Évaluation de l'éco-efficacité de l'hydroxyde de Ni-Co et de l'oxyde de graphène réduit pour le stockage d'énergie

Eco-efficiency of Ni-Co hydroxide and reduced Graphene Oxide for energy storage

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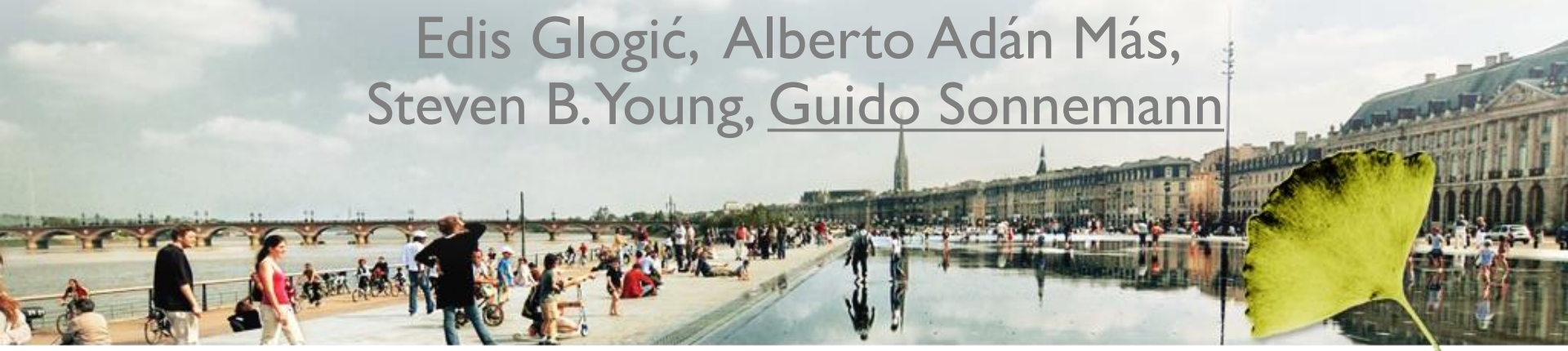

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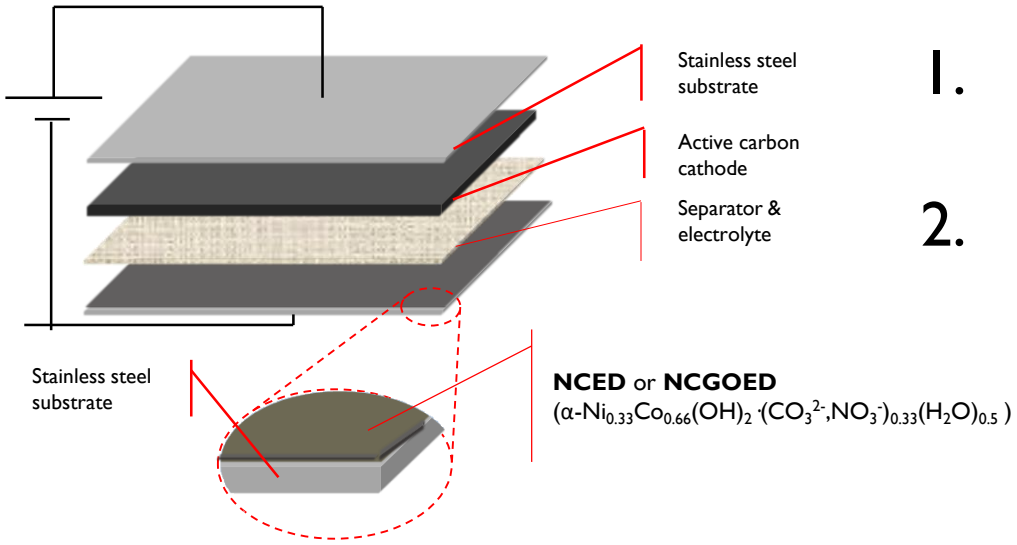
INTRODUCTION

- Energy storage technology – key to renewable energy proliferation
- Demand for new material subsitutes and improved performances (i.e., high power and energy density)
- New strategy in materials innovation – combining metals with carbon-based materials for storage electodes
- What is the eco-efficiency of the new materials?

