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# Examples for Recycling and Recovery Projects

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# Recycling and Recovery Projects

## Examples

1. UNFC testing for recovery of critical raw materials in Sweden from apatite iron ore tailings
2. The potential to recover tungsten from a tailings pile in Portugal
3. The potential to provide CRMs from Magnets in Austria
4. Critical raw materials recycling projects in France

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# UNFC testing for recovery of critical raw materials in Sweden from apatite iron ore tailings

Example 1

**Ronald Arvidsson**,
Anna Ladenberger,
Roger Hamberg, SGU

with contributions from Erika Ingvald, Lena Lundqvist, Magnus Johansson, Jonathan Hamisi

SGU Geological Survey of Sweden

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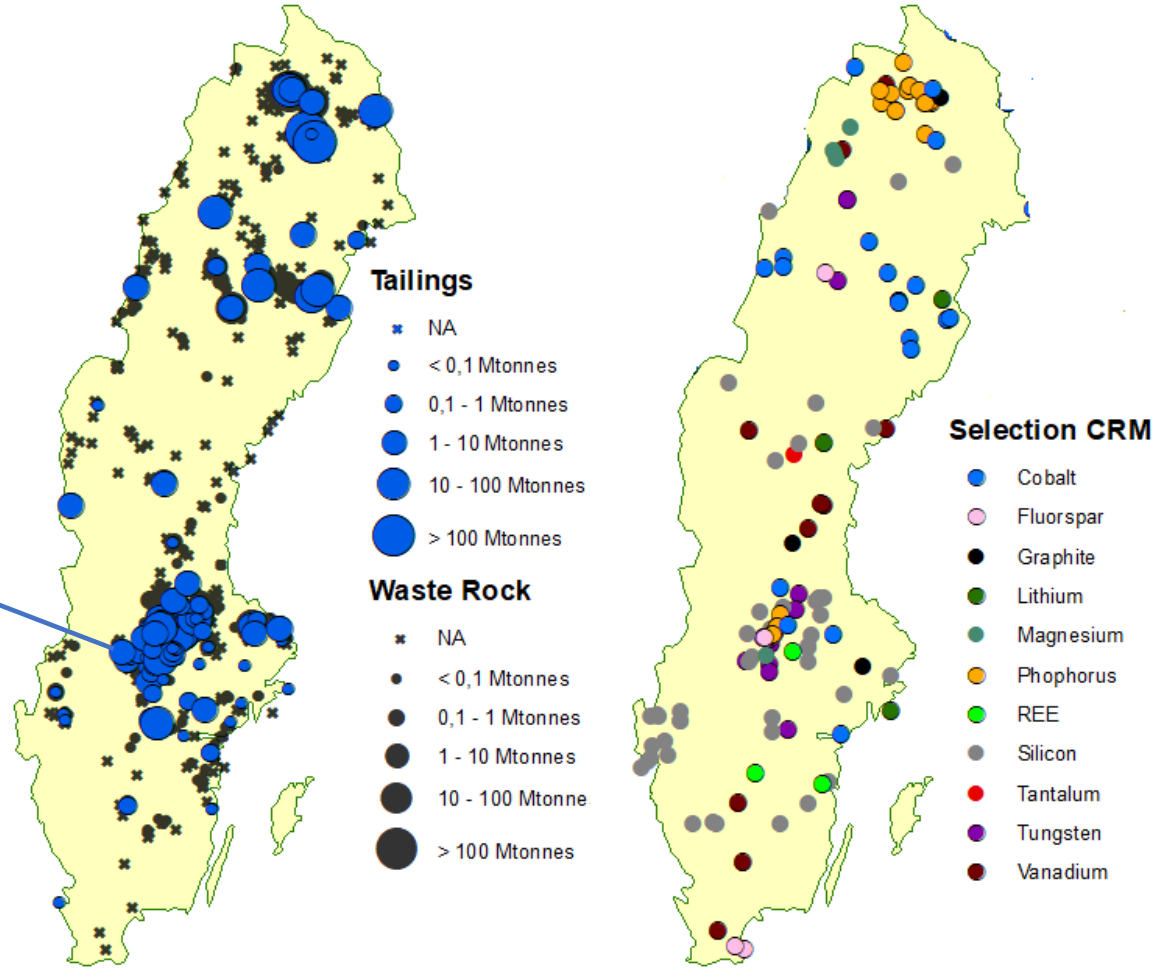
# Recovery of CRMs in Sweden

