Material Flow Analysis of NdFeB magnets in Hard Disk Drives: Case study of Denmark

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Challenge:

NdFeB (neodymium-iron-boron) magnets are the strongest known magnets today. These magnets are used in a wide array of modern technologies ranging from computers, cell phones and home appliances to clean energy technologies such as electric vehicles and wind turbines due to their current matchless properties. These magnets are dependent on Rare Earth Elements (REEs), especially neodymium (Nd), dysprosium (Dy) and, praseodymium (Pr).

Almost 87% of REEs supply originates from China although China hold 46% of the geological reserves (Figure 1). The stringent export quota introduced by China in the past and the resulting skyrocketed prices in 2011 have led the industry to focus on other solutions including efficient recycling of these elements from the waste electronic products. Thus it becomes very important to first know the potential of REEs in the waste flow (see Figure 2). We have performed a Material Flow Analysis (MFA) of NdFeB magnets contained in Hard Disk Drives (HDDs) in Denmark.

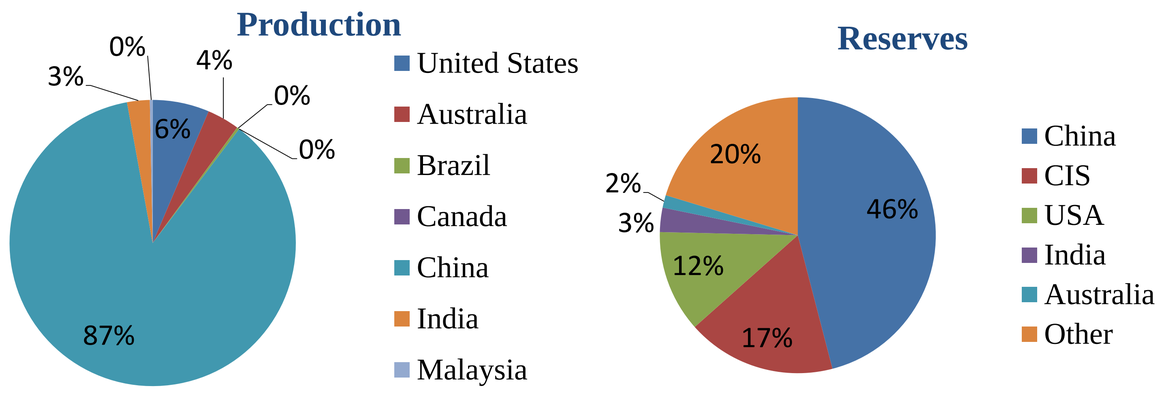

Figure 1: Distribution of REOs reserves and production by country (2012)

Research interests:

1. What is the chemical composition of Nd, Dy and Pr in HDD permanent magnet?
2. What is the potential of secondary supply of Nd, Dy and Pr from the electronic waste stream?

Approach:

We collected a sample of 53 HDDs from desktop PCs (Personal Computer) and 31 HDDs from laptops, dismantled them and separated the NdFeB magnets. We then removed the nickel coating of the magnets and analysed the chemical composition of magnets with the help of EDX (Energy Dispersive X-Ray Spectroscopy) (see Figure 3).

We later collected the sales and waste statistics of computers in Denmark in order to perform the MFA.

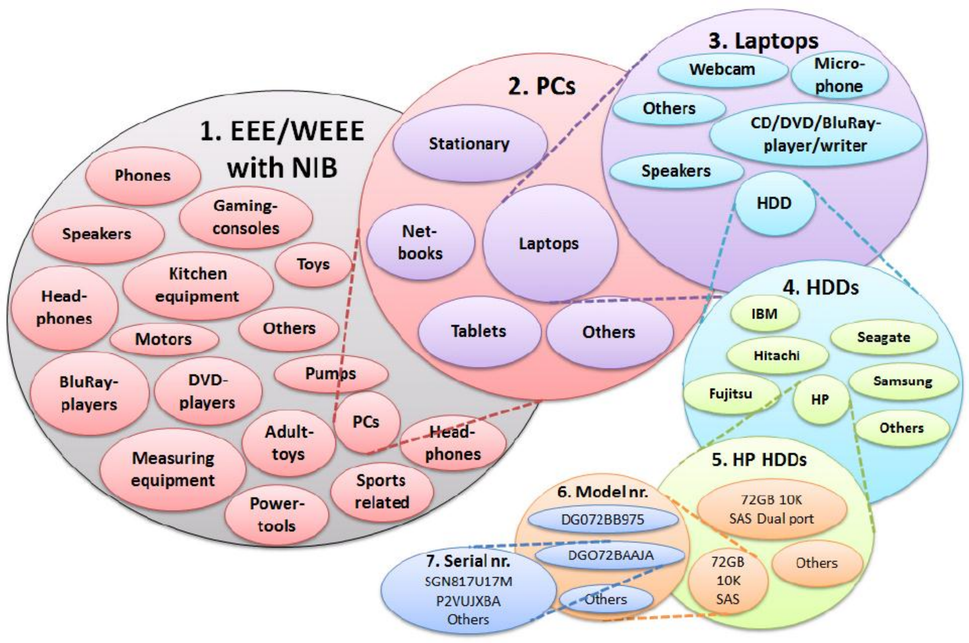

Figure 2: Grouping of EEE/WEEE with an example of systematic breakdown from the overall category of PCs to the final step of a specific HP HDD product series

Figure 3: NdFeB magnets from HDDs analysed by EDX

Results:

Table 1 shows the chemical characterization results for a total of 84 HDDs from both desktop PCs and laptops.

