, 2012). In addition to the environmental damage caused, remediation of contaminated sites can be expensive. For example, the estimated cost of remediating the Mitsubishi rare-earth element processing site in Bukit Merah, Malaysia, is USD 100 million (Bradsher, 2011). It is, therefore, important to ensure that the regulatory framework in the EU supports the development of a well-managed rare earth element industry with acceptably low environmental impact and a negligible effect on human health.

Activities involving materials with background concentrations of naturally occurring radionuclides are exempt from the EU's radiation protection regulations (Basic Safety Standards, 2013) to avoid the need to regulate the use of virtually every material on earth. The point where the mining and processing of ore (and other specified activities) require regulation is when the material contains more than 1 Bq g-1 of the radionuclides in the Uranium-238 or Thorium-232decay series, or 10 Bq g-1 40K (Basic Safety Standards, 2013).

Some rare earth element ores contain U and/or Th at elevated concentrations due to mineralization processes, although the concentrations vary widely. When rare-earth element ores are not exempt, there is a need to handle the materials and process the wastes according to the EU's Basic Safety Standards (2013). This new directive has integrated Naturally Occurring Radioactive Material (NORM) into its overall requirements, meaning industries processing NORM will be managed within the same regulatory framework as other practices.

6.6.1 STANDARDS BY ISO/TC 298 (RARE EARTH)

6.6.1.1 ISO 22450:2020 (Recycling of rare earth elements — Requirements for providing information on industrial waste and end-of-life products)

This specifies the recycling information to be provided for rare earth elements (REEs) in industrial waste and end-of-life (EOL) products from manufacturers or producers to recyclers. It includes a classification system and forms for providing the recycling information.

Rare earth elements (REEs) comprise the lanthanoid series elements, along with scandium and yttrium, which have similar chemical and physical properties and are often found in the same ores and deposits. The importance of REEs has increased greatly due to their role in high-performance and functional applications in electric vehicles, permanent magnets, motors, wind generators, light-emitting diodes (LED), and nickel-metal hydride (NiMH) batteries, among others.

Magnets account for the highest market share of REEs by value. REE-containing multi-component alloys can have a complex compositional make-up. The variants include compositions such as $Sm_{62}Co_{38}$, $Sm(Co_{0.69}Fe_{0.2}Cu_{0.1}Zr_{0.01})_{7.2}$, $Sm(Co_{0.67}Fe_{0.22}Cu_{0.1}Zr_{0.07}Ti_{0.01})_{7.1}$, $Sm_2Fe_{17}N_x$, $Nd(Fe,Mo)_{12}N_x$, $Sm_3(Fe,M)_{29}N_x$, sintered $Nd_2Fe_{14}B/\alpha\text{-}Fe$, $Sm_2Fe_{17}N_x/\alpha\text{-}Fe$, PrFeCuB, $TbxDy_{1-x}Fe_2$ (x ~0,3) and others are used in permanent magnets. Due to the complexity involved in the processing of these magnets, several different manufacturing routes are used. During the production stages, industrial waste containing REEs is produced and often recycled. Magnets found in end-of-life (EOL) or broken electronics, hard disk drives, motors, and generators also contribute to waste.

Phosphors and luminescence applications of REEs constitute about a one-third share of the total demand for REEs. REEs contained in $(La_{0.6}Ce_{0.27}Tb_{0.13})PO_4$, $(Y_{1.94}Eu_{0.06})_{03}$, $(Ba_{0.9}Eu_{0.1})MgAl_{10017}$, $Ca_{0.98}Eu_{0.02}AlSiN_3$, $(Y_{0.98}Ce_{0.02})_3Al_{5012}$, etc. are important materials used in phosphor and LED semiconductor technology. The LED manufacturing process is complex and is undergoing much change with the growth of the industry and the changes in demand patterns of associated commodities. During the production stages of LEDs, a lot of waste is created, which is recycled. EOL LEDs found in broken smartphones, TVs, display panels, and cameras also contribute to waste.

Batteries make up a relatively lower amount of the total demand for REEs. REEs contained in multi-component alloys such as LaNi5, $La_{0.8}Nd_{0.2}Ni_{2.5}Co_{2.4}Si_{0.1}$, $La_{0.8}Nd_{0.2}Ni_{2.5}Co_{2.4}Al_{0.1}$ and $MmNi_{3.5}Co_{0.7}Al_{0.8}$ are used in rechargeable NiMH batteries due to their superior hydrogen storage properties. The production of these NiMH batteries produces waste, which is generally recycled. EOL batteries also contribute to waste.

6.6.1.2 ISO/TS 22451:2021 (Recycling of rare earth elements — Methods for the measurement of rare earth elements in industrial waste and end-of-life products)

This provides measurement methods for quantifying rare earth elements (REEs) in industrial wastes and end-of-life products in solid, solid-liquid mixture, or liquid forms. It provides an overview of sample preparation and measurement of REEs in industrial waste and end-of-life products.

Increasing technical advancement has emphasized the importance of rare earth elements (REEs) due to their significant use in a number of applications, including green technologies. However, there are high supply risks arising from the dependence on a single source of extraction. Recycling and systemic management of rare earth elements are key issues for solving the waste and supply risks of REEs.

To efficiently recycle and systemically manage rare earth elements, a standard measurement method of REEs in industrial wastes and end-of-life cycled products is needed. Industrial wastes and end-of-life products can be found in solid, solid-liquid mixture, and liquid forms. For example, machining waste contains chips and flakes with coolant oils, greases, and numerous other forms of aqueous and nonaqueous contaminants. On the other hand, waste liquid slurries contain REEs, as in LEDs, and batteries contain numerous acids and bases. Furthermore, in order to verify the information provided by the producer about REEs in the waste, a standardized measurement procedure is necessary.

There are several scientific methods to quantitatively measure REEs in matters, such as X-ray fluorescence (XRF), coupled plasma mass spectroscopy (ICP-MS), coupled plasma optical emission spectroscopy (ICP-OES), and glow discharge mass spectrometry (GD-MS). However, these different characterization techniques often offer varied measurement results depending on the composition and physical state of the sample under observation. This is another reason to establish standard measurement methods.

6.6.1.3 ISO 22453:2021 (Exchange of information on rare earth elements in industrial wastes and end-of-life cycled products)

This specifies methods of information exchange between waste handlers and recyclers for rare earth elements (REEs) contained in industrial waste and end of life (EOL) products. This facilitates the efficient recycling of REEs so that dependency on mining can be reduced by the promotion of REE recycling.

Rare earth elements (REEs) have become essential for a wide range of industrial applications, including electric vehicles, batteries, smartphones, displays, transparent lenses, optical fiber, and so on. However, limited resource creates an imbalance between supply and demand. Therefore, the importance of REEs is increasingly significant. In order to overcome resource scarcity, the recycling or urban mining of industrial waste and end of life (EOL) cycle products is necessary.

For recyclers, it is of utmost importance to know what kind of REEs are present in the waste or scrap material and how much can be extracted. In order to facilitate recycling, it is important to define what information is required by the recycler and to establish a standard method of information exchange on REEs in industrial waste and EOL products.

Due to the lack of a standardized system and communication exchange mechanism between waste handlers and recyclers, the ability to recycle currently lags behind what it should be. There are many producers of the same product, but compositions and concentrations are different, which makes it difficult and complicated for recyclers to obtain exact information about the elements being recycled. Furthermore, if the producer and the recycler are located in different countries, information reliability and cross-border transaction of information exchange are problematic. Therefore, a system of information exchange between the waste handler and the recycler is needed.

This standard contains a system of information exchange between waste handlers and recyclers about REEs in industrial waste and EOL products. The system of information exchange involves a data exchange mechanism such as quick response (QR) codes and radio frequency identification (RFID).

6.7 TRADE ANALYSIS

6.7.1 CHINA'S GROWING CONFLICT WITH WORLD TRADE ORGANIZATION: THE CASE OF EXPORT RESTRICTIONS ON RARE EARTH RESOURCES

China is the leading exporter of rare earth elements, which are crucial to the development of high-tech products and new green technologies. In recent years, China has begun imposing export restrictions on rare earth metals to boost its domestic economic development. This reduces global supply and thus artificially leads to higher prices for importing countries. Some of the major importers, such as the EU, the US, and Japan, have launched a formal complaint in the WTO against China's export restrictions. China claims that these restrictions were implemented considering environmental protection. This case examines China's rare earth policy and its compliance with WTO rules.

6.7.2 CHINA'S GROWING CONFLICT WITH WTO

The first complaint on raw materials: 2009

The first formal complaint was in 2009—China's export restriction on a group of nine raw materials that dated back to 1994. This case was challenged by the EU, the US, and Mexico, resulting in the Appellate Body's final judgment in January 2012, which stated that the Chinese measures were in violation of WTO rules.

The second complaint on export restrictions: 2012

In July 2012, the EU, the US, and Japan together filed litigation against China's export restrictions on important rare earth materials, such as tungsten and molybdenum. The complainants argued that these restrictions violate China's WTO commitments and significantly distort global markets, which impacts the companies in importing countries.

Conclusion:

The first and foremost agenda was to find whether China's export measures are compatible with its WTO commitments. The Appellate Body stated in the first case that China's export duties on all raw materials, which are not specifically listed in the Annex to its Protocol of Accession, were prohibited. This is unlikely to change in the case of rare earth metals, which are also not listed in the Annex.

Secondly, with regard to China's export quotas, the evidence clearly shows that the Chinese government has been actively involved in the application of export quotas on rare earth metals for more than ten years now. Over the past few years, government regulation, supervision, and enforcement of those quotas have been expanded and tightened. So, to conclude, export restrictions cannot be considered as the optimal policy instrument which can increase environmental protection and conserve depletable natural resources. Instead of export restrictions, China should make use of more cost-effective, non-discriminatory policies, for instance, production taxes.

As export restrictions may impose high costs on major industrialized countries, which are the leading importers of rare earth metals, it directly helps China to accrue more profits. The rectification of this situation now lies in the hands of the WTO.

Source: Intereconomics.eu (Center for European Policy Studies)

TABLE 11 EXPORT TRADE DATA FOR RARE EARTH METALS (2019)

PRODUCT GROUP (HS CODE)	BIGGEST EXPORTING COUNTRIES	EXPORTS (USD MILLION)
280530	▪ China ▪ Thailand ▪ Japan ▪ Netherlands ▪ US ▪ Republic of Korea ▪ Russia ▪ UK ▪ Austria ▪ Philippines	▪ 116.03 ▪ 42.52 ▪ 12.93 ▪ 3.41 ▪ 1.81 ▪ 1.68 ▪ 1.3 ▪ 1.21 ▪ 0.62 ▪ 0.53

Source: UN COMTRADE

TABLE 12 IMPORT TRADE DATA FOR RARE EARTH METALS (2019)

PRODUCT GROUP (HS CODE)	BIGGEST IMPORTING COUNTRIES	IMPORTS (USD MILLION)
7403	▪ Japan ▪ Malaysia ▪ Thailand ▪ Republic of Korea ▪ US ▪ Spain ▪ Netherlands ▪ Germany ▪ Norway ▪ India	▪ 254.10 ▪ 73.51 ▪ 20.01 ▪ 9.97 ▪ 8.28 ▪ 4.08 ▪ 3.62 ▪ 3.43 ▪ 3.28 ▪ 2.79

Source: UN COMTRADE

6.8 TECHNOLOGY ANALYSIS

New environmentally friendly technologies promise to be “game-changers” in this field and enable to create a more stable and reliable domestic source of these essential metals. Rare earth metals are responsible for making technology smaller, lighter, and more powerful than before. Rare earth metals are used in products ranging from optical fibers to mobile phones, catalytic converters to green technology, and are even responsible for providing sharper and more vivid colors in our flat screen televisions and tablets. These metals have even been identified as essential for modern-day defense applications, for example, in guidance systems, lasers, and radar and sonar systems.

6.8.1 SEREN TECHNOLOGIES

The company has developed a revolutionary extraction method for recycling rare earth methods using ionic liquids. An ionic liquid is a salt in which the ions are poorly coordinated, resulting in these solvents being liquid below 100°C or even at room temperature. One benefit of using ionic liquids in recycling methods is that they have lower levels of volatility and flammability compared to organic solvents, providing a safer and more environmentally friendly method.

Seren Technologies’ research is based on the use of hydrophobic ionic liquids comprising a nitrogen donor and additional electron-donating groups, which act as a molecular recognition ligand to improve the selectivity and levels of recovery of rare earth metals. This new patented process (WO 2018/109483) can separate mixtures of dysprosium and neodymium with a selectivity of over 1000:1 in a single processing step, which means that this research can not only lead to increased levels of recycled rare earth metals but that this can be achieved in a less time-consuming, more cost-efficient, and a more environmentally friendly way.

The company opened its pre-commercial permanent magnet recycling plant at the Wilton Centre in the north of England on December 3, 2018, illustrating 98% selectivity of rare earth metals in a single separation step, taking only two hours, marking a significant reduction in the time required to select these rare earth metals. With the aim to bring this technology to market on an industrial scale, it could represent a significant leap forward in the viability of recycling rare earth metals in a safer and more economically viable way.

6.8.2 WORCESTER POLYTECHNIC INSTITUTE

The US government has been funding research into methods of effectively recycling rare earth metals. One project by the Worcester Polytechnic Institute has focused on extracting rare earth metals from machinery without the requirement of first dismantling the machine to be recycled. Typically, rare earth materials are contained within the innermost parts of the machine and are, therefore, not readily accessible. Accordingly, previously known methods have required substantial time and cost to access the relevant machinery part for recycling.

To tackle the challenge, Worcester Polytechnic Institute has produced a low-temperature method of extracting rare earth metals from fragmented end-of-life machinery. The patented method (US 2016/208364) requires demagnetization of the metal through heating. For example, the end-of-life machinery can be heated in a furnace at a temperature of at least 400°C for 60 minutes to demagnetize metals contained therein. The material is then shredded to break the present magnets. Finally, the rare earth metals are extracted with a leaching solution via hydrochloric acid to produce a solution of the dissolved magnet material, followed by precipitating the rare earth metals using oxalic acid. The method has been reported to provide recovery efficiencies of up to 82% with rare earth metals having a purity of over 99%.

6.9 PRICING ANALYSIS

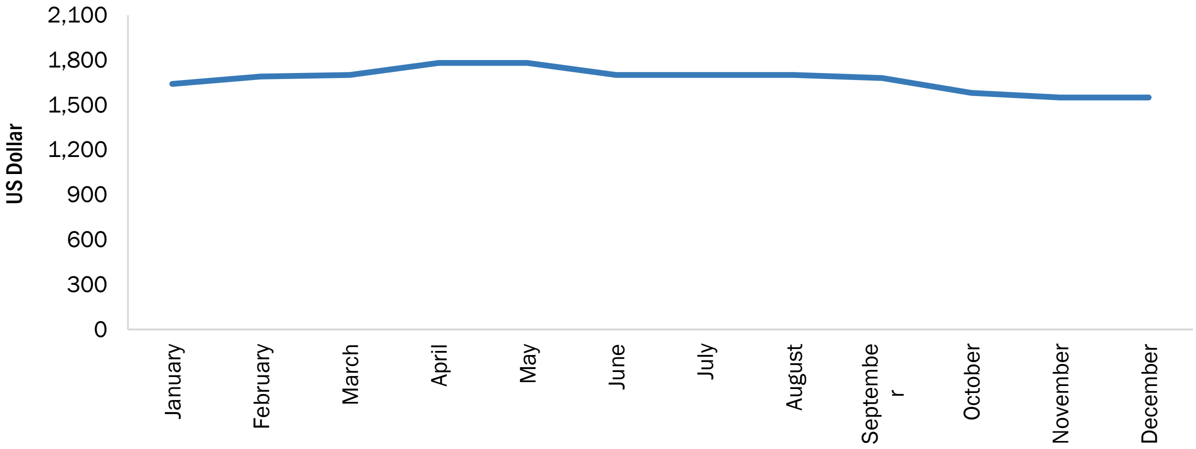
The prices of rare earth metals are very difficult to track and monitor as these metals are not traded in any exchange, like other metals, such as gold, silver, nickel, tin, copper, and aluminum. Also, these metals are often not sold in their pure form; instead, they are sold in mixtures with different levels of purity, for example, 99% neodymium.

The prices for rare earth metals had been constant for the most part of the 1990s and the mid-2000s until the Chinese imposed a lot of restrictions on exports in 2011. These restrictions were in the form of cuts on export quotas, constraints on mining to follow good environmental practices, and curb illegal practices. These restrictions imposed by China caused the prices of rare earth metals to increase exponentially, almost overnight, as it created a supply shortage. The price of some critical rare earth metals, such as neodymium and dysprosium, increased by over 500%.

At the start of 2019, the prices of rare earth metals witnessed an increase as China's Yunnan Province, which borders Myanmar, suspended imports of all resources, including rare-earth ores, from its neighbor in November 2018. It was thought that this move was a crackdown on the smuggling of rare earth metals into China from mines in neighboring Kachin State and other places in Myanmar, where many Chinese were working. The suspension of imports from Myanmar has pushed up rare earth metal prices, especially dysprosium, since the start of the year, paving the way for soaring rare earth metal prices in May and June over speculation that China could announce a ban on imports. Rare earth metal prices are particularly susceptible to movements in China's market, given their small size and the country's dominance. The suspension was lifted in late September. At the same time, the trade war between the US and China entered a "ceasefire," easing supply in the market, which, in turn, led to a decline in prices in mid-2019.

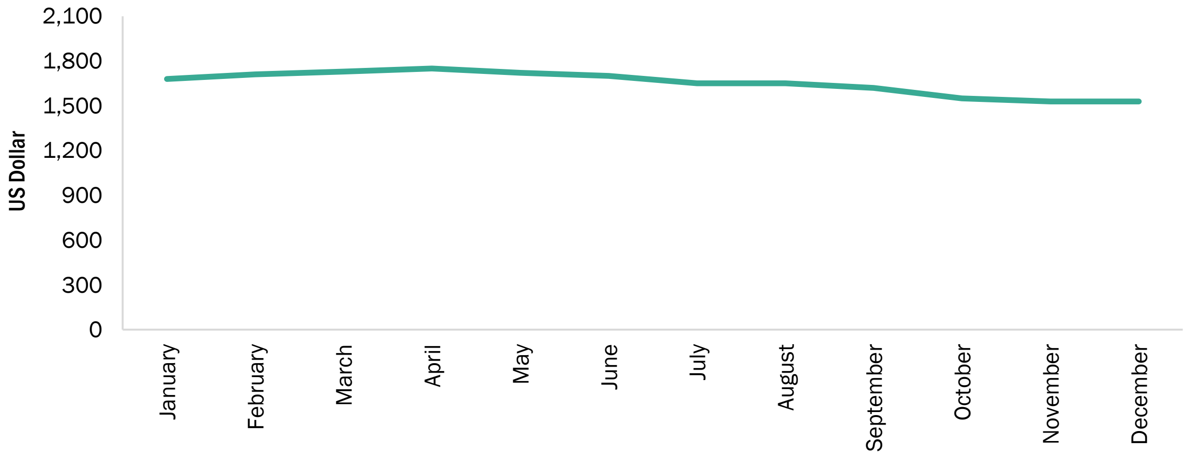
In 2020, the prices were relatively stable though the prices of rare earth oxides, such as neodymium and praseodymium, witnessed increases in the second half of the year. Spot supply rose in mid-2020 as Chinese operations resumed post-lockdown ahead of many key consuming countries, but downstream magnet demand remained a bit sluggish in the medium-term, which potentially weighed on the rare earth oxide prices for the rest of 2020.

FIGURE 35 MONTHLY CERIUM OXIDE PRICES, 2020



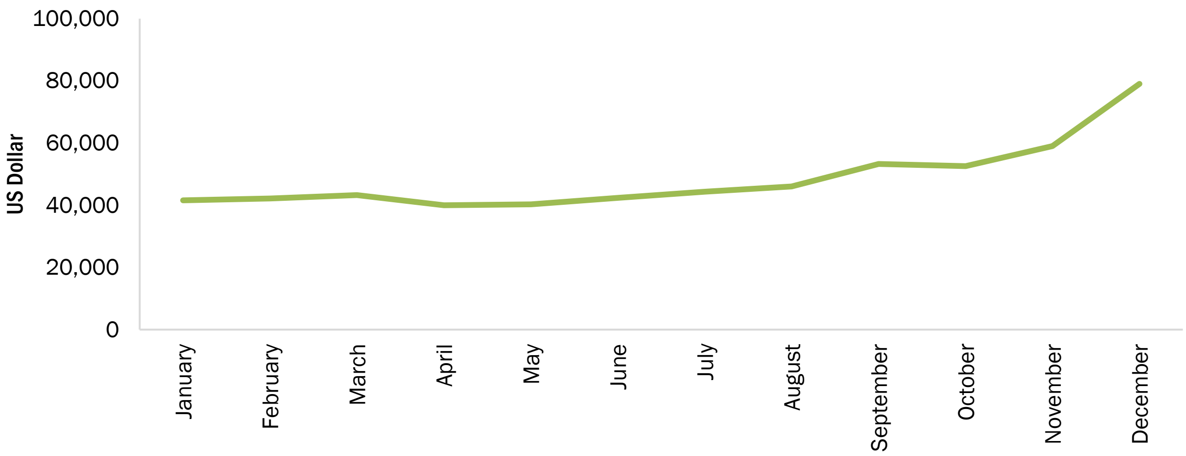
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 36 MONTHLY LANTHANUM OXIDE PRICES, 2020



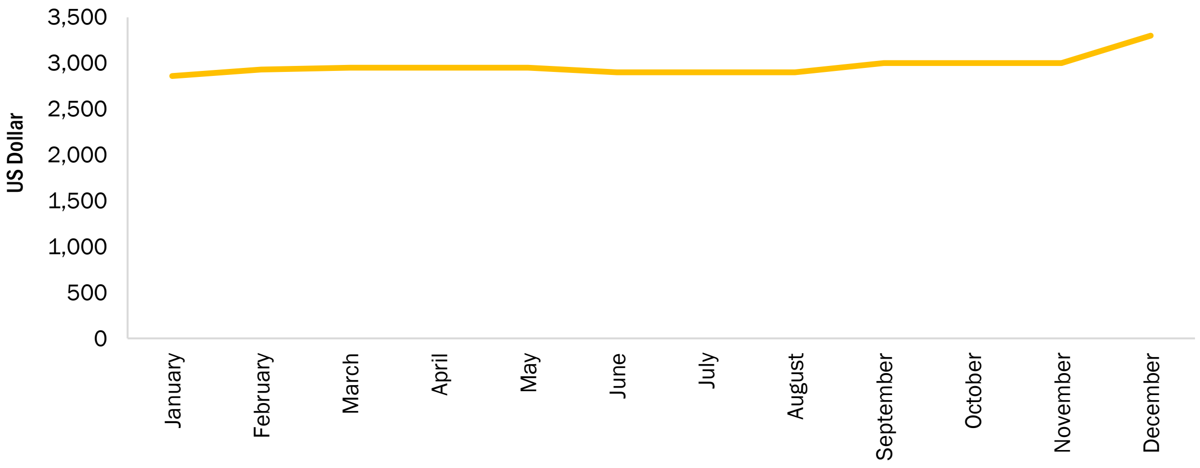
Source: Institut für Setline Erden und Metalle and MarketsandMarkets Analysis

FIGURE 37 MONTHLY NEODYMIUM OXIDE PRICES, 2020



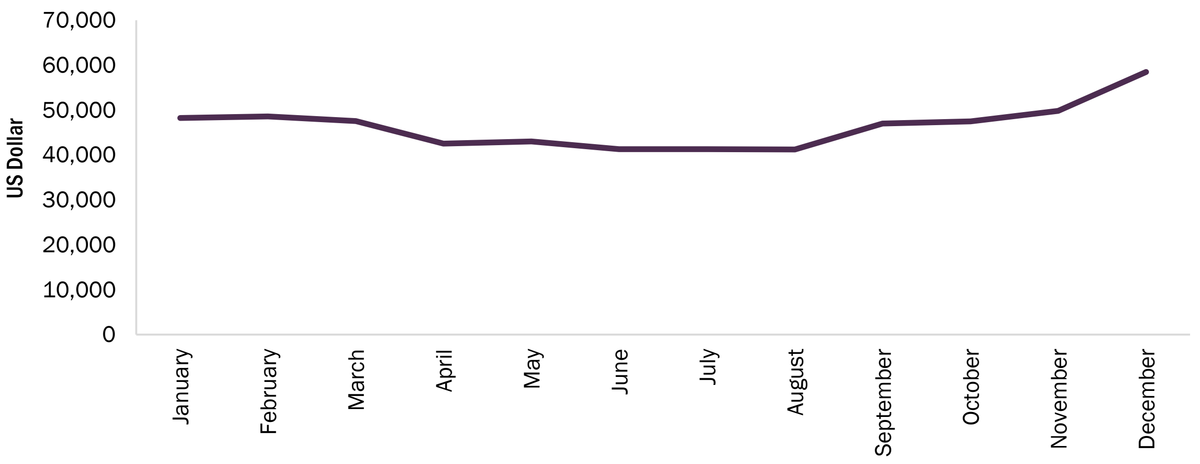
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 38 MONTHLY YTTRIUM OXIDE PRICES, 2020



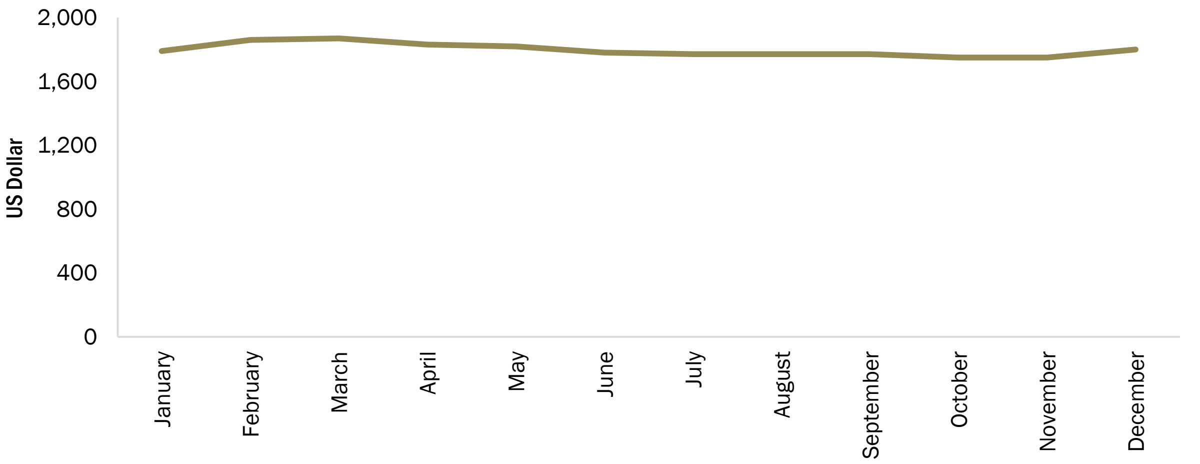
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 39 MONTHLY PRASEODYMIUM OXIDE PRICES, 2020