INTRODUCTION

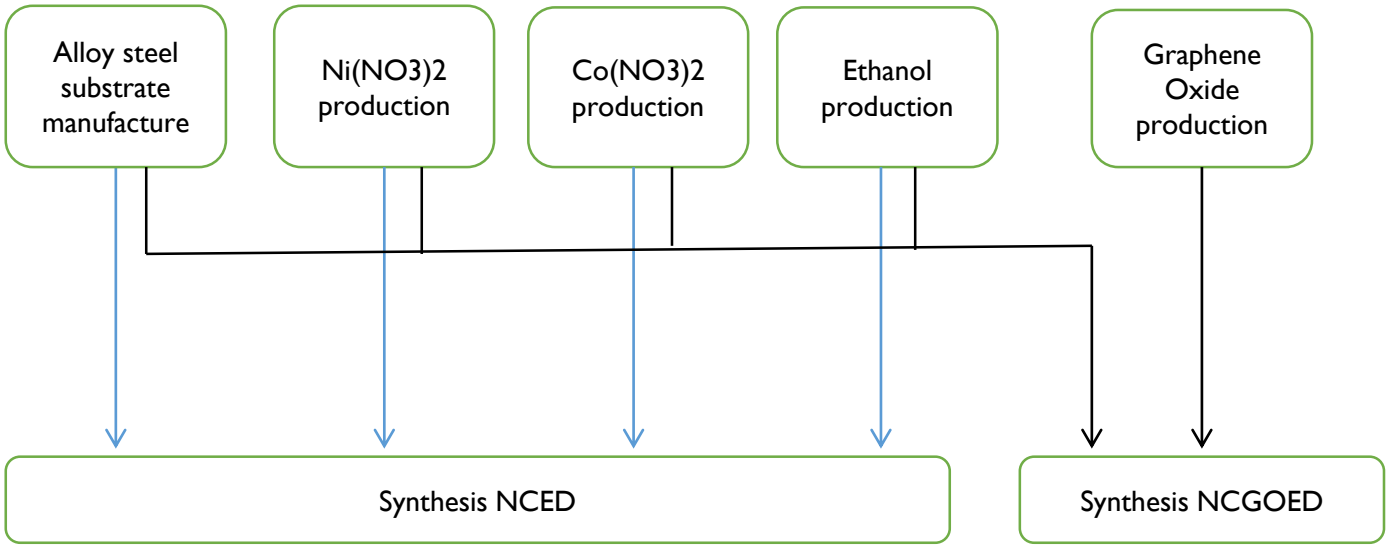
- Nano-enabled storage electrodes based on nickel-cobalt hydroxides combined with Graphene Oxide (GO)



1. Ni-Co electrode by electrodeposition (**NCED**)
2. Ni-Co-GO electrode by electrodeposition (**NCGOED**)

INTRODUCTION

- Synthesis of NCED and NCGOED by electrodeposition



Note: GO is reduced during electrodeposition and integrated in the electrode as a reduced-GO (rGO)

OBJECTIVE

- Compare two electrodeposited electrode materials (NCED and NCGOED) and determine if an addition of GO to Co-Ni composites is eco-efficient

METHODOLOGY

- Life Cycle Assessment
  - Cradle-to-gate
  - Data:
    - Foreground: up-scaled experimental data, empirical measurements
    - Background: ecoinvent database v3.4
  - Impact assessment method: 10 categories of ReCiPe Midpoint (H)

METHODOLOGY

- Sensitivity analysis
  - Compare materials at alternative-GO production route for NCGOED
  - GO production:
    - Baseline: so-called modified Hummer's method as described in Zaaba et al (2017)
    - Sensitivity: the most eco-efficient fabrication route described in Cosutta et al (2017), the Jeong variant, use of 0.7 g of graphite in comparison to 0.6g per gram of GO synthesised, but smaller use of acid (125g in comparison to 30g) which also results in smaller use of neutralizing agents to treat wastewater.
- Comparison with mature technology
  - Comparison of the best-scenario NCGOED with similar Ni-Co by coprecipitation - NCCP

