Highlight Talk Nr.5

i.FAST 2nd Annual Meeting / April 20th 2023 / Triest, Italy

Denise Völker / DESY / i.FAST WP 11

Content

- The Challenge
- Example: Permanent Magnets
  - Life Cycle Assessment (LCA)
  - Recycling
  - CoC Certification
- Next steps

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

The Challenge

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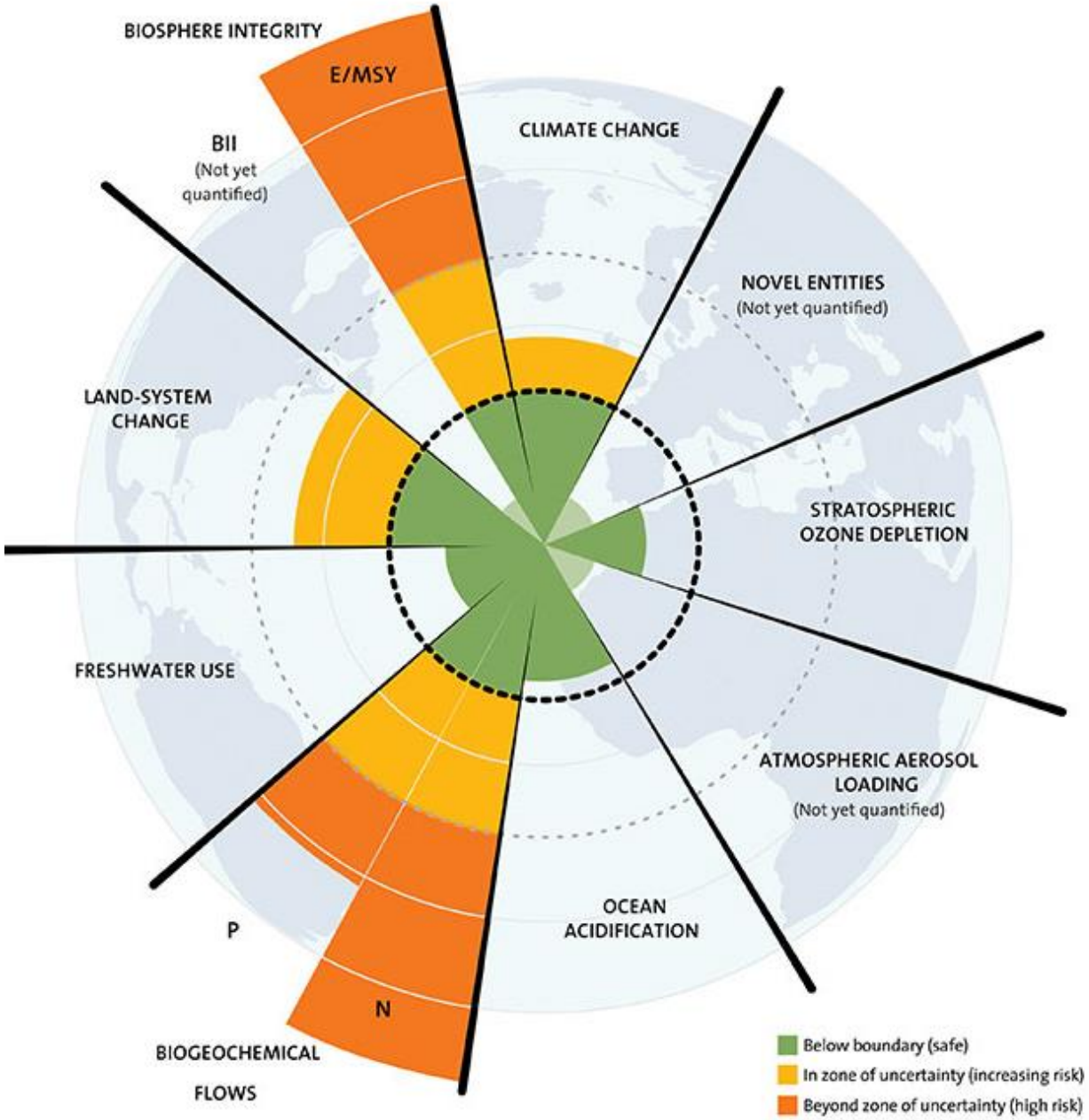
The Challenge



| Planetary Boundaries (including Climate Change)
Credit: J. Lokrantz/Azote based on Steffen et al. 2015

Public Perception

Sünden für die Forschung

Expeditionen, Teleskope und Großgeräte belasten das Klima. Langsam kommt es zum Umdenken

Von Ralf Nestler

Reisen oder nicht? Diese Frage stellen sich viele Forscherinnen und Forscher. Denn: Die pandemiebedingten Beschränkungen sind weitgehend abgeschafft, sie könnten wieder durchstarten zu Expeditionen, Speziallaboren und Konferenzen. Doch die Reisen belasten das Klima und vergrößern weiter den CO_2-Fußabdruck der je nach Disziplin ohnehin oft deutlich über dem Durchschnitt liegt.

Das liegt unter anderem an großen Forschungsbauten aus Beton und Stahl, die zudem viel Strom verbrauchen. Die Astronomie mit ihren Teleskopen und Rechenzentren gehört eindeutig zu den großen Emittenten. Doch auch die Teilchenphysik mit ihren Beschleunigern und die Umweltforschung – Stichwort Expeditionslogistik – tragen zum Klimawandel bei.

„Können Universum nicht auf Kosten des Planeten erforschen“

Wie viel, das lässt sich kaum fassen. Der „Klimaabdruck“ einer Spiegeloptik, einschließlich Herstellung, eines Gebäudes oder von Dienstreisen, kann geschätzt werden. Studien haben daher eine gewisse Unsicherheit, können Tendenzen jedoch deutlich machen.