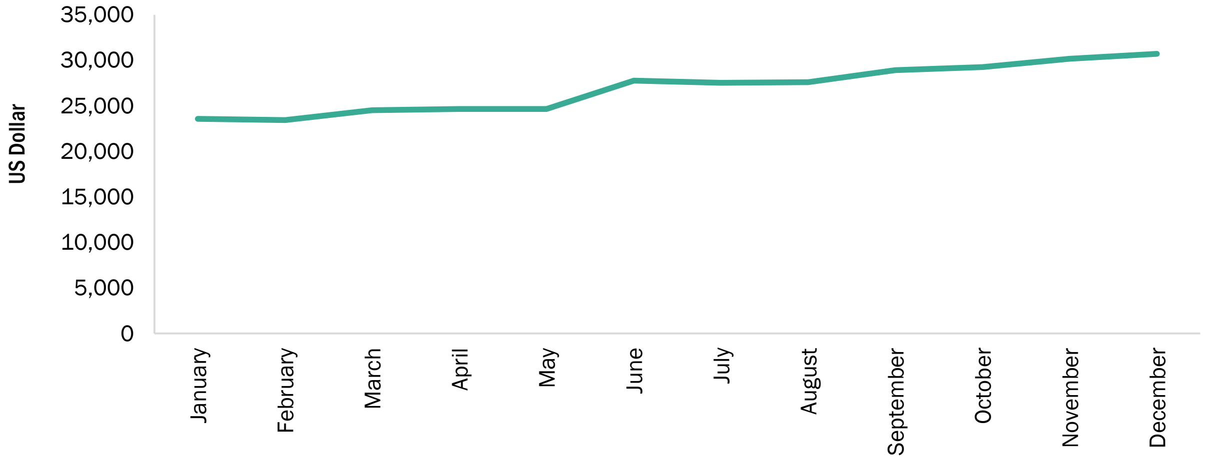
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 40 MONTHLY SAMARIUM OXIDE PRICES, 2020



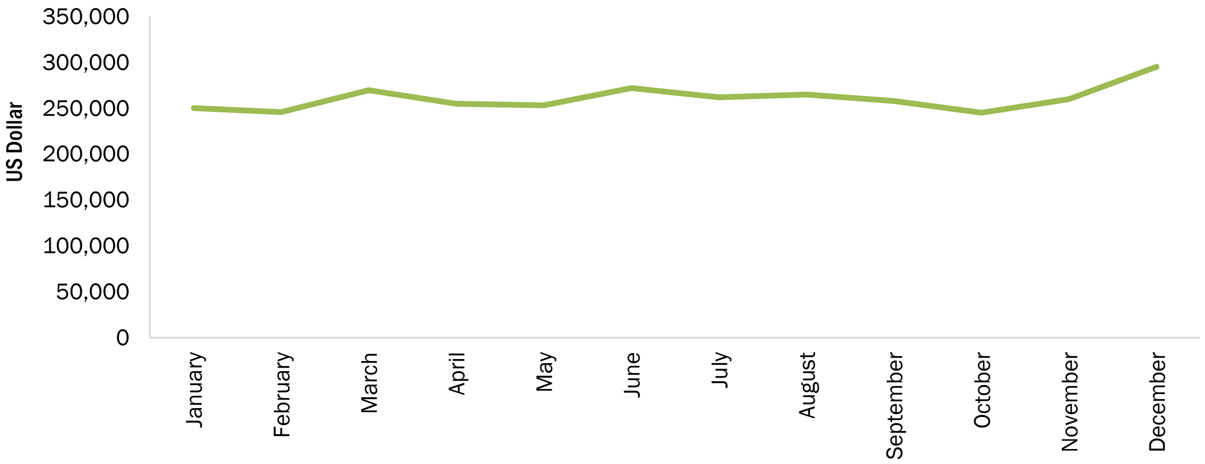
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 41 MONTHLY GADOLINIUM OXIDE PRICES, 2020



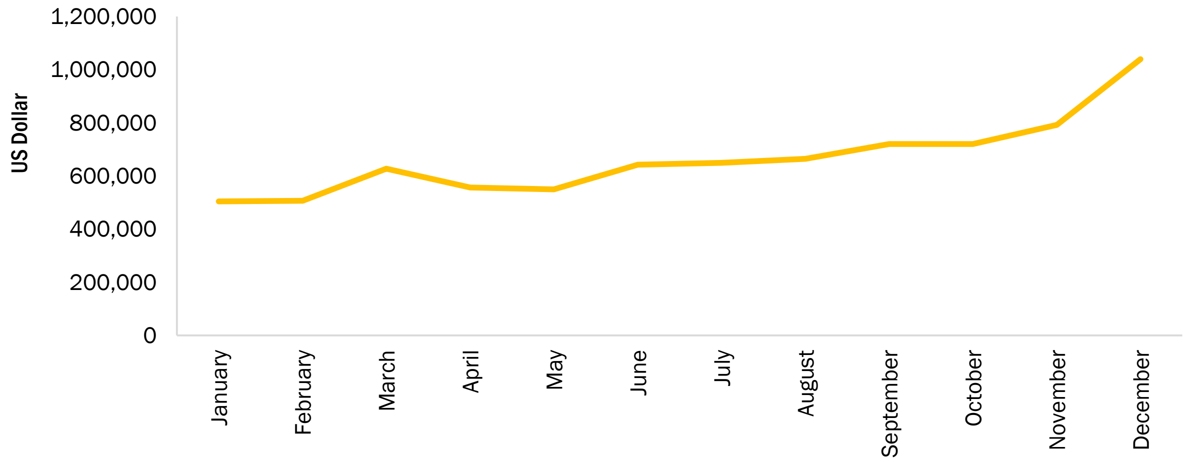
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 42 MONTHLY DYSPROSIUM OXIDE PRICES, 2020



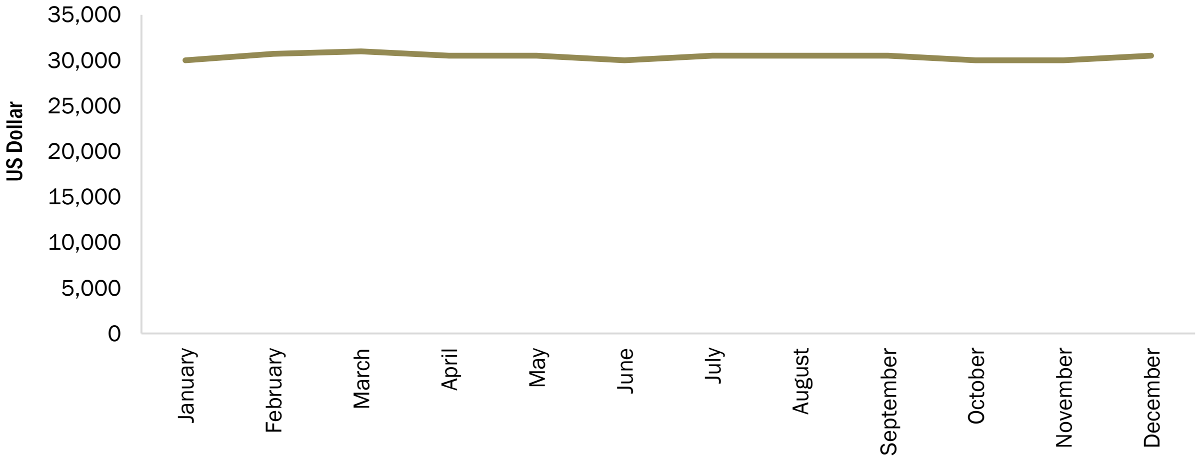
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 43 MONTHLY TERBIUM OXIDE PRICES, 2020



Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 44 MONTHLY EUROPIUM OXIDE PRICES, 2020



Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

TABLE 13 MONTHLY AVERAGE RARE EARTH OXIDE PRICES: JANUARY 2020-JUNE 2020 (USD/METRIC TON)

Type	January	February	March	April	May	June
Cerium Oxide	1,640	1,690	1,700	1,780	1,780	1,700
Lanthanum Oxide	1,680	1,710	1,730	1,750	1,720	1,700
Neodymium Oxide	41,580	42,150	43,240	40,000	40,300	42,300
Yttrium Oxide	2,860	2,930	2,950	2,950	2,950	2,900
Praseodymium Oxide	48,220	48,580	47,560	42,500	43,000	41,300
Samarium Oxide	1,790	1,860	1,870	1,830	1,820	1,780
Gadolinium Oxide	23,570	23,430	24,500	24,648	24,648	27,749
Dysprosium Oxide	250,040	245,750	269,530	255,000	253,000	272,000
Terbium Oxide	504,360	507,220	626980	557,000	550,000	642,000
Europium Oxide	30,000	30,720	30,990	30,500	30,500	30000
Others	140,774	139,936	142,116	333,938	331,286	338,248

Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

TABLE 14 MONTHLY AVERAGE RARE EARTH OXIDE PRICES: JULY 2020-DECEMBER 2020 (USD/METRIC TON)

Type	January	February	March	April	May	June
Cerium Oxide	1,700	1,700	1,680	1,580	1,550	1,550
Lanthanum Oxide	1,650	1,650	1,620	1,550	1,530	1,530
Neodymium Oxide	44,300	46,000	53,200	52,500	59,000	79,000
Yttrium Oxide	2,900	2,900	3,000	3,000	3,000	3,300
Praseodymium Oxide	41,300	41,200	47,000	47,500	49,800	58,500
Samarium Oxide	1,770	1,770	1,770	1,750	1,750	1,800
Gadolinium Oxide	27,532	27,574	28,922	29,233	30,154	30,697
Dysprosium Oxide	262,000	265,000	258,000	245,000	260,000	295,000
Terbium Oxide	650,000	665,000	720,000	720,000	792,000	1,038,740
Europium Oxide	30,500	30,500	30,500	30,000	30,000	30,500
Others	332,978	330,872	335,690	338,822	350,316	373,726

Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

TABLE 15 AVERAGE PRICES FOR RARE EARTH OXIDES (USD/METRIC TON), 2020

TYPE	PRICE (USD/TON)
Cerium Oxide	1,670.83
Lanthanum Oxide	1,651.67
Neodymium Oxide	48,630.83
Yttrium Oxide	2,970.00
Praseodymium Oxide	46,371.67
Samarium Oxide	1,796.67
Gadolinium	26,888.04
Dysprosium Oxide	260,860.00
Terbium Oxide	664,441.67
Europium Oxide	30,392.50
Others	290,725.17

Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

6.10 CASE STUDY ANALYSIS

6.10.1 NISSAN TESTING NEW RARE EARTH RECYCLING PROCESS

Nissan Motor Co., Ltd. and Waseda University have started testing a jointly developed recycling process in Japan that efficiently recovers high-purity rare earth compounds from electrified vehicle motor magnets. The testing is aimed at enabling the practical application of the new process. The automotive industry is promoting vehicle electrification to tackle climate change and to realize a carbon-neutral society. Most motors in electrified vehicles use neodymium magnets, which contain rare earth metals such as neodymium and dysprosium. Reducing the use of scarce rare earths is important not only because of the environmental impact of mining and refining, but also because the shifting balance of supply and demand leads to price fluctuations for both manufacturers and consumers.

To use limited and valuable resources more effectively, since 2010, Nissan has been working from the design stage to reduce the amount of heavy rare earth elements (REEs) in motor magnets. In addition, Nissan is recycling REEs by removing magnets from motors that do not meet production standards and returning them to suppliers. Currently, multiple steps are involved, including manual disassembly and removal. Therefore, developing a simpler and more economical process is important to achieve increased recycling in the future.

Since 2017, Nissan has been collaborating with Waseda University, which has a strong track record of researching non-ferrous metal recycling and smelting. In March 2020, the collaboration successfully developed a pyrometallurgy process that does not require motor disassembly.

Process overview:

- A carburizing material and pig iron are added to the motor, which is then heated to at least 1,400°C and begins to melt.
- Iron oxide is added to oxidize the REEs in the molten mixture.
- A small amount of borate-based flux, which is capable of dissolving rare-earth oxides even at low temperatures and highly efficiently recovering REEs, is added to the molten mixture.
- The molten mixture separates into two liquid layers, with the molten oxide layer(slag) that contains the REEs floating to the top and the higher density iron-carbon(Fe-C) alloy layer sinking to the bottom.
- The REEs are then recovered from the slag.

Testing has shown that this process can recover 98% of the motors' REEs. This method also reduces the recovery process and work time by approximately 50% compared to the current method because there is no need to demagnetize the magnets nor remove and disassemble them.

Moving forward, Waseda and Nissan will continue their large-scale facility testing with the aim of developing practical applications, and Nissan will collect motors from electrified vehicles that are being recycled and continue to develop its recycling system.

6.10.2 RECYCLING PROCESS OF RARE EARTH METALS FROM NI-MH BATTERIES PROPOSED BY HONDA

Honda Motor Co., Ltd. and the Japan Metals & Chemicals Co., Ltd. jointly established the world's first process to extract rare earth metals from various used parts in Honda products in an actual mass-production process at a recycling plant. Honda pursued the recycling of precious resources by utilizing the newly established process for the recycling of rare earth metals.

As part of this effort, Honda and Japan Metals & Chemicals extracted rare earth metals from used nickel-metal hydride batteries collected from Honda hybrid vehicles at Honda dealers inside and outside of Japan. Honda had been applying a heat treatment to used nickel-metal hydride batteries and recycling nickel-containing scrap as a raw material of stainless steel. However, the successful stabilization of the extraction process at the plant of Japan Metals & Chemicals Co., Ltd. made possible the extraction of rare earth metals in a mass-production process with purity as high as that of newly mined and refined metals.

The established process enables the extraction of as much as above 80% of rare earth metals contained in used nickel-metal hydride batteries. Honda strives to reuse extracted rare earth metals not only for nickel-metal hydride batteries, but also for a wide range of Honda products. Giving consideration to the recycling of resources used for its products, Honda has long been committed to the 3R (reduce, reuse, recycle) approach. For instance, Honda was the first Japanese automaker to begin sales of recycled parts and to collect/recycle oil filters and replaced bumpers.

6.10.3 BENTLEY AIMS TO REVOLUTIONISE SUSTAINABILITY OF ELECTRIC MOTORS

Bentley Motors, in February 2021, announced a three-year research study that aims to revolutionize the sustainability of electric motors. This would support Bentley's commitment to offer only hybrid or electric vehicles by 2026. the result could see recycled rare-earth magnets used in selected ancillary motors for the very first time.

The study, titled RaRE (Rare-earth Recycling for E-machines), intends to build on work completed at the University of Birmingham in devising a method of extracting magnets from waste electronics. Furthermore, the project will scale up this process and repurpose the extracted magnetic material into new recyclable magnets for use within bespoke ancillary motors.

Adding to the sustainability benefits that RaRE will provide, the bespoke motors created through this method promise to minimize complexity through manufacture while supporting the development of the UK supply chain for both mass production and low volume components.

RaRE would provide an opportunity to prove the importance and potential of short loop recycled magnetic material. HyProMag's recycling technologies allow the company to produce NdFeB magnets with a much lower embedded carbon cost than using virgin supply and with independence from Chinese supply, and the company is working closely with its major shareholder Mkango Resources to further grow the business.

6.11 COVID-19 IMPACT ON RARE EARTH METALS RECYCLING MARKET

COVID-19 is an infectious disease caused by a newly discovered coronavirus. This disease is impacting the growth of economies across the globe. The virus was first identified in Wuhan (China) in December 2019. The COVID-19 pandemic has wreaked havoc on the world.

COVID-19 significantly impacted the global GDP in 2020, and according to the World Bank, the global GDP fell in 2020. The estimates so far indicate the virus could bring down the global economic growth by at least 0.5%- 1.5%, but the exact impact will be known only after the effects peak. Owing to the swift spread of the disease, both lives and livelihoods are at risk. It is a global problem that calls for a global response. There cannot be estimates on how quickly this disease will retreat.

Various rare earth recyclers are finding solutions and ways to communicate with their end users to help assure them in these difficult times by providing information on their website and social media on how they are tackling the global challenges.

6.12 COVID-19 IMPACT ON RARE EARTH METAL RECYCLING END-USE INDUSTRIES

The COVID-19 pandemic has already caused profound effects on a global macroeconomic scale. In the automotive industry, for example, car manufacturers had announced a halt in production, which is now gradually resuming again. Tier 1 and Tier 2 suppliers and other market actors further upstream are similarly affected by this demand-side shock and have consequently ramped down their production as well. In addition to such demand-side shocks, supply chain steps located in countries strongly affected by the virus are hampered, leading to the breaking of the entire international supply chain. This makes it clearer than ever that the security of the supply of strategic raw materials needed for the long-term competitiveness and job security in key industries is of prime importance for the European Union. The European Green Deal targets 2050 climate neutrality and recognizes access to resources as a strategic security question to fulfill its ambition. The new Industrial Strategy for Europe sees raw materials as key enablers for a globally competitive, green, and digital Europe. It envisions European competitiveness based on a new Alliance on Raw Materials and highlights the importance of industrial ecosystems for accelerating innovation and growth in Europe. A more resilient, more protective, more sovereign, and more inclusive economic model that aligns with the Green Deal has also been prioritized by the recently launched Green Recovery Alliance. EIT RawMaterials, funded by the European Institute of Innovation and Technology (EIT), has the vision to develop raw materials into a major strength for Europe. It is the world's largest network in the raw materials sector, connecting industry, research, and education. This makes EIT RawMaterials a key contributor to secure sustainable access and supply of raw materials for a green, digital, and competitive Europe.

The coronavirus outbreak in China has had a foreseeable but unintended consequence. Truck drivers refused to make deliveries into areas either identified as or suspected of harboring the disease. This has interrupted not only the flow of minerals out of the affected areas but also the refining and manufacturing of metals, food, and fuel.

Rare earth-enabled components for moving machinery such as automobiles, trucks, trains, aircraft, industrial motors and generators, home appliances, and consumer goods are procured from China or Japan (which, of course, gets its rare earth magnets, alloys, phosphors, and catalysts from China). These items cannot be re-sourced due to China's monopoly of rare-earth metals production and its monopsony of rare earth-enabled component manufacturing.

7 RARE EARTH METALS RECYCLING MARKET, BY APPLICATION

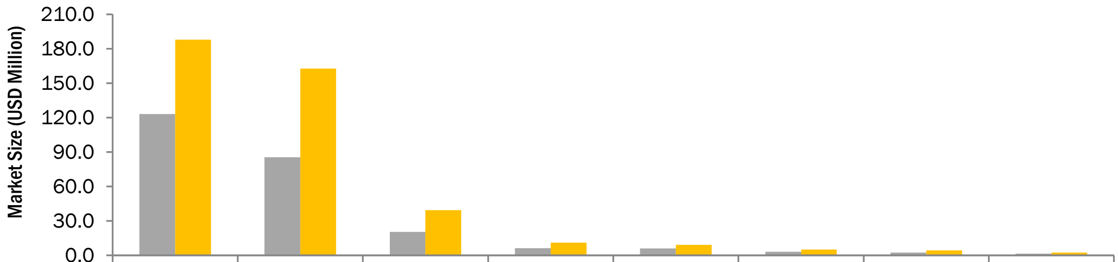
KEY FINDINGS

- The rare earth metals market is dominated by glass application, which accounted for a share of 50.66%, in terms of value, in 2020.
- The permanent magnets segment is projected to grow from USD 85.49 million in 2021 to USD 162.82 million by 2026, at a high CAGR of 13.75%.
- The phosphors segment accounted for the third-largest market share in 2021, with a share of 8.20%, in terms of value.
- The ceramics segment is projected to grow from USD 6.14 million in 2021 to USD 11.03 million by 2026, at a CAGR of 12.41%.

7.1 INTRODUCTION

Rare earth metals are increasingly used in new technologies in the clean energy, defense, and consumer electronics sectors. The rare earth metals recycling market is segmented based on application as alloy, catalyst, permanent magnets, glass, ceramics, phosphor, polishing materials, and hydrogen storage alloys.

FIGURE 45 GLASS APPLICATION TO LEAD OVERALL MARKET



	Glass	Permanent Magnets	Phosphor	Ceramics	Alloy	Catalyst	Polishing Materials	Hydrogen Storage Alloys
2021	123.1	85.5	20.3	6.1	5.9	3.2	2.4	1.4
2026	188.0	162.8	39.3	11.0	9.2	5.1	4.3	2.5
CAGR (2021-2026)	8.8%	13.8%	14.1%	12.4%	9.2%	9.6%	12.2%	11.8%

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 16 RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	79.38	75.04	85.49	162.82	13.8%
Alloy	5.66	5.44	5.93	9.21	9.2%
Polishing Materials	2.28	2.17	2.43	4.32	12.2%
Glass	117.72	113.27	123.14	188.03	8.8%
Catalyst	3.10	2.97	3.25	5.14	9.6%
Phosphor	19.34	17.90	20.34	39.28	14.1%
Ceramics	5.81	5.47	6.14	11.03	12.4%
Hydrogen Storage Alloys	1.35	1.28	1.44	2.51	11.8%
Total	**234.64**	**223.54**	**248.15**	**422.34**	**11.2%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 17 RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	1,299.7	1,230.0	1,395.1	2,591.0	13.2%
Alloy	573.9	553.0	597.9	886.7	8.2%
Polishing Materials	685.6	657.5	725.0	1,185.0	10.3%
Glass	388.0	374.7	405.7	605.2	8.3%
Catalyst	935.0	895.7	980.9	1,549.6	9.6%
Phosphor	384.7	358.7	402.0	712.0	12.1%
Ceramics	482.2	456.5	505.8	846.6	10.9%
Hydrogen Storage Alloys	174.5	166.3	184.4	310.2	11.0%
Total	**4,923.7**	**4,692.4**	**5,196.8**	**8,686.2**	**10.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

7.2 ALLOY

Rare earth elements are added to host metals, such as aluminum, iron, and steel, in small quantities to improve the physical properties of the resulting alloys. The elements are added as ferroalloys, master alloys, and mischmetal (a mix of mostly cerium and lanthanum oxides). Cerium is the largest used element in metallurgy applications, followed by lanthanum and neodymium. Lanthanum is added to steel to improve malleability. Cerium and cast-iron alloy are used in auto engines to improve machinability. Cerium is used in the production of stainless steel as a precipitation hardener. Praseodymium, in combination with neodymium, is used as an alloying agent in magnesium castings. These are used in the production of aircraft engines.

The batteries used in hybrid cars use an alloy of generic composition of lanthanum and nickel materials as anode elements. Rare earth elements used as anode materials enable the storage of large quantities of hydrogen required for the battery's operation. Nickel metal hydride batteries are likely to continue to be used in applications that favor cost savings over energy and power performance and will witness growth in demand in line with the growth of a particular company.

7.3 CATALYSTS

The highly effective metals of catalyst systems are cerium and lanthanum. They have properties such as absorbing, storing, and releasing oxygen and stabilizing the environments in which they operate. Automotive catalytic converters (autocats) for cars and utility vehicles and fluid cracking catalysts (FCCs) used in oil refineries are the major applications for rare earth catalysts.

Lanthanum and cerium are used as autocats. These elements are used for manufacturing catalytic converters, which convert the pollutants in engine exhaust to non-toxic compounds. Fluid cracking catalysts consisting of lanthanum and cerium are used in the refining of crude oil. The process of transformation of heavy molecules into more useful forms, such as gasoline, jet fuel, and diesel, requires these elements. The growth in the demand for rare earth oxides in catalysts will be directly dependent on the growth in automobile production and fluid cracking. The economic and technical viability of rare earth oxide catalysts at commercial sites could boost the demand in the automotive industry.

7.4 PERMANENT MAGNETS

The permanent magnets industry is the largest end user of rare earth elements. Magnets made from neodymium, praseodymium, and dysprosium are the strongest known permanent magnets. The automotive industry is a significant consumer of permanent magnets. Major industries requiring these permanent magnets are hybrid car engines and the growing wind power turbine industry. There may also be needed in regular power plants.

Permanent magnets are the preferred choice in major industrial and consumer electronic markets. These are also used for actuators in missile, satellite, and aircraft control systems. Neodymium-iron-boron rare-earth permanent magnets are used in wind turbines and electric motors. Samarium cobalt magnets are the ideal choice for permanent magnets of high-strength and high-temperature applications, such as accelerometers and gyroscopes, high-temperature magnetic bearings, magnetic couplers and actuators, high-performance pumps and mixers, and traveling wave tubes.

7.5 GLASS

The major rare earth elements used in glass are cerium and lanthanum, followed by smaller quantities of neodymium, praseodymium, yttrium, and erbium for additives. The mixture of lanthanum and other rare earth elements increases the refractive index of glass, which makes it easier to build better lenses. Cerium is used as a de-colorizer and a color additive. Glass containing cerium compositions has the property to absorb UV light. Glasses made of neodymium change color under different lighting conditions due to their yellow light filtering properties. Hence, it is used in rear-view mirrors of automobiles and goggles for welding applications. Along with neodymium, praseodymium is also used as a yellow colorant for glass in goggles and as dopants in fiber optic amplifiers.

7.6 CERAMICS

Yttrium is the most used metal, followed by lanthanum, whereas cerium, neodymium, and praseodymium are also used to a smaller extent for producing ceramics. Yttrium, along with Zirconia, is used in structural forms as well as coatings in applications, such as dentistry, jet engines, gas turbines, sensors, jewelry, knives, as well as in oxygen sensors used in auto engine systems. Neodymium, praseodymium, and erbium are used in the construction industry as they provide unique colors to tiles. In high-tech applications in electronics, rare earth metals are used as dopants in Barium Titanate Dielectric material, which are further used to produce ceramic chip capacitors. These are an essential part of advanced electronic packaging systems.

7.7 PHOSPHORS

Phosphors are used in many applications that require color in the light exhibited, namely, cathode ray tube displays, fluorescent lamps, and other applications. The important elements in this sector are europium, terbium, and yttrium. Phosphors are used to convert the incident radiation into the light of the designed colors.

Rare earth oxide phosphors are used in various instrument panels for backlighting applications. A suitable combination of phosphor coatings can convert the emissions of light from fluorescent lamps to any form of required lighting. The demand for rare earth oxide phosphor products is expected to increase due to government policies in the US, Canada, China, the European Union, and other countries where incandescent lamps are being replaced with fluorescent and LED lamps.

7.8 POLISHING MATERIALS

Rare earth oxide performs functions such as absorbing ultraviolet light, altering the refractive index, and colorizing or decolorizing when added to glass polishing. LCD screens, HDD, precision optical, ophthalmic, crystals, and flat glass use glass polishing powders.

Cerium oxide polishing powder is one of the best polishing materials useful for polishing discs of computer hard drives, glass, lenses, CRTs, jewels, silicon chips, TV screens, and monitors. Although rare earth-based polishing powders are the most effective, their rising prices have impacted the demand for polishing powders. The increase in the rare-earth oxide prices would lead to the introduction of improved glass manufacturing processes and the recycling of polishing powder slurries. The demand for rare earth-based polishing powders would increase according to the global glass demand. Cerium oxide is mainly used to polish glasses as well as polish out glass scratches.