METHODOLOGY

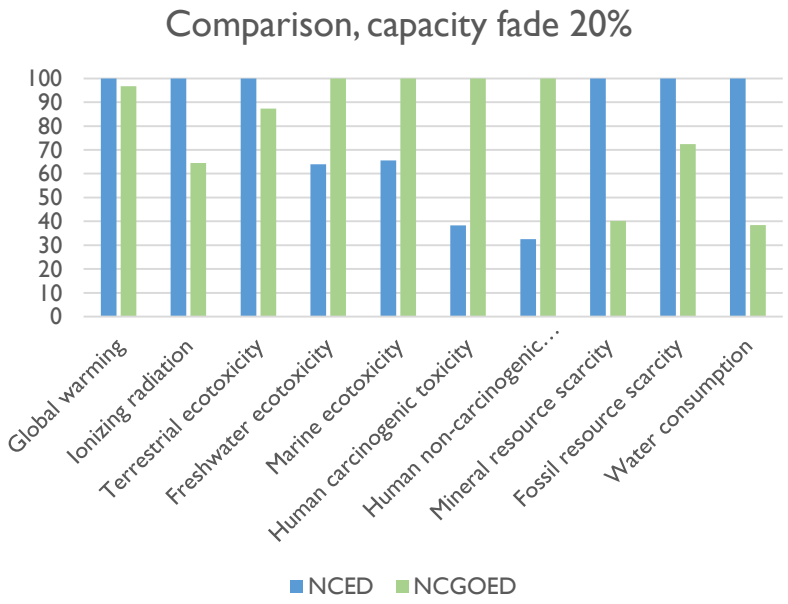
- Electrode functionality: capacity
  - **Rate capability** – initial capacity of material at specific current density, mAh/g
  - **Capacity (retention) fade** – drop of capacity with cycling (charge-discharge of the electrode)
- Functional unit(s)
  - To store1000mAh of current over the lifetime of the electrode material defined by capacity fade of 20% and 30% (at 1A/g current density)

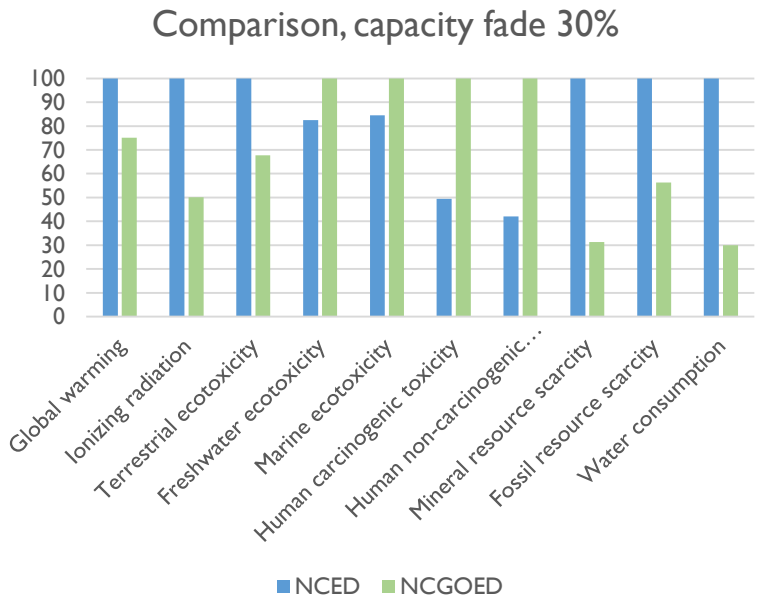
$$FU = X \cdot \frac{\sum_{n=1}^{n=n_{EOL}} \left\{ \frac{\sum_{i=1}^{i=n} C_i}{n} \right\}}{n_{EOL}}$$

X – amount of deposited electrode material
n_{EOL} – number of cycles before reaching capacity fade
C_i – rate capability