Demnach sind in der Astronomie die Infrastrukturen der dominierende Fak-

Fahrt fürs Klima. *Der Polarstern hat auf der „Mosaic“-Expedition rund 7000 Tonnen Schiffsdiesel verbraucht.* Foto: dpa/AWI

Sins for research

DER TAGESSPIEGEL

Brandbrief für Klimaschutz

02.09.2020, 17:34 Uhr

Dicke Luft bei Helmholtz

Mitarbeiter der Forschungsorganisation fordern weitreichende Maßnahmen für sofortigen Klimaschutz. VON JAN KIXMÜLLER

Die Standorte, wie hier am GFZ Potsdam, sollen klimaneutral werden. FOTO: SEBASTIAN GABSCH PNN

Trouble‘s brewing @ Helmholtz

SPIEGEL Wissenschaft

Studie zu Emissionen

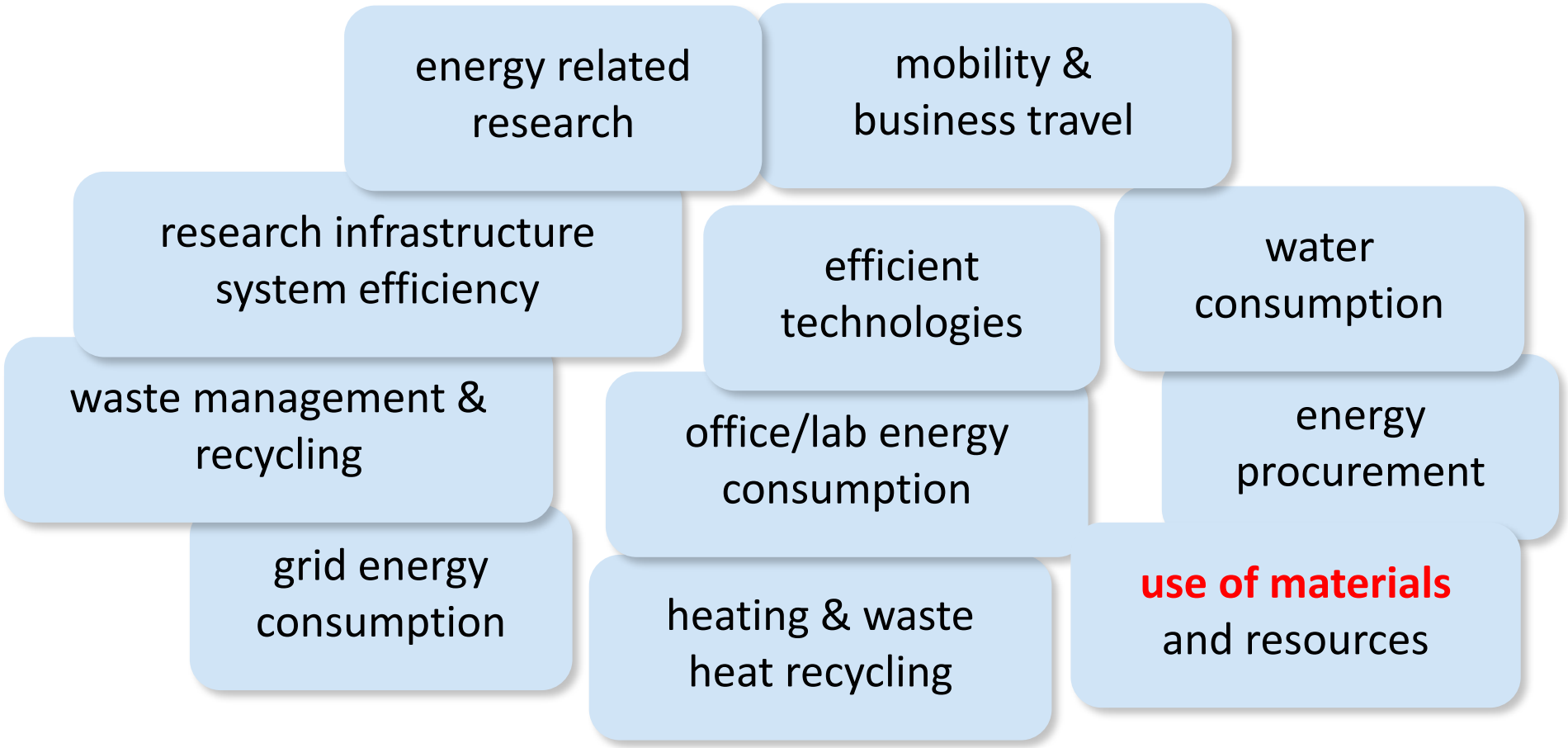
Wie klimaschädlich darf Grundlagenforschung sein?

In China soll ein riesiges Neutrino-Observatorium entstehen. Schon vor Baubeginn wird über ökologische Auswirkungen diskutiert. Das Beispiel zeigt: Die Klimakrise ist bei den Astronomen und Astronominnen angekommen.

Von **Christoph Seidler**
16.01.2021, 19.12 Uhr

How climate-damaging is basic research allowed to be?

Categories of Sustainability for RI‘s



Source: M.Seidel, Technologies for Sustainable Accelerators, First iFAST annual meeting, 2022, https://indico.cern.ch/event/1138690/contributions/4782721/

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

Permanent Magnets

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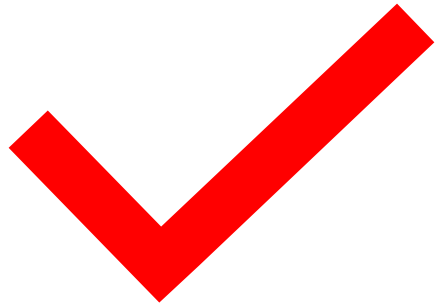
Energy Consumption

- Increasing use of PM in new lattices
- PMs run without electricity
- Hugh power savings
- ESRF: before upgrade 16.9 GWh / year
  after upgrade 8.5 GWh / year
- PSI: SLS 6.4 GWh / year
  SLS2.0 2.6 GWh / year
- HZB: BESSY II 5.1 GWh / year
  BESSY III < 1.3 GWh / year



I J.Chavanne, Permanent accelerator magnets for light sources, 5th ESSRI Workshop 2019, https://indico.psi.ch/event/6754/contributions/18013/

I M.Seidel, Technologies for Sustainable Accelerators, First iFAST annual meeting, 2022, https://indico.cern.ch/event/1138690/contributions/4782721/

