MARKETSANDMARKETS™

RARE-EARTH METALS MARKET

GLOBAL FORECAST TO 2026

BY TYPE (LANTHANUM, CERIUM, NEODYMIUM, PRASEODYMIUM, SAMARIUM, EUROPIUM, & OTHERS), AND APPLICATION (PERMANENT MAGNETS, METALS ALLOYS, POLISHING, ADDITIVES, CATALYSTS, PHOSPHORS, & OTHERS)

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL FORM
APAC	Asia Pacific
AUTOCATS	Automotive Catalytic Converters
BEV	Battery Electric Vehicle
BTU	British Thermal Unit
CIO	Chief Information Officer
CNRS	National Center for Scientific Research
CO	Carbon Monoxide
EIT	European Institute of Innovation and Technology
EV	Electric Vehicle
FCC	Fluid Cracking Catalysts
HEV	Hybrid Electric Vehicle
MIIT	Ministry of Industry and Information Technology
MRI	Magnetic Resonance Imaging
MW	MegaWatt
NiMH	Nickel Metal Hydride
NIST	National Institute of Standards and Technology
ORNL	Oak Ridge National Laboratory
PHEV	Plug-in Hybrid Electric Vehicle
REE	Rare-Earth Element
REO	Rare Earth Oxide
RoW	Rest of the World
SmCo	Samarium-Cobalt
US	United States
USD	United States Dollar
WTO	World Trade Organization
µm	Micro Meter

1 INTRODUCTION

1.1 OBJECTIVES OF STUDY

- To define, describe, segment, and forecast the rare-earth metals market based on type, application, and region, in terms of value and volume
- To provide detailed information regarding the major factors influencing the growth of the market (drivers, restraints, opportunities, and challenges)
- To strategically analyze the rare-earth metals market with respect to individual growth trends, future expansions, and contribution of each segment to the market
- To analyze market opportunities for stakeholders and provide details of the competitive landscape for market leaders
- To forecast the growth of the rare-earth metals market with respect to four key regions—Asia Pacific (APAC), Europe, North America, and Rest of the World
- To strategically profile key players and comprehensively analyze their core competencies[1]
- To track and analyze competitive developments in the market, such as contract & agreement and joint ventures

1.2 MARKET DEFINITION

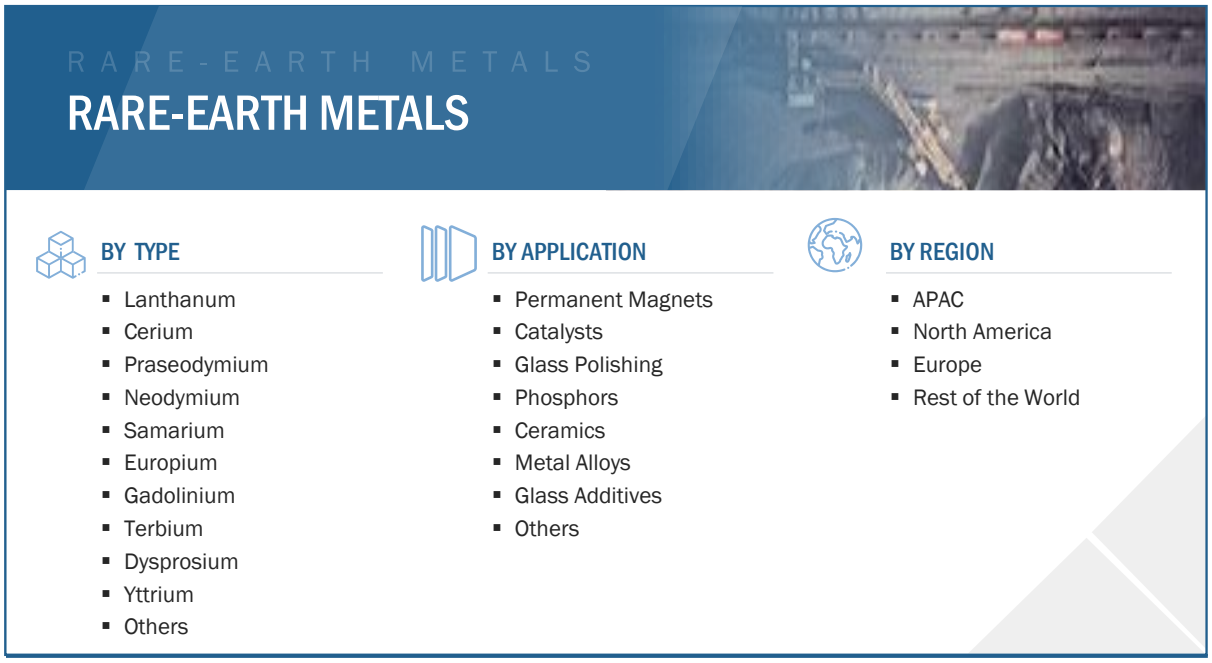
Rare-earth elements are a group of 17 chemical elements that occur together. The group consists of yttrium and the 15 lanthanide elements (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium). Scandium 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.

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

1.3 MARKET SCOPE

This report covers the rare-earth metals market, which is segmented based on type, application, and region.

FIGURE 1 RARE-EARTH METALS: MARKET SEGMENTATION



Source: Related Publications, Expert Interviews, and MarketsandMarkets Analysis

1.3.1 REGIONS COVERED

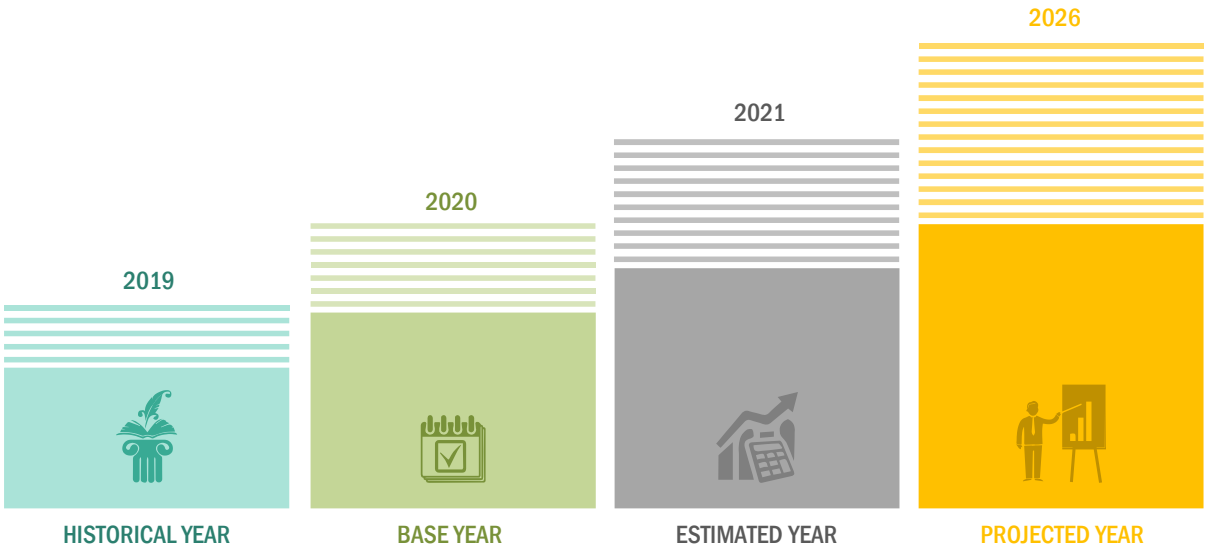
Notes: Rest of Europe includes Italy, Spain, Sweden, the Netherlands, Switzerland, and Poland.

Rest of APAC includes India, Australia, and Malaysia.

Rest of the World includes Argentina and the Middle East & African countries.

Source: Related Publications, Expert Interviews, and MarketsandMarkets Analysis

1.3.2 YEARS CONSIDERED FOR THE STUDY



Note: For company profiles where financials for the base year were not available, financials for the previous year were considered.

1.4 CURRENCY

- The currency used in the report is the United States dollar (USD), with the market size indicated in USD million/billion.
- Company revenues were obtained from company annual reports.
- The average annual currency conversion rate was used for companies that reported their revenue in their annual reports in currencies other than USD.

1.5 UNIT CONSIDERED

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

1.6 STAKEHOLDERS

- Raw material suppliers
- Rare-earth metal companies
- Manufacturers in end-use industries
- Rare-earth research and development (R&D) institutions
- Rare-earth metal associations
- Investment banks

1.7 LIMITATIONS

The quantitative information for some market segments is kept confidential by industry players. Hence, qualitative insights gathered during the period of the study were used to arrive at the market size for such segments.

1.8 SUMMARY OF CHANGES MADE IN THE REVAMPED VERSION

CHANGE	DESCRIPTION
Scope Of The Market	▪ Sub-segments are modified, based on secondary research and updated research analysis. ▪ The new edition of the report includes changes in the regional segments, where the market has been split into a country-level market segment by product type and application. Sub-segments have been modified based on the latest secondary research. The impact of COVID-19 on various countries and end-use industries has been considered while designing the market engineering process and forecasting the new edition of the rare-earth metals market report.
COVID-19 Impact	▪ The new version of the report includes an analysis of the impact of COVID-19 on the overall rear earth metals market.
Industry Trends	▪ In the new version of the report, the value chain and Porter's Five Forces analysis for the market have been added.
Competitive Leadership Mapping	▪ A competitive evaluation matrix is added wherein the players are categorized as star, emerging leaders, pervasive, and emerging companies. The top 20 manufacturers operating in the market have been evaluated in this section. The competitive landscape section studies the strength of product portfolio and business strategy excellence for the top 20 companies.
Company Profiles	▪ Company profiles provide a glimpse of the key players in the market with respect to business overviews, financials, product offerings, and recent developments. In this new edition of the report, the key players have been profiled based on recent agreements, joint ventures, and contracts ▪ Strategic developments have challenged the status quo of industry leaders, and it was prudent to analyze the changing business landscape. Therefore, companies have been studied for their current focus and strategies to stay competitive and their right to win in the market along with their winning imperatives.
New & Improved Representation of Financial Information	▪ The new edition of the report provides updated financial information till 2019 (depending on the availability) for each listed company in a graphical format in a single diagram. This is expected to help easily analyze the present status of profiled companies in terms of their financial strength, profitability, key revenue-generating regions/countries, segmental revenue, and business segment focus in terms of the highest revenue-generating segments.
Recent Market Developments	▪ Recent developments are helpful to know the market trends and growth strategies adopted by players in the market. In the new version of the report, updated developments are listed.
Latest Product Portfolio	▪ Tracking product portfolio helps analyze product offerings in the market. The new edition of the report provides an updated product portfolio of the profiled companies.

2 RESEARCH METHODOLOGY

2.1 RESEARCH DATA

This research involved extensive use of secondary sources and databases—such as press releases of companies, the Wall Street Journal, Rare Earth Association, the World Bank, Global Rare Earth Industry Association, Bloomberg, and Factiva—to identify and collect information useful for a technical and market-oriented study of the rare-earth metals market. The primary sources mainly involved industry experts from core & related industries and preferred suppliers, manufacturers, distributors, standards & certification organizations, and organizations related to all segments of the value chain in the market. In-depth interviews were conducted with various primary respondents—key industry participants, subject matter experts (SMEs), executives of key companies, and industry consultants—to obtain and verify critical qualitative and quantitative information as well as to assess growth prospects. The following is the methodology used for calculating the base year market size.

2.1.1 SECONDARY DATA

In the secondary research process, various secondary sources were referred to so as to identify and collect information. These secondary sources include company publications, press releases & investor presentations of companies, white papers, certified publications, articles by recognized authors, regulatory bodies, trade directories, and databases.

Secondary research was mainly used to obtain key information about the industry's supply chain, the total pool of key players, market classification & segmentation according to industry trends to the bottom-most level, and regional markets. It was also used to obtain information about the key developments from a market-oriented perspective.

2.1.1.1 Key data from secondary sources

PARAMETER	SOURCE
MARKET SIZE (Market Value)	▪ 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)	▪ Annual reports ▪ Company websites ▪ Public databases ▪ MarketsandMarkets data repository

2.1.2 PRIMARY DATA

Extensive primary research was conducted after acquiring information about the rare-earth metals market through secondary research. In the primary research process, experts from the supply and demand sides were interviewed to obtain qualitative and quantitative information and validate the data arrived at through secondary research. Several primary interviews were conducted with market experts from the demand (end-use industries) and supply (manufacturers and raw material suppliers) sides across the country. This primary data was collected through questionnaires, e-mails, and telephonic interviews.

2.1.2.1 Key data from primary sources

TYPE	PARAMETER	KEY DATA
REGIONAL SPLIT	▪ Regional segmentation of the rare-earth metals market ▪ CAGR of each region during the forecast period (2021-2026)	▪ Rare-earth metals market, by region – North America, Europe, APAC, Rest of the world
GLOBAL MARKET SIZE	▪ Market size for 2019 ▪ CAGR for the forecast period (2021-2026)	▪ Rare-earth metals market, in terms of value and volume
MARKET SPLIT	▪ Rare-earth metals market ○ By type ○ By application ○ By region	▪ Cerium oxide, lanthanum oxide, neodymium oxide, others ▪ Permanent magnets, metal alloys, catalysts, glass polishing, others ▪ North America, Europe, APAC, Rest of the World

2.2 MARKET SIZE ESTIMATION

2.2.1 APPROACH

Both bottom-up and top-down approaches were used to estimate the size of the rare-earth metals market, by type, application, and region.

The overall production, sales, and consumption data for different types of rare-earth metals was taken as a base. On the basis of this, the global market size of rare-earth metals was estimated, which was verified using primary research. Primary research includes interviews with key opinion leaders, such as CEOs, directors, industry experts (consultants), and marketing personnel.

The percentage shares for different applications and regions were identified by using primary research and analyzing different rare-earth metals market trends.

It also includes the calculation of the regional market size based on the consumption of rare-earth metals in every end-use industry in the regions.

The future market estimates for various regions, types, and applications, were derived by forecasting techniques based on rare-earth metals production and consumption trends, various other macro-economic factors, and company developments.

All USD million value tables were calculated by multiplying average yearly prices by volume.

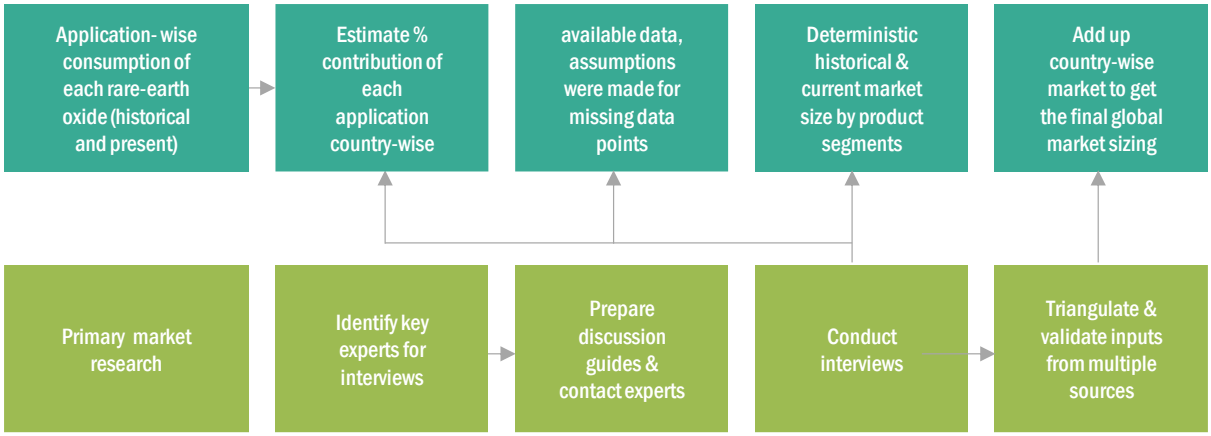
FIGURE 2 APPROACH (BOTTOM-UP)

- Total size of rare-earth metals market
- Summation of all rare-earth metals
- Summation of each rare-earth metal from all applications
- Consumption of different types of rare-earth metals, by application

FIGURE 3 APPROACH (TOP-DOWN)

- Global rare-earth metals market
- Regional split
- Country-wise split

FIGURE 4 METHODOLOGY FOR MARKET ESTIMATION



2.3 DATA TRIANGULATION

After arriving at the overall size of the rare-earth metals market from the estimation process explained above, the total market was split into several segments and subsegments. The data triangulation and market breakdown procedures were employed, 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. Along with this, the market size was validated using the bottom-up approach.

FIGURE 5 REAR-EARTH METALS MARKET: DATA TRIANGULATION

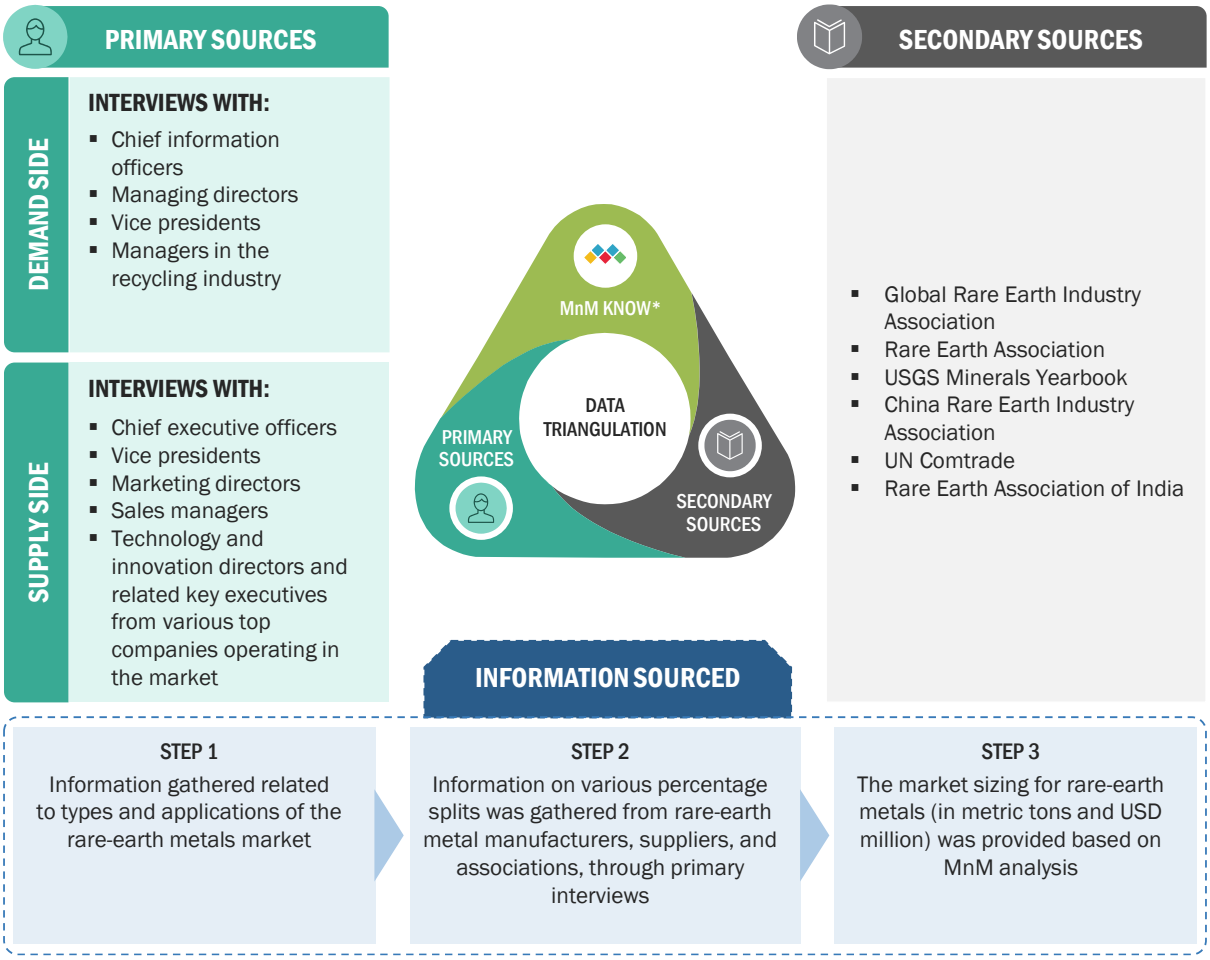


FIGURE 6 KEY MARKET INSIGHTS

Cerium oxide is the most widely-used rare-earth metals across several industries. While neodymium oxide has the highest value in the market due to high prices and volumes.

- General Manager
Arafura Resources Limited

Currently, majority of the demand for rare-earth metals is from China, followed by Japan, and US. Due to the vast manufacturing industry in China and support from the Chinese government, almost one-third of the total demand is from the country.

- General Manager
IREL (India)

I think the EV numbers are the dominant drivers, and the restraints would be the extent that substitute products can suffice (if rare-earth metal price spikes or China cuts supply). China is years ahead and strategically much longer-term thinking, so it will regulate what is best for its end game, and hinder Rest of the World's supply development in the process.

- Senior Advisor
Canada Rare Earth Corporation

The collaborations between several countries, including Japan, US, Australia, and Canada to reduce the reliance for rare-earth metals from China will not make very significant changes at least for the next 5-7 years. Currently, majority of the rare-earth metals being mined outside of China are still being sent to the country for processing. The collaborations might help to enhance the technical know-how, but it does not look very promising to me for reducing the dependence on China in the short-term.

- President & CEO
Canada Rare Earth Corporation

FIGURE 7 LIST OF STAKEHOLDERS INVOLVED AND BREAKDOWN OF PRIMARY INTERVIEWS

RARE-EARTH METAL MANUFACTURERS	RARE-EARTH METAL MANUFACTURERS	ASSOCIATIONS
Alkane Resources Limited	Northern Minerals	Global Rare Earth Industry Association
Arafura Resources Limited	China Minmetals Rare Earth Co, Ltd.	Rare Earth Association
Avalon Advanced Materials	Iluka Resources	China Rare Earth Industry Association
Baotou Hefa Rare Earth Co., Ltd.	Greenland Minerals	Rare Earth Association of India
Canada Rare Earth Corporation	Eutectix	
Lynas Corporation	American Rare Earths Limited	
Shin-Etsu Chemical Company		

2.4 RESEARCH ASSUMPTIONS & LIMITATIONS

2.4.1 ASSUMPTIONS

PARAMETER	ASSUMPTION
ECONOMIC STABILITY	▪ A positive economic climate has been assumed to continue in all the regions till 2025. ▪ Impact of COVID-19 has been considered for 2020 on the market.
EXCHANGE RATE	▪ The average USD exchange rate of countries has been considered for 2019. ▪ It has been assumed that the currency fluctuations would not be significant enough to affect the market projections to a notable extent.
PRICING TREND	▪ Inflation has not been considered for pricing. The values have been rounded-off at subsequent levels. ▪ Although prices have been different in countries, prices across countries within the same region have been considered based on material cost and workers' wages.
POLITICAL STABILITY	▪ A stable political environment has been assumed to prevail in key regions.

2.4.2 LIMITATIONS

PARAMETER	LIMITATION
PRIMARY INTERVIEWS, BY KEY PLAYER	▪ The quantitative information for some market segments is kept confidential by industry players. ▪ Qualitative insights gathered during the study have been used to arrive at the market size of such segments and subsegments.
PRIMARY INTERVIEWS, BY COUNTRY	▪ There are a limited number of industry experts in some countries. ▪ In such cases, the country-level market size was derived based on the weightage assigned to these markets through qualitative insights obtained from global industry experts.

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.

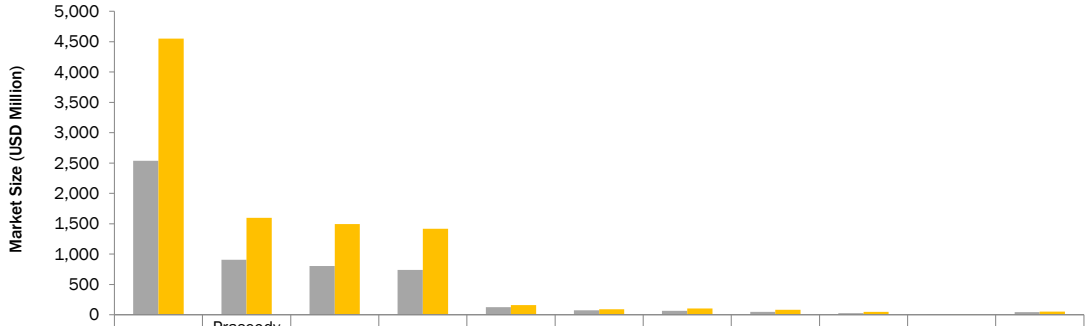
Rare-earth elements are all metals, and the group is often referred to as the "rare-earth metals." These metals have many similar properties, often causing them to be found together in geologic deposits. They are also referred to as "rare-earth oxides", as many of them are typically sold as oxide compounds.

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 market was valued at USD 5,366.84 million in 2021 and is projected to reach USD 9,600.22 million by 2026, at a CAGR of 12.33%, during the forecast period.

Increasing demand for rare-earth metals from the various end-use industries, especially in the APAC 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 markets. Rare earth elements are used in various applications that are further used in several end-use 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 and electric and hybrid vehicles.

FIGURE 8 NEODYMIUM OXIDE TYPE TO ACCOUNT FOR LARGEST MARKET SIZE



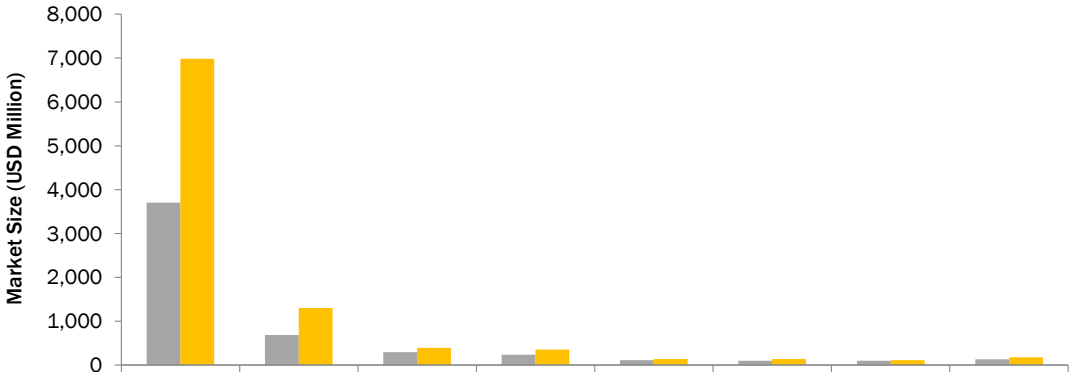
	Neodymium Oxide	Praseodymium Oxide	Dysprosium Oxide	Terbium Oxide	Cerium Oxide	Lanthanum Oxide	Yttrium Oxide	Gadolinium Oxide	Europium Oxide	Samarium Oxide	Others
2021	2,539.3	906.76	801.83	737.38	125.02	72.48	63.90	45.41	27.31	2.34	45.04
2026	4,552.1	1,598.3	1,496.1	1,415.5	159.61	92.08	101.59	82.40	46.07	3.21	53.00
CAGR (2021-2026)	12.38%	12.01%	13.29%	13.93%	5.01%	4.90%	9.72%	12.66%	11.02%	6.53%	3.31%

Note: Others include holmium, erbium, thulium, ytterbium, and lutetium.

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

The neodymium oxide segment accounted for a share of 47.30% of the overall market in 2020, in terms of value. Neodymium is used with praseodymium to create some of the strongest permanent magnets. This growth is attributed to the increasing adoption of permanent magnets in a lot of clean energy applications, including wind turbines, hybrid electric vehicles, and autocatalysts.

FIGURE 9 PERMANENT MAGNETS LEADS THE APPLICATION SEGMENT



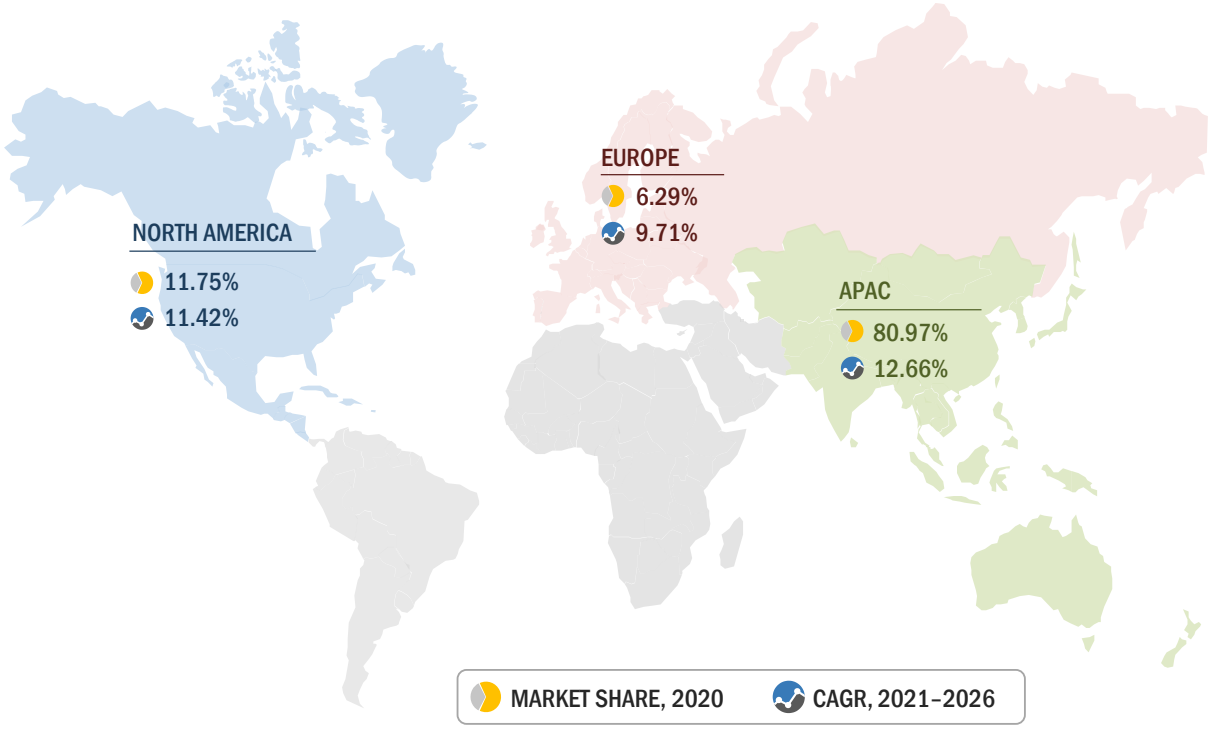
	Permanent Magnets	Phosphors	Metal Alloys	Ceramics	Catalysts	Glass Polishing	Glass Additives	Others
2021	3,704.36	688.29	293.97	238.14	112.44	101.06	97.77	130.81
2026	6,982.28	1,302.71	391.97	352.92	138.54	135.91	114.74	181.13
CAGR (2021-2026)	13.52%	13.61%	5.92%	8.19%	4.26%	6.11%	3.25%	6.73%

Note: Other applications include defense technologies and satellite power and communication systems.

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

The permanent magnets segment led the rare-earth metals market, by application, with a share of 27.10% of the overall market, in terms of volume, in 2020. The permanent segment is expected to grow at the CAGR of 13.52% from 2021 to 2026. The magnets made from neodymium, praseodymium, and dysprosium are the strongest known permanent magnets. The automotive industry is a significant demand driver for permanent magnets.

FIGURE 10 APAC TO GROW AT THE HIGHEST RATE IN THE RARE-EARTH METALS MARKET



Note: The share and CAGRs in the figure have been calculated in terms of value.

