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# Attractive Recycling Recycling of Rare Earth Metals

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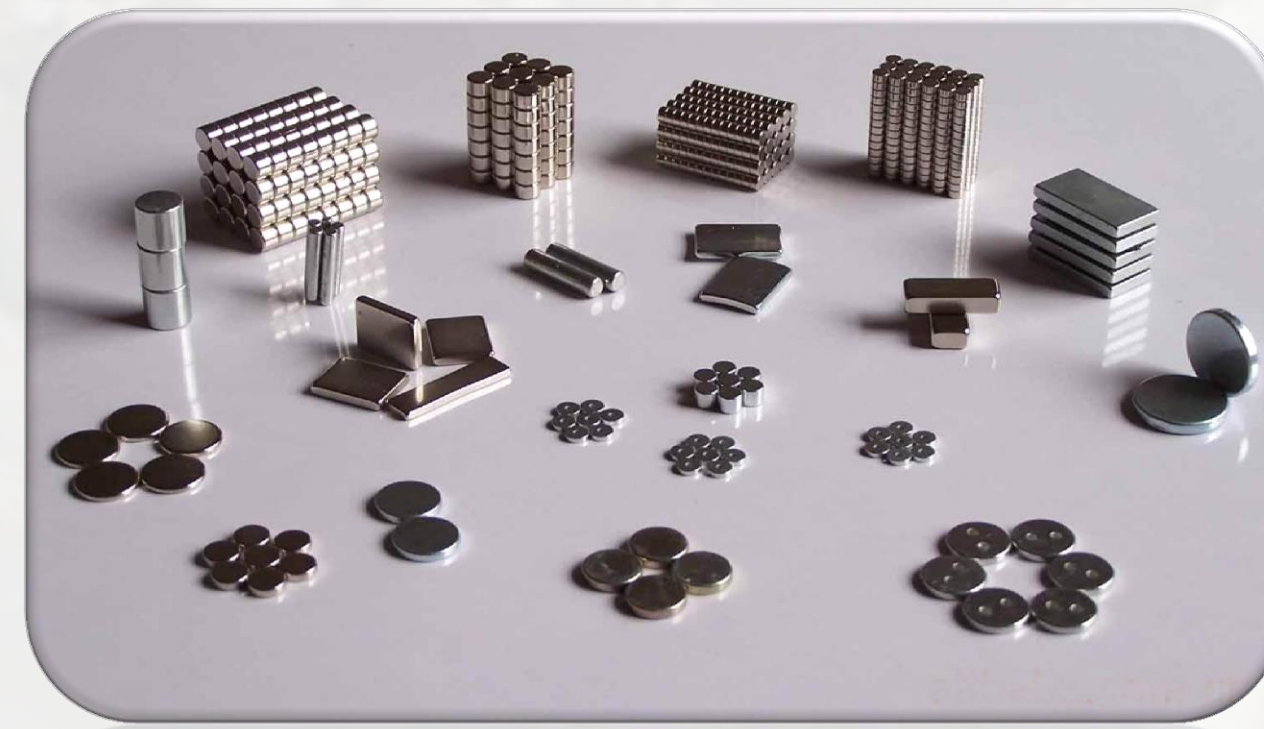
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## Abstract

Rare earth magnets (REM) are powerful magnets that are commonly used in household appliances, wind turbines, and other technological processes. A growing shortage of the elements needed in order to make REMs as well as trade disputes between the countries exporting the materials cause fluctuating costs for both manufacturers and consumers. The goal of this project was to investigate ways to increase REM recycling rates in end of life (EOL) products and devise a plan to establish this practice in the United States since there are currently no systems in place. Through research of recycling practices in Europe and Asia, along with research of different magnetic separation processes, we have developed a plan to address this problem. We recommend that the recycling of REMs be integrated into already existing recycling processes with the addition of magnetic resonance damping to separate the magnetic materials from the basic ferrous scrap.<sup>2,3,5,6</sup>