I J.Völker, Overview permanent magnets at accelerator facilities, iFAST REE workshop 2023, https://indico.desy.de/event/35655/timetable/#20230206.detailed

Current Situation

- Rare earths (REE) are mined and processed under destructive social and environmental conditions
- No alternative sources or certified mining and processing available
- So far no sufficient progress on recycling of old PM

I ORF, 2015, Auf der dunklen Seite des Fortschritts: https://orf.at/v2/stories/2272650/2272651/

I UK Guardian: article on shocking working conditions in cobalt mining, cobalt is also to be used in PM

Children as young as seven mining cobalt used in smartphones, says Amnesty

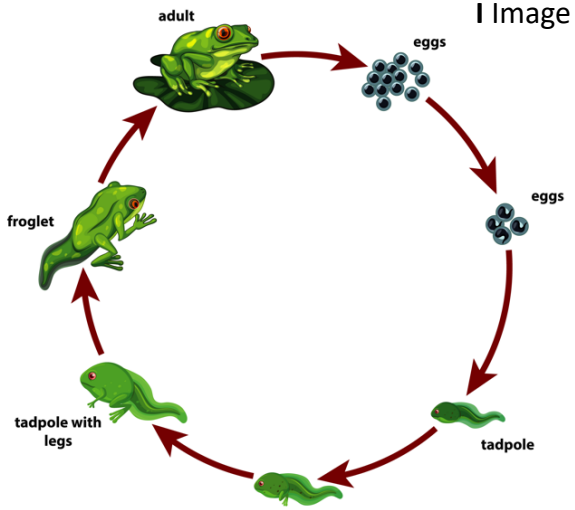
Amnesty International says it has traced cobalt used in batteries for household brands to mines in DRC, where children work in life-threatening conditions

▲ A cobalt mine between Lubumbashi and Kolwezi in the Democratic Republic of the Congo. Photograph: Federico Scoppa/AFP/Getty Images

I Spektrum, 2020, Politik bedroht unberührte Amazonasgebiete, https://www.spektrum.de/news/politik-bedroht-unberuehrte-amazonasgebiete/1754314

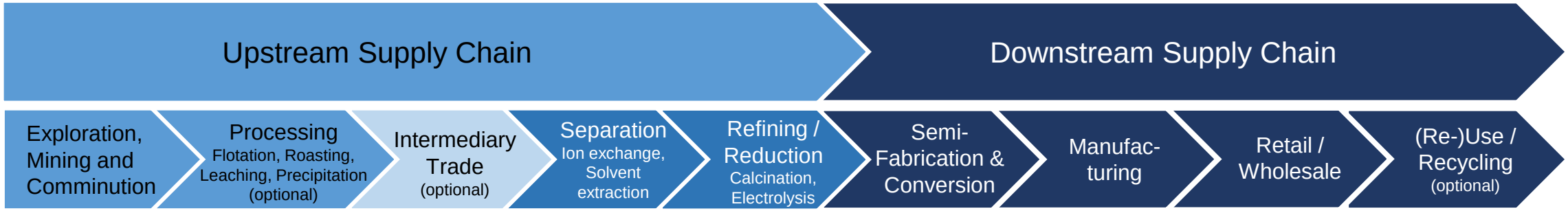
What to do?

- Implement life cycle management already in planning phase of new RIs
- Find best practice for recycling of these materials
- Support development of certification system for mining and processing of critical materials



I Image by brgfx on Freepik

I Image by juicy_fish on Freepik



I from M.Erdmann: https://indico.desy.de/event/35655/contributions/137541/

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

Permanent Magnets
→ Life Cycle Assessment

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What is LCA?

"LCA is a tool for the analysis of the **environmental** burden of **products** at all stages in their **life cycle**"

+ Social

+ Governance

European Commission, Joint Research Centre, Cristobal-Garcia, J., Pant, R., Reale, F., et al., *Life cycle assessment for the impact assessment of policies*, Publications Office, 2017, https://data.europa.eu/doi/10.2788/318544

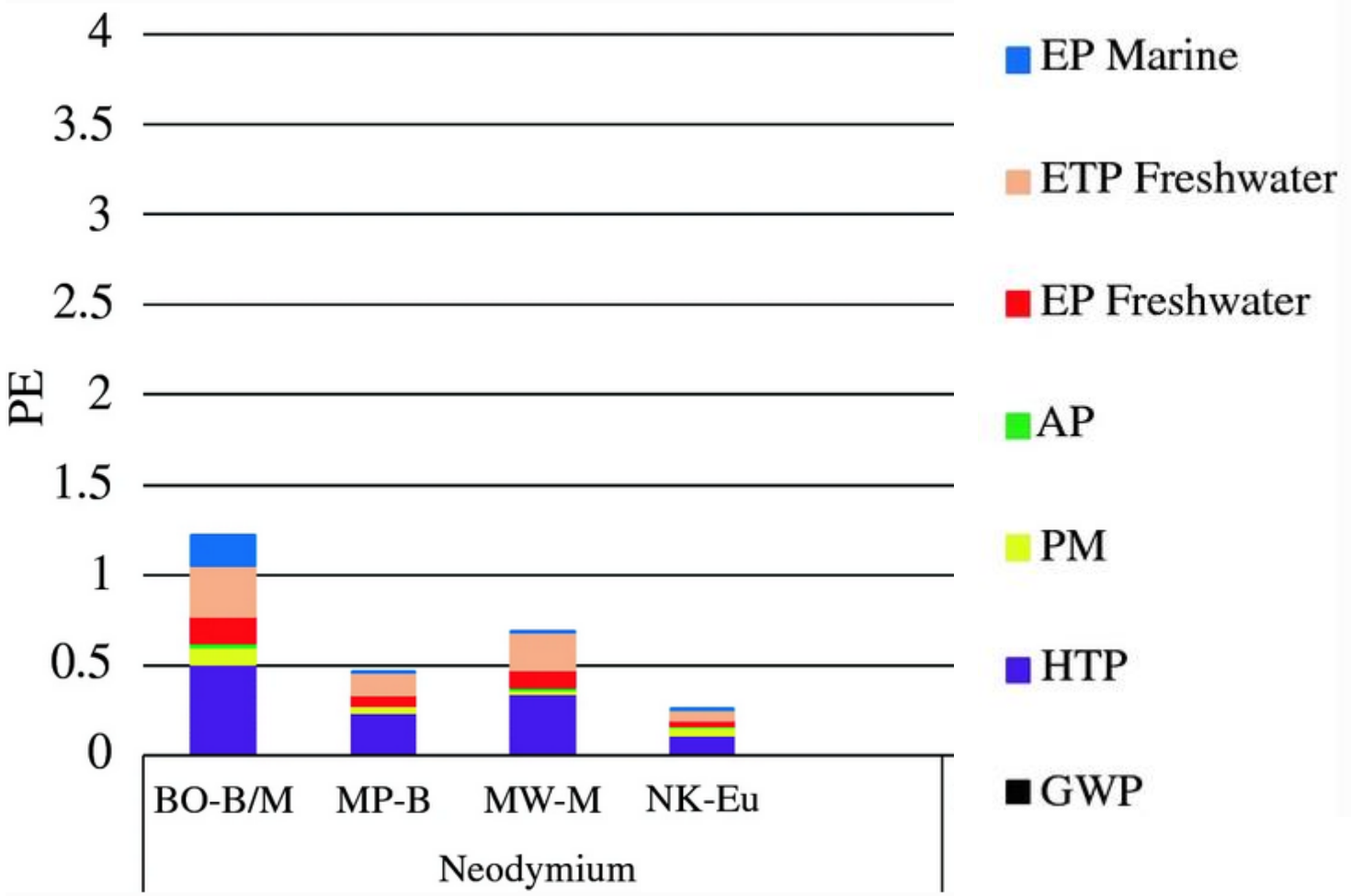
What is being looked at?

