WasteLCA_3: Life Cycle Sustainability Assessment For Waste Management And Resource Optimization

Proceedings

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Prospective life cycle assessment for nickel slag valorization by mineral carbonation

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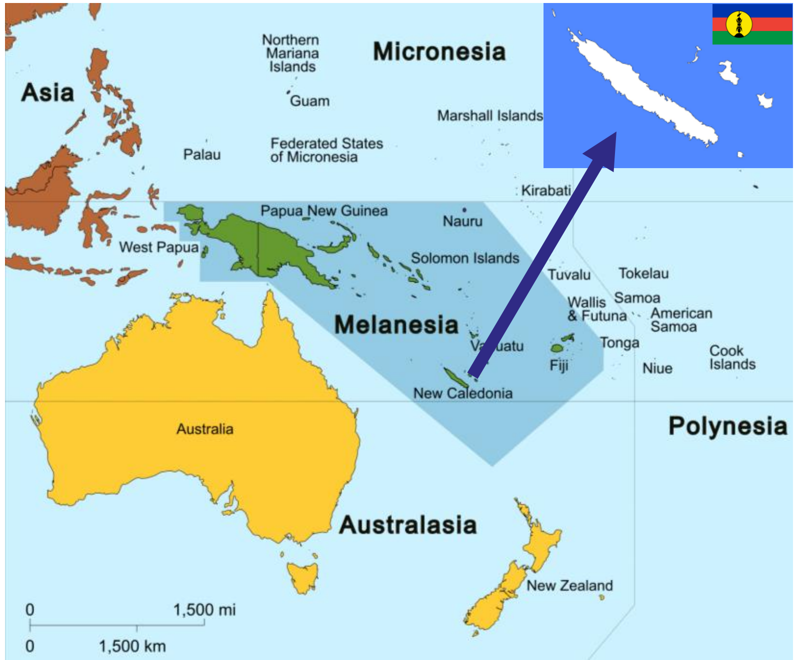
Prospective life cycle assessment for nickel slag valorization by mineral carbonation

CNRT Nickel & son environnement · LGC · Lmdc toulouse · brgm Géosciences pour une Terre durable · Université Gustave Eiffel · ESO UMR 6590 · iRSTV

The issue of nickel slag in New-Caledonia and the project for a solution



- One of the five largest nickel producers in the world.
- Per year :
  - 5,8 million tons of nickel and ferronickel
  - 9,5 million tons of slag, very little recycled, filling a stock of 20-25 million m^3
  - More than 1 million tons of CO_2 from the thermal power plants supplying the pyrometallurgical plants

Mineral carbonation

→ Supplementary cementious material (SCM)

Best conditions for the environmental performance of SCM production ?

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How to reach our objective ?

