

PRODUCTION OF RARE EARTH ELEMENTS IN EUROPE: DREAMS, MISBELIEFS MILESTONES, AND REALITIES

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Abstract

A whole decade has passed since the rare earth elements (REE) gained tremendous publicity in the sense that their demand was constantly increasing whereas their supply was in jeopardy, due to the Chinese monopolistic control of production and export restrictions that drove prices up nearly tenfold. The short-lived crisis of 2011 has long passed but much has been said and written about rare earth elements since then, particularly about ways to restart REE production outside of China. Nevertheless, in these last ten years little has changed in the global market of rare earths, needless to say in the European market as well. In this paper a thorough discussion is made focusing on the European REE market about the actions that have been taken, based on the dreams that have been made and the misbeliefs in which policy makers and stakeholders have steeped in. In addition, the milestones achieved by scientists are highlighted and finally the realities are mentioned that govern the production of rare earth elements in Europe.

Introduction

Many people are still not aware of the importance of rare earth elements due to their being hidden very well inside the high-tech devices that we use every day^{1,2}. Nevertheless, these critical metals govern the modern lifestyle that we live, while they are also playing a significant role in the transition to the digital and carbon-neutral industry that the EU has set as a primary goal to achieve³.

During the digital transition in industry, European countries among other nations around the world intend to remain sovereign and occupy a leading role in the development of digital technologies. However, the Chinese policy on the exports of purified rare earth metals and alloys and the constantly increasing share of the global market that high-technology Chinese companies are obtaining has irritated the rest of the world that has started taking actions to fight the Chinese monopoly.

The REE crisis of 2011 was sufficient to cause a global treasure hunt by way of exploration of rare earth deposits, and thus in just a few years the potential global resources of these strategic metals increased to an extent that could secure global supply for the next few hundreds of years^{4,5}. Europe in turn initiated its own exploration projects to reduce its reliance on imports of these critical raw materials; 57 significant localities or groups of localities have been identified, out of which nine are classified as resources, 13 as deposits, 30 as occurrences and five as potential by-product sources⁵. Yet, none of these projects has yet translated into an active mine. Similarly, and despite the numerous advanced exploration projects around the world, production outside of China has been rather limited and is taking place into just a handful of countries.

Correspondingly, in these last ten years following the crisis little has changed in the global market of rare earths, needless to say in the European market as well, despite many dreams, expectations and statements. Some milestones have indeed been achieved, however mostly in a laboratory scale, and thus could not be considered enough to change the ongoing situation. It could be even said that Europe and the rest of the world are still moving towards the wrong direction, applying erroneous policies.

This paper identifies some of the dreams and misbeliefs that plague the European rare earth industry, highlights the milestones achieved so far and suggests some realistic goals to be set and achieved by the European stakeholders in order to get on the right track, initiate sustainable production in Europe and reduce its dependency on imports from China.

Dreams and Misbeliefs

The skyrocketing of the prices of REE made investments in start-up projects seem temptingly easy. More than 400 REE exploration projects around the world were initiated during and immediately after the REE crisis. Yet, the prices plummeted in a relatively short time⁶. Despite that, many potential REE producers insisted on believing that they were holding the key to success, and by success they meant that they would produce significant amounts of rare earth elements, solve the issue of supply and break the monopoly of China.

Potential REE producers in Europe kept on chasing the same dream for several years, claiming that their resources/deposits would secure continental supply and reduce the dependence of Europe on China. These dreams, however, turned into misbeliefs. No production of rare earths in Europe has taken place so far, while out of the nine most advanced exploration projects with formal REE resource estimates, none has the perspectives to be translated into an active REE mine at least in the near future.

Those advanced exploration projects are located mainly in Greenland, Sweden, Norway, Turkey and Germany^{5,7}. The Norra Kärr REE project in Sweden is considered one of the most promising projects and was initially granted a mining license. However, the license was revoked due to social arguments and environmental concerns and the mining project does not seem likely to begin in the years to follow⁸. At first glance this may seem unfortunate for the Norra Kärr project owners, on second thoughts, however, it may prove better that the company did not initiate production. The reasons are rooted in other major misbeliefs that rare earth stakeholders have steeped in.