Indicator		Unit
Climate Change Potential (Global Warming)	GWP	kg CO_2 eq.
Eutrophication Potential (Over-fertilization)	EP	kg P eq./kg N eq.
Photochemical Ozone Depletion Potential (Summersmog)	POCP	kg Ethene eq.
Ozone Depletion Potential (Ozone hole)	ODP	kg CFC-11 eq.
Acidification Potential land and ocean (Acid rain)	AP	kg SO_2 eq.
Human toxicity	HTP	kg 1,4-DCB eq.
Ecotoxicity	FAETP / MAETP / TETP	kg 1,4-DCB eq.
Abiotic Resource Depletion (Resource scarcity)	ADP	kg Cu eq.
Water scarcity		m^3 world eq.
Land use		m^2a
……	…….	

Neodymium

Normalized impacts of 1 kg of neodymium.

BO-B/M: Bayan Obo bastnäsite/monazite (China)
MP-B: Mountain Pass bastnäsite (U.S.)
MW-M: Mt. Weld monazite (Australia/Malaysia)
NK-Eu: Norra Kärr eudialyte (Sweden)



P. Zapp, A. Schreiber, J. Marx and W. Kuckshinrichs: Environmental impacts of rare earth production; MRS Bulletin *2022* Vol. 47 Issue 3 Pages 267-275

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Permanent Magnets
→ Recycling

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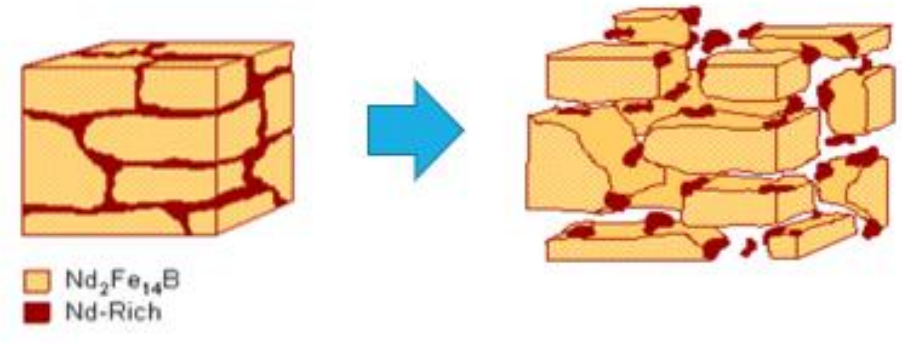
Rare Earth Recycling

Short loop

Recycling is technically feasible

- High yield
- High quality
- Low carbon footprint



Source: Speight, J.; Climate Change from a Materials Perspective, The University of Birmingham, 02.08.2019

DESY Workshop - Critical Materials and LCA: Rare Earths, © Prof. Dr. Carlo Burkhardt

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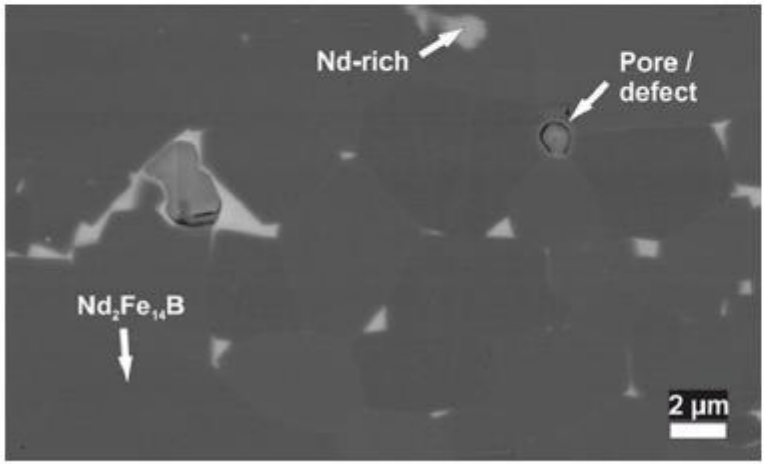
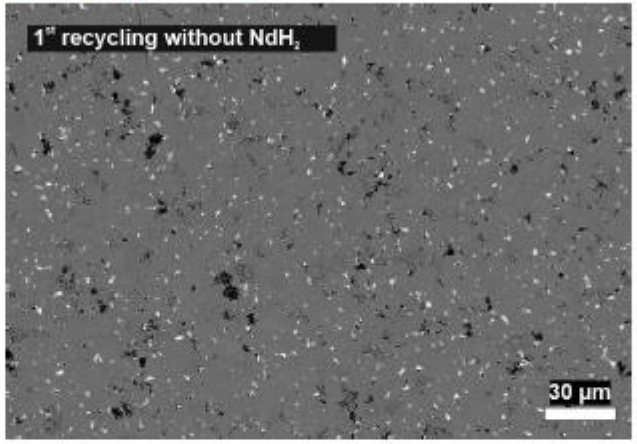
I from C.Burkhardt: https://indico.desy.de/event/35655/contributions/137453/