## Mission from the government development of UNFC and characterization of mining waste

- Some data >1000 sites
- About 70 sites waste sites sampled and characterised
- 14 tailings – drill and dense sampling and modeling

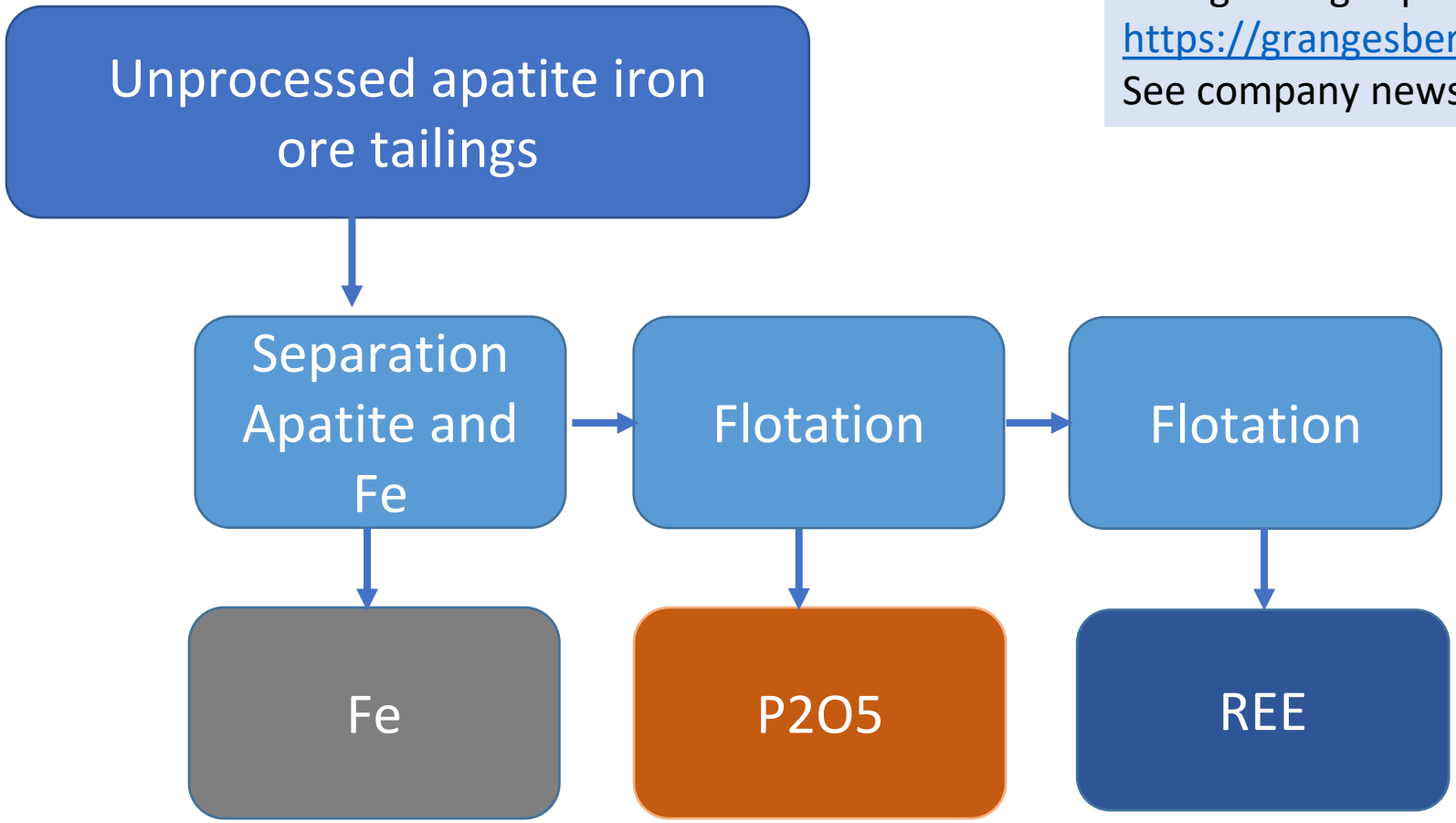
## Specific case here – Grängesberg tailings