RESULTS

- Main comparison

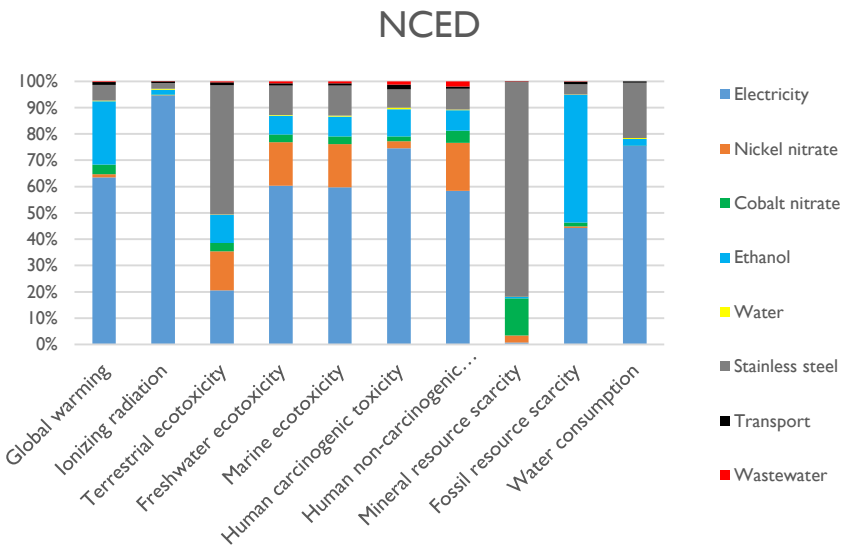


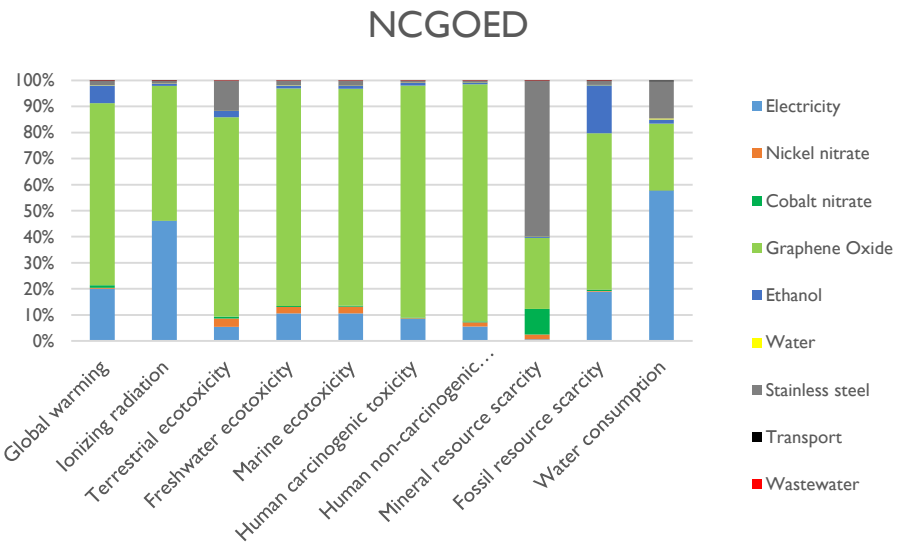


Trade-offs between toxicity and climate/ resource impacts with the addition of GO.

