

RARE EARTH ELEMENTS

THE PILLAR OF MODERN TECHNOLOGIES



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Resum

He triat aquest tema com a TDR perquè m'apassiona l'activitat minera. Crec que les terres rares són molt importants i estan presents en molts àmbits de la nostra vida. He vist l'oportunitat de donar-les a conèixer i ho he aprofitat. Amb aquest treball intento analitzar el seu impacte al món i veure si persones normals poden involucrar-se en aquest sector i sortir beneficiades. Aquest treball s'ha construït a base de analitzar diferents treballs acadèmics, informes governamentals, casos reals sobre mines i la investigació de diferents recursos d'inversió i empreses. Arribo a la conclusió de que tot i utilitzar-se en petites dosis, són molt rellevants pel funcionament òptim de les tecnologies modernes i dependre d'un únic país pel seu abastiment és molt perillós. S'espera que el volum d'aquest mercat augmenti i nosaltres ens en podem beneficiar.

Riepilogo

Ho scelto questo tema come *TDR* perché sono appassionato di attività minerarie. Credo che le terre rare siano molto importanti e presenti in molti ambiti della nostra vita. Con questo lavoro cerco di analizzare il suo impatto nel mondo e vedere se le persone comuni possono essere coinvolte in questo settore e trarne vantaggio. Questo lavoro è stato costruito analizzando diversi lavori universitari, rapporti governativi, casi reali sulle miniere e strumenti finanziari il cui valore è legato alle attività delle aziende che operano nel settore. Sono giunto alla conclusione che, pur essendo utilizzati in piccole dosi, sono molto importanti per il funzionamento ottimale delle moderne tecnologie e dipendere da un solo paese per il loro approvvigionamento è molto pericoloso. Il volume di questo mercato dovrebbe aumentare e generare benefici diffusi per la popolazione mondiale.

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*Després de tantes hores fent aquest treball sento que he d'agrair-ho a una persona en especial. Dedico aquest treball a aquella persona que em potència.
No ho hagués pogut fer sense tu, Joan, ets dinamita.*

Introduction

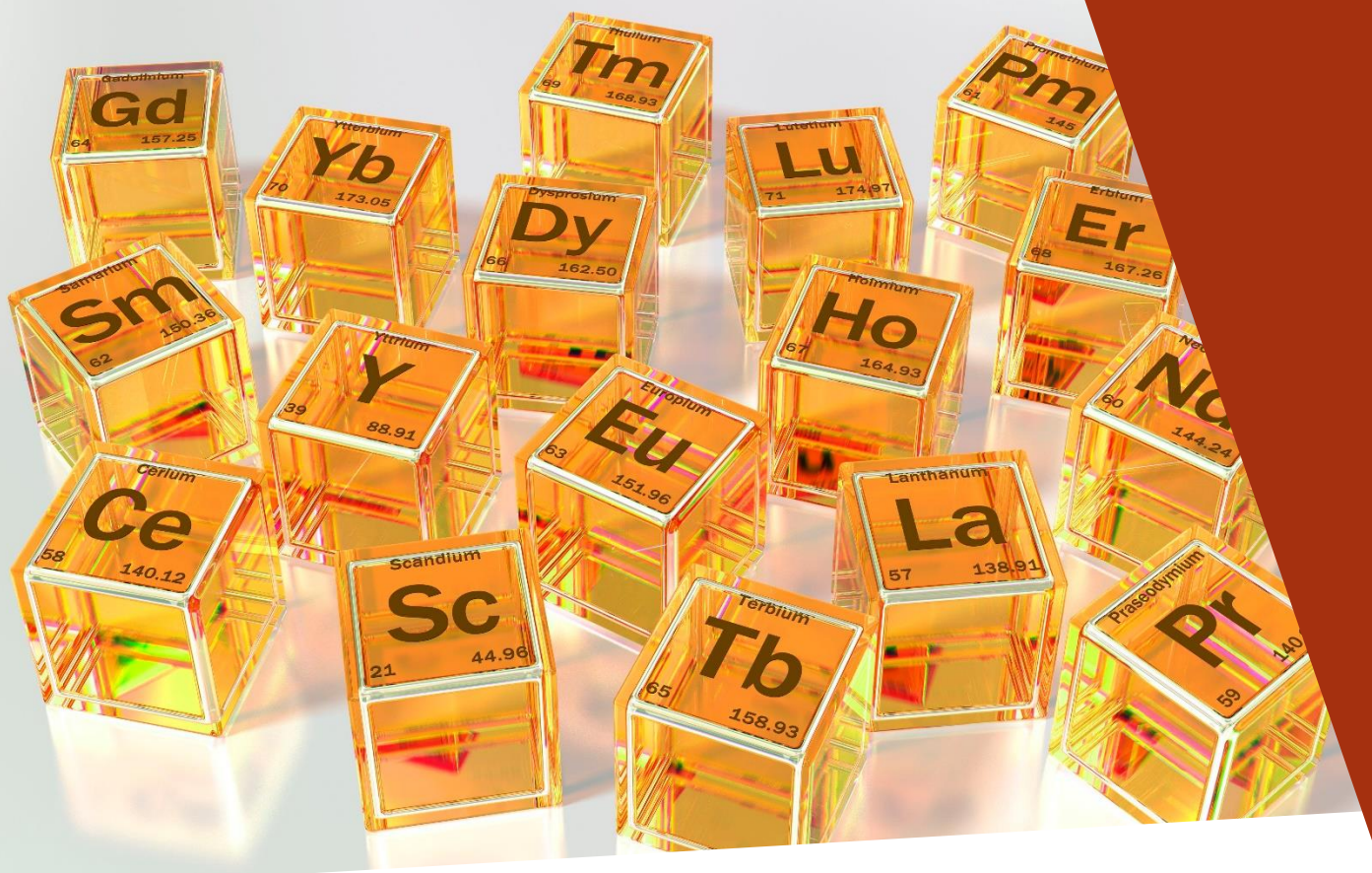
This work is a presentation and analysis of Rare Earth Elements (REE) and the impact it has on the world we live in. Taking a social, political, and economic standpoint.

I have chosen this subject because I feel passionate about the mining industry and I believe it's very important to our lives. When I got to know Rare Earths Elements, I was motivated to know them more deeply, and I took advantage of the situation and decided to select them as the subject of my *TDR*. They aren't known very widely but play an essential role in our lives, day a day. I am glad to give them more coverage and the recognition they should receive.