- 135 Mtonnes extracted apatite iron ore
- Target Jan-Matts tailings
  - Resources 3.4 Mtonnes (2022)
- Exploration continues



# Recovery of CRMs in Sweden

Grängesberg Exploration Holding AB
https://grangesbergexploration.se
See company news and scoping study



# Recovery of CRMs in Sweden

## UNFC determination

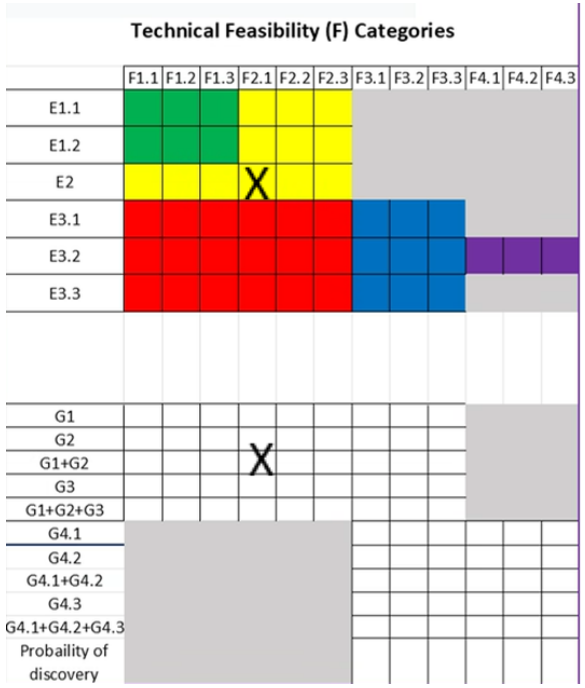
Conceptual study

- Resources
  - 3.46 Mtonnes
  - $P_2O_5$ 5.46%
  - Fe 9.46%

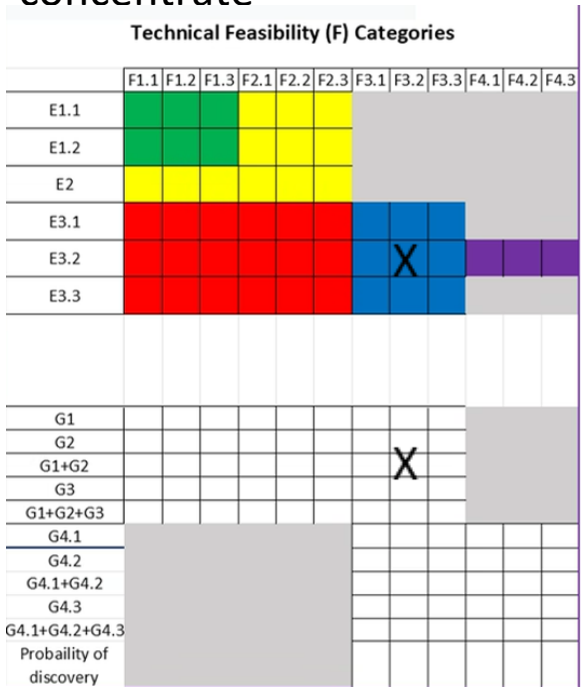
- Technical solution - $P_2O_5$ concentrate

