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LIFE CYCLE ASSESSMENT OF RARE EARTHS UNDER CONSIDERATION OF NEW SUPPLY TRENDS

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ABSTRACT

Rare earths contribute as material significantly to the Life Cycle Assessment of green technologies. New mining endeavors are likely to influence the future environmental profile of them. The developed method aspires to enable an estimation of the expected environmental characteristics. Based on a literature research the most influential factors are established. The process steps mining, beneficiation and separation are accounted for. Through a relevance analysis of potential and actual mining projects possible future production scenarios, based on best and worst case assumptions, are developed and reviewed. Their influence on the following parameters: country specific energy provision, type of mining, allocation method, rare earth oxide grade and Neodymium-grade is quantified

INTRODUCTION

Rare earths are 17 chemical very similar elements. Included are all lanthanides with the atomic number 57. to 71. as well as scandium (21.) and Yttrium (39.) (BGS, 2011). Their partial appearing, exceptional characteristics as fluorescence, high refraction index, strong paramagnetic property as well as a high capability to store hydrogen, make them highly interesting for many utilizations. Their field of application is therefore very broad. In many cases a substitution is not possible at all or can only be achieved by a total redesign (Gupta, 2005). An additional aspect is the Chinese monopoly on the supply of the industry with the demanded material. Rare earths are listed as critical raw material, as the supply situation is at risk while the usage has strategic importance (U.S. Department of Energy, 2010). As they are often used for so called green technologies (Schüle, 2011), Life Cycle Assessment (LCA) can be used to verify the environmental friendliness of those, thus enable proper comparison of new and conventional technique.

New mining endeavors globally could assure future provision but also change the environmental profile of rare earths (Graf, 2012). Aim of this study is to achieve a better understanding of the future development of the environmental profile of rare earths, deduced from their exploitation mix. Therefore the state of the art of rare earth production is compiled and transferred into inventory analysis in the LCA software GaBi 5 (PE International, 2012). The model comprises mining, beneficiation and separation into the individual elements. Through an investigation of the producing mines as well as the predicted mine openings, information of production countries, host rock, production rate and grades can be gathered. By linking these findings with each other, a systematic procedure for an estimation of future

LCA results can be developed. By means of different scenarios the tendency of the expected environmental profile of the “rare earth mix” can be assessed. This study focuses on the extraction of Neodymium oxide out of Monazite.

METHOD

How and which deposits will be exploited, will influence the future environmental profile of rare earth. The following aspects are regarded as important parameters for those aspects and will therefore be examined in more detail:

- Host rock, as it defines the way of production as well as byproducts
- Regional factors, which determine the assessed energy mix
- Grades, as they define how much material has to be exploited and how much chemicals and energy are necessary to gain a certain amount of REO
- Grade of the individual REO

In a first step rare earth deposits are investigated. Today available data of production volumes and grades of actual and potential production sites are therefore gathered and evaluated. Via a relevance analysis the mines with the highest potential are then determined. Based on these information scenarios are prepared. With a best and worst case approach five scenarios were created. The designed scenarios assume altered operating mines at different point in time. They cover the time horizon of 2010 as a reference year as well as the years 2015 and 2020. Thereby five different cases were developed (Scenario 2010, Scenario 2015 optimistic, Scenario 2015 pessimistic, Scenario 2020 optimistic, and Scenario 2020 pessimistic).

By using a relevance analysis, the mineral types which have to be taken into account are set. Additionally the five scenarios for the global rare earth mix are examined to evaluate the variations of the key driver named earlier. To quantify the impact of these key drivers on the environmental performance a generic LCA model (see figure 1) was developed which is able to illustrate the influence of the different aspects by using parameters to evaluate the gained information.

