Circular Approaches for Permanent Magnets from Wind Turbines

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Introduction

- Increasing demand of direct-drive permanent magnet wind power plants for German energy infrastructure
- Neodymium as critical resource, especially due to Chinese monopoly

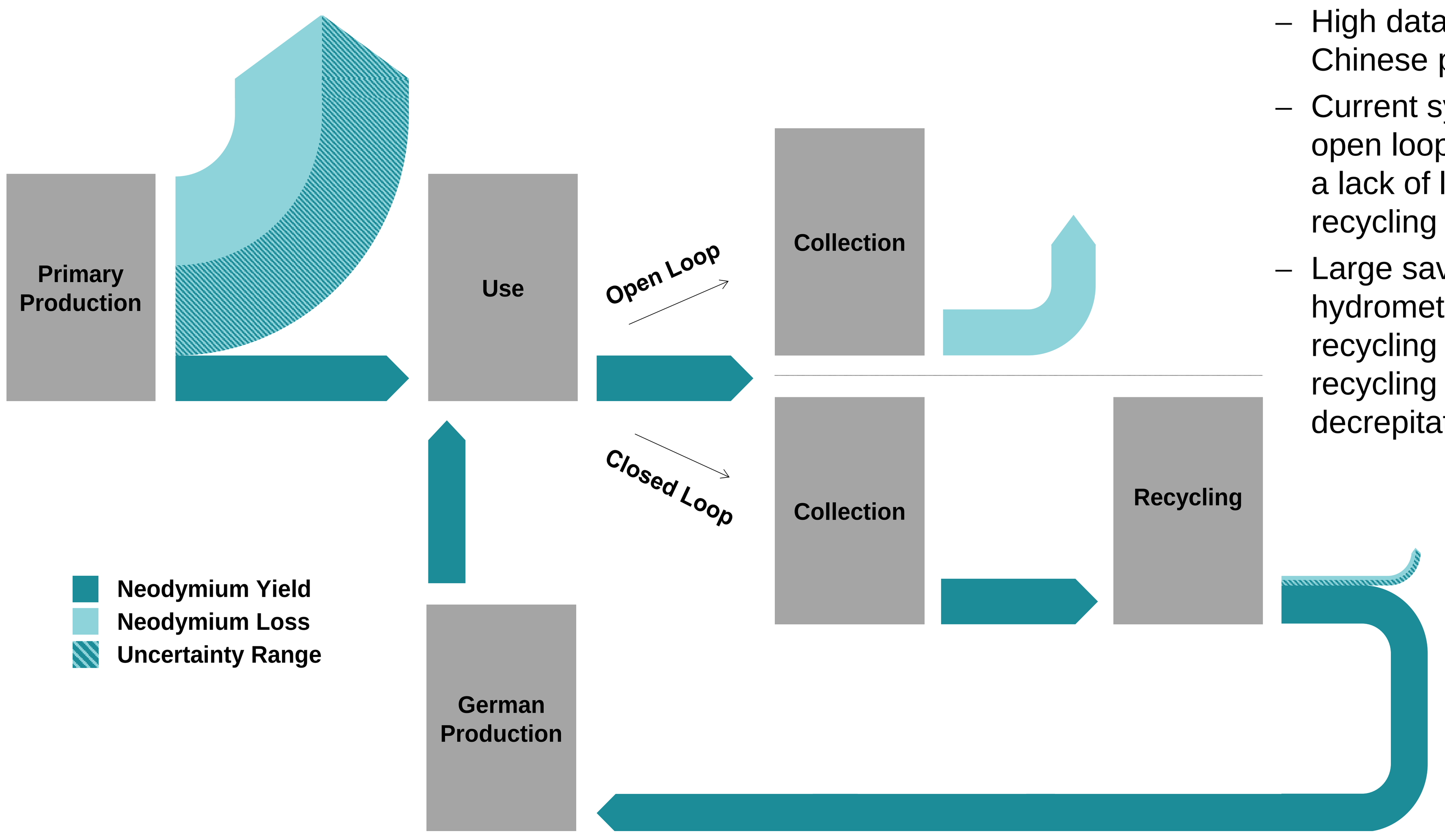
Objectives and Methods

- Identify the saving potential for recycling and reuse considering neodymium demand and climate change impact ➡ Neodymium substance flow analysis and identification of climate change impact based on a meta study
- Develop a trans-technological methodology for the identification of reuse applications ➡ Case study for identification of reuse applications and deduction of a trans-technological methodology

