

“Rare earth elements recycling from end-of-life electronics waste: The green approach with cloud point extraction”



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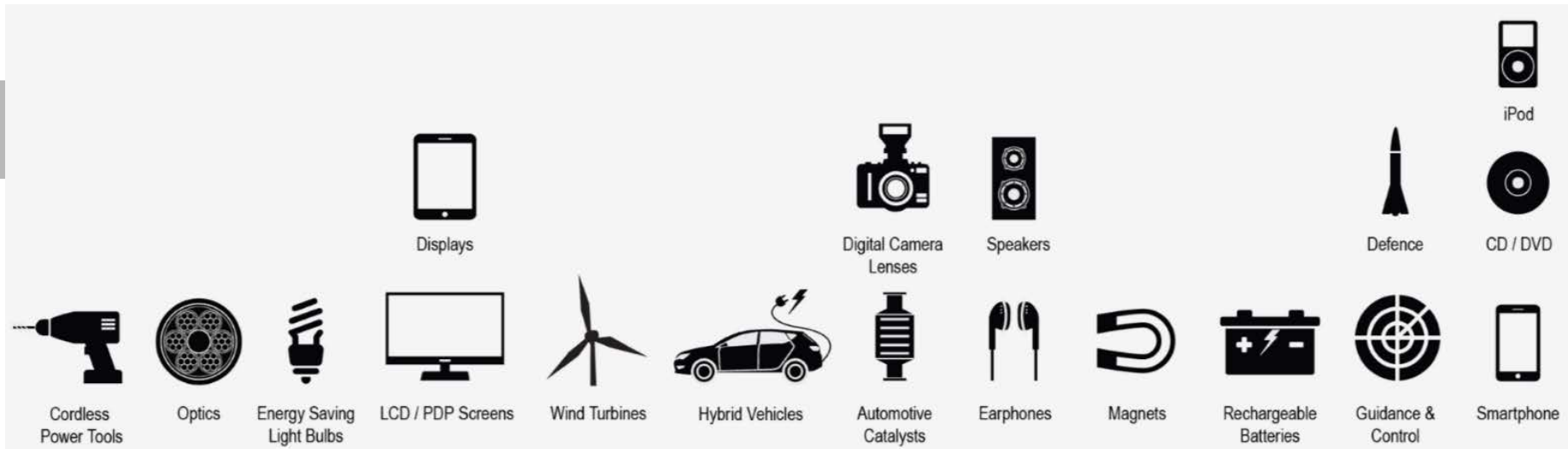
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Rare Earth Elements (REEs): critical raw materials



(source: China water risk)

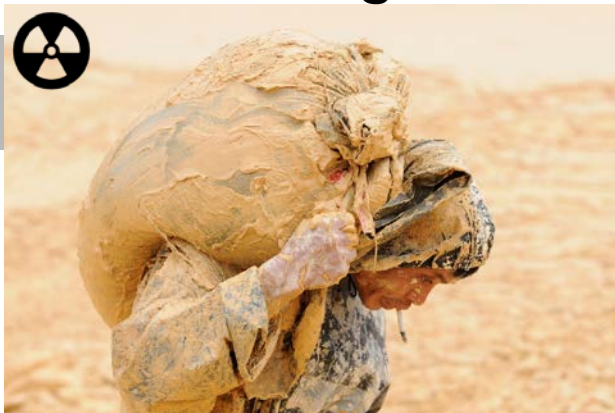
Recycling the key drivers of our economy



(source: coutercurrent.org, EU, US department of defense)

Supply & waste management of REEs

Mining



Photograph: Reuters

The tech-savvy



Landfilling



Photo Credit: Andrew McConnell / Panos

90% supply from single source (China)

- **Negative environmental impact**
- **Supply restrictions**
- **Non-viable, non-reliable**

PSI process: Swiss Made Technology



**PSI
Hydrometallurgical
Process**

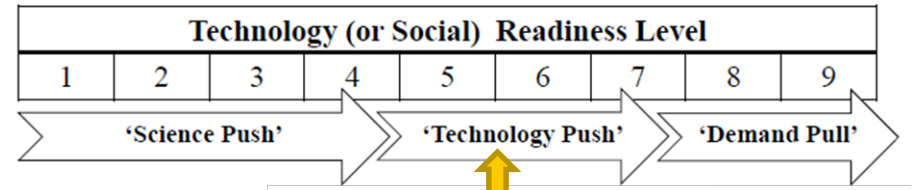


**Pure REE
products +
safe waste
management**
(customer specific)

**End-of-life computer HDDs magnets
as secondary resource**



Representation of proposed modular recycling facility
(actual facility will be different)



