

REE4EU



Rare earth recycling for a strong and independent European rare earth element supply chain: process development integrating Life Cycle Assessment and socio-economic analysis

avniR Conference – September 7th 2018 – Lille
Colin JURY – Inovertis

Context and objectives of the REE4EU project



13 % OF GLOBAL TRADE

- > €1.5 trillion of Rare Earth (RE) containing products
- > China monopolizes production (90%)
- > Almost no RE recycling

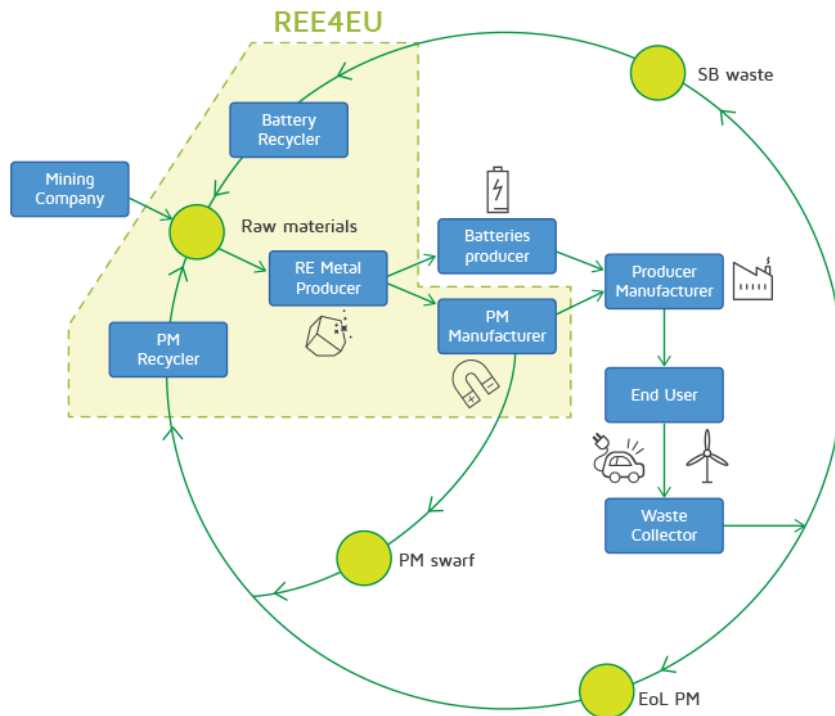
RE recycling in EU = Strategic and environmental challenge

REE4EU STRATEGY

Market analysis of REE-containing products to estimate amount of REE to recycle

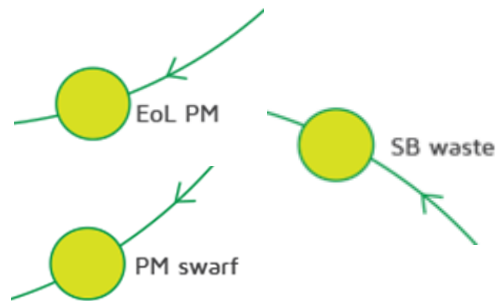
Development of innovative processes to recover REEs

Bringing innovative processes to commercial scale (4-7 yrs)



»»» The REE4EU recycling

Feedstock sorting and handling



RE recovery routes

**Ionic Liquid (IL)
or Hydrometallurgical
extraction**

to produce

RE OXIDES MIX

**High Temperature
Electrolysis (HTE)**

to convert RE oxides mix
or raw waste into

RE ALLOY

Strip casting

to adapt the REA
composition into

PERMANENT
MAGNET ALLOY

A socio-economic and environmental analysis is performed on 9 scenarios to



To **eco-design** the REE4EU rare earth recycling route

To evaluate if the implementation of the RE Recycling chain is of interest **compared to the conventional end of life routes**

