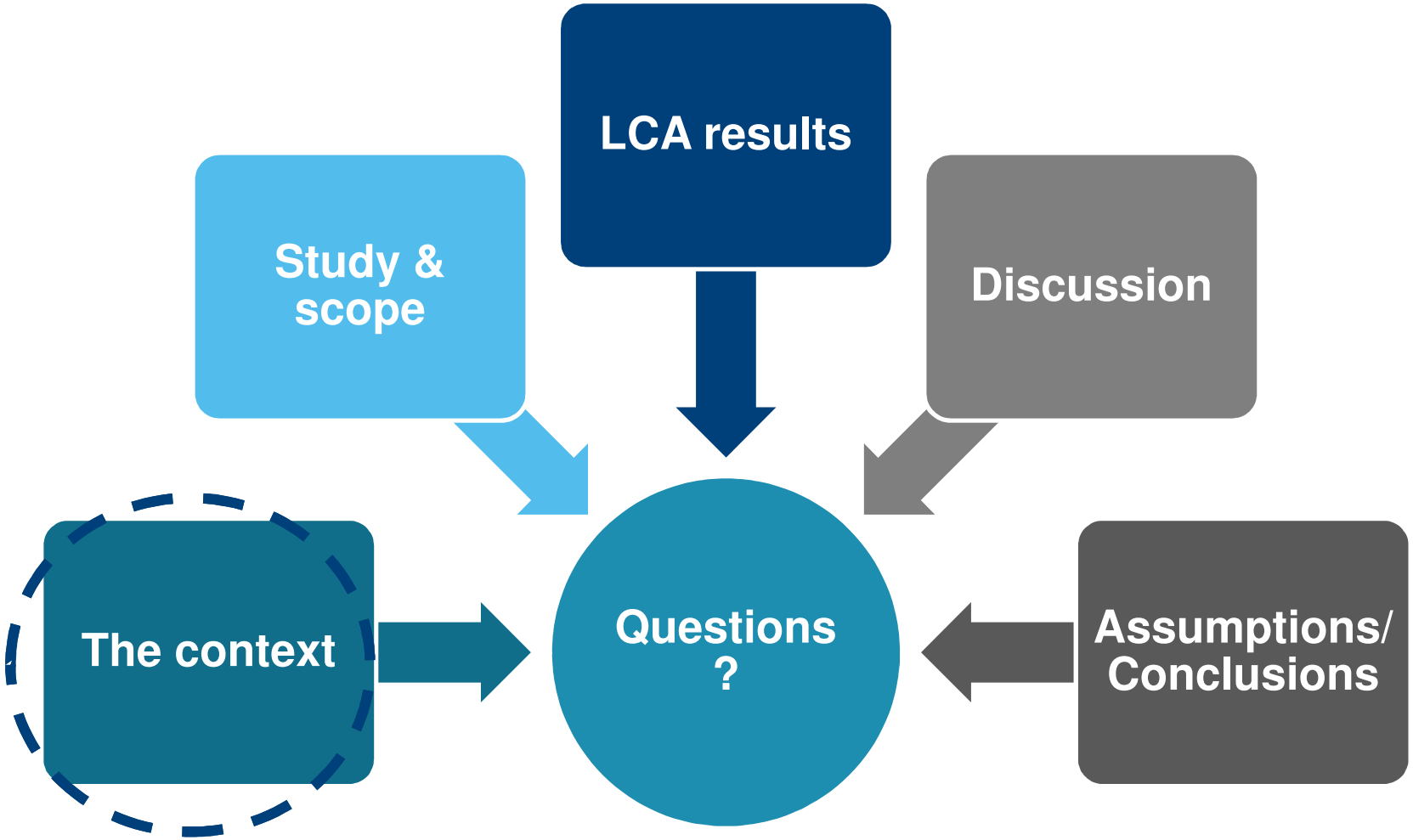
U LEUVEN

Life cycle assesment of the pyrometallurgical and hydrometallurgical routes used in rare earth recycling: *A case study of NdFeB magnets*

GWENDOLYN BAILEY
Gwendolyn.bailey@mtm.kuleuven.be

nda


LCA results
Study & scope
Discussion
The context
Questions ?
Assumptions/ Conclusions

ontext

Mining and the processing of metals is DIRTY

…but necessary!

There are options to help mitigate harmful emissio

but we must perform an **assessment** to find the **b**

option.

Pyro vs hydro: which is the more environmentally

friendly way to recycle these REE metals?

e Study: NdFeB magnets

plications with large amounts of rare earth elements (REE)

,5 MW wind turbine requires about 350 kg of REEs

Computer hard disk drives

Hybrid and electric vehicles

tical to applications, but not REE rich

ectronics such as cell phones, the REEs make up less than 0,5 wt% of the device

pply insecurity

hina is presently producing more than 90% of all rare earths

With limited supplies and increasing global demand, recycling of REE has beco increasingly important

KU LEU

troduction to **pyro**metallurgical techniques for recyclin

Pyrometallurgy, or the use of heat for the treatment of metals, often include **smelting** and **roasting**.

Large **energy** input required

Generates large amount of **solid waste**

Results in **hazardous wastes** and strong gas emissions such as:

CO_2 SO_2 CO

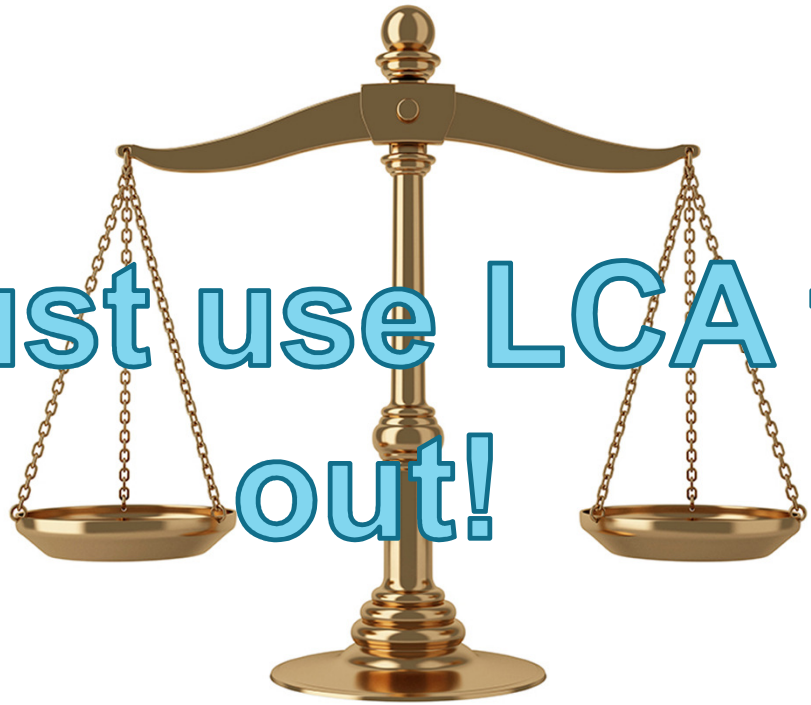
troduction to **hydro**metallurgical techniques

Hydrometallurgy, sometimes called leaching, involves the selective dissolu
of metals from their waste.

Large amount of **polluting chemicals** down the sink

Results in the generation of **hazardous wastewater**, which includes emiss
such as:

Which is better?