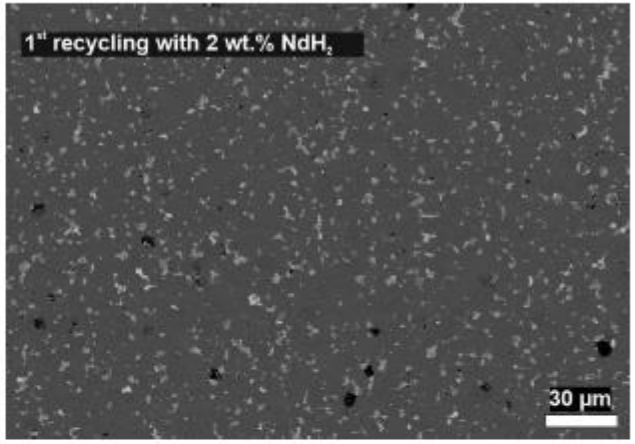
Rare-earth permanent magnet recycling

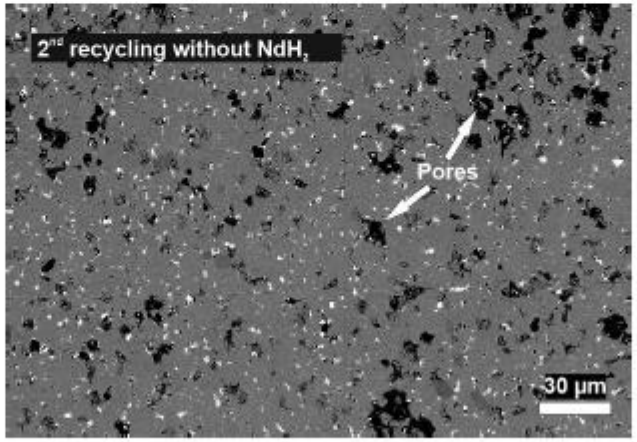
Sintered magnets multiple recycling

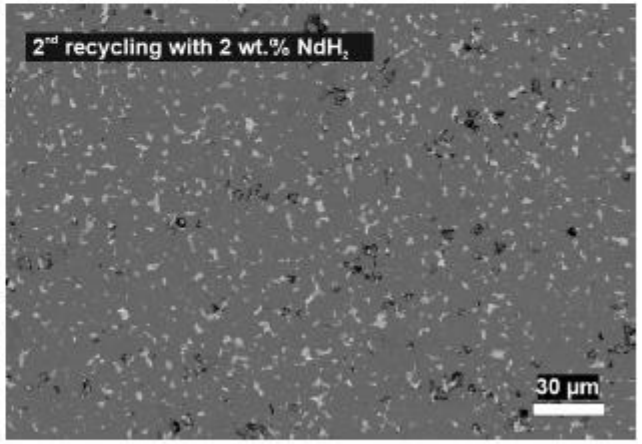
- Number of pores increases from scrap magnet to 1st and 2nd recycled one
- NdH_2 leads to a decrease of porosity and increase in density











Page 27 07.02.2023 © Fraunhofer IWKS

M. Schönfeldt et al., Journal of Alloys and Compounds, 939 (2022) 168709

Fraunhofer IWKS

I from J.Gassmann: https://indico.desy.de/event/35655/contributions/137452/

RE Magnets Recycling

Technical issues

Other technology metals (Ag, Pt, Pd) have recycling rates of ~30%

- Recycling rate of Nd is <1%

→ Large diversity of End-of-Life Magnets:

- SmCo, Ferrite, NdFeB....
- no design for recycling

→ Underdeveloped recycling schemes

DESY Workshop - Critical Materials and LCA: Rare Earths, © Prof. Dr. Carlo Burkhardt

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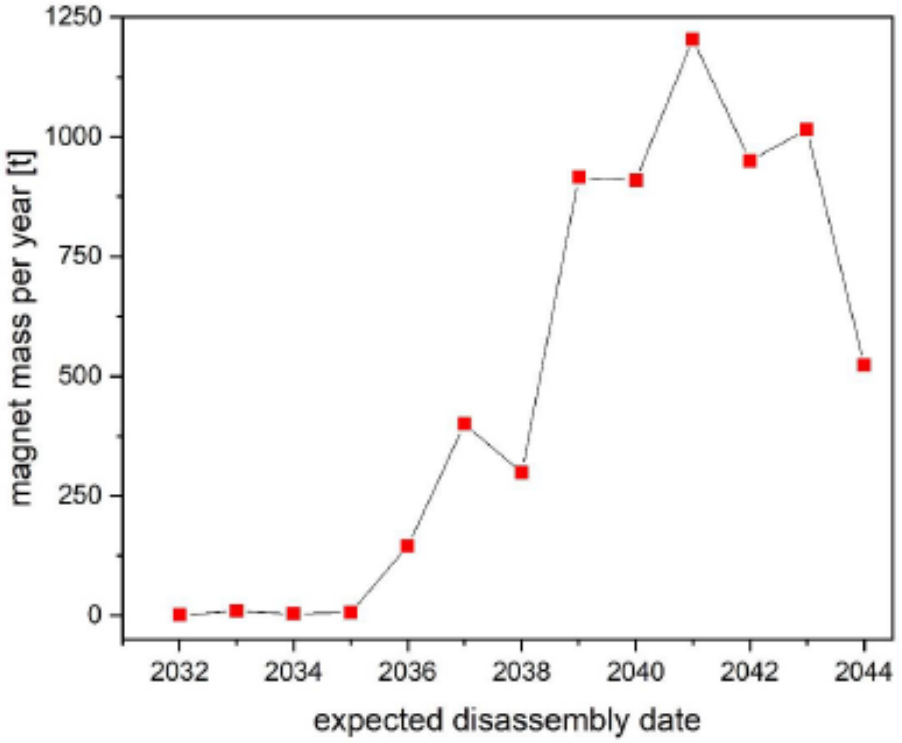
I from C.Burkhardt: https://indico.desy.de/event/35655/contributions/137453/