To determine **which feedstock and which route** are the most interesting



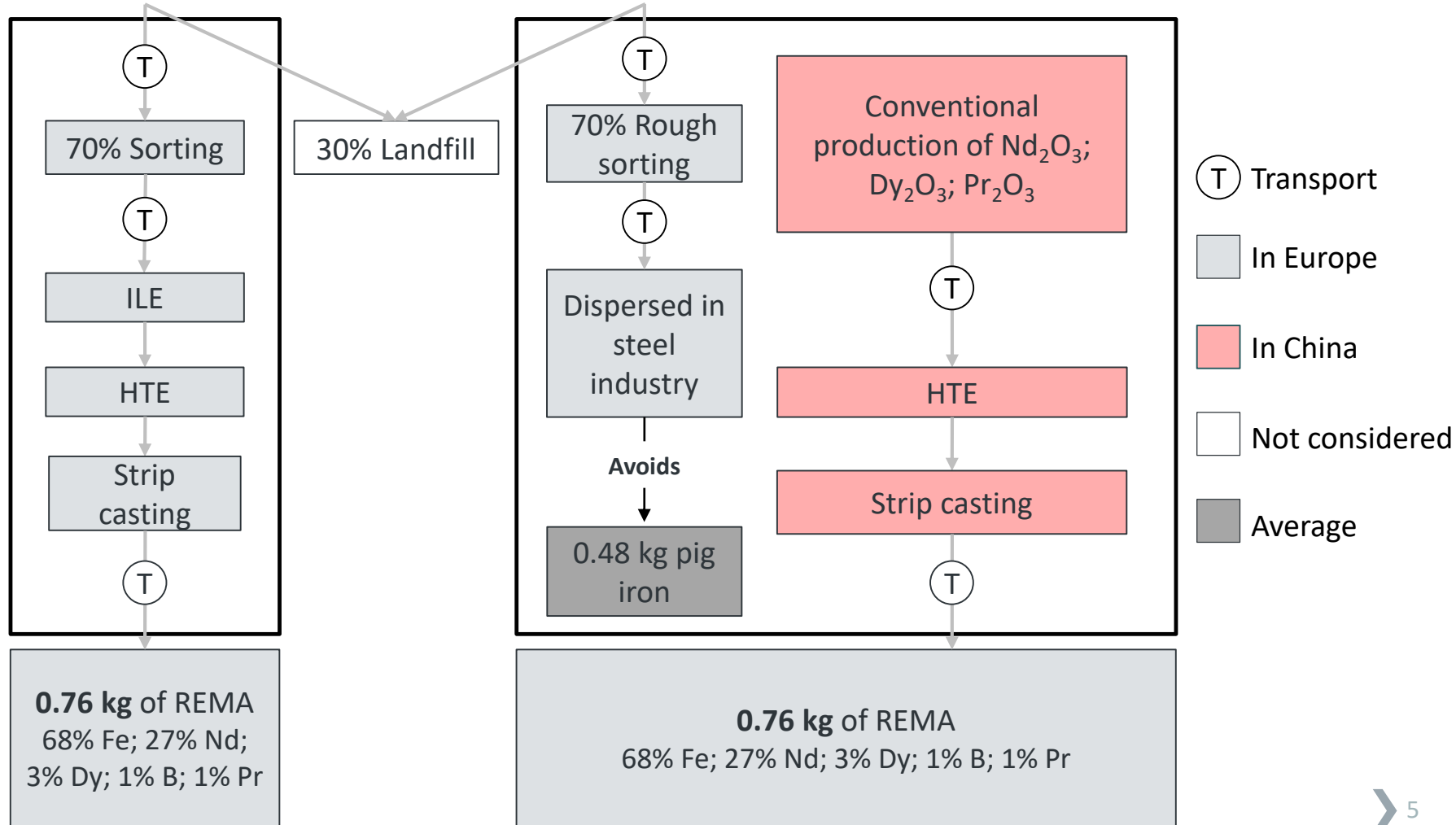
Life Cycle Assessment



Comparison 1: SPM vs. current (System boundaries)

