Pathway Towards Environmental Sustainability and Economic Feasibility: Integrating Material Flow Analysis (MFA) and Techno-Economic Assessment (TEA)

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This is a PhD research proposal focusing on the integration of Material Flow Analysis and Techno-economic Assessment (TEA) in methodology. It will be applied in optimizing pathways of neodymium (Nd) recycling and assessing their environmental sustainability and techno-economic feasibility. This project started from 1st Mar, 2021 to 29th Feb, 2024, supervised by Prof. Gang Liu in SDU Life Cycle Engineering, Department of Green Technology (IGT). Welcome to collaborate with us if you are interested.

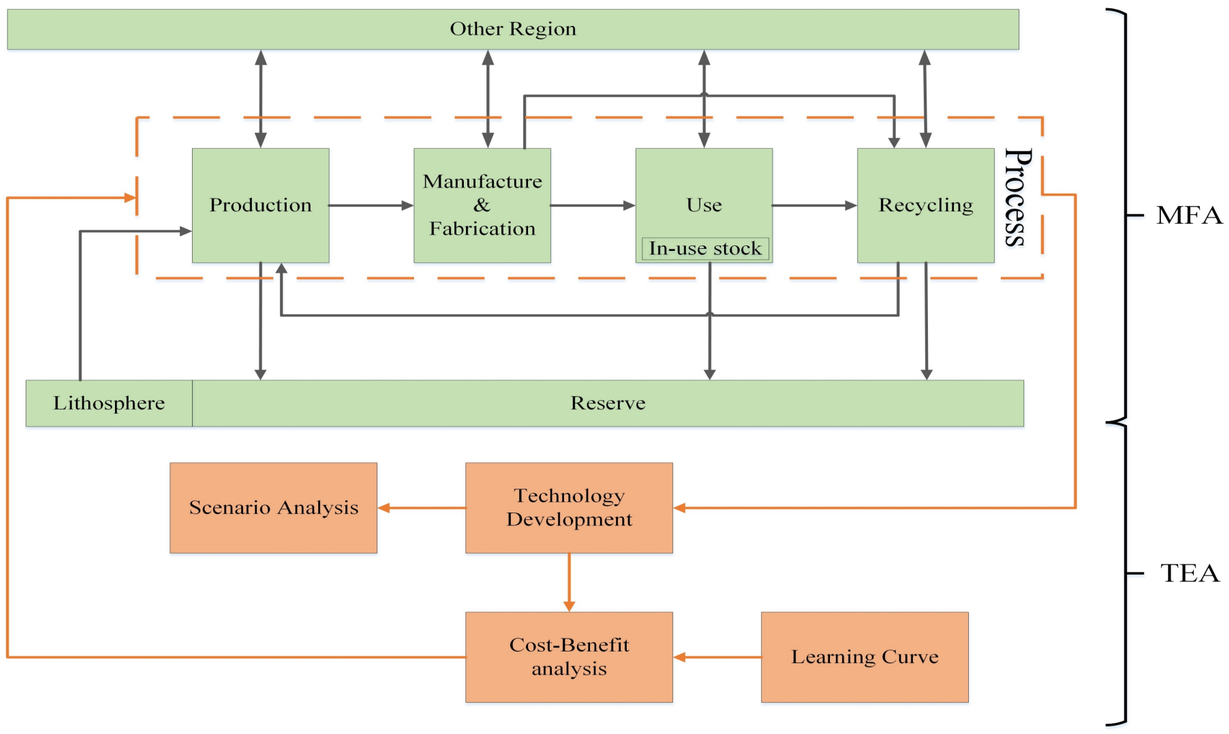

Figure 1. A general framework for integration of MFA and TEA

Year		2021		2022		2023	
Semester		S	F	S	F	S	F
Task 1 : Identification of Nd recycling barriers	Mapping the lifecycle of Nd	X					
	Identifying all products involved in the Nd lifecycle	X					
	Summarizing technological, economic, environmental limiting factors	X					
	Exploring the inter-relations for limiting factors		X				
	Proposing policy implications		X				
Task 2 : Estimating Nd recycling potentials	Collecting data for historical Nd products flows and lifetime		X				
	Calculating historical stocks and outflows for Nd		X				
	Simulating stocks for Nd products in the future			X			
	Calculating future stocks and recycling potentials for Nd			X			
	Sensitivity analysis and model validation			X			
	Setting up pathways for Nd recycling				X		
	Sensitivity analysis and model validation	X					
Task 3 : Assessing environmental sustainability and techno-economic feasibility	Setting up pathways for Nd recycling			X			
	Adding economic value based on MFA for Nd recycling			X			
	Calculating carbon emissions for different pathways			X			
	Discussing the technological feasibility for different pathways			X			
	Selecting the most practical pathway for Nd recycling					X	
	Proposing policy implications					X	

Table 1. Time Schedule

Background

Material flow analysis (MFA) is an important methodology in industrial ecology and has been well applied in environment, resource and waste management to meet the SDGs.

Rare earth metals are a group of metals which are critical to the industries especially for emerging industries in the future. With a large demand of REEs around the world but single dominating supplier, recycling provides a complementary and more environmentally sustainable source for securing future supply especially for Europe and Japan. Assessing the secondary resources provision and dynamics of REEs is therefore very important for securing the supply of REEs for the world.

However, despite increasing knowledge on the physical potentials of REEs secondary supply, the understanding on their technological and economic feasibility remains poor. In this regard, extending REEs MFAs to other tools such as Techno-Economic Analysis (TEA) would be important.

This thesis aims to integrate MFA and TEA models for REEs recycling. Neodymium was chosen as an example rare earth metal. This work will a) summarize the recycling barriers in socio-economy, b) estimate Nd recycling potentials, and c) assess the environmental sustainability and techno-economic feasibility for Nd recycling by integration of models.

Objectives

- Identification of limiting factors for Nd recycling, aggregated by Nd-containing products and semi-products, including environmental, economic, technological, social issues;
- Estimation of Nd recycling potentials, including calculating historical Nd stocks and forecast future stocks, calculating waste production in history and recycling potentials in the future;
- Assessment of environmental sustainability and techno-economic feasibility for Nd recycling, selecting pathways with lowest environmental impact, best technological feasibility and largest economic revenues.

Methods

- Dynamic MFA methods (flow driven and stock driven)
- Learning curve model
- Techno-economy Assessment