Rare-earth permanent magnet

Wind turbine application

Scrap magnets at the EoL from wind turbines in Germany

- Wind turbines seams to be a great candidate for scrap magnets
  - Huge amount of magnets per device (approx. 500 kg per MW)
  - Big block magnets
  - Homogeneity in chemical composition
  - No dissipation losses
  - Wind turbines can be tracked easily
- First significant amount of PM driven turbines will be disassembled in the mid 30th in Germany
- Circular economy for magnets from wind turbines needs to be implemented when the device reach the EoL



Own calculation with data from www.marktstammdatenregister.de

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Permanent Magnets
→ Certification/Auditing

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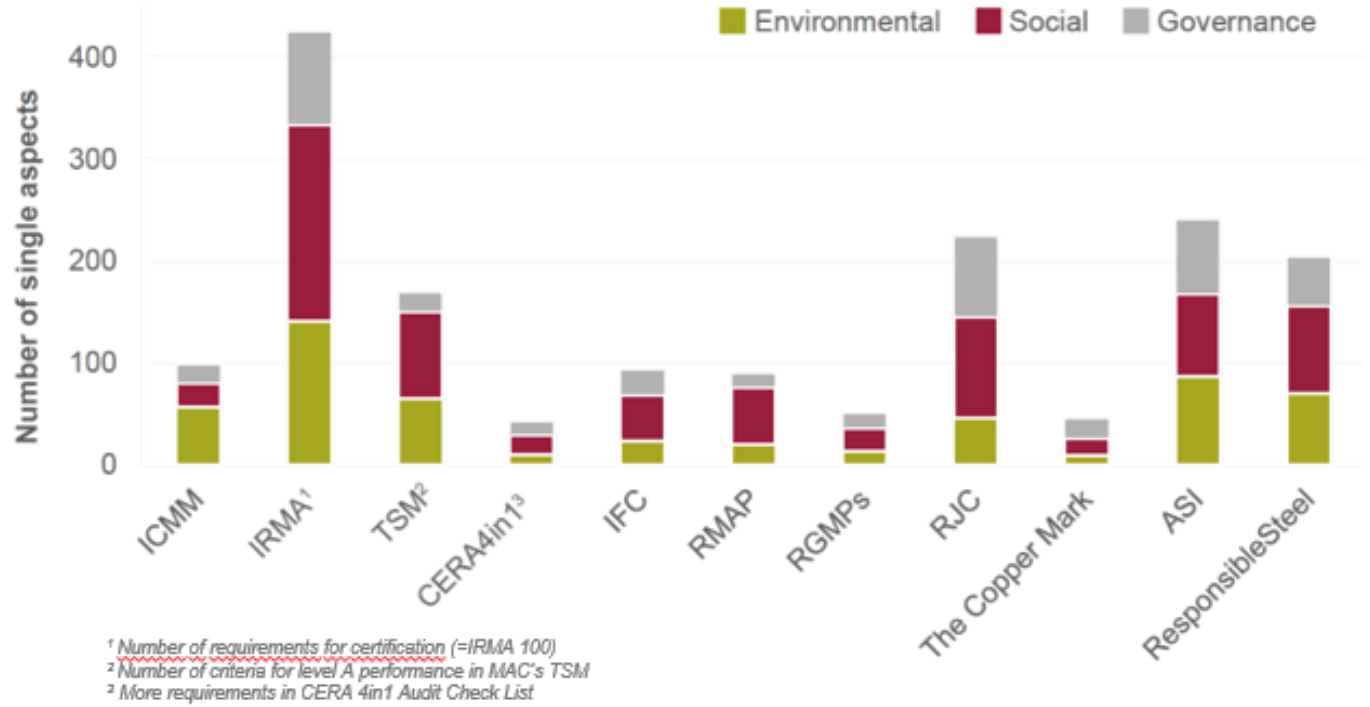
Voluntary Sustainability Standard Systems for Mineral Resources



¹ Number of requirements for certification (=IRMA 100)
² Number of criteria for level A performance in MAC's TSM
³ More requirements in CERA 4in1 Audit Check List

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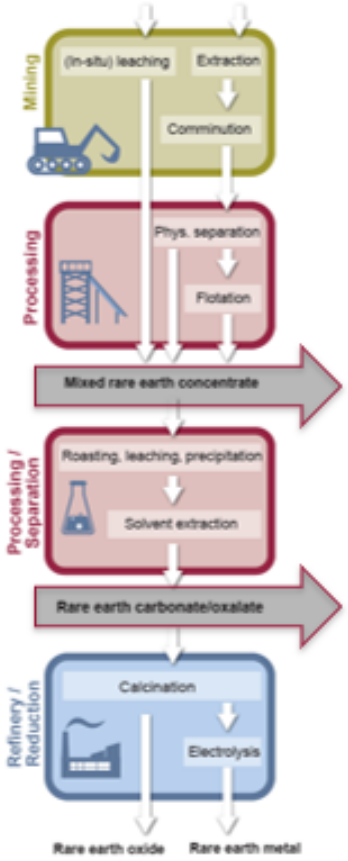
ICMM International Council on Mining & Metals
IRMA Initiative for Responsible Mining Assurance
The Mining Association of Canada
IFC International Finance Corporation
CERA4in1
Responsible Minerals Initiative
World Gold Council
Responsible Jewellery Council
The Copper Mark – Responsibly Produced Copper
asi Aluminium Stewardship Initiative
Responsible Steel
BGR Bundesanstalt für Geowissenschaften und Rohstoffe
GEOZENTRUM HANNOVER