Recycling Holds Large Environmental Saving Potentials

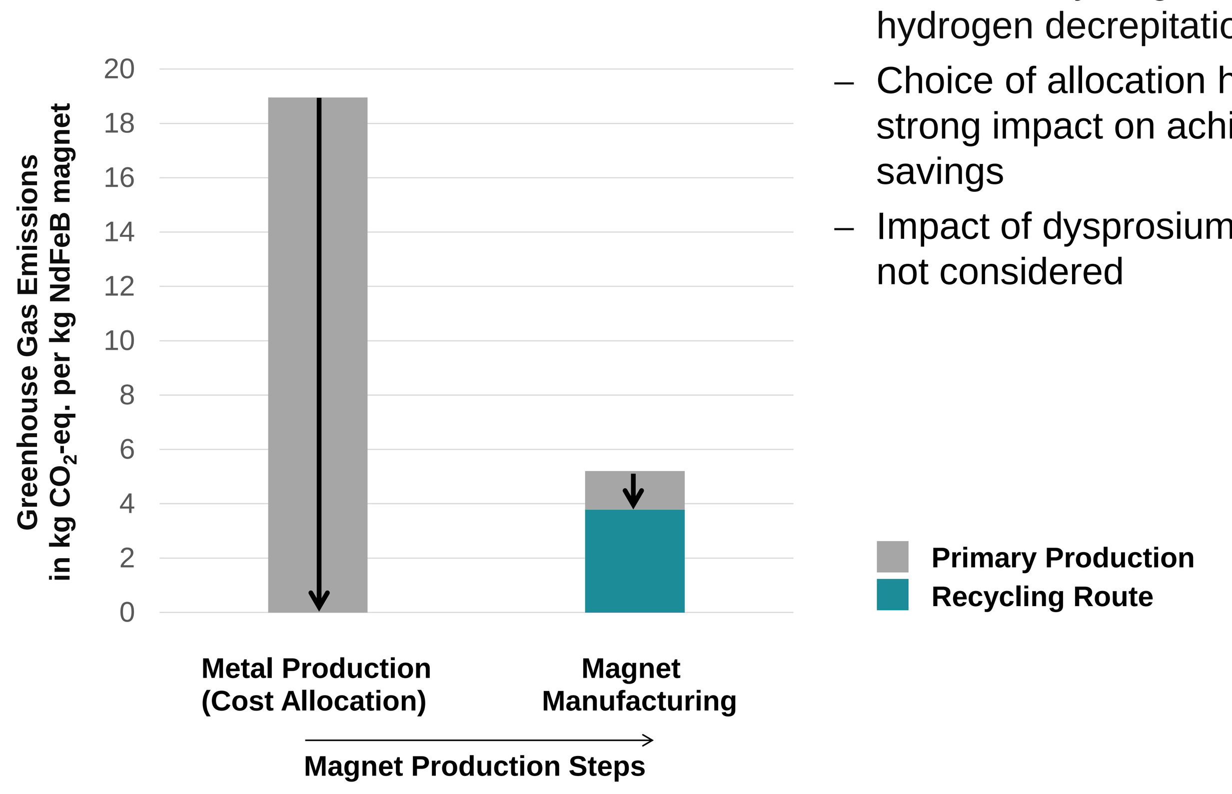
System Boundaries and Limitations: Primary production in Bayan-Obo (China), reuse and recycling limited to Germany, negligence of dysprosium due to a lack of data availability

Neodymium Savings[1,2,3,4,5,6]



- High data uncertainty in Chinese production
- Current system resembles open loop scenario due to a lack of large-scale recycling processes
- Large savings through hydrometallurgical recycling and material recycling via hydrogen decrepitation possible

Greenhouse Gas Emissions Savings[4,6]



- Material recycling via hydrogen decrepitation
- Choice of allocation has strong impact on achievable savings
- Impact of dysprosium content not considered

Barriers for the Implementation of Innovative Reuse Concepts

Trans-Technological Methodology for the Identification of Reuse Applications

1. Product Specification ➡
- Identification and quantification of relevant product parameters
- End-of-Life analysis

2. Portfolio Analysis ➡
- Overview of possible reuse applications
- Identification of technical requirements and innovation processes

3. Product Architecture ➡
- Product architecture defines possible variation in product specification and product adaptability