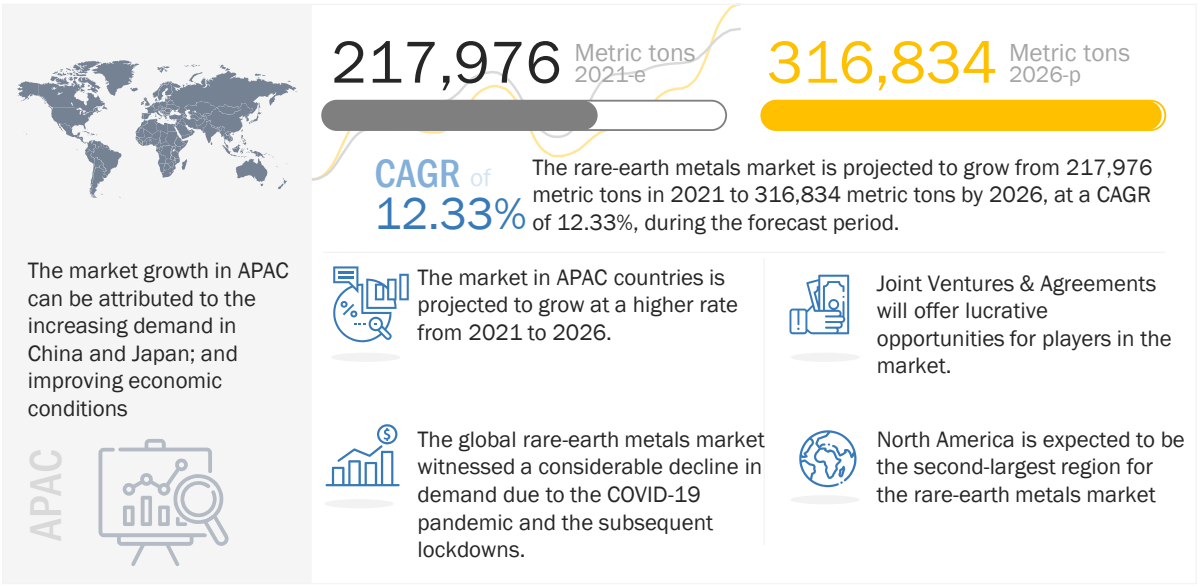
Source: Research Journals, Related Publications, Expert Interviews, and MarketsandMarkets Analysis

The APAC region is expected to account for the largest share of 80.97% of the rare-earth metals market in 2020. It is also expected to grow at the highest CAGR of 12.66% during the forecast period. The market in North America and Europe together accounted for a significant share of 18.04% of the global market in 2020, in terms of value. Growing industrialization and extraction activities in China and Japan are the major growth drivers of the market.

4 PREMIUM INSIGHTS

4.1 APAC TO WITNESS A HIGHER GROWTH RATE DUE TO HIGH GROWING DEMAND FOR SEVERAL APPLICATIONS

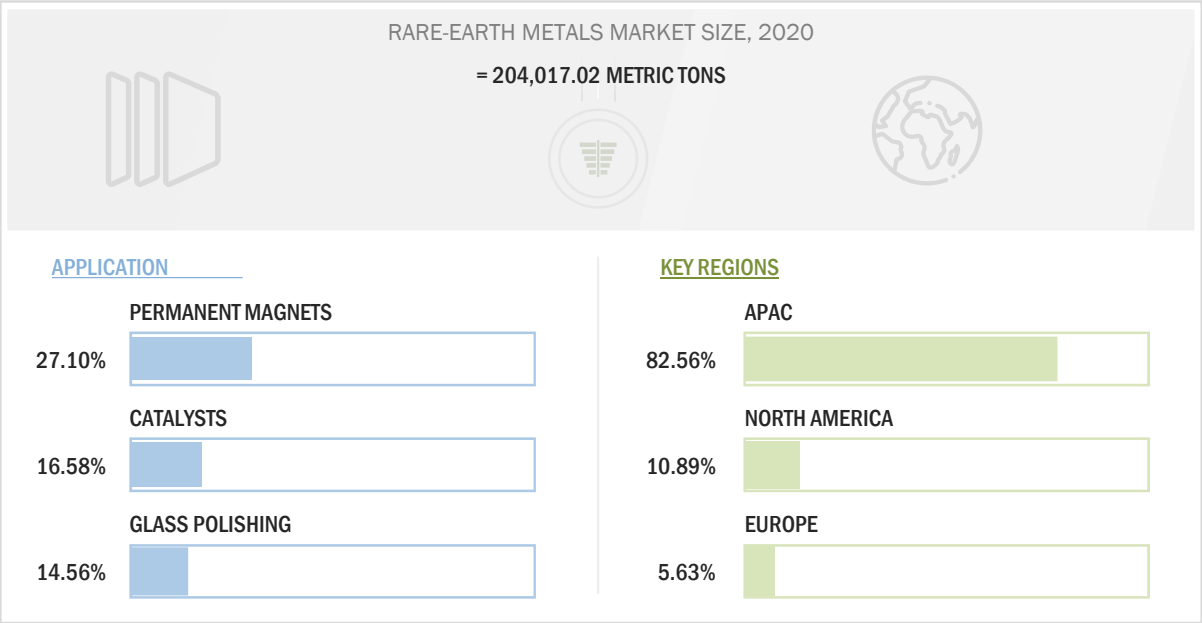
FIGURE 11 INCREASING DEMAND FOR ELECTRIC VEHICLES TO DRIVE THE RARE-EARTH METALS MARKET



Source: Industry Journals, Company Websites, Company Publications, Secondary Literature, Expert Interviews, and MarketsandMarkets Analysis

4.2 RARE-EARTH METALS MARKET: BY REGION AND APPLICATION

FIGURE 12 APAC AND PERMANENT MAGNETS LED THEIR RESPECTIVE SEGMENTS IN THE MARKET IN 2020

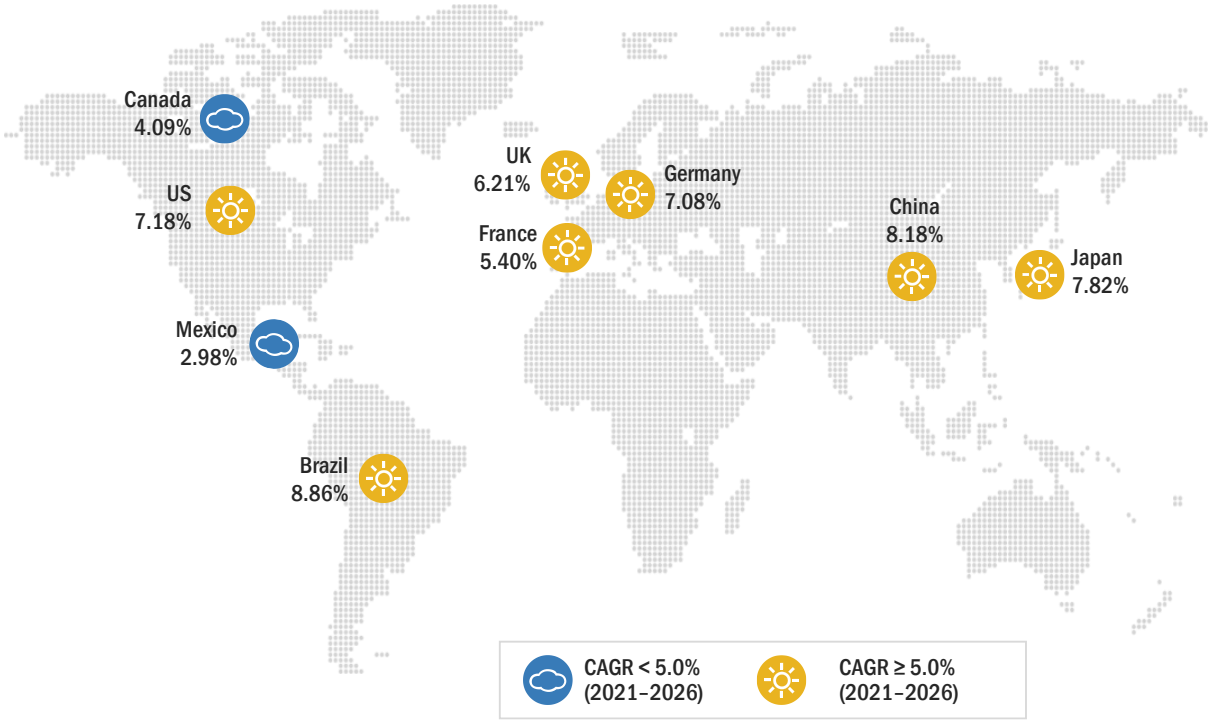


Note: The percentages of the segments will not add up to 100% as only the top-three segments have been considered

Source: Industry Journals, Company Websites, Company Publications, Secondary Literature, Expert Interviews, and MarketsandMarkets Analysis

4.3 RARE-EARTH METALS MARKET, BY COUNTRY

FIGURE 13 THE RARE-EARTH METALS MARKET IN BRAZIL IS PROJECTED TO GROW AT THE HIGHEST CAGR FROM 2021 TO 2026



Note: The CAGRs are provided in terms of volume.

Source: Industry Journals, Company Websites, Company Publications, Secondary Literature, Expert Interviews, and MarketsandMarkets Analysis.

5 MARKET OVERVIEW

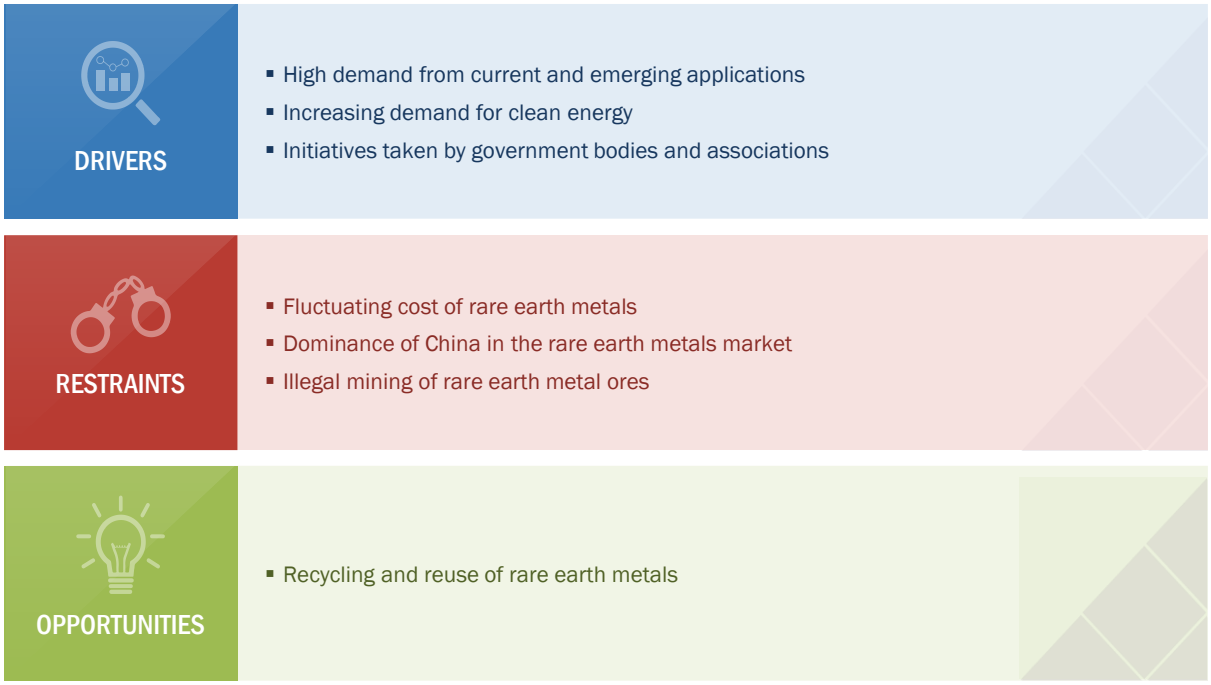
5.1 INTRODUCTION

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 markets. The rare-earth elements are used in various applications that are further used in several end-use 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 metals commodities is a derived demand, which differs from consumer goods demand.

The rare-earth metals market is driven by factors, such as high demand in the current and emerging applications, and increasing demand for clean energy, and initiatives taken by governments and associations.

5.2 MARKET DYNAMICS

FIGURE 14 DRIVERS, RESTRAINTS, OPPORTUNITIES, AND CHALLENGES, IN THE RARE-EARTH METALS MARKET



Source: Secondary Sources, Expert Interviews, 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.

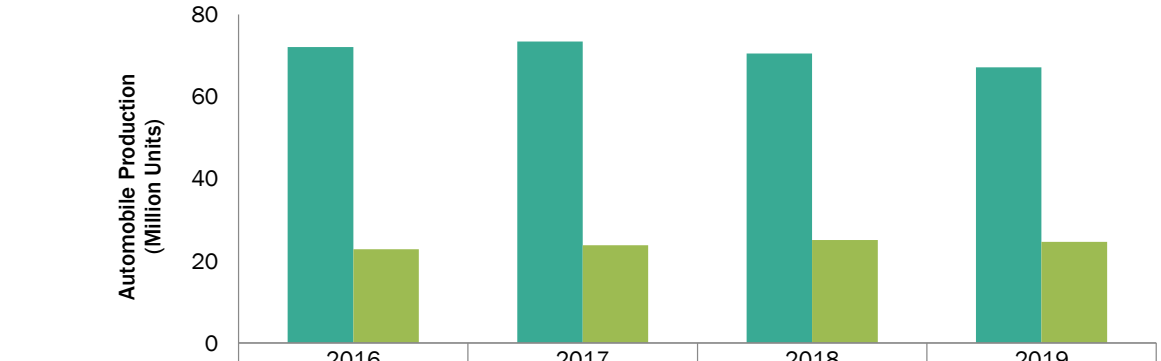
Rare-earth permanent magnets are expected to be the prime growth market over the next five to ten years. The major rare-earth elements that are used in the permanent magnet application are neodymium, praseodymium, dysprosium, terbium, and yttrium. These metals possess special properties, such as remanence, high coercivity, which keeps the 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. The 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 a stronger growth for rare-earth magnets in the near future as they use more rare-earth magnets per vehicle when 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, 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 in a catalyst system is to absorb, store, and release oxygen and stabilize the environments in which they operate. The 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 (FCC's) used in oil refineries. Apart from growth in worldwide unit sales, 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.

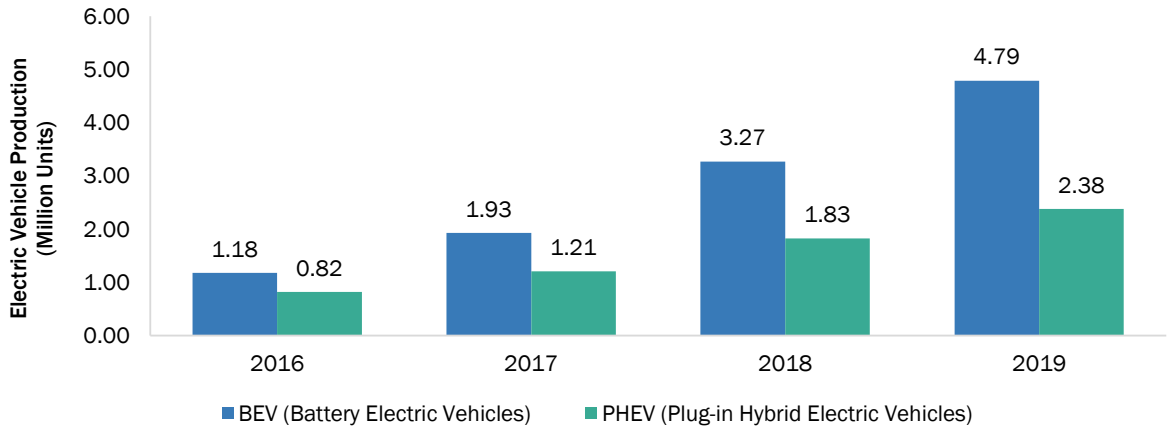
FIGURE 15 GLOBAL AUTOMOBILE PRODUCTION DATA, 2016-2019



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

Source: OICA

FIGURE 16 GLOBAL ELECTRIC VEHICLE PRODUCTION DATA, 2016-2019

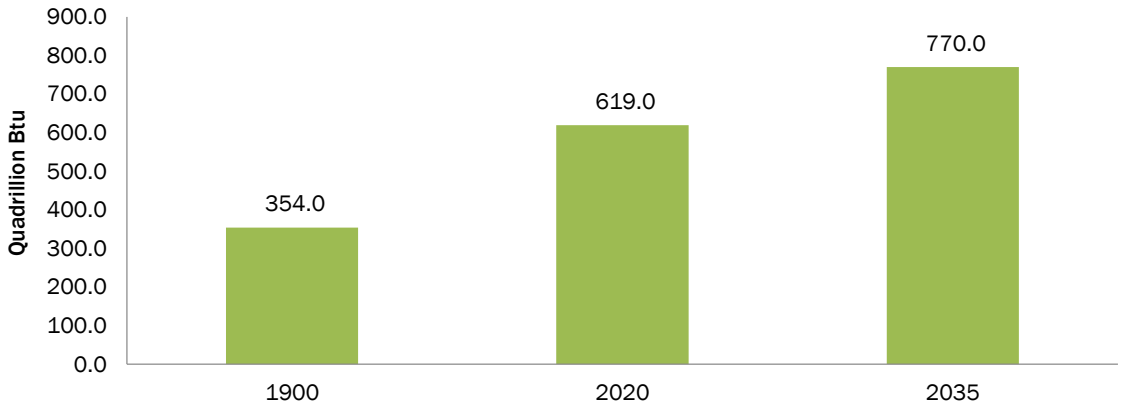


Source: International Energy Agency

5.2.1.2 Increasing demand for clean energy

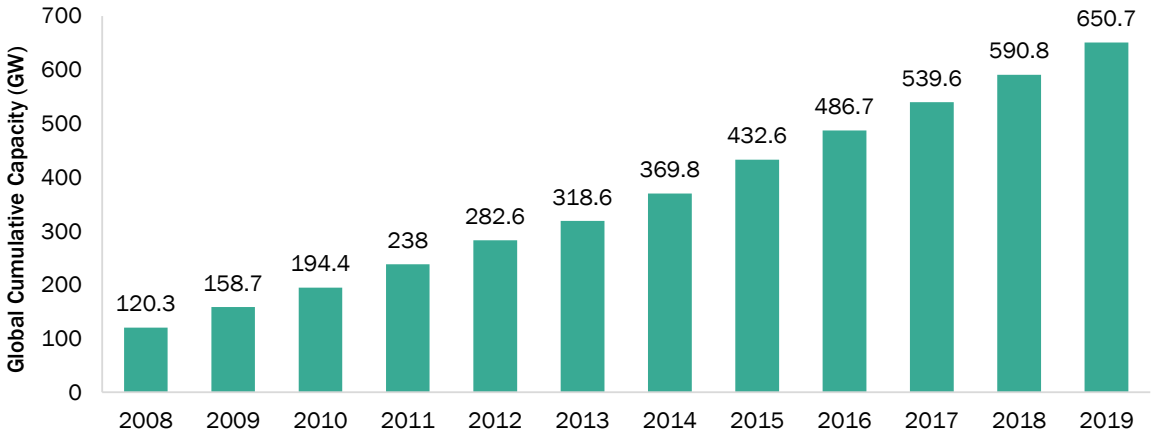
The green energy market is witnessing a significant boost as increasing legislations are passed by different regulatory bodies across the world. These legislations are banning the use of conventional mediums in industries, and they require the use of green technologies, such as wind turbines, hybrid electric vehicles, and compact fluorescent lighting. The 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 generating 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 markets that have significant usage of permanent magnets offer a huge impetus to these advanced materials, thereby acting as a huge driver of this market.

FIGURE 17 GLOBAL ENERGY DEMAND



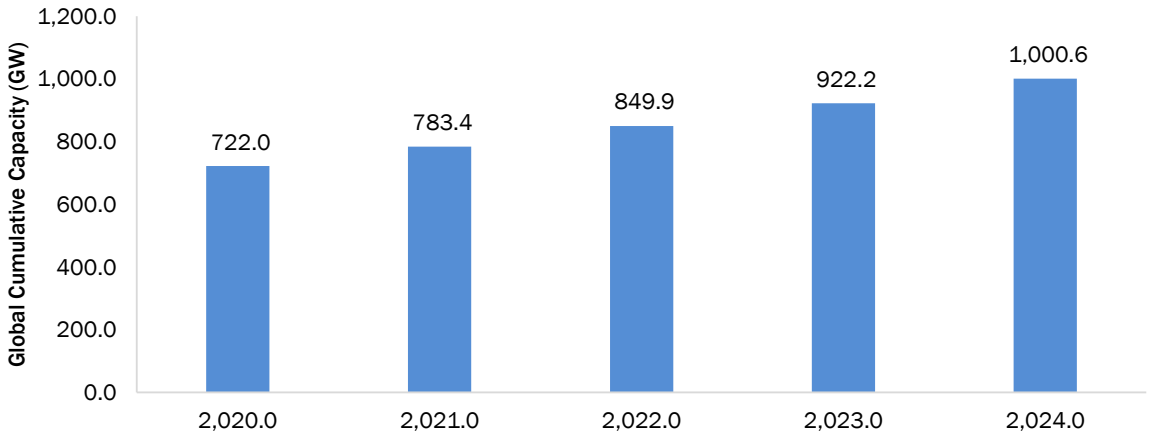
Source: US Department of Energy

FIGURE 18 GLOBAL WIND POWER CUMULATIVE CAPACITY



Source: Global Wind Energy Council

FIGURE 19 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 the 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 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, for instance, the automotive, to use light metals to comply with modern emission standards. For example, cerium-containing converters have been used to lower vehicle emissions.

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. The 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. The demand for rare-earth metals is dependent on the demand for its applications. Furthermore, the demand for the applications is dependent on the end-user industries. Hence, the rare-earth metal has a double supply chain, which further increases the final price demanded by manufacturers. Thus, 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 the 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 Dominance of China in the rare-earth metals market

The market for rare-earth metals applications witnessed a major boom in the 1970s when a lot of uses were discovered. This included their first use in high-strength permanent magnets. This expanding market caught the attention of the China. By the 1980s, China was aware that it possessed the majority of the known rare-earth element global reserves. A government program supporting innovation in extraction and processing, along with low labor costs and relaxed environmental standards, permitted China's rare-earth mining industry to grow at an annual average of 40% since then. It gradually overtook the existing hold of the US on the rare-earth metals market mainly due to its competitive pricing.

Since the 1990s, rare-earth metals are considered to be an important strategic and officially protected sector in China. This situation led to a complete ban on foreign investment in mining and even placed restrictions on joint ventures with Chinese firms. China imposed a lot of export quotas on the rare-earth metals to capitalize on its growing upstream dominance of rare-earth oxides. These restrictions generated a lot of media interest when China announced a 40% cut on exports even when the global demand was catching up with the supply. The Chinese instituted a formal system of invoices to track all rare-earth elements transactions. This system led to a short-term price crash because suppliers outside this new system dumped their inventories. This prompted the US, Japan, among other countries, to build a stockpile of rare-earth metals for future use.

The rare-earth metal prices drastically increased in 2011 after China stopped exports to Japan due to the Chinese embargo incident (2010). The price of neodymium oxide increased 2,360% between August 2009 and August 2011 buoyed by demand and concerns over future availability. The prices of rare-earth metals declined in the first half of 2012 as global economies slowed down and end users accessed the exiting stockpiles.

In order to reduce dependence on China, the US and Japan have made it a priority to diversify their sources of rare-earth metals. The US has added rare-earth metals to its list of critical minerals, and the government recently issued an executive order to encourage local production. Japan is making efforts to reduce China's share of its total rare-earth metal imports to less than 50% by 2025. Increasing rare-earth mining outside of China has reduced China's global share of mining, down from 97.7% in 2010 to 62.9% in 2019. But mining is merely a small step in the production of rare-earth metals.

Ultimately, the large majority of rare-earth metal refining, over 80%, resides in China. Therefore, even rare-earth metals mined overseas are sent to China for final processing. New North American refining facilities are being set up to tackle this issue, but the challenge lies in managing the environmental impacts of processing rare-earth metals.

5.2.2.3 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 in 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 for the industry. 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 the 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 and reuse of rare-earth metals

Rare-earth metals were comparatively cheaper before new applications were discovered for their use. This created a discrepancy in the supply and demand chain of the rare-earth metals, which was due to an enormous increase in the prices of the metals. Earlier, the metals were not as critical as they have become over the past five years. Hence, a lot of them were wasted due to inconsistent demand and supply. Currently, the situation is different for the rare-earth metals. Many critical industries, including the green technology and defense use a lot of rare-earth metals. The substantial price increase of the metals in 2011 made these metals even more critical and valuable for other countries, including the US, which has led to a global drive for recycling.

Recycling is a method to decrease the criticality of the metals and provide a secondary source of supply for the key metals. The existing recycling rate for the rare-earth metals is less than 5% which presents a significant opportunity for important recycling efforts. 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.

The US Department of Energy, in collaboration with Oak Ridge National Laboratory (ORNL) developed a recycling technology that uses a combination of hollow fiber membranes, organic solvents, and neutral extractants to recover rare-earth elements, such as neodymium, praseodymium, and dysprosium from magnets.

In laboratory testing, the membrane extraction system demonstrated the potential to recover more than 90 percent of these three elements in a highly pure form from scrap neodymium-based magnets. ORNL expects the figure to be closer to 97 percent. The resulting product is a 99.6 percent pure combination of rare-earth materials.

5.3 PORTER'S FIVE FORCES ANALYSIS

Porter's five forces analysis is a framework that determines the competitive intensity in the rare-earth metals 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 20 RARE-EARTH METALS MARKET: PORTER'S FIVE FORCES ANALYSIS

Source: Expert Interviews and MarketsandMarkets Analysis

TABLE 1 RARE-EARTH METALS 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

5.3.1 BARGAINING POWER OF SUPPLIERS

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

Therefore, the bargaining power of suppliers is moderate.

5.3.2 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 three stages—extraction, processing, and refining. These stages requires a lot of expert attention as mishandling can lead to hazardous pollution. Also, procuring and operating a rare-earth mine 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.

5.3.3 THREAT OF SUBSTITUTES

The rare-earth metals have traditionally been used in various applications including catalysts, phosphors, and glass additives. This has resulted in the rise in consumption of these elements at a steady growth rate for a number of years. Recently, these elements have been used in various emerging green technologies, such as wind turbines and hybrid electric cars. This has resulted in growth rate surge as they have become the key components in these emerging applications. The only downside with these elements is their high price. Therefore, the threat of substitutes for these metals is low in the short run, but can be significant later as the high prices and the limited quantity of the metals will encourage R&D for other products and substitutes.

Thus, the threat of substitutes is low.

5.3.4 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 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.

5.3.5 INTENSITY OF COMPETITIVE RIVALRY

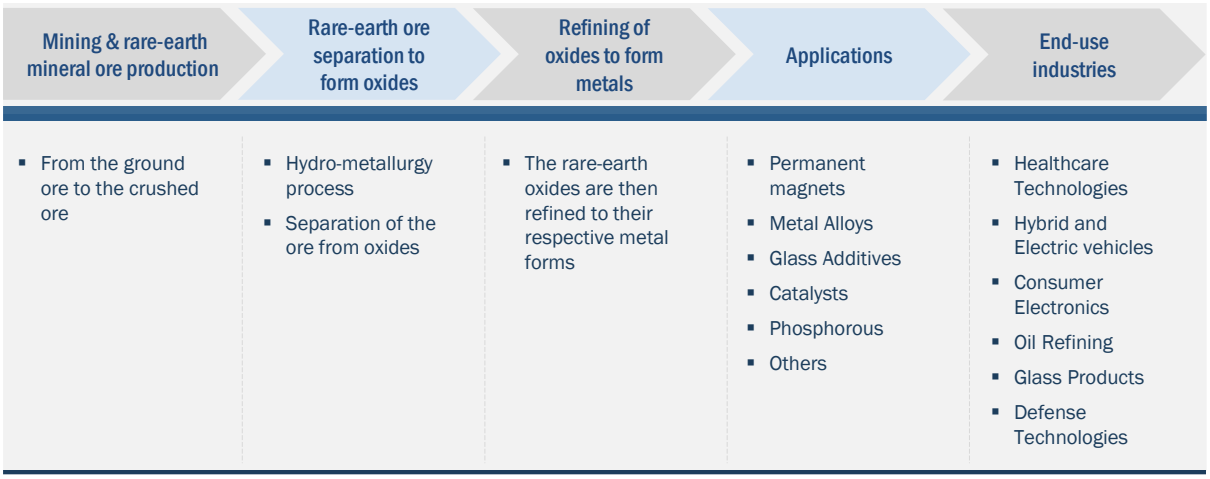
The rare-earth metals industry has been dominated by the Chinese companies for a long time. China contributed 85% of the total production of rare-earth metals in 2011. But with the country introducing production quotas on the companies due to environmental issues, its dominance has faded slightly. Companies, such as Lynas Corporation (Australia), Alkane Resources Ltd (Australia), and Arafura Resources Ltd (Australia) are major companies operating rare-earth mines, which will see their production of rare-earth metals increase substantially. This will further lessen the dependence for these metals on China, which will result in increased competition among companies in the industry to fill the void left 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.

5.4 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 the ores and their refining) to their respective applications in the end-user industries. The value chain for the rare-earth metals market is explained below in the figure.

FIGURE 21 RARE-EARTH METALS VALUE CHAIN



Source- Parliament of Canada Website

5.4.1 MINING & RARE-EARTH ORE PRODUCTION

The value chain of the rare-earth metals starts with its mining and ore production. The 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 the minerals' bastnaesite and monazite. China has the largest concentrations of rare-earth elements in its bastnaesite deposits, while the monazite deposits in Australia, China, South Africa, Brazil, South Africa, India, and South Africa, account for the second-largest concentrations of rare-earth elements. The lighter rare-earth elements, such as lanthanum, cerium, praseodymium, and neodymium, are more abundant and concentrated, and usually add up to about 80%-99% of a total deposit. The mineral deposit is identified, mined, and then compressed to crushed ore for further processing.

5.4.2 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 the rare-earth metals is preceded usually by following two simultaneous processes: milling and hydro-metallurgy.

Milling of the mined ore can be defined as the ore that is compressed into gravel, which is further grounded into smaller particles. These particles are sorted and sifted by means, such as flotation and electromagnetic separation to take out usable material and remove the waste products, called tailings, aside. The above process is followed by a complicated yet inexpensive and quick process of hydrometallurgy. Separation of rare-earth oxides is a broad term, which basically involves the process of isolating the rare-earth elements safely. This process gives out the 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.

5.4.3 REFINING OF THE RARE-EARTH OXIDES

The separation of the 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 the 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, for instance, carbon dioxide (CO_2), are removed by melting the metal compounds to a point where they are volatile.

5.4.4 APPLICATIONS

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

The use of rare-earth metals in permanent magnets is limited to the elements, neodymium, praseodymium, dysprosium, europium, and yttrium. Rare-earth permanent magnets are considered to be a key driving market for the rare-earth metals. The automotive (hybrid electric vehicles) and the green technology (wind turbines) markets are the chief drivers for the rare-earth metals in the permanent magnet market.

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 the elements, which are used extensively in this application. The two major markets using these elements are the automotive and the petroleum industries. The automotive industry uses environmentally-friendly catalysts, whereas the petroleum industry uses petroleum cracking catalysts.

5.4.5 END-USE INDUSTRIES

The rare-earth metals are indirectly used in a wide range of industries. The demand for the rare-earth elements in these industries is different from that of consumer goods. The rare-earth metals are used in various applications, such as permanent magnets, metal alloys, phosphors, polishing, and glass additives. These applications are key components in, automotive, green energy, glass, and other end-use industries.

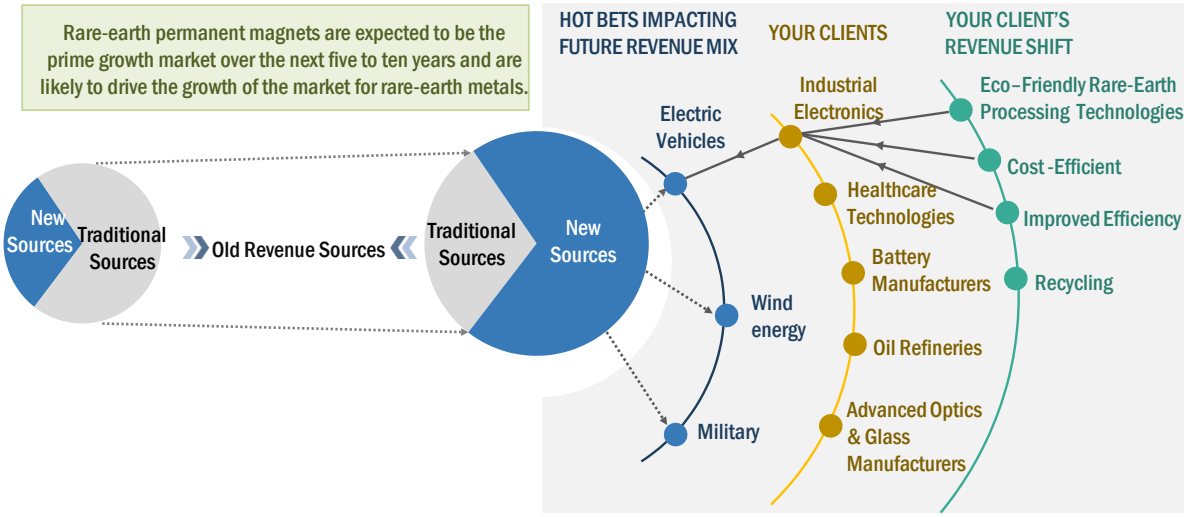
This demand is termed as derived demand as the demand for the applications in end-use industries will drive the demand of the rare-earth metals. Green technology is a major end-use industry that uses rare-earth metals . The main rare-earth metals that are used in this industry are neodymium, praseodymium, dysprosium, and holmium. The main application for these metals is permanent magnets, which, in turn, are used in green technologies, such as wind turbines, and hybrid electric vehicles.