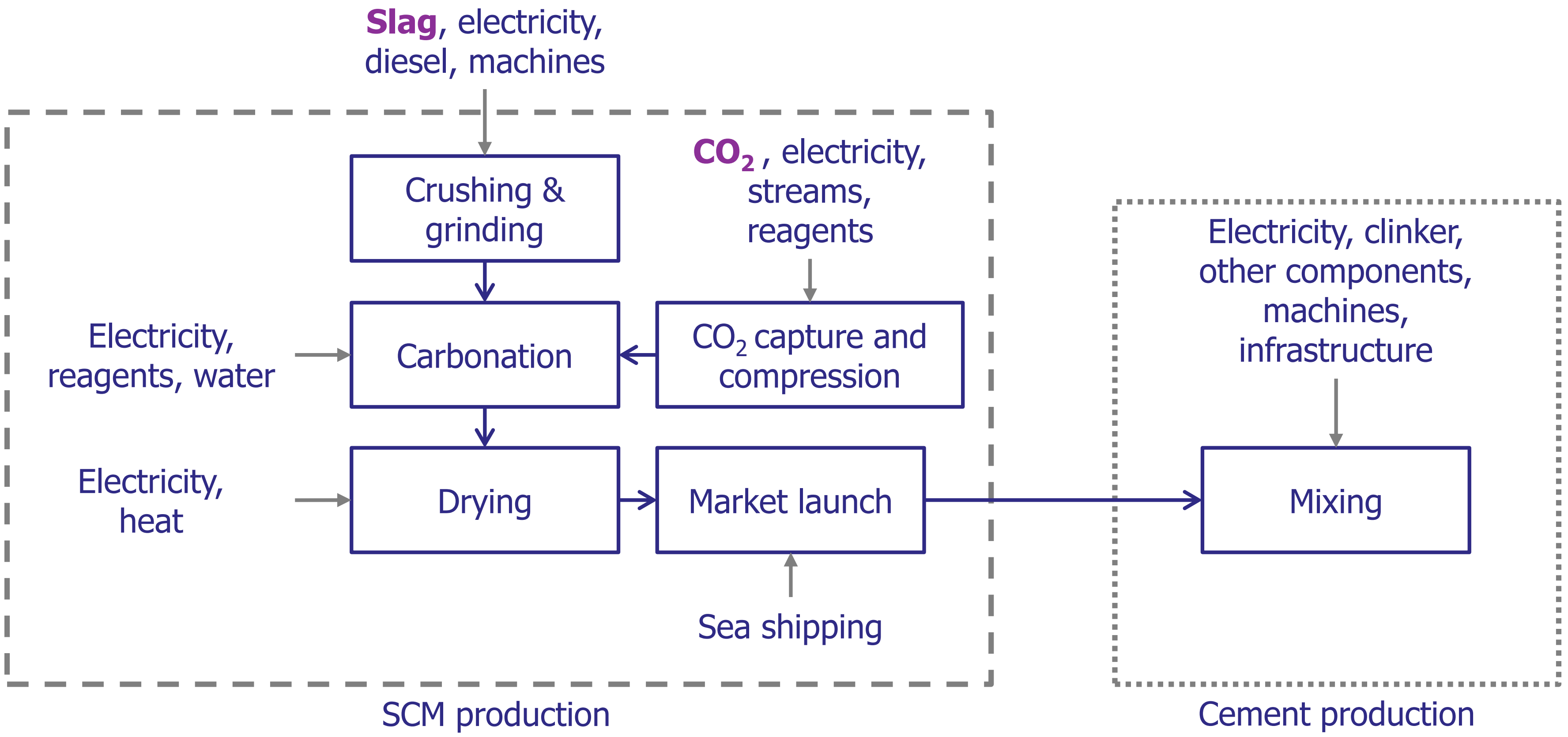
Study a low TRL process (lab scale) ?

→ **Prospective LCA**

"Studies of emerging technologies in early development stages, when there are still opportunities to use environmental guidance for major alterations" (Arvidsson et al., 2018)

The prospective Life Cycle Assessment model

The time-horizon for the industrial level : 2035
The system : production of 1 kg cement with clinker substitution of 40% by SCM (target for the future to meet the climate mitigation policies)



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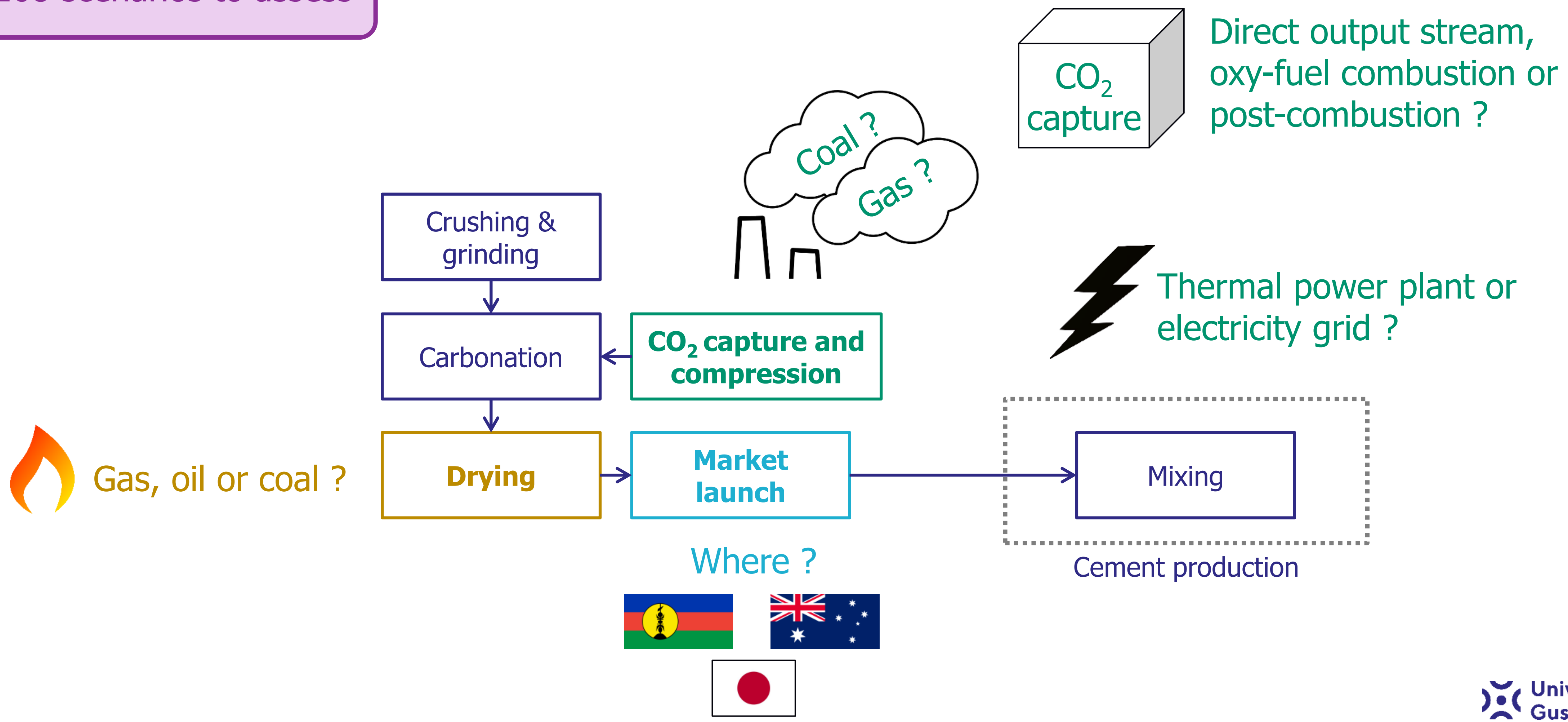
The prospective Life Cycle Assessment model