One must use LCA to find out!

What is Life Cycle Assessment?

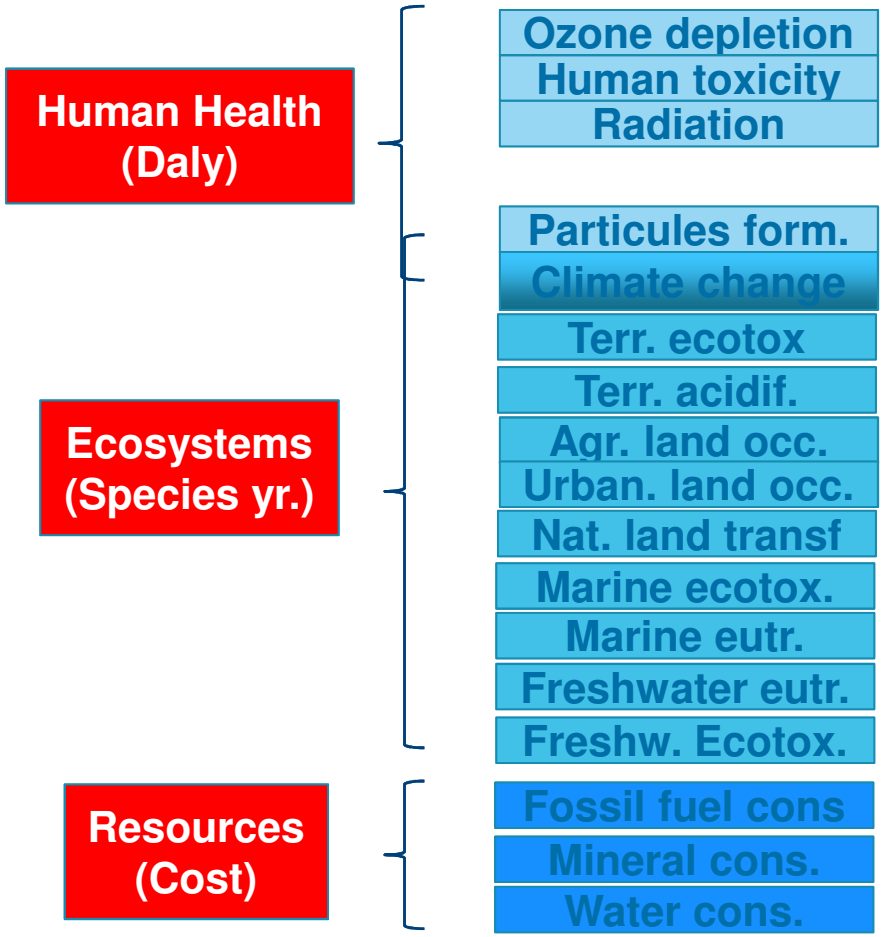
Hand Dryer

vs

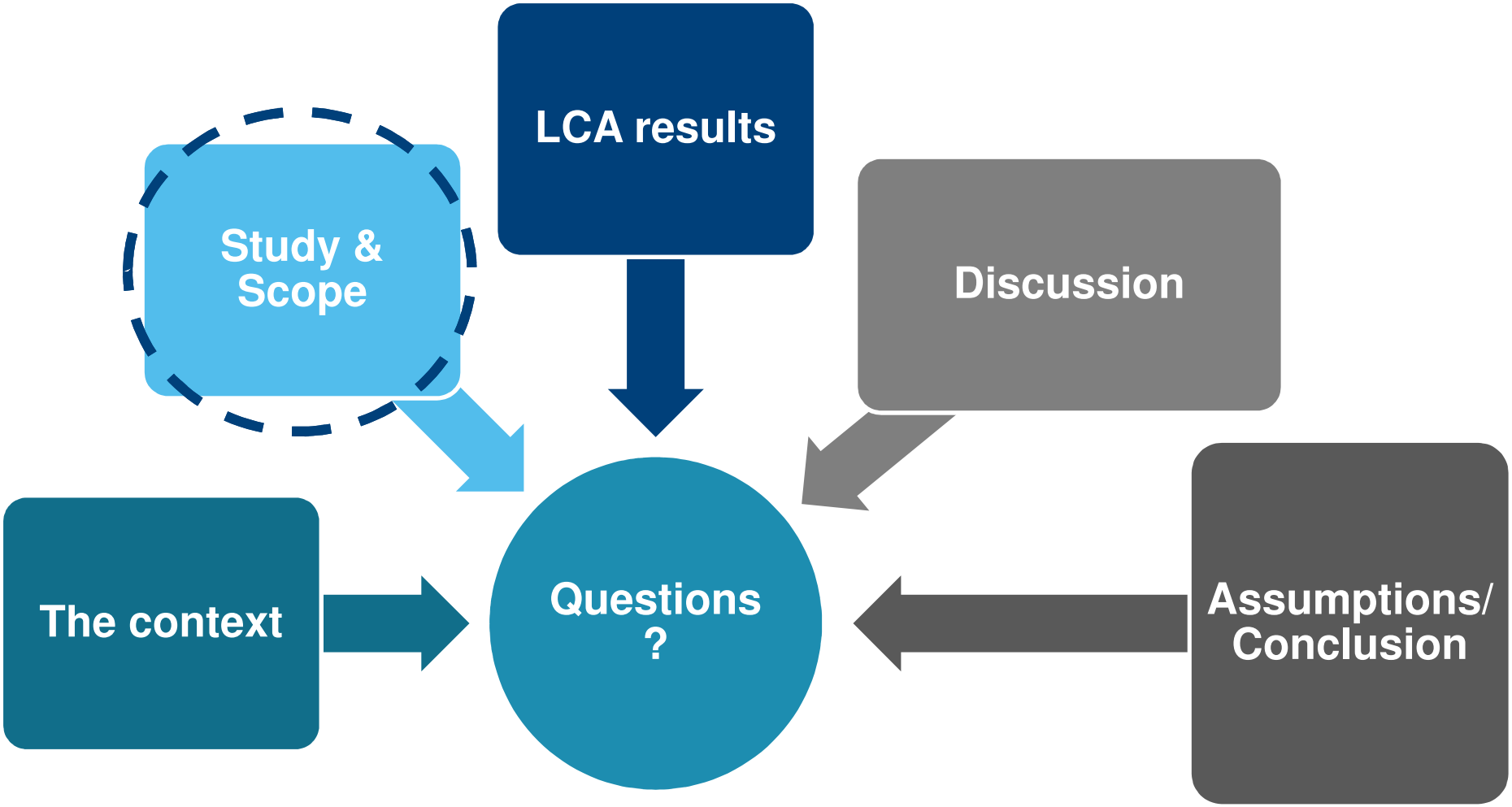
Cotton roll

The LCA framework

Impact Assessment



genda


LCA results
Study &
Scope
Discussion
The context
Questions
?
Assumptions/
Conclusion

What is Functional unit?