Another major application for the rare-earth metals is in the automotive industry. Rare-earth permanent magnets are used in hybrid electric vehicles to reduce emissions from cars. Rare-earth metals are used to reduce corrosions in the engine. Also, the cerium present in these lubricants reduces the toxicity of the carbon monoxide produced in the engine.

5.5 TRENDS

5.5.1 REVENUE SHIFT & NEW REVENUE POCKETS FOR RARE-EARTH METAL MANUFACTURERS

FIGURE 22 REVENUE SHIFT FOR RARE-EARTH METAL MANUFACTURERS



Source: MarketsandMarkets Analysis

MarketsandMarkets has witnessed a rapid ecosystem change in the rare-earth metals 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. Thus, the revenue streams of rare-earth metal companies are impacted by automotive, glass & ceramic industries, and the defense sector.

The players operating in the rare-earth metal 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 industries. 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 another method, 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.

5.6 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 an 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, processes and 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.

5.7 TECHNOLOGY ANALYSIS

New environmentally-friendly technologies promise to be "game changers" in this field and enable the US to create a more stable and reliable domestic source of these essential metals. Purdue University-patented extraction and purifying processes using ligand-assisted chromatography are shown to remove and purify such metals from coal ash, recycled magnets and raw ore safely, efficiently and with virtually no detrimental environmental impact.

The technology – developed and patented from the laboratory of Nien-Hwa Linda Wang, Purdue's Maxine Spencer Nichols Professor of Chemical Engineering – has successfully shown how to separate the rare-earth metals without the devastating environmental effects of conventional acid based methods with high yield and purity.

Conventional methods for producing high-purity rare-earth elements employ two-phase liquid-liquid extraction mechanisms, which require thousands of mixer-settler units in series or in parallel and generate large amounts of toxic waste. This method, however, uses a two-zone ligand-assisted displacement chromatography system with a new zone-splitting technique that is producing high-purity (>99%) metals with high yields (>99%). This is key because, at present, 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.

5.8 CASE STUDY ANALYSIS

5.8.1 CASE STUDY OF THE CHINA'S GROWING CONFLICT WITH THE WTO (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 restraints on the 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 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.

5.8.2 CHINA'S GROWING CONFLICT WITH THE 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 judgement 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, US, and Japan, together filed a litigation against China's export restrictions on the 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 exports 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.

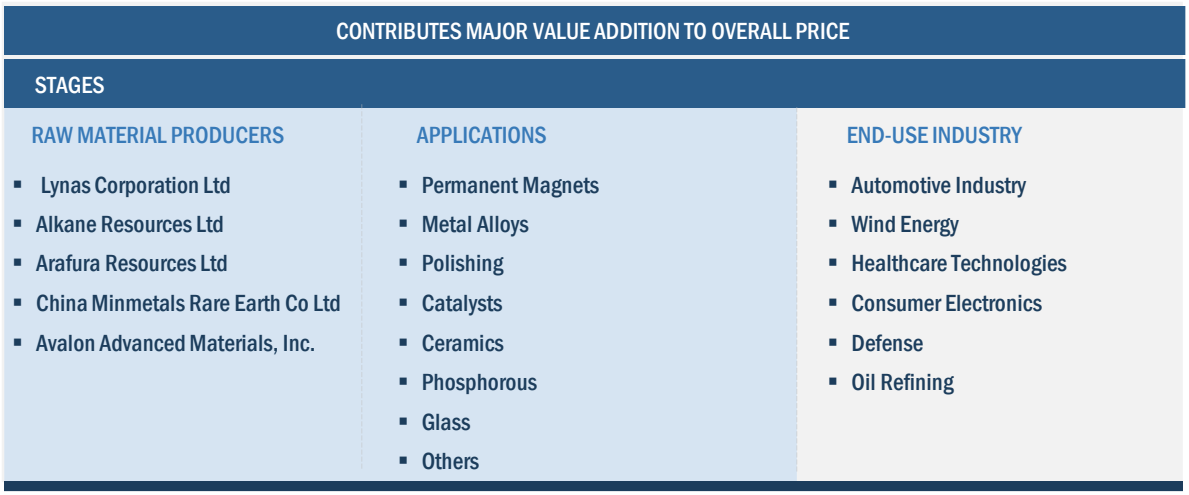
Secondly, with regard to China's export quotas, the evidence clearly shows that the Chinese government has been actively involved in the application of export quotas on rare-earth metals for more than ten years now. From the past few years, government regulation, supervision, and enforcement of those 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)

5.9 MARKET MAP

FIGURE 23 MARKET MAP FOR RARE-EARTH METALS MARKET



Source: MarketsandMarkets Analysis

The market map for rare-earth metals is the network of raw material suppliers, applications, and end users, which involves the processing of rare-earth metals for various applications in end-use industries. Each entity in the market map/ecosystem affects and is affected by the others, and they compete and collaborate with each other to survive. The above-mentioned figure includes the names of the entities in the rare-earth metals market.

5.10 RARE-EARTH METALS MARKET: PATENT ANALYSIS

5.10.1 INNOVATIONS & PATENT REGISTRATION

TABLE 2 IMPORTANT INNOVATION & PATENT REGISTRATION, 2016–2020

YEAR OF PATENT	PATENT/APPLICATION NUMBER	ASSIGNEE/ APPLICANT	COUNTRY	DESCRIPTION
2016	US 2016/0010178 A1	NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY	US	An adsorbent for rare-earth element and a method for recovering a rare-earth element, in which a rare-earth element contained in an aqueous solution can be simply and inexpensively adsorbed and recovered, and a rare-earth element present in an aqueous solution in combination with a base metal can be selectively adsorbed and recovered. The adsorbent includes a base material and diglycolamic acid introduced into the base material. The method for recovering a rare-earth element includes steps of: bringing an aqueous solution containing a rare-earth element into contact with the adsorbent for rare-earth element to allow the rare-earth element to be adsorbed on the adsorbent for rare-earth element; and desorbing the rare-earth element adsorbed on the adsorbent for rare-earth

				element with an acid of 1 N or less.
2016	US 2017/0275732 A1	RARE EARTH SALTS SEPARATION AND REFINING LLC	US	A method for extracting and separating rare-earth elements comprising providing a rare-earth-containing ore or tailings, grinding the rare-earth-containing ore to form powdered ore; leaching the powered ore with at least one mineral acid, forming a leach solution comprising at least one metal ion, rare-earth elements, and a solid material, separating the solid material from the leach solution to form aqueous-metal concentrate, precipitating the aqueous-metal concentrate to selectively remove the metal ion from the leach solution and obtain a precipitate of the rare-earth elements; heating the precipitate of the rare-earth elements in the air to form oxide of the rare-earth elements, mixing the oxide of the rare-earth elements with an ammonium salt and heating in a dry air/nitrogen, forming a mixture of anhydrous rare-earth salts in an aqueous solution, and separating the rare-earth elements from the aqueous solution by means of an electrowinning process.
2018	US 2018/0221951 A1	NITTO DENKO CORPORATION	US	Provided is a heretofore non-existing, novel rare-earth sintered magnet having both of an extremely low carbon content and an extremely small average particle size of magnet material particles. The sintered body for forming a rare-earth magnet comprises a large number of magnet material particles sintered together, wherein each of the magnet material particles contains a rare-earth substance and has an easy magnetization axis. This sintered body for forming a rare-earth magnet has a carbon content of 500 ppm or less, and the magnet material particles have an average particle size of 2 μm or less.
2018	2018/0221229 A1	Univ Iowa State Res Found Inc	US	A method is provided for separating different rare-earth metal oxalates by mixing the different rare-earth metal oxalates in an aqueous solution comprising oxalic acid and an organic base so that at least one rare-earth metal oxalate is soluble and at least another rare-earth metal oxalate is not soluble. The different rare-earth metal oxalates that can be separated can include at least one light rare-earth metal oxalate and at least one heavy rare-earth oxalate, or different heavy rare-earth metal oxalates.

				The separation method can be incorporated as a step in a solvent extraction method that generates rare-earth metal oxalates as an intermediate reaction product to simplify extraction processing and lower extraction costs.
2020	US 10648063 B2	IOWA STATE UNIVERSITY RESEARCH FOUNDATION INC	US	A chemical dissolution method is provided for use in recycling rare-earth metal-containing material, such as permanent magnet material including end-of-life magnet shapes, magnet scrap and Terfenol-D alloy material by mixing the rare-earth metal-containing material and an aqueous solution of a copper (II) salt to dissolve the material in the solution.

Source: Justia and The Lens

5.11 PRICING ANALYSIS

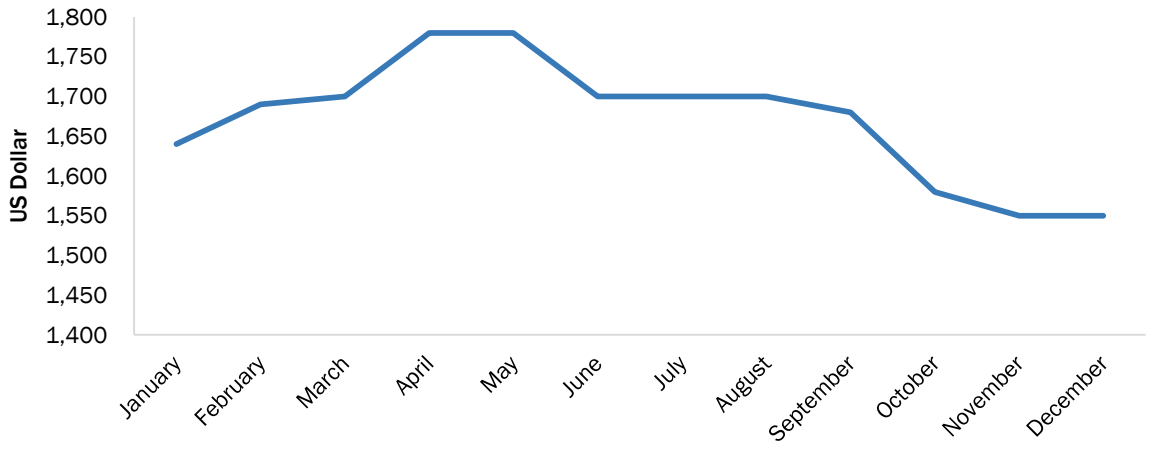
The prices of the rare-earth metals are very difficult to track and monitor as these metals are not traded in any exchange, like other metals, such as gold, silver, nickel, tin, copper, and aluminum. Also, these metals are often not sold in their pure form, but instead they are sold in mixtures with 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 the 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 mid-2019.

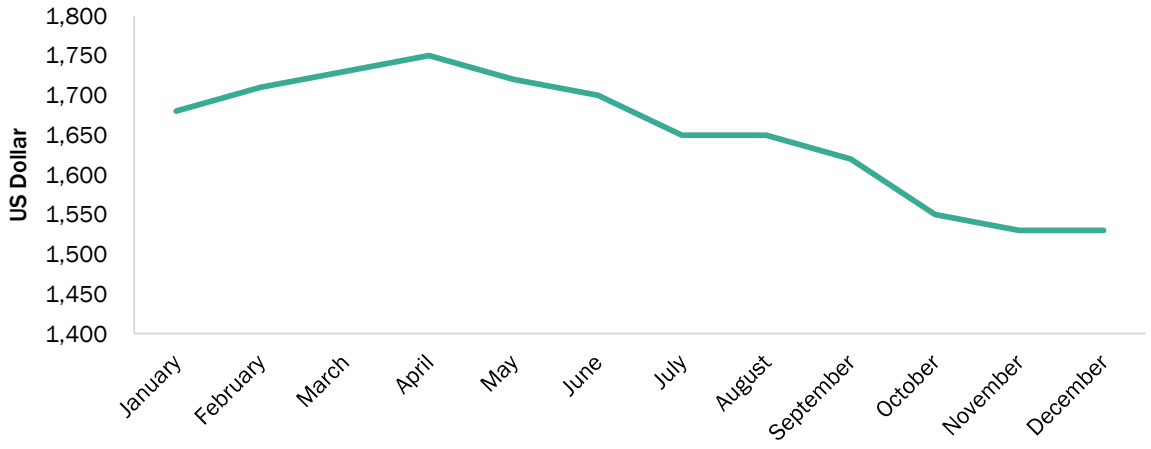
In 2020, the prices were relatively stable though the prices of rare-earth oxides, such as neodymium and praseodymium, witnessed increases in the second half of the year. Spot supply rose in mid-2020 as Chinese operations resumed post- lockdown ahead of many key consuming countries, but downstream magnet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

FIGURE 24 MONTHLY CERIUM OXIDE PRICES, 2020



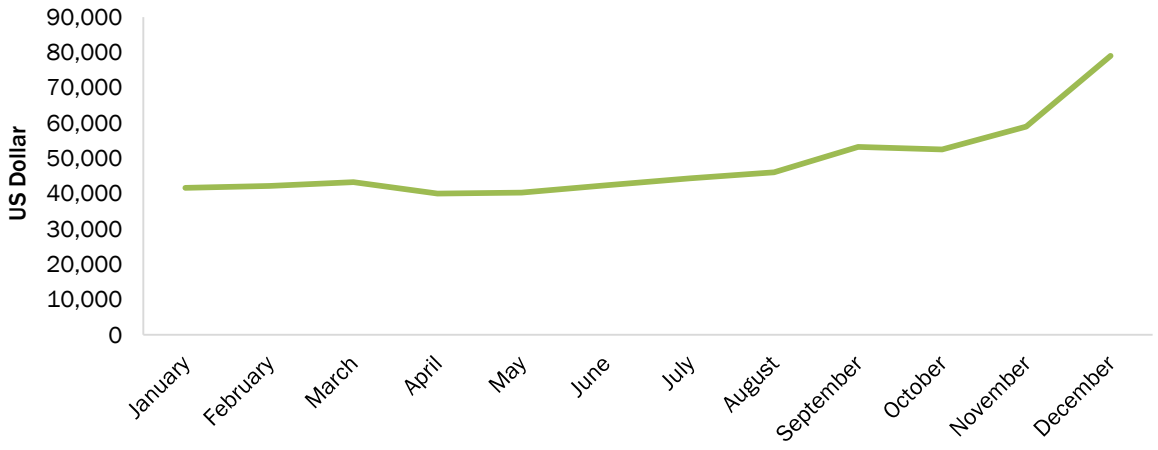
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 25 MONTHLY LANTHANUM OXIDE PRICES, 2020



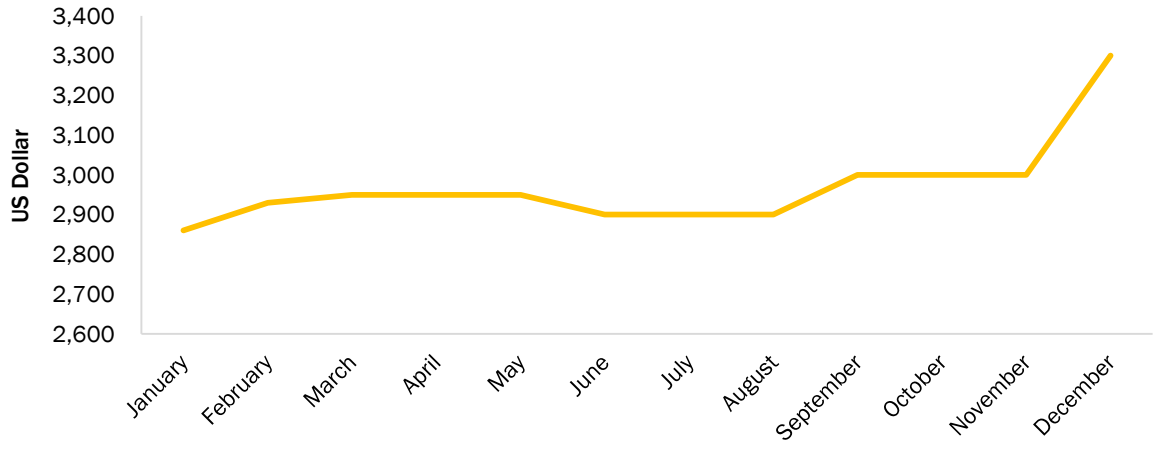
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 26 MONTHLY NEODYMIUM OXIDE PRICES, 2020



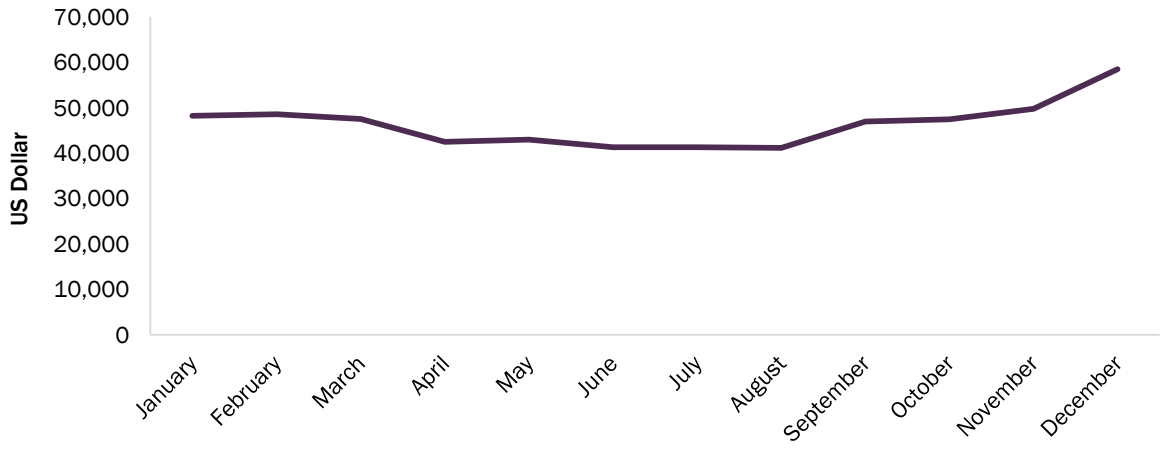
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 27 MONTHLY YTTRIUM OXIDE PRICES, 2020



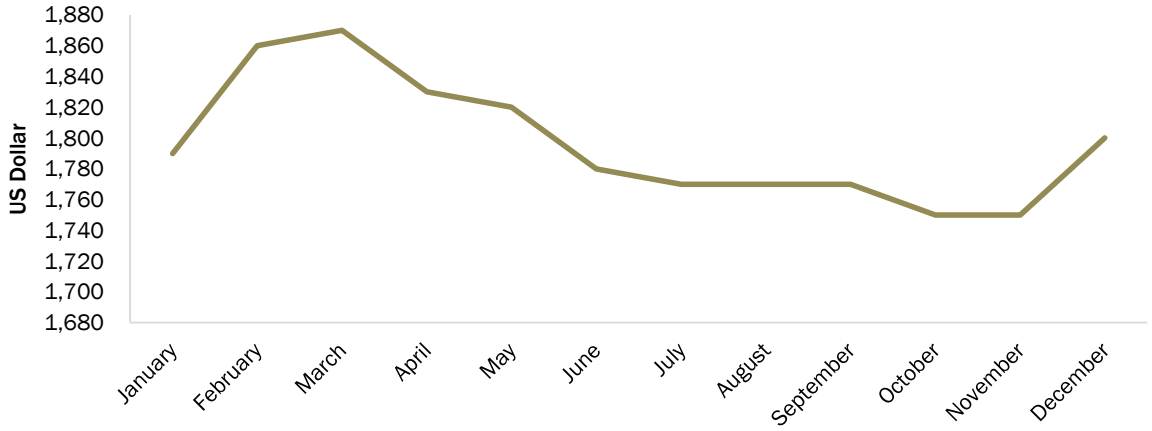
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 28 MONTHLY PRASEODYMIUM OXIDE PRICES, 2020



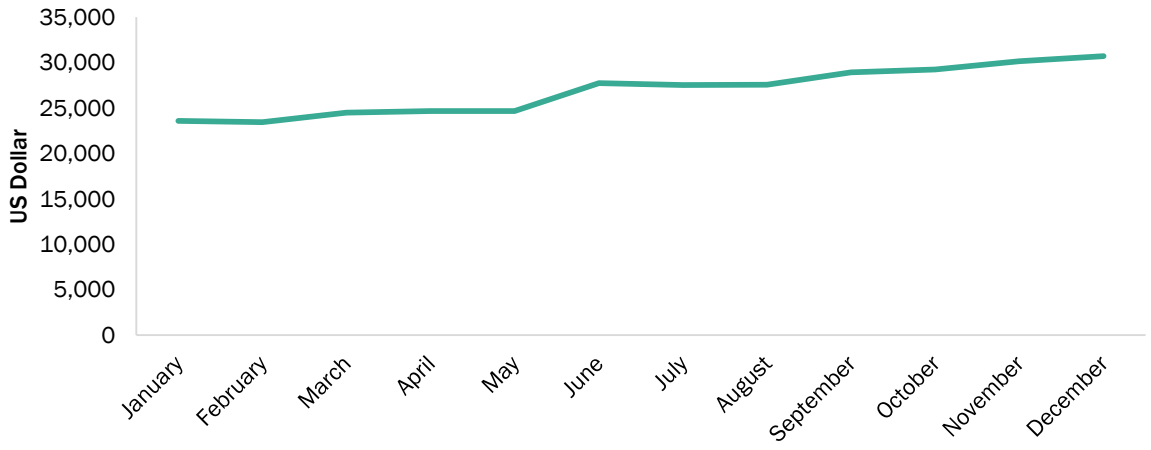
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 29 MONTHLY SAMARIUM OXIDE PRICES, 2020



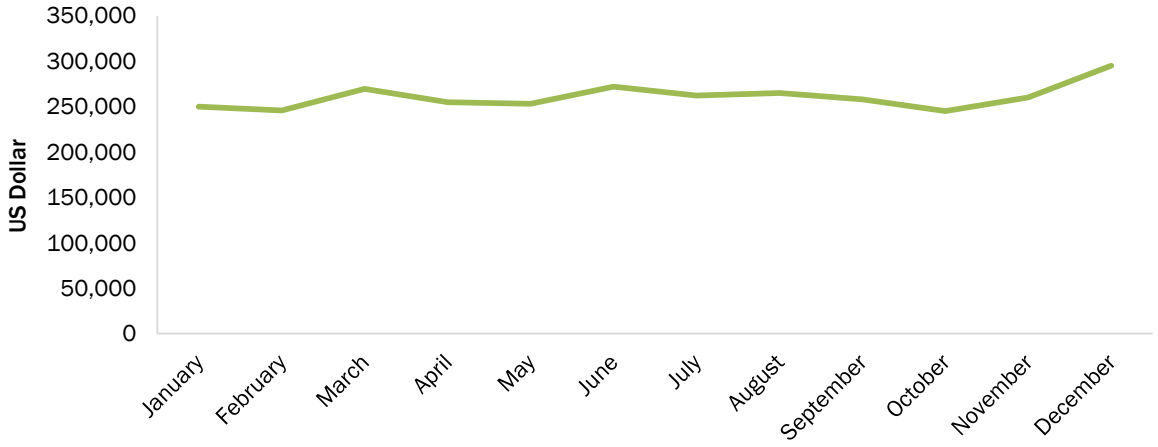
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 30 MONTHLY GADOLINIUM OXIDE PRICES, 2020



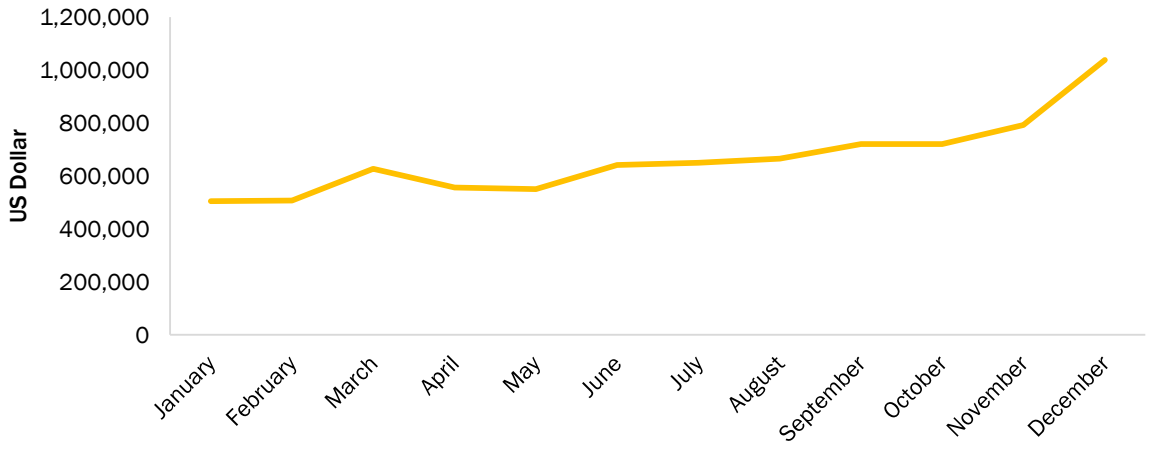
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 31 MONTHLY DYSPROSIUM OXIDE PRICES, 2020



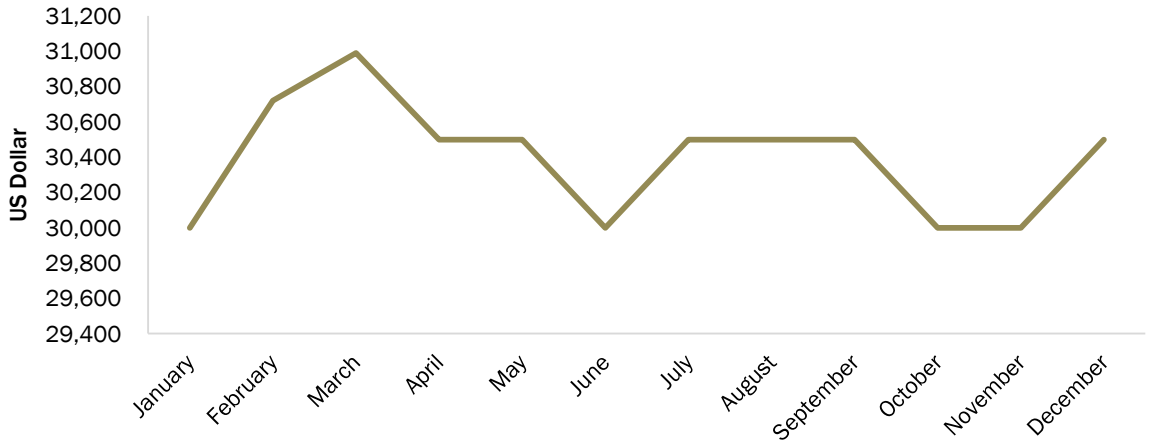
Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 32 MONTHLY TERBIUM OXIDE PRICES, 2020



Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

FIGURE 33 MONTHLY EUROPIUM OXIDE PRICES, 2020



Source: Institut für Seltene Erden und Metalle and MarketsandMarkets Analysis

TABLE 3 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 4 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 5 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

5.12 TRADE DATA

TABLE 6 EXPORT TRADE DATA FOR RARE-EARTH METALS (2019)

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

Source: UN COMTRADE

TABLE 7 IMPORT TRADE DATA FOR RARE-EARTH METALS (2019)

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

Source: UN COMTRADE

6 COVID-19 IMPACT ON RARE-EARTH METALS 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 has significantly impacted the global GDP in 2020, and according to the World Bank, the global GDP will fall slightly 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 is going to retreat. This situation is somewhat unusual, as it affects both supply and demand, thus, also affecting the supply of rare-earth metals globally.

Various rare-earth raw material suppliers 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.

6.1 COVID-19 IMPACT ON RARE-EARTH METAL END-USE INDUSTRIES

The COVID-19 pandemic has already by now caused profound effects at the 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, too, leading to the breaking of entire international supply chains. This makes it clearer than ever before 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 fulfil 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 have 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. Among the under-reported deficiencies, thereby caused the most important ones for the global rare-earth metals production and utilization industries is the interruption in the flow of chemical reagents necessary for refining rare-earth metals and for producing metals, alloys, and magnets.

Rare-earth-enabled components for moving machinery, such as automobiles, trucks, trains, aircraft, industrial motors and generators, home appliances, and consumer goods, almost all of these are procured from China or Japan (which of course gets its rare-earth magnets, alloys, phosphors, and catalysts from China). That flow is now slowing. This will have a domino effect on American and European industries. 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 MARKET, BY TYPE

KEY FINDINGS

- The neodymium oxide segment accounted for the largest share of 47.26%, the rare-earth metals market in terms of value, in 2020, and is projected to grow at the CAGR of 12.38% between 2021 and 2026.
- The praseodymium oxide segment accounted for the second-largest share of 16.93% of the rare-earth metals market in 2020 and is expected to grow at a CAGR of 12.01%, in terms of value, between 2021 and 2026.
- The neodymium oxide is one of the most widely used rare-earth metals to create some of the strongest permanent magnets.
- Praseodymium is an important component in a wide range of applications due to its excellent optical, magnetic, electrical, and chemical properties.
- Growing demand from various end-use industries, such as automotive, industrial, medical, and defense, is expected to boost the rare-earth metal demand.

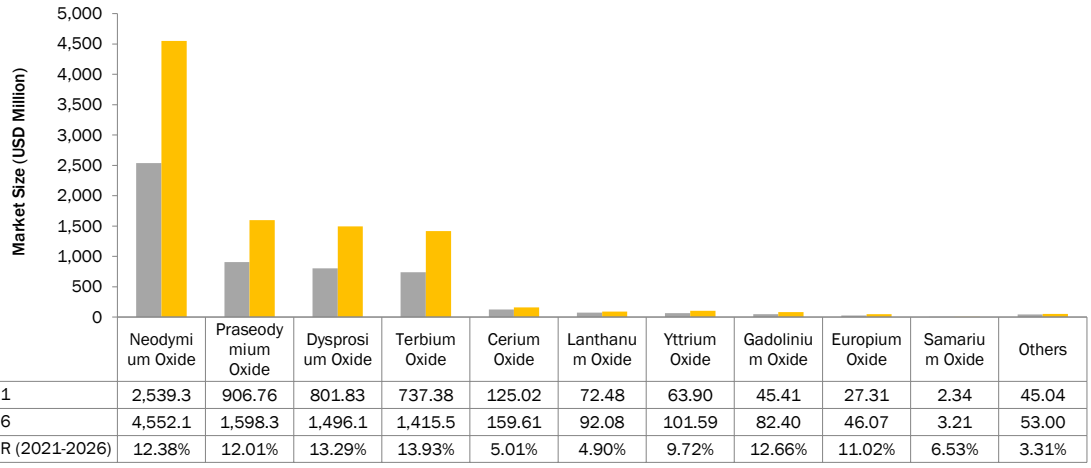
7.1 INTRODUCTION

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 number 57 and 71. The elements scandium and yttrium are also considered to be rare-earth elements as they are found in the same ore as the other rare-earth elements and show similar chemical properties.

These metals are growing in demand, especially in the green technology sector. Rare-earth elements, such as neodymium, praseodymium, and dysprosium, are key components in green technologies, such as wind energy and hybrid electric vehicles.

Although China has traditionally been the biggest producer of rare-earth metals with over 70% of the total production in 2018, the rest of the world is catching up as these metals are gaining importance in critical applications, including defense and clean energy.