- REE – technical solution not yet mature
- Permits under development

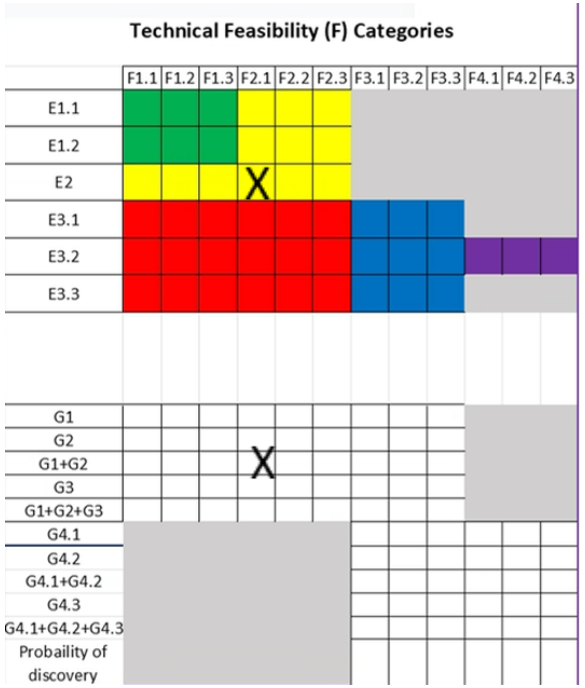
Apatite concentrate
16.3% P -> 304 kt




REE
0.8% in apatite concentrate




Magnetite
70% Fe  162kt



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# Recovery of CRMs in Sweden

## Conclusion

**UNFC is an instrument that in this case allows**

- Snapshot in time - current project status
- Challenge - extract CRM REE, permitting procedure
  - Recovery of CRM depends upon recovery of other RM
  - UNFC enables comparison between
    - different commodities like $P_2O_5$, Fe and REE
    - other cases

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# Thank you!

SGU Geological Survey of Sweden

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# The Potential to Recover Tungsten from a Tailings Storage Facility in Portugal

Example 2

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Soraya Heuss-Aßbichler (LMU)

HOLCIM

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

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# Potential Recovery of Tungsten in Portugal

## Introduction

**Goal:** test application of UNFC to base metal tailings (scientific scoping study)

**Scope**: private company

**Research question:** how is a case rated with CRIRSCO & UNFC ?

**Materials:** peer-reviewed scientific literature, public materials, model assumptions

**Assessment & classification approach[1]:**

define project ➡ characterise material ➡ evaluate status ➡ categorise & classify

[1]adopted from: Mueller et al. (2020)
https://doi.org/10.1016/j.jclepro.2020.120490

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# Potential Recovery of Tungsten in Portugal

## Introduction

**General information**

- Cabeço do Pião part of Minas da Panasqueira
- Abandoned in 1996 after ~ 90 years of operation
- $V_{tailings}$ = 0.7 mio. $m^3$
- Issues: physical instability, heavy metal pollution & acid mine drainage

**Scenarios:**

- S0: rehabilitation
- S1: $FeWO_4$ & ZnS recovery ~ 1 wt $\%_{tailings}$
- S2: $FeWO_4$, ZnS, $CuFeS_2$, $FeS_2$ recovery ~ 24 wt $\%_{tailings}$

# Potential Recovery of Tungsten in Portugal

## RESULTS

**S1 & S2 are economic** (W main economic driver & risk)

| | Communicated Information | CRIRSCO | UNFC |
|---|---|---|---|
| **S0** | economically not viable | ✗ | ✓ |
| **S0** | raw material potential preserved for future | ✗ | ✓ |
| **S1** | economic viability (relevant element: W) | ✓ | ✓ |
| **S2** | higher returns (additional relevant elements: Cu, S & Zn) | ✓ | ✓ |
| **S0, S1 & S2** | externalities (due to current & continued pollution) | ✗ | ✓ |

# Potential Recovery of Tungsten in Portugal

## Conclusions

✓ UNFC is applicable to base metal tailings

- **UNFC's strengths compared to CRIRSCO:**
  - more aspects are considered ➡ creates transparency
  - sustainability highlighted ➡ environmental & social benefits are driving factors

**UNFC's development potential:**

- more sophisticated categorisation on E-axis
- improvement of user guidance

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# The potential to provide CRMs from Magnets in Austria

Example 3

**Andrea Winterstetter**

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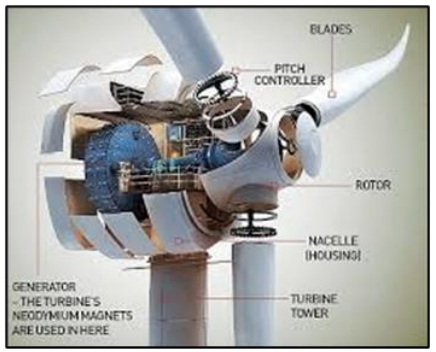
CUSTOM-ENGINEERED TPE AND MORE