*he **amount** of energy and material needed to*
*oduce enough **neodymium oxide for 1 kg of***
***dFeB recycled** magnetic material.*

omparative LCA of NdFeB

LCIA method chosen: ReCiPe 1.08 H Midpoint

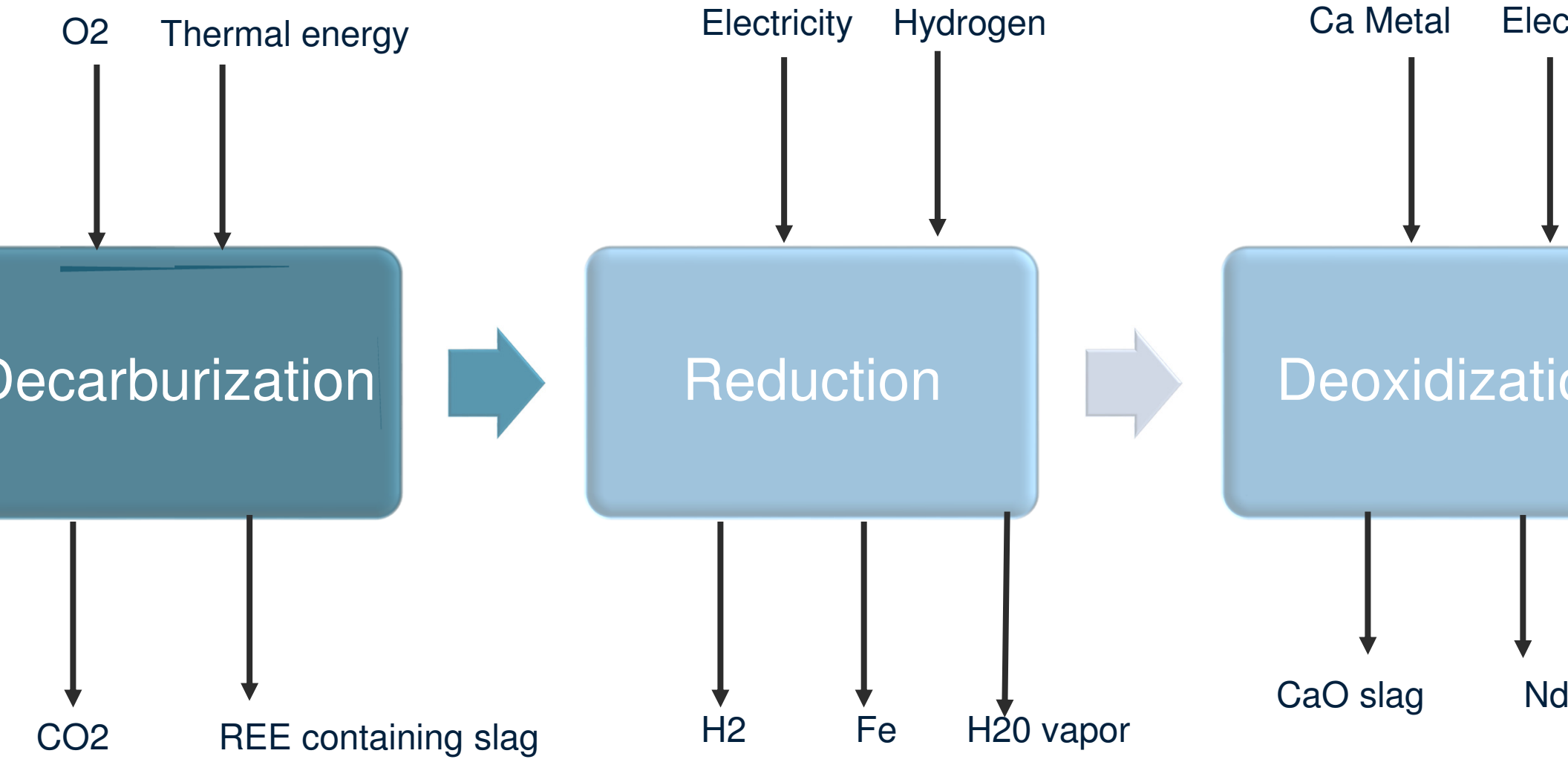
Economic allocation applied

Binnemans Routes –

- **Traditional hydro recycling process**
- **Procedure for direct melting**

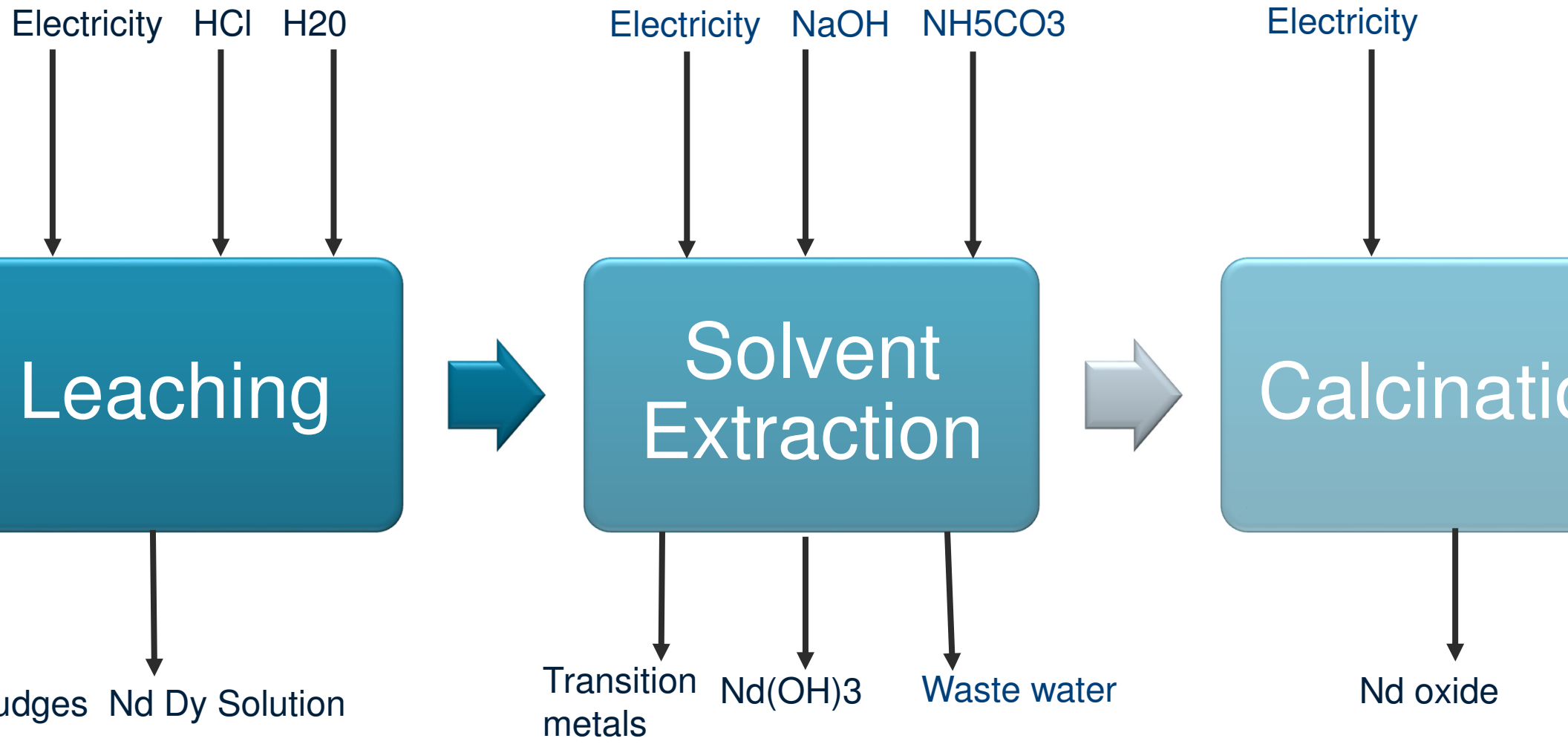
Sources: Binnemans, 2013. Recycling of rare earths: a critical review . Asabe, K., Saguchi, A., Takahashi, W., S
R., Ono, K., 2001. Recycling of rare earth magnet scraps: Part I carbon removal by high temperature oxidation
Trans. 42, 2487e2491.