FIGURE 34 NEODYMIUM OXIDE SEGMENT TO LEAD THE MARKET



	Neodymium Oxide	Praseodymium Oxide	Dysprosium Oxide	Terbium Oxide	Cerium Oxide	Lanthanum Oxide	Yttrium Oxide	Gadolinium Oxide	Europium Oxide	Samarium Oxide	Others
2021	2,539.3	906.76	801.83	737.38	125.02	72.48	63.90	45.41	27.31	2.34	45.04
2026	4,552.1	1,598.3	1,496.1	1,415.5	159.61	92.08	101.59	82.40	46.07	3.21	53.00
CAGR (2021-2026)	12.38%	12.01%	13.29%	13.93%	5.01%	4.90%	9.72%	12.66%	11.02%	6.53%	3.31%

.Note: Others include holmium, erbium, thulium, ytterbium, and lutetium.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 8 RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	123.39	119.53	125.02	159.61	5.01%
Lanthanum Oxide	71.66	69.36	72.48	92.08	4.90%
Neodymium Oxide	2474.36	2279.64	2539.37	4552.19	12.38%
Yttrium Oxide	62.53	58.66	63.90	101.59	9.72%
Praseodymium Oxide	883.98	816.56	906.76	1598.38	12.01%
Samarium Oxide	2.30	2.21	2.34	3.21	6.53%
Gadolinium Oxide	44.23	40.67	45.41	82.40	12.66%
Dysprosium Oxide	780.34	714.47	801.83	1496.15	13.29%
Terbium Oxide	716.90	653.57	737.38	1415.54	13.93%
Europium Oxide	26.67	24.80	27.31	46.07	11.02%
Other Oxides	44.67	43.71	45.04	53.00	3.31%
Total	**5231.02**	**4823.18**	**5366.84**	**9600.22**	**12.33%**

Note: Others include holmium, erbium, thulium, ytterbium, and lutetium.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 9 RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	73,170.24	71,133.16	74,028.55	92,007.41	4.44%
Lanthanum Oxide	42,979.76	41,722.88	43,447.67	54,128.38	4.49%
Neodymium Oxide	50,433.96	46,619.73	51,698.07	90,445.42	11.84%
Yttrium Oxide	20,865.12	19,640.88	21,296.15	33,004.10	9.16%
Praseodymium Oxide	18,896.33	17,511.74	19,360.69	33,324.22	11.47%
Samarium Oxide	1,269.99	1,220.66	1,288.26	1,725.52	6.02%
Gadolinium Oxide	1,630.51	1,504.66	1,672.09	2,958.57	12.09%
Dysprosium Oxide	2,965.39	2,724.58	3,043.54	5,538.34	12.72%
Terbium Oxide	1,069.66	978.34	1,099.00	2,060.69	13.40%
Europium Oxide	869.68	811.26	889.68	1,465.91	10.50%
Others	152.19	149.41	153.23	175.70	2.78%
Total	**214,302.82**	**204,017.28**	**217,976.91**	**316,834.27**	**7.77%**

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.2 LANTHANUM OXIDE

7.2.1 MOST PREFERRED TYPE FOR GLASS AND CAMERA LENSES

The rare-earth metal lanthanum is a readily oxidizing, silvery-grey metal, which is the first element in the lanthanide series that forms the major part of the rare-earth metals. It is a fairly abundant metal on the earth's crust, available at an average concentration of 30 parts per million. The chief source of lanthanum is from the LREE-mineral bastnaesite. Bastnaesite deposits in China and the US contain the largest percentage of lanthanum deposits in the world. Lanthanum is also extensively found in the mineral monazite and is the second-largest source of commercially viable lanthanum. Lanthanum is a silver-white metal that is one of the most reactive rare-earth elements. It is used in the manufacture of specialized optical glasses, including infrared absorbing glass as well as camera and telescope lenses. It can also be used to help make steel more malleable. Other applications for lanthanum include wastewater treatment and petroleum refining. Lanthanum nickel-metal hydride (NiMH) is required in rechargeable batteries used in hybrid and electric vehicles. They are used in laptop computers, telephones, power tools, toys, and cameras. Lanthanum acts as an essential catalyst in the production of fuel for planes, trains, and automobiles.

The mineral ore containing bastnaesite is mined through bench cut and open-pit methods. Firstly, the ore is drilled and blasted, loaded, and hauled to the mill. The ore is then crushed, screened, and processed to produce a concentrate. The concentrate is then sent to a dry mill for processing to break up the individual heavy-minerals by scrubbing, electromagnetic, drying, screening, electrostatic, magnetic, and gravity processes.

TABLE 10 LANTHANUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Catalyst	19.68	18.12	18.93	23.83	4.72%
Glass Polishing	15.49	15.30	15.88	19.43	4.11%
Phosphors	2.07	2.01	2.18	3.40	9.23%
Ceramics	5.81	5.71	6.03	8.09	6.08%
Metal Alloys	19.54	19.25	20.16	25.84	5.09%
Glass Additives	5.97	5.92	6.09	7.14	3.23%
Others	3.10	3.05	3.22	4.35	6.21%
Total	**71.66**	**69.36**	**72.48**	**92.08**	**4.90%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 11 LANTHANUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Catalyst	11,491.66	10,644.42	11,084.35	13,716.58	4.35%
Glass Polishing	9,474.21	9,373.22	9,691.04	11,615.07	3.69%
Phosphors	1,184.71	1,154.19	1,248.70	1,913.08	8.91%
Ceramics	3,387.01	3,331.08	3,506.11	4,629.42	5.72%
Metal Alloys	11,872.90	11,712.12	12,216.68	15,360.41	4.69%
Glass Additives	3,685.82	3,656.42	3,749.06	4,295.01	2.76%
Others	1,883.52	1,851.42	1,951.73	2,598.79	5.89%
Total	**42,979.76**	**41,722.88**	**43,447.67**	**54,128.38**	**4.49%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.3 CERIUM OXIDE

7.3.1 GENERALLY USED AS CATALYST IN AUTOMOTIVE EXHAUST SYSTEM

Cerium is a shiny silvery-dark grey metal that readily oxidizes in the presence of air. It is malleable and highly unstable. Cerium is the most abundant rare-earth metal and the 25th most abundant element, globally. It occurs at an average of 60 parts per million on the earth's crust. It is more abundant than common metals, such as copper and nickel. The chief source of cerium is the mineral deposits of bastnaesite. The deposits in China and the US contain the largest deposits of cerium. Cerium is also found in the mineral monazite, which is found in Australia, Brazil, China, India, Malaysia, South Africa, Sri Lanka, Thailand, among other countries. Cerium is a silvery-white metal that easily oxidizes in the air. It is the most abundant rare-earth element and has many uses, including as a catalyst in catalytic converters in automotive exhaust systems to reduce emissions. It is also a key component for precision glass polishing. Cerium can also be used in iron, magnesium, and aluminum alloys, magnets, certain types of electrodes, and carbon-arc lighting. It is extensively used in automotive catalytic converters to reduce the effects of the pollutant carbon monoxide (CO).

The mining process of cerium is similar to that of lanthanum. The mineral concentrate of either bastnaesite or monazite is then crushed, grounded, and treated with sulfuric acid to produce rare-earth sulfates soluble in water. These are ultimately converted to cerium oxides by the process of annealing.

TABLE 12 CERIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Catalyst	38.73	36.11	37.73	47.68	4.79%
Glass Polishing	33.41	32.92	34.44	44.01	5.03%
Phosphors	2.91	2.81	3.10	5.30	11.29%
Ceramics	3.77	3.70	3.90	5.14	5.70%
Metal Alloys	20.80	20.48	21.50	28.00	5.42%
Glass Additives	17.13	16.98	17.47	20.43	3.18%
Others	6.64	6.53	6.87	9.05	5.66%
Total	**123.39**	**119.53**	**125.02**	**159.61**	**5.01%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 13 CERIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Catalyst	23,432.30	22,042.29	22,908.81	28,128.37	4.19%
Glass Polishing	19,556.78	19,305.08	20,095.48	24,987.31	4.45%
Phosphors	1,740.06	1,686.40	1,851.85	3,074.63	10.67%
Ceramics	2,381.36	2,346.22	2,456.35	3,150.86	5.11%
Metal Alloys	12,210.49	12,036.90	12,581.25	15,995.73	4.92%
Glass Additives	9,968.23	9,892.61	10,131.34	11,532.78	2.63%
Others	3,881.03	3,823.66	4,003.47	5,137.72	5.12%
Total	**73,170.24**	**71,133.16**	**74,028.55**	**92,007.41**	**4.44%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.4 PRASEODYMIUM OXIDE

7.4.1 CAN BE USED FOR CREATING HIGH-STRENGTH METALS FOUND IN AIRCRAFT ENGINES

Praseodymium is soft, silvery metal was first used to create a yellow-orange stain for ceramics. Although it is still used to color certain types of glasses and gems, praseodymium is primarily used in rare-earth magnets. It can also be found in applications as diverse as creating high-strength metals found in aircraft engines and flint for starting fires. It is known for its magnetic, electrical, chemical, and optical properties. It occurs at an average of eight parts per million. The primary source of the metal is from the mineral bastnaesite. The bastnaesite deposits in China and the US comprise the largest source of praseodymium.

Praseodymium is an important component in a wide range of applications due to its excellent optical, magnetic, electrical, and chemical properties. It is used along with neodymium to create super-strong permanent magnets used in a lot of emerging clean energy applications. It is used along with magnesium to make high-strength alloys used in aircraft. It is also used as a glass additive as it gives a characteristic yellow color to glasses. Praseodymium oxide is widely used as a catalyst in making plastic and polyethylene products, such as soda bottles, bubble wraps, and milk packaging.

TABLE 14 PRASEODYMIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	659.75	596.68	673.34	1274.79	13.62%
Catalyst	32.39	31.99	33.23	40.86	4.22%
Glass Polishing	48.55	47.51	50.74	72.48	7.39%
Ceramics	60.08	58.64	63.10	93.86	8.27%
Metal Alloys	57.82	56.80	59.98	80.62	6.09%
Glass Additives	7.21	7.13	7.37	8.85	3.72%
Others	18.19	17.81	18.99	26.91	7.22%
Total	**883.98**	**816.56**	**906.76**	**1598.38**	**12.01%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 15 PRASEODYMIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	14,095.37	12,797.20	14,376.43	26,565.80	13.07%
Catalyst	697.68	690.12	713.91	858.18	3.75%
Glass Polishing	1,038.70	1,017.97	1,082.59	1,511.69	6.91%
Ceramics	1,278.50	1,249.66	1,339.35	1,950.49	7.81%
Metal Alloys	1,241.48	1,221.34	1,284.38	1,687.80	5.61%
Glass Additives	150.09	148.68	153.12	179.68	3.25%
Others	394.51	386.77	410.90	570.59	6.79%
Total	**18,896.33**	**17,511.74**	**19,360.69**	**33,324.22**	**11.47%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.5 NEODYMIUM OXIDE

7.5.1 USED FOR MAKING PERMANENT MAGNETS

Neodymium is a soft, silvery metal, neodymium, that is used with praseodymium to create some of the strongest permanent magnets available today. These magnets are found in most modern vehicles and aircraft as well as popular consumer electronics, such as headphones, microphones, and computer discs. Neodymium is also used to make high-powered, infrared lasers for industrial and defense applications. Neodymium metal is typically prepared by calciothermic reduction of the transparent violet-colored crystals of praseodymium fluoride. It is known for its magnetic, electrical, chemical, and optical properties. It occurs at an average of 28 parts per million. The primary source of the metal is the mineral bastnaesite. The bastnaesite deposits in China and the US comprises the largest source of neodymium.

Neodymium is an important component in a wide range of applications due to its excellent optical, magnetic, electrical, and chemical properties. It is used in high-strength permanent magnets that are also known as neodymium-iron-boron (NdFeB) magnets and are one of the strongest magnets in the world. A miniature NdFeB magnet is used in mobile vibrators as well. These permanent magnets are used in a lot of clean energy applications, including wind turbines, hybrid electric vehicles, and autocatalysts. These magnets are also broadly used in various products, such as microphones, loudspeakers, in-ear headphones, and hard disks.

TABLE 16 NEODYMIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	2044.17	1857.64	2091.83	3934.61	13.47%
Catalyst	22.13	21.94	22.55	26.17	3.03%
Ceramics	127.96	124.82	134.56	202.22	8.49%
Metal Alloys	184.63	181.42	191.45	256.41	6.02%
Glass Additives	21.81	21.63	22.20	25.60	2.89%
Others	73.66	72.19	76.77	107.17	6.90%
Total	**2,474.36**	**2,279.64**	**2,539.37**	**4,552.19**	**12.38%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 17 NEODYMIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	41,649.13	37,988.72	42,586.90	78,182.03	12.92%
Catalyst	451.46	448.19	458.52	518.95	2.51%
Ceramics	2,617.93	2,557.61	2,745.06	4,028.26	7.97%
Metal Alloys	3,765.46	3,705.90	3,892.38	5,080.87	5.47%
Glass Additives	439.33	436.36	445.75	500.43	2.34%
Others	1,510.65	1,482.94	1,569.46	2,134.88	6.35%
Total	**50,433.96**	**46,619.73**	**51,698.07**	**90,445.42**	**11.84%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.6 SAMARIUM OXIDE

7.6.1 USED FOR MAKING PERMANENT MAGNETS FOR DEFENSE & COMMERCIAL TECHNOLOGIES

Samarium is a silvery metal that can be used in several vital ways, including in very powerful magnets for transportation, defense, and commercial technologies. In conjunction with other compounds, it can also be used for intravenous radiation treatments to kill cancer cells. It is also used to help treat lung, prostate, breast, and some forms of bone cancers. Samarium is also used to control the rods of nuclear reactors as it is a stable neutron absorber. Samarium metal is typically prepared by calciothermic reduction of the transparent violet-colored crystals of neodymium fluoride. It is known for its magnetic, electrical, chemical, and optical properties. It is not as abundantly found in the earth's crust as it occurs at an average of 6 parts per million. The primary source of the metal is from the mineral bastnaesite. The bastnaesite deposits in China and the US comprises the largest source of samarium.

Samarium is an important component in a wide range of applications due to its excellent optical, magnetic, electrical, and chemical properties. It is used in high-strength permanent magnets, which are also known as samarium-cobalt (SmCo) magnets. These are among the strongest magnets in the world. These metals are key components in lasers used in biomedical applications, such as X-ray and MRI scanning. These magnets are also broadly used in various products, such as microphones, loudspeakers, in-ear headphones, and hard disks.

TABLE 18 SAMARIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	1.12	1.04	1.12	1.70	8.58%
Metal Alloys	0.85	0.84	0.88	1.10	4.53%
Others	0.33	0.32	0.34	0.42	4.38%
Total	**2.30**	**2.21**	**2.34**	**3.21**	**6.53%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 19 SAMARIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	600.70	559.24	602.11	887.99	8.08%
Metal Alloys	511.04	504.98	524.03	640.74	4.10%
Others	158.25	156.44	162.12	196.79	3.95%
Total	**1,269.99**	**1,220.66**	**1,288.26**	**1,725.52**	**6.02%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.7 EUROPIUM OXIDE

7.7.1 GENERALLY USED IN MAKING VISIBLE LIGHTS IN COMPACT FLUORESCENT BULBS

Europium is a hard metal used to create visible light in compact fluorescent bulbs and color displays, for instance, in LCD televisions. It is also used to make the special phosphors marks on the Euro notes to help prevent counterfeiting. This metal is the most reactive among rare-earth metals and can ignite at 302°F to 356°F. The metal is hard and brittle. Europium metal is typically prepared by calciothermic reduction of the transparent violet-colored crystals of neodymium fluoride. It is known for its magnetic, electrical, chemical, and optical properties. It occurs at an average of six parts per million. The primary source of the metal is from the mineral bastnaesite. The bastnaesite deposits in China and the US comprises the largest source of europium.

Compared to other rare-earth metals the commercial applications of rare-earth metals are few and specialized. It is known for its use in phosphors in television sets and fluorescent lamps. It is also used as a tag on currencies to prevent forgery. Europium borate (EuBr6) is also used in nuclear fission to absorb neutrons and control the fission process.

TABLE 20 EUROPIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	25.16	23.31	25.75	44.03	11.32%
Others	1.51	1.49	1.56	2.04	5.50%
Total	**26.67**	**24.80**	**27.31**	**46.07**	**11.02%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 21 EUROPIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	821.61	763.88	840.13	1,402.76	10.80%
Others	48.07	47.38	49.54	63.15	4.97%
Total	**869.68**	**811.26**	**889.68**	**1,465.91**	**10.50%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.8 GADOLINIUM OXIDE

7.8.1 USED AS A MAJOR CONTRIBUTOR TO MODERN HEALTHCARE SOLUTIONS

Gadolinium is a silvery-white rare-earth metal and a member of the light rare-earth elements group. Gadolinium has particular properties that make it especially suitable for shielding in nuclear reactors and neutron radiography. It is also used to help target tumors in neuron therapy as well as enhance magnetic resonance imaging (MRI). X-rays and bone density tests also use gadolinium, making this rare-earth element a major contributor to modern health care solutions. This metal is stable in a dry atmosphere but reacts with moisture in the air to form a greenish oxide coating. The metal is malleable and ductile. Gadolinium metal is typically prepared by calciothermic reduction of the transparent violet-colored crystals of gadolinium fluoride. Gadolinium shows ferromagnetic properties at temperatures below 68°F and is strongly paramagnetic above this temperature. It occurs at an average of five parts per million. The primary source of the metal is from the mineral bastnaesite. The bastnaesite deposits in China and the US comprise the largest source of gadolinium.

TABLE 22 GADOLINIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	33.50	30.25	34.05	64.09	13.48%
Phosphors	7.89	7.62	8.44	14.69	11.72%
Others	2.84	2.80	2.92	3.62	4.41%
Total	**44.23**	**40.67**	**45.41**	**82.40**	**12.66%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 23 GADOLINIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	1,231.57	1,116.51	1,250.66	2,292.91	12.89%
Phosphors	301.06	291.38	321.18	544.29	11.13%
Others	97.88	96.77	100.24	121.37	3.90%
Total	**1,630.51**	**1,504.66**	**1,672.09**	**2,958.57**	**12.09%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.9 TERBIUM OXIDE

7.9.1 USED IN COMPACT FLUORESCENT LIGHTING AND COLOR DISPLAYS

Terbium is the first element of the heavy rare-earth elements group. is a silvery rare-earth metal that is so soft it can be cut with a knife. Terbium is often used in compact fluorescent lighting, color displays, and as an additive, to permanent rare-earth magnets so they can function better under higher temperatures. It can also be found in fuel cells designed to operate at elevated temperatures and some electronic devices as well as naval sonar systems. Terbium in its alloy form has the highest magnetostriction of any such substance. Owing to its magnetization, in its alloy form it is easy to change its shape, making it a vital component of Terfenol-D, which is used in many defense and commercial technologies. It is one of the rarest rare-earth metals found in the earth's crust as it occurs at an average of 0.5 parts per million. Terbium is usually found in the heavy rare-earth-enriched minerals, such as monazite and xenotime. It is abundant in monazite deposits located in Canada. The element is mined from mineral-rich sands. The ore deposits are mined through dredge floating methods. This separates the heavy rare-earth minerals from the lightweight fractions. The process that then follows is similar to the one used for the light rare-earth metals.

Terbium is mostly used in green phosphors in all types of screens, including television, computers, and digital display boards. It is also used in alloys and the production of various electronic devices. It is used as a key component of Terfenol-D, which is further used in naval sonar systems, actuators, sensors, and other magneto-mechanical devices.

TABLE 24 TERBIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	611.40	552.55	622.69	1,187.81	13.79%
Permanent Magnets	105.51	101.03	114.68	227.73	14.71%
Total	**716.90**	**653.57**	**737.38**	**1,415.54**	**13.93%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 25 TERBIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	916.35	831.31	932.80	1,738.16	13.26%
Permanent Magnets	153.31	147.03	166.20	322.53	14.18%
Total	**1,069.66**	**978.34**	**1,099.00**	**2,060.69**	**13.40%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.10 DYSPROSIUM OXIDE

7.10.1 USED IN LASERS AND COMMERCIAL LIGHTING

Dysprosium is a bright silvery metal and one of the most expensive metals on the planet. Dysprosium is a soft, silver metal with one of the highest magnetic strengths of all of the rare-earth metals, matched only by holmium. Dysprosium is often added to permanent rare-earth magnets to help them operate more efficiently at higher temperatures. Lasers and commercial lighting use dysprosium as do hard computer disks and other electronics, which require certain magnetic properties. Dysprosium can also be used in nuclear reactors and modern, energy-efficient vehicles. It is soft and ductile, physically. Dysprosium is moderately stable in air and does not readily oxidize in the presence of air. This rare-earth metal is never found freely in nature, instead it is found in minerals, such as xenotime, bastnaesite, and monazite. Dysprosium is found mostly in ion–adsorption clay ores in China.

Dysprosium is mainly used in super-strong permanent magnets along with other rare-earth metals like neodymium. It is also one of the components of Terfenol-D, which is used in transducers and mechanical resonators. They are also used as catalysts to reinforce other metals.

TABLE 26 DYSPROSIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	768.28	702.63	789.33	1,479.37	13.39%
Permanent Magnets	12.05	11.84	12.50	16.78	6.07%
Total	**780.34**	**714.47**	**801.83**	**1,496.15**	**13.29%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 27 DYSPROSIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	2,920.70	2,680.60	2,997.33	5,477.92	12.82%
Permanent Magnets	44.69	43.98	46.21	60.42	5.51%
Total	**2,965.39**	**2,724.58**	**3,043.54**	**5,538.34**	**12.72%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.11 YTTRIUM OXIDE

7.11.1 GENERALLY USED TO PRODUCE SUPERCONDUCTORS

Yttrium is a silvery dark grey metal that is relatively stable in air, and turnings of the metal will ignite at temperatures above 752°F. It is a non-lanthanide rare-earth element used to produce superconductors, powerful pulsed lasers, cancer treatment drugs, rheumatoid arthritis medicines, and surgical supplies. Silvery metal in color, it is also used in many popular consumer products, such as televisions and camera lenses. The demand for yttrium is expected to grow in the future as more and more defense-related applications for yttrium oxide are being developed.

This rare-earth metal is relatively abundant, and occurs at an average concentration of 33 parts per million in the earth's crust. Yttrium is generally sourced from mineral ores, such as monazite and xenotime.

TABLE 28 YTTRIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	26.38	23.29	26.11	47.48	12.70%
Ceramics	29.24	28.62	30.56	43.61	7.37%
Glass Additives	1.19	1.17	1.22	1.53	4.60%
Others	5.72	5.58	6.01	8.97	8.35%
Total	**62.53**	**58.66**	**63.90**	**101.59**	**9.72%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 29 YTTRIUM OXIDE MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Phosphors	8,920.77	7,933.15	8,850.74	15,658.01	12.09%
Ceramics	9,652.38	9,462.92	10,053.79	13,964.56	6.79%
Glass Additives	414.08	409.30	424.33	516.14	3.99%
Others	1,877.89	1,835.50	1,967.30	2,865.40	7.81%
Total	**20,865.12**	**19,640.88**	**21,296.15**	**33,004.10**	**9.16%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

7.12 OTHERS

The other rare-earth metals besides the ones discussed above are holmium, erbium, thulium, ytterbium, and lutetium. These are all part of the heavy rare-earth metals group. The element is mined from mineral-rich sands. These mineral sands are extracted from heavy rare-earth-rich mineral ores, such as xenotime and monazite. The ore deposits are mined through dredge floating methods. This separates the heavy rare-earth minerals from the lightweight fractions. The process that follows then is similar to the one used for the light rare-earth metals.

Some of the major applications for these elements are lasers, permanent magnets, commercial lighting, signal amplification for fiber optic cables, high-temperature superconductors and guidance systems in defense applications, fluid cracking catalysts, and LED light bulbs.

TABLE 30 OTHER OXIDES MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Glass Additives	43.06	42.11	43.41	51.18	3.35%
Others	1.61	1.60	1.64	1.81	2.10%
Total	**44.67**	**43.71**	**45.04**	**53.00**	**3.31%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 31 OTHER OXIDES MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Glass Additives	146.82	144.07	147.81	169.82	2.82%
Others	5.37	5.34	5.42	5.88	1.63%
Total	**152.19**	**149.41**	**153.23**	**175.70**	**2.78%**

Note: Only applications which use above rare-earth metals have been considered.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8 RARE-EARTH METALS MARKET, BY APPLICATION

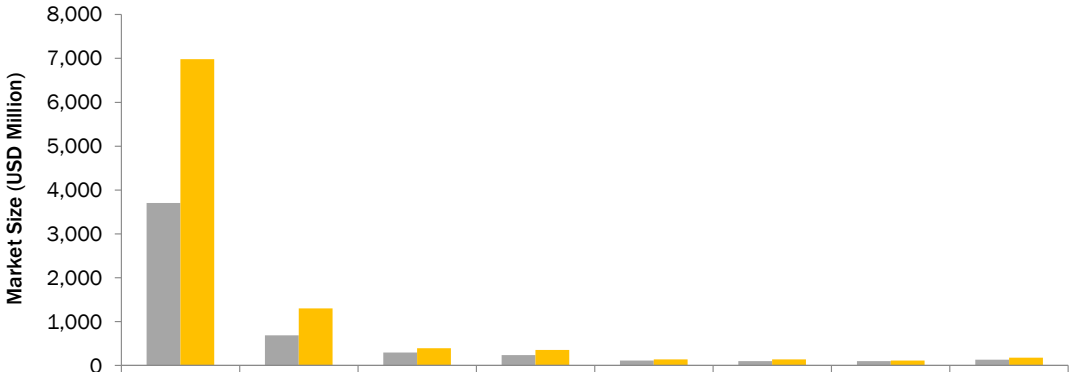
KEY FINDINGS

- The rare-earth metals market is dominated by the permanent magnets application, which accounted for a major share of 68.20%, in terms of value, in 2020.
- The permanent magnets segment is projected to grow from USD 3,704.36 million in 2021 to USD 6,982.28 million by 2026, at a high CAGR of 13.52%, by value.
- Phosphors have the second-largest market in 2021, with a share of 12.68% because of their high demand in fluorescent and LED lamps.
- In 2020, Neodymium accounted for the maximum share of 81.50% in the permanent magnets application.

8.1 INTRODUCTION

Rare-earth metals are used in mature markets and newer applications, which are high growth markets. The rare-earth metals are increasingly used in new technologies, such as clean energy, defense, and consumer electronics sectors. In terms of application of rare-earth oxides, this market can be segmented into eight types. The major applications of rare-earth oxides are permanent magnets, metal alloys, polishing, glass additives, catalysts, phosphors, and ceramics. The ever-rising demand for permanent magnets in the global automotive industry leads to an increase in the usage of rare-earth metals. Hence, in the present scenario, the permanent magnets application dominates the rare-earth metals usage.

FIGURE 35 PERMANENT MAGNETS SEGMENT TO LEAD THE MARKET



	Permanent Magnets	Phosphors	Metal Alloys	Ceramics	Catalysts	Glass Polishing	Glass Additives	Others
2021	3,704.36	688.29	293.97	238.14	112.44	101.06	97.77	130.81
2026	6,982.28	1,302.71	391.97	352.92	138.54	135.91	114.74	181.13
CAGR (2021-2026)	13.52%	13.61%	5.92%	8.19%	4.26%	6.11%	3.25%	6.73%

Note: Others include defense technologies and satellite power and communications systems.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 32 RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (USD MILLION)

Applications	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	3,612.34	3,289.26	3,704.36	6,982.28	13.52%
Metal Alloys	283.65	278.79	293.97	391.97	5.92%
Glass Polishing	97.44	95.73	101.06	135.91	6.11%
Glass Additives	96.37	94.93	97.77	114.74	3.25%
Catalysts	112.92	108.16	112.44	138.54	4.26%
Phosphors	675.80	611.59	688.29	1,302.71	13.61%
Ceramics	226.85	221.49	238.14	352.92	8.19%
Others	125.65	123.21	130.81	181.13	6.73%
Total	**5,231.02**	**4,823.18**	**5,366.84**	**9,600.22**	**12.33%**

Note: Others include defense technologies and satellite power and communications systems.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 33 RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	60,650.79	55,289.30	61,979.63	113,729.16	12.91%
Metal Alloys	29,601.37	29,181.24	30,498.72	38,765.55	4.91%
Glass Polishing	30,069.69	29,696.28	30,869.11	38,114.07	4.31%
Glass Additives	14,804.32	14,687.44	15,051.40	17,193.86	2.70%
Catalysts	36,073.10	33,825.02	35,165.59	43,222.10	4.21%
Phosphors	13,884.54	12,660.31	14,045.40	24,330.94	11.62%
Ceramics	19,317.20	18,947.50	20,100.66	27,723.59	6.64%
Others	9,901.82	9,730.21	10,266.40	13,755.00	6.03%
Total	**214,302.82**	**204,017.28**	**217,976.91**	**316,834.27**	**7.77%**

Note: Others include defense technologies and satellite power and communications systems.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.2 PERMANENT MAGNETS

8.2.1 GROWING AUTOMOTIVE INDUSTRY IS DRIVING THE SEGMENT

The permanent magnets industry is the largest end user of rare-earth elements. The magnets made from neodymium, praseodymium, and dysprosium are the strongest known permanent magnets. The automotive industry is a significant demand driver for 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.

The permanent magnets are the preferred choice in the 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.

TABLE 34 REAR EARTH METALS MARKET SIZE IN PERMANENT MAGNETS, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Neodymium Oxide	2,044.17	1,857.64	2,091.83	3,934.61	13.47%
Praseodymium Oxide	659.75	596.68	673.34	1,274.79	13.62%
Dysprosium Oxide	768.28	702.63	789.33	1,479.37	13.39%
Samarium Oxide	1.12	1.04	1.12	1.70	8.58%
Terbium Oxide	105.51	101.03	114.68	227.73	14.71%
Gadolinium Oxide	33.50	30.25	34.05	64.09	13.48%
Total	**3,612.34**	**3,289.26**	**3,704.36**	**6,982.28**	**13.52%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 35 REAR EARTH METALS MARKET SIZE IN PERMANENT MAGNETS, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Neodymium Oxide	41,649.13	37,988.72	42,586.90	78,182.03	12.92%
Praseodymium Oxide	14,095.37	12,797.20	14,376.43	26,565.80	13.07%
Dysprosium Oxide	2,920.70	2,680.60	2,997.33	5,477.92	12.82%
Samarium Oxide	600.70	559.24	602.11	887.99	8.08%
Terbium Oxide	153.31	147.03	166.20	322.53	14.18%
Gadolinium Oxide	1,231.57	1,116.51	1,250.66	2,292.91	12.89%
Total	**60,650.79**	**55,289.30**	**61,979.63**	**113,729.16**	**12.91%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.3 CATALYSTS

8.3.1 CATALYST ARE EXTENSIVELY USED IN AUTOMOTIVE EXHAUST SYSTEM

The highly effective metals of the catalyst systems are cerium and lanthanum. They have properties of absorbing, storing, and releasing oxygen and also stabilizing the environments in which they are operated. The 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. The 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 a catalyst's category of usage will be directly dependent on the worldwide growth in automobile production and fluid cracking. The economical and technical viability of rare-earth oxide catalysts at commercial sites could boost the demand in the automotive industry

TABLE 36 REAR EARTH METALS MARKET SIZE IN CATALYSTS, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	38.73	36.11	37.73	47.68	4.79%
Lanthanum Oxide	19.68	18.12	18.93	23.83	4.72%
Praseodymium Oxide	32.39	31.99	33.23	40.86	4.22%
Neodymium Oxide	22.13	21.94	22.55	26.17	3.03%
Total	**112.92**	**108.16**	**112.44**	**138.54**	**4.26%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 37 REAR EARTH METALS MARKET SIZE IN CATALYSTS, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	23,432.30	22,042.29	22,908.81	28,128.37	4.19%
Lanthanum Oxide	11,491.66	10,644.42	11,084.35	13,716.58	4.35%
Praseodymium Oxide	697.68	690.12	713.91	858.18	3.75%
Neodymium Oxide	451.46	448.19	458.52	518.95	2.51%
Total	**36,073.10**	**33,825.02**	**35,165.59**	**43,222.10**	**4.21%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.4 GLASS POLISHING

8.4.1 DEMAND FOR GLASS POLISHING IS INCREASING IN VARIOUS END-USE INDUSTRIES

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

The 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 the rare-earth-based polishing powders are most effective, its rising prices in previous years have impacted the demand for the glass 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. These uses increase its consumption level.