7.9 HYDROGEN STORAGE ALLOYS

Rare earth-based alloys play an important role in solid-state hydrogen storage field, which can be used as Ni/MH electrode materials. These materials have excellent hydrogen storage and electrochemical properties. The batteries used in hybrid cars use an alloy of generic composition of lanthanum and nickel materials as anode elements. Rare earth elements used as anode materials enable the storage of large quantities of hydrogen required for the battery's operation. Nickel metal hydride batteries are likely to continue to be used in applications that favor cost savings over energy and power performance.

8 RARE EARTH METALS RECYCLING MARKET, BY SOURCE

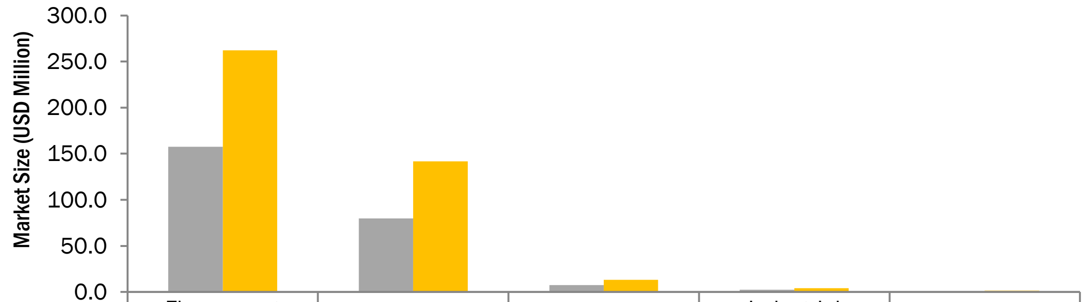
KEY FINDINGS

- The fluorescent lamps segment accounted for the largest market share of 63.83% in 2020 and is projected to register a CAGR of 10.70% during the forecast period.
- The magnets segment accounted for the second-largest share of 31.86% of the overall rare earth metals recycling market in 2020 and is expected to witness a CAGR of 12.16%, in terms of value, between 2021 and 2026.
- Growing demand from various end-use industries, such as automotive, industrial, medical, and defense, is expected to boost the demand for rare earth metal recycling.

8.1 INTRODUCTION

Rare earth metals are important materials that are widely used in different applications ranging from information and communication technologies (ICT) to catalysis. To reduce the impact of market price and reduce the environmental effect of soil extraction and recovery/purification, various methods to recycle rare earth metals should be explored. The recycling of rare earths is carried out on effluents, waste, and scraps from which a single rare earth metal or a mixture of rare earth metals are recovered. Electronic waste can be considered a great source of rare earths, and multiple rare earth metals recyclers have their focus on end-of-life waste to extract rare earth metals.

FIGURE 46 FLUORESCENT LAMPS SEGMENT TO LEAD OVERALL MARKET



	Fluorescent Lamps	Magnets	Batteries	Industrial Process	FCC
2021	157.6	79.8	7.4	2.4	0.9
2026	262.0	141.6	13.0	4.2	1.5
CAGR (2021-2026)	10.7%	12.2%	12.0%	11.7%	9.6%

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 18 RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	149.37	142.69	157.63	262.03	10.7%
Magnets	75.16	71.23	79.78	141.58	12.2%
Batteries	6.93	6.60	7.39	13.04	12.0%
FCC	0.89	0.85	0.93	1.47	9.6%
Industrial Process	2.28	2.18	2.43	4.22	11.7%
Total	**234.64**	**223.54**	**248.15**	**422.34**	**11.2%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 19 RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	2,430.1	2,316.8	2,560.3	4,231.4	10.6%
Magnets	1,166.9	1,107.2	1,235.0	2,138.3	11.6%
Batteries	771.7	736.5	817.7	1,383.1	11.1%
FCC	263.6	252.4	276.4	436.6	9.6%
Industrial Process	291.3	279.6	307.5	496.8	10.1%
Total	**4,923.7**	**4,692.4**	**5,196.8**	**8,686.2**	**10.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

8.2 FCC

Fluid cracking catalysts (FCC) are widely used in the petroleum industry, and they generate huge amounts of waste with rare earth metals, such as Lanthanum (La) and Cerium (Ce). Thus, it is important to have a proper recycling system for these materials. Fluid cracking catalysts (FCCs) are components used for hydrocarbon processing in the petroleum industry. FCCs aid in the cracking of large molecules from feedstocks, such as heavy or vacuum gas oil. Although their constitution can vary, they are mainly made of crystalline microporous aluminosilicates, also known as zeolites, which are synthesized in such a way as to increase their potential as a catalyst. The process of FCC recycling can be roughly divided into two major steps, i.e., the leaching process, in which strong acid solutions are used to transfer the metals into a liquid phase. The second step involves the separation of the rare earth metals from contaminants and, eventually, between them, if desirable, to enable their complete recovery.

8.3 FLUORESCENT LAMPS

Digitalization and use of electronic equipment and gadgets have triggered a substantial increase in e-waste with an astonishing 10% growth rate per year. Therefore, it is essential to establish economically viable recycling and treatment technologies to complement the United Nations Sustainable Development Goals (SDGs). This will help in targeting sustainability and adopting a circular economy, including sustainable cities and communities, responsible consumption, production, and climate action. Recycling of compact and linear fluorescent lamps can prove to be a useful source of yttrium, europium, and terbium, whereas recycling of permanent rare earth magnets used in wind and hydropower generation can become an important secondary source of neodymium, praseodymium, dysprosium, and terbium.

Fluorescent lamp contains more than 50 metal and non-metal components and filler materials due to the combined manufacturing or shredding. Economic boundary conditions make liquid-liquid extraction more favorable than chromatography in recycling. This is because recovering or separating concentrations on a huge scale cannot be achieved by chromatography. Different phosphorus-based ionic and amide ligands can be exploited for the separation of rare earth metals due to their hard nature and f-element chemistry.

8.4 MAGNETS

Rare earth metals are crucial for 'green' technology applications, and the demand is growing. Their main use is in permanent magnets made from an alloy of neodymium, iron, and boron (NdFeB) for highly efficient motors for hybrid-electric vehicles and wind turbine generators. Currently, rare earths can be extracted from their original electronic sources, but some, such as magnets, cannot be reused in the same way. One common method for recycling rare earths is acid dissolution to recover the materials as oxides.

The most common rare earth magnets are based on neodymium-iron-boron with small additives of Pr (Praseodymium), Tb (Terbium), and especially Dy (Dysprosium). Heavy rare earth metals are added to magnets to increase their temperature resistance. NdFeB magnets contain more than 30 weight percent of rare earth metals. It is estimated that 20-30% of NdFeB scraps will be produced in the manufacturing process. Furthermore, NdFeB magnet is easily oxidized at higher temperatures. The oxidized scraps cannot be reused in conventional magnet production. It is essential to recycle the magnets to extract the rare earth metals from oxidized magnet scraps.

8.5 BATTERIES

Various rare earth metals such as neodymium (Nd), praseodymium (Pr), and dysprosium (Dy) can be recycled from lithium-ion batteries at the end of their lifecycle. Nickel-metal hydride (NiMH) batteries are currently used in many applications such as hybrid and electric cars, laptops, and mobile phones. NiMH batteries have about twice the energy density of Ni-Cd batteries and a similar operating voltage as that of nickel-cadmium (Ni-Cd) batteries. They are expected to become a mainstay in current rechargeable batteries.

The main parts of a NiMH battery are cathode, anode, electrolyte, polymer separator, and steel case. The cathode is made of nickel coated with nickel hydroxide. The anode consists of a hydrogen storage alloy based on mischmetal (mainly cerium, lanthanum, praseodymium, and neodymium) and nickel alloys.

8.6 INDUSTRIAL PROCESS

Industrial waste residues contain rare earths (both present in historic landfills and freshly produced). These industrial waste residues contain much lower concentrations of rare earth metals than end-of-life consumer goods that are considered for recycling via urban mining activities. However, the volumes of these residues are enormous, which means that the total amount of rare earth metals locked in these residues is also very large. Very efficient pyrometallurgical processes have been developed for the recovery of metal from electronic scrap, spent automobile exhaust catalysts, and spent industrial catalysts. The list of recovered metals includes silver, gold, platinum group metals (platinum, palladium, ruthenium, rhodium, iridium), indium, bismuth, tin, selenium, tellurium, antimony, arsenic, and base metals such as copper, nickel, and lead. Wastewater could also be a source for rare earths, but the potential of this waste stream for the recovery of rare earths remains largely unexplored. Rare earths could be recovered from wastewater produced during the extraction and separation of rare earths. Acid mine drainage (AMD) often contains considerable concentrations of rare earths. 63 AMD is the outflow of acidic water from (old) metal mines or coal mines, and it is often heavily contaminated by metals. There is a considerable possibility to recover uranium and other metals from AMD by ion-exchange resins or by biosorption.

9 RARE EARTH METALS RECYCLING MARKET, BY TECHNOLOGY

KEY FINDINGS

- The rare earth metals recycling market is dominated by hydrometallurgical technology, which accounted for 72.97%, in terms of value, in 2020.
- The hydrometallurgical segment is projected to grow from USD 181.87 million in 2021 to USD 316.16 million by 2026, at a CAGR of 11.69%.
- The pyrometallurgical technology segment is projected to grow from USD 66.29 million in 2021 to USD 106.17 million by 2026, at a CAGR of 9.88%.

9.1 INTRODUCTION

Rare earth metals are vital inputs for the development of electric vehicles and the green energy sector. These metals help in designing and developing enhanced technological products which are used in our daily lives. China monopolizes the supply chain for rare earth metals, and there is a limited supply for rare earth metals in other countries. Hence, there is high demand for intensive research recycling for rare earth metals from wastes produced in various end-use industries which generate waste such as polishing powders, radioactive residues, catalysts, batteries, and magnetic materials, amongst others. Pyrometallurgical and hydrometallurgical processes have been used by many researchers and other professionals in the field of the recovery of material from various types of rare earth metals.

FIGURE 47 HYDROMETALLURGICAL SEGMENT TO LEAD OVERALL MARKET

	Hydrometallurgical	Pyrometallurgical
2021	181.9	66.3
2026	316.2	106.2
CAGR (2021-2026)	11.7%	9.9%

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 20 RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021-2026)
Hydrometallurgical	171.0	163.1	181.9	316.2	11.7%
Pyrometallurgical	63.7	60.4	66.3	106.2	9.9%
Total	**234.6**	**223.5**	**248.2**	**422.3**	**11.2%**

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

TABLE 21 RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021-2026)
Hydrometallurgical	3,593.5	3,430.5	3,816.2	6,516.8	11.3%
Pyrometallurgical	1,330.1	1,261.8	1,380.6	2,169.4	9.5%
Total	**4,923.7**	**4,692.4**	**5,196.8**	**8,686.2**	**10.8%**

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

9.2 HYDROMETALLURGICAL

Hydrometallurgical operation is an important part of extractive metallurgy and is used in various metal refining plants in the world. It is flexible, highly selective, and an environmentally friendly method for treating raw materials. The main processes during hydrometallurgical treatment of resources include leaching, solvent extraction, ion exchange, and precipitation, which differ depending on the raw material to be recovered.

Leaching rare earth metals from waste is an important part of rare earth processing using the hydrometallurgical route. Physically advanced concentrates are leached in a suitable extract directly or after heat treatment to dissolve the metallic elements. The known processes range from acid leaching with H_2SO_4, HCl, and HNO_3 to leaching with NaCl or $(NH_4)_2SO_4$ of ion adsorbed clays.

Solvent extraction is an important step that is used to separate and extract individual rare earths to get their mixed solutions and compounds from leached solutions after the leaching process using different cationic, anionic, and solvating extractants via D2EHPA, Cyanex 272, PC 88A, Versatic 10, TBP, and Aliquat 336. D2EHPA is the most widely studied extractant for rare earth separation from nitrate, sulfate, chloride, and perchlorate solutions. Saponified PC 88A is used for separation from chloride solutions, while tributyl phosphate (TBP), a solvating extractant, helps in extracting nitrates from the aqueous solutions.

During ion exchange process, different ion exchange cationic or anionic resins are used depending on the constituent of the aqueous solution using batch or continuous mode to extract rare earths from leached solutions with low rare earth concentration. Cation exchange is majorly used to obtain rare earth metals. The affinity of the exchanged ions for the cation exchanger depends majorly on the charge, size, and degree of hydration of the exchanged ions. However, the mechanism of the processes involved in anion exchangers is much more complex.

9.3 PYROMETALLURGICAL

Rare earths metals are considered the most critical, with the highest supply risk in Europe. As there exist only a few natural resources of rare earths in Europe, the European Union will have to rely on recycling rare earth metals from pre- and post-consumer scraps and, especially, end-of-life products. Nickel-metal hydride (NiMH) batteries and rare earth magnets are the typical urban mining resources. Pyrometallurgical process is able to separate and recover almost 99% of rare earth metals from waste NiMH batteries and NdFeB (neodymium magnet) scraps. Experimental results also show that rare earth metals obtained from the high-temperature treatment can reach purity of 96 weight percent. The current use of pyrometallurgical methods to recover rare earth metals from these materials is being analyzed, with the focus being on waste products such as high-coercivity magnets and nickel-metal-hydride batteries. Pyrometallurgical process includes melting, electroslag remelting, extraction with the use of molten magnesium, high-temperature treatment using halides and chlorides of metals, and the electrolysis of molten salts. The processes which are primarily based on high-temperature pyrometallurgical processes have gained traction owing to their low impact on the environment.

10 RARE EARTH METALS RECYCLING MARKET, BY REGION

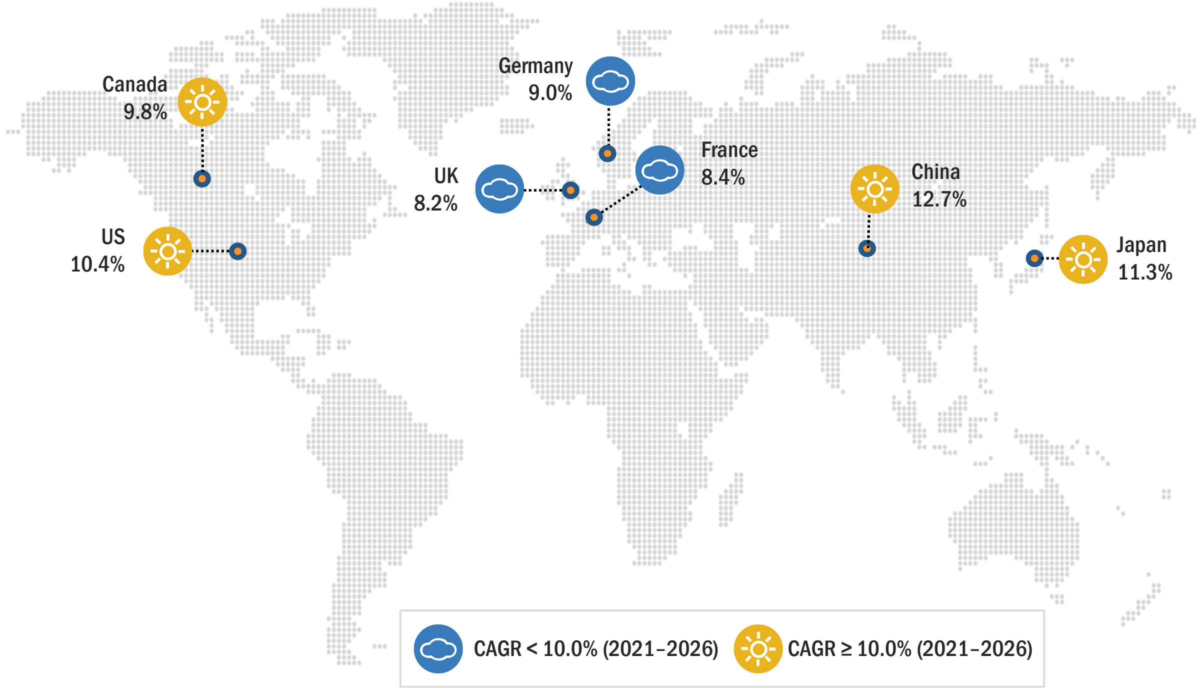
KEY FINDINGS

- The global market size for rare earth metals recycling was USD 248.2 million in 2021 and is projected to register a CAGR of 11.2% to reach USD 422.3 million by 2026.
- Asia Pacific dominated the global rare earth metals recycling market with a share of 68.4%, in terms of value, in 2020 and is projected to register a CAGR of 12.1% between 2021 and 2026.
- The market in North America was the second-largest, in terms of value, in 2021 and is projected to register a CAGR of 10.3% during the forecast period.
- China is the largest as well as the fastest-growing market for rare earth metals recycling.
- Increasing investments by leading automobile manufacturers and technological advancements in electric vehicles are contributing to the growth of the rare earth metals recycling market globally.

10.1 INTRODUCTION

The global demand for rare earth metals was estimated at 214,303 tons in 2019. Though the US Geological Survey expects that the world's reserves and undiscovered resources will be large enough to meet the demand, many universities, research organizations, and recyclers are finding ways to recycle rare earth metals from end-of-life products to reduce the dependency on mining of rare earth metals. Asia Pacific is the highest producer, and China is the most dominant country in the production of rare earth metals, with over 95% of the global output of rare earth minerals. A significant shift from traditional energy sources toward clean energy (for instance, the rise in the use of electric vehicles) is occurring, and wind turbines are being recognized on a global scale. This transition will lead to a continuous increase in demand for rare earth elements in the next few decades.

FIGURE 48 REGIONAL SNAPSHOT: CHINA PROJECTED TO BE FASTEST-GROWING MARKET FROM 2021 TO 2026



Note: The above figure depicts the CAGRs of the key countries, in terms of value, between 2021 and 2026.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 22 GLOBAL RARE EARTH METALS RECYCLING MARKET SIZE, BY REGION, 2019–2026 (USD MILLION)

Region	2019	2020	2021	2026	CAGR (2021–2026)
North America	31.0	29.4	32.3	52.9	10.3%
Europe	34.8	33.2	36.0	54.5	8.6%
Asia Pacific	160.3	153.0	171.2	303.0	12.1%
Rest of world	8.6	8.0	8.6	12.0	6.9%
Total	**234.6**	**223.5**	**248.2**	**422.3**	**11.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 23 GLOBAL RARE EARTH METALS RECYCLING MARKET SIZE, BY REGION, 2019–2026 (METRIC TON)

Region	2019	2020	2021	2026	CAGR (2021–2026)
North America	746.6	708.6	777.6	1,238.3	9.8%
Europe	585.3	558.4	605.2	905.2	8.4%
Asia Pacific	3,432.6	3,275.3	3,653.9	6,321.5	11.6%
Rest of world	159.1	150.2	160.2	221.2	6.7%
Total	**4,923.7**	**4,692.4**	**5,196.8**	**8,686.2**	**10.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 24 GLOBAL RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	79.4	75.0	85.5	162.8	13.8%
Alloy	5.7	5.4	5.9	9.2	9.2%
Polishing Materials	2.3	2.2	2.4	4.3	12.2%
Glass	117.7	113.3	123.1	188.0	8.8%
Catalyst	3.1	3.0	3.2	5.1	9.6%
Phosphor	19.3	17.9	20.3	39.3	14.1%
Ceramics	5.8	5.5	6.1	11.0	12.4%
Hydrogen Storage Alloys	1.4	1.3	1.4	2.5	11.8%
Total	**234.6**	**223.5**	**248.2**	**422.3**	**11.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

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Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	1,299.7	1,230.0	1,395.1	2,591.0	13.2%
Alloy	573.9	553.0	597.9	886.7	8.2%
Polishing Materials	685.6	657.5	725.0	1,185.0	10.3%
Glass	388.0	374.7	405.7	605.2	8.3%
Catalyst	935.0	895.7	980.9	1,549.6	9.6%
Phosphor	384.7	358.7	402.0	712.0	12.1%
Ceramics	482.2	456.5	505.8	846.6	10.9%
Hydrogen Storage Alloys	174.5	166.3	184.4	310.2	11.0%
Total	**4,923.7**	**4,692.4**	**5,196.8**	**8,686.2**	**10.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 26 GLOBAL RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	171.0	163.1	181.9	316.2	11.7%
Pyrometallurgical	63.7	60.4	66.3	106.2	9.9%
Total	**234.6**	**223.5**	**248.2**	**422.3**	**11.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

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Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	3,593.5	3,430.5	3,816.2	6,516.8	11.3%
Pyrometallurgical	1,330.1	1,261.8	1,380.6	2,169.4	9.5%
Total	**4,923.7**	**4,692.4**	**5,196.8**	**8,686.2**	**10.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 28 GLOBAL RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	149.4	142.7	157.6	262.0	10.7%
Magnets	75.2	71.2	79.8	141.6	12.2%
Batteries	6.9	6.6	7.4	13.0	12.0%
FCC	0.9	0.8	0.9	1.5	9.6%
Industrial Process	2.3	2.2	2.4	4.2	11.7%
Total	**234.6**	**223.5**	**248.2**	**422.3**	**11.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

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Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	2,430.1	2,316.8	2,560.3	4,231.4	10.6%
Magnets	1,166.9	1,107.2	1,235.0	2,138.3	11.6%
Batteries	771.7	736.5	817.7	1,383.1	11.1%
FCC	263.6	252.4	276.4	436.6	9.6%
Industrial Process	291.3	279.6	307.5	496.8	10.1%
Total	**4,923.7**	**4,692.4**	**5,196.8**	**8,686.2**	**10.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.2 ASIA PACIFIC

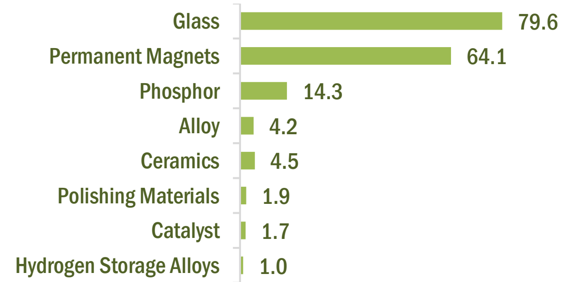
Asia Pacific is the largest consumer of rare earth metals due to the rapidly increasing demand in China, which accounts for the maximum global rare earth metals consumption. It was the largest consumer of rare earth metals in 2020, with an estimated market revenue of over USD 153 million. The region is also expected to witness the fastest growth in terms of consumption due to growing industrialization, extraction, and recycling activities in China. The increasing alliances among industry players coupled with leading innovations and developments are further expected to foster rare earth metals recycling in the Asia Pacific region.

FIGURE 49 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SNAPSHOT

ASIA PACIFIC

12.1% Projected CAGR of the market in the region, in terms of value	USD 171.2 Million Market size of the region in 2021	China Largest country-level market in the region	61.54% Share of the region in the global market in 2021, in terms of value

BY APPLICATION, 2021 (USD MILLION)



BY COUNTRY

COUNTRY/ REGION	MARKET SIZE, 2021 (METRIC TON)	CAGR (2021–2026)
China	2,296.4	12.2%
Japan	1,029.9	10.7%
Rest of Asia Pacific	327.6	9.9%

FACTORS DRIVING MARKET GROWTH IN ASIA PACIFIC

- Largest producer and consumer of rare earth metals
- New sources of rare earth metals will make Japan self-sufficient

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 30 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY COUNTRY, 2019–2026 (USD MILLION)

Country	2019	2020	2021	2026	CAGR (2021–2026)
China	97.6	93.6	105.4	191.9	12.7%
Japan	46.6	44.0	48.9	83.4	11.3%
Rest of Asia Pacific	16.1	15.4	16.9	27.8	10.4%
Total	**160.3**	**153.0**	**171.2**	**303.0**	**12.1%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 31 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY COUNTRY, 2019–2026 (METRIC TON)

Country	2019	2020	2021	2026	CAGR (2021–2026)
China	2,140.1	2,047.1	2,296.4	4,081.6	12.2%
Japan	981.5	930.2	1,029.9	1,713.9	10.7%
Rest of Asia Pacific	310.9	298.1	327.6	526.0	9.9%
Total	**3,432.6**	**3,275.3**	**3,653.9**	**6,321.5**	**11.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 32 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	59.6	56.1	64.1	124.7	14.2%
Alloy	3.9	3.8	4.2	6.7	10.0%
Polishing Materials	1.7	1.7	1.9	3.4	12.8%
Glass	74.9	72.5	79.6	127.0	9.8%
Catalyst	1.6	1.5	1.7	2.8	10.7%
Phosphor	13.4	12.5	14.3	28.1	14.6%
Ceramics	4.2	4.0	4.5	8.3	13.1%
Hydrogen Storage Alloys	0.9	0.9	1.0	1.8	12.7%
Total	**160.3**	**153.0**	**171.2**	**303.0**	**12.1%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 33 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	992.5	935.4	1,064.8	2,016.3	13.6%
Alloy	405.3	392.0	427.2	657.0	9.0%
Polishing Materials	535.7	515.9	572.1	960.0	10.9%
Glass	253.1	246.0	268.7	418.1	9.2%
Catalyst	495.0	475.1	525.8	873.1	10.7%
Phosphor	272.9	255.7	287.7	519.7	12.6%
Ceramics	355.3	337.8	376.5	648.7	11.5%
Hydrogen Storage Alloys	122.8	117.4	131.1	228.6	11.8%
Total	**3,432.6**	**3,275.3**	**3,653.9**	**6,321.5**	**11.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 34 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	113.9	108.9	122.6	222.5	12.7%
Pyrometallurgical	46.4	44.1	48.7	80.5	10.6%
Total	**160.3**	**153.0**	**171.2**	**303.0**	**12.1%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 35 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	2,448.9	2,341.4	2,626.0	4,659.9	12.2%
Pyrometallurgical	983.7	933.9	1,027.9	1,661.6	10.1%
Total	**3,432.6**	**3,275.3**	**3,653.9**	**6,321.5**	**11.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 36 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	102.68	98.25	109.49	189.67	11.6%
Magnets	50.73	48.14	54.33	99.99	13.0%
Batteries	4.64	4.42	4.98	9.10	12.8%
FCC	0.57	0.55	0.61	1.00	10.5%
Industrial Process	1.68	1.61	1.80	3.23	12.4%
Total	**160.31**	**152.96**	**171.22**	**302.99**	**12.1%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 37 ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	1,707.7	1,629.9	1,814.7	3,107.7	11.4%
Magnets	805.1	764.8	859.3	1540.1	12.4%
Batteries	527.0	503.6	563.0	983.8	11.8%
FCC	174.7	167.5	185.0	304.5	10.5%
Industrial Process	218.1	209.5	231.9	385.4	10.7%
Total	**3,432.6**	**3,275.3**	**3,653.9**	**6,321.5**	**11.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.2.1 CHINA

10.2.1.1 Largest recycler and consumer of rare earth metals

China is a dominant producer with over 95% of the global output of rare earth minerals. In 2015, mine production was primarily from bastnaesite and other rare earth minerals in Nei Mongol Autonomous Region and Sichuan province and from ion adsorption ores in Fujian, Guangdong, and Jiangxi provinces in south-eastern China. Despite being rich in rare earth resources and a producer of a number of different kinds of rare earth products, Chinese producers have struggled to maintain profitability. The rapid increase in the global consumption of rare earth metals, owing to the emergence of new clean-energy and defense-related technologies, combined with China's decisions to restrict exports of rare earth metals, has resulted in heightened concerns about the future availability of rare earth metals. As a result, industrial countries such as Japan, the US, and some countries of the European Union, face tighter supplies and higher prices for rare earth metals, which give a high degree of competitive advantage to China. Moreover, innovation and recycling technologies for rare earth metals will enable China to hold a dominant position in the rare earth recycling market.