ect melting recycling route



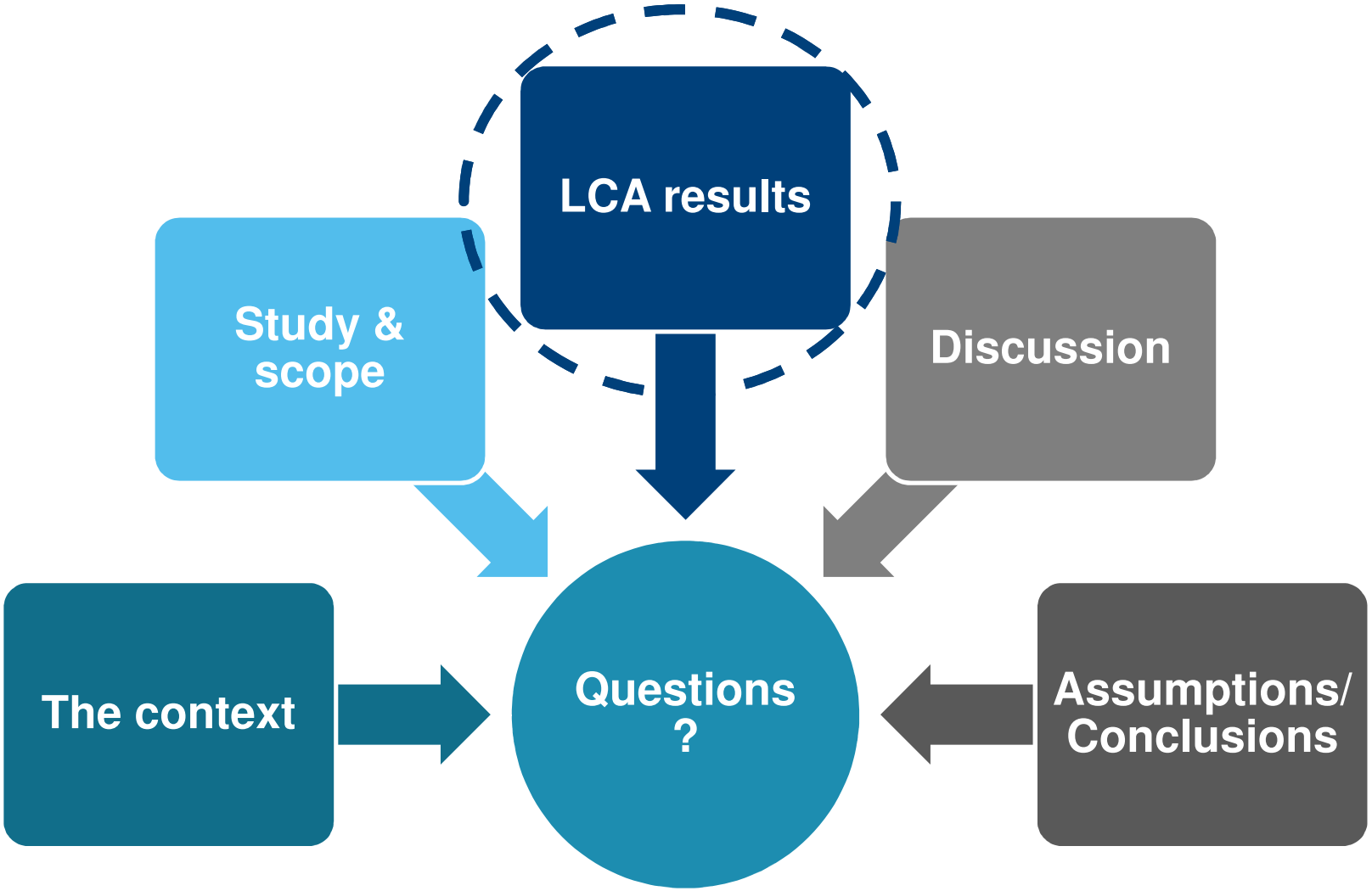
e: Schulze, Rita and Onai, Mehmet, EREAN, 2016