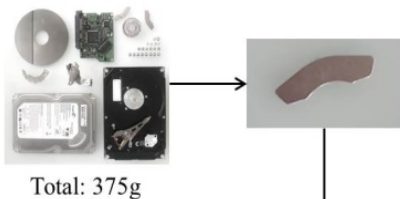
**TRL: 5-6
Technology
Demonstration**

**PATENT
PENDING**

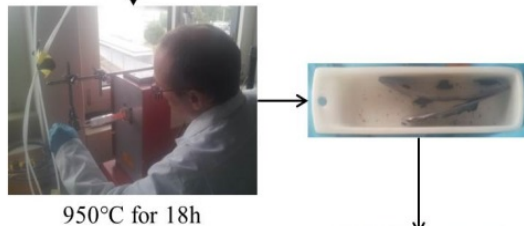
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Waste is a resource: urban mining

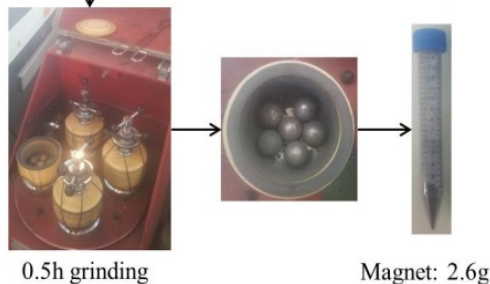
Dismantling



Demagnetizing



Grinding

**Table:** Magnet composition from HDD used in the present work (Wt-%)

Fe_2O_3	58.76 ± 2.21
Nd_2O_3	23.75 ± 0.74
NiO	4.27 ± 0.13
Pr_2O_3	5.25 ± 0.21
B_2O_3	3.04 ± 0.11
Dy_2O_3	1.54 ± 0.06
Al_2O_3	1.35 ± 0.09
CoO	0.29 ± 0.03
Total[#]	98.25[#]

[#] The deviation is due to the co-presence of other metal traces not considered in the present calculations

Cloud point extraction process for REEs

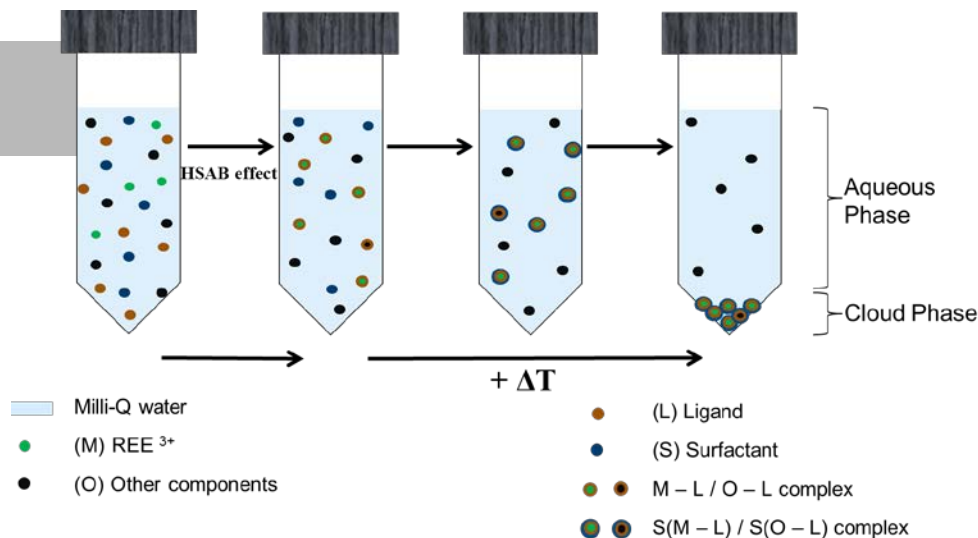


Figure: Cloud point extraction process
(HSAB: Hard-Soft Acid-Base Theory)

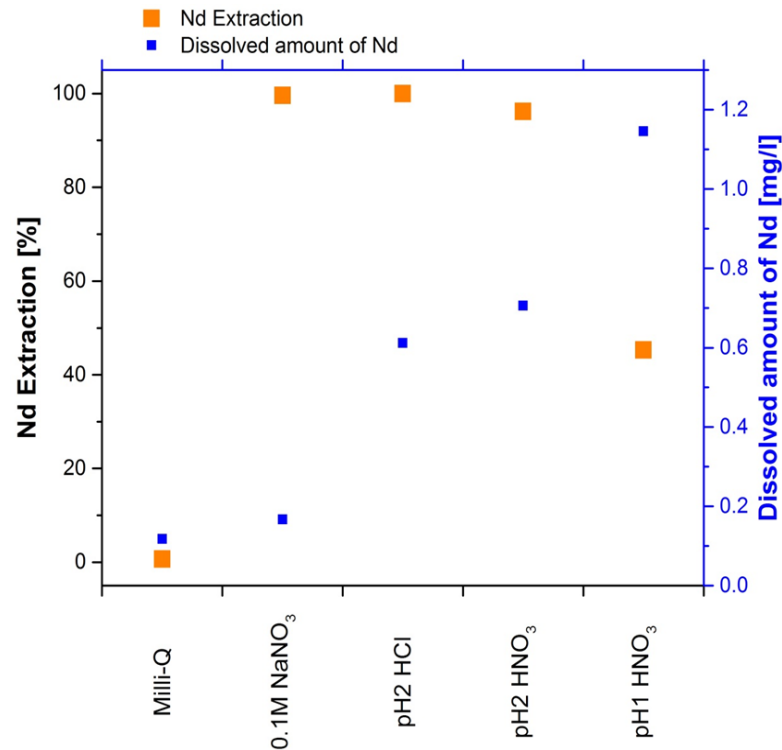


Figure: Dissolution and extraction results combined. (surfactant: 2% v/v Triton X-100)