I from M.Erdmann: https://indico.desy.de/event/35655/contributions/137541/

General Applicability of Standard Systems* for the Rare Earth Supply Chain



Intermediary trade

Intermediary trade

ICMM International Council on Mining and Metals - Sustainable Development Framework

IRMA Initiative for Responsible Mining Assurance - Standard for Responsible Mining

TSM Towards Sustainable Mining - Protocols and Frameworks

CERA 4in1 Performance Standard

IFC International Finance Corporation - Performance Standards on Environmental and Social Sustainability

No Chain-of-Custody (CoC) standard

INTERNATIONAL STANDARD **ISO 23664**

First edition 2021-10

Traceability of rare earths in the supply chain from mine to separated products

Traçabilité des terres rares dans la chaîne d'approvisionnement de la mine jusqu'aux produits séparés

TSM | **CERA 4in1** | **IFC**

TSM | **CERA 4in1** | **IFC**

RMAP Responsible Minerals Assurance Process - Mineral Supply Chain Due Diligence Standards + (voluntary) ESG Standard

*Standard systems that have been analyzed in BGR (2022) – Sustainability Standard Systems for Mineral Resources – A Comparative Overview

BGR Bundesanstalt für Geowissenschaften und Rohstoffe

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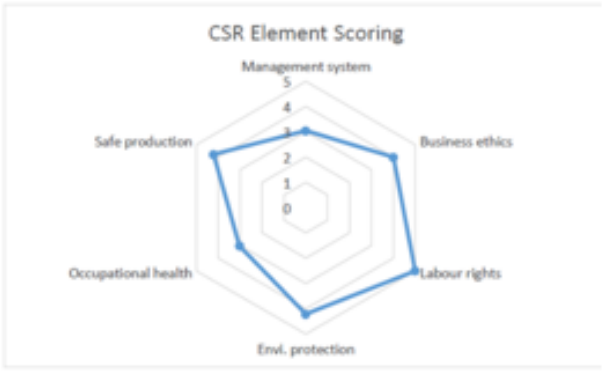
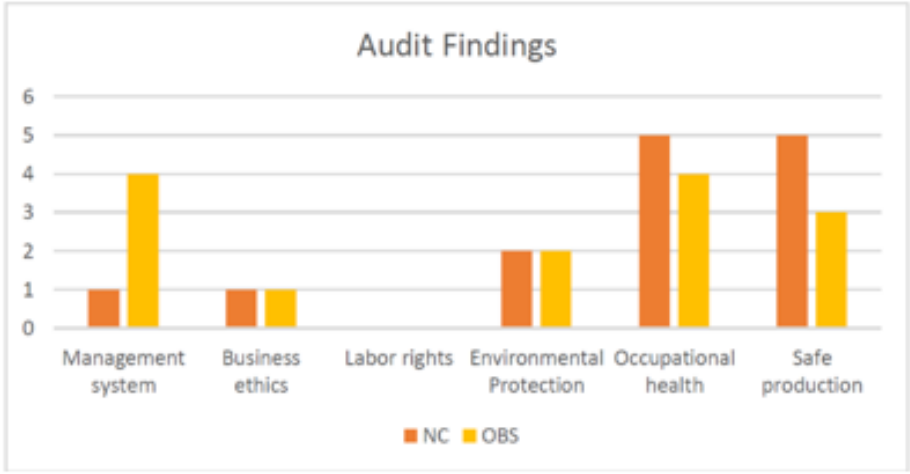
I from M.Erdmann: https://indico.desy.de/event/35655/contributions/137541/

Step 5: Certification Audit

BERNERSCONSULTING
Bridging China & Europe



CSR element	Full points	Applicable points	Scores	%	5 grading system
Management System	200	200	122	61%	3.05
Business Ethics	50	40	32	80%	4
Labor Rights	150	120	120	100%	5.00
Environmental Protection	250	215	181	84%	4.21
Occupational Health	300	200	121	61%	3.03
Safe Production	550	395	333	84%	4.22
Total	1500	1170	909	78%	3.88



I from L.Berners: https://indico.desy.de/event/35655/contributions/137504/

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Next Steps

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Next steps LCA

- Analyse existing LCA on rare earth
- Develop further down the supply chain
- Start LCA on other (easier) technical components with better data available → electronics

