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Analyzing feasibility of a new nickel slag valorization sector with prospective Life Cycle Assessment

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A new nickel slag valorization sector ?

One of the five largest nickel producers in the world

Nickel pyrometallurgical plants

Electricity

Thermal power plants

Nickel slag feedstock

Mineralization

CO_2 feedstock

Silico-magnesian cement

Assumption:
Equivalence with silico-calcic (Portland) cement

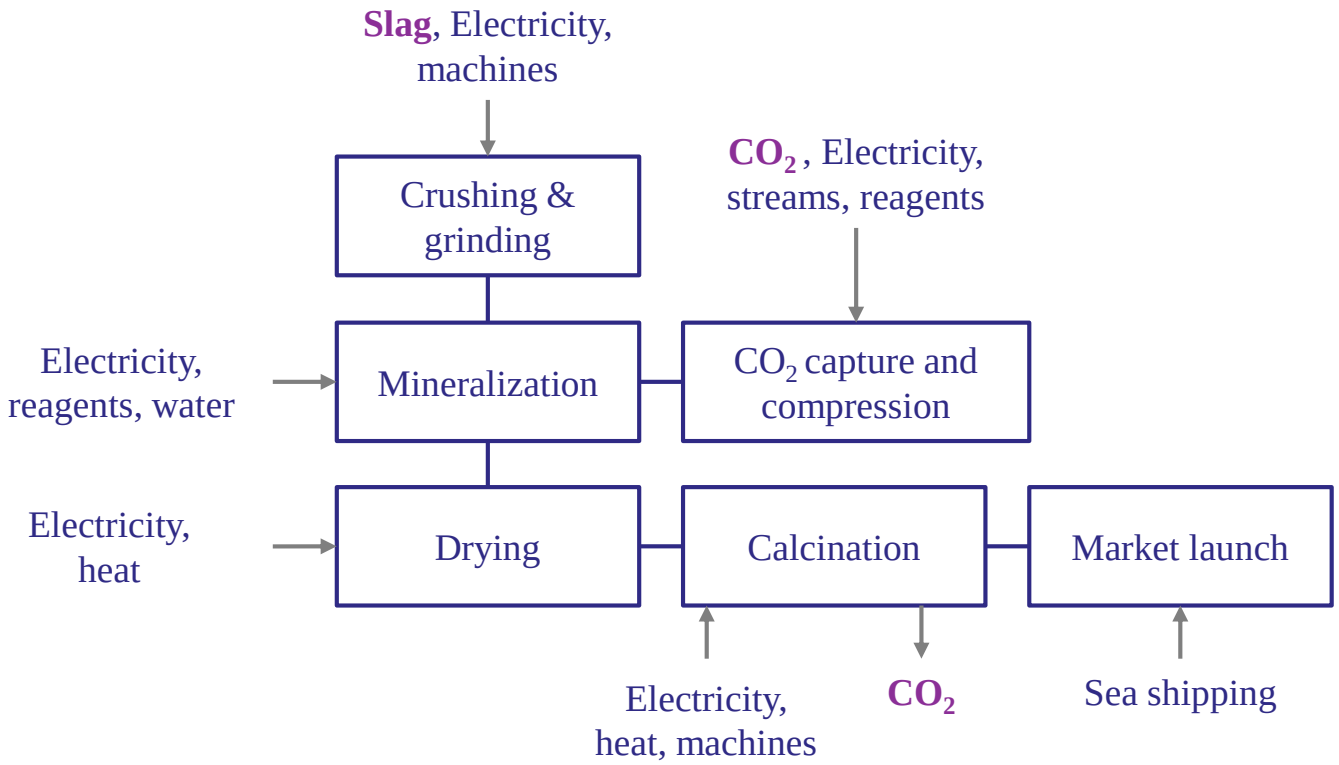
Currently at early stages of developments (lab scale): low TRL

Conditions for : feasability ? env. performances ?
→ Prospective Life Cycle Assessment