The decision variables, defined according to the territory

108 scenarios to assess



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The prospective Life Cycle Assessment model

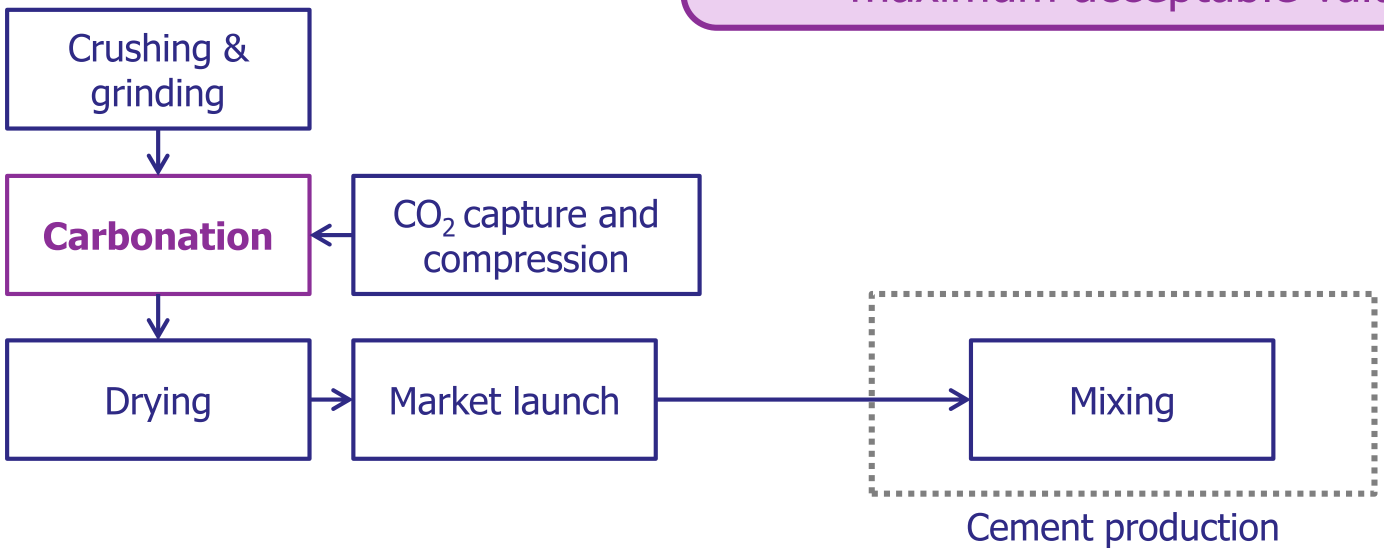
The technological issues

Carbonation electricity consumption ?
In lab, high consumption : from 0.6722 to 3.2063 kWh per carbonated slag.

Reduction is mandatory.
Assess from 0.1 to 1 kWh to obtain the maximum acceptable value.

Carbonation rate ?
In lab, 30 to 70%.

Assess to determine the best value.



How to reach our objective ?

Study a low TRL process (lab scale) ?

