



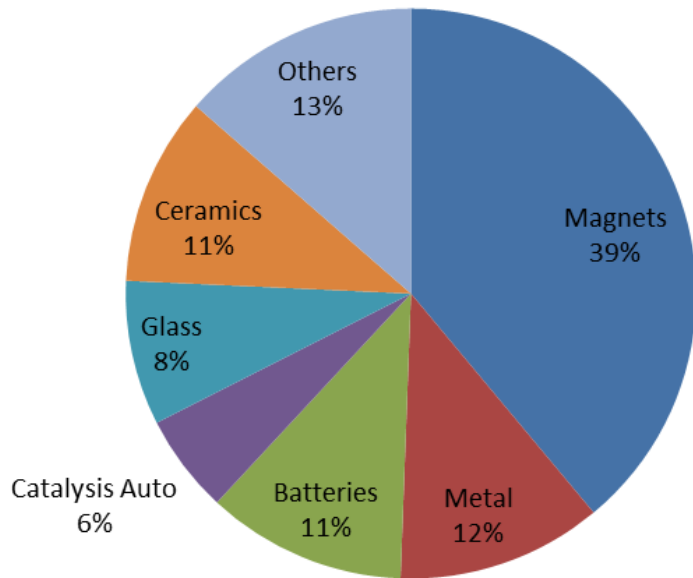
Material Flow Analysis for identifying Neodymium flows and stocks and recycling potentials in the EU-28

Planchon M, Guyonnet D, Rollat A, Escalon V,
Vaxelaire S, Tuduri J



Context

- High supply risks of Nd due to China's monopoly on extraction (86%).
- High economic importance to EU economy due to its use in several applications :



Main applications using NdFeB permanent magnets	Main applications using NiMH batteries
Electric and Non electric vehicles	Portable batteries (rechargeable batteries):
Hard drives	- Cameras
Cell phones	- Electric shavers
Laptops and desktops	- Cell phones and cordless phones
Wind turbines	- Laptops
RMI machines	- Handheld tools
Refrigerators	- Remote-controlled toys
Washing machines	- Emergency lighting equipment
Air conditioners	Industrial batteries
Cameras	- Hybrid and electric vehicles (HEV)
Headphones and earphones	- Electrical aircraft systems
CD player	- Satellite pinpointing systems
Fax, printers, scanner	
Shavers and electric epilators	

- Our study covers all these applications, contrary to many previous published studies that only focus on HEV, computers and wind power.

Objectives

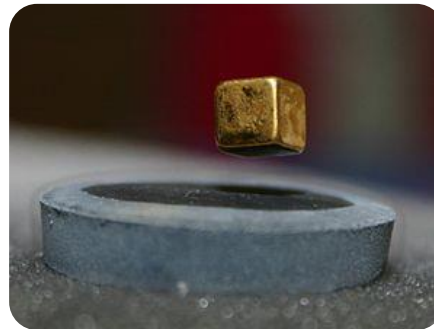
- Need of a comprehensive data inventory of Nd flows and stocks in the anthroposphere to get the solid ground for decision making about securing supply.
- French research project on systemic analysis of REEs that aims at assessing the flows and stocks of REEs in the European economy.

Nd, Pr, Dy, Tb



Objectives

- Material Flow Analysis (MFA) of Nd in EU27 economy in 2010:
 - Map of flows and stocks of Nd through the economy (production, trade) of EU27,
 - Over the entire life cycle/value chain of Nd:
 - Upstream steps: lithosphere, separation, fabrication
 - Downstream steps: manufacture, application, use, waste management
- Quantification of Nd embodied in raw materials/ products/ applications for each steps of its life cycle,
- Focus on the two main applications with recycling interest:
 - Permanent magnets (NdFeB)
 - NiMH Batteries