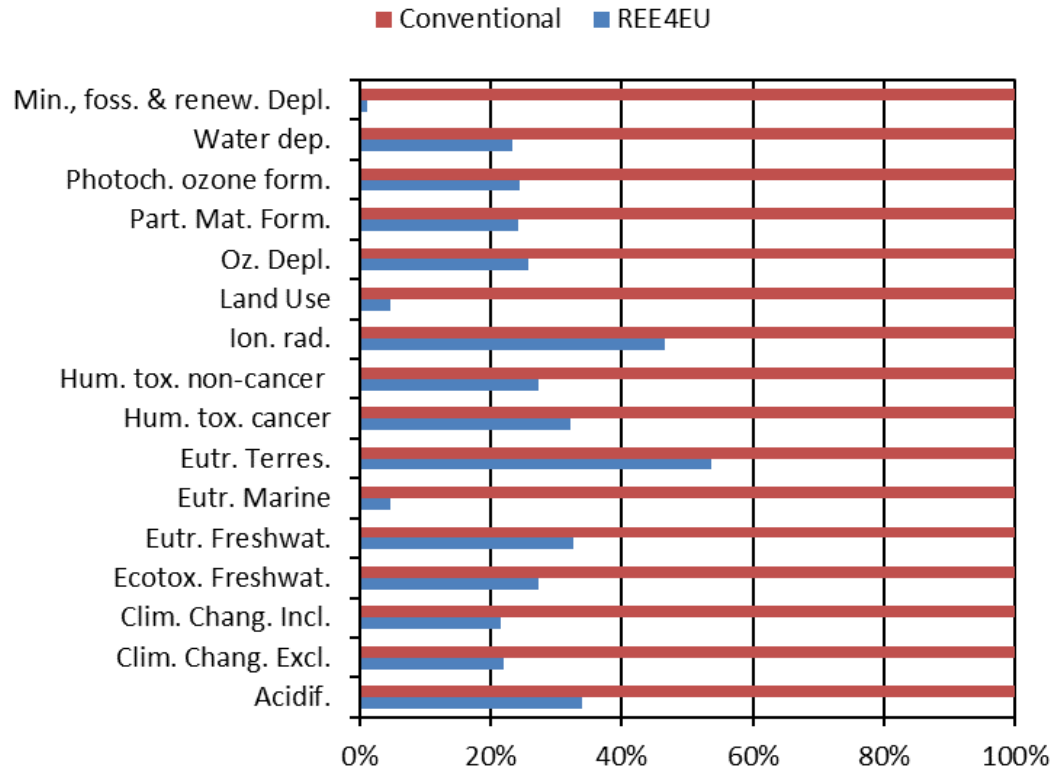
1 kg spent PM REE4EU

1 kg spent PM conventional





Comparison 1: SPM vs. current (preliminary results)