ydrometallurgical recycling route

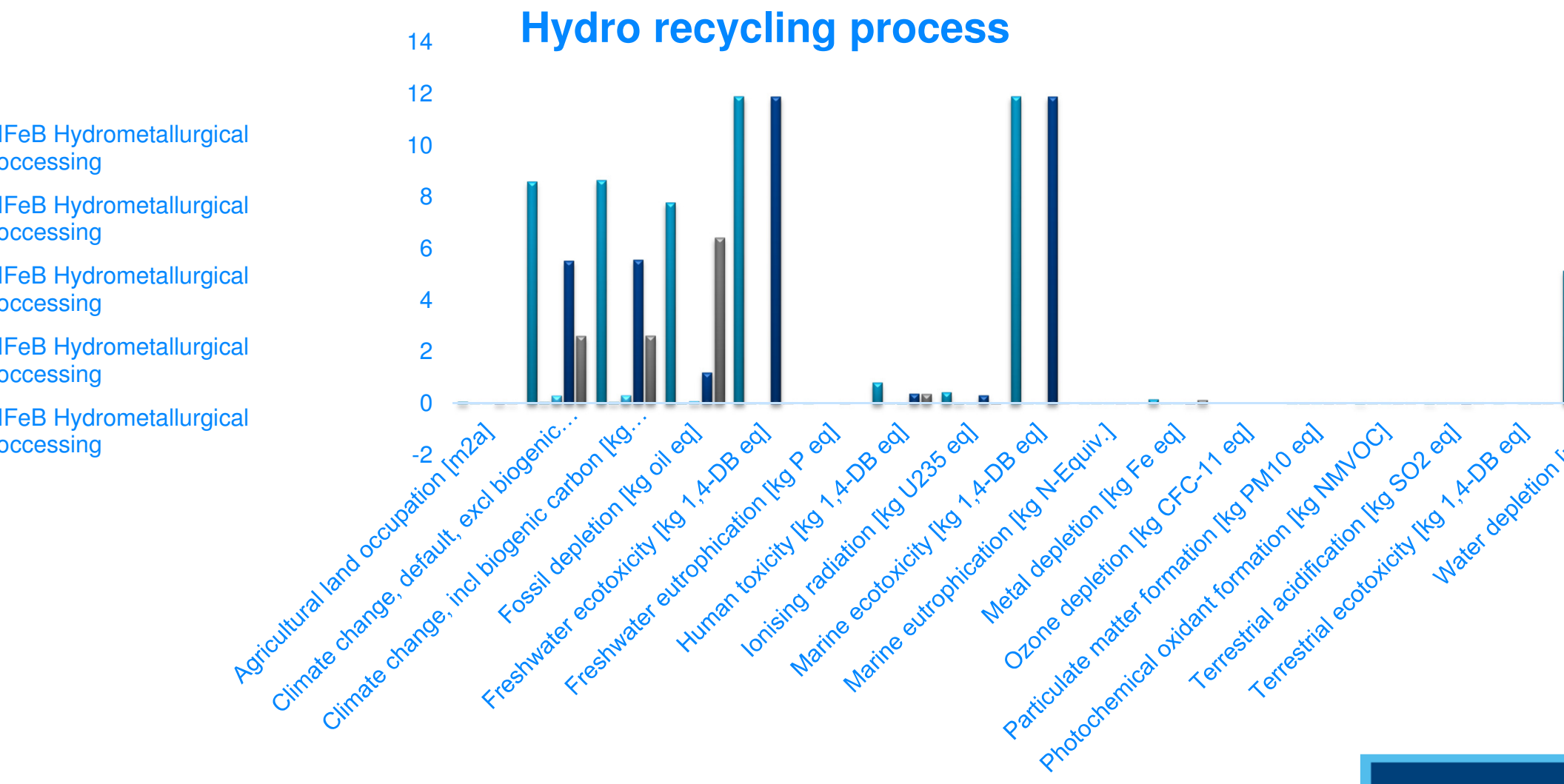


n der Hoogerstraete, T. Wellens, S. Veractert, K., Binnemans, K. “Removal of transition metals earths by solvent extraction 2013

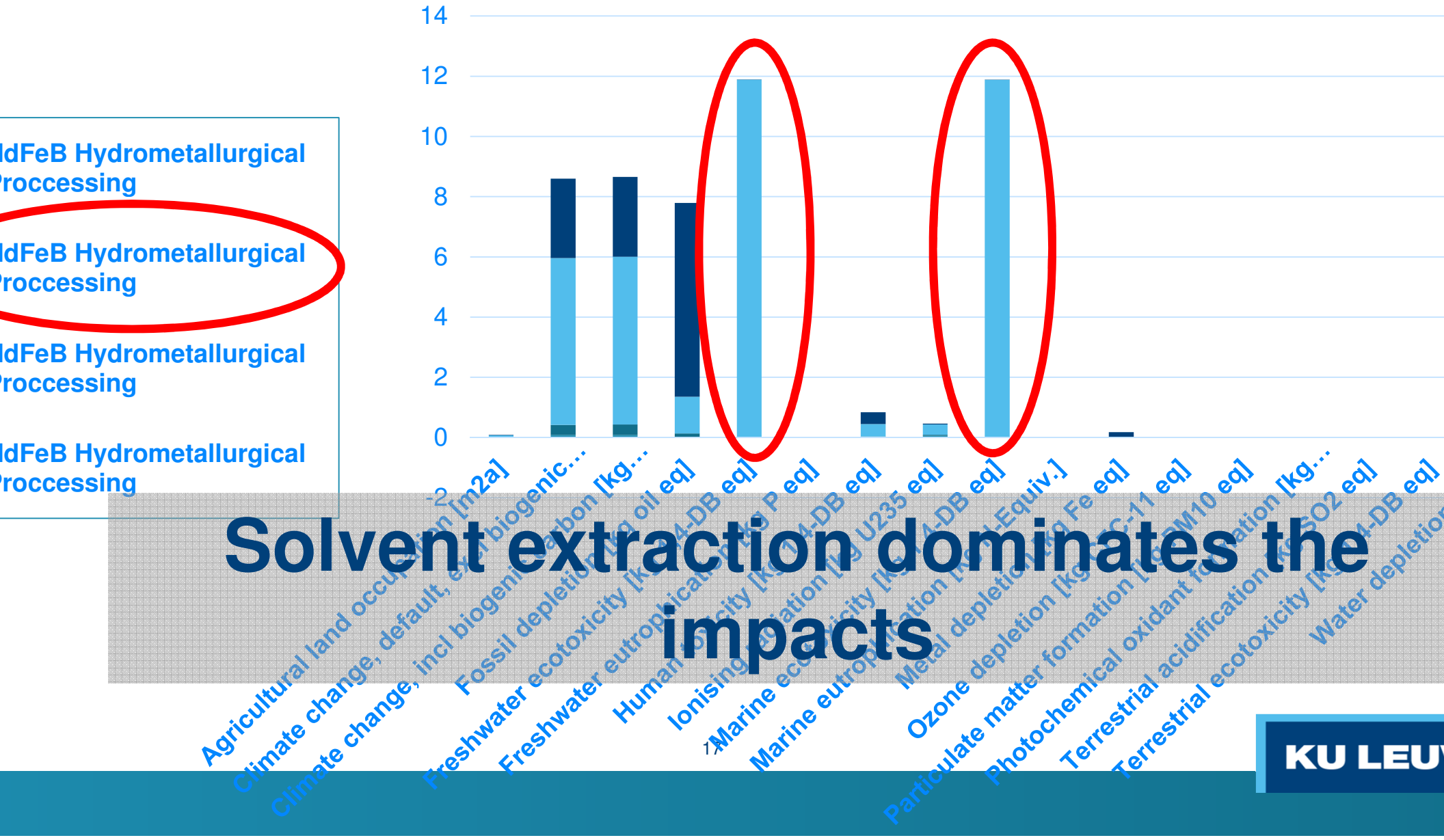
nda


LCA results
Study & scope
Discussion
The context
Questions ?
Assumptions/ Conclusions