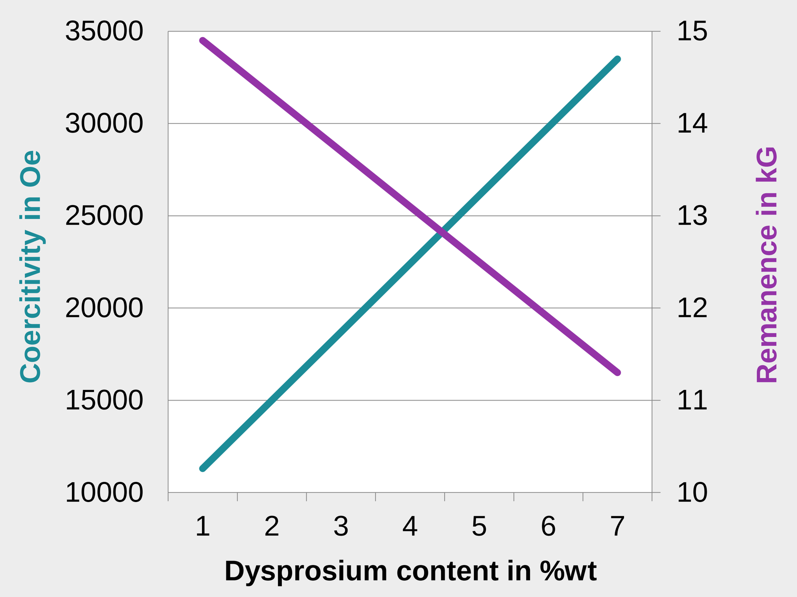
4. Matching ➡
- Identification of reuse applications
- Consideration of product specification, technical requirements and innovation processes

5. Preparation
- Identification of necessary preparation processes
- Consideration of technical feasibility of preparation and quality losses

Reuse of Magnets from Wind Turbines

Product Specification

Dysprosium Content impacts Magnet Parameters[7]



End-of-Life Analysis:
- Magnet composition: 31 % Nd, 2.3 % Dy
- Quality does not change during use in wind turbine
- Demounting is possible

Product Architecture

Magnet is system component
- Specifications need to match exactly to application
- No modification of magnet parameters possible

Matching

Reuse in wind turbines?

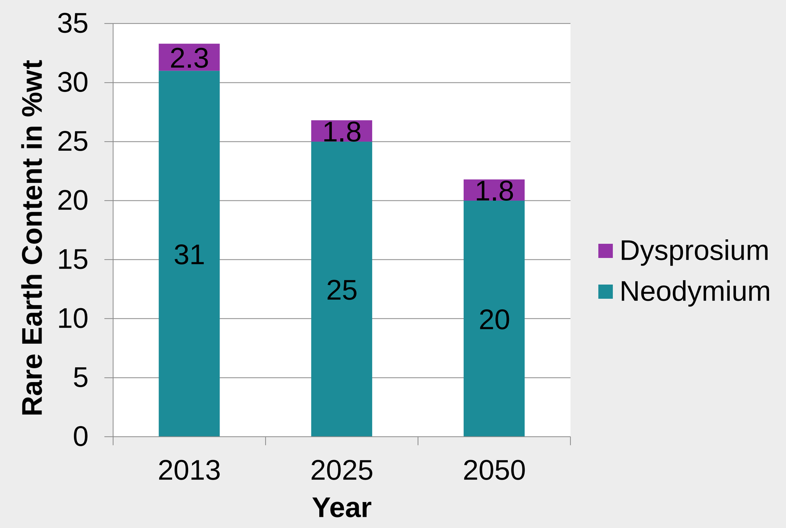
Not possible due to innovation cycles and limitations in product architecture

Reuse in other applications?

Not possible due to varying technical requirements and limitations in product architecture

Portfolio Analysis

Innovation Cycles impact Magnets in Wind Turbines[8]



Technical Requirements differ between Applications[5,9]

Application	Magnet Composition
E-Car Motor	20 % Nd, 10 % Dy
Hard Drive Disk	30.8 % Nd, 2.4 % Dy
Dryer	29 % Nd, 2 % Dy
Circular Pump	25 % Nd, 0.05 % Dy

Conclusion

- **Recycling** of magnets from wind turbines is technically feasible, offers great environmental savings and reduces the resource criticality of neodymium which is needed for the German energy infrastructure
- **Reuse** of magnets from wind turbines is technically not feasible within Germany, but may be of interest for the use of refurbished wind power plants outside of Germany

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