The objective of this research is to analyse the social, economic, and political impact Rare Earths Elements have and determine how important they are. Another objective is to determine the best way a regular person can take part in the REE market.

This research has been made by gathering and analysing information through academic surveys or governmental reports. The social impact research has been made from the analysis of two different real events, from China and Spain respectively. Trying to determine how to take part in the REE market has been done through a deep investigation and critical analysis of different financial options and more than 60 companies.

First of all, I'll make a presentation of these minerals, explaining what are they and their uses. Then follows the economic, social, and political standpoint investigation. Lastly, there is the investigation of the best way to invest in the market.



Rare Earth Elements

The situation of rare earth elements and application in the technology

What is the difference between our current lives and the life of our ancestors? One irrefutable answer is the technology that surrounds us is far more advanced. In the defence industry, our devices like mobile phones or the lens of our cameras, clean energy producers, or electric vehicles. But these devices need to be built up with certain elements. Some of these elements are the so-called **Rare Earth Elements** (REE).

This section is important to understand the basics of the REE.

1. Rare Earth Elements

1.1 What are rare earth elements?

Rare earth elements (**REE**) are an important group of 17 minerals that are chemically very similar and are usually found together. They hold unique magnetic properties, also they have high electrical conductivity, very useful in different applications.

H	Rare Earth Elements																He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt									
Lanthanides																	
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu																	
Actinides																	
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr																	

Figure 1 Rare Earth Elements in the Periodic Table.

1.2.1 Why are they important?

These metals are used in little amounts but are very significant when melted in different alloys with much more abundant metals such as iron. The global Rare Earth Industry Association (REIA) claims that this little use is often considered necessary for the optimal use of a lot of technologies:

“Rare earth elements are used in small, but often necessary, amounts in hundreds of different technologies, materials, and chemicals worldwide in commercial, industrial, social, medical, and environmental applications.”- REIA¹.

¹ The Rare Earth Industry Association (REIA)

The amount of REE used is so small that a single mine in Inner Mongolia, China, produces more than 50% of all Chinese REE production.

Rare earth elements are very important for modern technologies. They have numerous ways of applications: Some of them are used for making the screens of mobile phones or LED lights; others are used for digital camera lenses; also, many are used to build petroleum refineries or green energy technologies like large wind turbines and solar panels.



Figure 2 Wind turbines and Solar panels.

Electric cars rely on REE to function correctly (they are used in the motor, the audio speakers, the electric windows, and more). Most importantly, almost all the considered “new technologies” and “green energy” couldn’t work properly without REE.

1.2.2 F-35

Another key application is in the modern military. For example, the US military heavily relies on REE. All their technologically advanced arsenal demands these minerals. We can see that their star aviation product, their beloved F-35, uses 417 kilograms of rare earth materials. A 3% of every F-35 are REE. And more than 700 units had already been produced on 27 September 2021, while the US plans to incorporate a total of up to 2,443 units into their air force. Adding to this are other countries like Israel, which also plan to get their hands on some of these rare earth-loaded planes.



Figure 3 Lockheed Martin F-35 Lightning II.

1.3 Where are they?

Despite their name, rare earth elements are very common and they can be found all around the globe, but it is very difficult to find them very concentrated in a certain location. In almost every place REE aren't affordable to extract because of their low concentration.

1.4 Where do they come from?

Although REE reserves can be found almost anywhere, very few countries produce them and China is by far the largest producer in the world.

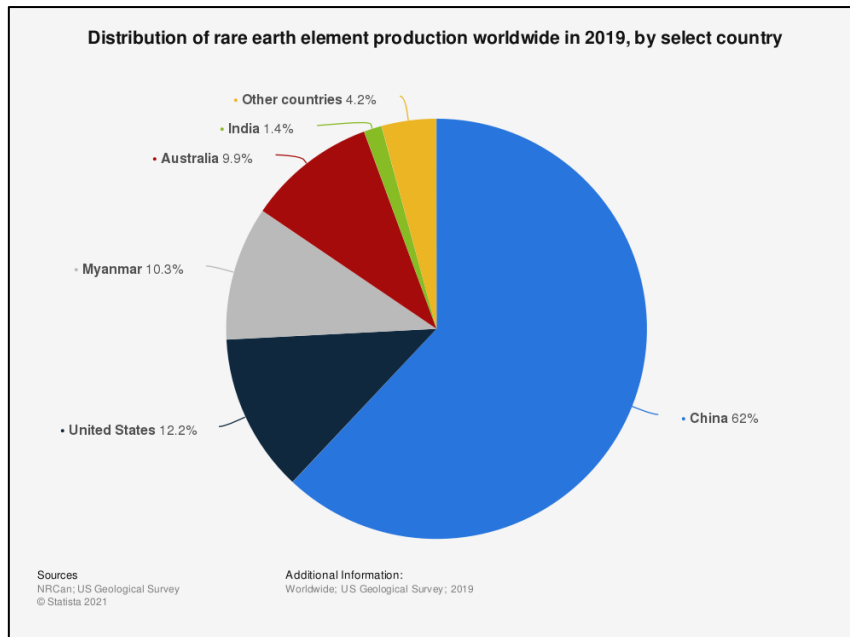


Figure 4. Distribution of REE production worldwide in 2019 by countries. By Statista.

	Mine production		Reserves ⁸
	2020	2021 ^e	
United States	39,000	43,000	1,800,000
Australia	21,000	22,000	⁹ 4,000,000
Brazil	600	500	21,000,000
Burma	31,000	26,000	NA
Burundi	300	100	NA
Canada	—	—	830,000
China	¹⁰ 140,000	¹⁰ 168,000	44,000,000
Greenland	—	—	1,500,000
India	2,900	2,900	6,900,000
Madagascar	2,800	3,200	NA
Russia	2,700	2,700	21,000,000
South Africa	—	—	790,000
Tanzania	—	—	890,000
Thailand	3,600	8,000	NA
Vietnam	700	400	22,000,000
Other countries	100	300	280,000
World total (rounded)	240,000	280,000	120,000,000

Figure 5. Global REE production by countries and their reserves. Expressed in metric tons. By the U.S Geological Survey.

But it wasn't always like this. Before the dominance of China in the REE market, the USA used to be the top producer with its REE mine of Mountain Pass, in California. But in 2002 the mine closed due to a toxic waste spill. And their concluding years pre-shutdown in 2002, it was experiencing a harsh time competing against the low prices of the REE Chinese companies.