Presentation of MFAs

S

F

M

A

U

W

Separation of RE mix in Nd compounds

Fabrication of the Nd-based product

Fabrication of the Nd-based product

Inclusion of the product in an application

Use of applications

Management of waste

Mix of REOs

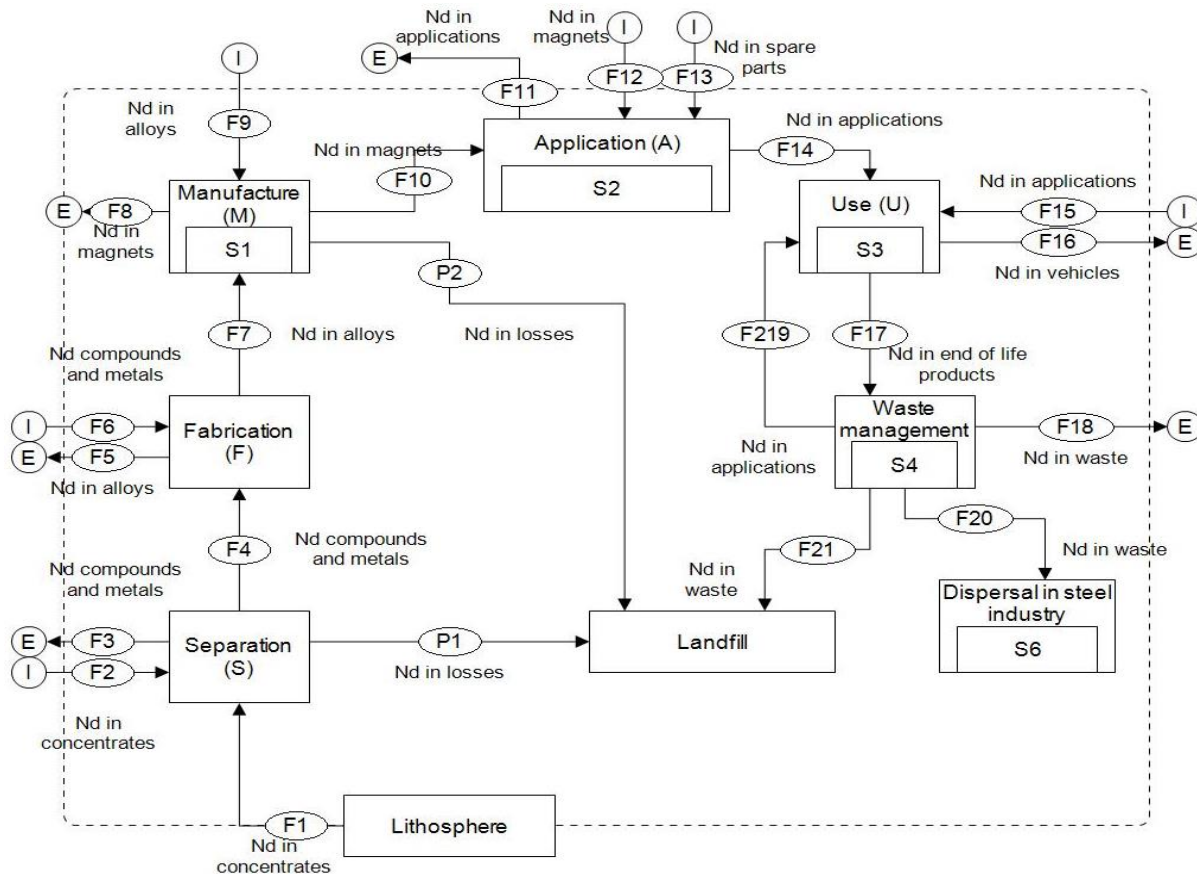
Nd oxides and metals

NdFeB alloy

NdFeB permanent magnet

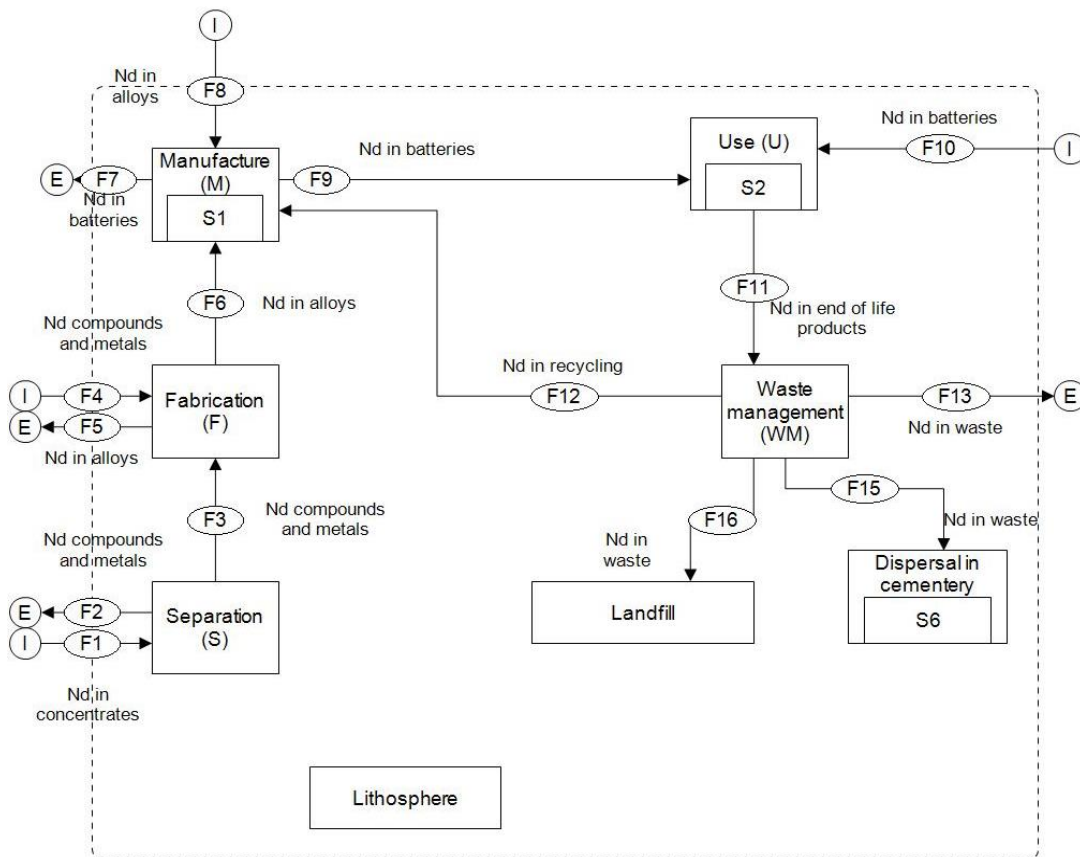
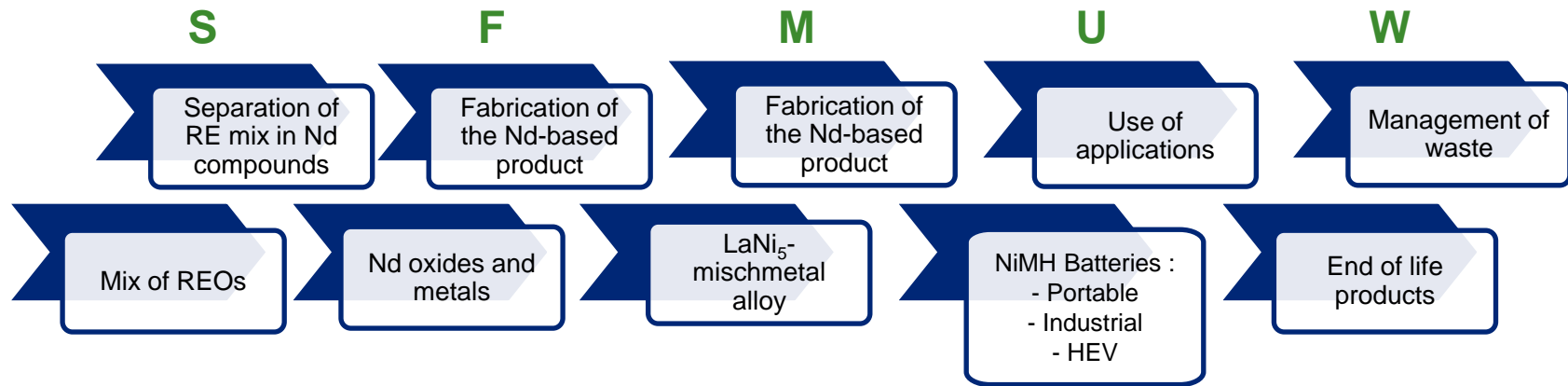
- Vehicles
- Laptop, desktop
- Cell phones, Printers
- Earphones
- Wind power
- MRI
- Fridges
- Etc.