## Goals/Objectives

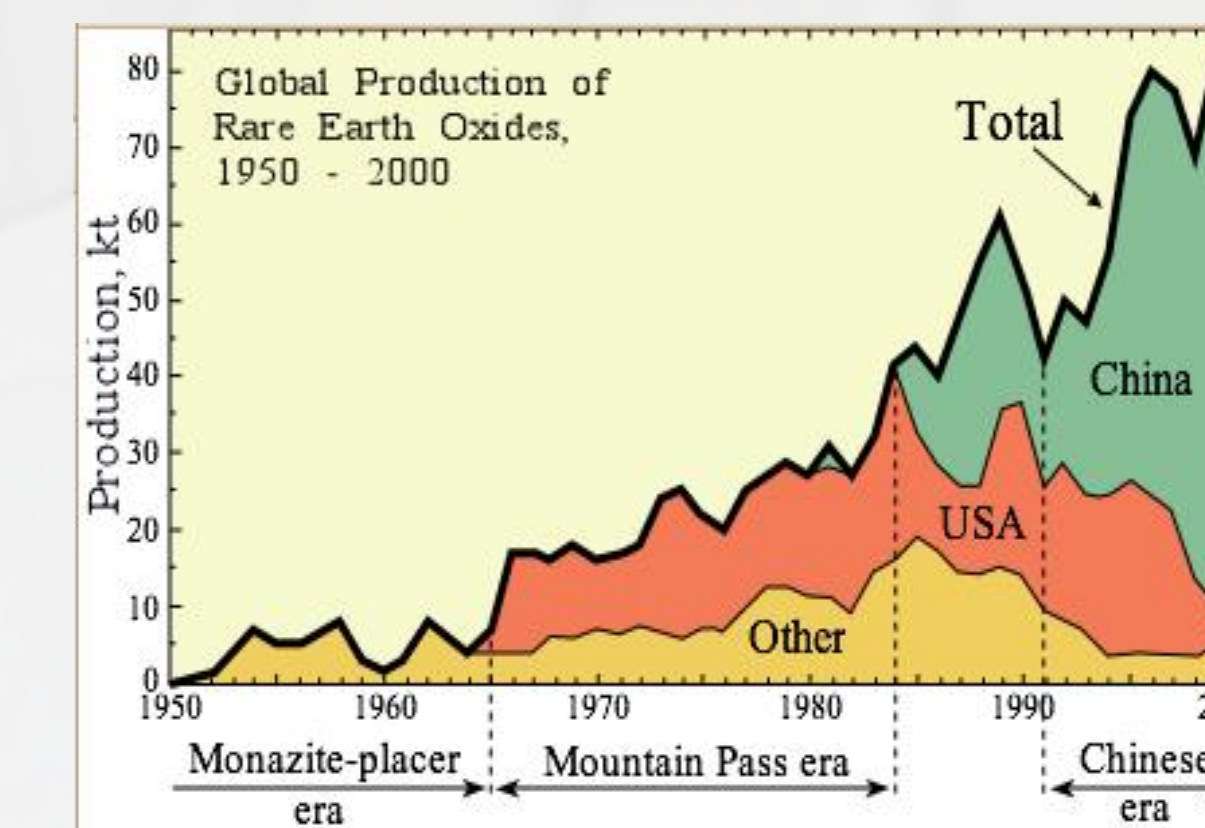
- Investigate existing rare earth magnet recycling processes
- Investigate different ways to separate magnetic materials
- Devise a plan to potentially institute rare earth magnet recycling in the U.S.