To begin with, many stakeholders still believe that the prices of REE will rise again. In fact this is recorded in all technical studies, preliminary economic assessment reports, pre-feasibility and final feasibility studies that have been conducted for advanced exploration projects worldwide since the REE crisis². To the disappointment of all, the prices have been kept in low levels during the last ten years (Figures 1 & 2). Consequently, all potential REE projects outside of China are economically unfeasible, while active REE producers around the world are struggling to sustain themselves; even some Chinese mining companies are facing problems.

Nevertheless, the difficulty of potential REE producers to enter the market is far beyond the issue of low prices. Even if the prices were higher, the European and other potential market entrants would have to merchandise part of their production into China that is the main global consumer of rare earths, and thus confront the mature domestic REE industry sector. In order to be competitive, future REE producers should then not only concentrate on the mining side but also try to offer the entire chain from mining to end-products in high demand and reach agreements with potential buyers inside and out of China before proceeding to production.

Thus, another misbelief can be identified here. Europe and the rest of the world believed that they could catch up with China and be able in a just a few years to successfully mine, process, separate, purify and refine rare earths and meet specific downstream technology applications. For the shake of comparisons, it is worth mentioning that it took almost ten years from 1985 to 1995 for China to take the lead in production from the U.S. and another few years to establish its complete dominance in the REE industry. Nowadays, China has a fully integrated value adding chain of REE that cannot be duplicated in the short term. To further highlight the significance of the lack of a fully integrated supply chain of rare earth elements outside China, it must be pointed out that before going bankrupt, Molycorp was shipping all of its non-cerium and lanthanum oxides to China for refining into high-value metals, alloys and then into valuable end-products⁹. No doubt that Norra Kärr would also produce a mixed concentrate and ship it to China.

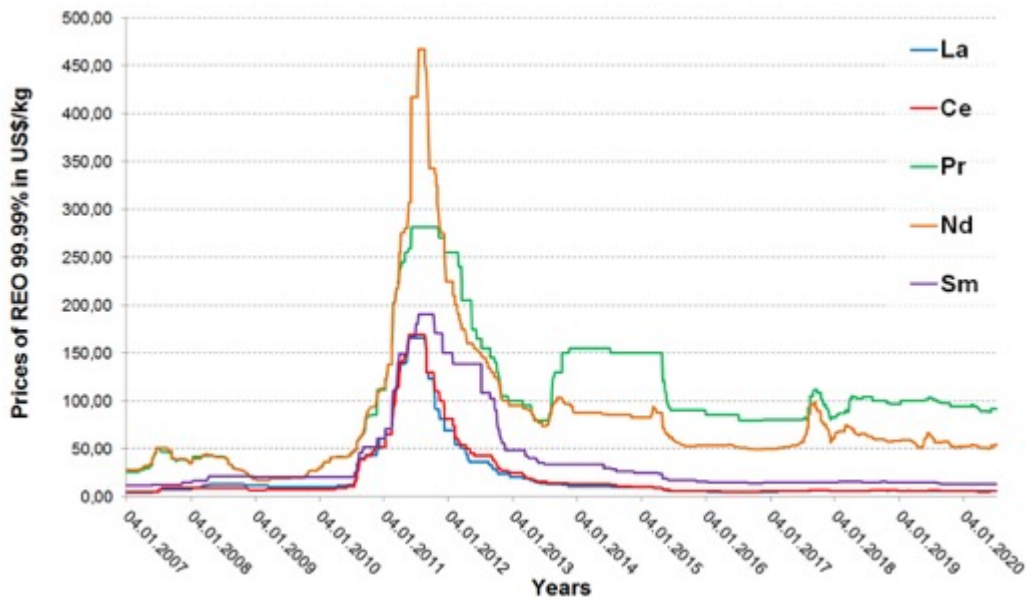


Figure 1: LREE Metal min 99% FOB China prices development (2007-2020)