End of life products



MFA Nd/magnets

Presentation of MFAs



MFA Nd/batteries

Methodological points

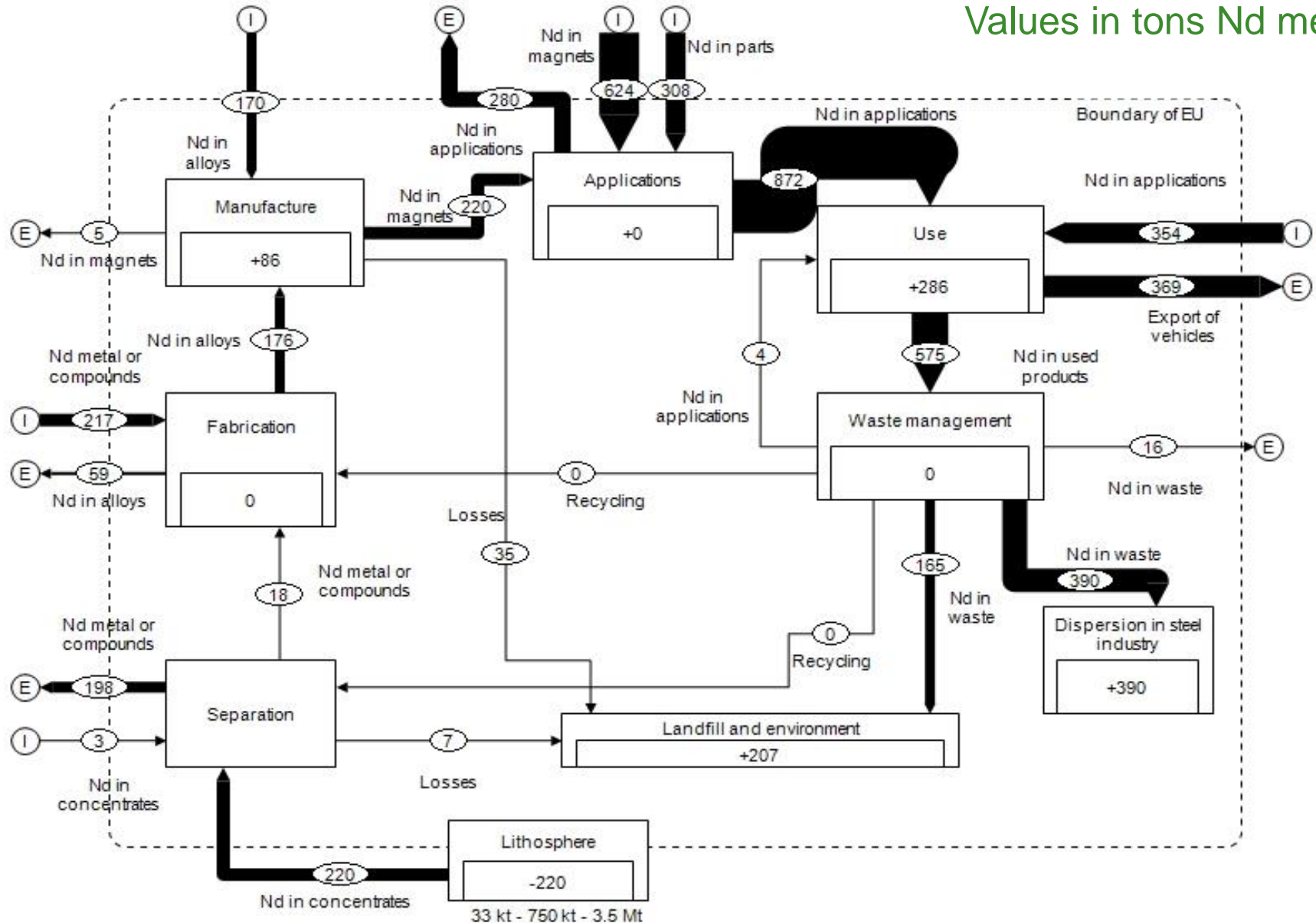
- To elaborate Nd MFAs, several types of data are required:
 - Upstream of the life cycle (S and F steps):
 - Quantities of REO produced, sold, exported, imported in EU-27 in 2010,
 - Share of Nd in those REO
 - Downstream of the life cycle (M, A, U, WM):
 - Quantities of intermediate products or applications produced, sold, imported, and exported in EU-28 per year,
 - Weights of these components in applications and
 - Quantities of REEs in intermediate products or components used in applications, and
 - Lifespan of the applications (NiMH batteries and permanent magnet-containing products).
- Use of lifespans to assess:
 - In-use stocks
 - End-of-life product flow