China's exports of rare earth compounds (HScode 2846) were 45,700 tons (gross weight) compared to 42,100 tons in 2018. The top five export destinations were the US (31%), Japan (27%), the Republic of Korea (11%), the Netherlands (9%), and Germany (6%). China's exports of rare earth metals under HS2805.30 were 5,510 tons (Global Trade Information Services Inc., 2018).

The competition among local governments and enterprises in China resulted in sustained high levels of production. Local governments being dependent on rare earth producers to provide employment and revenue for local economic development, did not always follow the national government's guidelines on rare earth metals. This resulted in exceeding the output of rare earth concentrate compared to the national production target.

TABLE 38 CHINA: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	37.60	35.61	40.93	81.66	14.8%
Alloy	2.49	2.41	2.66	4.41	10.6%
Polishing Materials	1.12	1.08	1.22	2.29	13.4%
Glass	45.40	44.20	48.80	80.22	10.5%
Catalyst	0.99	0.95	1.06	1.81	11.4%
Phosphor	6.84	6.35	7.31	15.04	15.5%
Ceramics	2.57	2.43	2.76	5.24	13.7%
Hydrogen Storage Alloys	0.59	0.56	0.64	1.19	13.3%
Total	**97.6**	**93.6**	**105.4**	**191.9**	**12.7%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 39 CHINA: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	631.3	598.5	684.8	1,330.1	14.2%
Alloy	260.3	252.0	276.1	436.3	9.6%
Polishing Materials	346.4	334.0	372.4	641.2	11.5%
Glass	154.8	151.2	166.2	266.2	9.9%
Catalyst	309.6	297.2	330.7	564.4	11.3%
Phosphor	140.5	131.4	149.1	280.8	13.5%
Ceramics	218.7	207.7	232.8	411.8	12.1%
Hydrogen Storage Alloys	78.5	75.0	84.3	150.8	12.3%
Total	**2,140.1**	**2,047.1**	**2,296.4**	**4,081.6**	**12.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 40 CHINA: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	69.2	66.7	75.6	141.6	13.4%
Pyrometallurgical	28.4	26.8	29.8	50.2	11.0%
Total	**97.6**	**93.6**	**105.4**	**191.9**	**12.7%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 41 CHINA: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	1,523.6	1,465.7	1,654.0	3,023.3	12.8%
Pyrometallurgical	616.5	581.4	642.4	1,058.3	10.5%
Total	**2,140.1**	**2,047.1**	**2,296.4**	**4,081.6**	**12.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 42 CHINA: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	59.98	57.77	64.77	115.46	12.3%
Magnets	33.35	31.71	35.98	67.85	13.5%
Batteries	2.85	2.72	3.09	5.80	13.4%
FCC	0.37	0.35	0.39	0.67	11.1%
Industrial Process	1.06	1.01	1.14	2.09	12.9%
Total	**97.60**	**93.58**	**105.37**	**191.86**	**12.7%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 43 CHINA: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	1,028.9	984.6	1,102.6	1,941.9	12.0%
Magnets	533.3	507.7	573.3	1052.5	12.9%
Batteries	326.9	313.2	352.1	631.9	12.4%
FCC	112.9	108.5	120.5	203.5	11.1%
Industrial Process	138.2	133.1	148.0	251.8	11.2%
Total	**2140.1**	**2047.1**	**2296.4**	**4081.6**	**12.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.2.2 JAPAN

10.2.2.1 New sources of rare earth metals to make country self-sufficient

Rare earth metals are crucial in the making of high-tech products, such as electric vehicles, mobile phones, and batteries, and the world relies on China for almost all the rare earth material requirements. Japan started seeking its own rare earth metals after China held back shipments in 2010 during a dispute over islands both countries claim. A major electronics manufacturer, Japan needs rare earth metals for components. The automotive industry is promoting vehicle electrification to tackle climatic changes. Many car manufacturers have stepped up to innovate efficient processes for the recovery of rare earth metals. For instance, Nissan has been collaborating with Waseda University to research on non-ferrous metal recycling. In March 2020, the collaboration successfully developed a pyrometallurgy process that does not require motor disassembly. Testing has shown that the process can recover 98% of the rare earth metals in motors.

In February 2020, the Japanese government partnered with the US and Australia for investing in processing facilities for rare earth metals to ease reliance on imports from China. Rare earth metals are essential in high-tech machinery like motors for electric vehicles. Japan imports 58% of its supply from China, leaving it vulnerable to manipulation by Beijing. Tokyo plans to bring the Chinese share down to 50% or less by 2025.

TABLE 44 JAPAN: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	17.41	16.16	18.30	33.97	13.2%
Alloy	0.99	0.96	1.04	1.62	9.2%
Polishing Materials	0.46	0.44	0.49	0.86	11.9%
Glass	20.98	20.11	21.91	33.67	9.0%
Catalyst	0.46	0.44	0.48	0.77	9.9%
Phosphor	4.69	4.35	4.93	9.37	13.7%
Ceramics	1.42	1.34	1.50	2.67	12.2%
Hydrogen Storage Alloys	0.24	0.23	0.26	0.45	11.8%
Total	**46.64**	**44.02**	**48.91**	**83.38**	**11.3%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 45 JAPAN: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	286.5	266.2	300.2	542.5	12.6%
Alloy	101.7	98.2	106.1	156.8	8.1%
Polishing Materials	139.1	133.5	146.9	236.7	10.0%
Glass	70.1	67.5	73.1	109.5	8.4%
Catalyst	140.0	134.2	147.4	235.4	9.8%
Phosphor	94.4	88.3	98.6	171.5	11.7%
Ceramics	118.2	112.3	124.2	205.7	10.6%
Hydrogen Storage Alloys	31.4	30.0	33.2	55.8	10.9%
Total	**981.5**	**930.2**	**1,029.9**	**1,713.9**	**10.7%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 46 JAPAN: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	33.3	31.3	34.9	60.5	11.7%
Pyrometallurgical	13.4	12.8	14.0	22.9	10.2%
Total	**46.6**	**44.0**	**48.9**	**83.4**	**11.3%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 47 JAPAN: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	702.6	663.2	737.0	1248.7	11.1%
Pyrometallurgical	279.0	267.0	292.9	465.3	9.7%
Total	**981.5**	**930.2**	**1029.9**	**1713.9**	**10.7%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 48 JAPAN: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	31.81	30.04	33.27	55.77	10.9%
Magnets	12.84	12.09	13.54	23.94	12.1%
Batteries	1.35	1.28	1.43	2.52	12.0%
FCC	0.16	0.15	0.17	0.27	9.8%
Industrial Process	0.48	0.45	0.51	0.88	11.6%
Total	**46.64**	**44.02**	**48.91**	**83.38**	**11.3%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 49 JAPAN: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	519.1	492.1	543.9	897.7	10.5%
Magnets	201.2	189.8	211.5	364.1	11.5%
Batteries	151.9	144.2	160.0	269.2	11.0%
FCC	47.9	45.6	50.0	79.4	9.7%
Industrial Process	61.4	58.6	64.4	103.5	9.9%
Total	**981.5**	**930.2**	**1029.9**	**1713.9**	**10.7%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.2.3 REST OF ASIA PACIFIC

The Rest of Asia Pacific includes India, Australia, and Malaysia. These countries are focused on the expansion of recycling and processing facilities to increase their home production to meet the growing demand. India's rapidly growing economy has an input deficiency of rare earth metals, which is essential for green technologies like LEDs and electric vehicles. Recycling India's e-waste can help in extracting rare earth metals. Apart from e-waste, rare earth recovery from waste products or residues from the processing of other minerals should be explored to augment the growth of rare earth metals recycling.

TABLE 50 REST OF ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	4.58	4.33	4.91	9.08	13.1%
Alloy	0.43	0.41	0.45	0.67	8.4%
Polishing Materials	0.17	0.16	0.18	0.30	11.1%
Glass	8.51	8.21	8.88	13.15	8.2%
Catalyst	0.15	0.14	0.16	0.24	9.1%
Phosphor	1.90	1.79	2.02	3.72	13.0%
Ceramics	0.22	0.21	0.24	0.41	11.4%
Hydrogen Storage Alloys	0.10	0.10	0.11	0.18	10.9%
Total	**16.07**	**15.36**	**16.93**	**27.75**	**10.4%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 51 REST OF ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	74.7	70.7	79.8	143.7	12.5%
Alloy	43.2	41.8	44.9	63.9	7.3%
Polishing Materials	50.2	48.4	52.8	82.1	9.2%
Glass	28.2	27.3	29.4	42.4	7.6%
Catalyst	45.4	43.7	47.6	73.4	9.0%
Phosphor	38.0	36.0	40.0	67.4	11.0%
Ceramics	18.5	17.8	19.5	31.2	9.8%
Hydrogen Storage Alloys	12.9	12.4	13.6	22.0	10.0%
Total	**310.9**	**298.1**	**327.6**	**526.0**	**9.9%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 52 REST OF ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	11.5	10.9	12.1	20.4	11.0%
Pyrometallurgical	4.6	4.5	4.8	7.4	8.7%
Total	**16.1**	**15.4**	**16.9**	**27.8**	**10.4%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 53 REST OF ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	222.7	212.5	235.0	387.9	10.5%
Pyrometallurgical	88.3	85.5	92.6	138.0	8.3%
Total	**310.9**	**298.1**	**327.6**	**526.0**	**9.9%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 54 REST OF ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	10.893	10.428	11.453	18.443	10.0%
Magnets	4.548	4.334	4.817	8.197	11.2%
Batteries	0.432	0.414	0.460	0.782	11.2%
FCC	0.047	0.045	0.049	0.073	8.4%
Industrial Process	0.146	0.140	0.155	0.257	10.7%
Total	**16.066**	**15.361**	**16.933**	**27.752**	**10.4%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 55 REST OF ASIA PACIFIC: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	159.7	153.2	168.2	268.1	9.8%
Magnets	70.6	67.4	74.5	123.5	10.6%
Batteries	48.1	46.2	50.9	82.7	10.2%
FCC	13.9	13.4	14.5	21.7	8.3%
Industrial Process	18.5	17.9	19.5	30.0	9.0%
Total	**310.9**	**298.1**	**327.6**	**526.0**	**9.9%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.3 NORTH AMERICA

North America is the second-largest producer of rare earth metals. The region's mineral deposits, innovative technologies, and R&D enable the region to meet the demand for rare earth metals to some extent.

The rare earth metals market of North America witnesses extreme cost increment due to unprecedented market forces. The growing effort to lower the use of carbon technologies in the region has a major role in the growth of the rare earth metals market. North America witnesses an average growth rate due to the increased use of hybrid electric vehicles and low carbon technologies. The demand for rare earth metals continues to grow in line with the growth in green technologies.

Governments increasingly mandate that a certain percentage of a manufacturer's vehicle sales must constitute fully battery-electric or at least hybrid battery-electric (cars with both a battery-powered motor and internal combustion engine). There are a variety of regulations that many state and federal governments around the world have enacted to ensure that automakers reduce the impacts their vehicles have on local environments. This has driven the need for rare earth metals recycling.

TABLE 56 NORTH AMERICA: RARE EARTH METALS RECYCLING MARKET SIZE, BY COUNTRY, 2019–2026 (USD MILLION)

Country	2019	2020	2021	2026	CAGR (2021–2026)
US	27.4	26.0	28.7	47.0	10.4%
Canada	3.6	3.4	3.7	5.9	9.8%
Total	**31.0**	**29.4**	**32.3**	**52.9**	**10.3%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 57 NORTH AMERICA: RARE EARTH METALS RECYCLING MARKET SIZE, BY COUNTRY, 2019–2026 (METRIC TON)

Country	2019	2020	2021	2026	CAGR (2021–2026)
US	675.3	641.2	704.0	1,124.1	9.8%
Canada	71.4	67.3	73.5	114.2	9.2%
Total	**746.6**	**708.6**	**777.6**	**1,238.3**	**9.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 58 NORTH AMERICA: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	8.68	8.29	9.43	17.71	13.4%
Alloy	0.68	0.64	0.70	1.03	8.1%
Polishing Materials	0.21	0.20	0.22	0.37	10.9%
Glass	17.16	16.31	17.61	25.88	8.0%
Catalyst	0.97	0.93	1.01	1.55	8.9%
Phosphor	2.23	2.03	2.31	4.53	14.4%
Ceramics	0.86	0.80	0.89	1.51	11.2%
Hydrogen Storage Alloys	0.17	0.16	0.17	0.29	10.8%
Total	**30.96**	**29.36**	**32.35**	**52.87**	**10.3%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 59 NORTH AMERICA: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	138.4	132.2	149.8	273.8	12.8%
Alloy	67.1	64.1	68.7	96.8	7.1%
Polishing Materials	62.3	58.7	64.0	98.7	9.0%
Glass	55.6	53.1	57.0	81.6	7.4%
Catalyst	289.2	275.7	300.2	459.0	8.9%
Phosphor	43.6	40.0	44.9	80.5	12.4%
Ceramics	69.6	65.1	71.4	113.2	9.7%
Hydrogen Storage Alloys	20.9	19.6	21.6	34.6	9.9%
Total	**746.6**	**708.6**	**777.6**	**1,238.3**	**9.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 60 NORTH AMERICA: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	23.4	22.2	24.6	41.0	10.8%
Pyrometallurgical	7.6	7.2	7.8	11.9	8.8%
Total	**31.0**	**29.4**	**32.3**	**52.9**	**10.3%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 61 NORTH AMERICA: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	565.3	537.8	592.7	963.6	10.2%
Pyrometallurgical	181.3	170.7	184.8	274.7	8.3%
Total	**746.6**	**708.6**	**777.6**	**1,238.3**	**9.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 62 NORTH AMERICA RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	18.085	17.206	18.836	29.840	9.6%
Magnets	11.215	10.579	11.765	20.094	11.3%
Batteries	1.190	1.128	1.255	2.149	11.4%
FCC	0.155	0.148	0.161	0.242	8.6%
Industrial Process	0.315	0.299	0.330	0.544	10.5%
Total	**30.960**	**29.360**	**32.348**	**52.870**	**10.3%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 63 NORTH AMERICA: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	362.1	343.8	375.8	586.6	9.3%
Magnets	170.4	160.9	178.2	296.3	10.7%
Batteries	129.7	123.3	136.0	222.7	10.4%
FCC	45.2	43.1	46.8	70.5	8.5%
Industrial Process	39.2	37.4	40.7	62.3	8.9%
Total	**746.6**	**708.6**	**777.6**	**1,238.3**	**9.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.3.1 US

10.3.1.1 Rising demand for electric vehicles driving market

One of the biggest challenges for the US has been China's dominance in the mining and processing of critical rare earth minerals. These are vital building blocks for products ranging from smartphones, electric vehicle batteries, and medical imaging machines to advanced defense weaponry. Hence, the reliance of the US on a less-than-friendly country for supply presents a huge political and economic risk. However, the US was recently able to find a core source of rare earth metals in the barren scrub of Far West Texas 85 miles east of El Paso, an unassuming 1,250-tall mountain called Round Top holds the promise of making America largely self-sufficient in these minerals. The mountain contains five out of six light rare earth metals (for example, neodymium), 10 out of 11 heavy rare-earth metals (for example, dysprosium), and all five permanent magnet materials. Round Top has large deposits of lithium, which is critical for batteries in electric vehicles and power storage. This would probably reduce the dependency of the US on rare earth metals from China.

According to the US Geological Survey, the measured and indicated resources of rare-earth metals were estimated at 2.7 million tons in the US in 2020.

The Department of Energy is funding research to make separating rare earths easier and more efficient, and to promote recycling. Its office of Basic Energy Sciences (BES) is adding five new national laboratory-led projects focusing on separation science totaling USD 7 million per year. The Department of Energy is investing USD 25 million per year in the Critical Materials Institute, focusing on securing supply chains for critical materials, largely focusing on rare earths and lithium. BES is also announcing USD 10 million per year in grants for basic research.

TABLE 64 US: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	7.14	6.85	7.82	14.89	13.7%
Alloy	0.58	0.55	0.60	0.89	8.2%
Polishing Materials	0.19	0.18	0.20	0.34	11.0%
Glass	15.55	14.77	15.96	23.51	8.1%
Catalyst	0.91	0.87	0.95	1.46	9.0%
Phosphor	2.08	1.89	2.16	4.24	14.5%
Ceramics	0.81	0.75	0.84	1.43	11.3%
Hydrogen Storage Alloys	0.14	0.13	0.15	0.25	10.9%
Total	**27.41**	**26.00**	**28.67**	**47.00**	**10.4%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 65 US: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	114.2	109.6	124.6	231.0	13.1%
Alloy	57.7	55.1	59.0	83.6	7.2%
Polishing Materials	56.7	53.3	58.2	89.9	9.1%
Glass	50.5	48.1	51.8	74.3	7.5%
Catalyst	271.7	259.5	282.6	432.8	8.9%
Phosphor	40.7	37.2	41.9	75.5	12.5%
Ceramics	65.6	61.3	67.2	106.8	9.7%
Hydrogen Storage Alloys	18.2	17.0	18.7	30.2	10.0%
Total	**675.3**	**641.2**	**704.0**	**1,124.1**	**9.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 66 US: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	20.7	19.7	21.8	36.5	10.9%
Pyrometallurgical	6.7	6.3	6.9	10.5	8.9%
Total	**27.4**	**26.0**	**28.7**	**47.0**	**10.4%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 67 US: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	511.9	487.3	537.4	875.8	10.3%
Pyrometallurgical	163.4	153.9	166.7	248.3	8.3%
Total	**675.3**	**641.2**	**704.0**	**1,124.1**	**9.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 68 US: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	15.932	15.160	16.603	26.360	9.7%
Magnets	9.981	9.421	10.487	17.984	11.4%
Batteries	1.069	1.013	1.129	1.941	11.4%
FCC	0.143	0.136	0.148	0.224	8.7%
Industrial Process	0.285	0.271	0.300	0.495	10.6%
Total	**27.409**	**26.002**	**28.666**	**47.005**	**10.4%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 69 US: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	329.4	312.9	342.2	535.0	9.3%
Magnets	152.0	143.6	159.1	265.7	10.8%
Batteries	116.7	110.9	122.5	201.5	10.5%
FCC	41.7	39.8	43.2	65.2	8.6%
Industrial Process	35.5	34.0	37.0	56.8	8.9%
Total	**675.3**	**641.2**	**704.0**	**1124.1**	**9.8%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.3.2 CANADA

10.3.2.1 Need for clean energy applications driving market

Rare earth metals have been categorized by the Canadian government as critical to its economy. The country is host to several advanced exploration projects and some of the largest reserves and resources (measured and indicated) of these metals. Many of Canada's most advanced rare earth element exploration projects contain high concentrations of globally valued heavy rare earth elements used in high-technology and clean-energy applications.

Canada has some of the largest known reserves and resources (measured and indicated) of rare earths in the world, estimated at over 14 million tons of rare earth oxides in 2021. Rare earth metals are used in various industrial applications, including electronics, clean energy, aerospace, automotive, and defense.

In 2020, Canada and the US finalized a joint action plan on critical minerals, including rare earths, which calls for increased cooperation on developing supply chains, research & development, and support for the industry.

Canadian firm Geomega Resources Inc. built a plant in Quebec for recycling rare earth elements from permanent magnets using a new processing technology that creates no acid waste.

TABLE 70 CANADA: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	1.544	1.441	1.613	2.816	11.8%
Alloy	0.096	0.092	0.099	0.143	7.6%
Polishing Materials	0.019	0.018	0.020	0.033	10.4%
Glass	1.608	1.541	1.655	2.372	7.5%
Catalyst	0.060	0.056	0.060	0.090	8.4%
Phosphor	0.151	0.141	0.159	0.285	12.5%
Ceramics	0.050	0.048	0.053	0.087	10.6%
Hydrogen Storage Alloys	0.022	0.021	0.023	0.038	10.3%
Total	**3.551**	**3.358**	**3.682**	**5.865**	**9.8%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 71 CANADA: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	24.2	22.6	25.2	42.8	11.2%
Alloy	9.4	9.0	9.6	13.2	6.6%
Polishing Materials	5.6	5.4	5.8	8.7	8.5%
Glass	5.1	4.9	5.3	7.3	6.9%
Catalyst	17.4	16.2	17.6	26.2	8.3%
Phosphor	2.9	2.7	3.0	5.0	10.5%
Ceramics	4.0	3.8	4.2	6.4	9.0%
Hydrogen Storage Alloys	2.7	2.6	2.8	4.5	9.4%
Total	**71.4**	**67.3**	**73.5**	**114.2**	**9.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 72 CANADA: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	2.65	2.51	2.76	4.50	10.2%
Pyrometallurgical	0.90	0.85	0.92	1.37	8.3%
Total	**3.55**	**3.36**	**3.68**	**5.87**	**10.4%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 73 CANADA: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	53.4	50.5	55.4	87.8	9.7%
Pyrometallurgical	17.9	16.8	18.1	26.4	7.8%
Total	**71.4**	**67.3**	**73.5**	**114.2**	**9.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 74 CANADA: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	2.153	2.046	2.234	3.479	9.3%
Magnets	1.234	1.157	1.278	2.110	10.5%
Batteries	0.122	0.115	0.127	0.209	10.5%
FCC	0.012	0.012	0.013	0.019	7.9%
Industrial Process	0.030	0.028	0.031	0.049	9.9%
Total	**3.551**	**3.358**	**3.682**	**5.865**	**9.8%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 75 CANADA: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	32.7	30.9	33.7	51.6	8.9%
Magnets	18.4	17.3	19.0	30.6	9.9%
Batteries	13.0	12.3	13.5	21.3	9.5%
FCC	3.6	3.4	3.6	5.3	7.8%
Industrial Process	3.6	3.4	3.7	5.5	8.2%
Total	**71.4**	**67.3**	**73.5**	**114.2**	**9.2%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.4 EUROPE

The European market for rare earth oxides is mostly dependent on imports and faces a rigorous challenge to meet the growing demand. Petroleum, automobile, energy, industrial, and catalyst markets are all set to grow moderately over the next five years, which will eventually increase the consumption of rare earths. Although Europe is rich in rare earth elements used to power batteries and produce magnets, political issues constrain the potential of the region to fully utilize its rare earth resources. To allow the cost-effective recovery of rare earth metals in end-of-life products, Europe has put efforts to reduce rare earth consumption in key applications and focused on the development of business models and separation technologies. The newly discovered deposits in Finland, as well as the tapping of abandoned mines, would alleviate the problem of the European industries. Europe focuses on investing in the necessary innovative technologies for rare earth metals recycling and substitution.

Owing to the lack of internal supply, the EU needs to import more than 90% of these metals, mainly from China. As the demand for rare earth metals is expected to grow, the EU aims to improve access to these metals, reduce their consumption, and improve extraction conditions in Europe. To help secure the supply, the European Rare Earths Competency Network (ERECON) was established.

In 2020, the European Commission launched the European Raw Materials Alliance (ERMA) to address challenges in the critical raw materials supply. The first value chain it addressed was rare earth magnets and motors. ERMA ran a stakeholder consultation process with more than 180 innovators from industry, academia, policymaking, and investment to better understand what needs to be done to revive a European rare earths industry. It led to key recommendations and actions that would mobilize investment in an EU rare earths industry.

TABLE 76 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY COUNTRY, 2019–2026 (USD MILLION)

Country	2019	2020	2021	2026	CAGR (2021–2026)
Germany	17.4	16.6	18.1	27.8	9.0%
France	12.1	11.5	12.4	18.6	8.4%
UK	3.5	3.3	3.6	5.3	8.2%
Rest of Europe	1.9	1.8	1.9	2.8	7.7%
Total	**34.8**	**33.2**	**36.0**	**54.5**	**8.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 77 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY COUNTRY, 2019–2026 (METRIC TON)

Country	2019	2020	2021	2026	CAGR (2021–2026)
Germany	307.1	294.3	319.6	483.0	8.6%
France	191.4	181.5	196.5	292.4	8.3%
UK	57.6	54.7	59.1	86.6	7.9%
Rest of Europe	29.3	27.9	30.0	43.3	7.6%
Total	**585.3**	**558.4**	**605.2**	**905.2**	**8.4%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 78 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	9.39	9.03	10.08	17.27	11.4%
Alloy	0.82	0.79	0.84	1.17	6.8%
Polishing Materials	0.24	0.23	0.25	0.39	9.5%
Glass	19.92	19.05	20.29	27.93	6.6%
Catalyst	0.39	0.37	0.40	0.57	7.5%
Phosphor	3.22	2.96	3.31	5.85	12.1%
Ceramics	0.61	0.57	0.63	1.00	9.8%
Hydrogen Storage Alloys	0.20	0.19	0.21	0.32	9.5%
Total	**34.80**	**33.19**	**36.01**	**54.51**	**8.6%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 79 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	142.0	136.7	151.9	253.3	10.8%
Alloy	77.3	74.0	78.3	103.7	5.8%
Polishing Materials	66.8	63.4	68.3	98.7	7.6%
Glass	61.0	58.5	62.0	83.2	6.0%
Catalyst	108.5	104.3	112.1	160.6	7.5%
Phosphor	59.5	55.1	60.7	98.2	10.1%
Ceramics	46.7	43.8	47.4	70.4	8.2%
Hydrogen Storage Alloys	23.6	22.6	24.5	37.0	8.6%
Total	**585.3**	**558.4**	**605.2**	**905.2**	**8.4%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 80 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	27.4	26.1	28.4	43.7	9.0%
Pyrometallurgical	7.4	7.1	7.6	10.8	7.3%
Total	**34.8**	**33.2**	**36.0**	**54.5**	**8.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 81 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	462.0	440.9	479.4	727.9	8.7%
Pyrometallurgical	123.3	117.5	125.8	177.2	7.1%
Total	**585.3**	**558.4**	**605.2**	**905.2**	**8.4%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 82 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	22.681	21.688	23.400	34.475	8.1%
Magnets	10.882	10.324	11.323	18.033	9.8%
Batteries	0.896	0.853	0.935	1.477	9.6%
FCC	0.124	0.119	0.127	0.179	7.1%
Industrial Process	0.213	0.203	0.222	0.343	9.1%
Total	**34.795**	**33.187**	**36.006**	**54.506**	**8.6%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 83 EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	277.3	264.7	286.2	422.4	8.1%
Magnets	156.5	148.7	162.3	251.7	9.2%
Batteries	92.3	88.2	95.8	144.7	8.6%
FCC	34.2	32.8	35.1	49.2	7.0%
Industrial Process	25.0	24.0	25.8	37.1	7.5%
Total	**585.3**	**558.4**	**605.2**	**905.2**	**8.4%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.4.1 GERMANY

10.4.1.1 Rising demand for electric vehicles driving market

Permanent magnets used in electric vehicles and wind turbines contain rare earth metals. Reducing the amount of these elements in magnets is important, as mining them is harmful both to health and the environment. German researchers have now developed a new machine learning tool to assist in quickly and easily predicting the ferromagnetic crystal properties of novel material compositions.