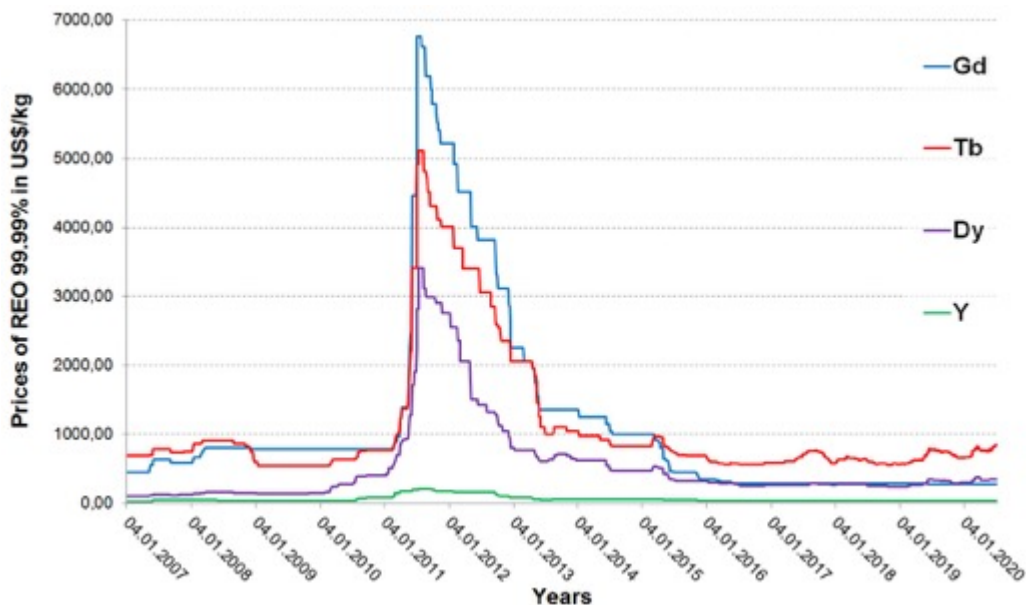


Figure 2: HREE Metal min 99% FOB China prices development (2007-2020)

The fact that the European REE resources are not that large resulted into extended scientific research for developing a diversified and sustainable REE supply chain for Europe. Substitution of REE with other metals in end applications has been considered but it does not offer a panacea to the rare earths challenge⁴. On the other hand, recycling has been thought to provide a valuable source in the future but the recycling rates for REE from end-of-life products are still reported to be very low (<1%).

Milestones and Realities

Substitution and recycling of rare earths may still seem to be a dream that cannot be realised in the near future, but there can be a number of potential advantages over primary production^{4,10}. Besides, the research that has been conducted so far regarding the processing, separation and refining of rare earth elements as well as their recycling and substitution is remarkable.

Especially in Europe, the research activities on rare earth elements have contributed significantly towards achieving some milestones. To address the issue of REE's supply, the European Commission has brought together experts to establish a European Rare Earths Competency Network (*ERECON*), the working groups of which focused on finding opportunities for the primary supply of REE within Europe, establishing resource efficiency and recycling, and dealing with rare earths supply trends and challenges. Several research projects were launched, funded through the Programmes of the European Commission. To name a few, the *SCREEN* project was based on experience gathered from *ERECON* and focused on forming an EU Expert Network covering the whole value chain not only for rare earths but for all present and future critical raw materials (screen.eu).

Furthermore, the *EURARE* project has set upon its completion the basis for the development of a European REE industry that will safeguard the uninterrupted supply of rare earths for the EU economy (eurare.eu). *RARE*³ was another KU Leuven funded project with the aim to develop breakthrough recycling processes based on non-aqueous technologies for permanent magnets and lamp phosphors, namely the two main applications of rare earths. *REEcover* (recover.eu) and *DEMETER* (etn-demeter.eu) were another two promising projects that aimed to securing the supply of rare earths in Europe by bringing forward opportunities in the REE recycling and recovery area. In continuation of the aforementioned and various other research projects, the global rare earth industry association (REIA) has been created under the auspices of the running EU funded GLOREIA project (global-reia.org).