## Methods

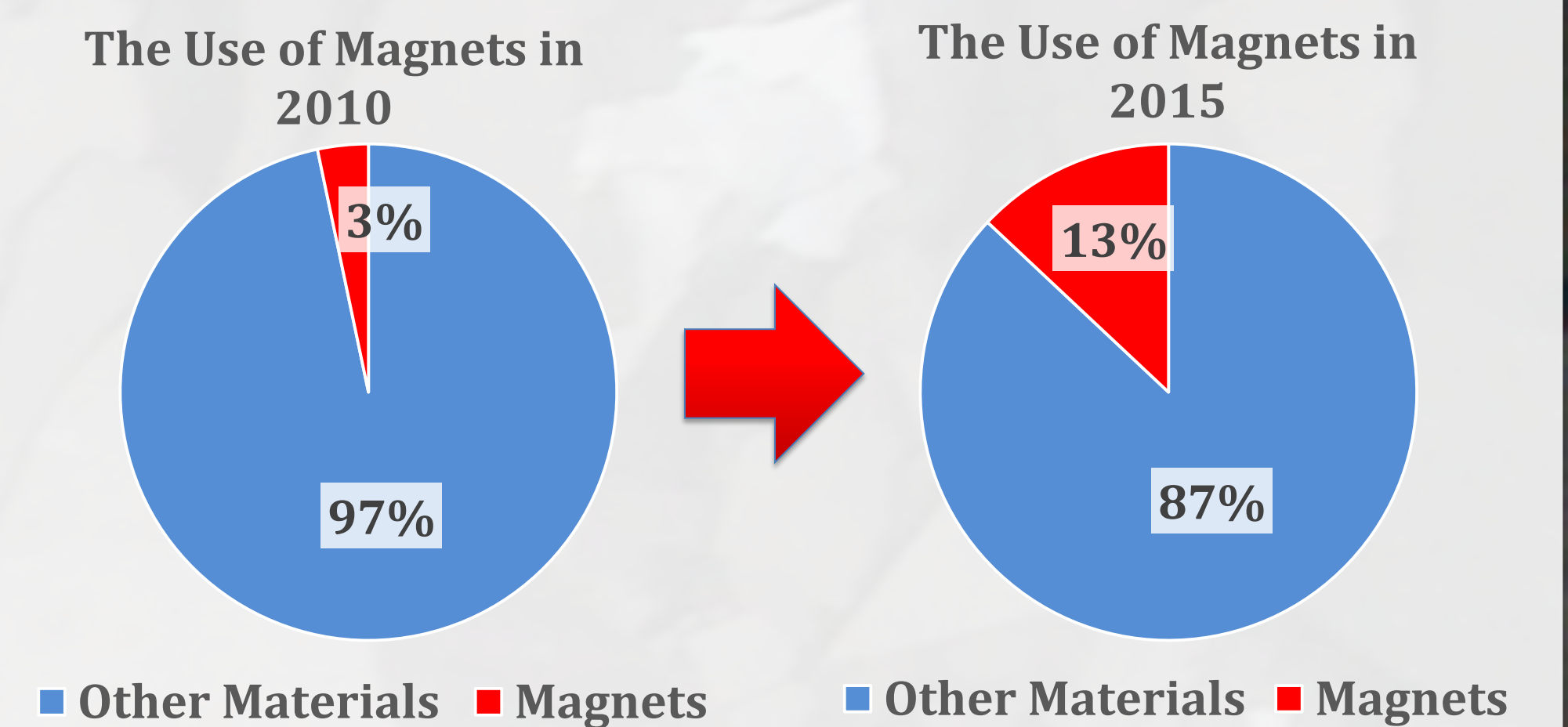
- Researched where rare earth elements are mined and how they are distributed
- Identified countries with REM recycling programs
- Analyzed existing plans for REM recycling in other countries, especially the Oeko-Institut’s plan for Europe
- Determined the unique characteristics of REMs compared to other magnetic/ferrous material and compared different ways to separate magnetic material

## Background

- The amount of rare earth elements in the soil is **finite and decreasing quickly**
- Trade restrictions cause **rising prices** for manufacturers and consumers of rare earth products
- **Technologies already exist** in Japan to recycle REM scraps that form during manufacturing
- Since the majority of REM processes occur in China, there is a **lack of understanding** about the materials in other parts of the world