The prospective Life Cycle Assessment model

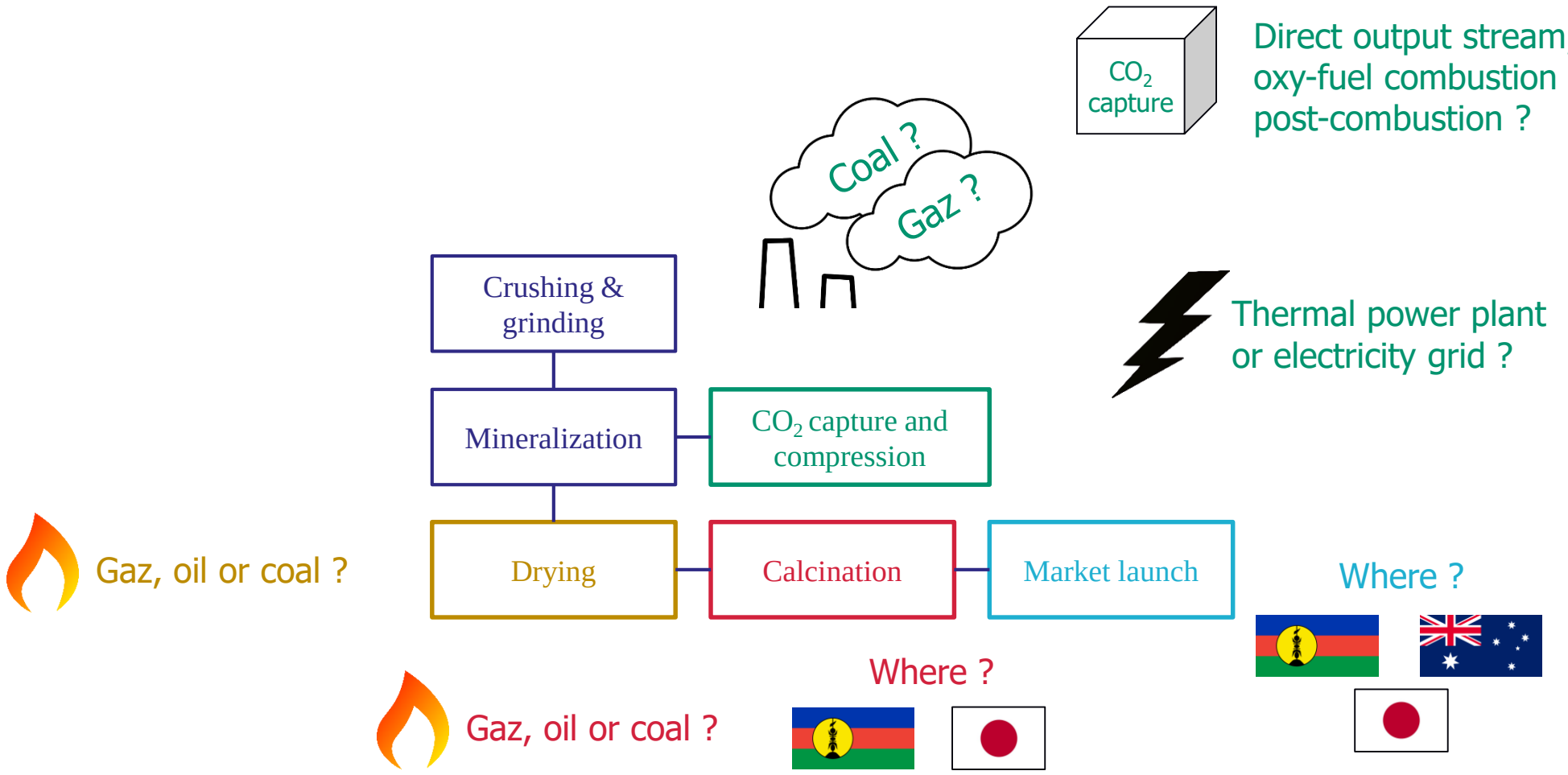
The LCA system

"1 kg of cement produced from nickel slag mineralization and delivered to market"
Production time-horizon : 2035



The prospective Life Cycle Assessment model

The decision variables



The prospective Life Cycle Assessment model

The scenarios

1 scenario = 1 alternative from each decision variable → 648 existing scenarios

Assessment of the scenarios according to technology, energy and geography

Application of constraints for association of some alternatives (e.g. if drying and calcination at the same site, use the same heating fuel) → 216 feasible scenarios

The background

Adaptation of the electricity grid supply of New-Caledonia and Japan (in case of calcination in Japan) for the production time-horizon (2035), according to :

- National energy plans
- Political visions
- If lack of data, average increase of renewable energy (2% each year)

How to identify the most sustainable scenarios ?