In August 2019, Northern Minerals, which is developing the Browns Range project in Australia, ended a sales agreement with Lianyugang Zeyu New Materials Sales and appointed Thyssenkrupp Materials Trading as its marketing partner, giving the German company the right to buy 100% of the rare earth metals being produced in a pilot plant. Further, HyProMag Limited ("HyProMag") subsidiary established in Germany rolled out the commercialization of HPMS (Hydrogen Processing of Magnet Scrap) technology in Germany and Europe to further support Government initiatives to strengthen European rare earth supply chains and accelerate the green transition.

TABLE 84 GERMANY: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	5.617	5.423	6.049	10.350	11.3%
Alloy	0.459	0.438	0.469	0.658	7.0%
Polishing Materials	0.110	0.105	0.115	0.183	9.8%
Glass	9.044	8.667	9.258	12.895	6.9%
Catalyst	0.194	0.187	0.202	0.293	7.8%
Phosphor	1.552	1.436	1.602	2.819	12.0%
Ceramics	0.279	0.262	0.288	0.466	10.1%
Hydrogen Storage Alloys	0.108	0.104	0.114	0.181	9.7%
Total	**17.365**	**16.623**	**18.096**	**27.844**	**9.0%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 85 GERMANY: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	85.7	82.9	92.0	153.3	10.7%
Alloy	43.6	41.7	44.2	59.2	6.0%
Polishing Materials	30.8	29.5	31.9	46.6	7.9%
Glass	28.0	27.0	28.7	38.9	6.3%
Catalyst	55.2	53.2	57.3	83.0	7.7%
Phosphor	29.0	27.0	29.7	47.9	10.0%
Ceramics	21.6	20.4	22.1	33.3	8.5%
Hydrogen Storage Alloys	13.1	12.6	13.7	20.9	8.8%
Total	**307.1**	**294.3**	**319.6**	**483.0**	**8.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 86 GERMANY: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	13.8	13.3	14.5	22.6	9.3%
Pyrometallurgical	3.5	3.4	3.6	5.2	7.7%
Total	**17.4**	**16.6**	**18.1**	**27.8**	**9.0%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 87 GERMANY: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	245.0	235.4	256.4	393.1	8.9%
Pyrometallurgical	62.1	58.9	63.2	89.8	7.3%
Total	**307.1**	**294.3**	**319.6**	**483.0**	**8.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 88 GERMANY: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	10.844	10.406	11.269	16.902	8.4%
Magnets	5.899	5.621	6.175	9.918	9.9%
Batteries	0.450	0.431	0.473	0.755	9.8%
FCC	0.066	0.063	0.068	0.096	7.2%
Industrial Process	0.105	0.101	0.110	0.173	9.4%
Total	**17.365**	**16.623**	**18.096**	**27.844**	**9.0%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 89 GERMANY: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	143.6	137.7	149.2	222.6	8.3%
Magnets	85.8	81.8	89.5	139.9	9.3%
Batteries	46.9	45.0	49.0	74.8	8.8%
FCC	18.3	17.7	18.9	26.7	7.1%
Industrial Process	12.5	12.1	13.0	19.0	7.8%
Total	**307.1**	**294.3**	**319.6**	**483.0**	**8.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.4.2 FRANCE

10.4.2.1 Increase in demand for rare earth metals in high-technology and low-carbon industries

Rapid industrialization and population growth are placing increasing pressure on the availability of raw materials. Recently, the Solvay Group, a chemical group headquartered in Brussels, officially opened two rare earth metals recycling plants in France. The two plants are designed to allow the company to diversify its supply of rare earth metals and preserve resources. The company has developed a process to recover rare earth metals from end-of-life products, such as light bulbs, batteries, and magnets.

TABLE 90 FRANCE: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	2.528	2.412	2.701	4.675	11.6%
Alloy	0.253	0.242	0.258	0.356	6.7%
Polishing Materials	0.091	0.085	0.093	0.146	9.4%
Glass	7.617	7.265	7.735	10.605	6.5%
Catalyst	0.129	0.123	0.133	0.190	7.4%
Phosphor	1.164	1.065	1.193	2.137	12.4%
Ceramics	0.228	0.212	0.232	0.368	9.7%
Hydrogen Storage Alloys	0.062	0.059	0.064	0.100	9.4%
Total	**12.072**	**11.462**	**12.408**	**18.577**	**8.4%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 91 FRANCE: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	37.8	36.1	40.3	67.9	11.0%
Alloy	23.6	22.5	23.8	31.4	5.7%
Polishing Materials	24.9	23.5	25.3	36.4	7.6%
Glass	23.1	22.2	23.5	31.4	6.0%
Catalyst	35.9	34.4	37.0	52.7	7.4%
Phosphor	21.3	19.6	21.7	35.6	10.4%
Ceramics	17.3	16.1	17.4	25.7	8.1%
Hydrogen Storage Alloys	7.3	7.0	7.5	11.3	8.5%
Total	**191.4**	**181.5**	**196.5**	**292.4**	**8.3%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 92 FRANCE: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	9.4	8.9	9.7	14.7	8.8%
Pyrometallurgical	2.7	2.5	2.7	3.8	7.1%
Total	**12.1**	**11.5**	**12.4**	**18.6**	**8.4%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 93 FRANCE: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	149.6	141.6	153.8	232.5	8.6%
Pyrometallurgical	41.7	39.9	42.7	59.9	7.0%
Total	**191.4**	**181.5**	**196.5**	**292.4**	**8.3%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 94 FRANCE: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	8.227	7.834	8.434	12.285	7.8%
Magnets	3.426	3.231	3.541	5.621	9.7%
Batteries	0.305	0.289	0.316	0.497	9.5%
FCC	0.040	0.039	0.041	0.058	7.0%
Industrial Process	0.073	0.070	0.076	0.116	8.9%
Total	**12.072**	**11.462**	**12.408**	**18.577**	**8.4%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 95 FRANCE: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	91.8	87.1	94.1	138.2	8.0%
Magnets	48.8	46.1	50.3	77.7	9.1%
Batteries	31.1	29.6	32.1	48.3	8.5%
FCC	11.0	10.5	11.3	15.8	7.0%
Industrial Process	8.6	8.2	8.8	12.5	7.3%
Total	**191.4**	**181.5**	**196.5**	**292.4**	**8.3%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.4.3 UK

10.4.3.1 Increased demand for rare-earth metals in wind turbines and electric vehicles

The manufacturing of low-carbon technologies is seen as a key area of growth for the UK. It is generally accepted that a consistent supply of raw materials is essential for this growth, and a concerted effort to develop a strategy to secure resources is needed. Two key areas which are expected to contribute to increased demand for rare earth metals in the UK are wind turbines and electric vehicle manufacturing.

Recently, Pensana Rare Earths Plc, headquartered in London, UK, announced that Saltend Chemicals Park, located in the Humber Local Enterprise Partnership, has been selected as the proposed site to build the UK's first rare earth processing facility to help create the world's first fully-sustainable magnet metal supply chain.

The UK's first re-manufacturing line for high-performance sintered rare earth magnets for use in electric vehicles, aerospace, renewable energy technologies, and low carbon technologies was developed by the University of Birmingham. The project was a part of the Driving the Electric Revolution Challenge at the UK Research and Innovation (UKRI) to support the creation of a competitive electrification supply chain in the UK. The plant will be based on the patented HPMS process (Hydrogen Processing of Magnet Scrap), which uses hydrogen as a processing gas to separate magnets from waste streams as an alloy powder. The powder will be used as a feedstock to re-manufacture sintered rare earth magnets.

TABLE 96 UK: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	0.877	0.843	0.937	1.576	11.0%
Alloy	0.071	0.068	0.072	0.098	6.3%
Polishing Materials	0.026	0.024	0.027	0.041	9.1%
Glass	2.070	1.975	2.096	2.829	6.2%
Catalyst	0.044	0.042	0.045	0.064	7.1%
Phosphor	0.324	0.295	0.328	0.573	11.8%
Ceramics	0.060	0.056	0.062	0.097	9.5%
Hydrogen Storage Alloys	0.018	0.017	0.018	0.028	9.0%
Total	**3.490**	**3.320**	**3.585**	**5.305**	**8.2%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 97 UK: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	13.0	12.5	13.8	22.7	10.4%
Alloy	6.6	6.3	6.6	8.6	5.3%
Polishing Materials	7.1	6.7	7.2	10.2	7.2%
Glass	6.2	6.0	6.3	8.3	5.6%
Catalyst	12.2	11.7	12.5	17.6	7.0%
Phosphor	5.9	5.4	5.9	9.4	9.8%
Ceramics	4.5	4.2	4.6	6.7	7.9%
Hydrogen Storage Alloys	2.1	2.0	2.1	3.1	8.1%
Total	**57.6**	**54.7**	**59.1**	**86.6**	**7.9%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 98 UK: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	2.72	2.58	2.80	4.19	8.4%
Pyrometallurgical	0.77	0.74	0.79	1.11	7.1%
Total	**3.49**	**3.32**	**3.59**	**5.31**	**8.2%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 99 UK: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	45.0	42.7	46.2	68.6	8.2%
Pyrometallurgical	12.5	12.0	12.9	18.0	6.9%
Total	**57.6**	**54.7**	**59.1**	**86.6**	**7.9%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 100 UK: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	2.338	2.230	2.397	3.459	7.6%
Magnets	1.025	0.968	1.057	1.646	9.3%
Batteries	0.094	0.089	0.097	0.150	9.0%
FCC	0.012	0.011	0.012	0.016	6.8%
Industrial Process	0.022	0.021	0.023	0.035	8.6%
Total	**3.490**	**3.320**	**3.585**	**5.305**	**8.2%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 101 UK: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	27.9	26.5	28.6	41.5	7.7%
Magnets	14.5	13.7	14.9	22.5	8.7%
Batteries	9.5	9.0	9.8	14.4	8.1%
FCC	3.2	3.0	3.2	4.4	6.7%
Industrial Process	2.6	2.5	2.6	3.7	7.0%
Total	**57.6**	**54.7**	**59.1**	**86.6**	**7.9%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.4.4 REST OF EUROPE

The Rest of Europe includes major rare earth metal-producing countries such as Italy, Spain, Sweden, the Netherlands, Switzerland, and Poland. The market in this region is driven by technological advancement in the growing automotive and energy industries. Owing to the increasing pressure on global resources, countries are expected to use varying strategies to meet their needs. Schemes such as the EU Raw Materials Initiative are designed to identify critical materials, develop new technologies, and make policies to prevent or mitigate supply issues.

TABLE 102 REST OF EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	0.368	0.356	0.397	0.669	11.0%
Alloy	0.040	0.038	0.040	0.054	6.0%
Polishing Materials	0.014	0.014	0.015	0.023	8.7%
Glass	1.192	1.139	1.205	1.599	5.8%
Catalyst	0.019	0.018	0.019	0.027	6.8%
Phosphor	0.182	0.168	0.187	0.325	11.7%
Ceramics	0.044	0.041	0.045	0.069	9.0%
Hydrogen Storage Alloys	0.010	0.009	0.010	0.015	8.7%
Total	**1.869**	**1.783**	**1.918**	**2.780**	**7.7%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 103 REST OF EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	5.4	5.2	5.8	9.5	10.4%
Alloy	3.6	3.5	3.6	4.6	5.0%
Polishing Materials	3.9	3.7	4.0	5.5	6.9%
Glass	3.6	3.4	3.6	4.6	5.3%
Catalyst	5.1	4.9	5.3	7.3	6.7%
Phosphor	3.3	3.0	3.3	5.3	9.7%
Ceramics	3.3	3.1	3.3	4.7	7.5%
Hydrogen Storage Alloys	1.1	1.1	1.2	1.7	7.8%
Total	**29.3**	**27.9**	**30.0**	**43.3**	**7.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 104 REST OF EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	1.42	1.35	1.46	2.16	8.1%
Pyrometallurgical	0.44	0.43	0.46	0.62	6.3%
Total	**1.87**	**1.78**	**1.92**	**2.78**	**7.7%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 105 REST OF EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	22.4	21.3	23.0	33.76	8.0%
Pyrometallurgical	6.9	6.6	7.1	9.53	6.2%
Total	**29.3**	**27.9**	**30.0**	**43.3**	**7.6%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 106 REST OF EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	1.272	1.217	1.301	1.829	7.1%
Magnets	0.532	0.504	0.549	0.848	9.1%
Batteries	0.047	0.045	0.049	0.075	9.0%
FCC	0.006	0.006	0.006	0.008	6.4%
Industrial Process	0.012	0.012	0.013	0.019	8.4%
Total	**1.869**	**1.783**	**1.918**	**2.780**	**7.7%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 107 REST OF EUROPE: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	13.99	13.35	14.30	20.19	7.1%
Magnets	7.50	7.12	7.72	11.62	8.5%
Batteries	4.77	4.55	4.92	7.25	8.1%
FCC	1.63	1.56	1.66	2.25	6.3%
Industrial Process	1.40	1.34	1.43	1.99	6.8%
Total	**29.28**	**27.92**	**30.03**	**43.30**	**7.6%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

10.5 REST OF WORLD

The Rest of World includes rare earth metals producing countries such as South Africa, Brazil, Argentina, and some Middle East & African countries, which prefer to buy rare earth elements than recycle them. However, the rising demand has compelled some countries to recycle to prevent shortages.

In June 2021, lighting and electronic-waste recycling company EWaste Africa started construction of a prototype rare earth metals recycling facility in Pietermaritzburg, in KwaZulu-Natal, South Africa.

TABLE 108 REST OF WORLD: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	1.714	1.626	1.823	3.126	11.4%
Alloy	0.248	0.234	0.246	0.314	5.1%
Polishing Materials	0.072	0.067	0.072	0.105	7.8%
Glass	5.747	5.384	5.646	7.172	4.9%
Catalyst	0.145	0.139	0.147	0.195	5.8%
Phosphor	0.456	0.412	0.457	0.781	11.3%
Ceramics	0.134	0.122	0.132	0.195	8.1%
Hydrogen Storage Alloys	0.057	0.054	0.058	0.084	7.7%
Total	**8.574**	**8.038**	**8.581**	**11.973**	**6.9%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 109 REST OF WORLD: RARE EARTH METALS RECYCLING MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	26.9	25.5	28.5	47.6	10.8%
Alloy	24.2	22.9	23.8	29.1	4.1%
Polishing Materials	20.8	19.5	20.7	27.6	6.0%
Glass	18.3	17.2	18.0	22.2	4.4%
Catalyst	42.4	40.6	42.9	56.8	5.8%
Phosphor	8.8	8.0	8.7	13.6	9.4%
Ceramics	10.6	9.8	10.4	14.3	6.6%
Hydrogen Storage Alloys	7.1	6.7	7.2	10.0	6.9%
Total	**159.1**	**150.2**	**160.2**	**221.2**	**6.7%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 110 REST OF WORLD: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (USD MILLION)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	6.30	5.89	6.30	8.92	7.2%
Pyrometallurgical	2.27	2.15	2.28	3.05	6.0%
Total	**8.57**	**8.04**	**8.58**	**11.97**	**6.9%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 111 REST OF WORLD: RARE EARTH METALS RECYCLING MARKET SIZE, BY TECHNOLOGY, 2019–2026 (METRIC TON)

Technology	2019	2020	2021	2026	CAGR (2021–2026)
Hydrometallurgical	117.4	110.4	118.1	165.4	7.0%
Pyrometallurgical	41.8	39.8	42.1	55.8	5.8%
Total	**159.1**	**150.2**	**160.2**	**221.2**	**6.7%**

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 112 REST OF WORLD: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (USD MILLION)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	5.922	5.549	5.897	8.045	6.4%
Magnets	2.333	2.188	2.361	3.464	8.0%
Batteries	0.212	0.200	0.215	0.313	7.8%
FCC	0.033	0.031	0.033	0.043	5.5%
Industrial Process	0.074	0.070	0.075	0.107	7.5%
Total	**8.574**	**8.038**	**8.581**	**11.973**	**6.9%**

Note: Three decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

TABLE 113 REST OF WORLD: RARE EARTH METALS RECYCLING MARKET SIZE, BY SOURCE, 2019–2026 (METRIC TON)

Source	2019	2020	2021	2026	CAGR (2021–2026)
Fluorescent Lamps	83.03	78.38	83.51	114.66	6.5%
Magnets	34.86	32.73	35.15	50.22	7.4%
Batteries	22.72	21.47	22.93	31.86	6.8%
FCC	9.50	9.01	9.50	12.38	5.4%
Industrial Process	9.01	8.56	9.06	12.05	5.9%
Total	**159.13**	**150.16**	**160.16**	**221.18**	**6.7%**

Note: Two decimal places are considered for data representation.

Source: Secondary Research, Interviews with Experts, and MarketsandMarkets Analysis

11 COMPETITIVE LANDSCAPE

11.1 OVERVIEW

This section covers the key strategies adopted by companies, market ranking, company evaluation quadrant, and competitive scenario & trends in the rare earth metals recycling market. The global rare earth metals recycling market is competitive with many international, regional, and domestic players. It is characterized by the presence of multiple companies at local and regional levels. Recyclers of rare earth metals recycling have raised the level of competition by offering innovative and high-quality solutions which are cost-efficient to steady the supply chain for rare earth metals.

- Solvay SA, Hitachi Metals, Ltd., Umicore, Osram Licht AG, Energy Fuels, Inc., Global Tungsten & Powders Corp., and REEcycle Inc. are the major players that undertook most of the development strategies.
- These key players have focused on market consolidation by adopting inorganic growth strategies such as mergers & acquisitions. These companies adopted acquisitions as the key growth strategy between 2016 and 2021.

FIGURE 50 COMPANIES ADOPTED ACQUISITION AS KEY GROWTH STRATEGY BETWEEN 2016 AND 2021

COMPANY NAME	INORGANIC GROWTH STRATEGIES	
	MERGER & ACQUISITION	PARTNERSHIP & COLLABORATION
SOLVAY SA	Solvay acquired Energain™ technology from DuPont and extended its advanced li-ion batteries offerings. This acquisition will lead to competencies in areas like modeling and formulations, thus boosting the execution of Solvay's technological roadmap in batteries.	Solvay joined the World Alliance for Efficient Solutions to promote efficient technologies, processes, and systems that help improve the quality of life on earth. The collaboration would result in innovation into daily applications for a more sustainable planet and growth.
HITACHI METALS, LTD.	Hitachi Metals, Ltd. acquired Santoku Corporation. The acquisition will help in accelerating the growth of the manufacturing of neodymium magnet alloys and the development of new recycling technologies.	
UMICORE		Audi and Umicore completed strategic research, which resulted in recovering more than 90% of the cobalt and nickel in high-voltage batteries. The car manufacturer and the materials technology and recycling expert cooperated on a closed-loop for cobalt and nickel. The recovered materials have been used in new battery cells.

Source: Press Releases, Company Website, and MarketsandMarkets Analysis

11.2 MARKET RANKING ANALYSIS

FIGURE 51 RANKING OF TOP FIVE PLAYERS IN RARE EARTH METALS RECYCLING MARKET, 2020

RANK

1. Solvay SA
2. Hitachi Metals, Ltd.
3. Umicore
4. Energy Fuels, Inc.
5. Global Tungsten & Powders Corp.

Source: Annual Reports, Investor Presentations, Expert Interviews, and MarketsandMarkets Analysis

11.2.1 SOLVAY SA

Solvay SA is a manufacturer and distributor of chemical and plastic products. It operates through the following segments: advanced formulations, advanced materials, performance chemicals, and corporate and business services. The advanced formulations segment offers specialty formulations that impact surface chemistry and alter liquid behavior. The advanced materials segment offers materials for multiple applications in the automotive, aerospace, electronics, and health sectors. The performance chemicals segment operates in mature and resilient markets and has positions in chemical intermediates. The corporate and business services segment includes corporate and other business services such as research & innovation. The company has more than 20 research & innovation centers and has geographical presence in more than 64 countries. Solvay has two sites in France for recycling rare earth elements.

11.2.2 HITACHI METALS, LTD.

Hitachi Metals, Ltd. is engaged in the manufacturing and sale of products for automobile, electronics, and infrastructure sectors. It operates through four divisions, namely, specialty steel, magnetic materials, functional components, and cable materials. The specialty steel division includes high-grade special steel, rolls, steel and ceramic structural parts, injection molding machine parts, and soft magnetic materials. The magnetic materials division comprises magnets and ceramic products. The functional components division consists of high-grade casting components for automobiles, piping and infrastructure components, and construction components. The cable materials division offers electric wires and functional items such as industrial wire, equipment wire, industrial rubber, cable processed products, automotive electrical components, and brake hose. The company has plants and research & development facilities in Osaka, Saga, Shimane, Mie, Saitama, Tochigi, and Ibaraki and overseas offices in New York, Dusseldorf, London, Paris, Shanghai, Hong Kong, Taipei, and Singapore, among other cities.

11.2.3 UMICORE

Umicore is engaged in the materials technology business. It operates through the catalysis, energy & surface technologies, recycling, and corporate business segments. The catalysis segment consists of automotive catalysts for gasoline, diesel light, and heavy-duty diesel applications, including on-road and off-road vehicles. The energy and surface technologies segment is comprised of cobalt and specialty materials, electro-optic materials, electroplating, rechargeable battery materials, and thin film products business units. The recycling segment offers precious metals refining, jewelry and industrial metals, precious metals management, technical materials, and platinum engineer materials. The corporate segment covers corporate activities, shared operational functions, and research, development, and innovation unit of the Group.

11.2.4 ENERGY FUELS, INC.

Energy Fuels is a leading producer of uranium in the US, which is vital for carbon- and emission-free nuclear energy. Nuclear energy is expected to see strong growth in the coming years as nations around the world work to provide plentiful and affordable energy while combating climate change and air pollution. Energy Fuels is also a major producer of vanadium and an emerging player in the commercial rare earth business, where it is working to help re-establish a fully integrated US supply chain. The company has diverse cash flow-generating opportunities, including vanadium production, uranium recycling, and rare earth processing. It holds three of America's key uranium production centers - The White Mesa Mill in Utah, the Nichols Ranch ISR Facility in Wyoming, and the Alta Mesa ISR Facility in Texas. Its White Mesa Mill is the only conventional uranium mill in the US and has a licensed capacity of approximately 8 million pounds of U3O8 per year. Nichols Ranch is in production and has a licensed capacity of approximately 2 million pounds of U3O8 per year. Alta Mesa is currently on standby. Energy Fuels also owns several licensed and developed uranium and vanadium mines on standby and other projects in development.

11.2.5 GLOBAL TUNGSTEN & POWDERS CORP.

Global Tungsten & Powders is a supplier of tungsten and molybdenum powders, semi-finished parts and Solid Oxide Fuel Cells (SOFC) components. The company produces ammonium paratungstate (APT), tungsten oxide, tungsten metal powder (WMP), tungsten carbide (WC), ready-to-press grade powder (RTP), thermal spray powders (TSP), moly powder, semi-finished parts, and components for the SOFC market segment. Global Tungsten & Powders Corp. also has two manufacturing facilities in Europe. In the Czech Republic, the company produces tungsten metal powders and tungsten carbides, and in Finland, it produces recycled tungsten carbide-cobalt powders using zinc process. The company has been certified with ISO 9001:2015, ISO 17025:2017 and ISO 14001:2015. The company offers a wide range of tungsten recycling programs (chemical recycling, zinc reclaim, tolling). In addition, it also recycles and reuses key process materials such as hydrogen, ammonia, and water. The company serves various industries, such as aerospace, plastic, hard materials, automotive, energy, lighting, electronics, medical, and power generation.

AERC. Inc. (AERC Recycling Solutions) partnered with Global Tungsten & Powders Corporation (GTP) for the recovery of rare earth metals from spent fluorescent lamps. This will help the company to solve some of the demand requirements for rare earth metals by extracting these materials from recycled fluorescent lamps. Through this partnership with AERC, Global Tungsten & Powders Corporation is helping to identify new sources of rare earth metals and creating a recovery process to utilize the materials in new products.

11.3 MARKET SHARE ANALYSIS

This section of the report analyzes the market share of the key players based on various parameters such as geographical presence, product portfolios, and the strategic developments undertaken by them pertaining to the rare earth metals recycling market.

Solvay SA, Hitachi Metals, Ltd., Umicore, Energy Fuels, Inc., and Global Tungsten & Powders Corp. were the leading players in the rare earth metals recycling market in 2020. These players have recorded substantial strategic developments to support their business expansions, along with investments in R&D to develop a competitive product portfolio.

The global rare earth metals recycling market is competitive. The cumulative share of the top five companies was between 25-50% of the total market in 2020. The degree of competition in the rare earth metals recycling market is defined as below:

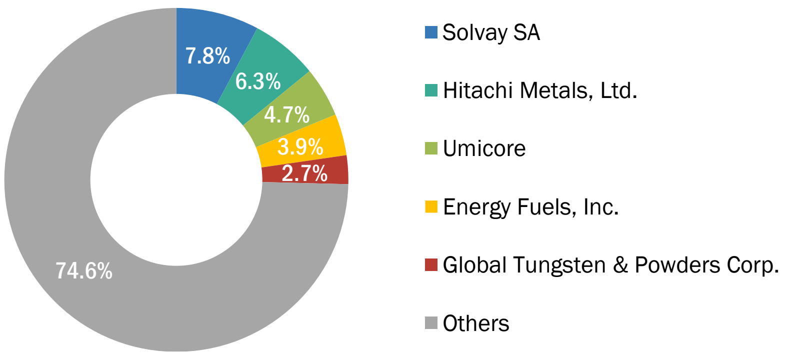
- Fragmented: When top 5 players have a total market share < 25%
- Competitive: When top 5 players have a total of 25%-50% market share
- Consolidated: When top 5 players have a total market share > 50%

TABLE 114 RARE EARTH METALS RECYCLING MARKET: MARKET SHARE OF KEY PLAYERS

COMPANY	SHARE
Solvay SA	7.8%
Hitachi Metals, Ltd.	6.3%
Umicore	4.7%
Energy Fuels, Inc.	3.9%
Global Tungsten & Powders Corp.	2.7%

Source: Company Website, Expert Interviews, and MarketsandMarkets Analysis

FIGURE 52 RARE EARTH METALS RECYCLING MARKET: MARKET SHARE ANALYSIS



Source: Company Website, Expert Interviews, and MarketsandMarkets Analysis

11.4 COMPANY EVALUATION QUADRANT

This section of the report provides an overview of the company evaluation quadrant of the rare earth metals recycling market. The company evaluation has been carried out based on the outcome of the qualitative and quantitative analyses of various factors, such as the companies' product portfolio, technological innovations, market presence, revenues, and the opinion of primary respondents.

11.4.1 STAR

Vendors that fall in this category generally receive high scores for most evaluation criteria. These players have established a service/product portfolio and a powerful market presence. They also devise effective business strategies. The companies falling under this category include Solvay SA, Seren Technologies Ltd., Umicore, Energy Fuels, Inc., and Hitachi Metals., Ltd.

11.4.2 EMERGING LEADERS

Emerging leaders are vendors that have demonstrated substantial service innovations compared to their competitors. However, they lack solid growth strategies for their overall business. The companies falling under the emerging leaders category are REEcycle Inc., Rocklink GmbH, and Clean Earth Inc.