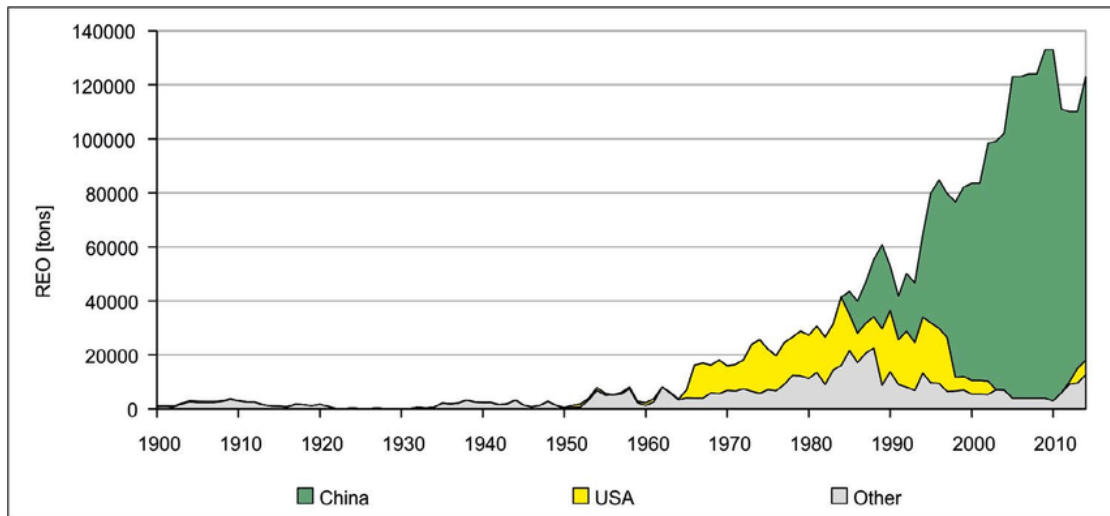


Figure 6. Global REE production from 1900 to 2015.

Nowadays the Chinese have this dominance over the market because the Chinese Communist Party saw the potential of these minerals and decided to start a major project to extract and process these minerals.

There are many important REE deposits in China, and the former leader of the CCP, Deng Xiaoping, compared the Middle East situation with petroleum alike the Chinese situation with rare earth elements. Referring to the quantity of raw material, not to the giant cash flow that many of these Arab countries have been found in. “There is petroleum in the Middle East and China has Rare Earth Minerals”.



Figure 7. Deng Xiaoping. Chinese Communist Party's leader from 1978 to 1989.

So, with this mindset, the Chinese government started to open new factories and new facilities to process the minerals. They had a huge advantage over the competition because the communist regime was able to ignore the conditions of work of the laborers and the environmental issues that represent the exploitation of REE, making the production costs far cheaper than the rest of the countries.



Economic Standpoint

The economic impact of producing and trading Rare Earth Elements

The REE industry is another way for companies to get profits. In this market, like many others, supply and demand are important for its environment and its changing nature. Businesses succeed or fail depending on their ability to adapt to this climate. And prices are set depending on the fluctuations of these factors. This section covers these changing aspects and their consequences that rule the market.

2. REE economic standpoint

2.1 Increasing REE demand

The progress in technology has increased the demand for REE over time. From 30.000 tons in 1983 to 150.000 tons in 2015. This translates to an increase in the market size with plenty of business ready for the cash flow. The market size in 2020 was USD 2,607.4 million. The sector has grown a lot since its beginning, but will it keep growing? Everything points to a positive answer. Almost all the devices that need rare earth materials to run are expected to have a boost in their production. Devices like laptops, tablets, and mobile phones are estimated to experience growing demand in developing economies. Also, the rise in demand for electric vehicles will increase the need for REE. Moreover, environmental concerns will increase the use of green energy, demanding more solar panels, wind turbines, etc.

The market is projected to more than double in 7 years from 2021: from USD 2,831 million in 2021 to USD 5,520 million in 2028.

2.2 The REE monopoly

2.2.1 Where does the courage to rival the Chinese giants come from?

For many years there has been clear Chinese control over the market, but will China keep its monopoly in this market? There is no doubt about Chinese state-owned companies will have to face a growing number of western (and Australian) competitors during the following years. That is because there is a growing concern in the West about depending on their antagonist in the production and process of these critical minerals. They realized that their dependency was a problem when in 2010 the Chinese government (with 95% of the global REE production at the time) used their position as a political weapon against Japan (further explanation on page 24). And also, in the following year, China started to restrict its exports to all countries to foster their domestic industry. The export quotas plummeted and export taxes on some REE incremented from 15% to 25%. In this environment, prices surged in the global market. REE prices like Neodymium, which is necessary for products like electric cars or even headphones, soared from USD 42 a kilogram to USD 283 a kilogram. That year the market grew to record numbers, trading a total value of USD 7,000. Million. But later on, with the

international protests against export taxes, the World Trade Organization² struck down their use.

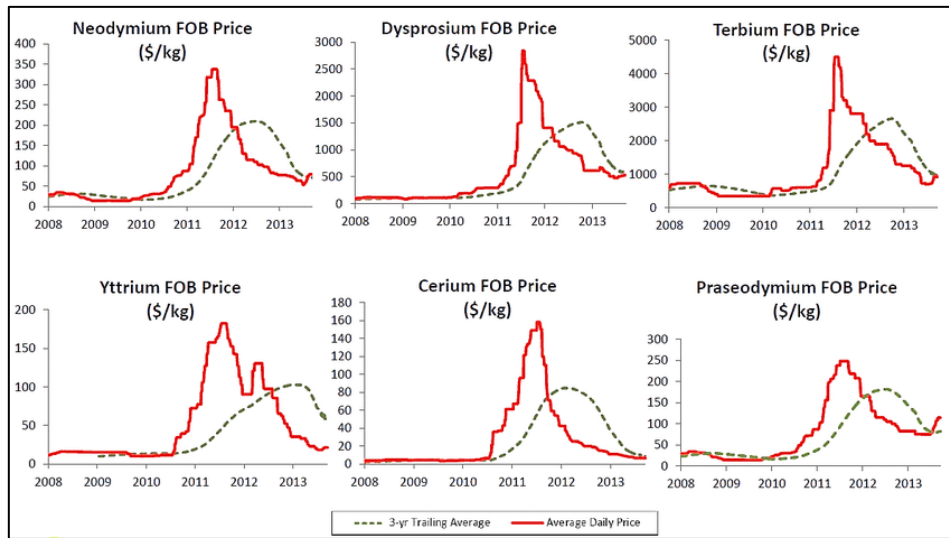


Figure 8. Evolution of FOB³ prices of different rare earth elements. From ResearchGate, by Jeroen De Decker.