Methodological points

- Data sources:
 - Statistical customs data
 - Annual reports of manufacturers or suppliers
 - Scientific articles or specialised reports
 - Scientific or industry experts, etc.
- Coherence check between various source due to uncertainties on data
- Data gap filling and coherence check with specialised experts
- Sankey Diagrams to illustrate the MFAs
- 🖐️ Reminder : due to uncertainties, results are only **estimates** and **not** absolute values

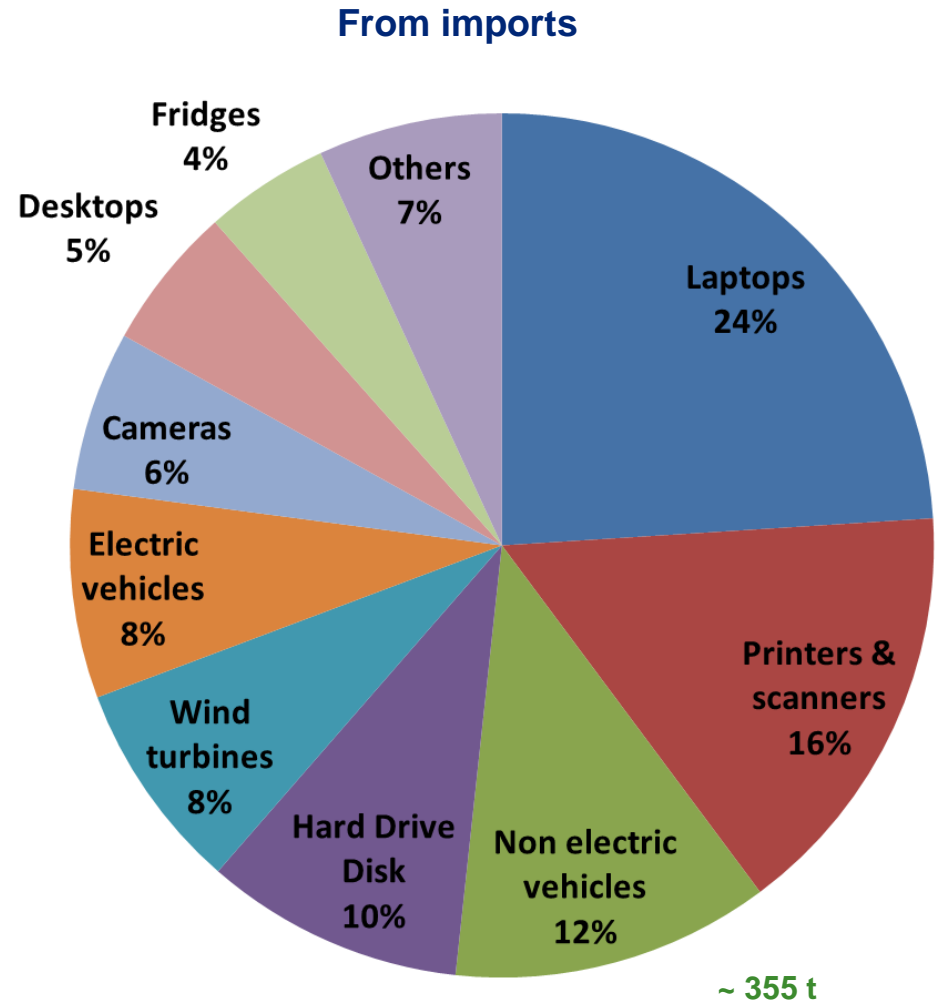
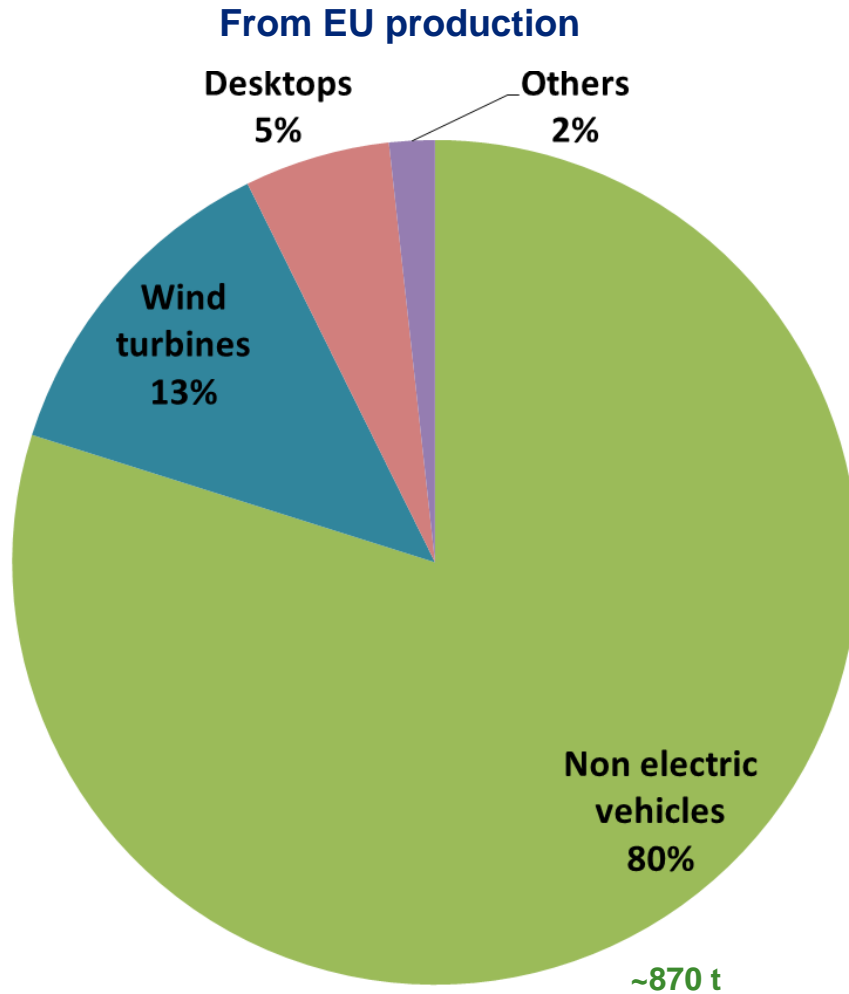
Results: Sankey diagrams