Real waste: balance between dissolution and extraction efficiency :: green method

Overall process: e-waste to raw materials

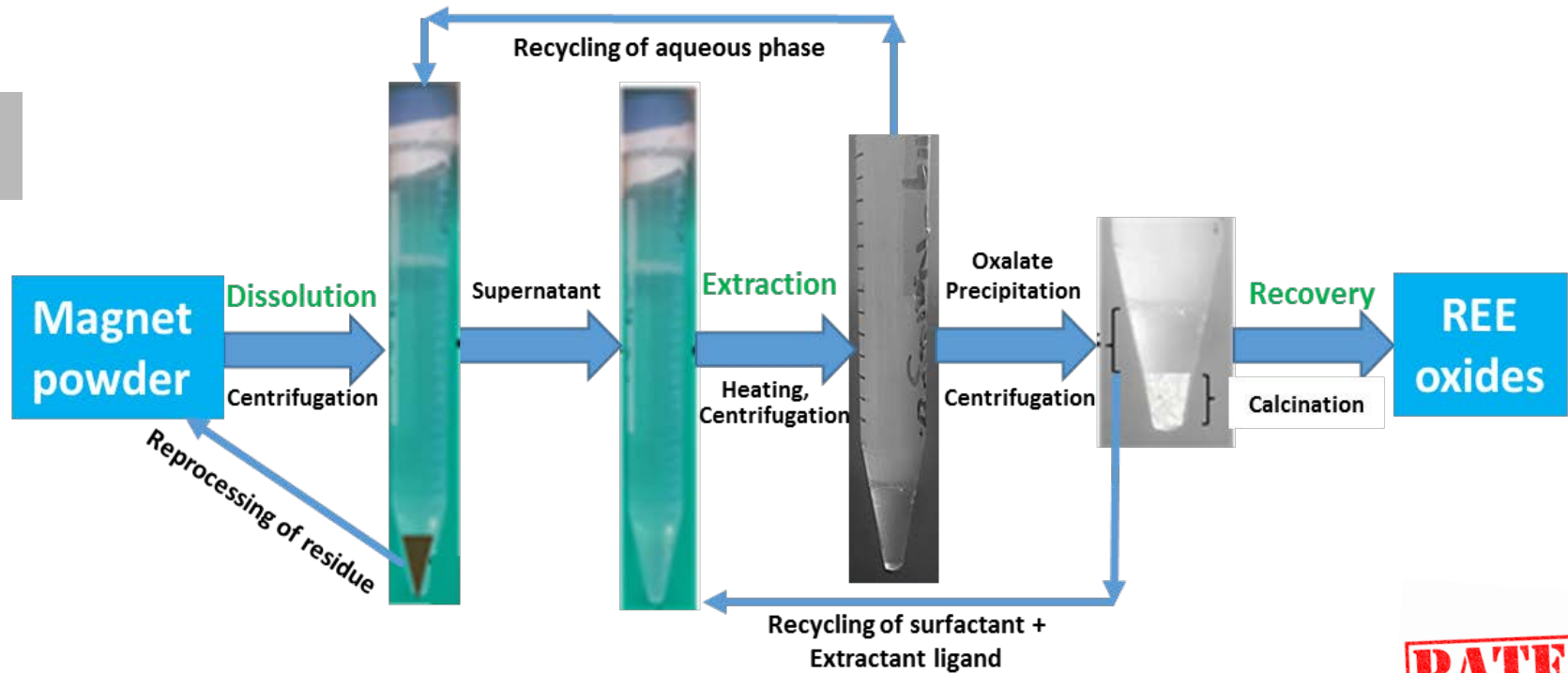


Figure: Treatment steps in our process

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Economic, green and easy method for REEs recovery from e-waste

Conclusion and future perspective

- Efficient digestion of critical rare earths (REEs)
- Effective separations of REEs: Neodymium (Nd), Dysprosium (Dy) and Praseodymium (Pr) from HDD magnet e-waste
- Easy to scale up and commercialization
- REMRETEch (a PSI spin-off) will commercialize the process
- E-waste to resource by urban mining: low environmental impact

Wir schaffen Wissen – heute für morgen

Thanks are due to...



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Office for the Environment (FOEN)



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"God ain't making any more."

- Mark Twain