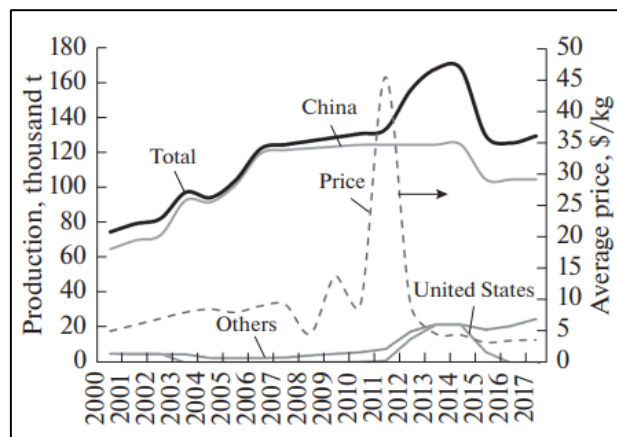


Figure 9. Official REE mining in the world (2000-2017) and the evolution of average prices (\$/kg).

² The WTO is a multilateral institution conceived by 164 countries. The main function of this intergovernmental organization is to enforce international trade rules and agreements-

³ FOB is the international commercial term for “Free on Board”. A quote in this term, or ‘FOB price’, includes the factory price of the good plus all the costs the seller takes on until the product is boarded on the ship at the agreed port.

As a reaction to the ruling, China shifted its strategy to focus on the processing of rare earth minerals. After that, China started importing REE from other countries to process more of these materials in their factories and use them in their manufactured products. The Chinese fraction of the world's REE consumption in 2018 exceeded 70% for the main fields of use (such as magnets, polishing materials, phosphors, and additives in glasses and alloys). In conclusion, China dominates supply and demand, producing 85% of the world's REE-refined products in 2020.

2.2.2 Boosting the world's REE supply

To face Chinese dominance and gain autonomy, other countries or organizations in the world launched programs to increase production. For example, the Australian company Lynas corporation opened one of the largest and most modern processing plant in Malaysia.

Furthermore, the European Union (which depends totally on imports from other countries) has launched the EURARE project. An ambitious project that aims to safeguard the supply of these critical minerals to Europe in a sustainable, economically viable, and environmentally friendly way. And it has a budget of a total of 13,845,950 EUR. This means that in the following years, more companies will join the REE trend to take a stake in it. This translates to more supply and competitiveness, lowering world trade prices. Leading to headlines like the following, from the Monthly MetalMiner Index for REE:

“Rare Earths MMI: Rare Earth Prices Slide Further as World Looks for New Supplies” -MetalMiner, 2022

The prices are already going down as MetalMiner claims. New projects are being planned all over the globe to gain independence from Chinese rare earth supplies. The US reopened an REE mine in California and is currently planning new working plants to increase self-sufficiency. The Canadian company Vital Metals is coming out with promising test results in REE separation processes. Moreover, international interests are all over Turkey since they announced their big find. After big efforts of searching and 125,000 meters of drilling completed, Turkish president Recep Tayyip announced that a 694 million tonne deposit of REE has been found in Turkey.



Figure 10. Turkish Energy Minister outside the REE mine in Eskisehi. By Ragip Soylu.

This would be the second-largest REE deposit in the world. Companies from China, Us and Japan are very interested in this discovery and they are already approaching the nation in order to take part in the future activities of the deposit.

Despite all the international actions to tear down the Chinese monopoly, it is not going to fall that easy. The new companies, or even the big Australian company Lynas corporation, will have to face the Chinese giants. And they are not willing to give up that quickly. In September 2021, three Chinese REE state-owned companies merged to create a new giant. This consolidation of the industry has the purpose of controlling the prices of these strategic minerals, increasing efficiency, and shearing technology. This giant will control 31% of the Chinese total mining of REE and 29% of the Chinese national smelting of these minerals.

In conclusion, the rare earth market is in changing order. With the Chinese monopoly still in place, the new and numerous emerging companies will have to face the Chinese giants that use their influence to set the prices at their own choice. There is no doubt that the capitalization of this market is going to experience a turning point as a result of millionaire investments from both public and private sources.



Social Impact of REE Activity

Impact of REE mining and industrial activity over near population

In order to have rare earth minerals to use, someone has to extract them from the soil through a mine. These mines lift and destroy the ground, affecting its surroundings. Very often, many villages are situated near these mines and their citizens are the ones that suffer its consequences.

This section details the change that the local population near REE activities goes through and how it reacts, using two real cases as examples.

3. Social Impact

3.1 How does the biggest REE mine affect its surroundings?

The Bayan Obo mine deposit (located in China) is the largest REE mine in the world, and the minerals extracted are processed in the city of Baotou, situated 120 km in the South. In fact, in 2012 Baotou processed 70% of the world's REE production.

Sadly, this REE's activity has brutally impacted its surroundings.

According to several investigations in 2011, exposure to gamma radiation is very significant in mining areas. This external gamma exposure can cause several illnesses to the workers. And it is reported that over 3000 workers of the mine are exposed to "*thorium containing airborne dust*". Thorium is radioactive and can cause bone cancer, inhaled in massive amounts may be lethal.



Figure 11. Worker in Bayan Obo mine. November 28, 2010.

The mining activity and its consequences have been a catastrophe for the neighbouring villages of the factories of Baotou. The company responsible for the processing of these metals in Baotou, *Baotou Iron and Steel Group*, has caused damage to the five surrounding villages and it has affected more than 3000 farmers.

Xinguang Sancun is a village situated near the Baotou factories. It used to be an area with huge fields and vegetables growing everywhere, now there is a huge radioactive 10 km² lake. The REE industrial activity led to the creation of a big spillway with water loaded with chemicals. This toxic water comes from the treatment that is used to separate the REE from the rest of the rocks. This treatment separates and purifies the REE using hydrometallurgical processes and acid baths.



Figure 12. The artificial lake in Baotou was formed by polluted water from the treatment plants of REE. By Cecile Degremont. From the newspaper “Le Monde”

“Before the arrival of the factories, there were only fields here, as far as the eye could see! Instead of this radioactive sludge, you could see watermelons, eggplants, tomatoes...”, sighs Li Guirong, a local peasant of the Xinguang Sancun village in *Le Monde*. He claims that industrial activity began when he was 10 years old. That was when the lake appeared but the pollution was unnoticed at the moment.

