Modeling neodymium material flows in Germany with the purpose of establishing a recycling chain

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Introduction

Neodymium (Nd) is one of the most frequent occurring rare earth elements (REE) and is used in technological applications such as neodymium magnets, lasers, ceramic colors and glass colors. Neodymium magnets are realized as a compound of neodymium, iron and boron and also known as NdFeB magnets. By the current state of technology they are the strongest permanent magnets and therefore they are particularly suitable for applications where power density or size of electric motors and generators matter (Gutfleisch et al. 2011).

NdFeB magnets are subject of a continuous market and production growth. Further dissemination of neodymium and China’s role as a monopolist lead to a high criticality of neodymium and force the markets to think about new solutions of neodymium usage and end-of-use handling. These solutions are primarily economically and technically motivated, but also have ecological and social impacts (if e.g. less neodymium has to be mined and produced under bad conditions). This paper has a look at the recycling potential of neodymium in Germany. The System Dynamics model of Nd material flows presented in this paper builds the basis for answering the question under which conditions a market for recycled Nd could be established.

Model

With the model we can develop an idea of amounts of neodymium that are processed in and exported out of Germany. Figure 1 gives a rough overview of the model scheme with the declared focus of the model. At this point main interest is on material flows to understand the market structure and controlling options.

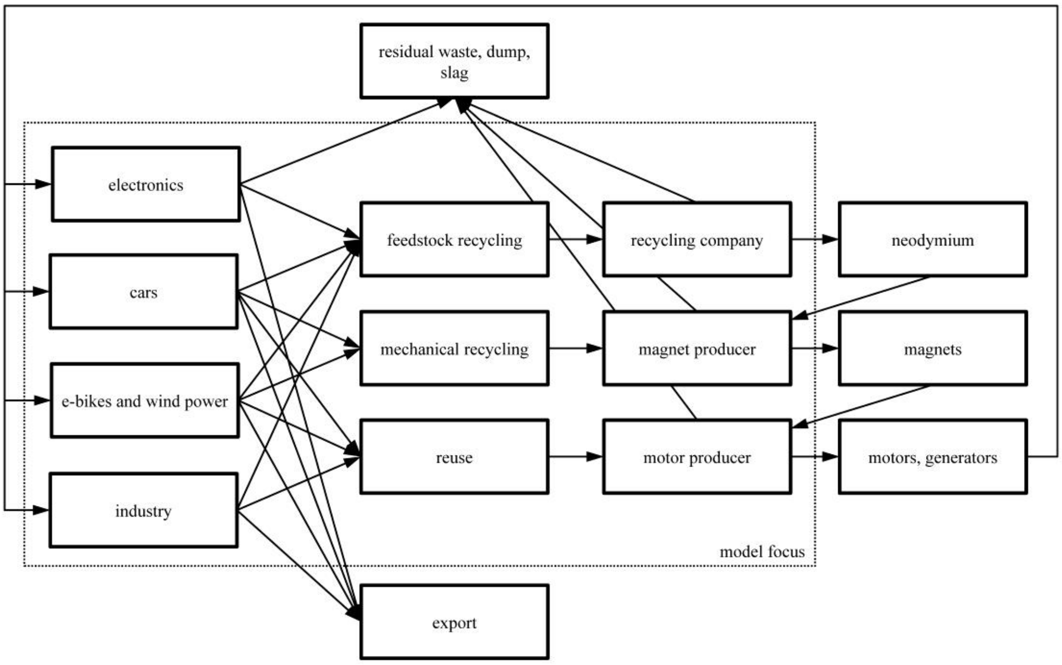

Figure 1: Scheme of the model with the model focus (own diagram).

Simulation Results

The simulation shows the demand and possible availability rates of neodymium in the years 2007 to 2030 (see figure 2). The noticeable peak at 2027/2028 originates from a peak in installing wind power 20 years before. Figure 2 also illustrates the relatively high difference between neodymium in end-of-use products and maximally available neodymium for processing. Most of the neodymium is exported, dumped or in the slag of steel and copper production.

With the chosen values a market entry of all three recycling types (feedstock recycling, mechanical recycling and reuse) is visible within time horizon. The sequence of entry is according to their market potential. The total amount of processed neodymium in 2030 is roughly 200t respectively 300t for a forced start of motor recycling. Those values are below predicted demand in Germany, so the sales of the material is ensured.

Discussion

Results show that feedstock and material recycling starts right from the year 2018. In the simulation there is enough profit for the companies to start processing. Feedstock recycling would start even from 2007 if allowed. But in reality apparently there are barriers that are not part of the model. These barriers of emerging markets have to be examined in further research.

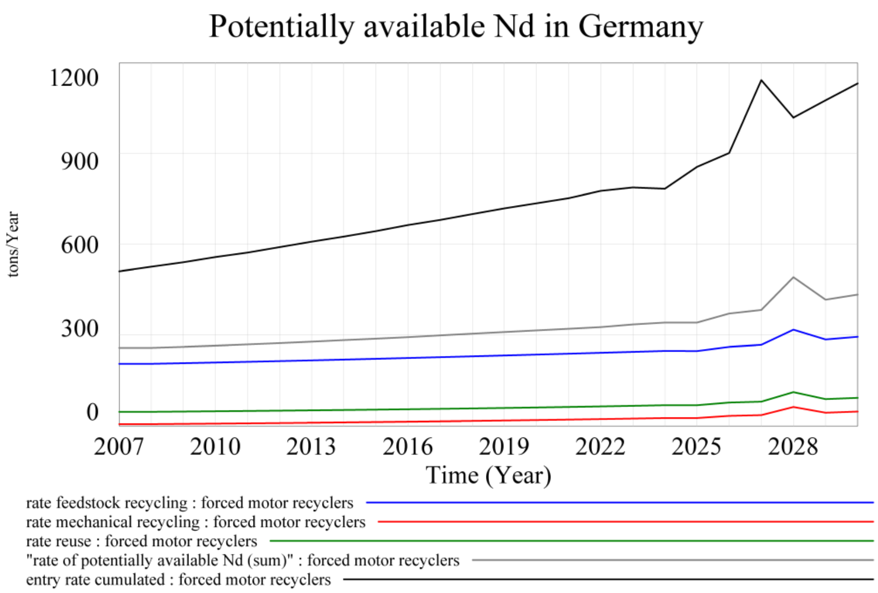

Figure 2: Potentially available processed Nd in Germany.

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