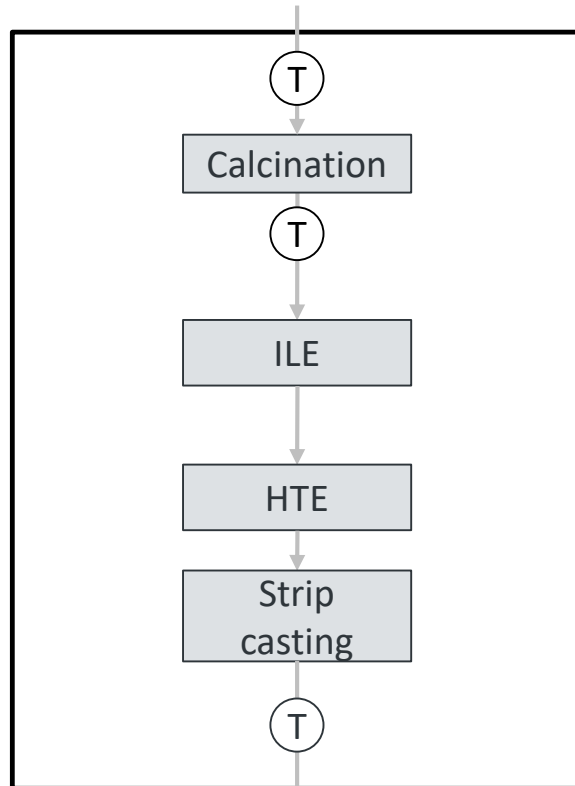


- > Worst scenario set to 100%
- > ILCD impacts recommandation

- **The REE4EU recycling of spent PM is the best scenario**
 - > Impacts more than two times lower than for the conventional

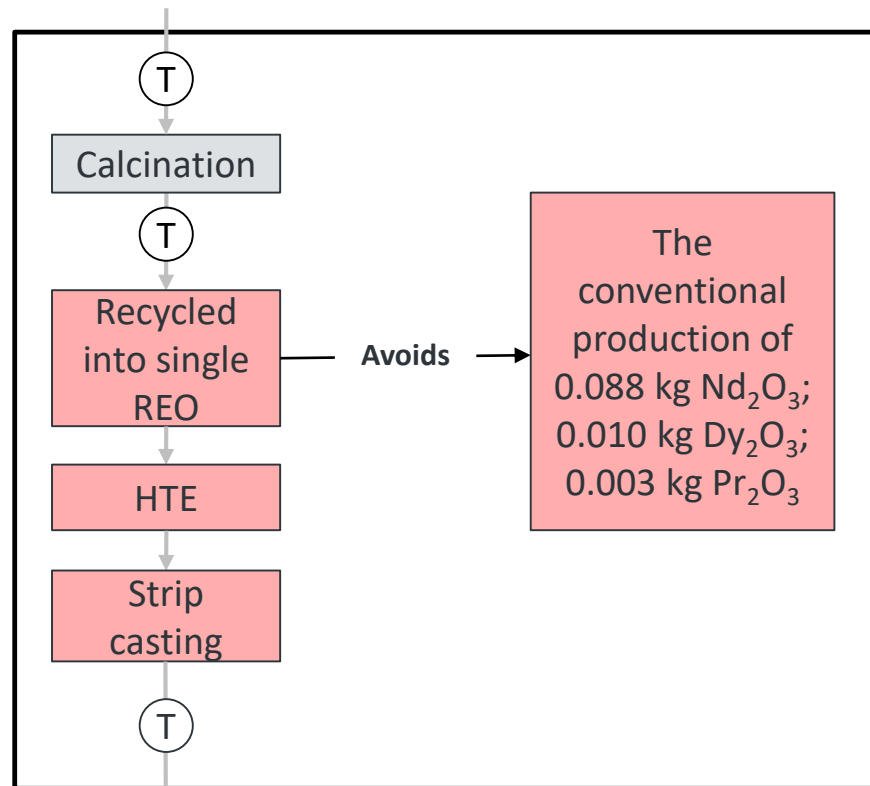
Comparison 2: PMS vs. current (System boundaries)