It wasn't until the end of the 1980' that the effects of pollution could be seen. The plants started to grow badly. They didn't give any fruit in good condition. 10 years later the

vegetables weren't even growing. Many peasants abandoned certain fields, and the rest only planted wheat and maize.

Years later it got worse. At a certain point, the villagers started to breathe in solvent fumes and coal dust. Many animals were falling sick and dying.

The inhabitants fled. The Xinguang Sancun village decreased from 2000 inhabitants to just 300. Diseases were abundant among the villagers who couldn't leave and stayed. Victims ensure that there were a lot of cases of diabetes, osteoporosis, leg pains, and lung problems.



Figure 13. Image of a road near the Baotou factories.

In conclusion, the REE activity combined with the Chinese lack of respect for environmental regulations had a calamitous effect in the exploitation areas. We can see that it led to the destruction of numerous lives, causing a large variety of diseases, the destruction of many sources of income or food, and it has forced many people to move to another place

3.2 Rejection from democracy's citizens

It is fair to think that having an REE mine near the area you live in is a bad idea with the bad reputation it has gained over the years. What would you do if a company wanted to open a new mine near your home? This is the situation the citizens of Campo de Montiel (a region of Castilla-La Mancha, Spain) were in. The Spanish company *Quantum Minería S.L.* wanted to open a new REE mine in 2013. They calculated that the mining activity would cover up to 34%

of the Europe demand (and leaving the rest being covered by imports, right now the imports bring 100% of rare earth minerals to the EU), extracting 15.000 tons during the 10 years of mining activity. The mining company isn't going to use any chemicals to treat the minerals and all the processes will be mechanical, so there won't be left any radioactive waste.

*“It is a very simple project. **This is not like in China**, where you have to blow up the land and make ponds of toxic waste. Here the material is loose and has a very low environmental impact. We remove packages of land, treat them mechanically and keep 3 kilos for each ton. The other 997 kilos are returned to the same place, and there is never more than half a hectare open. The earth is extracted on one side and replenished on the other. The soil can even improve since it returns more oxygenated and with more humidity”* -Enrique Burkhalter, the project director of *Quantum Minería*.

The residents were concerned for numerous reasons. They fear for the denominations of origin of the area, like the denomination for *Campo de Montiel oil*, *Valdepeñas wine*, and partly also Mancha, the denomination of origin *Queso Manchego*, *Cordero Manchego*. Because they claim that at the moment there is a contamination issue, their reputation can tumble. But the mining denies it, reaffirming does not produce spills nor is it radioactive because they weren't going to use any chemical product:

” How is a half-hectare gravel pit going to affect the Denomination of Origin Queso Manchego? They are creating a false alarm”, complains the person in charge of *Quantum Minería*.

Residents were also worried about the local fauna like the lynx or the black vulture. Also, gossip was started among the citizens which fueled an important concern around the generation of diseases like cancer.

People began to organize demonstrations and collect signatures to cancel the construction of the mine. The environmental organization *Sí a la Tierra viva* (Translated to Yes to a living soil) played an important role in this situation.



Figure 14. A protest in Castile-La Mancha, Spain. The demonstrators are showing their opposition against the construction of the mine. Organized by *Sí a la Tierra Viva*. By Maria Jose Valle.

In 2017 after intense pressure exercised by different organizations, local politicians, and people from the surrounding villages, the project was finally turned down by the community of Castile-La Mancha, the Spanish-affected region. The mining company claims that they aren't surprised how events turned out.

In conclusion, this case revealed the intense sentiment of rejection against REE activities. Also, this case is an example of how irrational fears can overcome critical thinking. Because the main fear of the locals was the potential pollution problems and the destruction of the current farming activities. And all these reasons were belied long ago, it was known that the mine would mechanically obtain the rare earth minerals, generating very low pollution; and the mining area would have been concentrated in very little space.



REE Influence on Politics

Rare earth's interests that inspire political actions

When a country is privatized from its REE supply to satisfy its demand, its industry can go through a hard time, threatening the economy. So, it's reasonable for its rulers to attempt to secure a trustful supply chain. For these reasons, rare earth elements can also be used as a geopolitical weapon against other countries.

This section covers how politicians approach their REE activity and supply.

4. REE impact on politics

From the beginning of the 2000s century democracies didn't have to worry about having an REE mine or processing plant poisoning their land because there was no need to. The supply of these critical minerals could be trusted to other countries with fewer environmental concerns like China. Because, by that time, the REE activity usually led to toxic spills, and citizens in democracies have the tools to protest against it.

With this lack of will from democracies, added to a Chinese enthusiasm to conquer the REE market, the Chinese Communist Party created a near-monopoly by the beginning of the century.

4.1 REE used as a political weapon

Chinese ambition to control the global REE market could be encouraged by geopolitical relevance instead of an economic standpoint. Because they didn't mind using their power against Japan as a political weapon.

The dispute over the Senkaku/Diaoyu Islands (situated in the East Asian Sea) escalated. These islands contain a rich fishing area as well as being located in an important strategic position from a military standpoint. The Senkaku islands are proclaimed by Japan and on September 8, 2010, a Chinese fishing boat was arrested for operating in the area. The Chinese government put pressure on Japan to release the captain's ship with a trade embargo, stopping all REE exports to Japan. On September 24, Japan released the captain but in the following months, the Japanese REE imports from China kept in a static situation. It wasn't until December that the flow of metals came back with the same abundance as always.