# Potential of CRMs from Magnets in Austria

## Introduction

Compare two scenarios for **future utilization of end-of-life permanent magnets in wind turbines**, in use in Austria (2014)

- Reuse vs Recycling?
- Focus on economic viability and technical feasibility
- Develop suitable management strategies for future waste flows





- Winterstetter, A. 2016. Mines of Tomorrow: Evaluating and Classifying Anthropogenic Resources: A new Methodology Doctor of Science in Civil Engineering PhD Thesis Vienna University of Technology. https://doi.org/10.34726/hss.2016.39327
- Winterstetter, A., et al. (2016a.) "Evaluation and classification of different types of anthropogenic resources: The cases of old landfills, obsolete computers and in-use wind turbines". J. of Cleaner Production. https://doi.org/10.1016/j.jclepro.2016.05.083
- Winterstetter et al. (2021) "The role of anthropogenic resource classification in supporting the transition to a circular economy." J. of Cleaner Production, https://doi.org/10.1016/j.jclepro.2021.126753

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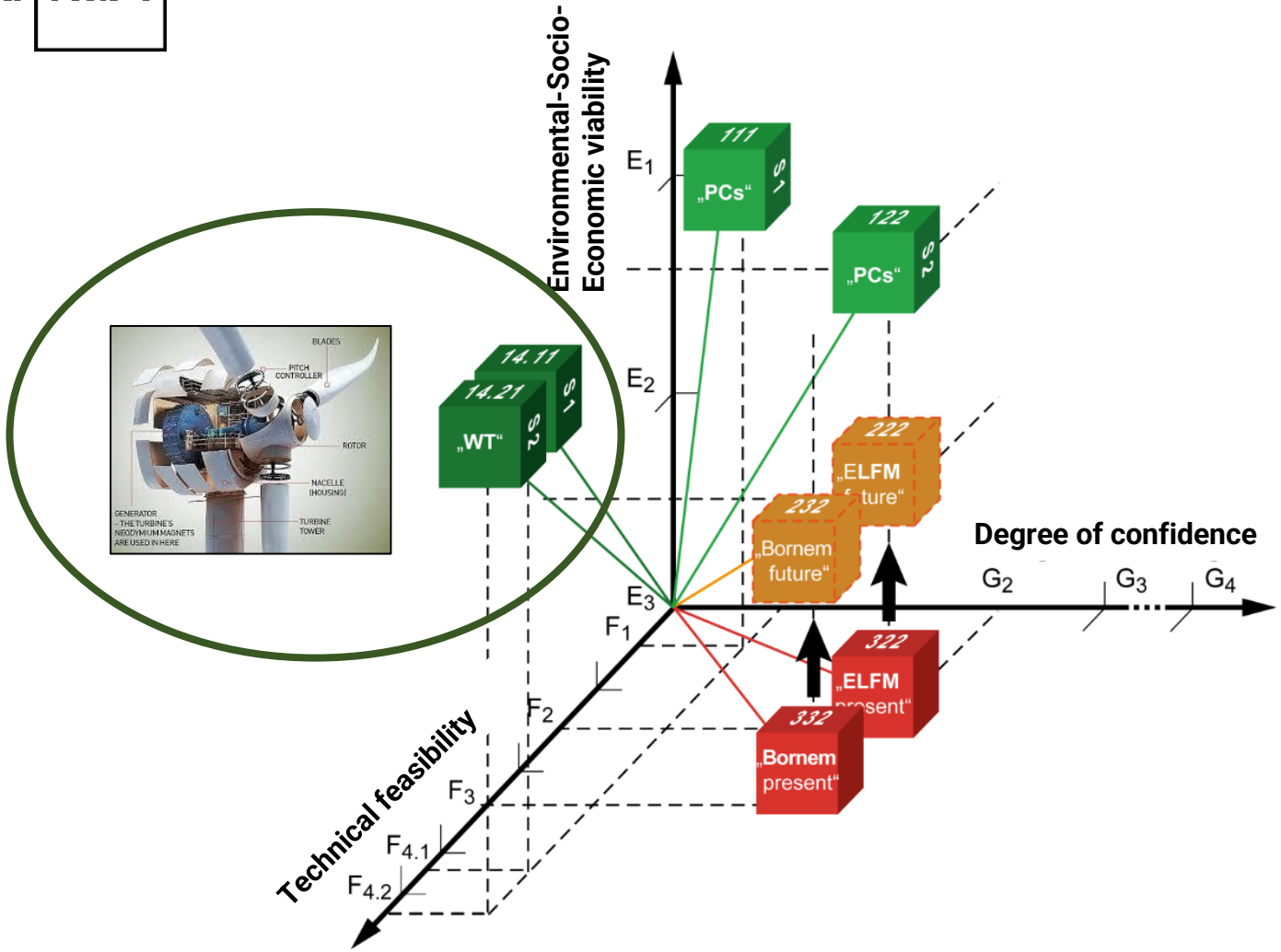
# Potential of CRMs from Magnets in Austria