Methodology

Calculate the scenarios performance for all the 16 impacts of the ILCD 2.0 2018 midpoint method

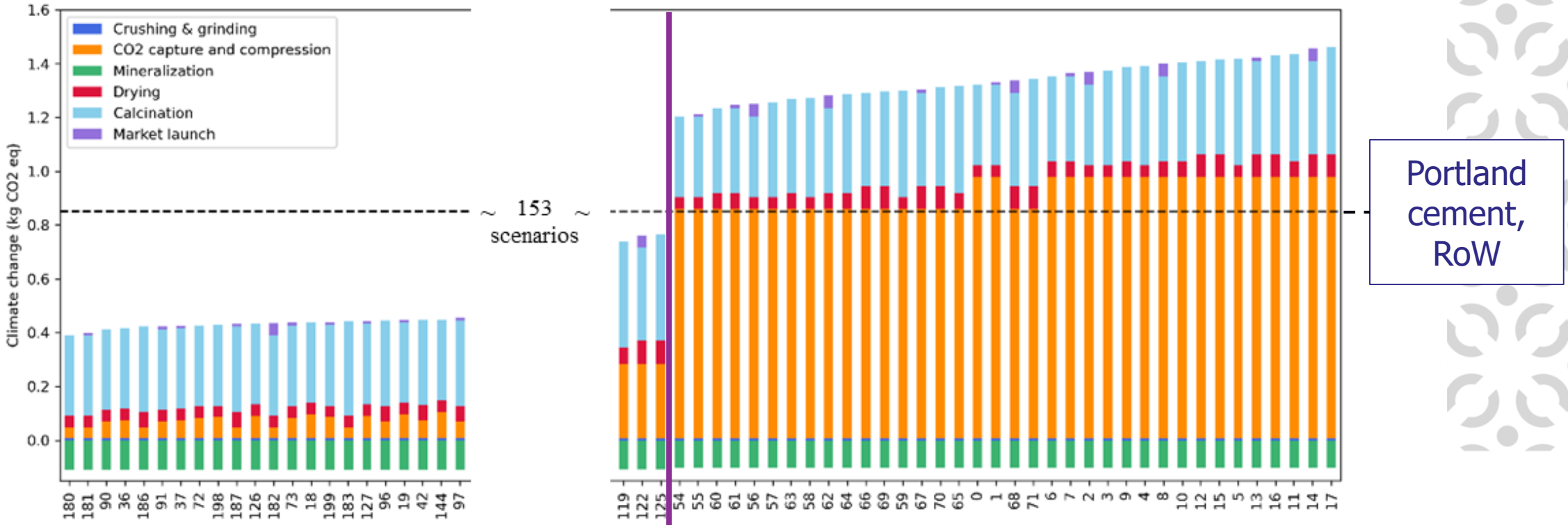
One impact after another :

- Comparison with production of 1 kg Portland cement, RoW
- Only scenarios that perform better are kept and assessed in the next impact
- If no scenario can be kept, skip the impact

The final set of scenarios = the most sustainable scenarios for as many impacts as possible

How to identify the most sustainable scenarios ?

Example of the climate change impact



180 scenarios perform better than cement Portland → will be assessed in the next impact

The 36 least sustainable scenarios are with CO_2 capture from direct output streams of a gaz power plant.

Which are the most sustainable scenarios for a new nickel slag valorization sector ?

For as many impacts as possible (from the 16 impacts of the ILCD 2.0 2018 midpoint method)

Compared to Portland cement, RoW :

- No scenario perform better for 3 impacts (freshwater eutrophication, dissipated water and fossil resources impacts)
- Ozone layer depletion is hardly fulfilled
- 13 scenarios perform better for the 12 remaining impacts

The most important choices of these 13 most sustainable scenarios :

- No strict preference for

and

- No capture from direct output streams

- Gaz for drying and for calcination
- Calcination 
- Market  or 

Conclusion

Highlights from the prospective LCA study

- There is an environmental interest for the production of cement from a nickel slag valorization sector

- Prospective LCA helps defining constraints required for future developments:
  - Scenarios to exclude
  - Set of preferable scenarios

- Current limits :
  - Assumptions concerning the equivalence with a Portland traditional cement (to be confirmed)
  - Assumptions concerning the energy consumption of the mineralization process

Next steps of the study

- Other conditions to ensure environmental performances :
  - still uncertainties for electricity consumption: **define the upper limit of energy consumption** for future developments
  - Reassess with a **detailed and parametrized inventory of the mineralization process** (operational conditions may be key action levers)
  - **Redefine the reference** : « Better than Portland » is probably not the good reference (the cement industry has to decrease its GHG emissions, not to maintain them)

- Conditions to ensure economical competitivity of the silico-magnesian cement ? → same approach applied with a cost model

- Other possible products : same approach for the production of supplementary cement materials, which also can be obtained from nickel slag mineralization

THANKS FOR YOUR ATTENTION

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