11.4.3 PERVASIVE

Pervasive players are established vendors with powerful business strategies. However, they lag in terms of service/product/solution portfolio. They generally focus on a specific type of technology related to the product/service. The companies falling under the pervasive category include OSRAM Licht AG and Global Tungsten & Powders Corp.

FIGURE 53 COMPETITIVE LEADERSHIP MAPPING: RARE EARTH METALS RECYCLING MARKET, 2020

Source: Company Websites, Expert Interviews, and MarketsandMarkets Analysis

11.5 SME MATRIX, 2020

The SME matrix analysis provides information related to the emerging players that offer rare earth metals recycling. This analysis provides information related to the performance of rare earth metals recycling players in terms of product offerings and business strategies. The emerging companies are classified into four categories based on certain criteria. The categories are progressive, starting blocks, responsive, and dynamic.

11.5.1 PROGRESSIVE COMPANIES

These companies perform exceedingly well in both product excellence and business excellence parameters. They have a substantial partner ecosystem and well-developed marketing channels and have received extensive funding for the development of their product portfolio. These companies have been instrumental in achieving growth, thereby attaining high partner attractiveness. American Rare Earth LLC, Showa Denko K.K., and Okon Metals, Inc. are recognized as progressive companies among SMEs in the rare earth metals recycling market.

11.5.2 RESPONSIVE COMPANIES

These companies have performed substantially well in terms of business excellence. However, they are slightly low in product excellence as compared to the leaders. They generally focus on a specific type of technology related to the product or service offering. Taiyuan Chemical Industry Group Co. Ltd., Guangsheng Nonferrous Metals Co., Ltd., and Mitsubishi Electric Corporation are recognized as responsive companies in the rare earth metals recycling market.

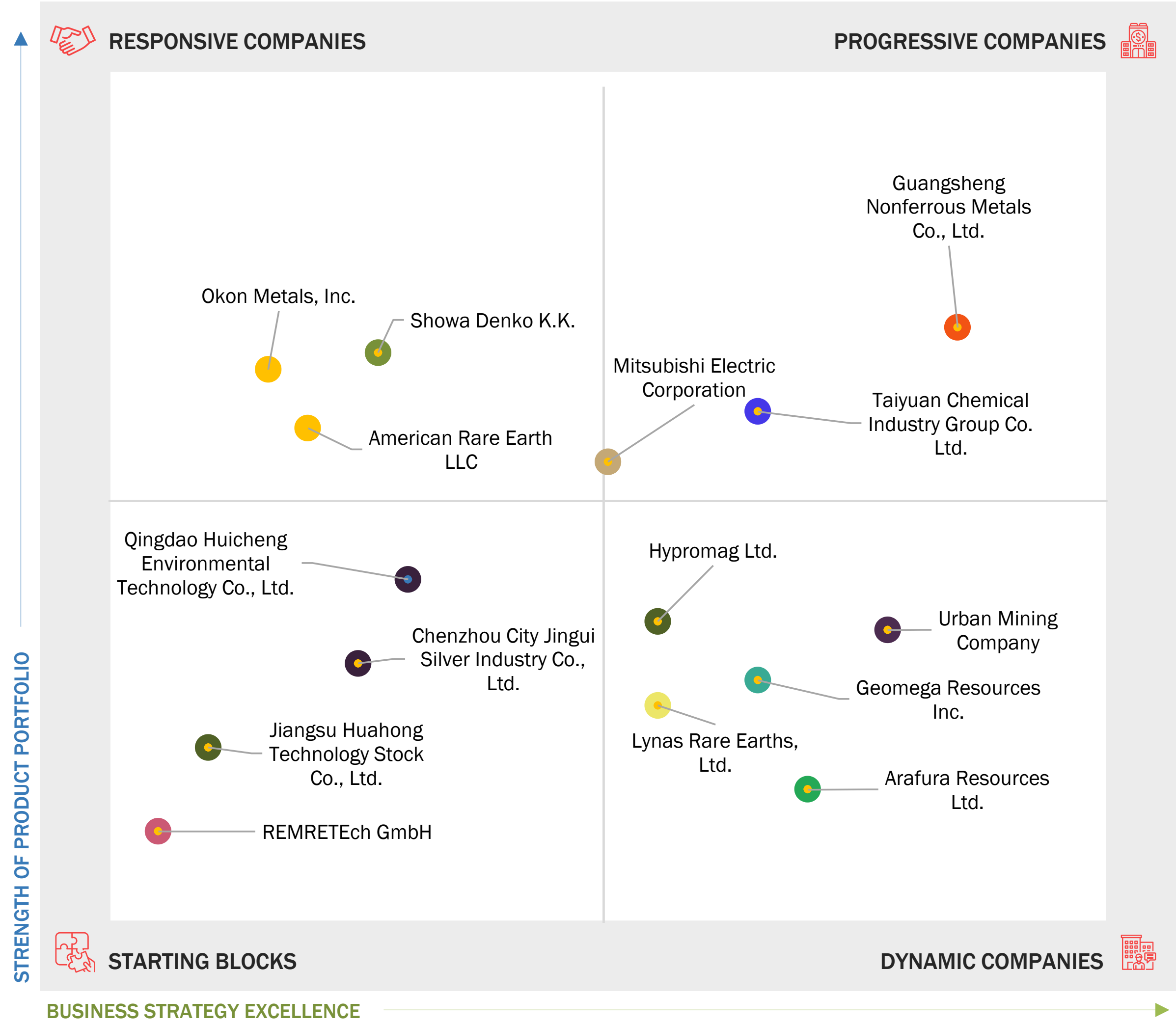
11.5.3 DYNAMIC COMPANIES

These companies are technology disruptors with highly innovative product offerings as compared to their competitors. They are focused on the constant development of their products/services portfolio and bringing innovations to the market. However, they lag in the business excellence parameter as compared to other start-ups. These companies perform marketing activities and seek partnerships. Geomega Resources Inc., Lynas Rare Earths, Ltd., Urban Mining Company, Arafura Resources Ltd., and Hypromag Ltd. are the dynamic companies in the rare earth metals recycling market.

11.5.4 STARTING BLOCKS

These companies with niche offerings are starting to gain their position in the market. They do not have strong business excellence and product excellence compared to other established start-ups. However, they are always on the lookout for opportunities to consolidate their marketspace. They might be new entrants in the market and require some more time before they can get significant traction in the market. REMRETEch GmbH, Taiyuan Chemical Industry Group Co. Ltd., Chenzhou City Jingui Silver Industry Co., Ltd., and Guangsheng Nonferrous Metals Co., Ltd. are recognized as the starting block in the rare earth metals recycling market.

FIGURE 54 SME MATRIX: RARE EARTH METALS RECYCLING MARKET, 2020



Source: Secondary Research and MarketsandMarkets Analysis

11.6 COMPETITIVE SCENARIO

This section studies the growth strategies adopted by the major market players between 2016 and 2021. Collaboration & acquisition is the key strategy adopted by the players to achieve growth in the rare earth metals recycling market.

11.6.1 COLLABORATION & ACQUISITION

TABLE 115 COLLABORATION & ACQUISITION, 2016–2021

MONTH & YEAR	DEAL TYPE	COMPANY 1	COMPANY 2	DESCRIPTION	DEAL SIZE
December 2021	Collaboration	Umicore	Volkswagen AG	Umicore and Volkswagen AG established a joint venture to build precursor and cathode material production capacities in Europe to supply Volkswagen AG's European battery cell production, making a considerable contribution to the region's transition towards cleaner mobility.	NA
December 2019	Collaboration	Umicore	Audi	Audi and Umicore completed strategic research, which resulted in recovering more than 90% of the cobalt and nickel in high-voltage batteries. The car manufacturer and the materials technology and recycling expert cooperated on a closed-loop for cobalt and nickel. The recovered materials have been used in new battery cells.	NA
May 2018	Acquisition	Hitachi Metals, Ltd.	Santoku Corporation	Hitachi Metals, Ltd. acquired Santoku, a rare earth metal recycler, as a wholly-owned subsidiary. The acquisition will help in accelerating the growth of the manufacturing of neodymium magnet alloys and the development of new recycling technologies. Through the acquisition of Santoku, Hitachi Metals aimed to develop a stable production system and achieve sustainable growth in the global market by establishing an integrated production system that covers the manufacturing of alloys and magnets for the neodymium magnets business to recycling.	NA
September 2017	Collaboration	Solvay SA	World Alliance for Efficient Solutions	Solvay joined the World Alliance for Efficient Solutions to promote efficient technologies, processes, and systems that help improve the quality of life. The collaboration would result in innovation in daily applications for a more sustainable planet and growth.	NA
February 2017	Acquisition	Solvay SA	DuPont (Energain™)	Solvay acquired Energain™ technology from DuPont and extended its advanced li-ion battery offerings. This acquisition will lead to competencies in areas like modeling and formulations, thus boosting the execution of Solvay's technological roadmap in batteries.	NA

Source: Company Websites

12 COMPANY PROFILES

12.1 KEY COMPANIES

12.1.1 SOLVAY SA

12.1.1.1 Business overview

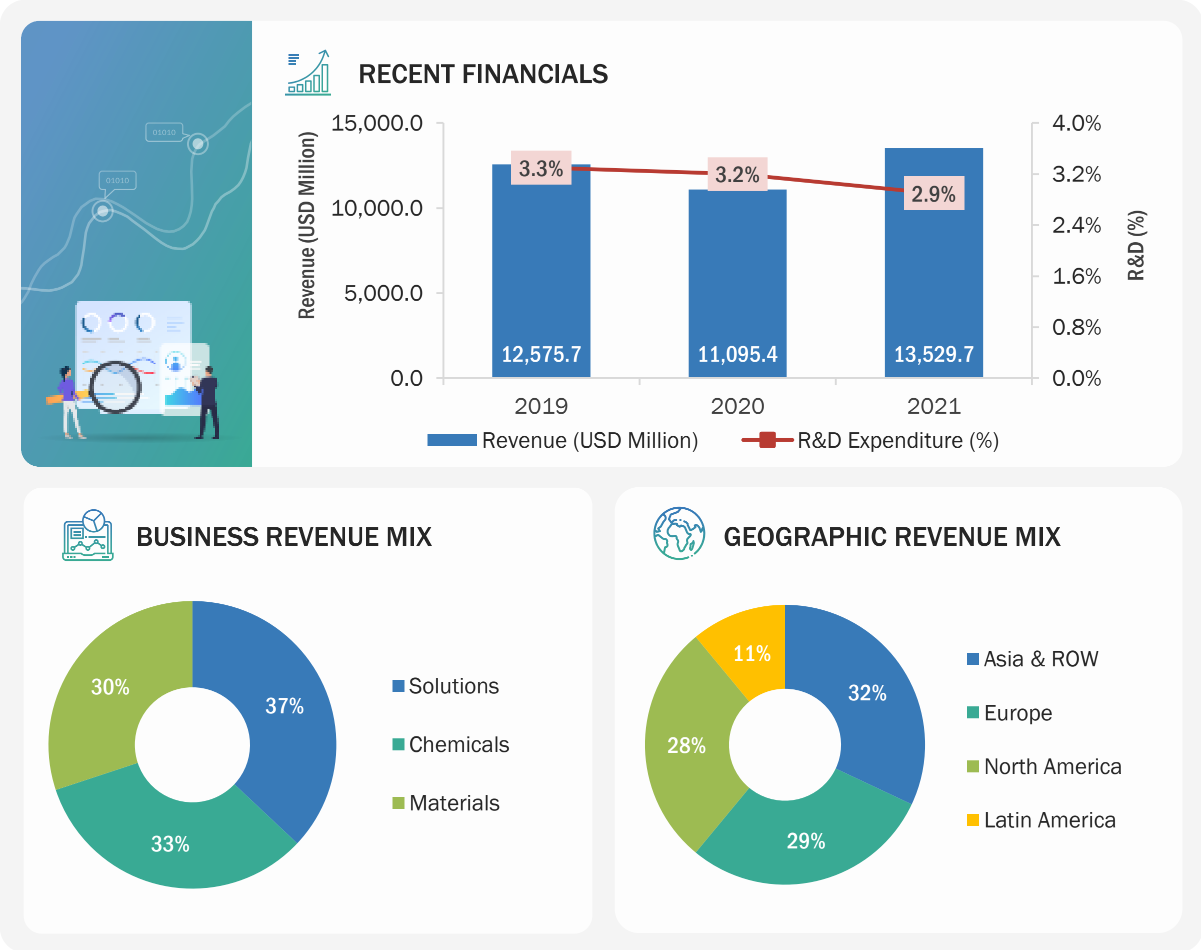
Solvay SA is a manufacturer and distributor of chemical and plastic products. It operates through the following segments: advanced formulations, advanced materials, performance chemicals, and corporate and business services. The advanced formulations segment offers specialty formulations that impact surface chemistry and alter liquid behavior. The advanced materials segment provides materials for multiple applications in the automotive, aerospace, electronics, and health sectors. The performance chemicals segment operates in mature and resilient markets and has positions in chemical intermediates. The corporate and business services segment includes corporate and other business services, such as research & innovation center. The company has more than 20 research & innovation centers and presence in more than 64 countries. Solvay has two sites in France for recycling rare earth elements.

TABLE 116 SOLVAY SA: BUSINESS OVERVIEW

Year Founded	1863
Country	Belgium
City	Brussels
Employee	23,663
Ownership	Public

Source: Company Website

FIGURE 55 SOLVAY SA: COMPANY SNAPSHOT



Source: Company Website and MarketsandMarkets Analysis

12.1.1.2 Products and solutions

TABLE 117 SOLVAY SA: PRODUCT OFFERED

PRODUCT TYPE	PRODUCT	DESCRIPTION/ APPLICATION
Rare Earth Metals Extractant	CYANEX®	▪ CYANEX® is formulated for the extraction and purification of rare earth elements. ▪ It has an extraction strength profile that allows efficient extraction of heavy rare earth elements while allowing the back extraction and stripping operation to utilize lower strip acid concentrations.
Rare Earth Metals Extractant	DEHPA®	▪ DEHPA® is an extractant used commercially in hydrometallurgical processing to remove metal impurities such as iron, manganese, and zinc or to recover uranium, vanadium, zinc, rare earths, and other valuable metals. ▪ DEHPA®, the registered trade name for di (2-ethylhexyl) phosphoric acid, may be used alone or in combination with other synergistic extractants, including trioctylphosphine oxide, tributyl phosphate, and dibutyl butyl phosphonate.

Source: Company Website

12.1.1.3 Recent developments

TABLE 118 SOLVAY SA: DEALS

MONTH & YEAR	DEAL TYPE	COMPANY NAME 1	COMPANY NAME 2	DESCRIPTION	DEAL SIZE
September 2017	Collaboration	Solvay SA	World Alliance for Efficient Solutions	Solvay joined the World Alliance for Efficient Solutions to promote efficient technologies, processes, and systems that help improve the quality of life. The collaboration would result in innovation in daily applications for a more sustainable planet and growth.	NA
February 2017	Acquisition	Solvay SA	DuPont (Energain™)	Solvay acquired Energain™ technology from DuPont and extended its advanced li-ion battery offerings. This acquisition will lead to competencies in areas like modeling and formulations, thus boosting the execution of Solvay's technological roadmap in batteries.	NA

Source: Company Website

12.1.1.4 MnM view

12.1.1.4.1 Key strengths/right to win

The company has a broad product portfolio catering to diverse end markets. For the consumer goods market, the company develops a range of products used in detergents, personal care products, nutrition, human health, and textiles. Solvay's products for the construction market include blowing agents and flame retardants, which are used in paints and coatings, thermal insulation, windows, electrical wiring, cabling, as well as pipes and fittings for heating and cooling systems. To its customers in the automobile market, Solvay provides a range of solutions for sustainable mobility with a range of high-performance products and applications and materials based on rare earths that reduce polluting emissions.

In addition, Solvay provides advanced solutions and products for producing energy from solar and other renewable resources. For its customers in the environment market, the company offers solutions for air emission control, soil remediation, and water supply and treatment, among others. Solvay's products, such as conductive and photovoltaic materials, coatings and coating additives for flat panel displays, and semiconductors, address the needs of its customers in the electronics market. The broad product portfolio has enabled Solvay to build a balanced revenue stream for sustainable growth.

12.1.1.4.2 Strategic choice made

Solvay focuses on strengthening its business through various strategic agreements and partnerships. In January 2022, the company entered into an agreement with Trillium Renewable Chemicals to develop the supply chain for bio-based acrylonitrile (bio-ACN). Through this partnership, the company aims to produce carbon fiber for use in various applications such as aerospace, automotive, energy, and consumer goods. In December 2021, the company signed a long-term agreement with Avio to supply advanced composite and adhesive materials which have extensive applications in the aerospace sector. In November 2021, the company entered into an agreement with 9T Labs to manufacture carbon fiber-reinforced plastic (CFRP) parts. In June 2021, the company partnered with Novotech to supply composites, adhesives, and technical support to develop the structure of their hybrid Seagull water landing aircraft. These partnerships enhance the company's revenues, market presence, and reputation.

12.1.1.4.3 Weaknesses and competitive threats

Unfavorable changes in foreign currency exchange rates are likely to increase the company's expenses. The company has operations in Asia, Europe, Latin America, North America, and other regions. The appreciation of non-reporting currencies such as Australian dollar, Hong Kong dollar, Indonesian rupiah, Malaysian ringgit, New Taiwan dollar, Indian rupee, and Canadian dollar, among others, over Euro or vice versa could incur increased costs to the company and increase capital expenditure.

12.1.2 HITACHI METALS, LTD.

12.1.2.1 Business overview

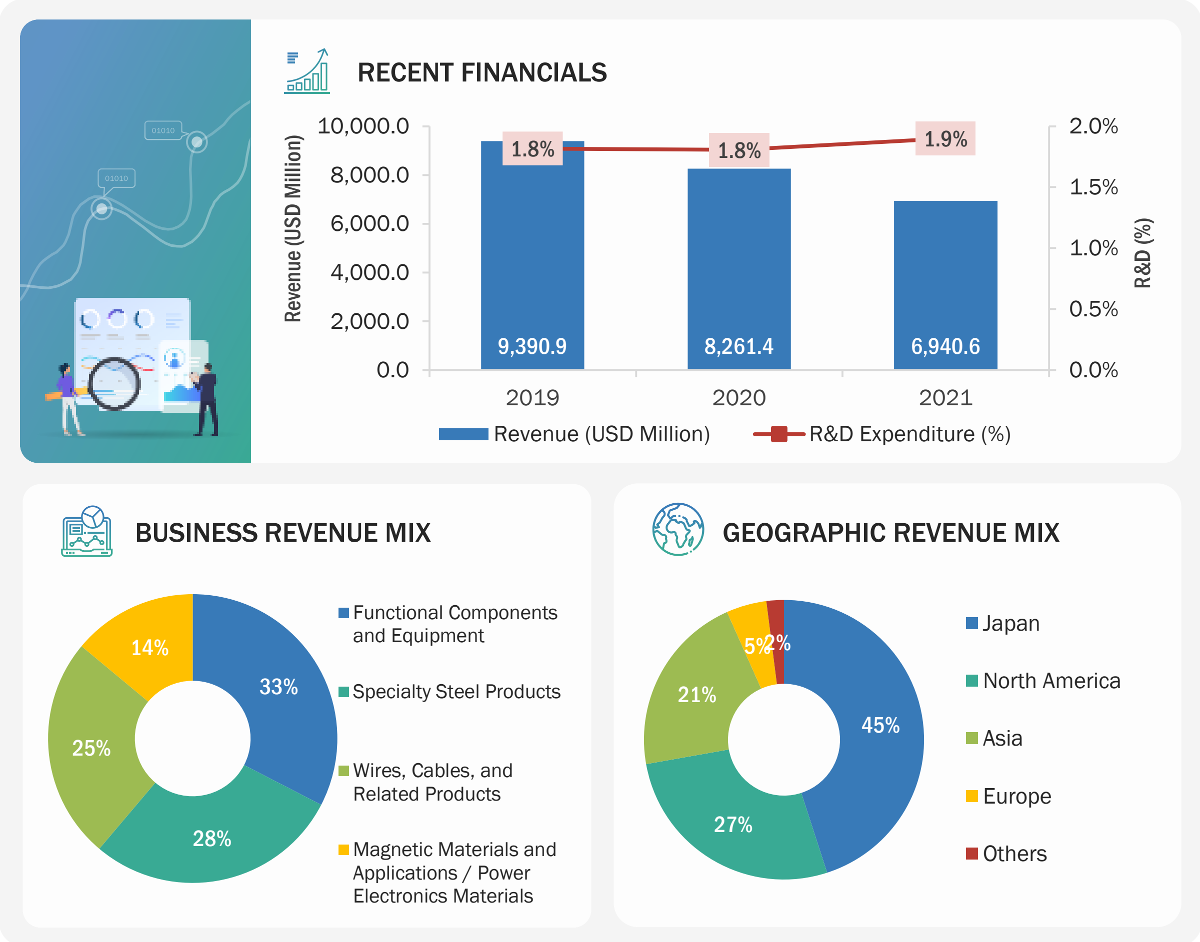
Hitachi Metals, Ltd. is engaged in the manufacturing and sale of products for the automobile, electronics, and infrastructure sectors. It operates through the specialty steel, magnetic materials, functional components, and cable materials business divisions. The specialty steel division offers high-grade special steel, rolls, steel and ceramic structural parts, injection molding machine parts, and soft magnetic materials. The magnetic materials division offers magnets and ceramic products. The functional components division provides high-grade casting components for automobiles, piping and infrastructure components, and construction components. The cable materials division offers electric wires and functional items such as industrial wire, equipment wire, industrial rubber, cable processed products, automotive electrical components, and brake hose. The company has plants and research & development facilities in Osaka, Saga, Shimane, Mie, Saitama, Tochigi and Ibaraki and overseas offices in New York, Dusseldorf, London, Paris, Shanghai, Hong Kong, Taipei, and Singapore, among other cities.

TABLE 119 HITACHI METALS, LTD.: BUSINESS OVERVIEW

Year Founded	1956
Country	Japan
City	Tokyo
Employee	28,620
Ownership	Public

Source: Company Website

FIGURE 56 HITACHI METALS, LTD.: COMPANY SNAPSHOT



Source: Company Website and MarketsandMarkets Analysis

12.1.2.2 Products and solutions

TABLE 120 HITACHI METALS, LTD.: PRODUCT OFFERED

PRODUCT TYPE	PRODUCT	DESCRIPTION/ APPLICATION
Performance Magnets	NEOMAX® - Neodymium Magnets	NEOMAX® is used in small and advanced electronic devices. It also has uses in various fields such as automobiles, IT, home appliances, industrial machinery, medicine, environment, and energy.

Source: Company Website

12.1.2.3 Recent developments

TABLE 121 HITACHI METALS, LTD.: DEALS

MONTH & YEAR	DEAL TYPE	COMPANY NAME 1	COMPANY NAME 2	DESCRIPTION	DEAL SIZE
May 2018	Acquisition	Hitachi Metals, Ltd.	Santoku Corporation	Hitachi Metals, Ltd. acquired Santoku, a rare earth metal recycler, as a wholly-owned subsidiary. The acquisition will help in accelerating the growth of the manufacturing of neodymium magnet alloys and the development of new recycling technologies. Through the acquisition of Santoku, Hitachi Metals aimed to develop a stable production system and achieve sustainable growth in the global market by establishing an integrated production system that covers the manufacturing of alloys and magnets for the neodymium magnets business to recycling.	NA

Source: Company Website

12.1.2.4 MnM view

12.1.2.4.1 Key strengths/right to win

Hitachi Metals invests in new technology to develop energy-efficient products. The company's R&D efforts focus on developing special steel, raw materials, electric wire materials, and magnetic materials. It operates R&D bases in various cities of Japan. The company's R&D bases include the Global Research & Innovative Technology center (GRIT) in Saitama-ken, Specialty Steel Research Department of Metallurgical Research Laboratory in Shimane-ken, Functional Components Research Department of Metallurgical Research Laboratory in Tochigi-ken, Kuwana Works R&D center in Mie-ken, Magnetic Materials Research Department in Saitama-ken, Power Electronics Materials Research Department in Tottori-ken, and Cable Materials Research Department of Advanced Components & Materials Research Laboratory in Ibaraki-ken. It helps the company to enable closer collaboration with its production facilities in the same region.

12.1.2.4.2 Strategic choice made

Rare earth magnets, mostly made of neodymium, are widely seen as the most efficient way to power electric vehicles (EVs). As per the International Energy Agency (IEA), consumers spent USD 120 billion on electric car purchases in 2020, a 50% increase from 2019, which breaks down to a 41% increase in sales and a 6% rise in average prices. Rare earths are critical for the electronics, defense, and renewable energy industries. Electric cars with permanent magnets require less battery power than those with ordinary magnets. Hence, such vehicles can go longer distances before recharging.

12.1.2.4.3 Weaknesses and competitive threats

Hitachi Metals is required to comply with stringent regulations at the federal, state, and local levels. Products that do not comply with legislation outlined by regulatory bodies could face a delay in reaching their customers. Non-compliance with legislation could also lead to penalties and legal proceedings, which could damage the company's image. Under the United Nations Framework Convention on Climate Change, the government of Japan targeted to reduce greenhouse emissions by 25% from 1990 levels by 2020 in all its development operations in Japan. The company also requires complying with state regulatory agencies and various regulatory agencies in the countries of operation, and any non-compliance with applicable regulations may lead to fines and other penalties. The compliance or change in regulations may force the company to update its products or manufacturing processes, which can increase the capital expenditure and impact its financial position.