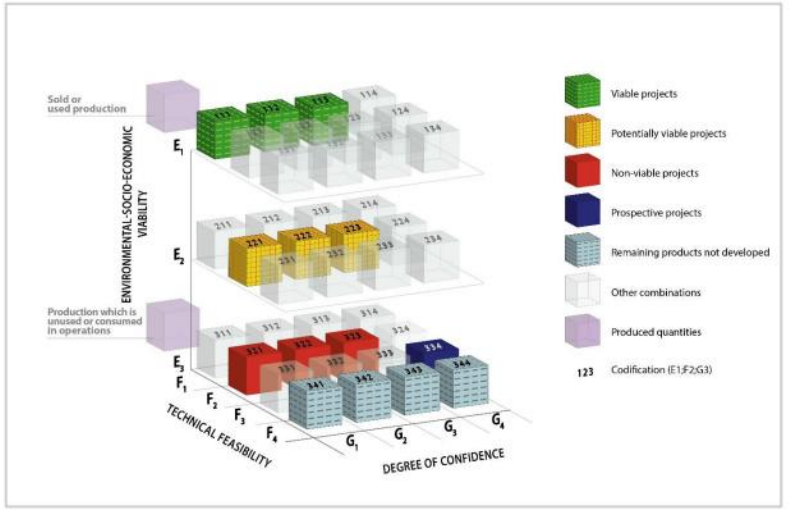
## Reuse vs recycling of magnets

| | Scenario 1 - **Reuse** | Scenario 2 - **Recycling** |
|---|---|---|
| **Type of deposit** | NdFeB permanent magnets in wind turbines in Austria | |
| **Data source** | Data on production & installation of wind turbines & their capacity in Austria | |
| **Different options for dismantling** | Reuse of permanent magnets | Hydrometallurgical method to extract Nd,Fe,B, Dy & Pr |
| **Cost** | Separating magnets & demagnetization | Separating magnets & demagnetization<br><br>Rare earth elements extraction from magnet |
| **Prices for secondary products** | Price of used permanent magnets | Prices of REE and metals |

# Potential of CRMs from Magnets in Austria

## Results



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# Potential of CRMs from Magnets in Austria

## Conclusion

**Resource classification has to be performed on a case by case basis:**

1. **Drivers of the project**
2. **Site-specific parameters**
3. **Project-specific parameters**
4. **Systemic context**
5. **Timing of mining**

**Provides decision support for mining the anthroposphere**

- establish **inventories** of available and accessible anthropogenic resources at regional and national level
- compare different **resource recovery projects & scenarios**
- makes critical factors & potential **barriers visible**

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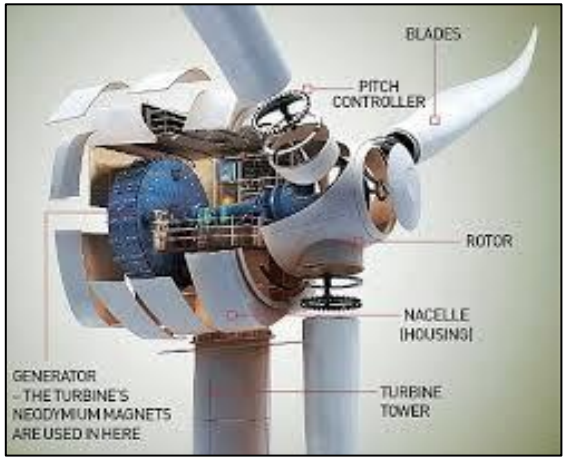