1 kg PM swarf REE4EU



0.61 kg of REMA
68% Fe; 27% Nd; 3% Dy; 1% B;
1% Pr

1 kg PM swarf conventional



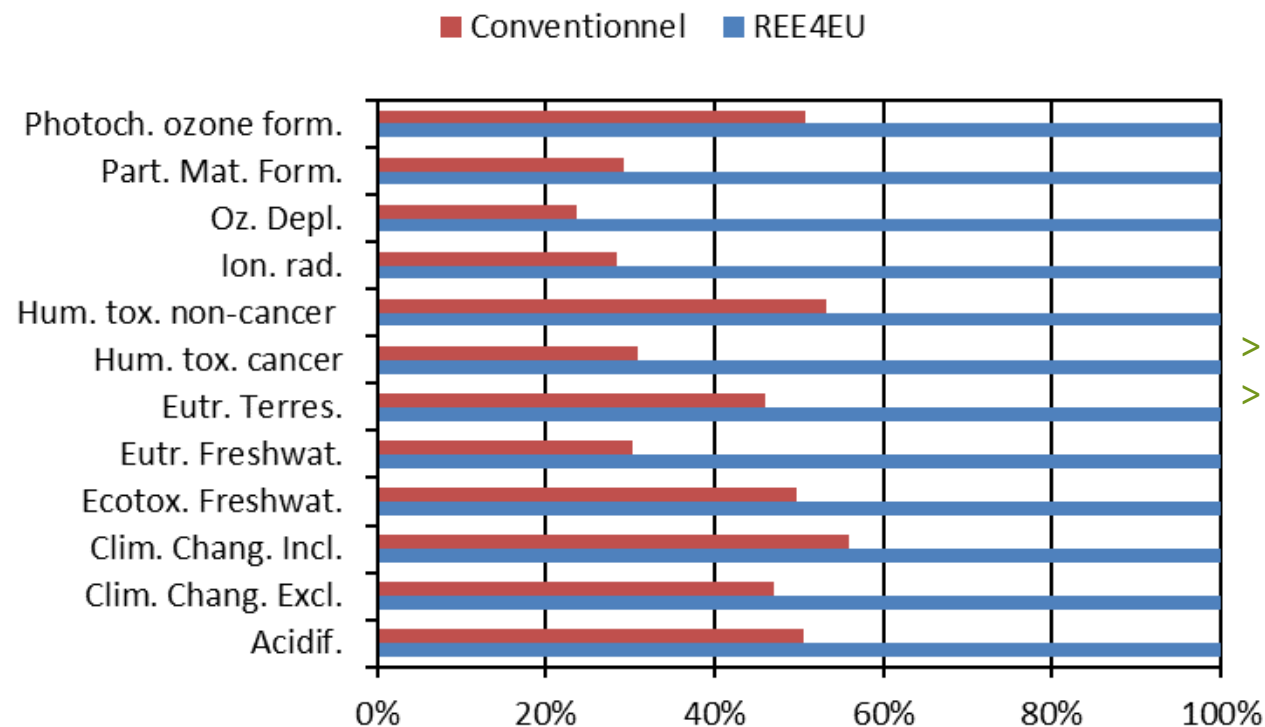
0.61 kg of REMA
68% Fe; 27% Nd; 3% Dy; 1% B; 1% Pr

(T) Transport

□ In Europe

□ In China

Comparison 2: PMS vs. current (preliminary results)