I from A.Lotan: https://indico.desy.de/event/35655/contributions/137465/

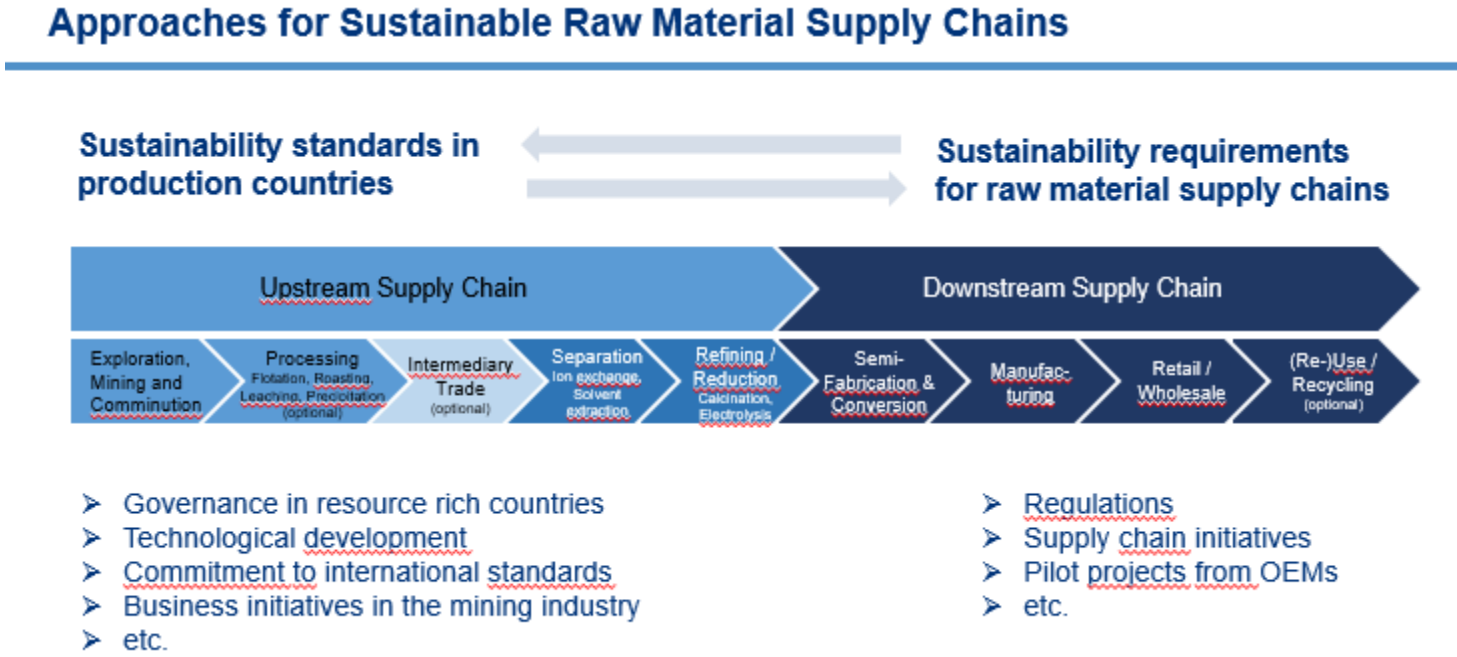
Next steps Recycling

- Include questions of RC already in design
- Help make REE recycling a successful business case
- Cooperation with institutes and industry developing REE RC

European Commission, Joint Research Centre, Cristobal-Garcia, J., Pant, R., Reale, F., et al., *Life cycle assessment for the impact assessment of policies*, Publications Office, 2017, https://data.europa.eu/doi/10.2788/318544

Next steps Certification

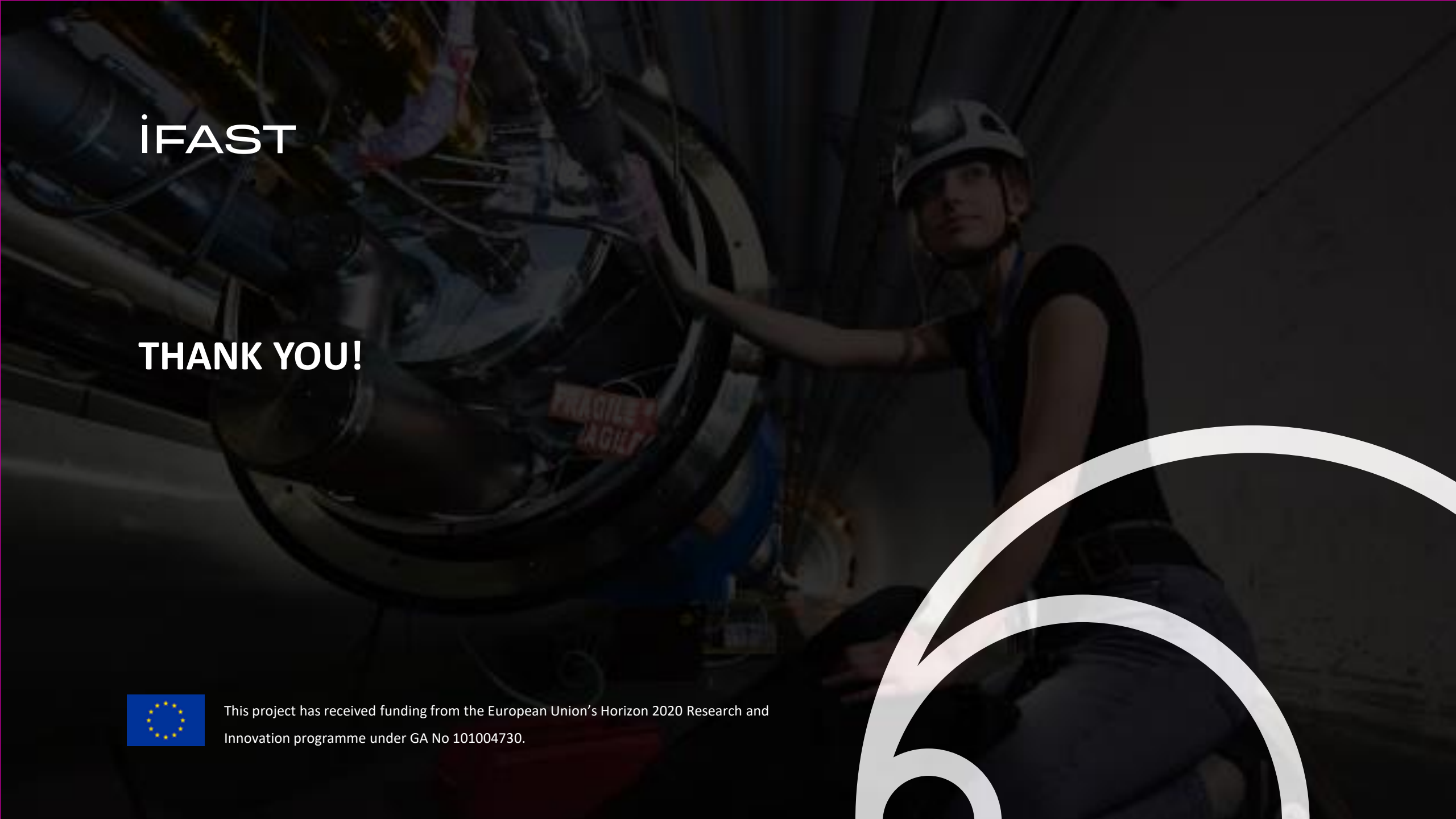
- Raise awareness
- Get better data/transparency
- develop and establish a first set of criteria to be specified in the procurement tenders → together
- start with transparency, auditability and initial questions on the biggest issues
- become more stringent over time
- Support political processes for CoC Certification



I from M.Erdmann: https://indico.desy.de/event/35655/contributions/137541/

Scources

- Infos taken from several presentations given at the iFAST Workshop “Critical Materials and Life Cicly Management: The example of Rare Earths – curse or blessing” 06.-08.02.2023 at DESY; indico: https://indico.desy.de/e/ree



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