RESULTS

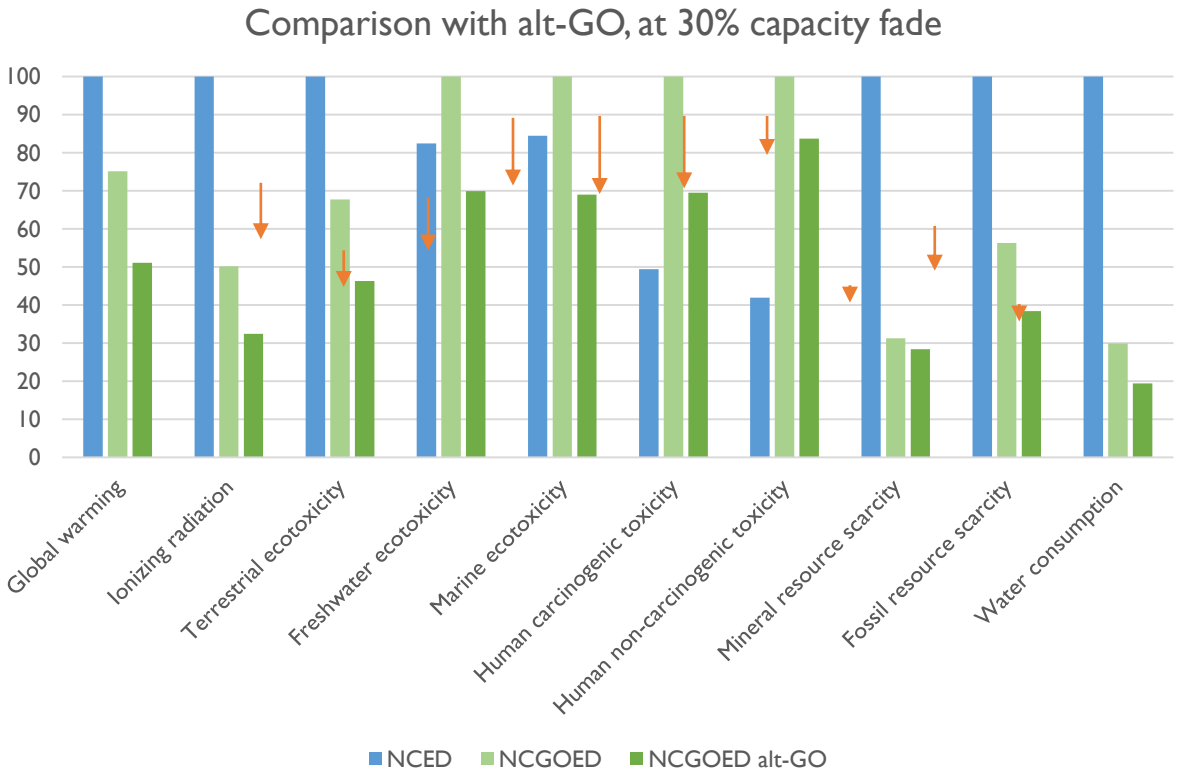
- Impact contributions





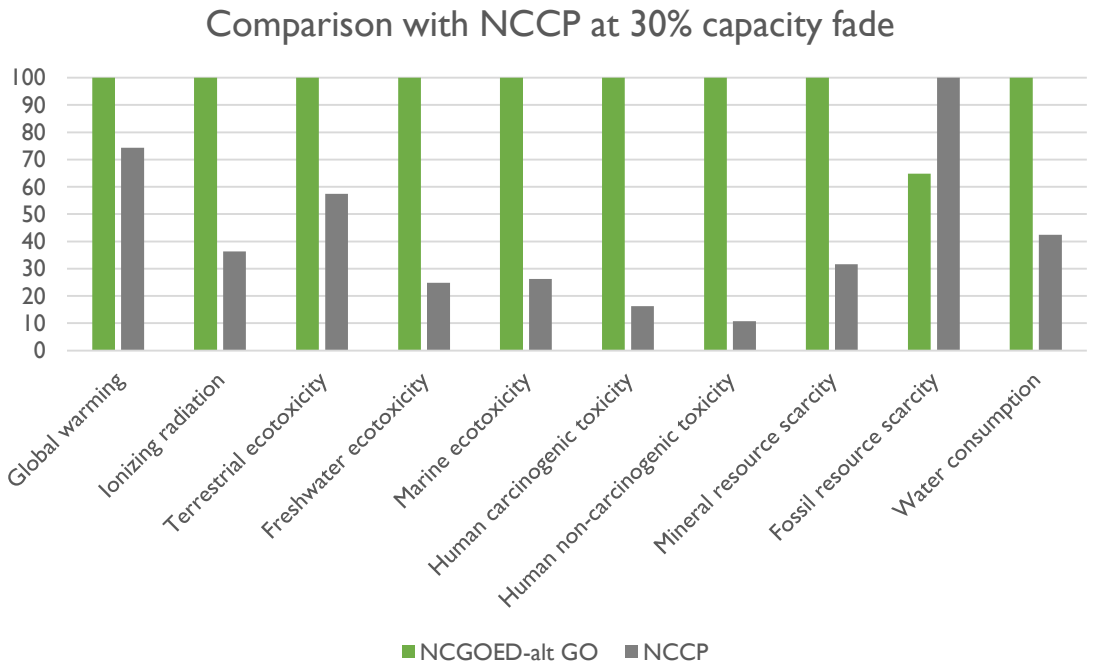
RESULTS

- Sensitivity analysis



DISCUSSION

- Comparison with mature technology process: coprecipitated Ni-Co electrode



CONCLUSIONS

- Addition of GO preferable especially at the higher allowance for capacity retention fade (of 30%)
- Choice of GO production route significant for environmental impact reduction of NCGOED
- Electrodeposition less preferred to more mature technology process of coprecipitation

FUTURE WORK

- Investigate consequences of improved performance of additional heating stage
  - Early experiments suggest potential increase in capacity values by approximately 30%
  - Potential of NCGOED to be more competitive to NCCP electrode
- Consider wastewater in amore detailed manner
- More sensitivity and uncertainly analysis

THANK YOU!

- Acknowledgments:

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https://cyvigroup.org/

QUESTIONS?

REFERENCES

- Cossutta, M., McKechnie, J. & Pickering, S.J., 2017. A comparative LCA of different graphene production routes. *Green Chemistry*, 19(24), pp.5874–5884.
- Zaaba, N.I. et al., 2017. Synthesis of graphene oxide using modified hummers method: solvent influence. Procedia engineering, 184, pp.469–477.