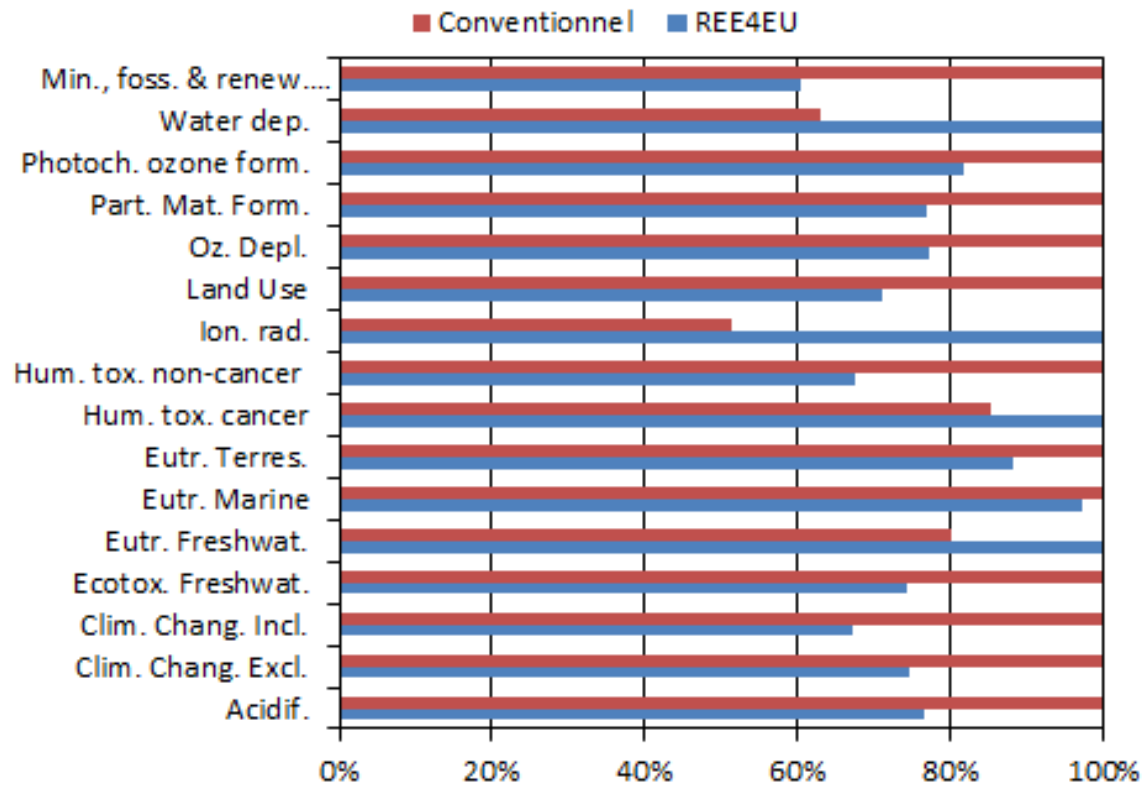


- > Worst scenario set to 100%
- > ILCD impacts recommandation

❑ The REE4EU recycling of PM swarf is the worst scenario

- > Some categories are not reported because far below 0%
- > Issue of comparing a technology in development to an industrial and already optimised one
- > Efficiency improvement and ecodesign are required

Comparison 2: PMS vs. current (preliminary results)



- > Worst scenario set to 100%
- > ILCD impacts recommandation

Assuming equivalent recycling efficiency, the REE4EU is competitive

- > Better impacts (around 20%) without ecodesign
- > Ecodesign needed to ensure best performances over all of the impact categories and especially ionizing radiation and water depletion





Social analysis



»»» Social analysis methodology

- ❑ **In this project, the social analysis aims at estimating the pros and cons of implementing an activity in a region or another**
 - > It has to be noticed that in the PMS scenario, the implementation of the REE4EU recycling route in EU leads to an increased activity in China. So, the results of the social analysis is a mix of both regions

- ❑ **Impact categories chosen according to UNEP recommendations**
 - > **Local communities**
 - Delocalization and migration
 - Community engagement
 - Cultural heritage
 - Respect of indigenous rights
 - Local employment
 - Access to material resources
 - Access to immaterial resources
 - Health/Environment
 - > **Workers**
 - Freedom of association and collective bargaining
 - Child labor
 - Fair salary
 - Hours of work
 - Forced labor
 - Equal opportunities
 - Health and Safety
 - Social benefit / Social security
 - > **Value chain actors**
 - Fair competition
 - Respect of intellectual rights properties
 - Suppliers relationship
 - Promoting social responsibility

- ❑ **Data sources**
 - Especially developed in the project (e.g., risk analysis performed by Inovertis to estimate the workers' health and safety)
 - Literature (e.g, to evaluate the impact of mining on local communities in China)
 - Databases (e.g., International Labor office to estimate the poverty and working poverty)