Table 1: Nd, Dy and Pr content of NdFeB magnets from HDDs

	Weight of HDD (g)	Neodymium (g)	Dysprosium (g)	Praseodymium (g)
Desktop	544 ±85	3.8 ± 2.2	0.2 ± 0.2	0.5 ± 0.5
Laptop	115 ± 39	1.0 ± 0.5	0.1 ± 0.0	0.1 ± 0.1

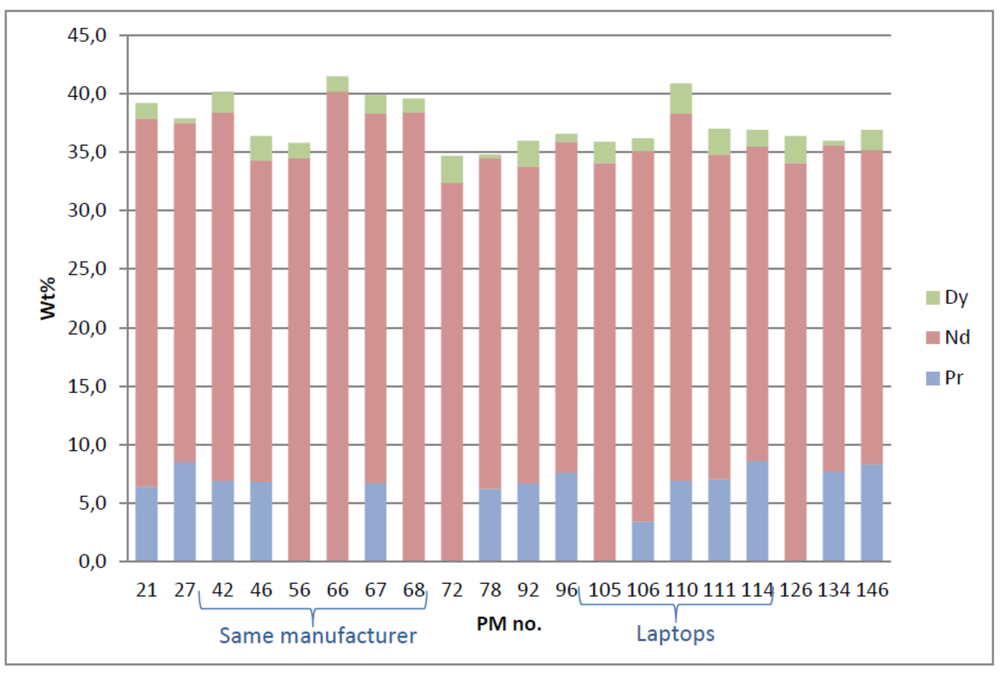

Figure 4: wt% of REEs in 20 different NdFeB magnets from HDDs

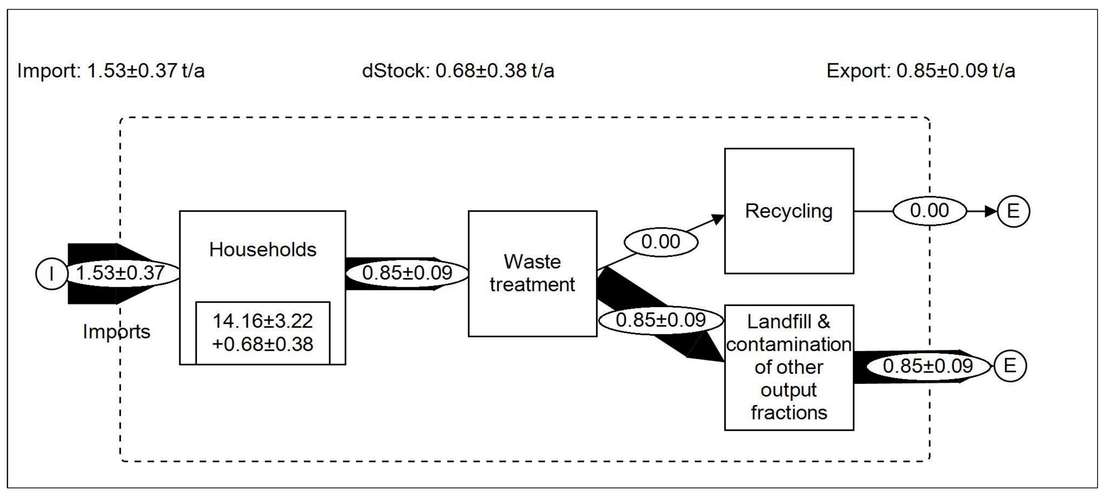

Figure 5: Simplified MFA diagram of Nd (tons year^{-1}) contained in NdFeB magnets of HDDs in Denmark (2010)

Conclusions:

- HDDs found in laptops have almost 75% less REEs compared to desktop PCs
- Nearly 850 kg of Nd, 140 kg of Pr and, 40 kg of Dy can be recovered annually in Denmark from the waste computer HDDs

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