Results - Hydrometallurgical



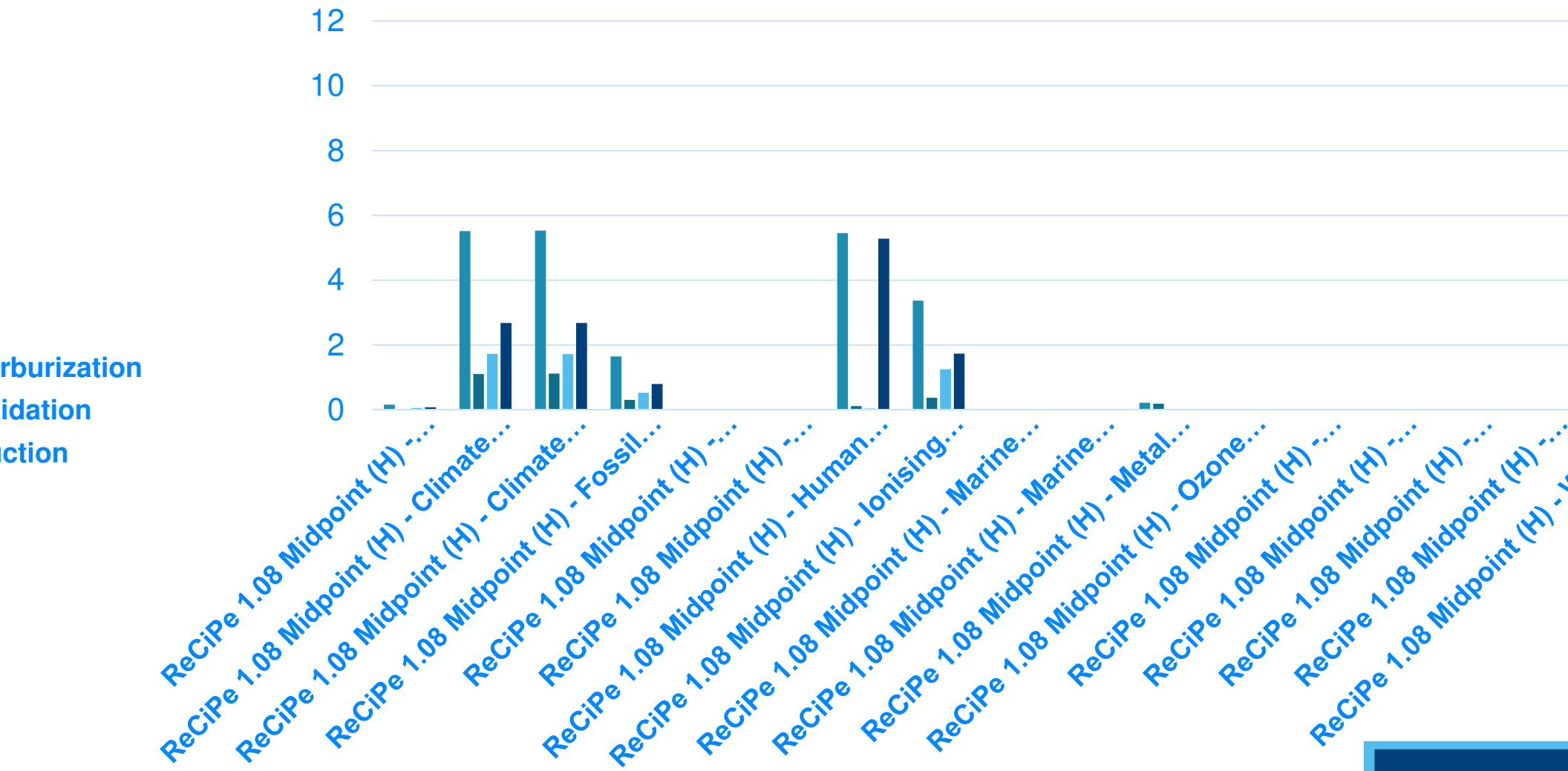
esults - hydro recycling process



Solvent extraction dominates the impacts

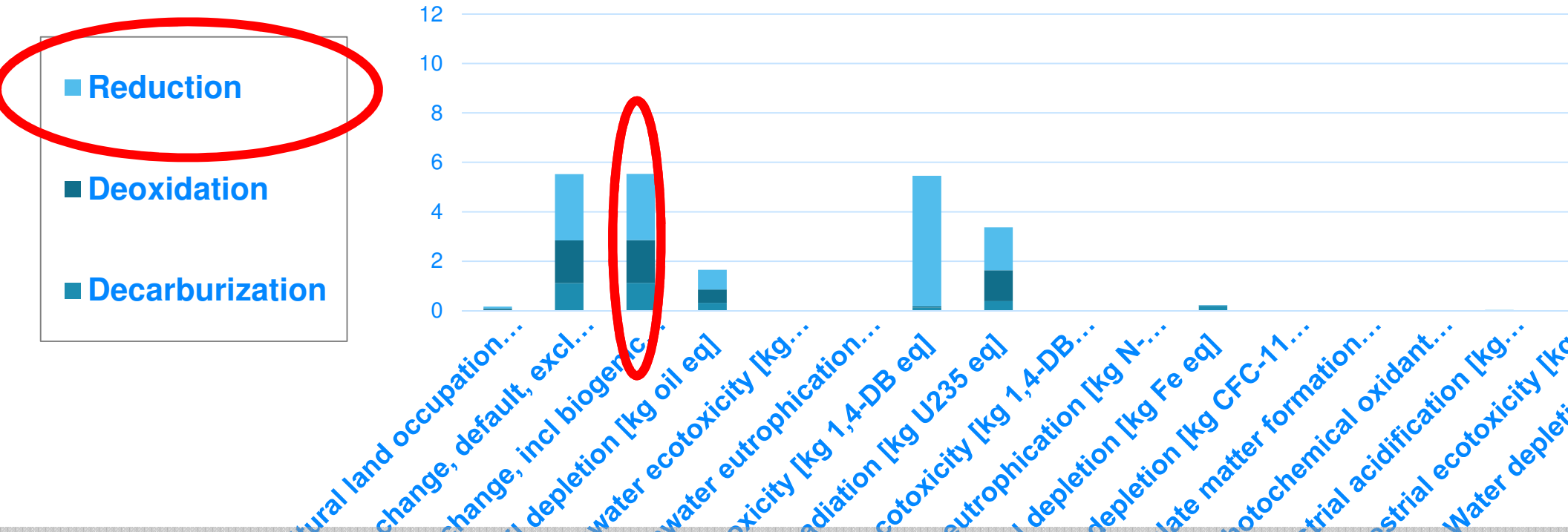
KU LEU

esults – Pyrometallurgical



KU LEU

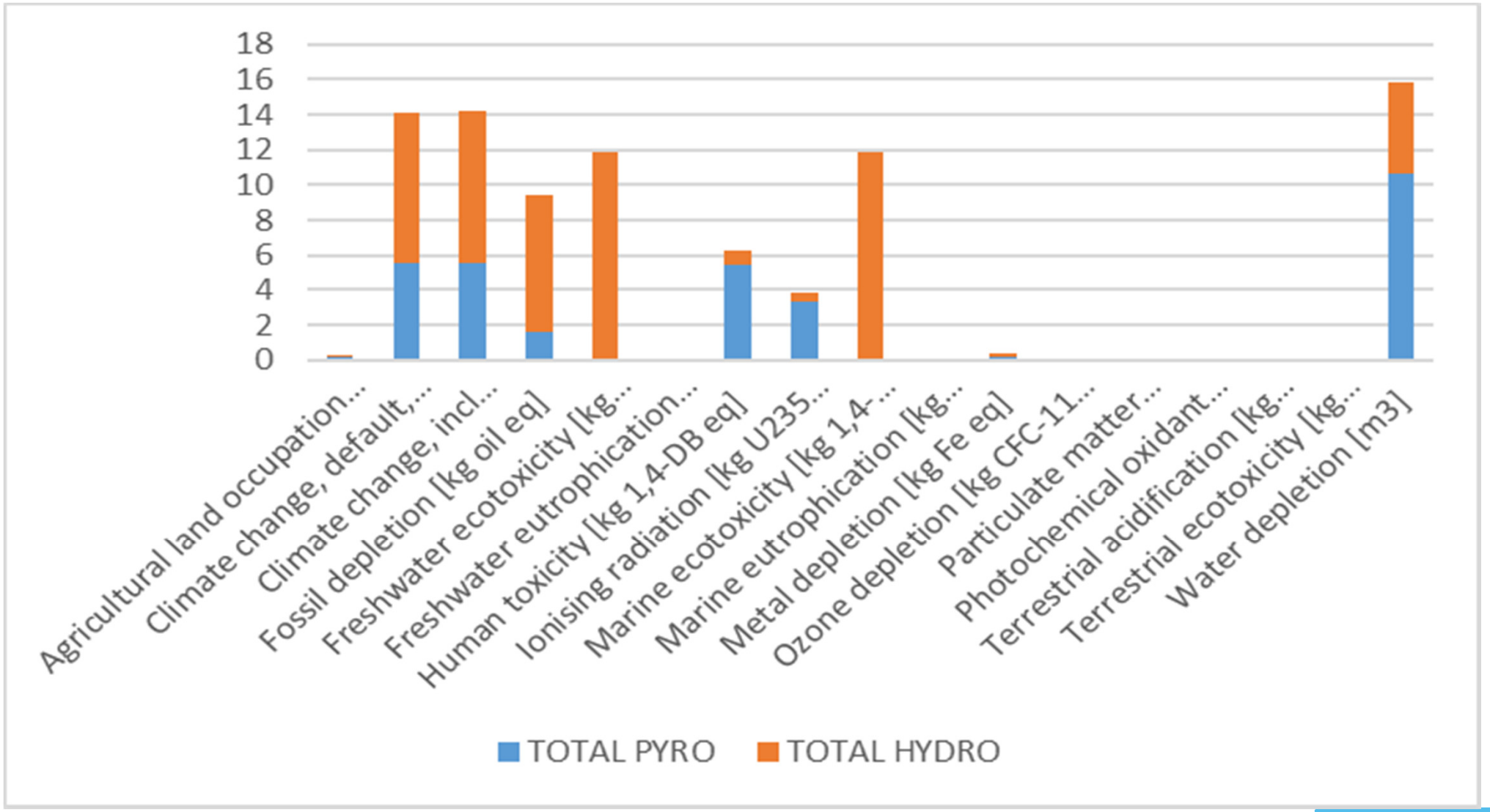
esults – Pyro recycling process



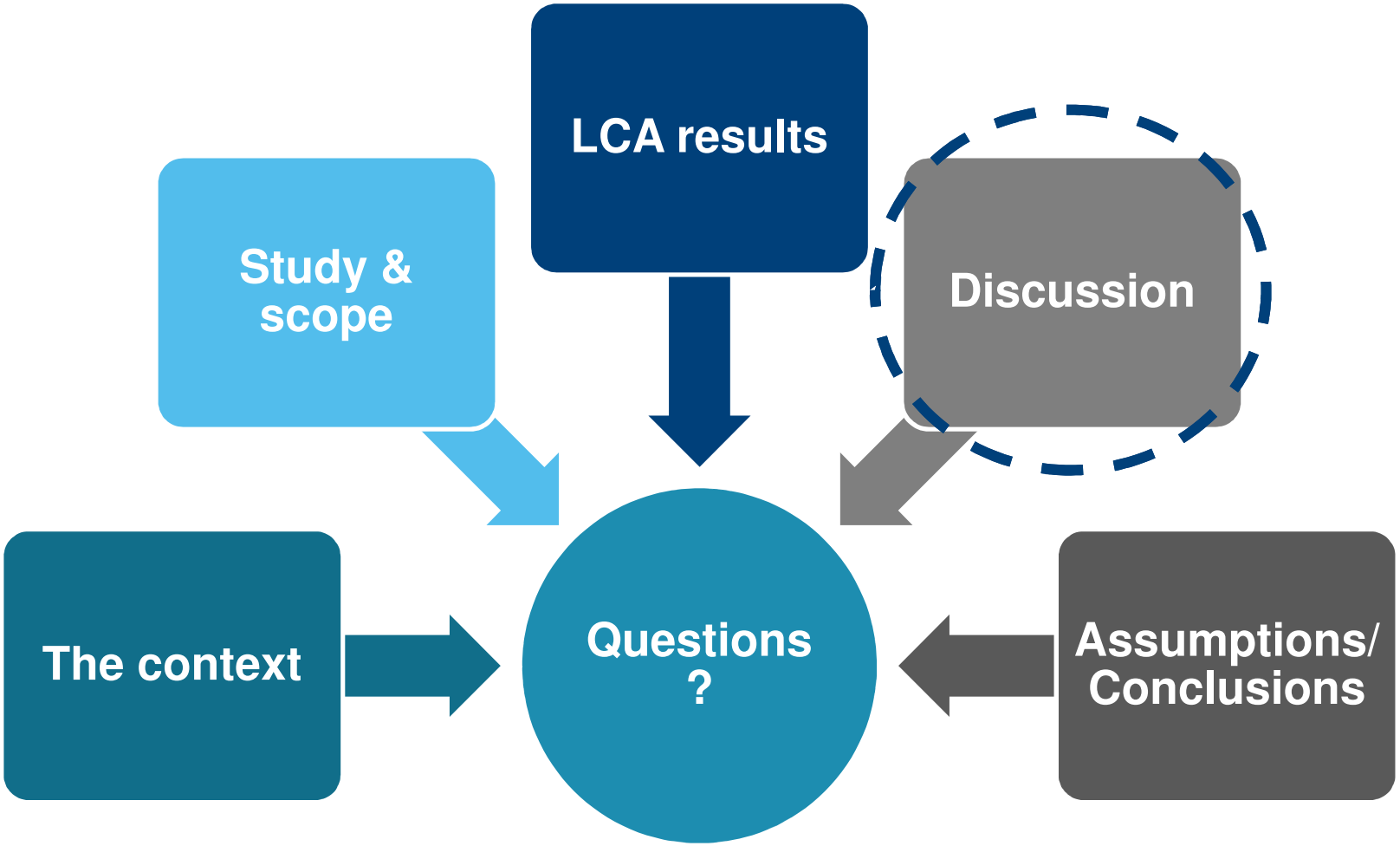
Reduction dominates the impacts

KU LEU

is the winner!



nda


LCA results
Study & scope
Discussion
The context
Questions ?
Assumptions/ Conclusions

iscussion of Results

Hydro impacts are found mostly within the **marine and freshwater ecotoxicity** categories.