MFA Nd/magnets
Values in tons Nd metal



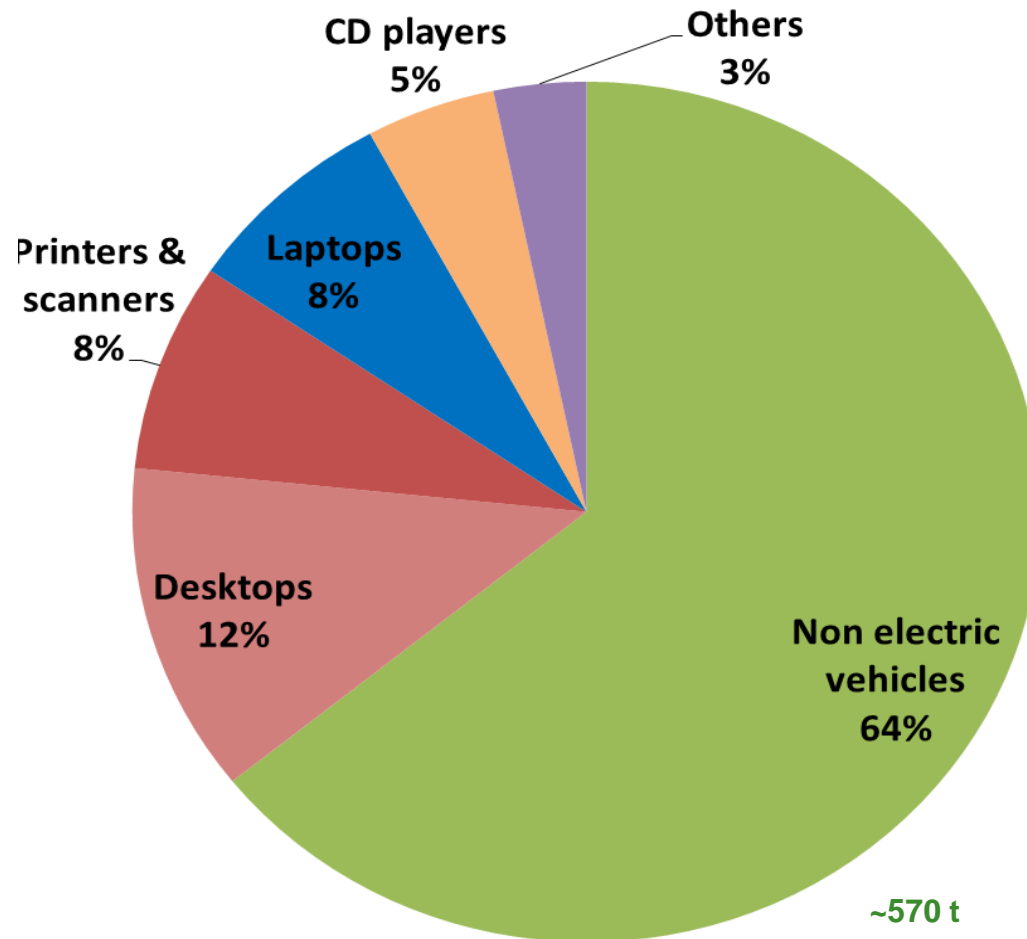
Results – Focus on permanent magnets

- Flow of Nd into “ Use “

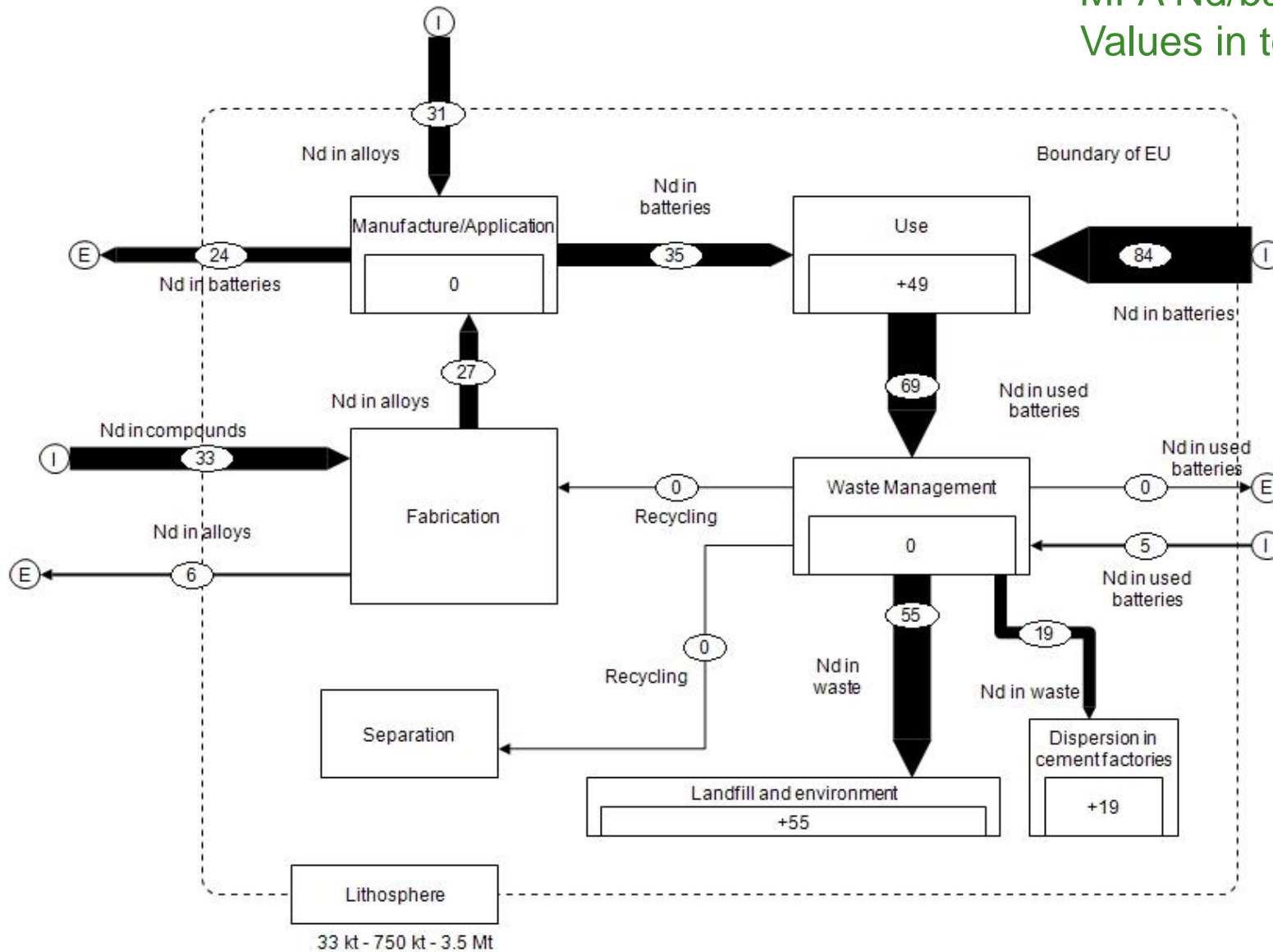


Results – Focus on permanent magnets

- Flow of Nd into “ Waste “



MFA Nd/batteries Values in tons Nd metal



Conclusions

- MFA

- Upstream input flows of Nd in the EU economy in 2010 : ~ 600 tonnes
- Downstream input flows of Nd in the EU economy in 2010 : ~1,500 tonnes
- In-use stock for Nd in EU economy in 2010 : ~ 18,000 tonnes
- Upper bound of Nd in the EU waste flow in 2010 : ~ 630 tonnes
 - potentially recyclable in the future if appropriate collection and recycling processes are developed

- Prospective:

- Relaxation of Nd criticality with the diversification of supply sources in Australia and the US
- Recycling

Contact

- Mariane Planchon
mplanchon@bio.deloitte.fr
- Dominique Guyonnet
d.guyonnet@brgm.fr
 - Alain Rollat
Alain.Rollat@solvay.com



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