# Thank you!

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# Critical raw materials recycling projects in France

Example 4

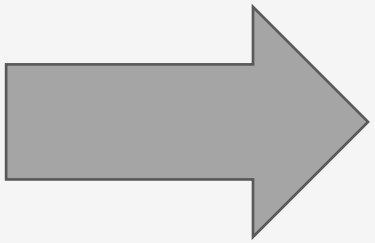
**Daniel Monfort**
Léane Verhulst BRGM

Géosciences pour une Terre durable
brgm

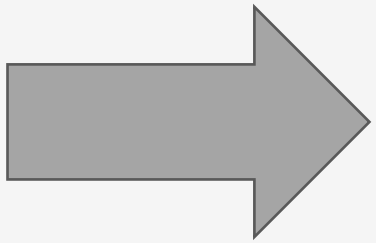
# CRM recycling projects in France

## Introduction

- First action after DG GROW request in 2021, map ongoing and potential primary CRM projects in France using UNFC (around 40 sites/projects)
- But we stayed also 2 facts
  - France is already a producer of some CRM as a by-product (In from Zn and Hf from Zr)
  - France is also a CRM producer via recycling (mostly WEEE)



Include ongoing projects producing CRM after recycling or after by-product recovery process

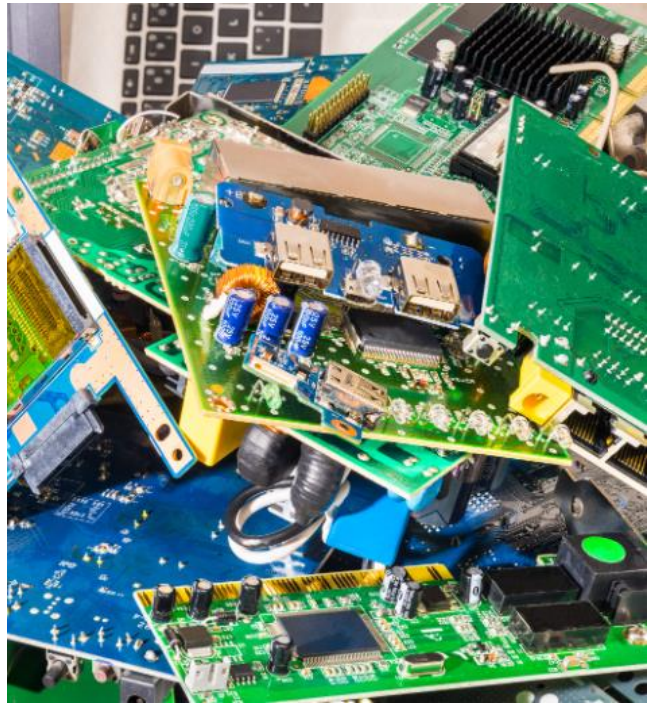


Viable projects in terms of UNFC

# CRM recycling projects in France

## Potential viable projects

- 2nd step, evaluate potential viable CRM recycling projects (industrial projects in upscaling process)
  - Batteries and WEEE
- Evaluation with publicly accessible data
- Checklist:
  - **The degree of maturity** of recycling projects.
  - **Projects in industrial plants** with already the environmental authorizations?
  - **Knowledge of the composition** of the recycled products/flows
    - Chemistry of batteries, chemistry of permanent magnets, etc.
  - Which capacity to collect the waste streams? Partnership with **waste collector**?
  - Information about quantities. Expected annual production?



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# CRM recycling projects in France

## Conclusion

- Projects producing secondary CRMs can be mapped and classed in UNFC terms quite "easily"
- Keep in mind the comparability with primary resources!
- UNFC is a good tool to monitor the progress of projects and which criteria is "blocking": acceptability, feasibility, waste collection...

| | Viable projects | Potential viable | Non-viable projects |
|---|---|---|---|
| Primary resources | Quarries and mines exploiting and producing | Active research & exploration permits | Non active projects |
| Secondary resources | Recycling plants | Recycling R&D projects of industrial upscaling. | |

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# Thank you!

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