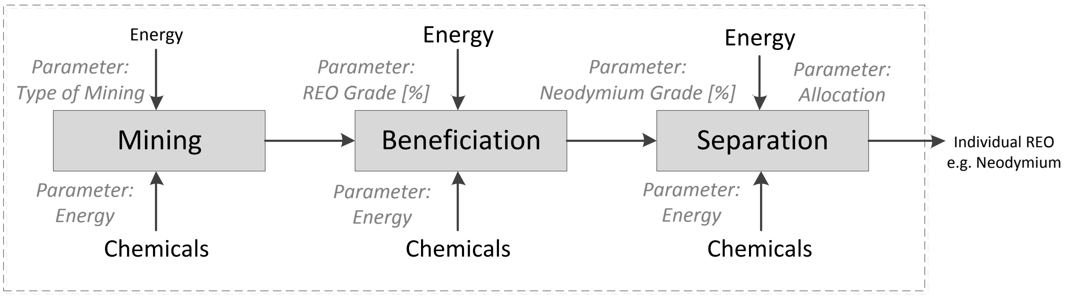

Figure 1. Borders and parameters of the GaBi model

RESULTS

The prime results of the analysis of the evaluated scenarios are outlined in the following. A higher diversity in the rare earth supply is very likely. New exploitation sources might be used in respect of type of mineral and country of production. Those new sources will have an influence on the environmental profile of REO. The importance of Monazite for the global supply will increase. The rare earth deposits which are taken into account for the five different cases (scenario 2010, scenario 2015 optimistic, scenario 2015 pessimistic, scenario 2020 optimistic, scenario 2020 pessimistic) have a very high variation in the REO content of the mined material as well as in the Neodymium grade. For the considered impact categories global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), photochemical oxidant creation potential (POCP) and primary energy demand (PED), reduction capabilities between 10 and 30 percent were detected. In all future production scenarios the environmental impacts seem to be reduced.

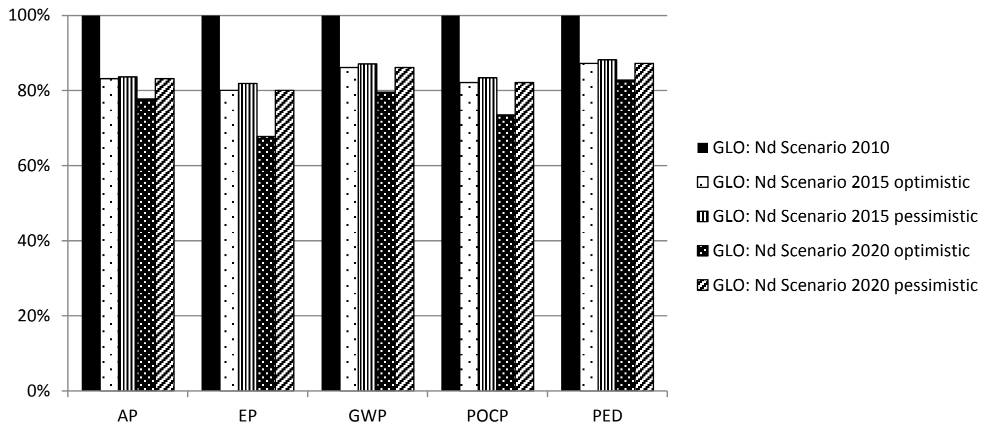

Figure 2. Comparison of scenarios in different impact categories

DISCUSSION

Variation in grade and the site of production is very influential on the environmental profile of rare earth. The latter primarily due to the country specific energy provision. As the host rock determines which process ways are used, as well as the byproducts, adapted LCA models are necessary for every mineral type. The results of the relevance analysis suggest that other mineral types and other REO sources such as Bastnaesite, Ion-adsorption clay and recycling should also be reflected. The model could also easily be expanded to include other rare earth elements besides Neodymium. More work is needed in respect of allocation and efficiency figures.

CONCLUSIONS

The environmental profile of rare earth depends on the supply situation. New mining sites will most likely reduce the environmental impact.

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