- This is due to the sodium hydroxide which could contaminate the water table harmfully affecting aquatic life
- This is due to the heavy metals which are being leached and polluting freshwater

- Pyro impacts dominate the **wate depletion** category.
  - This is due to the large amou of water lost in the water vapo the reduction
  - Climate change category is a affected due to the high temperature heating used in t direct melting

mitations to the Study

Assumptions:

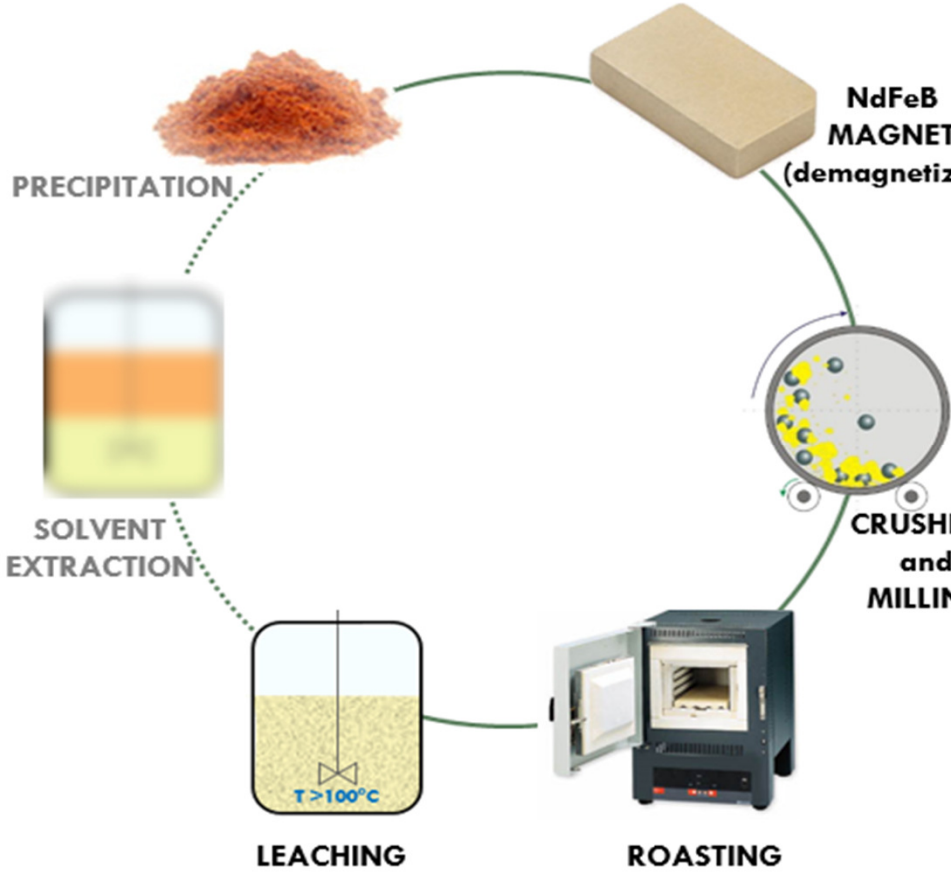
- MAP instead of ammonium bicarbonate
- Deoxidization process modelled is worst case conditions