»»» Social analysis results – Local communities

Category	Impact indicator	CN	EU
Delocalization and migration	Forced evictions stemming from economic development [1]		
Community engagement	Freedom of peaceful assembly and association [2]		
Local employment	% of workforce employed locally		
	Creation of employment	N.A.	N.A.
	Unemployment statistics by country [3]		
	poverty and working poverty [3]		
	% spending on locally based suppliers	N.A.	N.A.
	freedom of expression in country of operation [2]		
Indigenous rights	levels of FDI and technology transfer [4]		
	Disruption of social life and structure [1]		
Access to material resources	Annual freshwater withdrawals % of internal resources [4]		
	Land in the local community used by the company for landfill, incineration or any type of land disposal [5-6]		N.A.
	Extraction of material resources (Mt/y) [4]		
	Inflation in the area	N.A.	N.A.
	Territorial coverage : drinking water and sanitation networks index [4]		

[1] COHRE Forced Evictions Global Survey No.10 2006 [2] U.S. Dept. of State Country Reports on Human Rights Practices [3] ILO Stats [4] World bank

»»» Social analysis results – Value Chain Actors

Category	Impact indicator	CN	EU
Freedom of association / collective bargaining	Operations identified in which the right may be at significant risk [2]	Orange	Green
	Collective bargaining [4]		
	Functioning of social dialogue [4]		
Fair salary	Income disparity compared to local communities and industries	N.A.	N.A.
	Minimum wage by country / standard of living [4]	Orange	Green
Child labor	Child labor [4]	Orange	Green
	Operations identified as having a significant risk of child labor [2]	Orange	Green
Supplier relationship	Absence of coercive communication	N.A.	N.A.
	Reasonable volume fluctuation	N.A.	N.A.
	Sufficient lead time	N.A.	N.A.
	Payments on time	N.A.	N.A.
Fair competition	Sectoral regulation [6]	Orange	Green
	Bribery and corruption [2]	Orange	Green
	Charge for the use of intellectual properties [4]	Orange	Green

[6] uschina.org [2] U.S. Dept. of State Country Reports on Human Rights Practices [4] Worldbank

»» Social analysis results – Workers

Category	Impact indicator	CN	EU
Hours of work	Excessive hours of work [2]		
	Mean weekly hours [7]		
Forced labor	Risk of forced labor [7]		
Equal opportunity	Country gender index [7]		
Health & Safety	Health and Safety [2]		
	Non fatal occupational injuries / 100 000 employees [7]	N.A.	
	Fatal occupational injuries / 100 000 employees [7]	N.A.	
	Inspectors / 10 000 employees [7]	N.A.	
	Occupational accident rate [7]	N.A.	
Social benefit	Public social protection expenditure [7]		

- ❑ **1 criterium is in favour of China**
- ❑ **2 criteria equivalent**
- ❑ **22 criteria in favour of the REE4EU project and the implementation in EU**
- ❑ **12 criteria still not evaluated**

[2] U.S. Dept. of State Country Reports on Human Rights Practices [4] Worldbank [7] International Labor Organization



Conclusion



□ Environmental analysis

> Spent permanent magnet

- Even at the earliest step of development, the first environmental results clearly show the added value of the implementation of the recycling of rare earth from SPM in europe

> Permanent Magnet Swarf

- The ILE/HTE recycling route shows promising results provided that:
 - Recycling efficiency is improved
 - Ecodesign is performed (ongoing)
 - The LCI of the conventional route is updated (REO conversion to REA is probably underestimated)

Social analysis

> Spent permanent magnet

- Even at the earliest step of development, the first social results clearly show the added value of the implementation of the recycling of SPM in EU

> Permanent Magnet Swarf

- Because of the current lower efficiency, the implementation of a PMS recycling route in EU results in a mix of social improvement (implementation in EU), and of social aggravation (increase CN production)
- The only way to ensure a better or equivalent result is an increase of the recycling efficiency in order to avoid additional production of REOs in China.



The REE4EU project



Thank you for your attention