TABLE 38 REAR EARTH METALS MARKET SIZE IN GLASS POLISHING, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	33.41	32.92	34.44	44.01	5.03%
Lanthanum Oxide	15.49	15.30	15.88	19.43	4.11%
Praseodymium Oxide	48.55	47.51	50.74	72.48	7.39%
Total	**97.44**	**95.73**	**101.06**	**135.91**	**6.11%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 39 REAR EARTH MARKET SIZE IN GLASS POLISHING, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	19,556.78	19,305.08	20,095.48	24,987.31	4.45%
Lanthanum Oxide	9,474.21	9,373.22	9,691.04	11,615.07	3.69%
Praseodymium Oxide	1,038.70	1,017.97	1,082.59	1,511.69	6.91%
Total	**30,069.69**	**29,696.28**	**30,869.11**	**38,114.07**	**4.31%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.5 PHOSPHORS

8.5.1 INCREASING NEED FOR FLUORESCENT AND LED LAMPS DRIVES THE DEMAND FOR PHOSPHORS

Phosphors 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 designed colors. This is based on the properties of the elements that are included in the phosphors.

Rare-earth oxide phosphors are used in various instrument panels for backlighting applications. The suitable combination of phosphor coatings can convert the emissions of light from fluorescent lamps to any form of required lighting. The lighting industry accommodates relatively high rare-earth oxide prices, which would have a worse effect on the economics of the sector. The demand for rare-earth oxide phosphor products is expected to increase, due to the government policies in US, Canada, China, among other countries, and the European Union, where the incandescent lamps are being replaced with fluorescent and LED lamps.

TABLE 40 REAR EARTH METALS MARKET SIZE IN PHOSPHORS, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Yttrium Oxide	26.38	23.29	26.11	47.48	12.70%
Cerium Oxide	2.91	2.81	3.10	5.30	11.29%
Lanthanum Oxide	2.07	2.01	2.18	3.40	9.23%
Europium Oxide	25.16	23.31	25.75	44.03	11.32%
Gadolinium Oxide	7.89	7.62	8.44	14.69	11.72%
Terbium Oxide	611.40	552.55	622.69	1,187.81	13.79%
Total	**675.80**	**611.59**	**688.29**	**1,302.71**	**13.61%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 41 REAR EARTH METALS MARKET SIZE IN PHOSPHORS, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Yttrium Oxide	8920.77	7933.15	8850.74	15658.01	12.09%
Cerium Oxide	1740.06	1686.40	1851.85	3074.63	10.67%
Lanthanum Oxide	1184.69	1154.19	1248.70	1913.08	8.91%
Europium Oxide	821.61	763.88	840.13	1402.76	10.80%
Gadolinium Oxide	301.06	291.38	321.18	544.29	11.13%
Terbium Oxide	916.35	831.31	932.80	1738.16	13.26%
Total	**13884.54**	**12660.31**	**14045.40**	**24330.94**	**11.62%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.6 CERAMICS

8.6.1 INCREASED USE OF CERAMICS IN INDUSTRIAL ELECTRONICS

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 the Barium Titanate Dielectric material, which are further used to produce the ceramic chip capacitors. These are an essential part of advanced electronic packaging systems.

TABLE 42 RARE-EARTH METALS MARKET SIZE IN CERAMICS, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Yttrium Oxide	29.24	28.62	30.56	43.61	7.37%
Cerium Oxide	3.77	3.70	3.90	5.14	5.70%
Lanthanum Oxide	5.81	5.71	6.03	8.09	6.08%
Praseodymium Oxide	60.08	58.64	63.10	93.86	8.27%
Neodymium Oxide	127.96	124.82	134.56	202.22	8.49%
Total	**226.85**	**221.49**	**238.14**	**352.92**	**8.19%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 43 RARE-EARTH METALS MARKET SIZE IN CERAMICS, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Yttrium Oxide	9,652.38	9,462.92	10,053.79	13,964.56	6.79%
Cerium Oxide	2,381.36	2,346.22	2,456.35	3,150.86	5.11%
Lanthanum Oxide	3,387.02	3,331.08	3,506.11	4,629.42	5.72%
Praseodymium Oxide	1,278.50	1,249.66	1,339.35	1,950.49	7.81%
Neodymium Oxide	2,617.93	2,557.61	2,745.06	4,028.26	7.97%
Total	**19,317.20**	**18,947.50**	**20,100.66**	**27,723.59**	**6.64%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.7 METAL ALLOYS

8.7.1 INCREASED USE OF RARE-EARTH METALS FOR IMPROVING THE PHYSICAL PROPERTIES OF THE ALLOYS

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, 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 the cast iron alloy is used in auto engines to improve machineability. 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 economic growth of a particular company.

TABLE 44 RARE-EARTH METALS MARKET SIZE IN METAL ALLOYS, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	20.80	20.48	21.50	28.00	5.42%
Lanthanum Oxide	19.54	19.25	20.16	25.84	5.09%
Neodymium Oxide	184.63	181.42	191.45	256.41	6.02%
Praseodymium Oxide	57.82	56.80	59.98	80.62	6.09%
Samarium Oxide	0.85	0.84	0.88	1.10	4.53%
Total	**283.65**	**278.79**	**293.97**	**391.97**	**5.92%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 45 RARE-EARTH METALS MARKET SIZE IN METAL ALLOYS, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	12,210.49	12,036.90	12,581.25	15,995.73	4.92%
Lanthanum Oxide	11,872.90	11,712.12	12,216.68	15,360.41	4.69%
Neodymium Oxide	3,765.46	3,705.90	3,892.38	5,080.87	5.47%
Praseodymium Oxide	1,241.48	1,221.34	1,284.38	1,687.80	5.61%
Samarium Oxide	511.04	504.98	524.03	640.74	4.10%
Total	**29,601.37**	**29,181.24**	**30,498.72**	**38,765.55**	**4.91%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.8 GLASS ADDITIVES

8.8.1 RARE-EARTH METALS IMPROVE REFRACTIVE INDEX OF GLASS, WHICH DRIVES THE MARKET

The major rare-earth elements used in glass additives are cerium and lanthanum followed by smaller quantities of neodymium, praseodymium, yttrium, and erbium. The mixture of lanthanum and other rare-earths elements increases the refractive index of glass, which makes it easier to build better lenses. Cerium is used as a de-colorizer and also a color additive. Glass containing cerium compositions have the property to absorb UV light. The glasses made out of neodymium change color under different lighting conditions due to its yellow light filtering properties. Hence, it is used in rearview 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.

TABLE 46 RARE-EARTH METALS MARKET SIZE IN GLASS ADDITIVES, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	17.13	16.98	17.47	20.43	3.18%
Lanthanum Oxide	5.97	5.92	6.09	7.14	3.23%
Neodymium Oxide	21.81	21.63	22.20	25.60	2.89%
Praseodymium Oxide	7.21	7.13	7.37	8.85	3.72%
Yttrium Oxide	1.19	1.17	1.22	1.53	4.60%
Other Oxides	43.06	42.11	43.41	51.18	3.35%
Total	**96.37**	**94.93**	**97.77**	**114.74**	**3.16%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 47 RARE-EARTH METALS MARKET SIZE IN GLASS ADDITIVES, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	9,968.23	9,892.61	10,131.34	11,532.78	2.63%
Lanthanum Oxide	3,685.77	3,656.42	3,749.06	4,295.01	2.76%
Neodymium Oxide	439.33	436.36	445.75	500.43	2.34%
Praseodymium Oxide	150.09	148.68	153.12	179.68	3.25%
Yttrium Oxide	414.08	409.30	424.33	516.14	3.99%
Other Oxides	146.82	144.07	147.81	169.82	2.82%
Total	**14,804.32**	**14,687.44**	**15,051.40**	**17,193.86**	**2.70%**

Note: Only rare-earth metals used for this application have been considered

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

8.9 OTHERS

Rare-earth oxides are significant to current defense technologies because they are essential ingredients in some of the world's strongest permanent magnets. The military weapons that require these magnets are jet fighter electrical systems, missile guidance systems, underwater mine detection systems, antimissile defense systems, and satellite power and communications systems. Many countries believe that the continued supply of rare-earth oxides is a crucial element of national security because rare-earth oxides are vital to such expensive military technologies.

TABLE 48 RARE-EARTH METALS MARKET SIZE IN OTHER APPLICATIONS, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	6.64	6.53	6.87	9.05	5.66%
Praseodymium Oxide	18.19	17.81	18.99	26.91	7.22%
Lanthanum Oxide	3.10	3.05	3.22	4.35	6.21%
Neodymium Oxide	73.66	72.19	76.77	107.17	6.90%
Samarium Oxide	0.33	0.32	0.34	0.42	4.38%
Gadolinium Oxide	2.84	2.80	2.92	3.62	4.41%
Yttrium Oxide	5.72	5.58	6.01	8.97	8.35%
Dysprosium Oxide	12.05	11.84	12.50	16.78	6.07%
Europium Oxide	1.51	1.49	1.56	2.04	5.50%
Other Oxides	1.61	1.60	1.64	1.81	2.10%
Total	**125.65**	**123.21**	**130.81**	**181.13**	**6.73%**

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 49 RARE-EARTH MARKET SIZE IN OTHER APPLICATIONS, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	3,881.03	3,823.66	4,003.47	5,137.72	5.12%
Praseodymium Oxide	394.51	386.77	410.90	570.59	6.79%
Lanthanum Oxide	1,883.50	1,851.42	1,951.73	2,598.79	5.89%
Neodymium Oxide	1,510.65	1,482.94	1,569.46	2,134.88	6.35%
Samarium Oxide	158.25	156.44	162.12	196.79	3.95%
Gadolinium Oxide	97.88	96.77	100.24	121.37	3.90%
Yttrium Oxide	1,877.89	1,835.50	1,967.30	2,865.40	7.81%
Dysprosium Oxide	44.69	43.98	46.21	60.42	5.51%
Europium Oxide	48.07	47.38	49.54	63.15	4.97%
Other Oxides	5.37	5.34	5.42	5.88	1.63%
Total	**9,901.82**	**9,730.21**	**10,266.40**	**13,755.00**	**6.03%**

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

9 RARE-EARTH METALS MARKET, BY REGION

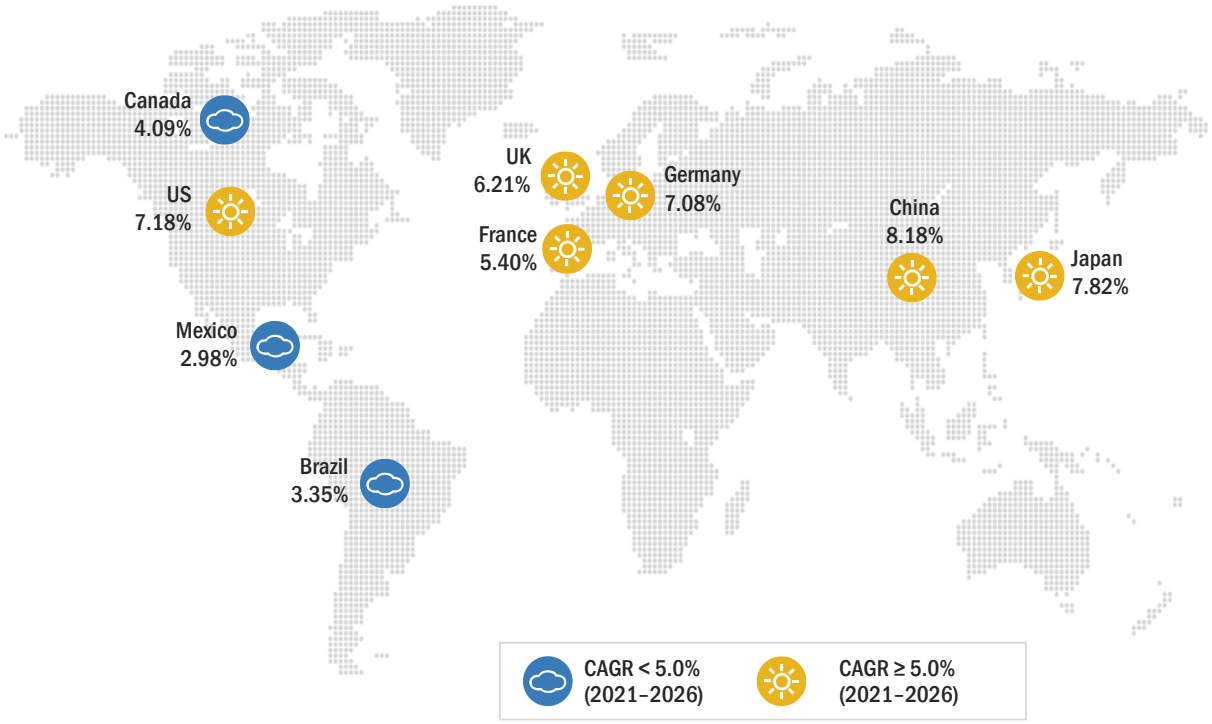
KEY FINDINGS

- The global demand for rare-earth metals was estimated at 217,977 metric tons in 2021.
- APAC is the top region in terms of total rare-earth material consumption in terms of volume due to rapidly increasing demand in China, which accounts for approximately 47.03% of global rare-earth metals consumption.
- Neodymium oxide accounted for the highest market share in terms of value in APAC with 37.30% of the total share in 2020.
- The APAC market for rare-earth metals, in terms of volume, is projected to grow at the highest CAGR of 7.98% from 2021 to 2026.
- Increasing investments by leading automobile manufacturers in European countries and technological advancement in electric vehicles are contributing to the growth of the rare-earth metals market, globally.

9.1 INTRODUCTION

The global demand for rare-earth oxides REOs was estimated at 214,303 tons in 2019. The new mining projects could take as long as 5 to 10 years to reach production. However, in the long run, the US Geological Survey expects that the world's reserves and undiscovered resources would be large enough to meet the demand. APAC is the highest producer, where 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, 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, and such increasing demand leads to the need for higher the global production of rare-earth elements, requiring a steady supply chain in the long run.

FIGURE 36 REGIONAL SNAPSHOT: CHINA TO BE THE FASTEST-GROWING COUNTRY-LEVEL MARKET FROM 2021 TO 2026



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

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 50 RARE-EARTH METALS MARKET SIZE, BY REGION, 2018–2025 (USD MILLION)

Region	2019	2020	2021	2026	CAGR (2021–2026)
North America	586.00	566.78	625.88	1074.84	11.42%
Europe	308.33	303.28	329.24	523.18	9.71%
APAC	4,286.61	3,905.17	4,359.12	7,910.53	12.66%
Rest of the World	50.08	47.95	52.60	91.67	11.75%
Total	**5,231.02**	**4,823.18**	**5,366.84**	**9,600.22**	**12.33%**

Note: Rest of the World includes Argentina and the Middle East & African countries.

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 51 RARE-EARTH METALS MARKET SIZE, BY REGION, 2018–2025 (METRIC TON)

Region	2019	2020	2021	2026	CAGR (2021–2026)
North America	23,341.15	22,881.80	24,307.69	34,209.04	7.07%
Europe	12,054.53	11,942.65	12,520.98	16,504.97	5.68%
APAC	176,501.82	166,867.74	178,646.26	262,202.41	7.98%
Rest of the World	2,405.33	2,325.10	2,501.98	3,917.84	9.38%
Total	**214,302.82**	**204,017.28**	**217,976.91**	**316,834.27**	**7.77%**

Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 52 RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	123.39	119.53	125.02	159.61	5.01%
Lanthanum Oxide	71.66	69.36	72.48	92.08	4.90%
Neodymium Oxide	2474.36	2279.64	2539.37	4552.19	12.38%
Yttrium Oxide	62.53	58.66	63.90	101.59	9.72%
Praseodymium Oxide	883.98	816.56	906.76	1598.38	12.01%
Samarium Oxide	2.30	2.21	2.34	3.21	6.53%
Gadolinium Oxide	44.23	40.67	45.41	82.40	12.66%
Dysprosium Oxide	780.34	714.47	801.83	1496.15	13.29%
Terbium Oxide	716.90	653.57	737.38	1415.54	13.93%
Europium Oxide	26.67	24.80	27.31	46.07	11.02%
Others	44.67	43.71	45.04	53.00	3.31%
Total	**5,231.02**	**4,823.18**	**5,366.84**	**9,600.22**	**12.33%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 53 RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	73,170.24	71,133.16	74,028.55	92,007.41	4.44%
Lanthanum Oxide	42,979.76	41,722.88	43,447.67	54,128.38	4.49%
Neodymium Oxide	50,433.96	46,619.73	51,698.07	90,445.42	11.84%
Yttrium Oxide	20,865.12	19,640.88	21,296.15	33,004.10	9.16%
Praseodymium Oxide	18,896.33	17,511.74	19,360.69	33,324.22	11.47%
Samarium Oxide	1,269.99	1,220.66	1,288.26	1,725.52	6.02%
Gadolinium Oxide	1,630.51	1,504.66	1,672.09	2,958.57	12.09%
Dysprosium Oxide	2,965.39	2,724.58	3,043.54	5,538.34	12.72%
Terbium Oxide	1,069.66	978.34	1,099.00	2,060.69	13.40%
Europium Oxide	869.68	811.26	889.68	1,465.91	10.50%
Others	152.19	149.41	153.23	175.70	2.78%
Total	**214,302.82**	**204,017.28**	**217,976.91**	**316,834.27**	**7.77%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 54 RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

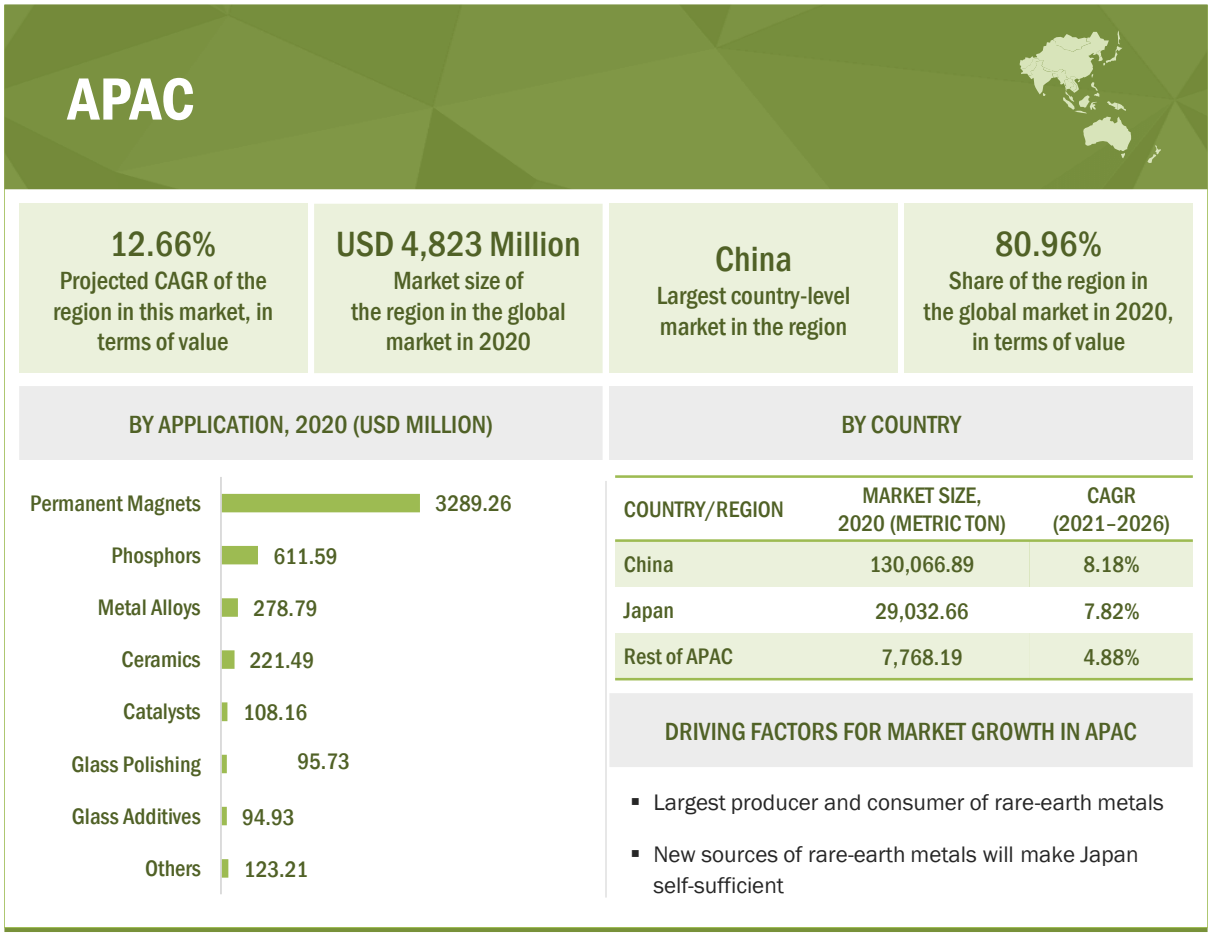
Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	60,650.79	55,289.30	61,979.63	113,729.16	12.91%
Metal Alloys	29,601.37	29,181.24	30,498.72	38,765.55	4.91%
Glass Polishing	30,069.69	29,696.28	30,869.11	38,114.07	4.31%
Glass Additives	14,804.32	14,687.44	15,051.40	17,193.86	2.70%
Catalysts	36,073.10	33,825.02	35,165.59	43,222.10	4.21%
Phosphors	13,884.54	12,660.31	14,045.40	24,330.94	11.62%
Ceramics	19,317.20	18,947.50	20,100.66	27,723.59	6.64%
Others	9,901.82	9,730.21	10,266.40	13,755.00	6.03%
Total	**214,302.82**	**204,017.28**	**217,976.91**	**316,834.27**	**7.77%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.2 APAC

APAC is the top region in terms of total rare-earth material consumption due to rapidly increasing demand in China, which accounts for maximum global rare-earth consumption. It was the largest consumer of rare-earth elements in 2019, with an estimated market revenue of over USD 5.2 billion. The region is also expected to witness the fastest-growth in terms of consumption due to growing industrialization and extraction activities in China. The major companies in APAC are China Northern Rare Earth (Group) High-Tech Co., Ltd. (China), and China Minmetals Rare Earth Co Ltd (China). The increasing growth of the industry alliances coupled with leading innovations and developments are further expected to foster the industrial growth of the rare-earth metals in the APAC region

FIGURE 37 APAC: RARE-EARTH METALS MARKET SNAPSHOT



Source: Related Research Publications, Government Publications, Company Press Releases, Company Websites, Company Publications, and MarketsandMarkets Analysis

TABLE 55 APAC: RARE-EARTH METALS MARKET SIZE, BY COUNTRY, 2019–2026 (METRIC TON)

Country	2019	2020	2021	2026	CAGR (2021–2026)
China	138,586.96	130,066.89	139,741.18	207,032.77	8.18%
Japan	29,936.54	29,032.66	30,834.65	44,927.84	7.82%
Rest of APAC	7,978.32	7,768.19	8,070.42	10,241.80	4.88%
Total	**176,501.82**	**166,867.74**	**178,646.26**	**262,202.41**	**7.98%**

Note: Other countries in APAC include India, Australia, and Malaysia.

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 56 APAC: RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	99.94	96.39	100.88	128.94	5.03%
Lanthanum Oxide	58.69	56.50	59.26	76.64	5.28%
Neodymium Oxide	2027.77	1,845.58	2,062.65	3,753.26	12.72%
Yttrium Oxide	51.23	47.61	52.02	83.83	10.01%
Praseodymium Oxide	724.46	661.41	736.77	1,317.13	12.32%
Samarium Oxide	1.89	1.80	1.91	2.65	6.80%
Gadolinium Oxide	36.24	32.92	36.87	67.88	12.99%
Dysprosium Oxide	639.78	578.17	651.06	1,233.44	13.63%
Terbium Oxide	588.14	528.96	598.63	1,164.96	14.24%
Europium Oxide	21.85	20.10	22.21	38.00	11.34%
Others	36.62	35.72	36.87	43.81	3.51%
Total	**4,286.61**	**3,905.17**	**4,359.12**	**7,910.53**	**12.66%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 57 APAC: RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	59,816.08	57,935.05	60,320.08	74,997.45	4.45%
Lanthanum Oxide	35,534.47	34,343.23	35,850.41	45,204.53	4.75%
Neodymium Oxide	41,697.13	38,117.95	42,401.28	75,233.30	12.15%
Yttrium Oxide	17,250.52	16,099.96	17,505.71	27,485.60	9.44%
Praseodymium Oxide	15,622.91	14,324.33	15,883.00	27,701.47	11.77%
Samarium Oxide	1,050.15	1,003.61	1,061.83	1,439.45	6.27%
Gadolinium Oxide	1,347.80	1,229.78	1,370.75	2,458.77	12.40%
Dysprosium Oxide	2,452.58	2,226.71	2,495.16	4,604.79	13.04%
Terbium Oxide	885.16	799.60	900.78	1,710.39	13.68%
Europium Oxide	719.05	664.20	730.53	1,219.93	10.80%
Others	125.97	123.33	126.72	146.72	2.97%
Total	**176,501.82**	**166,867.74**	**178,646.26**	**262,202.41**	**7.98%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 58 APAC: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	53,850.32	48,422.88	54,228.06	99,282.20	12.86%
Metal Alloys	24,897.09	24,550.16	25,661.62	32,548.90	4.87%
Glass Polishing	26,536.89	26,260.62	27,273.44	33,461.47	4.17%
Glass Additives	11,656.42	11,591.05	11,863.88	13,426.60	2.51%
Catalysts	24,109.67	22,064.42	23,044.91	28,897.73	4.63%
Phosphors	11,320.29	10,217.22	11,406.40	20,240.19	12.15%
Ceramics	16,026.71	15,779.69	16,746.90	23,101.09	6.64%
Others	8,104.42	7,981.70	8,421.05	11,244.23	5.95%
Total	**176,501.82**	**166,867.74**	**178,646.26**	**262,202.41**	**7.98%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.2.1 CHINA

9.2.1.1 Largest producer 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, which enabled it to become a prominent supplier of rare-earth metals. Despite being rich in rare-earth resources and producer of a number of different kinds of rare-earth products, the 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.

China's exports of rare-earth compounds (HScode 2846) were 45,700 t (gross weight) compared with 42,100 t in 2018. The top five export destinations were (in descending order), 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 t (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 upon 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 of the country's actual output of rare-earth concentrate compared to the national production target.

TABLE 59 CHINA: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	41,701.18	37,264.93	42,035.72	77,365.62	12.98%
Metal Alloys	19,835.00	19,250.14	20,207.67	26,259.80	5.38%
Glass Polishing	21,221.82	20,461.88	21,364.22	26,941.07	4.75%
Glass Additives	9,055.60	8,845.23	9,087.13	10,512.81	2.96%
Catalysts	18,880.29	18,121.67	19,004.28	24,564.89	5.27%
Phosphors	8,315.18	7,577.58	8,405.35	14,655.69	11.76%
Ceramics	13,184.25	12,436.83	13,171.71	17,953.45	6.39%
Others	6,393.64	6,108.63	6,465.11	8,779.45	6.31%
Total	**138,586.96**	**130,066.89**	**139,741.18**	**207,032.77**	**8.18%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.2.2 JAPAN

9.2.2.1 New sources of rare-earth metals will make the 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 still relies on China for almost all of its rare-earth material. Japan started seeking its own rare-earth metals after China held back shipments in 2010 during a dispute over islands both countries claim, Reuters reported in 2014. A major electronics manufacturer, Japan needs rare-earth metals for components. But recently, researchers have found hundreds of years' worth of rare-earth materials underneath Japanese waters — enough to supply to the world on a "semi-infinite basis," according to a study published in Nature Publishing Group's Scientific Reports. The seabed contains more than 16 million tons of rare-earth oxides, according to the study. That's equivalent to 780 years' worth of yttrium supply, 620 years of europium, 420 years of terbium, and 730 years of dysprosium.

In February 2020, the Japanese government partnered with the US. And Australia on investing in processing facilities for rare-earth metals, looking to ease reliance on imports from China.

Rare-earth metals are essential to high-tech machinery like motors for electric vehicles. But 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 60 JAPAN: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	8,682.67	8,141.21	9,000.06	15,948.96	12.12%
Metal Alloys	3,689.45	3,660.16	3,805.20	4,839.25	4.93%
Glass Polishing	4,051.14	3,998.01	4,139.60	5,125.80	4.37%
Glass Additives	1,956.12	1,935.34	1,969.18	2,230.78	2.53%
Catalysts	4,078.38	4,021.51	4,177.01	5,281.86	4.81%
Phosphors	2,677.89	2,588.17	2,822.33	4,788.35	11.15%
Ceramics	3,419.78	3,335.02	3,517.31	4,885.63	6.79%
Others	1,381.11	1,353.25	1,403.96	1,827.20	5.41%
Total	**29,936.54**	**29,032.66**	**30,834.65**	**44,927.84**	**7.82%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.2.3 REST OF APAC

Other countries in APAC include India, Australia, and Malaysia, which contribute to the global production of rare-earth metals to some extent. These countries focused on expansion to increase their home production to meet the growing demand. India's producers of rare-earth-bearing heavy-mineral concentrates include Indian Rare Earths Ltd. (IREL) and Kerala Metals & Minerals Ltd. India's monazite production capacity was reported by the Indian Bureau of Mines to be 6,240 t/yr. Also, Lynas continued to increase the production of rare-earth compounds at its Lynas Advanced Material Plant (LAMP) near the Port of Kuantan in the State of Pahang, Malaysia.

TABLE 61 REST OF APAC: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	1,926.83	1,791.33	1,914.52	2,777.66	7.73%
Metal Alloys	1,321.23	1,311.89	1,346.69	1,594.49	3.44%
Glass Polishing	1,224.07	1,210.64	1,240.59	1,450.25	3.17%
Glass Additives	665.49	660.55	671.34	745.47	2.12%
Catalysts	1,101.36	1,088.57	1,117.52	1,323.75	3.45%
Phosphors	912.26	888.74	940.41	1,347.15	7.45%
Ceramics	418.25	412.57	423.05	497.40	3.29%
Others	408.83	403.93	416.29	505.63	3.97%
Total	**7,978.32**	**7,768.19**	**8,070.42**	**10,241.80**	**4.88%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.3 NORTH AMERICA

North America is the second-largest region in the world to produce rare-earth elements. The region's mine deposits, innovative technologies, and R&D enable the region to meet the demand for the rare-earth metals market 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 contributes a major role in the growth of the rare-earth market, though North America witnesses an average growth rate due to increased use of hybrid electric vehicles and low carbon technologies. The demand for rare-earths metals continues to grow in line with the growth in green technologies.

Governments increasingly mandate that a certain percentage of a manufacturers' 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, in turn, driven the demand for rare-earth metals.