12.1.3 UMICORE

12.1.3.1 Business overview

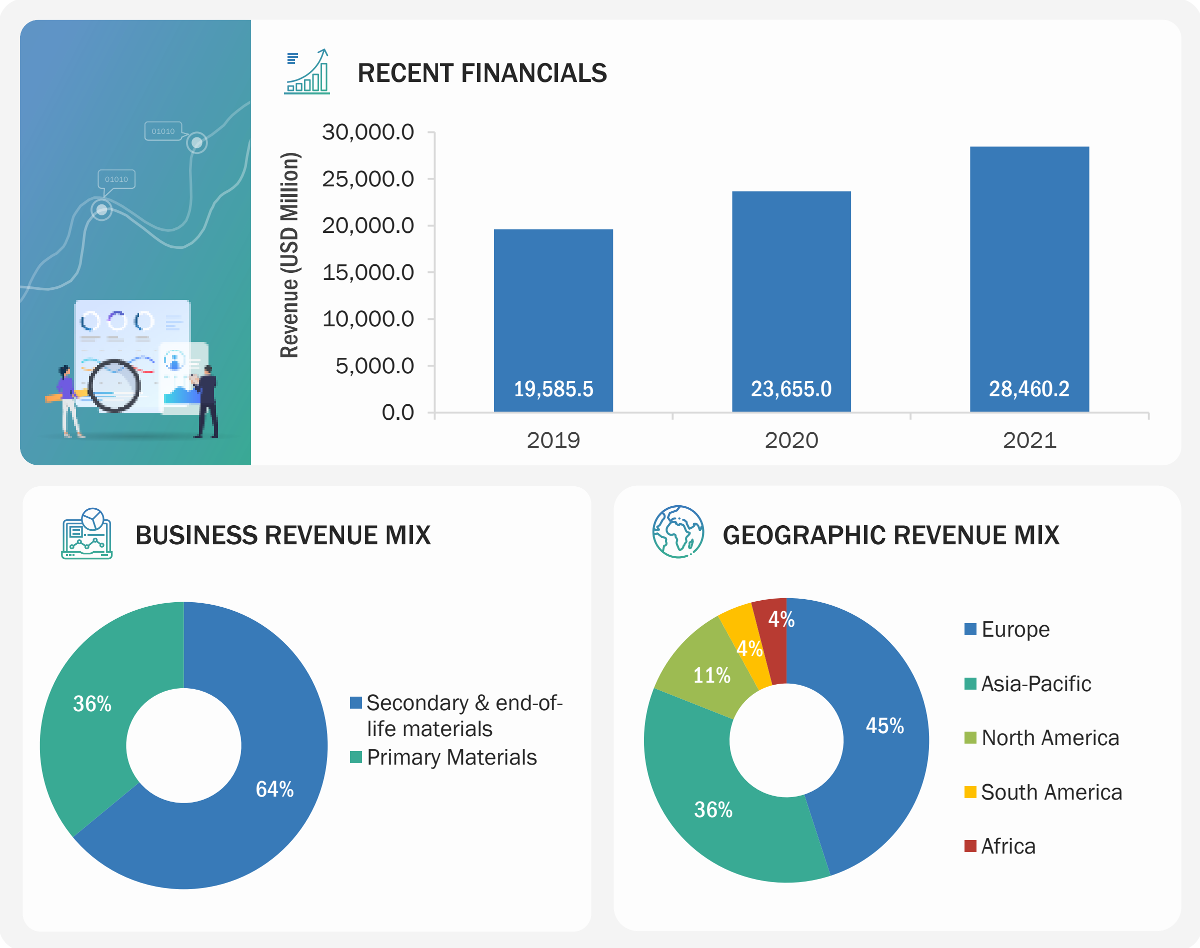
Umicore is engaged in the materials technology business. It operates through the following business segments: catalysis, energy & surface technologies, recycling, and corporate. The catalysis segment deals in automotive catalysts for gasoline and diesel light and heavy-duty diesel applications, including on-road and non-on-road vehicles. The energy and surface technologies segment is comprised of cobalt and specialty materials, electro-optic materials, electroplating, rechargeable battery materials and thin film products business units. The recycling segment offers precious metals refining, jewelry and industrial metals, precious metals management, technical materials, and platinum engineer materials. The corporate segment covers corporate activities, shared operational functions, and research, development, and innovation unit of the group.

TABLE 122 UMICORE: BUSINESS OVERVIEW

Year Founded	1904
Country	Belgium
City	Brussels
Employee	10,859
Ownership	Public

Source: Company Website

FIGURE 57 UMICORE: COMPANY SNAPSHOT



Source: Company Website and MarketsandMarkets Analysis

12.1.3.2 Products and solutions

TABLE 123 UMICORE: PRODUCT OFFERED

PRODUCT TYPE	PRODUCT	DESCRIPTION/ APPLICATION
Rare earth metals	Neodymium	Neodymium is used with iron and boron to create powerful permanent magnets, also called NIB magnets. They are used in computers, cell phones, medical equipment, toys, motors, wind turbines, and audio systems.

Source: Company Website

12.1.3.3 Recent developments

TABLE 124 UMICORE: DEALS

MONTH & YEAR	DEAL TYPE	COMPANY NAME 1	COMPANY NAME 2	DESCRIPTION	DEAL SIZE
December 2021	Collaboration	Umicore	Volkswagen AG	Umicore and Volkswagen AG established a joint venture to build precursor and cathode material production capacities in Europe to supply Volkswagen AG's European battery cell production, making a considerable contribution to the region's transition towards cleaner mobility.	NA
December 2019	Collaboration	Umicore	Audi	Audi and Umicore completed strategic research, which resulted in recovering more than 90% of the cobalt and nickel in high-voltage batteries. The car manufacturer and the materials technology and recycling expert cooperated on a closed-loop for cobalt and nickel. The recovered materials have been used in new battery cells.	NA

Source: Company Website

12.1.3.4 MnM view

12.1.3.4.1 Key strengths/right to win

Umicore has a strong and robust product portfolio. It is involved in several activities and serves industries such as electronics, automotive, recycling, energy, chemicals, construction, optics, displays, and precious metals. The company deals in rechargeable battery materials for portable electronics, recycling and recovering precious and specialty metals, and electroplating solutions for technical and decorative applications. It offers emission control catalysts for cleaner air, cobalt compounds for better tires, and cobalt and nickel compounds to remove impurities from petroleum. The company provides jewelry recycling for the re-use of precious metals and zinc recycling for the galvanizing industry. Further, the company is involved in various other activities such as zinc powder for cylindrical alkaline batteries, platinum equipment for the production of high-quality glass, and high potency active pharmaceutical ingredients.

12.1.3.4.2 Strategic choice made

Umicore focuses on strengthening its business through various strategic agreements and joint ventures. In December 2021, the company established a joint venture with Volkswagen AG to build precursor and cathode material production capacities in Europe. Under the agreement, the company is agreed to supply Volkswagen AG's European battery cell production and make a contribution to Europe's transition towards cleaner mobility. The partnership is expected to achieve the ambitions of the European Green Deal, including the establishment of a battery supply chain and a strong initiative for the ongoing roll-out of battery cell technologies and capabilities in the region. In October 2021, the company entered into an agreement with Ganfeng Lithium Co. Ltd. and Vulcan Energy Resources. The five years agreement is expected to provide Umicore with a sustainable and regional supply of raw materials to meet the growing demand for cathode materials from its global automotive customers. It also supports the company in the growth of its customers through the creation of a sustainable battery materials value chain.

12.1.3.4.3 Weaknesses and competitive threats

Umicore is exposed to various regulatory environments in the countries or regions where it does business. Some environmental legislation presents operational challenges. The Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) Directive came into force in the European Union in 2007, and it introduced the need for new operational procedures regarding the registration, evaluation, and authorization of chemical substances. Moreover, Umicore could be negatively impacted by regulatory policy changes or actions from European or national regulatory entities. Among other things, the company's revenue and profit could be affected by increased taxation, additional consumer regulation, and wholesale regulation. Failure to comply with applicable regulations could subject the company to fines, penalties, or other enforcement action by authorities.

12.1.4 OSRAM LICHT AG

12.1.4.1 Business overview

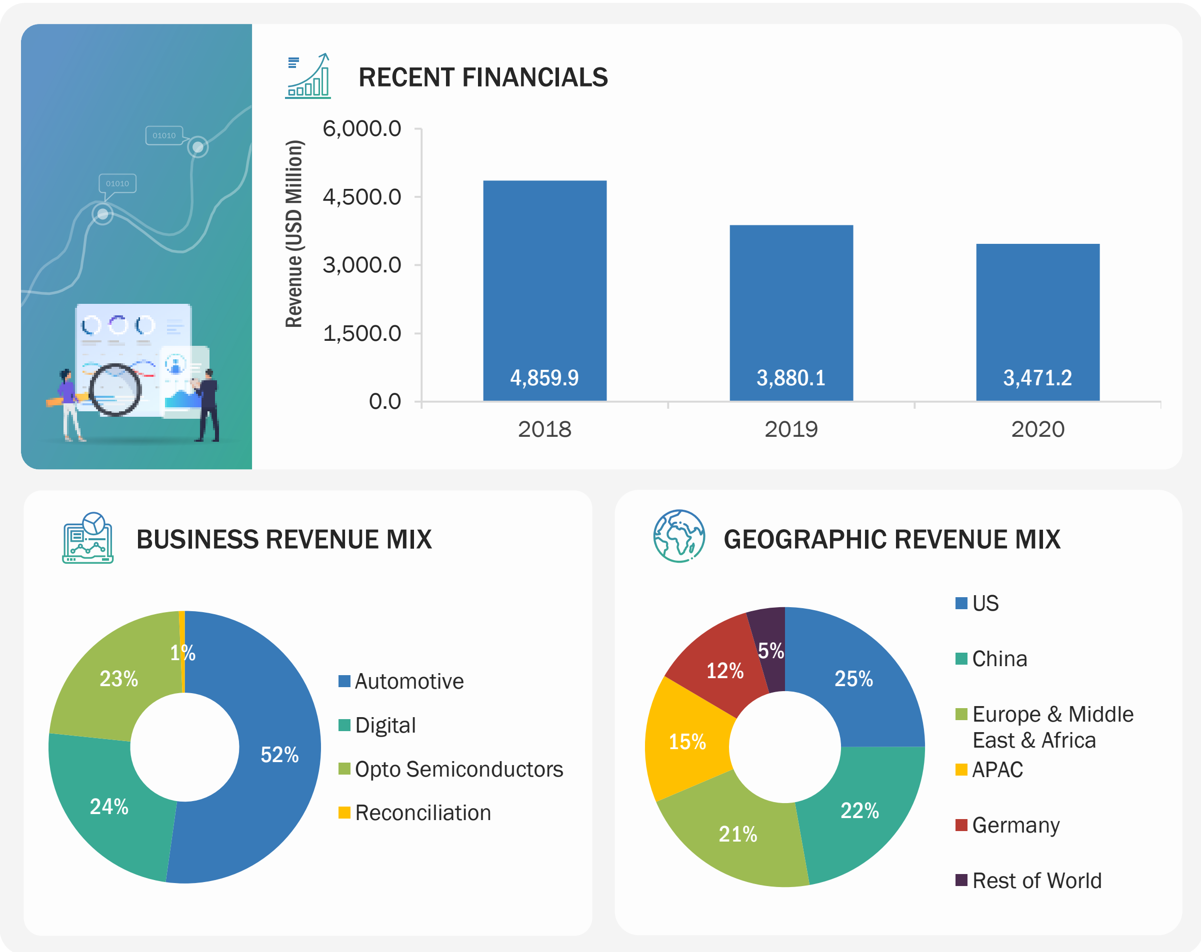
OSRAM Licht AG is engaged in the manufacturing and sale of lighting products. It operates through the following segments: opto semiconductors, automotive, and digital. The opto semiconductors segment offers light-emitting diodes in low, mid, high, and ultra-high-power classes for general lighting, automotive, consumer, and industrial applications, as well as infrared, laser, and optical sensors. The automotive segment develops, produces, and sells lamps, light modules, and sensors to original equipment manufacturers. The digital segment includes electronic components and lighting systems, hardware and software for high-performance light management, and Internet of Things solutions.

TABLE 125 OSRAM LICHT AG: BUSINESS OVERVIEW

Year Founded	2012
Country	Germany
City	Munich
Employee	26,000
Ownership	Private

Source: Company Website

FIGURE 58 OSRAM LICHT AG: COMPANY SNAPSHOT



Source: Company Website and MarketsandMarkets Analysis

12.1.4.2 Products and solutions

TABLE 126 OSRAM LICHT AG: PRODUCT OFFERED

PRODUCT TYPE	PRODUCT	DESCRIPTION/ APPLICATION
Rare earth metals recycling	Fluorescent lamps and discharge lamps	▪ The company recycles fluorescent lamps and discharge lamps which contain small amounts of mercury and valuable raw materials such as rare earths. ▪ LED lamps and luminaires also contain valuable raw materials as well as electronic components. The company recycles these lamps in accordance with the WEEE directive. ▪ EU Directive 2002/96/EC WEEE (Waste Electrical and Electronic Equipment) sets the framework for the collection and recycling of old lamps in Europe.

Source: Company Website

12.1.4.3 MnM view

12.1.4.3.1 Key strengths/right to win

OSRAM provides a diversified set of offerings through its three business divisions. It develops and produces lamps and lighting systems for the automotive sector, studio, stage and television (TV) applications, projection systems, as well as special lamps for industrial and medical applications. It also comprises luminaires and solutions business. This includes both the production and sale of luminaires and the design and implementation of solutions for internal and external lighting. The company's Opto Semiconductors segment manufactures optoelectronic semiconductors. The product portfolio includes both LEDs, which generate visible light for a wide range of lighting applications, and other opto semiconductors, which emit invisible light or receive incoming light and convert it into signals. Strategically balanced product portfolio and revenue streams enable the company to reach out to a wider customer base and tap opportunities in new and existing markets.

12.1.4.3.2 Strategic choice made

OSRAM's R&D efforts are focused primarily on advanced process technologies. Its R&D activities are principally directed toward the development and implementation of more advanced and lower-cost process technologies. The company's robust R&D capabilities allowed it to achieve significant milestones in recent times. The company focuses on the development of spectroscopy solutions for analyzing medicines and food and for determining skin parameters. It also intends to develop solutions to measure the levels of glucose, lactate, cholesterol, and urea. The company also introduced a digital health tool, a sensor-based COVID-19 rapid lateral flow test kit.

12.1.4.3.3 Weaknesses and competitive threats

OSRAM faces competition from a growing number of competitors with a strong brand image. Competition in the global market is based on a number of factors, including performance, innovation, product features, quality, cost, selling price, distribution, and financial incentives, such as cooperative advertising, marketing funds, sales incentives, and volume rebates. The company competes with Koninklijke Philips, Zumbotel, Lutron, Toshiba, Panasonic, and Delta Electronics in the digital systems segment. Increasing competition could lead to price wars, which in turn, could affect the market share of OSRAM.

12.1.5 ENERGY FUELS, INC.

12.1.5.1 Business overview

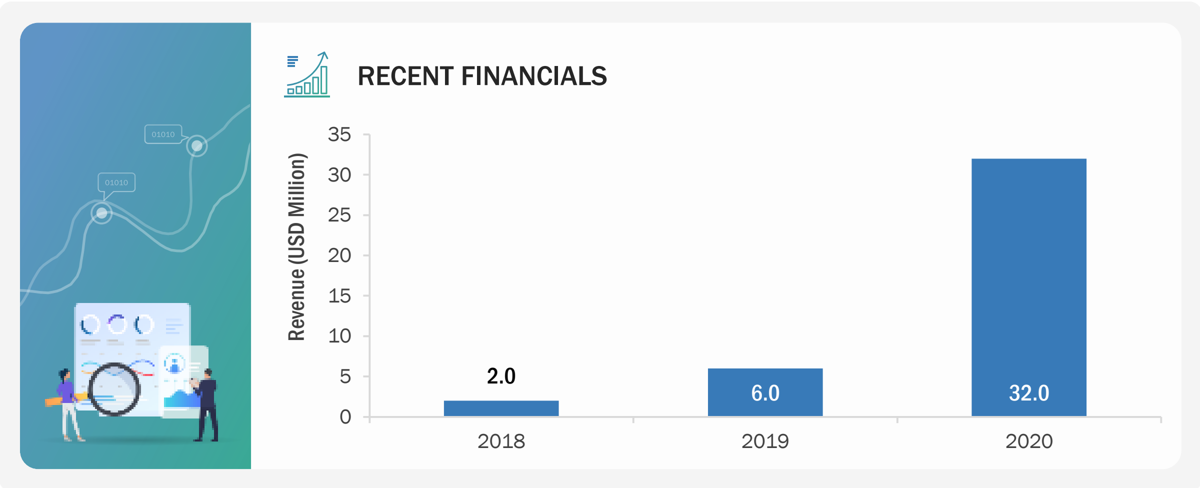
Energy Fuels is the leading producer of uranium in the US. Nuclear energy is expected to see strong growth in the coming years as nations around the world work to provide plentiful and affordable energy while combating climate change and air pollution. Energy Fuels is also a major producer of vanadium and is an emerging player in the commercial rare earth business. The company has diverse cash flow-generating opportunities, including vanadium production, uranium recycling, and rare earth processing. It holds three of America's key uranium production centers, The White Mesa Mill in Utah, the Nichols Ranch ISR Facility in Wyoming, and the Alta Mesa ISR Facility in Texas. Its White Mesa Mill is the only conventional uranium mill in the US and has a licensed capacity of approximately 8 million pounds of U3O8 per year. Nichols Ranch is in production and has a licensed capacity of approximately 2 million pounds of U3O8 per year. Alta Mesa is currently on standby. Energy Fuels also owns several licensed and developed uranium and vanadium mines on standby and other projects in development.

TABLE 127 ENERGY FUELS, INC.: BUSINESS OVERVIEW

Year Founded	1987
Country	US
City	Colorado
Employee	94
Ownership	Public

Source: Company Website

FIGURE 59 ENERGY FUELS, INC.: COMPANY SNAPSHOT



Source: Company Website and MarketsandMarkets Analysis

12.1.6 GLOBAL TUNGSTEN & POWDERS CORP.

12.1.6.1 Business overview

Global Tungsten & Powders is a supplier of tungsten and molybdenum powders, semi-finished parts, and solid oxide fuel cells (SOFC) components. The company produces ammonium paratungstate (APT), tungsten oxide, tungsten metal powder (WMP), tungsten carbide (WC), ready-to-press grade powder (RTP), thermal spray powders (TSP), moly powder, semi-finished parts, and components for the SOFC market. Global Tungsten & Powders Corp. has two manufacturing facilities in Europe. In the Czech Republic, the company produces tungsten metal powders and tungsten carbides, and in Finland, the company produces recycled tungsten carbide-cobalt powders using the zinc process. The company has been certified with ISO 9001:2015, ISO 17025:2017 and ISO 14001:2015. The company offers a wide range of tungsten recycling programs (chemical recycling, zinc reclaim, tolling). In addition, it also recycles and reuses key process materials such as hydrogen, ammonia, and water. The company serves various industries, such as aerospace, plastic, hard materials, automotive, energy, lighting, electronics, medical and power generation.

AERC. Inc. (AERC Recycling Solutions) partnered with Global Tungsten & Powders Corporation (GTP) for the recovery of rare earth metals from spent fluorescent lamps. This will help the company to solve some of the demand requirements for rare earth metals by extracting these materials from recycled fluorescent lamps. Through its partnership with AERC, Global Tungsten & Powders Corporation is helping to identify new sources of rare earth metals and creating a recovery process to utilize the materials in new products.

TABLE 128 GLOBAL TUNGSTEN & POWDERS CORP.: BUSINESS OVERVIEW

Year Founded	2008
Country	United States
City	Pennsylvania
Employee	830
Revenue	USD 239.15 Million
Ownership	Private

Source: Company Website

12.1.6.2 Products and solutions

TABLE 129 GLOBAL TUNGSTEN & POWDERS CORP.: PRODUCT OFFERED

PRODUCT TYPE	PRODUCT	DESCRIPTION/ APPLICATION
Tungsten and Tungsten Carbide	▪ Tungsten Powder ▪ Tungsten Carbide Powder	The company's tungsten and tungsten carbide powders offer purity and uniform particle size distribution. They are demanded by manufacturers of high-performance components. The powders range from ultra-fine to extra-coarse.
Tungsten Chemicals	▪ Ammonium Paratungstate (APT) ▪ Ammonium Metatungstate (AMT) ▪ Tungsten Oxide	These are manufactured from both secondary raw material (SRM or scrap) or virgin tungsten ore, including wolframite, hubnerite, and scheelite. These are used in numerous different sectors such as aerospace, electronics, hard materials, energy, and others.
Zinc Powders	▪ Zinc Reclaimed WC-Co Powders	Zinced powders are used in a wide range of industries such as tire studs, energy exploration, construction, automotive, and mining.

Source: Company Website

12.1.6.3 MnM view

The company has a strong portfolio of various chemicals, such as tungsten and molybdenum powders, semi-finished parts, and components. The company has a strong market in Europe and North America. The company stands to benefit from the growth of the global automotive and energy manufacturing sector. It collaborates with recycling companies, which has resulted in the development of new technologies. The company, in collaboration with AERC Recycling Solutions, extracts rare earth metals from fluorescent lamps and identifies new sources of rare earth metals.

12.1.7 REECYCLE INC.

12.1.7.1 Business overview

REEcycle Inc. uses a patented process to recover magnetic rare earth elements locked inside discarded scrap. From 2014 to 2016, REEcycle won top honors and national awards at business plan competitions hosted by many top universities. In late 2014, REEcycle won all three top prizes at the US Department of Energy's National Clean Energy Prize Competition. The company recycling process enables sustainable recovery of the highest amount of rare earth elements from electronic waste with low environmental impact. The company purchases disposed NdFeB magnets from recyclers. The source of these magnets is very broad, including wind turbines, electric vehicles and bikes, hard drives, MRI machines, and magnet swarf. The company recovers neodymium, dysprosium, praseodymium, and terbium.

TABLE 130 REECYCLE INC.: BUSINESS OVERVIEW

Year Founded	2013
Country	US
City	Texas
Ownership	Private

Source: Company Website

12.1.8 SEREN TECHNOLOGIES LIMITED

12.1.8.1 Business overview

Seren Technologies focuses mainly on the separation of rare earth metals. Seren has developed processes for the separation and recovery of rare earth metals from mining ore concentrates and waste permanent magnets. It has developed a toolkit of separation techniques and solvent systems incorporating both conventional organophosphorus extractants and ionic liquids (ILs) that can be combined and applied to different mixed rare earth feeds. Seren's processes will provide an efficient, non-hazardous, and economically viable means of recycling rare earths from magnets. Additionally, the processes and technology are applicable to the separation of rare earth metals from mining concentrates and could improve the efficiency and environmental footprint of current practices.

TABLE 131 SEREN TECHNOLOGIES LIMITED: BUSINESS OVERVIEW

Year Founded	2015
Country	Switzerland
City	Zug
Ownership	Private

Source: Company Website

12.1.9 ROCKLINK GMBH

12.1.9.1 Business overview

Rocklink is engaged in the trading of compounds and metals as well as recycling of rare earths, nickel, cobalt, lithium, and tungsten. The company indulges in the collection, processing, and trading of rare earth magnet and lithium-ion battery raw materials. The company's activities are divided into Fine Metals & Chemicals and Rare Metals Recycling. The Fine Metals & Chemicals division is involved in the distribution of rare earths, nickel, cobalt, manganese, and lithium compounds and metals. The products are manufactured by its affiliated companies as well as by selected manufacturers. The Rare Metals Recycling division focuses on the recycling of rare earths, nickel, and cobalt-containing waste and secondary raw materials as well as the trading of lithium-ion batteries for second-use applications. With a wide range of dismantling and treatment solutions for these material streams, the company creates access to untapped raw material sources and can allocate them to the optimal recycling route. Rocklink's recycling facilities are certified according to ISO 9001:2015 and ISO 14001:2015 standards and are regularly audited. Rocklink is a registered collector, trader, and broker of non-hazardous and hazardous waste in compliance with German and Dutch regulations.

TABLE 132 ROCKLINK GMBH: BUSINESS OVERVIEW

Year Founded	2016
Country	Germany
City	Düsseldorf
Ownership	Private

Source: Company Website

12.1.9.2 Products and solutions

TABLE 133 ROCKLINK GMBH: PRODUCT OFFERED

PRODUCT TYPE	PRODUCT	DESCRIPTION/ APPLICATION
Magnet Recycling	▪ (NdFeB) Neodymium-Iron-Boron, sintered ▪ (NdFeB) Neodymium-Iron-Boron, hybrid ▪ (SmCo) Samarium-Cobalt, sintered ▪ (AlNiCo) Aluminum-Nickel-Cobalt, sintered and cast	Recycling solutions for separated magnets as well as for assemblies containing NdFeB, SmCo, and AlNiCo magnets
Battery Recycling	▪ Cells and Systems ▪ Shredded Fractions ▪ Cathodes: Scrap and Granules ▪ Anodes: Scrap and Granules ▪ Black Mass and Cathode Slurry	Recycling solutions for active systems and cells; company offers comprehensive concepts for efficient economic and ecological recycling of non-ferrous metal waste from battery cell manufacturing

Source: Company Website

12.1.10 CLEAN EARTH INC.

12.1.10.1 Business overview

Clean Earth is a provider of environmental and regulated waste management services. The company offers remediation, disposal, recycling, and beneficial reuse solutions for contaminated soil, dredged material, and hazardous and non-hazardous waste. Its portfolio of technologies and services is used by multiple industries such as energy, infrastructure, commercial, industrial, retail, and healthcare. The company is capable of providing a one-source, full-service solution to handle multiple waste streams from a single customer. Clean Earth (formerly AERC) offers an integrated strategy that allows its clients to reduce the amount of waste produced, implements best practices for handling waste on-site, and provides a full range of treatment options. It owns and operates electronics processing facilities in four separate geographic locations. Each Clean Earth electronics processing facility has the distinct industry designation of being an R2/RIOS Certified Electronics Recycler™ facility and has been independently certified to achieve these industry designations. These facilities are in Allentown, PA, Richmond, VA, West Melbourne, FL, Modesto, CA, and Hayward, CA, in the US.

Each Clean Earth facility is fully EPA-approved and complies with all state & federal EPA, OSHA, and DOT Regulations.