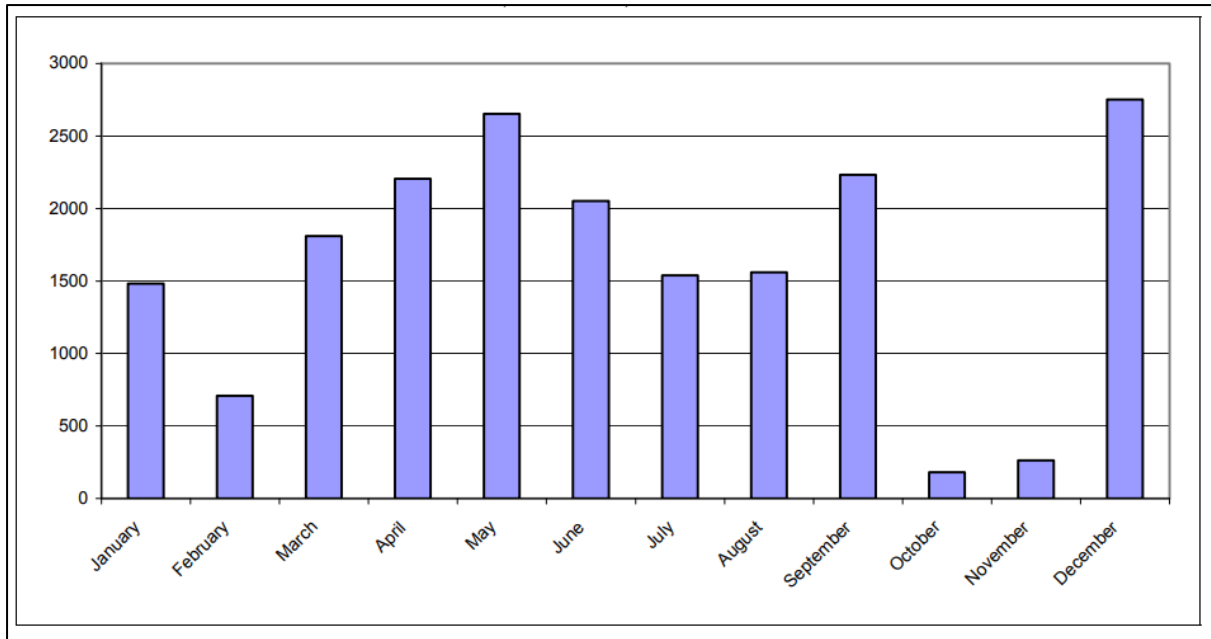


Figure 15. Chinese Monthly Rare Earth exports to Japan in 2010 in metric tons.

4.2.1 What did it change?

Although the Chinese government was able to get the captain back, they received a lot of criticism from the other global powers. In the long run, their actions may have backfired them. They put in shock many politicians from all around the world. If China imposed an REE trade embargo on Japan over a conflict leading them to a shortage of these materials, China can impose an REE trade embargo on anyone, leading to the same situation.

So, many nations worldwide realized they could no longer trust Chinese companies to satisfy all their REE supply needs.

4.2.2 How did the world react?

How can a country escape from this mousetrap? Japan was the first nation to take action. In the 2 months under the embargo, Japanese companies had to adapt. And when the embargo was lifted, they kept trying to reduce their dependence on Chinese REE exports.

Japanese companies started to invest in research of new ways to reduce the rare earth minerals needed to build up their products. This measure was then applied by different

countries, like the US. For example, the American company General Electric was able to reduce 80% of REE use in products like jet engines and wind turbines.

Another measure first applied by Japan was to get other suppliers. By that time there weren't many. But Japanese companies like Toyota Tsusho Corporation managed to get a deal with a state-owned company in Vietnam that would provide Japan with more than 20% of Japan's REE needs. Additionally, a USD 325 million loan was handled by a Japanese trading house (half of the loan was provided by Japan's government) to the Australian company Lynas Corporation. For exchange Lynas accorded to give 8,500 tons of REE annually for 10 years. This volume represents 28 % of Japan's annual consumption. Other countries, like the US, have also financed the Australian company.

In 2019, for new REE supplies (among other minerals) and the potential business it represents, President Trump expressed an interest in buying Greenland, an area filled with plenty of minerals, and also important reserves of REE.



Figure 16. Former president of the United States of America, Donald Trump. By Patrick Semansky

Also, the European Union launched the EURARE project in 2013. This project plans to make the EU take part in REE production. The European Commission will help the financing with EUR 9,000,000. The mining project will open the first REE mines in the democracies of the EU.

In conclusion, the political events in 2010 led to an extended feeling of discomfort in those countries that depend on the Chinese REE monopoly. It also sparked a desperate search for a reliable supply chain, led by Japan. This search made some governments willing to invest in the market or even attempt to buy new land (like the US deal to buy Greenland).

How can we invest in REE?

Thesis: A regular person can invest in the REE market without spending millions.

1. Ways to invest in the REE market

Big companies spend millions when they invest in Rare Earths, building mines or processing plants. Does this mean we must do the same to invest in Rare Earths? No, we have other choices, but not as many as other markets. There are no futures for Rare Earth elements so we have to look for other ways. Our options are to **invest in Rare Earth companies** or to **buy the minerals of the processing plants and re-sell them**. The second choice requires a special place to keep the stock and it can be hard to find someone willing to pay for the minerals acquired. While the first option is more simple and far easier to generate profits. So, investing in Rare Earth companies is the simplest and safest option. Investing is known for having its risks, and investing in a company to access the REE market is not truly investing in the market. Because a single business doesn't represent the whole market, it can go down when Rare Earths minerals are rising and getting more profitable. That's why we need to go further and invest in an **Exchange-Traded Fund (ETF)** with many companies, so we can be protected from the irregularities of a single company.

1.2 What is an ETF?

An **Exchange-Traded Fund (ETF)** is a type of pooled investment security. It works like a regular stock, it can be purchased or sold on a stock exchange. It is known for holding multiple investing assets. Investing in an ETF means investing in multiple assets instead of only one.

1.3 ETF of REE

There is one problem with this option, it's very hard to find an ETF dedicated only to Rare Earths because they also add other strategic metals like zinc or lithium. And the changes in these other metals can be reflected in the ETF performance. For these reasons, we need to create our ETF of REE if we want to invest in the best way possible in the market.

2. Building an ETF of Rare Earth Minerals

To build the ETF we'll work with Excel to put down the information of each company and elaborate graphics.

First of all, to build our ETF we need to determine the characteristics of the companies we want in.

We want an ETF with trustful companies, that are expected to grow and respect environmental policies.

Our ETF:

-The companies are required to have an REE activity or future plans in the sector.

-Non-complier with environmental policies won't get in.

-The stake of Chinese holdings of the ETF is going to be below 15 %, because it is expected that the countries that are looking to not depend on China invest in companies that come from other countries, increasing their value.

-The Price/Exchange of the companies needs to be below 20 points because we want trustful companies and a high ratio of P/E indicates that the stock is expensive and, in the future, it will probably fall.

3. Where do we look for the companies?

We have checked other ETFs that hold many companies of Rare Earths and other strategic metals, like the [DMAT](#) and the [MVREMXTR](#). We gathered more than 60 companies, and when we applied our requirements, we cut the number down to 27 companies.

Those 27 companies will be the ones used for our ETF.

4. How do we determine each company's stake in our ETF?

In order to select the stake of each company that will compose our ETF, we need to look at the total Market Capitalization and calculate the percentage that represents every company. We'll use that percentage to compose the stake of every composer. Otherwise, the selection would be completely arbitrary.