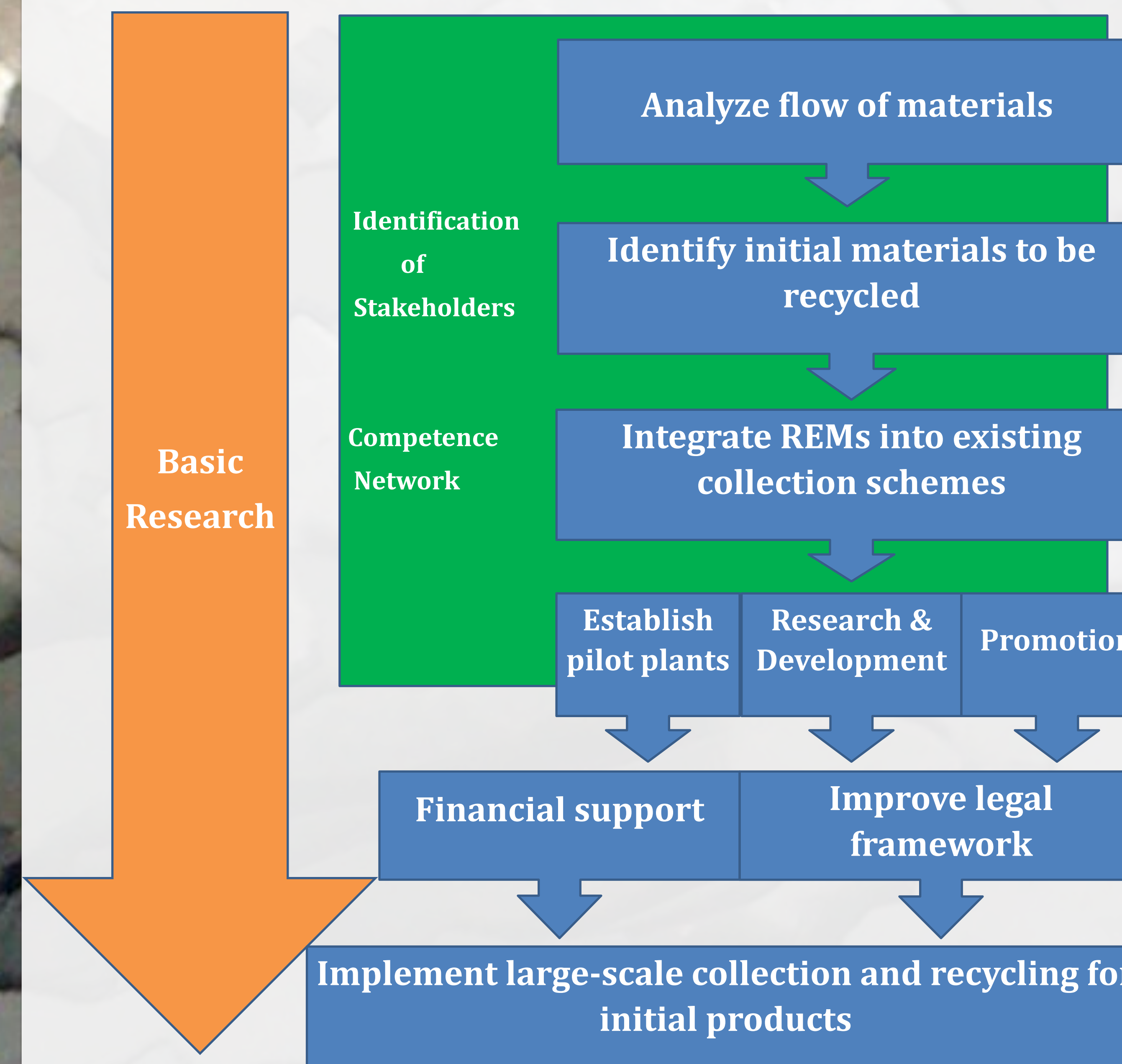


- **95%** of the world’s rare earth elements come from China<sup>4</sup>



- The Increasing Demand of Magnets in the U.S.<sup>4</sup>

## Proposed REM Recycling Plan



• This flowchart has been adapted from the Oeko-Institut’s proposal for REM recycling in Europe<sup>6</sup>

## Results & Recommendations<sup>3</sup>

- Numerous countries have begun looking into REM recycling, but **only a few countries** (notably Germany, Japan, and China) **actually have systems in place**
- **Magnetic resonance damping** is the best option for separating magnetic materials
- This method uses the **least amount of energy** and cause **no damage** to the REMs or the ferrous material
- Based on a proposal that the Oeko-Institut formed for Europe, we formed a plan to potentially institute REM recycling in the United States (see flow chart)
- A REM recycling system will reduce reliance on exportation and thus reduce trade limitations and cost
- Recycling REMs will create a **no-waste, closed-loop cycle**

## Acknowledgements

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