TABLE 134 CLEAN EARTH INC.: BUSINESS OVERVIEW

Year Founded	1990
Country	US
City	Pennsylvania
Ownership	Private

Source: Company Website

12.2 OTHER COMPANIES

12.2.1 GEOMEGA RESOURCES INC.

TABLE 135 GEOMEGA RESOURCES INC.: BUSINESS OVERVIEW

Founded	2008
City	Québec
Country	Canada
Ownership	Public
Business Overview	The company develops technologies for the extraction and separation of rare earth metals and other critical metals vital for a sustainable future. The company has focus on renewable energies, vehicle electrification, automation, and reduction in energy usage. Rare earth magnets or neo-magnets (NdFeB) are at the center of all these technologies. Geomega has adopted a consistent approach to reduce the environmental impact and is contributing to lower greenhouse gas emissions by recycling the major reagents in the process. The company's core project is based around ISR Technology (Innord's Separation of Rare Earths), which is a proprietary, economical, environmentally friendly way to tap into the global market to recycle magnet production waste and end-of-life magnets profitably & safely.
Products/Solutions/ Services Offered	Rare earth metals recycling, extraction of critical metals, bauxite residues processing
Geographical Presence	North America

12.2.2 TAIYUAN CHEMICAL INDUSTRY GROUP CO. LTD.

TABLE 136 TAIYUAN CHEMICAL INDUSTRY GROUP CO. LTD.: BUSINESS OVERVIEW

Founded	1992
City	Taiyuan
Country	China
Ownership	Private
Business Overview	Taiyuan Chemical Industry Group Co. Ltd. specializes in the development, production, and sale of chemical products and raw materials. The company offers fertilizers, coke, and biochemical products. The business of the company is spread over 80 countries, with around 200 clients from Asia, Africa, Europe, and South and North America.
Products/Solutions/ Services Offered	Chemical products
Geographical Presence	Asia Pacific, Africa, Europe, South and North America

12.2.3 GUANGSHENG NONFERROUS METALS CO., LTD.

TABLE 137 GUANGSHENG NONFERROUS METALS CO., LTD.: BUSINESS OVERVIEW

Founded	1992
City	Guangzhou
Country	China
Ownership	Public
Business Overview	The company engages in mining beneficiation, smelting and separation, intensive processing, application of scientific research, and trade of rare earth tungsten. It is also engaged in the development of rare earth high-tech industries, such as rare earth permanent magnet, hydrogen storage, catalytic, luminescent, polishing, and functional materials. The company also offers products such as nickel-hydrogen batteries, automobile exhaust purification, rare earth energy-saving lamps, and rare earth functional ceramics which use rare earth materials.
Products/Solutions/ Services Offered	Tungsten and related products, rare earth metals and related products
Geographical Presence	Asia Pacific, Europe, and North America

12.2.4 CHENZHOU CITY JINGUI SILVER INDUSTRY CO., LTD.

TABLE 138 CHENZHOU CITY JINGUI SILVER INDUSTRY CO., LTD.: BUSINESS OVERVIEW

Founded	2004
City	Chenzhou
Country	China
Ownership	Public
Business Overview	The company is primarily engaged in the non-ferrous metal smelting business. It operates its businesses by recycling non-ferrous metals from lead concentrate and waste residue and waste liquid of lead smelting processes, such as gold, bismuth, antimony, zinc, copper, and indium. The company's main business is silver smelting and deep processing. Its main products consist of silver, electrolytic lead, gold, sulfuric acid, and secondary zinc oxide, among others. The company is also involved in the non-ferrous metal and mine product trading business. It distributes its products to the domestic and overseas markets.
Products/Solutions/ Services Offered	Electrolytic lead and high-purity silver, high-purity silver nitrate, nano-antibacterial agent, electrolytic zinc, high-purity indium, high-purity bismuth, silver tin oxide composite powder, silver plating bone plate, tellurium ingot, lead ingot, and silver plating
Geographical Presence	Asia Pacific

12.2.5 LYNAS RARE EARTHS, LTD.

TABLE 139 LYNAS RARE EARTHS, LTD.: BUSINESS OVERVIEW

Founded	1983
City	Perth
Country	Australia
Ownership	Public
Business Overview	Lynas Rare Earths Limited is engaged in the extraction and processing of rare earth minerals, primarily in Australia and Malaysia, along with the development of rare earth deposits. Lynas operates a processing plant in Malaysia, where it produces rare earth materials for export to manufacturing markets in Asia, Europe, and the US. The company's subsidiaries include Lynas Malaysia Sdn Bhd, Lynas Services Pty Ltd., Mount Weld Holdings Pty Ltd., Mount Weld Mining Pty Ltd., and Lynas Kalgoorlie Pty Ltd.
Products/Solutions/ Services Offered	Neodymium and Praseodymium (NdPr), Lanthanum (La), Cerium (Ce), and Mixed Heavy Rare Earths (SEG)
Geographical Presence	Asia Pacific, Europe, North America

12.2.6 ARAFURA RESOURCES LTD.

TABLE 140 ARAFURA RESOURCES LTD.: BUSINESS OVERVIEW

Founded	1997
City	Perth
Country	Australia
Ownership	Public
Business Overview	Arafura Resources Ltd. is engaged in the exploration and development of rare earths. The firm's projects include the Nolans and Exploration. Its main products include rare earths, phosphate, gold, nickel, and vanadium. The company's flagship project is the Nolans Rare Earths Project located in Australia's Northern Territory. The Nolans Project will encompass a mine, process plant (comprising beneficiation, extraction, and separation plants), and related infrastructure. The project's cornerstone asset is the Nolans Bore rare earths-phosphate-uranium-thorium (REE-P-U-Th) deposit.
Products/Solutions/ Services Offered	Neodymium-Praseodymium (NdPr) oxide and mixed middle-heavy rare earths (SEG/HRE) oxide
Geographical Presence	Asia Pacific

12.2.7 QINGDAO HUICHENG ENVIRONMENTAL TECHNOLOGY CO., LTD.

TABLE 141 QINGDAO HUICHENG ENVIRONMENTAL TECHNOLOGY CO., LTD.: BUSINESS OVERVIEW

Founded	2006
City	Qingdao
Country	China
Ownership	Public
Business Overview	Qingdao Huicheng Environmental Technology Co., Ltd. engages in the provision of waste catalyst treatment and disposal services. It specializes in hazardous waste treatment and disposal services for the petrochemical industry and recycling hazardous wastes. Its products include FCC catalyst, zeolite, and FCC additives.
Products/Solutions/ Services Offered	Fluid Catalytic Cracking Catalysts (FCCs), Zeolite and FCC additives
Geographical Presence	Asia Pacific

12.2.8 MITSUBISHI ELECTRIC CORPORATION

TABLE 142 MITSUBISHI ELECTRIC CORPORATION: BUSINESS OVERVIEW

Founded	1921
City	Tokyo
Country	Japan
Ownership	Public
Business Overview	Mitsubishi Electric Corporation is engaged in the manufacturing, development, and sale of electric and electronic equipment. It operates under the following business segments: Energy and Electric Systems, Industrial Automation Systems, Information and Communication Systems, Electronic Devices, Home Appliances, and Others. The Energy and Electric Systems segment offers power and transportation systems, elevators, escalators, and supervisory control systems. The Industrial Automation Systems segment covers industrial automation products and systems, measurement and control systems, automotive and electronic products, and car multimedia systems. The Information and Communication Systems segment includes wireless, closed-circuit television, space, satellite communication systems, antennas, radar devices, and information communications network systems. The Electronic Devices segment provides power, high-frequency systems, optical devices, and liquid crystal displays. The Home Appliances segment covers air-conditioning and photovoltaic power generation systems, televisions, recorders, and players. The Others segment comprises material procurement, logistics, real estate, advertising, and financial services. The company is engaged in the development of recycling technology for the recovery of rare earth metals from motors of scrapped vehicles, laptops, computers, and air conditioners.
Products/Solutions/Services Offered	Air conditioning systems, home products, building systems, information and communications systems, factory automation systems, energy systems, semiconductors and devices, transportation systems, automotive equipment, visual information systems, space systems, and public systems
Geographical Presence	Asia Pacific, Europe, North America, and Middle East & Africa

12.2.9 JIANGSU HUAHONG TECHNOLOGY STOCK CO., LTD.

TABLE 143 JIANGSU HUAHONG TECHNOLOGY STOCK CO., LTD.: BUSINESS OVERVIEW

Founded	2004
City	Jiangsu
Country	China
Ownership	Public
Business Overview	Jiangsu Huahong Technology Stock Co., Ltd. is engaged in the manufacture and sale of processing equipment for recycling resources and escalator components. It manufactures scrap metal baler, shear, scrap metal shredder, waste automotive dismantling equipment, non-metal baler, compressor, and a comprehensive line of equipment for recycling household garbage. The products are used in the National Circular Economy Park, National Urban Renewable Resource Base, Steel and Nonferrous Metal Enterprise, Waste Steel Processing Center (Base), and Household Garbage Processing Center. The company officially implemented NdFeB production and processing recycling material in October 2021, which standardized the industry standard of recycling material, along with the regulations of rare earth management.
Products/Solutions/ Services Offered	Waste treatment products and disposal machinery
Geographical Presence	Asia Pacific

12.2.10 SHOWA DENKO K.K.

TABLE 144 SHOWA DENKO K.K.: BUSINESS OVERVIEW

Founded	1939
City	Tokyo
Country	Japan
Ownership	Public
Business Overview	Showa Denko K.K. is engaged in the manufacture and sale of chemical products. It operates through the following segments, Petrochemicals, Chemicals, Electronics, Inorganics, Aluminum, and Others. The Petrochemicals segment produces and merchandises olefins, organic chemicals, and synthetic resin products. The Chemicals segment manufactures and sells functional polymers, industrial gases, basic chemicals, information electronic chemicals, and coating materials. The Electronics segment covers hard disks, silicon carbide epitaxial wafers, compound semiconductors, and lithium-ion battery materials. The Inorganics segment deals with graphite electrodes and ceramics. The Aluminum segment manufactures and sells high-purity aluminum foil for capacitors, cylinders for laser beam printers, extruded and forged products, heat exchangers, and beverage cans. The Others segment deals with wholesale and building materials. The company's Vietnam subsidiary processes raw materials and recycles magnets purchased from various sources inside and outside Vietnam. The plant uses proprietary processing technologies while adopting efficient effluent treatment and other environmental protection measures.
Products/Solutions/ Services Offered	Petrochemicals, chemicals, electronics, inorganics, aluminum, and others
Geographical Presence	Asia Pacific

12.2.11 HYPROMAG LTD.

TABLE 145 HYPROMAG LTD.: BUSINESS OVERVIEW

Founded	2018
City	Birmingham
Country	UK
Ownership	Private
Business Overview	The company has a full recycling supply chain for rare earth magnets based on neodymium iron boron (NdFeB). Hypromag has licensed the patented technology called HPMS (Hydrogen Processing of Magnet Scrap) developed in the Magnetic Materials Group (MMG) at the University of Birmingham. The company's strategy is supported by 25% shareholder Maginito Limited, a subsidiary of Mkango Resources and technology metals investor Talaxis Limited. This patent and related intellectual property are at the core of HyProMag. HPMS is a hydrogen-based process that is used to extract NdFeB magnets from electrical products such as hard disk drives. The extracted NdFeB powder is in the form of an alloy that can be re-processed into different forms, which can be sold back into the supply chain for rare earth magnets. HyProMag is also a partner in the Innovate UK funded project, "Rare-Earth Recycling for E-Machines" ("RaRE"), together with the University of Birmingham, Advanced Electric Machines Research Limited, Bentley Motors Limited, Intelligent Lifecycle Solutions Limited, and Unipart Powertrain Applications Limited, which will establish an end-to-end supply chain to incorporate recycled rare earth magnets into electric vehicles.
Products/Solutions/ Services Offered	NdFeB alloy powder
Geographical Presence	Europe

12.2.12 OKON METALS, INC.

TABLE 146 OKON METALS, INC.: BUSINESS OVERVIEW

Founded	1992
City	Texas
Country	US
Ownership	Private
Business Overview	The company majorly recycles neodymium magnets along with other rare earth metals. Okon Metals recycles millions of pounds of ferrous and non-ferrous metals each month. The company offers customized recycling services and has a 20-acre modernized, concreted facility that is specifically designed to deliver community recycling services.
Products/Solutions/ Services Offered	Scrap metal container services, utility recycling, waste hauling, MRI magnet decommissioning/recycling, chiller & AC recycling, rare earth/neodymium magnet recycling, oil, gas & energy recycling, and wind turbine recycling
Geographical Presence	North America

12.2.13 URBAN MINING COMPANY

TABLE 147 URBAN MINING COMPANY: BUSINESS OVERVIEW

Founded	2014
City	Texas
Country	US
Ownership	Private
Business Overview	Urban Mining Company delivers Nd-Fe-B rare earth magnet products to end-users. The company uses alternative raw materials and waste magnetic material to support the manufacturing of rare earth permanent magnets. Urban Mining Company sources Nd-Fe-B materials from end-of-life channels and industrial reverse-logistics networks, including motor assemblies, medical devices, data storage, direct-drive wind-turbine assemblies, and other equipment that contains Nd-Fe-B material. The company's M2M® technology utilizes waste or recycled magnetic material to support its Nd-Fe-B magnet manufacturing process. The GBE® technology uses proprietary alloys to produce magnets with higher magnetic performance in terms of coercivity (iHc) and overall energy product (BHmax). The company's value chain consists of preparing raw materials to build finished magnet assemblies. It operates all the steps within the magnet value chain internally.
Products/Solutions/ Services Offered	Nd-Fe-B magnets and sintered Nd-Fe-B magnets
Geographical Presence	North America

12.2.14 AMERICAN RARE EARTH LLC

TABLE 148 AMERICAN RARE EARTH LLC.: BUSINESS OVERVIEW

Founded	2017
City	Indiana
Country	US
Ownership	Private
Business Overview	American Rare Earth is a subsidiary of American Resources Corporation. The company utilizes high-value technology for the isolation and purification of rare earth and battery metals. The company captures end-of-life products (windmill generators, electric vehicle motors, lithium-ion batteries/black mass, and carbon-based deposit feedstocks), then digests them into a salt and separates displacement chromatography to isolate and purify the individual elements at 99%+ purity. The company is currently in the design phase of its commercial facility (magnitude of 10 to 20x current facility) that will operate up to 12 production trains to isolate and purify rare earth elements and battery metals from a multitude of feedstocks, capable of producing over 3.0 million kilograms of rare earth and critical elements. Its first facility is in the final stages of completion and is capable of generating more than USD 5 million of revenues, producing 56,000 kilograms of 99%+ purity of sellable rare earth elements and battery metals. American Rare Earth developed its innovative and scalable “Capture-Process-Purify” process chain in conjunction with its licensed intellectual property, including 16 patents and technologies and sponsored research partnerships with three leading universities to support the domestic supply chain’s growing demand for magnet and battery metals.
Products/Solutions/ Services Offered	Recycling (rare earth permanent magnets and lithium-ion batteries)
Geographical Presence	North America

12.2.15 REMRETECH GMBH

TABLE 149 REMRETECH GMBH: BUSINESS OVERVIEW

Founded	2021
City	Brugg
Country	Switzerland
Ownership	Private
Business Overview	The company recycles rare earth metals from e-waste. REMRETEch uses the solution chemistry approach to solve the problem of complexity of e-waste management and supply criticality of rare earth metals. The specific f-elements chemistry of these hard metals has been tuned in such a way that its open pot process can handle different feedstocks and produce >99% purity for individual rare earth metals.
Products/Solutions/ Services Offered	Recycling rare earth metals, urban mining, and waste management
Geographical Presence	Europe

13 APPENDIX

13.1 DISCUSSION GUIDE

Q. 1. **Please share your views on the growth prospects of the global rare earth metals recycling market. What is the current scenario, and how is it expected to change in the future?**

Primary source's viewpoint: ____

Q. 2. **What are the drivers, challenges, and opportunities that influence the growth of the rare earth metals recycling market?**

Primary source's viewpoint: ____

Q. 3. **What are the factors inhibiting the growth of the rare earth metals recycling market?**

Primary source's viewpoint: ____

Q. 4. **Could you please quantify the market size for rare earth metals recycling at the global level (in terms of volume and value)? Also, please mention CAGRs, in terms of volume and value, for the global rare earth metals recycling market.**

MARKET SIZE (2020)	CAGR (2021–2026)
Value: USD _____Million	
Volume: ___ Metric Tons	

Q. 5. **What would be the projected growth rate (CAGR) for the global rare earth metals recycling market in the next five years (2021–2026)?**

Primary source's viewpoint: ____

Q. 6. **Please provide your estimates on the market share and the CAGRs of the following regions in the rare earth metals recycling market.**

REGION	MARKET SHARE, 2020	CAGR (2021–2026)
North America		
Europe		
Asia Pacific		
Rest of World		

Q. 7. **What are the percentage contribution and the CAGRs of the following applications of rare earth metals recycling, and what were their respective shares in 2020? Please validate and notify if any specific application is missing.**

APPLICATION	MARKET SHARE, 2020	CAGR (2021–2026)
Alloy		
Catalyst		
Permanent magnets		
Glass		
Ceramics		
Phosphor		
Polishing materials		
Hydrogen storage alloys		

Q. 8. **What are the percentage contribution and the CAGRs of the following sources of rare earth metals recycling, and what were their respective shares in 2020? Please validate and notify if any specific source is missing.**

SOURCE	MARKET SHARE, 2020	CAGR (2021–2026)
FCC		
Fluorescent lamps		
Magnets		
Batteries		
Industrial process		

Q. 9. **What are the various technologies for rare earth metals recycling? Could you please provide the percentage contribution and the CAGRs for the below-mentioned technologies?**

TECHNOLOGY	MARKET SHARE, 2020	CAGR (2021–2026)
Hydrometallurgical		
Pyrometallurgical		

Q. 10. **What are the upcoming technologies/product areas that will have a significant impact on the rare earth metals recycling market?**

Primary source's viewpoint: ____

Q. 11. What are the major trends evident in the global rare earth metals recycling market?

Primary source's viewpoint: ____

Q. 12. Please name some of the key players in rare earth metals recycling and their respective market shares.

KEY PLAYERS	MARKET SHARE, 2020

Q. 13. Please provide your insights on rare earth metals recycling in different countries/regions? Please notify if any key country/region for this market is missing.

COUNTRY/REGION	MARKET SIZE (USD MILLION), 2020
US	
Mexico	
Canada	
Germany	
UK	
France	
Russia	
China	
India	
Japan	
Australia	
Brazil	
Argentina	

13.2 KNOWLEDGE STORE: MARKETSANDMARKETS' SUBSCRIPTION PORTAL

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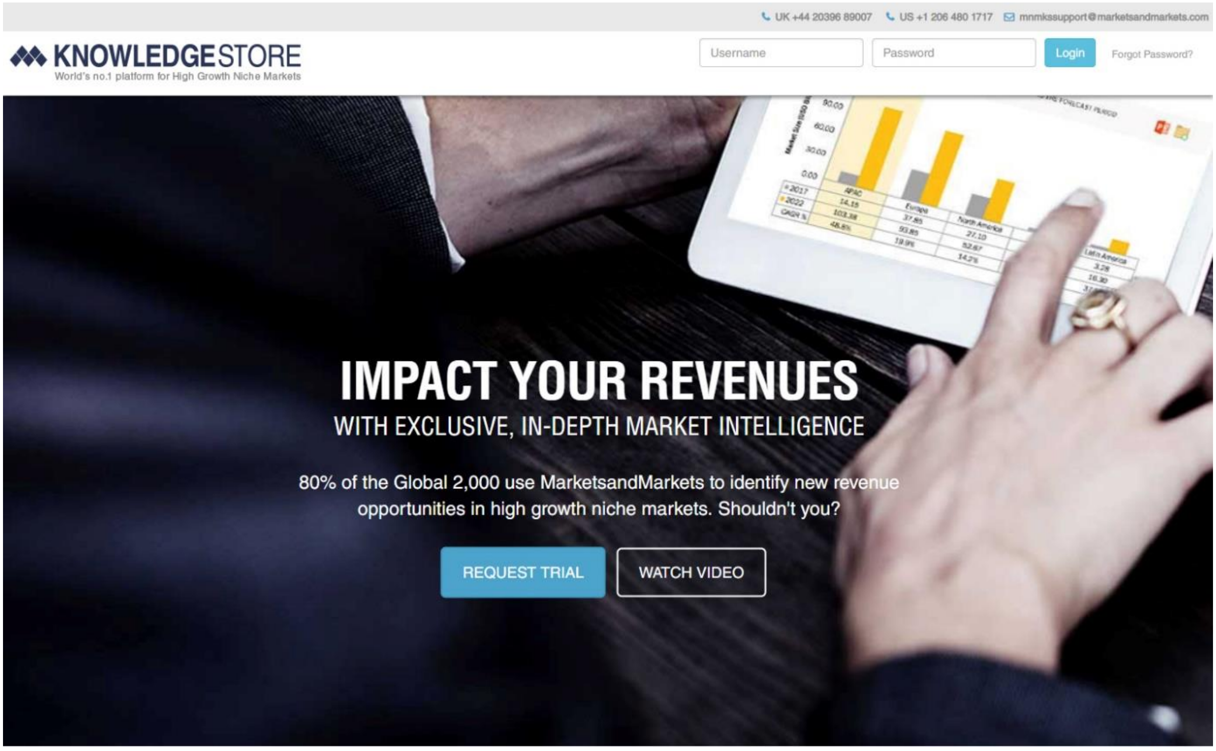

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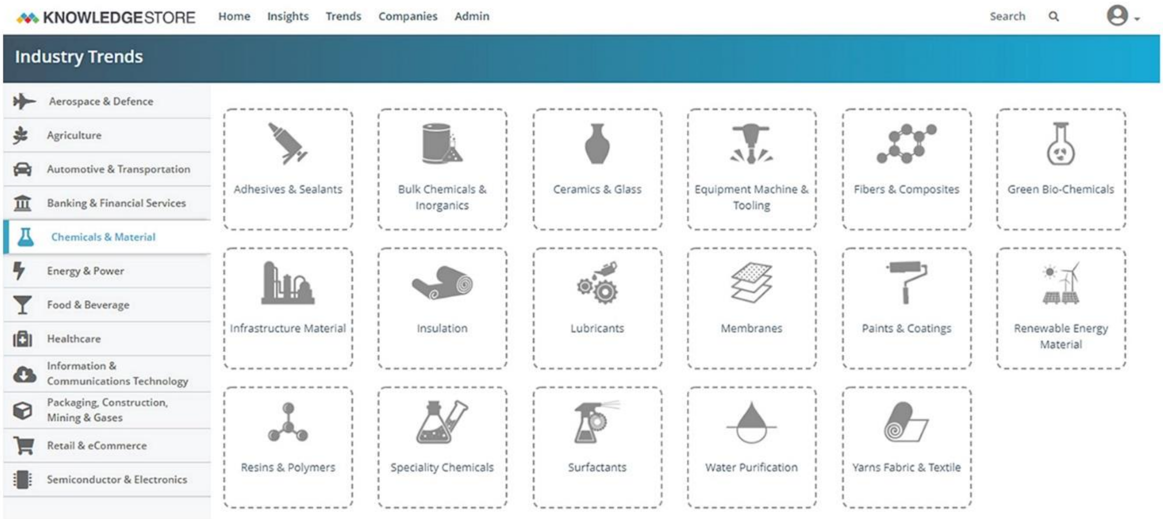

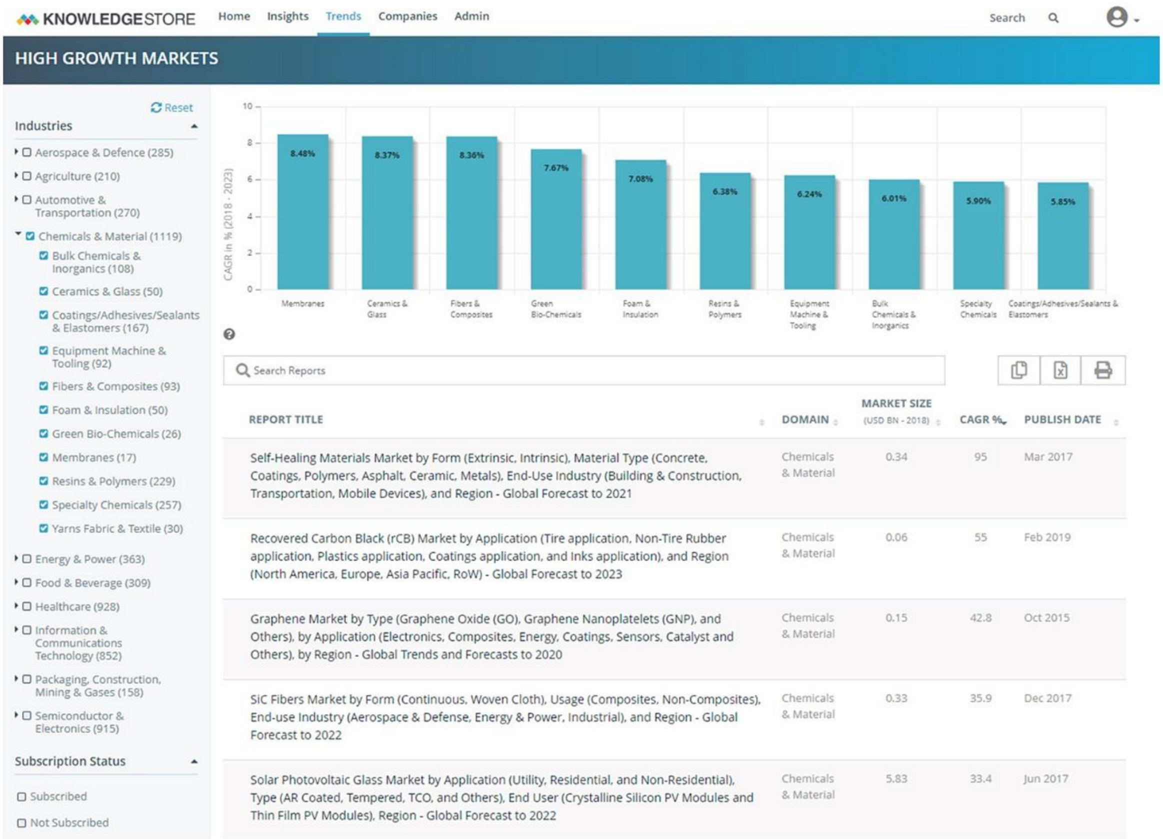

13.3 AVAILABLE CUSTOMIZATIONS

Along with the market data, MarketsandMarkets offers customizations according to client-specific needs. The following customization options are available for the report:

PRODUCT ANALYSIS

- Product matrix, which provides a detailed comparison of the market for different rare earth metals recycling

GEOGRAPHIC ANALYSIS

- A further breakdown of the rare earth metals recycling market for additional countries

COMPANY INFORMATION

- Detailed analysis and profiling of additional market players (up to five)

13.4 RELATED REPORTS

SR. NO.	REPORT TITLE	PUBLISHED DATE
1	**PERMANENT MAGNET MARKET – GLOBAL FORECAST TO 2021** By Type (Neodymium Iron Boron Magnet, Ferrite Magnet, Samarium Cobalt Magnet), End-Use Industry (Consumer Electronics, General Industrial, Automotive, Medical Technology, Environment & Energy) https://www.marketsandmarkets.com/Market-Reports/permanent-magnet-market-806.html	March 2017
2	**AUTOMOTIVE CATALYST MARKET– GLOBAL FORECAST TO 2023** By Type (Platinum, Palladium and Rhodium), Vehicle Type (Light-Duty Vehicles, Heavy-Duty Vehicles), and region (North America, APAC, Europe, South America, and Middle East & Africa) https://www.marketsandmarkets.com/Market-Reports/automotive-catalyst-market-96120211.html	August 2018

13.5 AUTHOR DETAILS

Lakshmi Narayanan
AVP
– Chemicals and Materials

A technically proficient and result-driven professional with over 15 years of experience and has been associated on key roles with firms like IPCL, Anabond Ltd., Frost & Sullivan, Bussetti Gmbh, and Jet Airways.

He holds rich experience in technology, market research experience in the Chemicals and Materials domain, and leads a global, cross-functional team of consultants for projects with major chemical companies with actionable insights. Most of the projects are in the sales & marketing, business development, and strategic planning and implementation functions; Key consulting projects undertaken are distribution channel optimization, new product development, new market entry strategy, pricing strategy, growth strategy, identification of acquisition targets, and due diligence of targets.

Dr. A.P. Joshi
Principal Consultant
– Chemicals and Materials

PhD in Chemical Technology with over 25 years of experience in bio-chemicals, specialist having a detailed knowledge of the broad spectrum of chemical products and material derivatives that can be produced from crude oil-based feedstocks. This expertise extends from the full range of feedstocks through to intermediaries – “platform” chemicals and the major end-use products: lubricants, plastics, solvents, surfactants and coatings.

Designed and executed many market research projects in the chemicals vertical, including coatings for leading industry players. He has authored over 100 techno-commercial papers on a variety of chemicals and related industries. He has a strong hold on automotive refinish, packaging, can and coil, packaging and marine coatings

He provides an objective analysis of the full value chain of the bio-chemical industry in different parts of the world. He helps clients plan effectively and successfully to identify and seize opportunities and to pre-empt threats.

Contributors

Dinesh Venkatesan
Research Manager

Akash Gupta
Senior Research Associate

Neha Singh Thakur
Senior Research Associate

For information regarding permission, contact:
Tel: +1-888-600-6441