5. VDL RARE EARTH MINERALS ETF

VDL RARE EARTH MINERALS ETF⁴

FUND DETAILS

Fund Ticker	VDLREM
Management Company	VDL
Domicile	Spain
UCITS Complaint	No
Inception Date	1 Oct 2022
Number of Holdings	27
Base Currency	USD
SFDR Classification	Article 8

OBJECTIVES AND POLITICS OF INVERSION

The main goal of this fund is to create a growth ETF of Rare Earth Elements that is environmentally friendly.

To achieve this objective, VDL (the management company) determined that the fund is going to invest in shares of companies or corporations that are involved in Rare Earth activity. The companies and corporations invested in are expected to grow progressively in the following years. Also, to reduce the incurred risk, the companies of the fund are required to have a Price/Exchange ratio below 20 points and respect the respective environmental policies.

The firms in this ETF are listed on the Hong Kong stock exchange; the JSE Limited; the Shanghai stock exchange; the ASX; the Euronext Paris; the London Stock Exchange; the Stockholm Stock Exchange; or the Tokyo Stock Exchange (TSE).

Fund Currency of Reference: USD

⁴ This is a hypothetical ETF with real data. It hasn't been launched and their management company is unreal.

PROFILE OF RISKS AND BENEFITS

Low risk

Usually, lower benefits

High risk

Usually, higher benefits



1	2	3	4	5	6	7
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The 1 doesn't mean there is no risk or that the invested money is safe. This category can change with time.

This ETF fund is considered a high-risk investment because the market has experienced huge ups and downs in the past. This means that there is a lot of volatility.

These risks can be explained because rare earth elements consolidate a small market, and any changes in it represent a huge percentage of the sector.

Also, commodity companies are highly dependent on supply, demand, and the price of natural resources. Any international event, political or economic, can alter those companies.

PORTFOLIO ANALYTICS

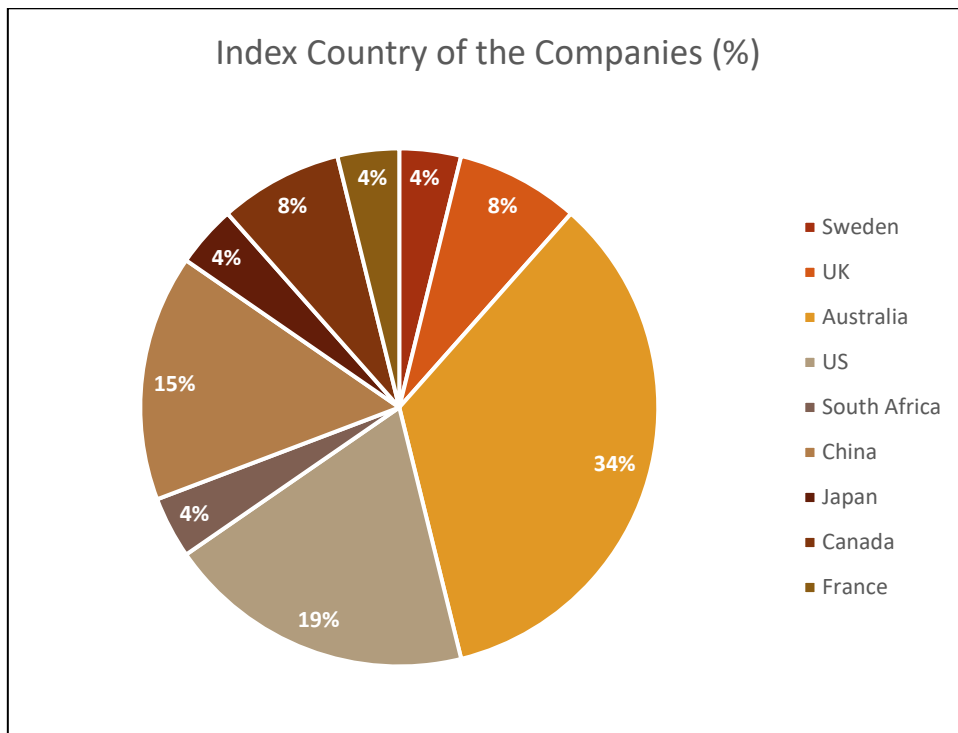


Figure 17 Pie chart index of all the ETFs' companies by country of origin. Source: VDL

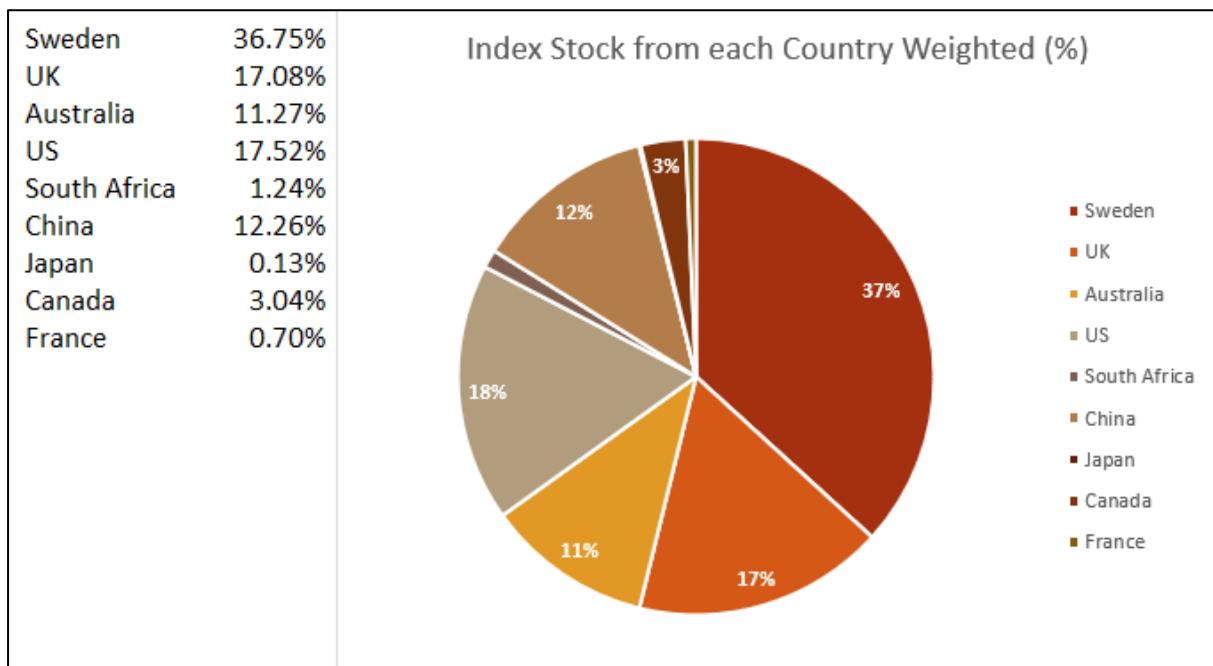


Figure 18 Pie chart index of all the ETFs' holdings by country of origin. Source: VDL

