42nd Cement and Concrete Science Conference
11-12 September 2023
Imperial College London, United Kingdom

A sensitivity analysis on the upscaling of a novel bauxite residue vitrification technology: An ex-ante life cycle assessment case study

Maria Georgiades [a,1], Cansu Özcan Kilcan[b,2], Michiel Giels [c,3], Tobias Hertel[c,4], Alan H. Tkaczyk[b,5], Christopher Cheeseman [a,6], Rupert J. Myers [a,7]
[a] Department of Civil and Environmental Engineering, Imperial College London, London, SW7 2AZ, UK
[b] Institute of Technology, University of Tartu, Nooruse 1, 50411 Tartu, Estonia
[c] KU Leuven, Department of Materials Engineering, 3001 Leuven, Belgium
Email: [1]maria.georgiades19@imperial.ac.uk

ABSTRACT
Cement production continues to be a major contributor to global CO_2 emissions, primarily emerging from the clinkerisation of limestone and fossil-based fuel mix. Significant efforts are being directed towards mitigating these emissions through well-established and emerging measures including the adoption of alternative fuels, carbon capture and storage, alternative raw materials, and supplementary cementitious materials (SCMs). An example of such emerging technology is the vitrification of bauxite residue (BR) as an SCM, but due to the relatively low technology readiness level (TRL) of this technology, assessing its environmental impacts at an industrial scale is challenging. This study focuses on evaluating the environmental performance of BR vitrification as an exemplar emerging low carbon cement technology, by examining the different data scales and upscaling approaches.

An ex-ante, cradle-to-gate, life cycle assessment was performed in Activity Browser 2.8 based on a functional unit of 1 kg of treated BR suitable as an SCM in blended cement. The environmental performance of the vitrification technology was evaluated at laboratory, pilot and industrial scale. Upscaling to the industrial level was performed by considering multiple approaches i.e., proxy technology, regression analysis, thermodynamic software, and process modelling. Six industrial scale scenarios were developed: (1-2) proxy technology – ceramic tile production (using two different inventory data sources), (3-4) regression analysis (power and linear), (5) thermodynamic calculations, (6) process modelling. Background processes were modelled based on Ecoinvent (v.3.9.1) assuming a European geographical context.

Results showed improvements in all impact categories during upscaling from lab to pilot (between ~74-92%) and from lab to industrial scale (~88-100%) (Figure 1). This result highlights the significant influence of upscaling on improving process efficiency and hence the substantial impact reduction. Comparing the industrial scale results shows a small variance in all impacts categories. For instance, the reduction in global warming potential for the industrial scale scenarios were similar (92%, 88%, 92%, 92%, 91%, and 94% respective reduction in global warming potential). This result suggests that all the upscaling approaches studied here are applicable for early-stage assessment of emerging low carbon cement technologies.

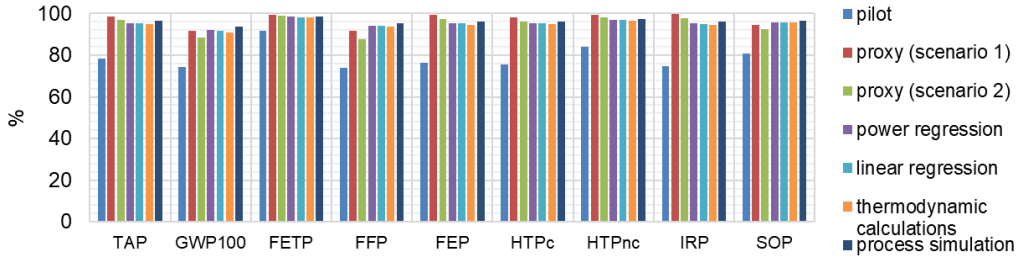

Figure 1: Percentage improvements in impact categories of vitrified BR from laboratory to pilot and laboratory to industrial scale for the six scenarios studied.

Acknowledgement: The research leading to these results was performed within the ReActiv project and received funding from the European Community's Horizon 2020 Programme (H2020/2014-2020) under grant agreement n°958208.

References: Tsalidis, G. A., & Korevaar, G. (2022). *Resources, Conservation and Recycling*, 176.. United Nations (UN). (2017). World Population Prospects Data Booklet 2017.