TABLE 62 NORTH AMERICA: RARE-EARTH METALS MARKET SIZE, BY COUNTRY, 2019–2026 (METRIC TON)

Country	2019	2020	2021	2026	CAGR (2021–2026)
US	22,558.72	22,099.27	23,499.74	33,233.55	7.18%
Canada	600.49	600.09	621.11	759.13	4.09%
Mexico	181.91	182.44	186.85	216.37	2.98%
Total	**23,341.15**	**22,881.80**	**24,307.69**	**34,209.04**	**7.07%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 63 NORTH AMERICA: RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	13.86	13.68	14.24	17.70	4.45%
Lanthanum Oxide	8.03	7.95	8.20	9.70	3.42%
Neodymium Oxide	277.45	268.27	296.50	509.74	11.45%
Yttrium Oxide	7.01	6.83	7.39	11.34	8.94%
Praseodymium Oxide	99.12	95.94	105.73	178.94	11.10%
Samarium Oxide	0.26	0.25	0.27	0.36	5.96%
Gadolinium Oxide	4.97	4.80	5.32	9.27	11.75%
Dysprosium Oxide	87.43	84.33	93.86	167.54	12.29%
Terbium Oxide	80.05	77.02	86.28	159.45	13.07%
Europium Oxide	2.97	2.89	3.16	5.12	10.17%
Others	4.85	4.82	4.94	5.68	2.84%
Total	**586.00**	**566.78**	**625.88**	**1074.84**	**11.42%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 64 NORTH AMERICA: RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	7,979.72	7,889.28	8,173.74	9,907.49	3.92%
Lanthanum Oxide	4,678.56	4,626.01	4,791.31	5,797.78	3.89%
Neodymium Oxide	5,490.08	5,317.16	5,849.90	9,812.52	10.90%
Yttrium Oxide	2,271.56	2,216.76	2,386.88	3,564.01	8.35%
Praseodymium Oxide	2,056.91	1,994.06	2,187.90	3,616.59	10.57%
Samarium Oxide	137.74	135.59	142.33	185.19	5.41%
Gadolinium Oxide	177.91	172.17	189.85	322.33	11.17%
Dysprosium Oxide	322.54	311.59	345.25	601.75	11.75%
Terbium Oxide	115.93	111.72	124.63	225.32	12.57%
Europium Oxide	94.12	91.50	99.61	157.87	9.65%
Others	16.07	15.97	16.29	18.19	2.23%
Total	**23,341.15**	**22,881.80**	**24,307.69**	**34,209.04**	**7.07%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 65 NORTH AMERICA: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	3,862.62	3,925.83	4,435.58	8,374.79	13.55%
Metal Alloys	2,436.60	2,388.38	2,514.96	3,332.87	5.79%
Glass Polishing	1,846.29	1,783.55	1,890.28	2,590.57	6.51%
Glass Additives	1,635.39	1,600.56	1,658.70	2,014.27	3.96%
Catalysts	9,196.90	9,015.98	9,329.00	11,231.94	3.78%
Phosphors	1,274.21	1,198.42	1,323.88	2,269.06	11.38%
Ceramics	2,123.92	2,039.74	2,159.00	2,940.29	6.37%
Others	965.22	929.33	996.30	1,455.25	7.87%
Total	**23,341.15**	**22,881.80**	**24,307.69**	**34,209.04**	**7.07%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.3.1 US

9.3.1.1 Rising demand for electric vehicles drives market

One of the biggest recent challenges for the US has been China's dominance in mining and processing critical rare-earth minerals. These are vital building blocks for everything from smartphones, Electric vehicles 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. But 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, critical for batteries in electric vehicles and power storage. This would probably reduce the dependency of the US on rare-earth metals from China. Thus, the rising demand for electric vehicles to reduce CO_2 emissions is expected to propel the use of permanent magnets in the production of batteries. Electric vehicles need magnets, and they are mainly made from rare-earth metals.

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

TABLE 66 US: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	3,608.01	3,667.06	4,160.87	7,992.97	13.95%
Metal Alloys	2,308.71	2,261.22	2,385.24	3,186.90	5.97%
Glass Polishing	1,787.42	1,725.32	1,830.71	2,522.51	6.62%
Glass Additives	1,581.85	1,547.34	1,604.80	1,956.24	4.04%
Catalysts	9,011.13	8,831.20	9,142.10	11,031.95	3.83%
Phosphors	1,245.77	1,170.58	1,294.80	2,231.54	11.50%
Ceramics	2,082.96	1,999.30	2,117.66	2,893.27	6.44%
Others	932.86	897.26	963.55	1,418.17	8.04%
Total	**22,558.72**	**22,099.27**	**23,499.74**	**33,233.55**	**7.18%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.3.2 CANADA

9.3.2.1 Need for clean energy applications drives the market

Canada has a high potential for rare-earth production because of the availability of its deposits and mines. Rare-earth elements have been categorized by the Canadian government as critical to its economy. The country is host to a number of advanced exploration projects and some of the largest reserves and resources (measured and indicated) of these metals, estimated at almost 15 million tons of rare-earth oxides. Many of Canada's most advanced rare-earth element exploration projects contain high concentrations of the globally valued heavy rare-earth elements used in high-technology and clean-energy applications.

The Canadian companies are getting some assistance from their government with the formation of a new association – the Canadian Rare Earth Elements Network – hoping to break the monopoly that China has on the metals used in everything from the latest smartphones to wind turbines and missile guidance systems. The Canadian exploration companies are targeting scores of rare-earth metal projects around the world with help from the Federal government.

TABLE 67 CANADA: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	195.41	198.50	211.30	297.14	7.06%
Metal Alloys	98.15	97.52	99.74	113.81	2.67%
Glass Polishing	45.18	44.63	45.79	53.15	3.03%
Glass Additives	41.09	40.82	41.39	44.95	1.66%
Catalysts	142.57	141.72	143.56	154.87	1.53%
Phosphors	21.83	21.32	22.38	29.59	5.75%
Ceramics	31.43	30.99	31.76	36.69	2.92%
Others	24.83	24.59	25.18	28.92	2.81%
Total	**600.49**	**600.09**	**621.11**	**759.13**	**4.09%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.3.3 MEXICO

9.3.3.1 Green technology, consumer electronics, and high-tech applications drive the demand for rare-earth metals

Rare-earth metals are becoming increasingly significant in a wide variety of industries, including green technology, consumer electronics, and high-tech applications. Recent reports conducted by universities in Mexico have shown economically viable rare-earth deposits in the States of Sonora and Chihuahua as well as further south in Oaxaca and Chiapas. The possibility of mining for rare-earth metals represents a great economic prospect for Mexico as the country has been looking for an optimal way of providing it with a high-performance technology sector.

The mining industry in Mexico is the country's fourth-largest industry in terms of value, behind automotive, oil, and electronics.

TABLE 68 MEXICO: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	59.20	60.27	63.40	84.68	5.96%
Metal Alloys	29.74	29.64	29.98	32.16	1.42%
Glass Polishing	13.69	13.60	13.78	14.91	1.60%
Glass Additives	12.45	12.41	12.50	13.08	0.91%
Catalysts	43.20	43.06	43.34	45.12	0.81%
Phosphors	6.61	6.52	6.71	7.93	3.40%
Ceramics	9.52	9.45	9.57	10.33	1.54%
Others	7.52	7.48	7.58	8.16	1.50%
Total	**181.93**	**182.44**	**186.85**	**216.37**	**2.98%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.4 EUROPE

The European market of rare-earth oxides is mostly dependent on imports and faces a rigorous challenge to meet the growing demand. Petroleum, automobile, and air emission, industrial, and other catalyst market segments are all set to grow moderately over the next five years, which would eventually increase the rare-earth consumption. Although Europe is rich in the rare-earth elements used to power batteries and produce magnets, political issues constrain the potential of the region to fully utilize its rare-earth metal availability. In order 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 the development of business models and separation technologies. However, 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. In order to help secure the supply, the European Rare Earths Competency Network (ERECON) was established.

TABLE 69 EUROPE: RARE-EARTH METALS MARKET SIZE, BY COUNTRY, 2019–2026 (METRIC TON)

Country	2019	2020	2021	2026	CAGR (2021–2026)
Germany	3,292.02	3,277.64	3,478.52	4,898.03	7.08%
UK	1,989.31	1,963.46	2,064.39	2,790.29	6.21%
France	1,718.78	1,696.94	1,777.52	2,311.70	5.40%
Rest of Europe	5,054.43	5,004.60	5,200.56	6,504.95	4.58%
Total	**12,054.53**	**11,942.65**	**12,520.98**	**16,504.97**	**5.68%**

Note: Rest of Europe includes Italy, Spain, Sweden, Netherlands, Switzerland, and Poland.

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 70 EUROPE: RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	7.92	7.87	8.16	10.05	4.25%
Lanthanum Oxide	4.22	4.20	4.29	4.84	2.46%
Neodymium Oxide	145.64	143.25	155.55	246.71	9.66%
Yttrium Oxide	3.68	3.64	3.87	5.46	7.15%
Praseodymium Oxide	52.03	51.20	55.46	86.77	9.36%
Samarium Oxide	0.14	0.14	0.14	0.17	3.97%
Gadolinium Oxide	2.59	2.55	2.77	4.46	9.98%
Dysprosium Oxide	45.76	44.94	49.16	81.30	10.58%
Terbium Oxide	42.00	41.19	45.37	77.89	11.42%
Europium Oxide	1.59	1.56	1.68	2.52	8.42%
Others	2.76	2.75	2.79	3.01	1.54%
Total	**308.33**	**303.28**	**329.24**	**523.18**	**9.71%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 71 EUROPE: RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	4,356.41	4,329.23	4,470.53	5,354.54	3.67%
Lanthanum Oxide	2,344.42	2,336.72	2,376.86	2,615.71	1.93%
Neodymium Oxide	2,750.88	2,708.31	2,927.58	4,528.19	9.11%
Yttrium Oxide	1,138.10	1,125.40	1,191.08	1,637.27	6.57%
Praseodymium Oxide	1,030.67	1,015.25	1,094.73	1,670.05	8.81%
Samarium Oxide	69.68	69.27	71.39	84.53	3.44%
Gadolinium Oxide	88.55	87.13	94.45	148.42	9.46%
Dysprosium Oxide	161.13	158.39	172.51	278.29	10.04%
Terbium Oxide	58.07	56.99	62.51	104.84	10.90%
Europium Oxide	47.90	47.26	50.57	73.93	7.89%
Others	8.71	8.70	8.77	9.20	0.97%
Total	**12,054.53**	**11,942.65**	**12,520.98**	**16,504.97**	**5.68%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 72 EUROPE: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	2,541.81	2,560.46	2,877.59	5,123.00	12.23%
Metal Alloys	1,827.22	1,814.89	1,859.33	2,142.17	2.87%
Glass Polishing	1,388.40	1,365.47	1,402.07	1,637.09	3.15%
Glass Additives	1,252.15	1,244.59	1,261.83	1,368.12	1.63%
Catalysts	2,142.63	2,131.63	2,158.82	2,325.29	1.50%
Phosphors	1,174.43	1,136.51	1,196.51	1,616.56	6.20%
Ceramics	1,022.30	992.04	1,046.71	1,436.24	6.53%
Others	705.59	697.05	718.11	856.49	3.59%
Total	**12,054.53**	**11,942.65**	**12,520.98**	**16,504.97**	**5.68%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.4.1 GERMANY

9.4.1.1 Rising demand for electric vehicles drives the market

Permanent magnets used in electric vehicles and wind turbines currently 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.

TABLE 73 GERMANY : RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	898.52	899.24	1,022.00	1,938.06	13.65%
Metal Alloys	560.23	556.85	574.42	683.94	3.55%
Glass Polishing	306.96	304.85	315.80	385.04	4.04%
Glass Additives	277.30	276.35	281.33	311.05	2.03%
Catalysts	570.31	568.51	577.90	633.68	1.86%
Phosphors	280.59	276.99	295.60	425.64	7.56%
Ceramics	205.38	203.14	214.72	293.02	6.42%
Others	192.69	191.72	196.76	227.61	2.96%
Total	**3,291.98**	**3,277.64**	**3,478.52**	**4,898.03**	**7.08%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.4.2 UK

9.4.2.1 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 future 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 turbine 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.

TABLE 74 UK: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	432.98	434.46	489.85	901.98	12.99%
Metal Alloys	269.02	266.59	274.26	325.55	3.49%
Glass Polishing	231.25	225.51	232.76	281.47	3.87%
Glass Additives	201.19	199.61	202.66	222.14	1.85%
Catalysts	408.70	405.93	411.48	446.78	1.66%
Phosphors	187.84	178.99	189.92	270.83	7.36%
Ceramics	141.93	138.27	144.22	186.05	5.23%
Others	116.44	114.10	119.23	155.50	5.46%
Total	**1,989.35**	**1,963.46**	**2,064.39**	**2,790.29**	**6.21%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.4.3 FRANCE

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

Rapid global industrialization and population growth are placing increasing pressure on the availability of raw materials. A group of elements known as rare-earth metals have become a highly sought-after resource for high-technology and low carbon industries. 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 75 FRANCE: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	322.51	325.35	366.33	644.74	11.97%
Metal Alloys	253.25	251.23	257.39	295.70	2.81%
Glass Polishing	212.16	207.39	213.27	250.04	3.23%
Glass Additives	196.33	194.75	197.70	215.47	1.74%
Catalysts	311.69	309.55	313.72	338.72	1.55%
Phosphors	179.16	171.41	180.76	244.44	6.22%
Ceramics	143.10	138.44	145.74	195.49	6.05%
Others	100.61	98.84	102.61	127.10	4.37%
Total	**1,718.80**	**1,696.94**	**1,777.52**	**2,311.70**	**5.40%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.4.4 REST OF EUROPE

Rest of Europe includes major rare-earth metal producing countries, such as, Italy, Spain, Sweden, Netherlands, Switzerland, and Poland. Owing to the increasing pressure on global resources, countries are expected to use varying strategies to meet their needs – according to industry experts. 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. Thus, technological advancement in the growing automotive and energy industries drives the rare-earth metals market.

TABLE 76 REST OF EUROPE: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	887.80	901.41	999.41	1,638.22	10.39%
Metal Alloys	744.72	740.22	753.27	836.98	2.13%
Glass Polishing	638.04	627.72	640.24	720.55	2.39%
Glass Additives	577.33	573.88	580.14	619.46	1.32%
Catalysts	851.93	847.64	855.72	906.11	1.15%
Phosphors	526.84	509.14	530.23	675.65	4.97%
Ceramics	531.90	512.19	542.03	761.69	7.04%
Others	295.85	292.39	299.52	346.28	2.94%
Total	**5,054.41**	**5,004.60**	**5,200.56**	**6,504.95**	**4.58%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.5 REST OF THE WORLD

Rest of the World includes major rare-earth metals producing countries, such as South Africa and Brazil. South Africa is into the production of rare-earth metals through its plant Steenkampskraal (SKK) Mine in the Western Cape owned by Great Western Minerals Group Ltd. In 2017, the company was downsizing its mining and processing design plans, based on the production of 2,700 t/yr of rare-earth oxide equivalent, and planned production of cerium and cerium-depleted mixed carbonates. The current production trend is focused on meeting local demands rather than being an import-oriented country. The discovery of rare-earth metal deposits has proved Brazil to be a significant market.

TABLE 77 REST OF THE WORLD : RARE-EARTH METALS MARKET SIZE, BY COUNTRY, 2019–2026 (METRIC TON)

Country	2019	2020	2021	2026	CAGR (2021–2026)
Brazil	582.64	563.66	604.06	923.28	8.86%
Other countries	1,822.69	1,761.43	1,897.92	2,994.56	9.55%
Total	**2,405.33**	**2,325.10**	**2,501.98**	**3,917.84**	**9.38%**

Note: Others include Argentina and the Middle East and African countries.

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 78 REST OF THE WORLD : RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (USD MILLION)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	1.66	1.60	1.74	2.93	10.95%
Lanthanum Oxide	0.72	0.71	0.73	0.89	4.07%
Neodymium Oxide	23.51	22.53	24.67	42.48	11.48%
Yttrium Oxide	0.60	0.59	0.63	0.96	8.88%
Praseodymium Oxide	8.36	8.00	8.80	15.54	12.06%
Samarium Oxide	0.02	0.02	0.02	0.03	5.67%
Gadolinium Oxide	0.42	0.41	0.45	0.78	11.81%
Dysprosium Oxide	7.36	7.03	7.75	13.88	12.35%
Terbium Oxide	6.72	6.40	7.10	13.24	13.27%
Europium Oxide	0.26	0.25	0.27	0.44	10.14%
Other Oxides	0.43	0.43	0.44	0.50	2.45%
Total	**50.08**	**47.95**	**52.60**	**91.67**	**11.75%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 79 REST OF THE WORLD : RARE-EARTH METALS MARKET SIZE, BY TYPE, 2019–2026 (METRIC TON)

Type	2019	2020	2021	2026	CAGR (2021–2026)
Cerium Oxide	1,018.02	979.60	1,064.19	1,747.94	10.43%
Lanthanum Oxide	422.31	416.91	429.09	510.36	3.53%
Neodymium Oxide	495.87	476.31	519.31	871.42	10.91%
Yttrium Oxide	204.94	198.76	212.48	317.23	8.35%
Praseodymium Oxide	185.83	178.10	195.05	336.11	11.50%
Samarium Oxide	12.42	12.19	12.71	16.34	5.15%
Gadolinium Oxide	16.24	15.58	17.03	29.04	11.26%
Dysprosium Oxide	29.14	27.90	30.62	53.51	11.81%
Terbium Oxide	10.51	10.03	11.08	20.13	12.69%
Europium Oxide	8.60	8.30	8.96	14.18	9.61%
Other Oxides	1.43	1.42	1.45	1.59	1.90%
Total	**2,405.33**	**2,325.10**	**2,501.98**	**3,917.84**	**9.38%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

TABLE 80 REST OF THE WORLD: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	396.03	380.13	438.40	949.18	16.71%
Metal Alloys	440.46	427.80	462.80	741.60	9.89%
Glass Polishing	298.10	286.64	303.31	424.94	6.98%
Glass Additives	260.36	251.24	267.00	384.87	7.59%
Catalysts	623.90	612.98	632.86	767.13	3.92%
Phosphors	115.61	108.16	118.61	205.12	11.58%
Ceramics	144.27	136.03	148.05	245.97	10.69%
Others	126.60	122.12	130.95	199.03	8.73%
Total	**2,405.33**	**2,325.10**	**2,501.98**	**3,917.84**	**9.38%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.5.1 BRAZIL

9.5.1.1 Rising demand for rare-earth metals in wind turbines and electric vehicles

Brazil has the second-largest reserve of rare-earth metals in the world, 22 million tons, according to the US Geological Survey, Mineral Commodity Summaries, January 2016. The rare-earth metals are extracted from the tailings of the niobium produced by the Companhia Brasileira de Metalurgia e Mineração – CBMM, the largest niobium producer in the world and the first mining company to be certified by ISO 14.001. In 2015 IPT, CBMM, and the Brazilian Industrial Research and Innovation Company (Embrapii) established a partnership for the process development of the neodymium-praseodymium alloy production from the oxides of those elements. Rare-earth magnets are crucial for the production of wind turbines, motors of electric cars and electronic devices, which are growing in demand, which indirectly motivates Brazilian companies to export various intermediary products of the permanent magnet value chain from this strategic resource, offering alternatives to the supply and consumption of the global market

TABLE 81 BRAZIL: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	95.93	92.66	106.44	225.14	16.16%
Metal Alloys	106.69	104.17	112.24	175.60	9.36%
Glass Polishing	72.21	68.26	71.88	97.85	6.36%
Glass Additives	63.07	61.22	64.78	90.96	7.02%
Catalysts	151.13	149.09	153.24	180.88	3.37%
Phosphors	28.00	25.31	27.67	47.06	11.20%
Ceramics	34.95	33.21	36.02	58.55	10.21%
Others	30.67	29.75	31.78	47.23	8.25%
Total	**582.64**	**563.66**	**604.06**	**923.28**	**8.86%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

9.5.2 OTHER COUNTRIES IN REST OF THE WORLD

Other countries in Rest of the World include the remaining rare-earth-metal producing countries, such as Argentina, and some of the Middle East & African countries, which specifically prefer to buy rare-earth elements than mine. However, the rising demand has compelled some countries to reopen production to prevent shortages.

TABLE 82 OTHER COUNTRIES IN REST OF THE WORLD: RARE-EARTH METALS MARKET SIZE, BY APPLICATION, 2019–2026 (METRIC TON)

Application	2019	2020	2021	2026	CAGR (2021–2026)
Permanent Magnets	300.10	287.47	331.96	724.03	16.88%
Metal Alloys	333.77	323.63	350.56	566.00	10.06%
Glass Polishing	225.89	218.38	231.43	327.09	7.16%
Glass Additives	197.29	190.01	202.22	293.91	7.76%
Catalysts	472.78	463.90	479.62	586.26	4.10%
Phosphors	87.60	82.85	90.93	158.06	11.69%
Ceramics	109.33	102.82	112.04	187.42	10.84%
Others	95.93	92.37	99.16	151.80	8.89%
Total	**1,822.69**	**1,761.43**	**1,897.92**	**2,994.56**	**9.55%**

Source: Related Research Publications, Government Publications, Press Releases, Annual Reports, Company Websites, Publications, and MarketsandMarkets Analysis

10 COMPETITIVE LANDSCAPE

10.1 KEY PLAYER STRATEGIES

This section of the report provides an overview of the current competitive scenario of the rare-earth metals market.

Contract & agreement is one of the growth strategies adopted by a few of the leading companies, including Lynas Corporation, Alkane Resources ltd, Arafura Resources Ltd, China Minmetals Rare Earth Co Ltd and Avalon Advanced Materials, Inc. Apart from contracts & agreements, companies operating in the rare-earth metal market are mainly focused on partnerships & collaborations to increase their market shares and regional presence. Joint venture and contract & agreement are the followed strategies by leading industry players to achieve growth in the rare-earth metals market.

TABLE 83 OVERVIEW OF KEY STRATEGIES DEPLOYED BY TOP PLAYERS, 2019–2020

COMPANY	PRODUCT TYPE	DEVELOPMENT	REGION	MANUFACTURING
Lynas Corporation	Lynas Corporation offers Yttrium, Lanthanum, Cerium, Praseodymium, Neodymium for commercial, and industrial end-use applications.	Lynas Corporation and Blue Line announced a joint venture to develop rare-earth metal separation capacity in the US.	Lynas Corporation has a strong presence in Asia.	The Lynas Corporation manufacturing plants is located in Malaysia.
Alkane Resources Ltd	Lynas Corporation offers zirconium, niobium, hafnium, gold, yttrium for various end-use applications.	In April 2019, the company invested USD 2.16 million in Calidus Resources Limited, a gold exploration company in Australia.	The company only caters to the Australian region.	The majority of its manufacturing plants are located in Australia.
Arafura Resources Ltd	Arafura Resources Ltd offers products, such as Neodymium-Praseodymium (NdPr) oxide and Cerium (Ce) oxide.			Arafura Resources Ltd manufacturing plant is in Australia
China Minmetals Rare Earth Co Ltd	China Minmetals Rare Earth Co Ltd offers ceria, lanthanum oxide, neodymium oxide, europium oxide, praseodymium oxide, neodymium oxide, terbium oxide, dysprosium oxide, holmium, gadolinium, lutetium, praseodymium, samarium, erbium, yttrium, and europium oxides, among others for end-use applications.		China Minmetals Rare Earth Co Ltd has a presence in APAC	China Minmetals Rare Earth Co Ltd has manufacturing locations in China.

Avalon Advanced Materials, Inc	Avalon Advanced Materials, Inc offers lithium, tantalum, niobium, cesium, indium, gallium, germanium, rare-earth elements, yttrium, and zirconium.		The company operates in Canada and the US.	Its manufacturing plant is in Canada.

Source: Company Websites and Press Releases

10.2 MARKET EVALUATION FRAMEWORK

Since all markets follow a predictable lifecycle, understanding the present stage of the market after analyzing the market dynamics in the last three–five years becomes essential to forecast how the market will shape in the future. This analysis involves assessing the consolidation in the market by identifying the number of market players that account for over 44%–46% of market share and expansions, including capacity additions in existing production facilities and setting up greenfield facilities, product launches, Merger & Acquisition , and strategic alliances & joint ventures. MarketsandMarkets' Market Evaluation Framework provided below captures the key data for the 2019 –2020 for the rare-earth metals market.

TABLE 84 MARKET EVALUATION FRAMEWORK

COMPANY NAME	CONTRACTS & AGREEMENTS	PARTNERSHIPS & COLLABORATIONS	MERGERS & ACQUISITIONS	NEW PRODUCT LAUNCHES	JOINT VENTURES	INVESTMENTS & EXPANSION	TOTAL
Lynas Corporation	1				1		2
Alkane Resources Limited	1						1
Total	2				1		3

Source: Annual Reports, Press Releases, and MarketsandMarkets Analysis

10.3 COMPANY EVALUATION QUADRANT

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

10.3.1 STAR

Vendors that fall in this category generally receive high scores for most evaluation criteria. These players have established service/product portfolios, as well as a powerful market presence. They also devise effective business strategies. The companies falling under this category include Lynas Corporation Ltd, Arafura Resources Ltd, China Minmetals Rare Earth Co Ltd, Iluka Resource Ltd, and Avalon Advanced Materials, Inc.

10.3.2 EMERGING LEADERS

Emerging leaders are vendors that have demonstrated substantial service innovations compared to their competitors. They have a much-focused service portfolio. However, they lack solid growth strategies for their overall business. The companies falling under the emerging leaders' category include Baotou HEFA Rare Earth Co. Ltd, Canada Rare Earth Corporation, Alkane Resources Ltd, and Northern Minerals Limited.

10.3.3 PERVASIVE

They are established vendors with powerful business strategies. However, they do not have a strong service/product/solution portfolio. They generally focus on a specific type of technology related to products/services. The companies falling under the pervasive category include Greenland Minerals Ltd, Neo Materials, Shin-Etsu Chemical Co., Ltd, and Eutectix, LLC.

10.3.4 PARTICIPANT

They are vendors who have started gaining momentum in the market with their niche product offerings. They do not pursue many strong business strategies compared to other established vendors. They may be new entrants in the market and could require some more time before gaining prominence in the market. The companies falling under this category include China Nonferrous Metal Industry's Foreign Engineering and Construction Co., Ltd, American Rare Earths Limited, Baotou Jinmeng Rare Earth Co., Ltd, Ucore Rare Metals Inc, Mitsubishi Corporation RtM Japan Ltd., and Medallion Resources Ltd.

FIGURE 38 COMPETITIVE LEADERSHIP MAPPING: RARE-EARTH METALS MARKET, 2019

Source: Company Websites, Press Releases, Company Annual Reports, Expert Interviews, and MarketsandMarkets Analysis

TABLE 85 COMPANY PRODUCT FOOTPRINT

COMPANY	NEODYMIUM OXIDE	PRASEODYMIUM OXIDE	DYSPROSIUM OXIDE	SCORE
Lynas Corporation Ltd	Yes	Yes	Yes	3.00
Alkane Resources Ltd	Yes	Yes	Yes	3.00
Arafura Resources Ltd	Yes	Yes	Yes	3.00
China Minmetals Rare Earth Co Ltd	Yes	Yes	Yes	3.00
Avalon Advanced Materials, Inc.	Yes	Yes	Yes	3.00
Baotou HEFA Rare Earth Co. Ltd	Yes	Yes	NA	2.00
Canada Rare Earth Corporation	Yes	Yes	Yes	2.00
Northern Minerals Limited	No	Yes	Yes	1.00
Greenland Minerals Ltd	Yes	Yes	NA	2.00
Neo Materials	Yes	Yes	NA	1.00
Shin-Etsu Chemical Co., Ltd	No	Yes	Yes	1.00
Iluka Resource Ltd	No	Yes	NA	1.00
Eutectix, LLC	NA	NA	Yes	0.00
China Nonferrous Metal Industry's Foreign Engineering and Construction Co., Ltd	NA	NA	Yes	1.00
American Rare Earths Limited	Yes	Yes	Yes	2.00
Baotou Jinmeng Rare Earth Co	NA	Yes	NA	1.00
Ucore Rare Metals Inc	Yes	Yes	NA	2.00
Mitsubishi Corporation RtM Japan Ltd	NA	NA	Yes	1.00
Medallion Resources Ltd	NA	NA	NA	0.00

Note: Footprint is based on top three products based on value.

Source: Company Website

TABLE 86 COMPANY APPLICATION FOOTPRINT

COMPANY	GLASS/CERAMICS	CATALYST	PERMANENT MAGNET	SCORE
Lynas Corporation Ltd	No	Yes	Yes	1.00
Alkane Resources Ltd	NA	NA	Yes	0.00
Arafura Resources Ltd	Yes	Yes	Yes	3.00
China Minmetals Rare Earth Co Ltd	Yes	Yes	Yes	3.00
Avalon Advanced Materials, Inc.	Yes	Yes	Yes	3.00
Baotou HEFA Rare Earth Co. Ltd	Yes	Yes	NA	2.00
Canada Rare Earth Corporation	Yes	NA	Yes	2.00
Northern Minerals Limited	No	Yes	Yes	1.00
Greenland Minerals Ltd	Yes	Yes	NA	2.00
Neo Materials	Yes	Yes	NA	1.00
Shin-Etsu Chemical Co., Ltd	No	Yes	Yes	1.00
Iluka Resource Ltd	No	Yes	NA	1.00
Eutectix, LLC	NA	NA	Yes	0.00
China Nonferrous Metal Industry's Foreign Engineering and Construction Co., Ltd	NA	NA	Yes	1.00
American Rare Earths Limited	Yes	Yes	Yes	2.00
Baotou Jinmeng Rare Earth Co	NA	Yes	NA	1.00
Ucore Rare Metals Inc	Yes	Yes	NA	2.00
Mitsubishi Corporation RtM Japan Ltd	NA	NA	Yes	1.00
Medallion Resources Ltd	NA	NA	NA	0.00

Source: Company Website

TABLE 87 COMPANY INDUSTRY FOOTPRINT

COMPANY	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	SCORE
Lynas Corporation Ltd	NA	Yes	Yes	2.00
Alkane Resources Ltd	NA	Yes	Yes	2.00
Arafura Resources Ltd	NA	Yes	Yes	2.00
China Minmetals Rare Earth Co Ltd	NA	Yes	Yes	2.00
Avalon Advanced Materials, Inc.	NA	Yes	Yes	2.00
Baotou HEFA Rare Earth Co. Ltd	NA	Yes	Yes	2.00
Canada Rare Earth Corporation	NA	Yes	Yes	2.00
Northern Minerals Limited	NA	No	Yes	1.00
Greenland Minerals Ltd	NA	NA	Yes	0.00
Neo Materials	NA	Yes	Yes	2.00
Shin-Etsu Chemical Co., Ltd	NA	NA	Yes	0.00
Iluka Resource Ltd	NA	NA	Yes	0.00
Eutectix, LLC	NA	No	Yes	1.00
China Nonferrous Metal Industry's Foreign Engineering and Construction Co., Ltd	NA	Yes	Yes	2.00
American Rare Earths Limited	NA	NA	Yes	0.00
Baotou Jinmeng Rare Earth Co	NA	Yes	Yes	2.00
Ucore Rare Metals Inc	NA	Yes	Yes	2.00
Mitsubishi Corporation RtM Japan Ltd	NA	Yes	Yes	2.00
Medallion Resources Ltd	NA	NA	Yes	0.00

Source: Company Website

TABLE 88 COMPANY REGION FOOTPRINT

COMPANY	NORTH AMERICA	EUROPE	APAC	SCORE
Lynas Corporation Ltd	No	Yes	Yes	5.00
Alkane Resources Ltd	Yes	Yes	Yes	5.00
Arafura Resources Ltd	Yes	Yes	Yes	5.00
China Minmetals Rare Earth Co Ltd	Yes	Yes	Yes	5.00
Avalon Advanced Materials, Inc.	Yes	Yes	Yes	5.00
Baotou HEFA Rare Earth Co. Ltd	Yes	Yes	Yes	5.00
Canada Rare Earth Corporation	Yes	Yes	Yes	5.00
Northern Minerals Limited	Yes	Yes	Yes	4.00
Greenland Minerals Ltd	No	No	Yes	1.00
Neo Materials	No	No	Yes	1.00
Shin-Etsu Chemical Co., Ltd	Yes	Yes	Yes	5.00
Iluka Resource Ltd	Yes	Yes	Yes	5.00
Eutectix, LLC	Yes	No	No	1.00
China Nonferrous Metal Industry's Foreign Engineering and Construction Co., Ltd	Yes	No	No	1.00
American Rare Earths Limited	No	No	Yes	1.00
Baotou Jinmeng Rare Earth Co	No	No	Yes	2.00
Ucore Rare Metals Inc	Yes	Yes	Yes	5.00
Mitsubishi Corporation RtM Japan Ltd	No	Yes	Yes	3.00
Medallion Resources Ltd	Yes	Yes	Yes	5.00

Source: Company Website

10.4 COMPETITIVE SCENARIO

Contracts & agreements was among the key strategies adopted by the players to strengthen their global presence and offerings. It was also a key revenue-generating tool for market players. Industry players that adopted this strategy are Lynas Corporation and Alkane Resources Ltd. Joint Ventures/Contracts & Agreements also proved to be a successful approach for most companies.

Rare-earth Metals Market: Joint Ventures and Contracts & Agreements

TABLE 89 JANUARY 2019–JANUARY 2021

MONTH & YEAR	COMPANY NAME	PRODUCT TYPE	PRODUCT NAME	SYNERGY
May 2019	Lynas Corporation and Blue Line	Rare-earth Metals	Rare Earths	Lynas Corporation and Blue Line announced a joint venture to develop rare earths separation capacity in the US.
April 2019	Alkane Resources Limited and Calidus Resources Limited	Rare-Earth Metals	Rare Earths	In April, the company invested USD 2.16 million in Calidus Resources Limited, a gold exploration company in Australia.
March 2019	Lynas Corporation	Rare-Earth Metals	Rare Earths	Lynas Corporation signed an MoU with MARA to commercialize the neutralization underflow residue from the Lynas Malaysia plant.