In parallel to the aforementioned research activities, the EU has also managed to establish a robust regulatory framework after the REE crisis. Nowadays, the mining and processing of rare earth elements falls into the scope of a wide variety of EU directives that cover several aspects of the REE industry sector^{11,12}.

Despite all these achievements, little has changed and the EU among with the rest of the world is still totally dependent on the Chinese monopoly. Apparently the biggest challenge facing scientists is how best to extract and process these elements in both an economically efficient way that would allow EU producers to compete the Chinese,

and at the same time environmentally friendly manner that would allow them to comply with the regulations and meet the social requirements. All scientific achievements are still in laboratory scale and it still needs a lot of time and effort to build an integrated REE supply chain that can catch up and compete with the low costs and high capacity of the Chinese REE industry.

Another prohibitive factor is the low current level of REE prices; many attribute the issue of Chinese monopoly power to this status. When REE prices were high, the exploitation of numerous REE exploration projects seemed to be prosperous. But when the prices plummeted, the truth was unveiled; uncertainties, environmental problems and dependencies, which made investors become far more circumspect as to putting their money into potential REE projects. A lesson learnt after so many years is that no matter how many reports will come up with predictions that the prices of REE will rise significantly, the situation is not likely to change. The prices are currently at low levels mainly due to the fact that unregulated and illegal mining in China and smuggling of REE out of the country is flourishing and that keeps the global supply and demand of rare earths in a balance. In fact, unregulated mining in China is the largest competitor of regulated Chinese mining in the country and the government is trying to find ways to eliminate it, but it cannot be easily restricted^{2,13}. But even if illegal mining is controlled, the prices will only rise to a level that will secure the feasibility of Chinese mining and processing companies only. Given that China has the absolute control of the global REE market, it will not allow for the prices to go high again, especially now that there are REE mining projects almost ready to launch all over the world.

Additionally, there are several other impact factors that need to be taken into account as well when it comes to developing meaningful and realistic policies towards a sustainable production of rare earth elements in Europe and worldwide. For instance, the wrong perception that mining of rare earth elements is a dirty and environmentally harmful business needs to be changed, and people must understand that regulated mining and processing of such commodities will not result in polluting the environment. In addition, the authorities and communities need to realise that we cannot choose where mineral and metal deposits are located and that we need to get rid of the not-in-my-back-yard syndrome (NIMBY). About 80% of Europe's surface area is shaped by land use in cities, agriculture and forestry¹⁴, and thus any newly discovered REE deposit will most likely remain unexploited at least until a land use solution is found and social arguments are resolved. This is also a reason why the mining industry in Europe is diminishing during the last decades. While Europe accounted for almost 40 % of global mining output at the beginning of the last century, it now has a share of only about 3 %¹⁵.

Conclusions

It is merely impossible to describe in detail the situation of the European REE industry in just a few pages. Hence, some of the most significant issues have been discussed afore. Accordingly, it is even more difficult to fit all possible, suggestions, ideas and future scenarios hereinafter.

It should be mentioned that Europe is in a crossroad and more decisive actions need to be taken towards a sustainable supply of rare earth elements (and other critical raw materials) in the future. EU will have to accept the fact that either it will finally become only a REE end-product customer of China or, alternatively, it will have to re-establish the raw materials value chain from the very beginning – having to take a steep and risky road to re-industrialisation, in order to compete with China.

The work done so far related to the exploration and discovery of new REE deposits is remarkable but not complete; exploration in bigger depths is required, while new regulations about the land use in Europe need to be established and the people need to understand the necessity of primary sourcing of critical raw materials. Recycling and substitution of REE can be considered as potential sources of the future but mining and processing were, are and will continue to be the primary source of rare earths or any other commodity. Hence the focus of research should be on how to efficiently increase the mining and processing capacity of REE in an industrial scale within Europe.

However, we have to bear in mind that the mining and processing of rare earths in Europe or elsewhere outside of China will not affect the leading role of China in the REE industry at least for the years to come, but it may well secure the future supply of rare earth elements within Europe and put the EU in the map of production.

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