All processes done on lab scale

Does not accurtately reflect industry practice

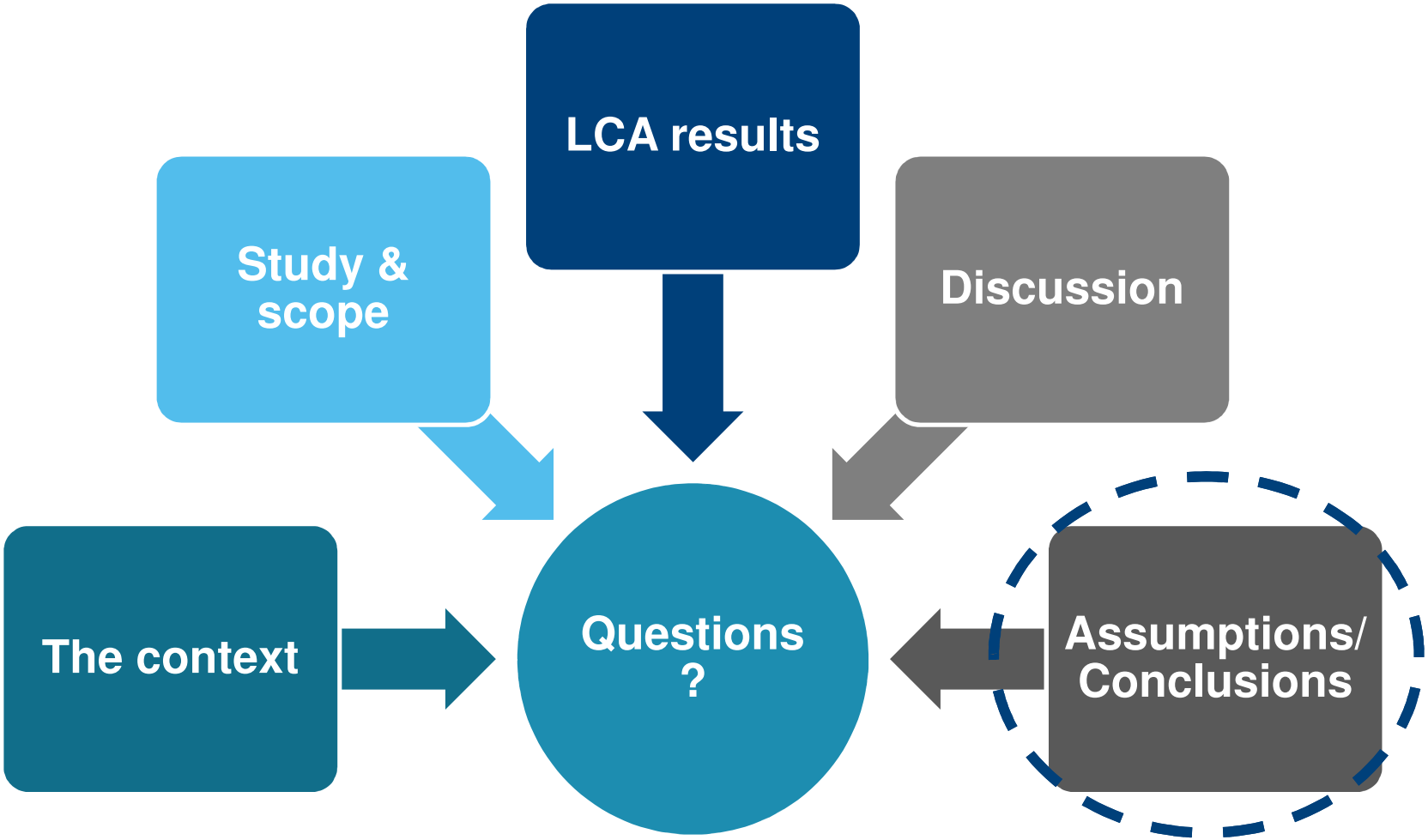
- Neither pure pyro techniques nor pure hydro techniques practiced soley in industry

Common route for NdFeB recyling



KU LEU

nda


LCA results
Study & scope
Discussion
The context
Questions ?
Assumptions/ Conclusions

ummary

- Hydrometallurgical processes operate at lower temperatures and if organic chemicals are reused (like in industry) then it has the potential to be the mo sustainable solution.
- Pyrometallurgical recycling could be a real sustainable process considering small amount of impacts at lab scale.
- LCA displays potential hot spots despite uncertainties

knowledgments: This project has received funding from the European Union's EU Framew ogramme for Research and Innovation Horizon 2020 under Grant Agreement No 674973

an Commission

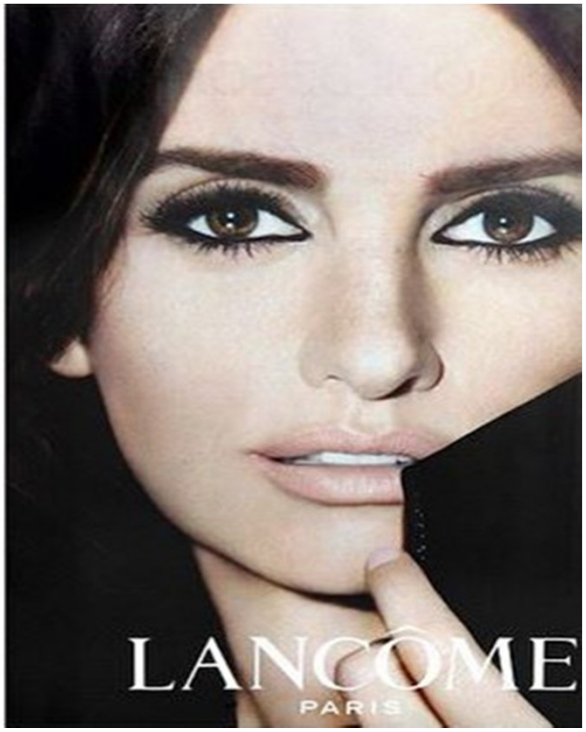
KU LEU

onclusion

There's no way to reflect reality…

But with LCA you are on your way!

LCA



Reality

uestions? Contact me Gwendolyn.bailey@mtm.kuleuven.