Prospective LCA

"Studies of emerging technologies in early development stages, when there are still opportunities to use environmental guidance for major alterations" (Arvidsson et al., 2018)

Assess a large number of scenarios and parameters ?

Brightway

- Parametrized LCA model with the database Ecoinvent 3.7.1 cut-off
- Python script to create the sets of scenarios and parameters, to adapt the LCA model and to calculate the LCA impacts

Adapt the background to the future time horizon ?

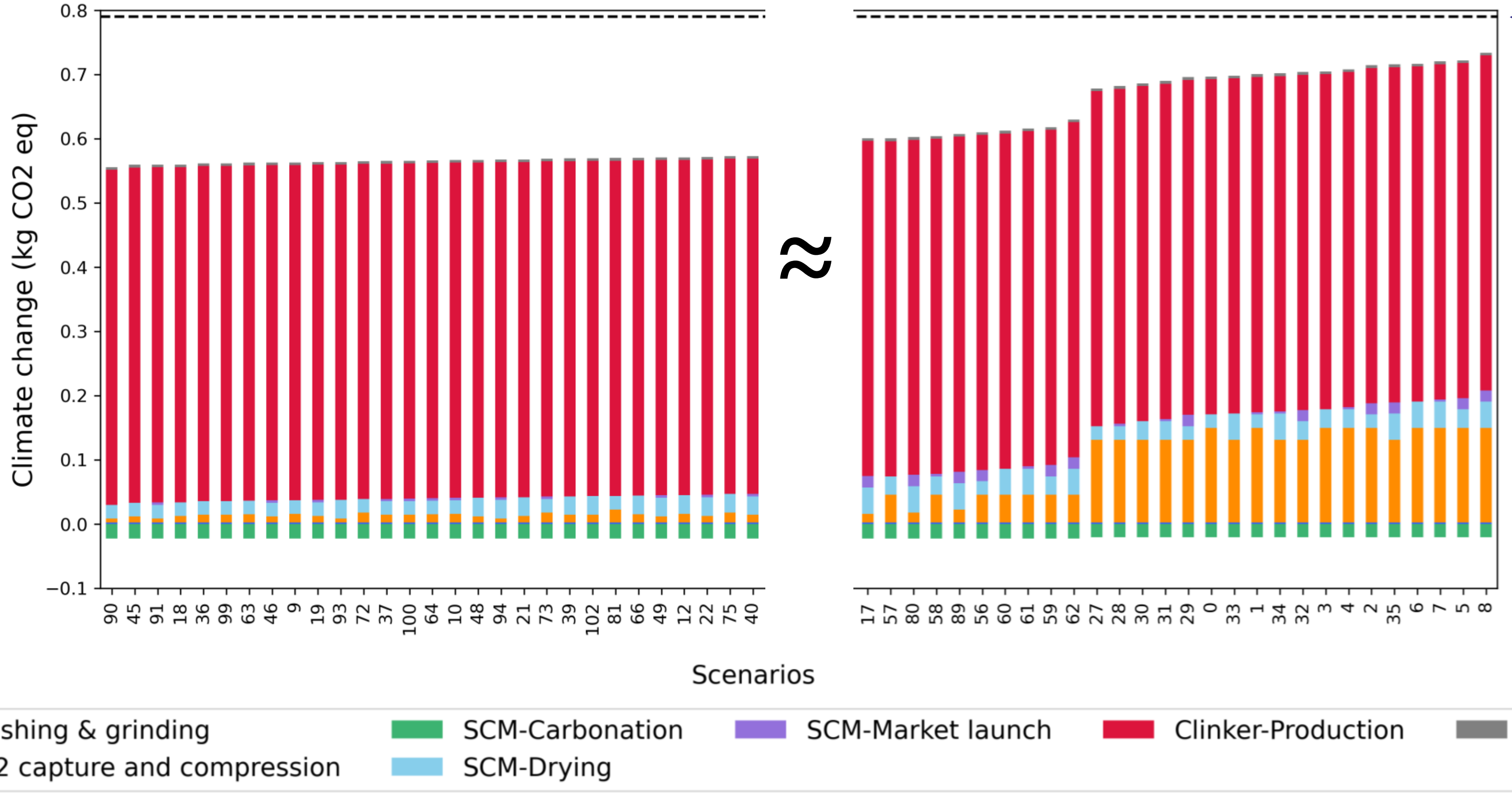
premise

- Automatic projection of the Ecoinvent database
- Manual projection (e.g. electricity production mix for New-Caledonia).

What are the most favorable scenarios and technological values ?