11 COMPANY PROFILES

11.1 KEY PLAYERS

11.1.1 LYNAS CORPORATION

11.1.1.1 Business overview

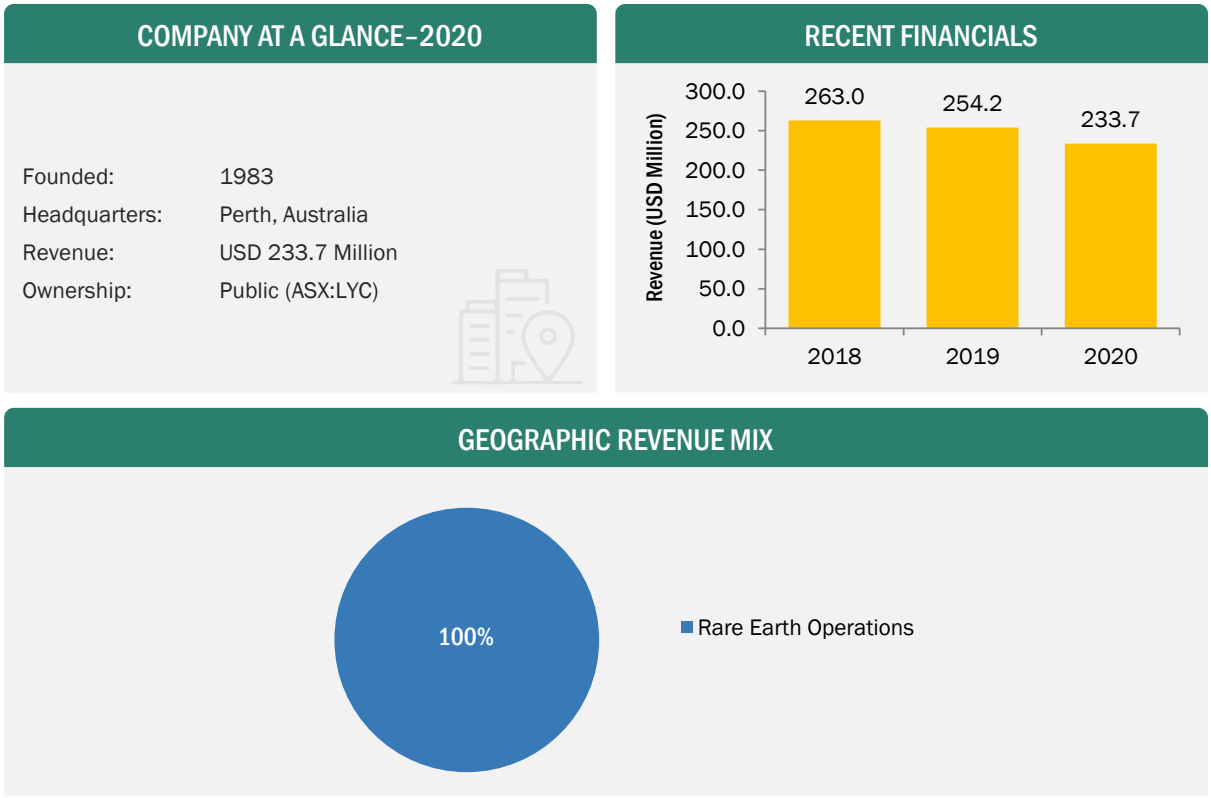
Lynas Corporation Ltd (Lynas Corporation) is a minerals explorer. The company offers rare-earth oxides from mines. Its rare earths are a group of chemical elements with unique magnetic, luminescent, and electrochemical properties. Lynas Corporation's rare earth elements include europium, lutetium, lanthanum, samarium, scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, dysprosium, and lutetium. Its products find application across aerospace, metal alloys, batteries, fiber optic technology, solar panel, lasers, and glass colorant sectors. The company operates in Malaysia and Australia. Lynas Corporation is headquartered in East Perth West Australia, Australia.

TABLE 90 LYNAS CORPORATION: BUSINESS OVERVIEW

Year Founded	1983
Country	Australia
City	Perth
Ownership	Public (ASX:LYC)

Source: Company Website

FIGURE 39 LYNAS CORPORATION: COMPANY SNAPSHOT



Note: The financial year of the company ends on December 31.

Source: Company Website, Press Releases, and Company Annual Reports

11.1.1.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Yttrium	It is a silvery-metallic transition metal chemically similar to the lanthanides	Rare Earth Metal	Phosphorous, ceramics, metal alloys
Lanthanum	Lanthanum is one of the rare-earth elements used to make carbon arc lights, which are used in the motion picture industry for studio lighting and projector lights	Rare Earth Metal	Batteries, catalysts for petroleum refining
Cerium	Cerium is a soft, ductile, and silvery-white metal that tarnishes when exposed to air, and it is soft enough to be cut with a steel kitchen knife.	Rare Earth Metal	Autocatalysts, Chemical Catalyst, glass polishing, metal alloys
Praseodymium	It is the third member of the lanthanide series and is traditionally considered to be one of the rare-earth metals	Rare Earth Metal	High power magnets, yellow ceramic pigment, Autocat
Neodymium	Neodymium belongs to the lanthanide series and is a rare-earth element. It is a hard, slightly malleable silvery metal that quickly tarnishes in air and moisture	Rare Earth Metal	High power magnets

Samarium	It is a moderately hard silvery metal that slowly oxidizes in air. Being a typical member of the lanthanide series, samarium usually assumes the oxidation state +3.	Rare Earth Metal	High temperature magnets
Europium	Europium phosphors are used in television tubes to give a bright red color and as an activator for yttrium-based phosphors.	Rare Earth Metal	Fluorescent lighting
Gadolinium	Gadolinium is a silvery-white metal when oxidation is removed. It is only slightly malleable and a ductile rare-earth element	Rare Earth Metal	Magnetic resonance imaging contrast agent, nuclear reactor rods
Terbium	It is a silvery-white, rare-earth metal that is malleable, ductile, and soft enough to be cut with a knife.	Rare Earth Metal	Phosphors for lighting, high power high temperature magnets
Dysprosium	It is a rare-earth element with a metallic silver luster. Dysprosium is never found in nature as a free element, though it is found in various minerals, such as xenotime	Rare Earth Metal	High power high temperature magnets, lasers
Ytterbium	Ytterbium is a soft, malleable, and ductile chemical element that displays a bright silvery luster when pure. It is a rare-earth element and is readily dissolved by the strong mineral acids.	Rare Earth Metal	Fiber optic technology, solar panels
Lutetium	It is a silvery white metal, which resists corrosion in dry air, but not in moist air. Lutetium is the last element in the lanthanide series, and is traditionally counted among the rare-earth metals.	Rare Earth Metal	PET scanners

Source: Company Website

11.1.1.3 Recent developments

Partnerships/Collaborations/Joint Ventures/Contracts & Agreements/Mergers & Acquisitions

MONTH & YEAR	DEAL TYPE	COMPANY 1	COMPANY 2	SYNERGY	DEAL SIZE
May 2019	Joint Venture	Lynas Corporation	Blue Line	Lynas Corporation and Blue Line announced a joint venture to develop rare earths separation capacity in the US.	NA
March 2019	Agreement	Lynas Corporation	MARA	Lynas Corporation signed an MoU with MARA to commercialize the neutralization underflow residue from the Lynas Malaysia plant.	NA

Source: Company Website and Press Releases

11.1.1.4 MnM view

11.1.1.4.1 Key strengths/Right to win

Lynas is the only producer of scale of separated rare-earth metals outside of China and the second largest in the world. Its rare-earth metal deposits in Mt Weld, Western Australia, is acknowledged as one of the highest grade rare earths mine in the world and operates the world's largest single rare earths processing plant in Malaysia. Also, Lynas Corporation recently signed an MoU with MARA to commercialize the neutralization underflow residue from the Lynas Malaysia plant.

11.1.1.4.2 Strategic choices made

The company is expanding its industrial footprint with a planned Rare Earths Processing Facility in Kalgoorlie, Western Australia. Lynas Rare Earths are used in many high tech and future facing industries, including electronics, wind turbines, catalytic converters, and electric and hybrid motor vehicles. In comparison to other rare-earth manufacturers, Lynas offers its customers, products with assured quality from the mine to finished product.

11.1.1.4.3 Weakness and competitive threats

Unfavorable changes in foreign currency exchange rates are likely to increase the expenses for the company. The non-AUD currencies, such as CNY, USD and EUR appreciation over AUD or vice versa, could incur additional costs for the company, as well as increase capital expenditures in AUD terms.

11.1.2 ALKANE RESOURCES LTD

11.1.2.1 Business and financial overview

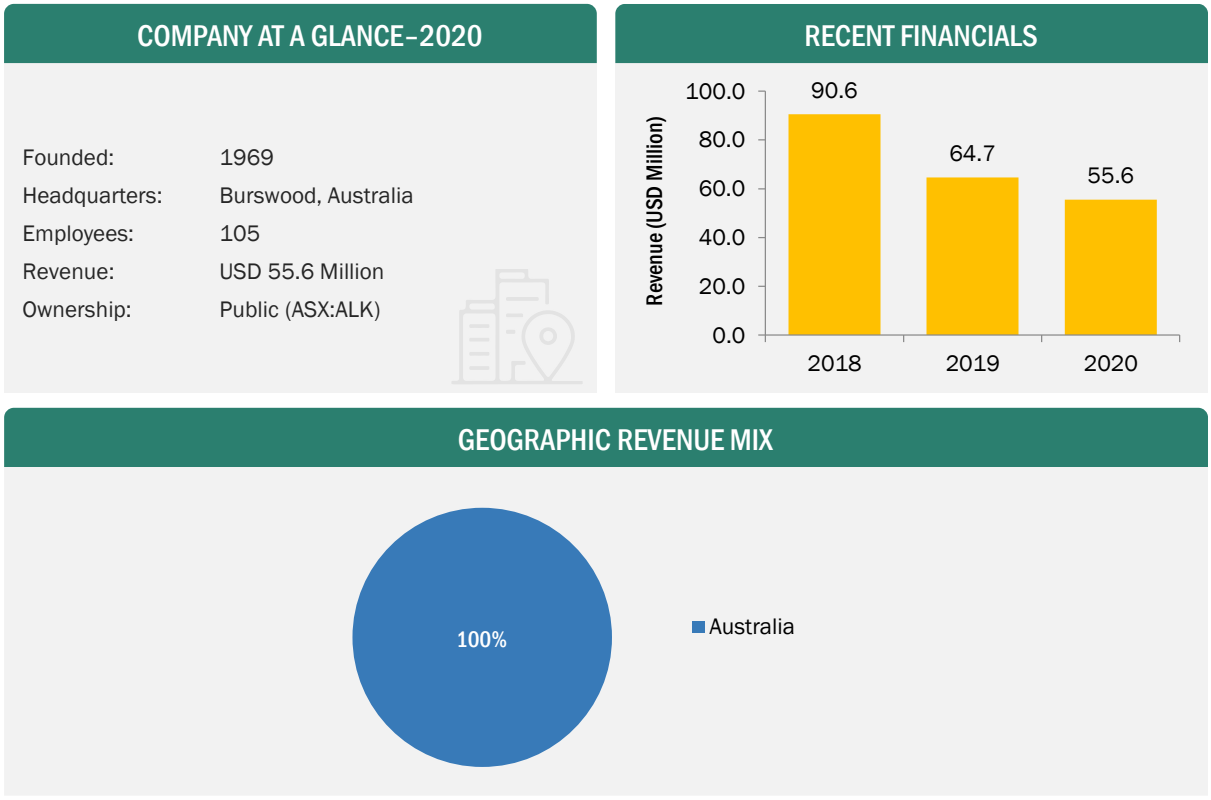
Alkane Resources Ltd (Alkane Resources) is a mineral exploration company. The company offers exploration and development of copper, diamond, gold, zirconium, niobium, yttrium, and rare-earth elements and properties, among other services It provides exploration projects, such as Tomingley Gold, Dubbo, Rockley Project, Peak Hill Gold Mines, among others. Alkane Resources offers projects, such as Wellington, Cudal, Diamond Creek, Northern Molong Porphyry Project, and Elseinora. The company operates in Australia and the British Virgin Islands. Alkane Resources is headquartered in Perth, Western Australia, Australia.

TABLE 91 ALKANE RESOURCES LTD: BUSINESS OVERVIEW

Year Founded	1969
Country	Australia
City	Burswood
Ownership	Public (ASX:ALK)

Source: Company Website

FIGURE 40 ALKANE RESOURCES LTD: COMPANY SNAPSHOT



Note: The financial year of the company ends on December 31.

Source: Company Website, Press Releases, and Company Annual Reports

11.1.2.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Zirconium	Zirconium dioxide is a white crystalline oxide of zirconium. Its most naturally occurring form is the mineral baddeleyite.	Rare earth metals	End user: Industrial
Niobium	It is a rare metal with anticorrosive properties	Rare earth metals	End user: Industrial
Hafnium	A lustrous, silvery gray, tetravalent transition metal, hafnium chemically resembles zirconium and is found in many zirconium minerals.	Rare earth metals	End user: Industrial
Yttrium	A soft, silvery metal. Yttrium is often used as an additive in alloys.	Rare earth metals	End user: Industrial

Source: Company Website

11.1.2.3 Recent development

Partnerships/Collaborations/Joint Ventures/Contracts & Agreements/Mergers & Acquisitions/ Investments & Expansions

MONTH & YEAR	DEAL TYPE	COMPANY 1	COMPANY 2	SYNERGY	DEAL SIZE
April 2019	Contract	Alkane Resources Limited	Calidus Resources Limited	In April, the company invested USD 2.16 million in Calidus Resources Limited, a gold exploration company in Australia.	USD 2.16 million

Source: Company Website and Press Releases

11.1.2.4 MnM view

11.1.2.4.1 Key strengths/Right to win

A wide product portfolio enables Alkane to cater to a diversified customer base and generate higher revenues. It also enhances the revenue stream of the company by balancing the overall business risk. The increasing production of gold could help the company enhance its business. According to the Global Data report on gold mining, the global production of gold stood at 119.9 million ounces (Moz) in 2019, and is expected to grow at a CAGR of 2.4% during the forecast period (2019-2023) to reach 132.1 Moz in 2023.

11.1.2.4.2 Strategic choices made

The company could benefit by adopting the latest technologies and equipment that are efficient and more productive. The mining industry has been witnessing the emergence of advanced technologies and equipment, which is changing the way the mining processes take place. New emerging mining machines detect problems automatically and could be operated remotely. Improvements in mining methods, hazardous gas monitoring, gas drainage, electrical equipment, and ventilation have reduced many of the risks of rock falls, explosions, and unhealthy air quality.

11.1.2.4.3 Weakness and competitive threats

The increasing minimum wage rates for employees in Australia may increase the cost to the company. The Fair Work Commission, Australia's national workplace relations tribunal, announced 3% increase in minimum wages with effect from July 1, 2019. Such increase in wages by the Australian government would increase the indirect costs of the company, affecting its financial position.

11.1.3 ARAFURA RESOURCES LTD

11.1.3.1 Business and financial overview

Arafura Resources Ltd (Arafura) is a rare-earth metals mining and exploration company. It is involved in exploration and development of various mineral sources including rare earths, phosphate, uranium, iron, vanadium and gold. It primarily focuses on Nolans Rare Earths project, which includes a proposed rare earths mine and processing operation near Aileron, in Central Australia. The company also owns other exploration projects including the Aileron-Reynolds project. Its rare-earth products are used in magnetic, optical, catalytic and electronic applications in key growth sectors, such as automotive technology, clean energy technology, and consumer electronics. These are also used in oil refining, healthcare, lighting, robotics, industrial, and aerospace sectors. Arafura is headquartered in Perth, Australia.

TABLE 92 ARAFURA RESOURCES LTD: BUSINESS OVERVIEW

Year Founded	1997
Country	Australia
City	Perth
Ownership	Public (ASX:ARU)

Source: Company Website

11.1.3.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Neodymium-Praseodymium (NdPr) oxide	NdPr oxide is Arafura's flagship product for use by advanced magnet and magnet alloy customers.	Rare Earth Metal	Automotive technology, clean energy technology, and consumer electronics
Cerium (Ce) oxide	It is an important commercial product and an intermediate in the purification of the element from the ores.	Rare Earth Metal	

Source: Company Website

11.1.3.3 MnM view

11.1.3.3.1 Key strengths/Right to win

Focus on the Nolans Project enables the company to enhance its operational performance and revenue base. Nolans Rare Earths project is situated 135 km north of Alice Springs in Northern Territory. It is located in close proximity to the Stuart Highway, the Amadeus gas pipeline and the Adelaide to Darwin Railway. It comprises a mine, beneficiation plant, extraction plant, and separation plant. The mine also has a slurry pipeline to a chemical processing plant, which produces rare earths-rich intermediate products; and an operations and logistics center and office in Alice Springs. Its other infrastructure includes a small carbonate quarry north-west of the mine; and piping water from borefields south-west of the mine.

11.1.3.3.2 Strategic choices made

The positive outlook of the global automotive industry provides opportunities for Arafura, which may translate into rising demand for the company's products, in turn, increasing its top-line performance. Arafura is mainly involved in the exploration and development of Neodymium praseodymium (NdPr), a critical raw-material that is used in the manufacturing process of permanent magnets, which in turn, are necessary to manufacture electric, hybrid, and conventional motor vehicles.

11.1.3.3.3 Weakness and competitive threats

The company reported an increase in debt in FY2020. Increasing debt could hamper the operational performance of the company, as a major portion of its earnings would be diverted to servicing its debt obligations. This could be of concern to investors as it becomes difficult for the company to raise funds on favorable terms from the market.

11.1.4 CHINA MINMETALS RARE EARTH CO LTD

11.1.4.1 Business and financial overview

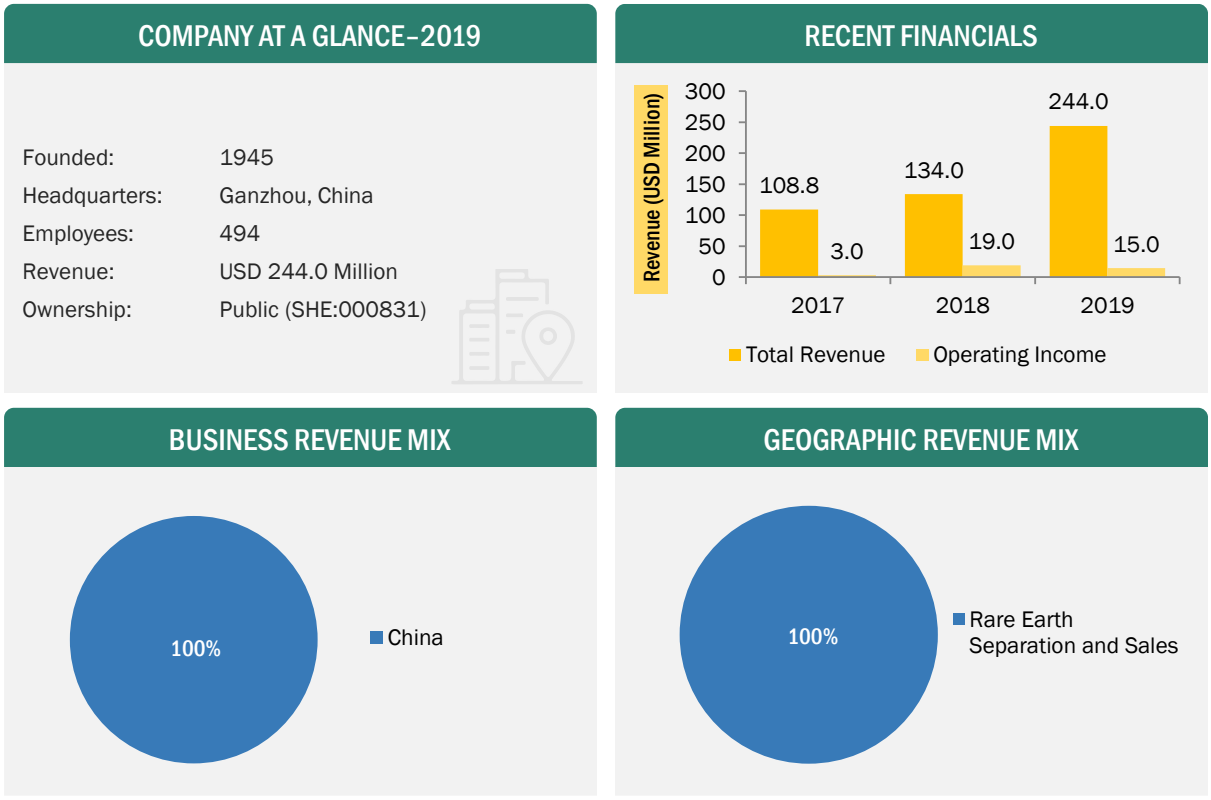
China Minmetals Rare Earth Co Ltd (China Minmetals), formerly Shanxi Guanlu Co Ltd, is an ionic rare-earth separation and processing company. The company explores, mines, produces, and distributes rare-earth metals, rare-earth oxides, and processed products of rare earth. Its rare-earth oxides include ceria, lanthanum oxide, neodymium oxide, europium oxide, praseodymium oxide, neodymium oxide, terbium oxide, dysprosium oxide, holmium, gadolinium, lutetium, praseodymium, samarium, erbium, yttrium, and europium oxides. China Minmetals offers services, such as rare-earth techniques, and R&D; and consultation services. China Minmetals is headquartered in Ganzhou, China.

TABLE 93 CHINA MINMETALS RARE EARTH CO LTD: BUSINESS OVERVIEW

Year Founded	1998
Country	China
City	Ganzhou
Ownership	Public (SHE:000831)

Source: Company Website

FIGURE 41 CHINA MINMETALS RARE EARTH CO LTD: COMPANY SNAPSHOT



Note: The financial year of the company ends on December 31.

Source: Company Website, Press Releases, and Company Annual Reports

11.1.4.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/END USER
Dysprosium oxide	Dysprosium oxide is a white or light yellow powdery solid. Dysprosium is an essential element for the preparation of the rare-earth super magnetostrictive material Terfenol Alloy (Terfenol Alloy).	Rare-Earth Metal	Ceramics, glass, phosphors, lasers
Lutetium oxide	Lutetium oxide is a brown powdery solid, insoluble in water, but soluble in inorganic acids. Lutetium can be used to make some special alloys.	Rare-Earth Metal	Ceramics, glass, phosphors, and lasers
Praseodymium oxide	Praseodymium oxide is a black or brown powder. Praseodymium oxide plays an important role in many fields and has a good sales market prospect. It is mainly used for ceramic pigment praseodymium yellow, raw materials for color-changing spectacle lenses, glass colorants, artificial gems, and raw materials for metal praseodymium, shirt making, praseodymium, cobalt permanent magnet alloy, etc.	Rare-Earth Metal	Magnetic material Catalyst
Europium oxide	Europium oxide is a light red powdery solid, insoluble in water but soluble in acid. Mainly used as a red luminescent material and in plasma flat panel displays. It has become a new generation light source with high illuminance, high power saving, high color rendering, and long life.	Rare-Earth Metal	Electronic devices
Yttrium oxide	White powdery solid, mainly used in rare-earth Color TV phosphors, phosphors for three-color lamps, plasma display phosphors, solid laser crystals, functional ceramics, precision structure ceramics, communication fibers, optical glass, artificial gemstone neodymium iron boron permanent magnet alloys additives, giant magnetostrictive materials, magneto-optical materials, etc.	Rare-Earth Metal	Ceramics catalyst
Lanthanum oxide	Lanthanum oxide is a white powdery solid, insoluble in water and alkali, but slightly soluble in acid. Mainly used in the manufacture of high-quality large-aperture, large field of view, high-quality cameras, periscope lenses, particle accelerators, electron microscopes, and other large-scale electron and electron optical instruments anode thermionic emission materials.	Rare-Earth Metal	Medical Electronics
Cerium oxide	Cerium oxide is a pale yellow powdery solid, mainly used in automobile exhaust environmental protection catalysts, glass ceramic additives and colorants, polishing powder, agricultural plant growth regulators, etching agents, phosphors (green powder for lamps), plastic stabilization and modification agent, feed additive.	Rare-Earth Metal	Corrosion protection, solar cells, fuel oxidation catalysis, and automotive exhaust treatment

Neodymium oxide	Neodymium oxide is a lavender powdery solid, which is mainly used in permanent magnet motors, generators, nuclear magnetic resonance imaging machines, magnetic separators, magnetic lifting, instrumentation, liquid magnetization, magnetic therapy equipment, etc. It has become a car manufacturing, general-purpose functional materials that are indispensable for machinery, electronic information industry, and cutting-edge technology.	Rare-Earth Metal	Catalyst, Glass, Ceramics
Gadolinium oxide	Gadolinium oxide is a white powdery solid, insoluble in water but soluble in acid. It is mainly used in magnetic refrigeration. Gadolinium oxide is a promising and practical room temperature magnetic refrigeration material.	Rare-Earth Metal	Additives, Electronics, Catalysts, and dopants

Source: Company Website

11.1.4.3 MnM view

11.1.4.3.1 Key strengths/Right to win

The company focuses on maintaining quality standards across its operations, as quality plays a pivotal role in retaining its customers. It implements stringent quality management principles to ensure delivery of quality services to its clientele. The company's quality and environment department continuously strives for standardizing management systems, adding criteria and behavior models, and implementing the standards to achieve integration of processes.

11.1.4.3.2 Strategic choices made

The integration of the business lines and functional organizations allows the company to capture significant value across the business portfolio, at manufacturing sites, and more broadly, in the management of critical and shared activities. Comprehensive integrated services add to the company's financial growth and allow it to offset losses in any one segment with profits in another.

11.1.4.3.3 Weakness and competitive threats

Rising labor costs in China may impact the company's operations. According to the China Labour Bulletin (CLB), China has increased the minimum wage rates after consumer prices surged. Several regional governments of China have announced or increased the minimum wage. Currently, seven regional governments have a minimum wage rate higher than USD 306.4 per month, which includes Beijing, Hebei, Shandong, Henan, Shanghai, Zhejiang, and Guangdong.

11.1.5 AVALON ADVANCED MATERIAL INC

11.1.5.1 Business and financial overview

Avalon Advanced Materials, Inc. is a mineral exploration and development company, which engages in the acquisition, exploration, evaluation, and development of specialty metal and mineral properties. The firm focuses on metals and mineral deposits including lithium, tantalum, niobium, cesium, indium, gallium, germanium, rare-earth elements, yttrium, and zirconium. It holds interest in projects Lilypad, Nechalacho, Separation Rapids Lithium, Warren Township, and East Kemptville Tin-Indium.

TABLE 94 AVALON ADVANCED MATERIAL INC: BUSINESS OVERVIEW

Year Founded	1991
Country	Canada
City	Toronto
Ownership	Public (TSE:AVL)

Source: Company Website

11.1.5.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Lithium	Economic concentrations of lithium occur in salts from surface and subsurface brines, and in granitic pegmatites in the lithium minerals petalite, spodumene, amblygonite, and lepidolite.	Rare-Earth Metals	▪ Ceramics and Glass ▪ Lithium Batteries
Cerium	Cerium is primarily obtained through solvent extraction processes of light rare-earth minerals, such as bastnaesite.	Rare-Earth Metals	▪ Glass and Ceramics ▪ Lighting ▪ Solar panels ▪ Catalysts ▪ Alloys and Metals
Cesium	Cesium is a very rare element, mostly found in unusual, highly evolved granitic pegmatite rocks in form of the mineral pollucite and in certain brines.	Rare-Earth Metals	▪ Biomedical Uses ▪ Manufacturing: ▪ Electronics ▪ Magneto-Hydrodynamics and Ion Propulsion Motors
Dysprosium	Dysprosium has a metallic, bright silver luster. It is relatively stable in air at room temperature, but dissolves readily with the evolution of hydrogen, in mineral acids.	Rare-Earth Metals	▪ Magnets – Electromotive ▪ Magnets – Electronics ▪ Energy ▪ Ceramics and Specialty Glass
Erbium	Pure erbium metal is soft, malleable and has a bright, silvery, metallic luster. The metal is fairly stable in air and does not oxidize as rapidly as some of the other rare earth metals.	Rare-Earth Metals	▪ Ceramics and Specialty Glass ▪ Energy ▪ Materials ▪ Medical

Tin	Tin is obtained mainly from the minerals cassiterite, a tin oxide, and stannite, a tin sulfide. Both may carry some indium: a rare metal with many opto-electronic applications.	Rare-Earth Metals	▪ Alloyed Material ▪ Glassmaking ▪ Tinplating ▪ Solders
Yttrium	Yttrium is highly crystalline. The pure element is relatively stable in air in a solid form.	Rare-Earth Metals	▪ Materials and Chemicals ▪ Electronics ▪ Ceramics and Specialty Glass ▪ Medical

Source: Company Website

11.1.5.3 MnM view

11.1.5.3.1 Key strengths/Right to win

The company can benefit by adopting the latest technologies and equipment that are efficient and productive. The mining industry has been witnessing the emergence of advanced technologies and equipment, which is changing the way the mining processes take place. New emerging mining machines detect problems automatically and could be operated remotely. Improvements in mining methods, hazardous gas monitoring, gas drainage, electrical equipment, and ventilation have reduced many of the risks of rock falls, explosions, and unhealthy air quality.

11.1.5.3.2 Strategic choices made

The company is highly spending on R&D to innovate with new products and upgrade the existing technologies. It has adopted various business strategies, such as mergers & acquisitions and contracts & agreements to boost its position in the rare-earth metals market.

11.1.5.3.3 Weakness and competitive threats

The outbreak of COVID-19 has forced the global mining industry to suspend operations at many locations, across the world. Mining companies are responsible for health and safety of its employees, contractors, and local communities. The outbreak of COVID-19 has forced the mining players to either slow down or halt their operations. Also, most of the mining companies are temporarily suspending construction activities at their mining sites.

11.1.6 BAOTOU HEFA RARE EARTH CO LTD

11.1.6.1 Business and financial overview

Baotou HEFA Rare Earth Co. Ltd. brings the opportunity to purchase rare earths directly from one of the world's largest and most experienced producers. Baotou HEFA Rare Earth, located in Baotou, Inner Mongolia, China - a region with 80% of the world's rare-earth resources. Inner Mongolia HEFA Rare Earth Science & Technology Development Co., Ltd. is located in the High & New Technology Development Zone of Baotou, Inner Mongolia Autonomous Region. It is one of largest rare-earth enterprises in China, with five rare-earth processing factories and greater than 5,000 metric ton rare-earth oxide capacity.