HOLDINGS

Holding	Ticker	Market Cap (B\$)	Market cap. Portfolio (%)	P/E	Country	% of holdings
AFRICAN RAINBOW	ARI SJ	\$ 3.302	1.24%	4.34	South Africa	1.24%
ALLKEM LTD	AKE AU	\$ 7.549	2.84%	17.37	Australia	2.84%
ANGLO AMERICAN PLC	AAL LN	\$ 34.683	13.06%	5.13	UK	13.06%
ANTOFAGASTA PLC	ANTO LN	\$ 10.680	4.02%	13.65	UK	4.02%
AVZ MINERALS LTD	AVZ AU	\$ 2.752	1.04%	N/A	Australia	1.04%
BOLIDEN AB	BOL SS	\$ 97.620	36.75%	8.52	Sweden	36.75%
CHINA NONFERROUS	1258 HK	\$ 11.853	4.46%	4.88	China	4.46%
CHINA NORTHERN-A	600111 C1	\$ 13.686	5.15%	15.57	China	5.15%
CORE LITHIUM LTD	CXO AU	\$ 2.119	0.80%	N/A	Australia	0.80%
ERAMET	ERA FP	\$ 1.860	0.70%	1.38	France	0.70%
FREEPORT-MCMORAN INC	FCX	\$ 39.505	14.87%	8.38	US	14.87%
GRAFTECH INTERNATIONAL	EAF	\$ 1.124	0.42%	2.31	US	0.42%
ILUKA RESOURCES LTD	ILU AU	\$ 3.960	1.49%	7.64	Australia	1.49%
LAKE RESOURCES NL	LKE AU	\$ 1.355	0.51%	N/A	Australia	0.51%
LITHIUM AMERICAS CORP	LAC US	\$ 3.014	1.13%	N/A	US	1.13%
LUNDIN MINING CORP	LUN CN	\$ 5.094	1.92%	5.08	Canada	1.92%
LYNAS RARE EARTHS	LYC AU	\$ 6.797	2.56%	12.73	Australia	2.56%
MMG LTD	1208 HK	\$ 2.201	0.83%	6.45	Australia	0.83%
NICKEL INDUSTRIES LTD	NIC AU	\$ 2.048	0.77%	7.50	Australia	0.77%
NIPPON DENKO CO LTD	5563 JP	\$ 0.335	0.13%	4.33	Japan	0.13%
PIEDMONT LITHIUM INC	PLL US	\$ 0.944	0.36%	N/A	US	0.36%
SHENGHE RESOUCE-A	600392 SS	\$ 3.831	1.44%	14.69	China	1.44%
SIGMA LITHIUM CORP	SGML US	\$ 2.989	1.13%	N/A	Canada	1.13%
SYRAH RESOURCES LTD	SYR AU	\$ 1.153	0.43%	N/A	Australia	0.43%
TRONOX HOLDINGS PLC	TROX US	\$ 1.952	0.73%	3.43	US	0.73%
WESTERN MINING CO-A	601168 SS	\$ 3.194	1.20%	7.30	China	1.20%

[Download Excel](#)

Conclusions

Summing up, Rare Earth Elements are the pillar of modern technology. They are very important to renewable energy, the defence industry, the hybrid/electric automobiles industry, and modern devices like phones. The more progress and the more expansion these areas develop, the higher demand and relevance REE will experience. If the supply of these minerals is interrupted, all of these areas are going to fall into crisis.

For many years, Chinese state-owned companies held an almost monopoly on the production and processing of these critical minerals. They achieved that position by ignoring basic working conditions in their mines and polluting the environment around them, making their production cheaper and far more competitive. So, this behaviour added to accidental toxic spills of other companies around the world generated long ago a belief that the activity of these minerals is directly related to local contamination. And this generates many fears that already turn down very important mining projects that would generate very low pollution.

The concern of a Chinese-controlled world supply of these minerals didn't show up until 2010 when the Chinese state interrupted the supply to Japanese companies over a political dispute over some islands in the Pacific. Worldwide leaders understood that they needed to gain more independence from the Chinese supply. Companies outside China are receiving investments from concerned governments, and it is expected to be more benefits to these businesses in order to fight against the current monopoly. Because REE are going to be more important in the following years. The market is projected to more than double in 7 years from 2021: from USD 2,831 million in 2021 to USD 5,520 million in 2028.

How can a regular person invest in this market and benefit from this growth? In conclusion, investing in the *VDL Rare Earth Minerals ETF* is the best option. It's the safer option, and it's also environmentally friendly. The problem is that this ETF is still very risky, but that's because of the nature of the market. It's a small market, which means that any change is going to have a huge impact. But the volatility can also be translated into higher benefits, and the general demand for Rare Earth minerals is expected to surge in the following years.

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FIGURE 2 WIND TURBINES AND SOLAR PANELS. FROM:
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FIGURE 3 LOCKHEED MARTIN F-35 LIGHTNING II. FROM <[https://en.wikipedia.org/wiki/Lockheed_Martin_F-35_Lightning_II#/media/File:F-35A_flight_\(cropped\).jpg](https://en.wikipedia.org/wiki/Lockheed_Martin_F-35_Lightning_II#/media/File:F-35A_flight_(cropped).jpg)>

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FIGURE 16 FORMER PRESIDENT OF THE UNITED STATES OF AMERICA, DONALD TRUMP. BY PATRICK SEMANSKY. FROM: <<https://www.npr.org/2019/08/19/752274659/no-joke-trump-really-does-want-to-buy-greenland>>

FIGURE 17 PIE CHART INDEX OF ALL THE ETFS' COMPANIES BY COUNTRY OF ORIGIN. SOURCE: VDL (MYSELF)

FIGURE 18 PIE CHART INDEX OF ALL THE ETFS' HOLDINGS BY COUNTRY OF ORIGIN. SOURCE: VDL (MYSELF)