Example on the climate change impact with 30% of carbonation and 0.1 kWh

Up to 33% reduction



Future ordinary Portland cement

All scenarios are better. But this is only for climate change.

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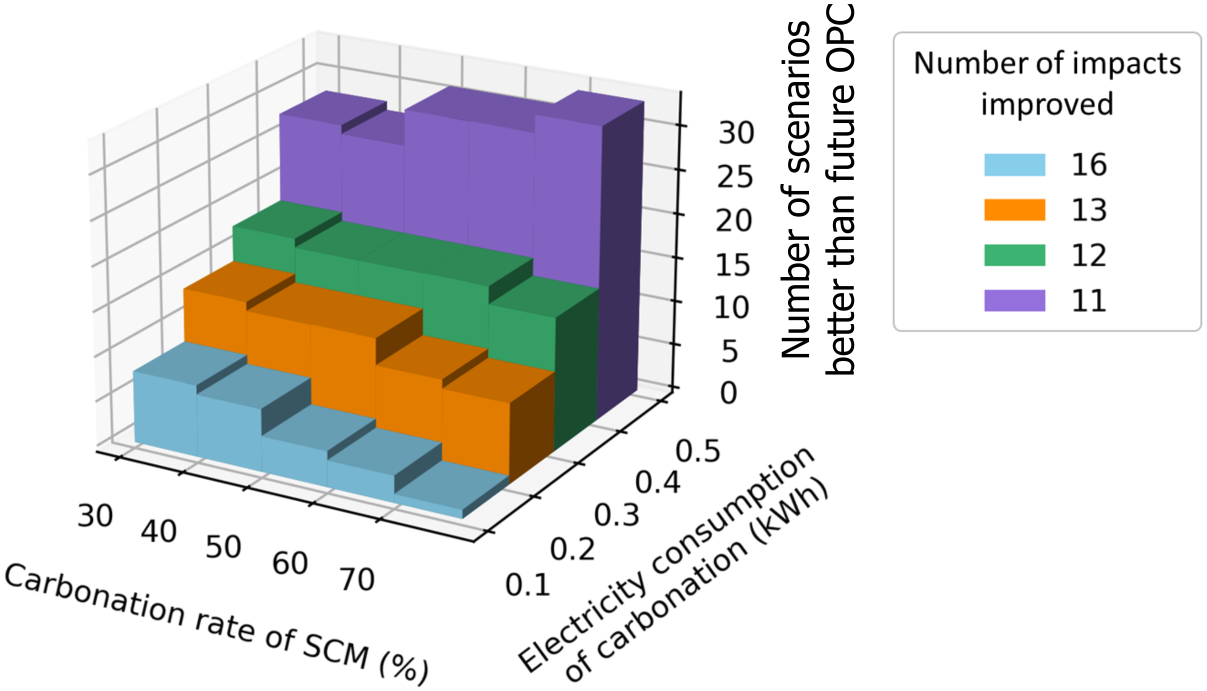
What about the other environmental impacts ?

Assessment on the 16 impacts of the ILCD 2.0 midpoint method

- The higher the electricity consumption, the lower the number of impacts improved

- The higher the carbonation rate, the lower the number of better scenarios. → when the climate change impact decreases (due to CO_2 capture), the other impacts generally increase.



The most favorable technological solutions are 30% for the carbonation rate and 0.1 kWh of the electricity consumption.

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What are the most favorable scenarios ?

8 scenarios perform better than future ordinary Portland cement on the 16 impacts of the ILCD 2.0 midpoint method

Decision variable	2 solutions for a coal power plant	6 solutions for a gas power plant
Electricity for CO_2 capture and compression	0 power plant and 2 electricity grid	4 power plant and 2 electricity grid
CO_2 capture technology	0 direct output stream, 2 oxy-fuel combustion and 0 post-combustion	0 direct output stream, 2 oxy-fuel combustion and 4 post-combustion
Fuel to dry carbonated slag	2 gas, 0 oil and 0 coal	6 gas, 0 oil and 0 coal
Market	1 New-Caledonia, 1 Australia, 0 Japan	3 New-Caledonia, 3 Australia, 0 Japan

To be further coupled with an economic analysis

Conclusion

Highlights of the prospective LCA study

- There is an environmental interest for the production of SCM from nickel slag valorization
- The conditions to reach the best environmental performance are identified :
  - **The best scenarios → decision making to settle the valorization process on the territory of New-Caledonia**
  - **The technological values → targets to continue the development of the process**

Perspectives

- Assess the economic viability of the selected scenarios
- Compare the SCM with other future SCMs

THANKS FOR YOUR ATTENTION

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