TABLE 95 BAOTOU HEFA RARE EARTH CO LTD: BUSINESS OVERVIEW

Country	Canada
City	Richmond
Employees	900
Ownership	Private

Source: Company Website

11.1.6.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/END USER
Lanthanum	Lanthanide zirconates are used for their catalytic and conductivity properties and lanthanum stabilized zirconia has useful electronic and mechanical properties.	Rare-Earth Metals	▪ Optical glass ▪ Catalysts ▪ Ceramic
Cerium	In glass industry, it is considered to be the most efficient glass polishing agent for precision optical polishing. It is also used to decolorize glass by keeping iron in its ferrous state.	Rare-Earth Metals	▪ Catalyst ▪ Glass production ▪ Polishing powder ▪ Ceramics
Praseodymium	It is highly valued for ceramics as a bright yellow pigment in praseodymium doped zirconia because of its optimum reflectance at 560 nm.	Rare-Earth Metals	▪ Pigments ▪ Glass ▪ Ceramics
Neodymium	The neodymium-based magnet is used extensively in the automotive industry with many applications, including starter motors, brake systems, seat adjusters, and car stereo speakers. Its largest application is in the voice coil motors used in computer disk drives.	Rare-Earth Metals	▪ Glass ▪ Ceramics ▪ Alloy ▪ Laser crystal ▪ Electric capacitor ▪ Rubber additives
Samarium	These are utilized in lightweight electronic equipment, where size or space is a limiting factor and where functionality at high temperature is a concern.	Rare-Earth Metals	▪ Catalysts ▪ Ceramics ▪ Glass ▪ Neutron absorption

Europium	In energy efficient fluorescent lighting, Europium provides not only the necessary red, but also the blue. Several commercial blue phosphors are based on Europium for Color TVs, computer screens, and fluorescent lamps.	Rare-Earth Metals	▪ Phosphor for CRT & three bands lamps; flat plasma screen
Yttrium	While not part of the rare-earth series, it resembles the heavy rare earths, which are sometimes referred to as the yttrics for this reason.	Rare-Earth Metals	▪ Ceramics ▪ Catalysts ▪ Phosphor ▪ Crystal ▪ Jewelry ▪ Optical lasers
Scandium	Scandium oxide is suitable for the high index component of UV, AR, and bandpass coatings due to its high index value, transparency, and layer hardness.	Rare-Earth Metals	▪ Electronics ▪ CRT Phosphor ▪ Ceramics

Source: Company Website

11.1.7 CANADA RARE EARTH CORPORATION

11.1.7.1 Business and financial overview

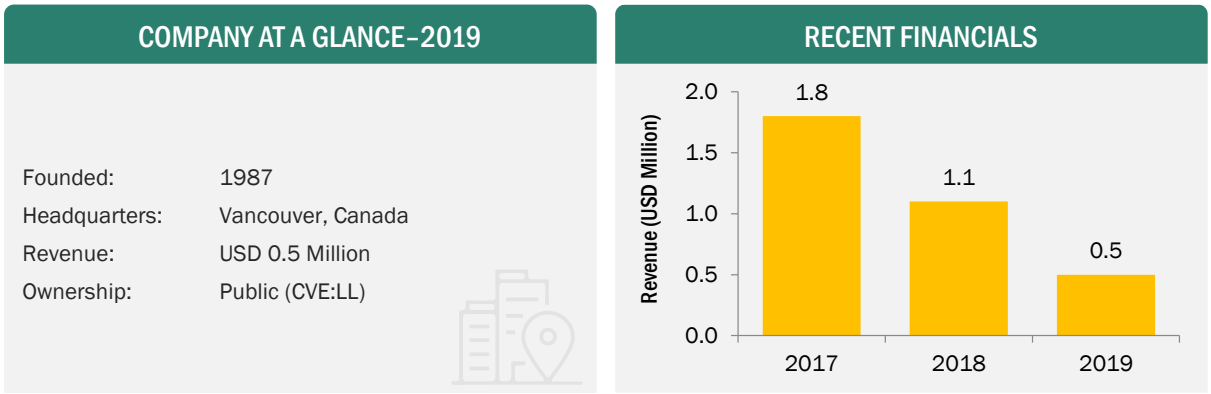
Canada Rare Earth Corporation (CRE) is a development stage company. The company engages in the acquisition and exploration of mineral property interests. CRE offers products, such as dysprosium oxide, europium oxide, holmium oxide, terbium oxide, yttrium oxide, praseodymium oxide, cerium oxide, and gadolinium oxide. It also provides rare-earth fluorides including lanthanum fluoride, yttrium fluoride, and neodymium fluoride. CRE involves in identifying rare-earth sources. The company offers its products and services in North America, South America, Africa, Asia, and Southeast Asia.

TABLE 96 CANADA RARE EARTH CORPORATION: BUSINESS OVERVIEW

Year Founded	1987
Country	Canada
City	Vancouver
Ownership	Public (CVE:LL)

Source: Company Website

FIGURE 42 CANADA RARE EARTH CORPORATION: COMPANY SNAPSHOT



Note: The financial year of the company ends on March 31.

Source: Company Website, Press Releases, and Company Annual Reports

11.1.7.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Yttrium	It is a silvery-metallic transition metal chemically similar to the lanthanides and has often been classified as a "rare-earth element".	Rare-Earth Metals	▪ Ceramics ▪ Catalyst
Gadolinium	Gadolinium is a soft, shiny, ductile, silvery metal belonging to the lanthanide group of the periodic chart. The metal does not tarnish in dry air, but an oxide film forms in moist air.	Rare-Earth Metals	▪ Phosphorous ▪ Electronics
Dysprosium	Dysprosium has a metallic, bright silver luster. It is relatively stable in air at room temperature, but dissolves readily with the evolution of hydrogen, in mineral acids.	Rare-Earth Metals	▪ Magnets – Electromotive ▪ Magnets – Electronics ▪ Energy ▪ Ceramics and Specialty Glass
Neodymium	The neodymium-based magnet is used extensively in the automotive industry with many applications including starter motors, brake systems, seat adjusters, and car stereo speakers. Its largest application is in the voice coil motors used in computer disk drives.	Rare-Earth Metals	▪ Glass ▪ Ceramics ▪ Alloy ▪ Laser crystal ▪ Electric capacitor ▪ Rubber additives

Source: Company Website

11.1.8 ILUKA RESOURCE LTD (ILUKA)

11.1.8.1 Business and financial overview

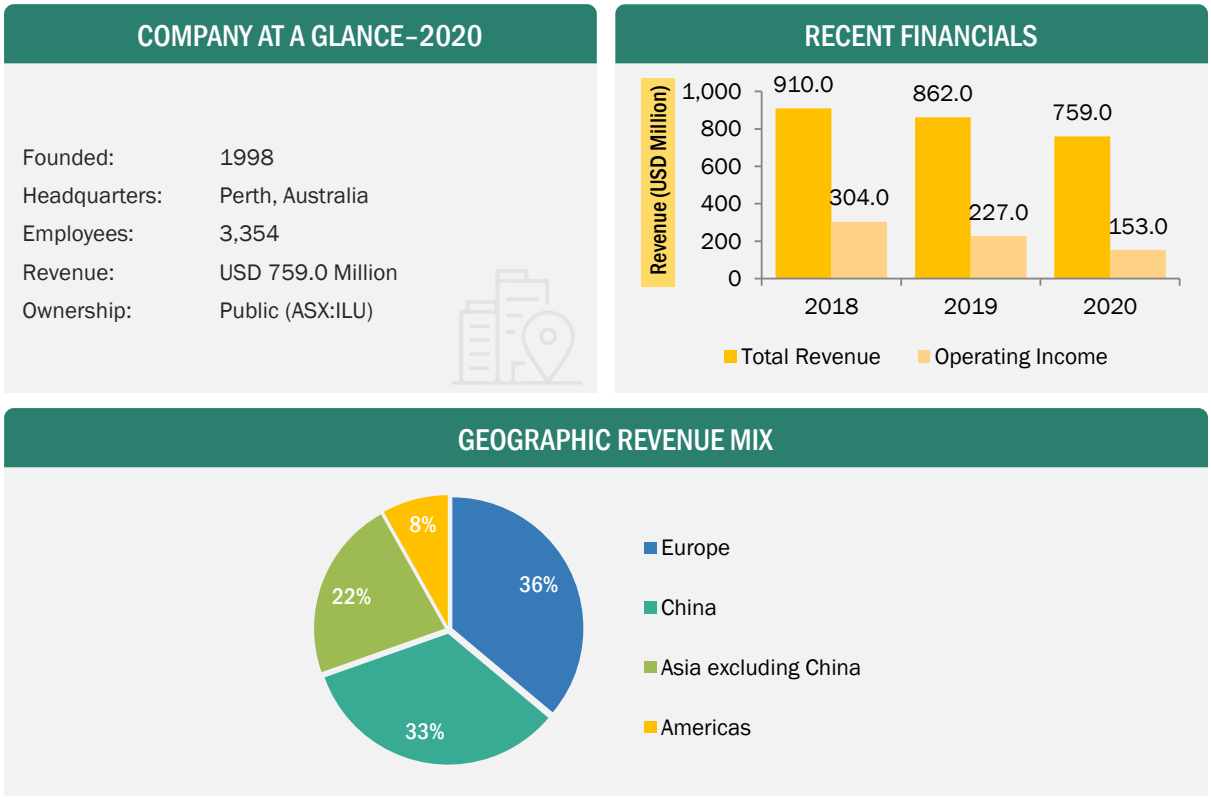
Iluka Resource Ltd (Iluka) is a mineral sands company. It is involved in exploration, project development, operation and marketing of mineral sands products. The company's key assets and operations are located in Australia, with a mining and processing operation in Virginia, the US. Iluka is the largest producer of zircon in the world. It also produces titanium dioxide minerals, such as rutile, ilmenite, and synthetic rutile. The company also has a royalty over iron ore sales revenue from certain tenements of BHP Billiton's Mining Area C province in Western Australia. Its products find application in a diverse range of sectors, such as consumer, industrial, manufacturing, aircraft and healthcare. Iluka is headquartered in Perth, Western Australia, Australia.

TABLE 97 ILUKA RESOURCE LTD (ILUKA): BUSINESS OVERVIEW

Year Founded	1998
Country	Australia
City	Perth
Ownership	Public (ASX:ILU)

Source: Company Website

FIGURE 43 ILUKA RESOURCE LTD: COMPANY SNAPSHOT



Note: The financial year of the company ends on March 31.

Source: Company Website, Press Releases, and Company Annual Reports

11.1.8.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Neodymium	Neodymium belongs to the lanthanide series and is a rare-earth element. It is a hard, slightly malleable silvery metal that quickly tarnishes in air and moisture.	Rare-Earth Metal	▪ Wind Turbines, ▪ Electric Vehicles
Praseodymium	It is the third member of the lanthanide series and is traditionally considered to be one of the rare-earth metals. Widely used to measure natural gas and coal gas.	Rare-Earth Metal	▪ Wind Turbines, ▪ Electric Vehicles

Source: Company Website

11.1.9 NORTHERN MINERALS LIMITED

11.1.9.1 Business and financial overview

Northern Minerals Limited is engaged in the exploration and evaluation of rare-earth minerals, such as dysprosium and terbium. The company holds interest in Browns Range Project located approximately 160 kilometer (km) south east of Halls Creek, in the north of Western Australia. It also holds interest in the John Galt Project located in Western Australia and Boulder Ridge Project in Northern Territory regions of Australia. Northern Minerals is engaged in the exploration and evaluation of rare-earth minerals, such as dysprosium and terbium. The company operates in Australia, where it is headquartered in West Perth.

TABLE 98 NORTHERN MINERALS LIMITED: BUSINESS OVERVIEW

Year Founded	2006
Country	Australia
City	Perth
Ownership	Public (ASX:NTU)

Source: Company Website

11.1.9.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Dysprosium	An essential element in the production of NdFeB permanent magnets. Dysprosium makes magnets long lasting and able to retain efficiency at extremely high temperatures.	Rare Earth Metal	▪ Hybrid and electric vehicles ▪ Wind turbines ▪ Miniaturization electronics ▪ Radiation detection equipment ▪ Refractive glass material
Lutetium	Lutetium is the last element in the lanthanide series, and it is traditionally counted among the rare-earth metals.	Rare Earth Metal	▪ Detectors used in PET scanners ▪ Catalysts in the chemical industry
Terbium	One of the rarest of the lanthanides and is often substituted with dysprosium, due to the similar physical and chemical properties. It is used for the colored phosphors it produces and in permanent magnets.	Rare Earth Metal	▪ Actuators and sonar transceivers ▪ X-ray screens ▪ Hybrid cars and wind turbines ▪ Stabilizer in fuel cells ▪ Televisions

Source: Company Website

11.1.10 GREENLAND MINERALS LTD

11.1.10.1 Business and financial overview

Greenland Minerals Ltd. engages in the exploration and evaluation of minerals. Its projects include Iimaussaq Complex-Specialty Metals; Kvanefjeld-REEs, uranium, zinc; Sørensen; Zone 3; and Steenstrupfjeld. The company was founded on February 21, 2006 and is headquartered in Subiaco, Australia.

TABLE 99 GREENLAND MINERALS LTD: BUSINESS OVERVIEW

Year Founded	2006
Country	Australia
City	Subiaco
Ownership	Private

Note: This is a privately-held company. Hence no financial information is available in the public domain.

Source: Company Website

11.1.10.2 Products/solutions/services offered

PRODUCT	DESCRIPTION	PRODUCT TYPE	APPLICATION/ END USER
Uranium	Uranium is the fuel used to produce electricity in commercial nuclear power plants.	Rare-Earth Metal	Nuclear power plants.
Zinc	Zinc is most commonly used as an anti-corrosion agent and galvanization (coating of iron or steel) is the most familiar form. Half of all zinc produced today is used to galvanize steel to prevent against corrosion.	Rare-Earth Metal	Anti-corrosion agent and galvanization
Fluorspar	Fluorspar (fluorite, CaF2) is an industrial mineral used in a number of chemical, ceramic, and metallurgical processes.	Rare-Earth Metal	Chemical, ceramic, and metallurgical processes

Source: Company Website

11.2 OTHER PLAYERS

11.2.1 NEO MATERIALS

Founded	1983
Headquarters	Ontario, Canada
Ownership	Public
Business Overview	Neo Rare Metals produces, reclaims, refines, and markets, high value niche metals and their compounds. These include tantalum, niobium, hafnium, rhenium, gallium, and indium. The advanced industrial materials that Neo Rare Metals produces for its customers are used in a variety of end-use applications ranging from wireless technologies, LED lighting and flat panel displays to turbine, solar, steel additives, and electronic applications, among others. The rare metals business is truly global, serving customers across North America, Europe, and Asia.
Products Offered	Tantalum, niobium, hafnium, rhenium, gallium, and indium
Geographical Presence	North America, Europe, and Asia

Source: Company Website

11.2.2 SHIN-ETSU CHEMICAL CO., LTD

Founded	1926
Headquarters	Tokyo, Japan
Ownership	Private
Business Overview	Shin-Etsu Chemical Co., Ltd. engages in the manufacture and sale of industrial chemicals. Its operations are carried out through the following segments: Polyvinyl Chloride (PVC)/Chlor-Alkali Business, Silicone Business, Specialty Chemicals Business, Semiconductor Silicon Business, Electronics and Functional Materials Business, and Diversified Business. The Electronics and Functional Materials Business segment provides rare-earth magnets, coating materials, photomask blanks, oxide single crystals, and liquid fluoroelastomers. The Diversified Business segment includes processed plastics, international trading, engineering, and information processing.
Products Offered	Rare-Earth Metals
Geographical Presence	Japan, US, China

Source: Company Website

11.2.3 EUTECTIX, LLC

Founded	2014
Headquarters	New Jersey, US
Ownership	Private
Business Overview	Eutectix, LLC manufactures and processes metal alloys and battery electrodes at its facilities in Troy Michigan and manufactures rare-earth elements and rare-earth alloys at its Tolleson Arizona factory. Its custom alloys are used as additives for manufacturing high tolerance specialty alloys and hydrogen storage, battery, and magnet applications. Current production has focused on hydrogen reactive metals, oxygen scavenging alloys, and magnetic alloys.
Products Offered	Lanthanum, cerium, neodymium, praseodymium, nickel, cobalt, manganese, and/or aluminum.
Geographical Presence	North America

Source: Company Website

11.2.4 CHINA NONFERROUS METAL INDUSTRY'S FOREIGN ENGINEERING AND CONSTRUCTION CO., LTD

Founded	1983
Headquarters	China
Ownership	Public
Business Overview	The company's business covers a wide spectrum of nonferrous metal project execution ranging from engineering, consultancy, equipment supply and installation, technical service, commissioning to personnel training. The company has also established its major markets, which are Central and North Asia centered with Kazakhstan, Central, and South Africa centered with Zambia, and neighboring countries such as Vietnam, Laos, Mongolia, North Korea, Indonesia, and Philippines.
Products Offered	Rare-Earth Metals
Geographical Presence	Central and North Asia

Source: Company Website

11.2.5 AMERICAN RARE EARTHS LIMITED

Founded	1986
Headquarters	Sydney, Australia
Ownership	Private
Business Overview	American Rare Earths Limited (ARR) is an Australian exploration company targeting the discovery and development of strategic technology mineral resources in the US and Australia. The company announced in August 2019 its entry into the lucrative US rare earth market, through the acquisition of the La Paz Rare Earth Project in Arizona, which contains an existing NI 43-101 Resource. The firm focuses on the discovery and development of strategic mineral resources across two primary geographical areas; the Murray Basin Region and the Broken Hill Region. It holds interest in Cobalt, Sulfuric Acid, and Titanium and Zirconium projects.
Products Offered	Rare-Earth Metals

Source: Company Website

11.2.6 CHINA NORTHERN RARE EARTH (GROUP) HIGH-TECH CO., LTD.

Founded	1961
Headquarters	Baotou, China
Ownership	Private
Business Overview	China Northern Rare Earth (Group) High-Tech Co., Ltd. is engaged in the production and sale of rare earth raw materials and rare earth functional materials. It offers rare-earth oxides, rare earth metals, rare earth salt products and magnetic materials. The company was founded in 1961 and is headquartered in Baotou, China.
Products Offered	Rare-Earth Metals
Geographical Presence	APAC

Source: Company Website

11.2.7 BAOTOU JINMENG RARE EARTH CO., LTD

Founded	2009
Headquarters	China
Ownership	Private
Business Overview	Baotou Jinmeng Rare Earth Co., Ltd , a wholly-owned subsidiary of Jinmeng Group, has the production lines of annually processing 120,000 tons of rare earth concentrates and separating 2,000 tons of rare-earth oxides, providing each branch with abundant materials for the R &D and the application of rare earth functional materials. The company is also a shareholder of Baotou Rare Earth International Trade and a strategic partner of Inner Mongolia Baotou Steel Rare-earth Hi-Tech Co., Ltd
Products Offered	Rare-Earth Metals
Geographical Presence	APAC

Source: Company Website

11.2.8 UCORE RARE METALS INC

Founded	2006
Headquarters	Canada
Ownership	Private
Business Overview	Innovation Metals Corp. (IMC), a wholly-owned subsidiary of Ucore Rare Metals Inc, has developed the proprietary RapidSXprocess, for the low-cost separation and purification of rare-earth elements, Nickel (Ni), Cobalt (Co), Lithium (Li), and other technology metals, via an accelerated form of solvent extraction. IMC is commercializing this approach for a number of metals, to help enable mining and metal-recycling companies to compete in today's global marketplace. .
Products Offered	Rare-Earth Elements, Nickel (Ni), Cobalt (Co), Lithium (Li)
Geographical Presence	APAC, South Africa, and Middle East

Source: Company Website

11.2.9 MITSUBISHI CORPORATION RTM JAPAN LTD.

Founded	1947
Headquarters	Japan
Ownership	Public
Business Overview	The company's Rare Metals Department handles products used as raw materials in permanent magnets, carbide tools, electronic materials, refractories, and catalysts. The main products include rare earths, tungsten, tantalum, neodymium, and zirconium minerals, for instance, baddeleyite.
Products Offered	Smart Metering Solutions
Geographical Presence	APAC

Source: Company Website

11.2.10 MEDALLION RESOURCES LTD

Founded	1989
Headquarters	Canada
Ownership	Private
Business Overview	Medallion Resources Ltd. engages in the acquisition, exploration, and evolution of mineral properties. This includes evaluating the merits of these properties using various techniques, such as sampling, trenching, drilling, and geophysical and geochemical survey methods. It focuses on rare earth business strategy involving the mineral monazite. The rare-earth elements are inputs to electric and hybrid vehicles, electronics, imaging systems, wind turbines, and strategic defense systems. The company was founded on December 8, 1989, and is headquartered in Vancouver, Canada.
Products Offered	Extraction and Development of Rare-Earth Elements
Geographical Presence	Canada

Source: Company Website

12 APPENDIX

12.1 DISCUSSION GUIDE

RARE-EARTH METALS MARKET (2021–2026)

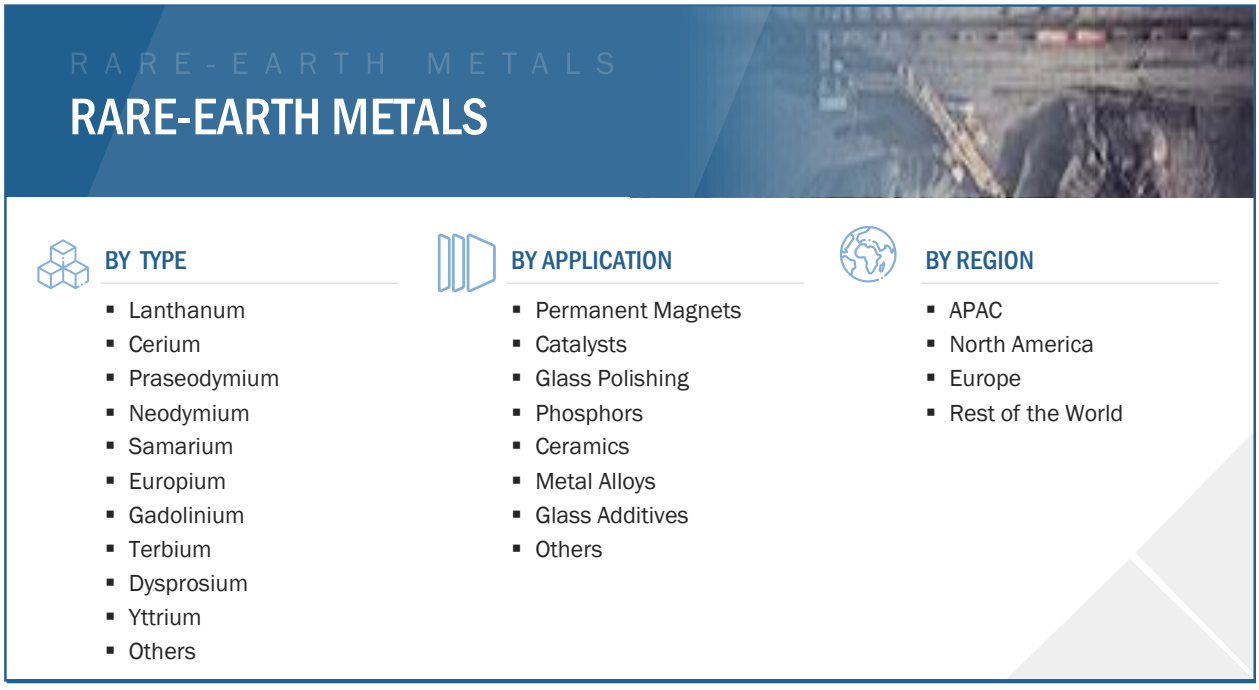
The report aims to present an analysis of the rare-earth metals market for the period 2021-2026. It provides information related to the growth of the market by identifying drivers, restraints, opportunities, and challenges faced by the industry, globally. It also includes an in-depth analysis of key industry players in the global market. The report provides a forecast of the rare-earth metals market, by type, application, and region.

SECTION-1: INTRODUCTION

Rare-earth elements are a group of seventeen 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 its rare-earth element definition.

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

MARKET SEGMENTATION



SECTION-2: MARKET DYNAMICS

Different factors are driving the rare-earth metals market. These factors are– increasing demand from end-use industries, increasing demand for clean energy, and initiative of associations & regulatory bodies

A few questions related to the market have been provided below, and for which your expert opinion would be highly appreciated.

Q. 1. What are the drivers and restraints of the rare-earth metals market? Which other factor will have a significant impact on regional market dynamics the next five years?

Your Viewpoint:_____

Q. 2. What are the upcoming trends in the rare-earth metals market? How are these trends expected to shape the future demand for rear earth metals?

TRENDS	DESCRIPTION

Q. 3. Lynas Corporation Ltd, Alkane Resources Ltd, Arafura Resources Ltd, China Minmetals Rare Earth Co Ltd, and Avalon Advanced Materials, Inc are some of the leading players in the rare-earth metals market. Please share your thoughts on the same, and suggest if there are any other major players that need to be considered in the market.

Your Viewpoint:_____

China is identified to be the largest market for rare-earth metals globally, with the market projected to grow at a high rate during the forecast period. Please share your insights on the same and suggest required changes, if any.

Your Viewpoint:_____

Q. 4. China is identified as the fastest-growing rare-earth metal market for in the APAC region. Please share your insights on the same and suggest required changes, if any.

Your Viewpoint:_____

Q. 5. What are the upcoming trends in the rare-earth metals market?

Your Viewpoint:_____

Q. 6. What are your views on the growth prospect of the rare-earth metals market? What is the current scenario, and how is the market expected to grow in the near future?

Your Viewpoint:_____

Q. 7. Please share your views regarding the competition in the global rare-earth metals market. Which are the key applications wherein rare-earth metals play a significant role?

Your Viewpoint:_____

Q. 8. Who are the emerging players in the rare-earth metals market?

Your Viewpoint:_____

12.2 KNOWLEDGE STORE: MARKETSANDMARKETS' SUBSCRIPTION PORTAL

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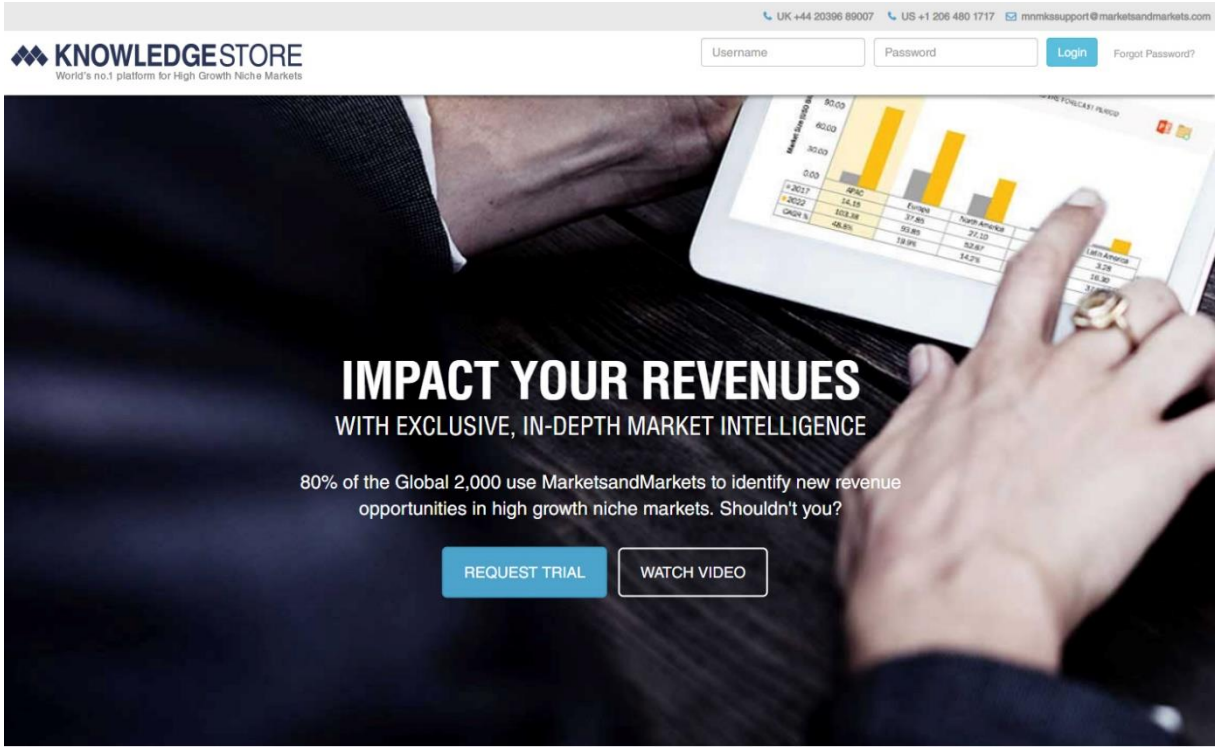

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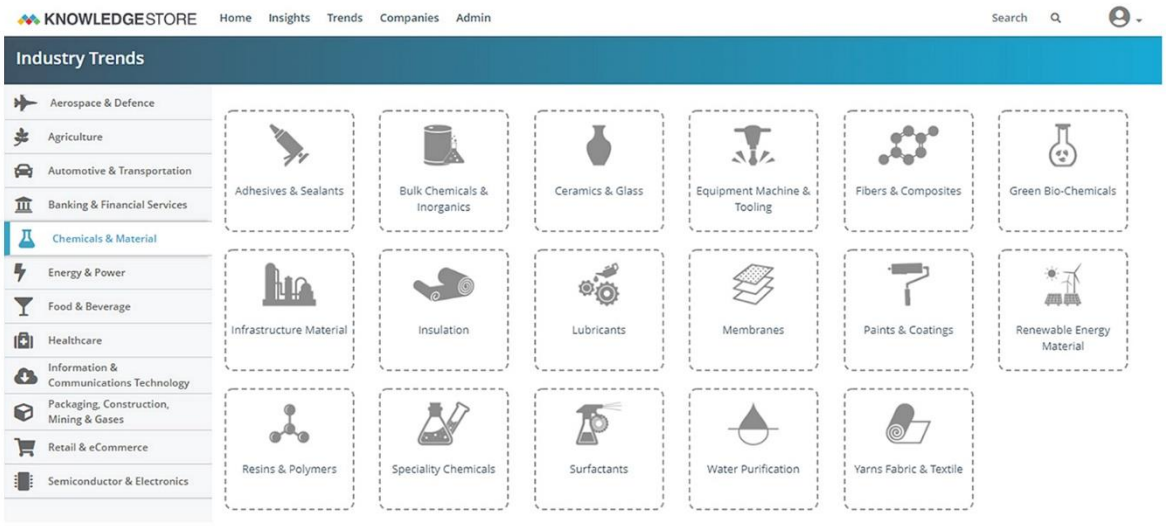

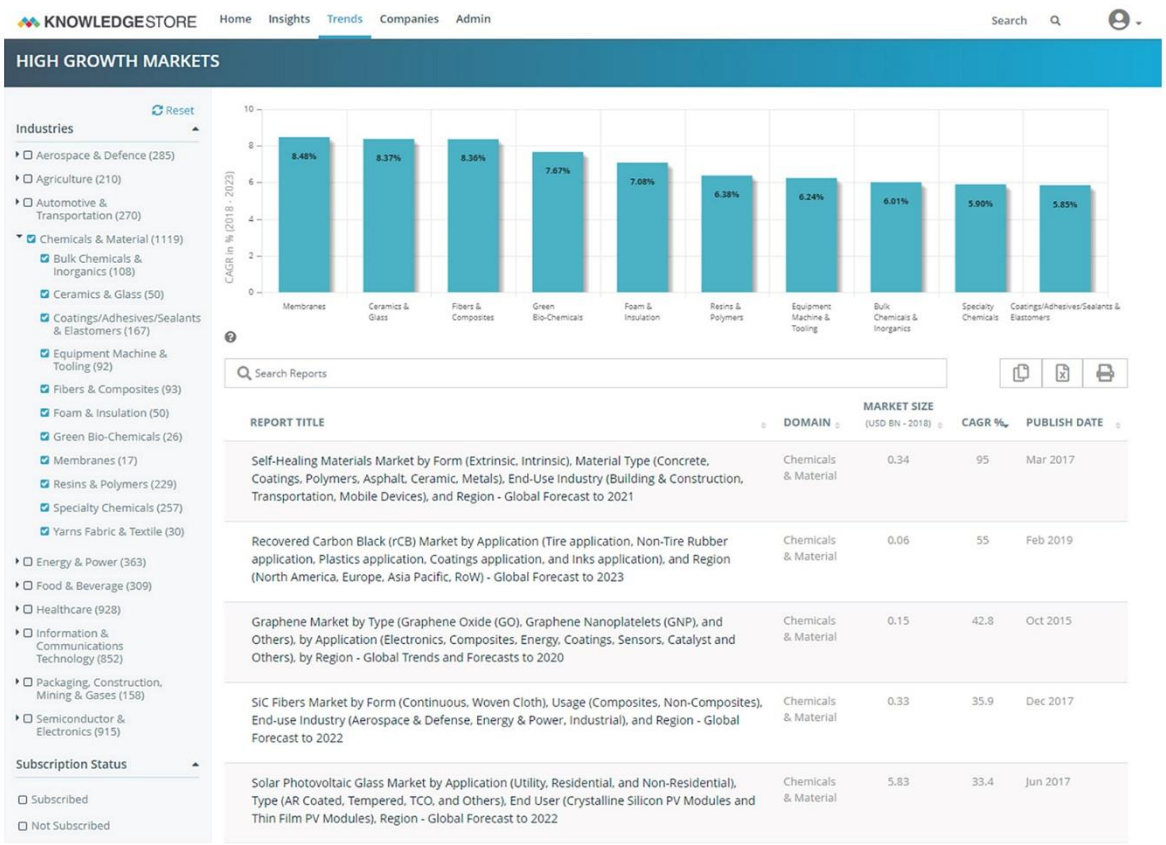

12.3 AVAILABLE CUSTOMIZATIONS

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

PRODUCT ANALYSIS

- Product matrix, which provides a detailed comparison of the market for different rear earth metal types

REGIONAL ANALYSIS

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

COMPANY INFORMATION

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

12.4 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

12.5 AUTHOR DETAILS

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A technically proficient and result-driven professional with over 15 years of experience and has been associated with 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 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.

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Ph.D. 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 stronghold 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.

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