

How can process simulation be used to get more reliable data for LCA of mining emerging technologies?

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1. Introduction

In the context of the Raw materials initiative launched by the European Commission in 2008, that aims notably at ensuring access to raw materials and fosters sustainable supply of raw materials from European sources [1]; the European funded research project IMP@CT¹ goal is to unlock the access to small complex mineral deposits (particularly of critical materials) existing in Europe. The project's main objective is to develop modularized mobile plants (MMP) that can economically operate different types of ores in different types of geological and geographical contexts. More specifically, the project aims at deploying a pilot MMP that contains new technological methods related to mining, mineral beneficiation and waste and water management.

The environmental sustainability of the developed new technologies is assessed through Life cycle assessment (LCA), notably the potential benefits against business as usual (BAU) solutions. Emerging technologies developed in the case of IMP@CT have low Technology Readiness Levels (TRL), i.e. are developed at lab or pilot scale. This means that operational data for foreground inventory modelling are only available at that scale. In this context, two challenges arise in the environmental assessment of IMP@CT technologies: 1/ the upscaling effect: how can we ensure that pilot technologies and BAU ones are comparable and that this comparison is made of reliable data 2/ contextual assessment of IMP@CT technologies: how can we provide conclusions depending on different scenarios based on the geological and geographical contexts?

This paper aims to treat these two challenges by coupling process simulations and life cycle inventory (LCI) models in a specific Excel tool developed for the IMP@CT project.

2. Materials and methods

In mineral processing engineering, since the 1960s, process models are developed to predict performances of an industrial mineral processing plant based on lab/pilot-scale experimental data [2]. For sizing a plant, in a simplified way, each unit process of the system is mathematically modeled and experimental data are used to calibrate the model. Once it has been calibrated, the model can be used to simulate the system at its "industrial scale", i.e. for given flow rates [3]. Process simulation has been used in several cases in the field of raw materials to simulate newly developed technologies [4], [5] as well as in environmental assessment of raw material recovery as described in [6].

The outputs of process simulation consist in each unit process operating variables notably in terms of flow rates (for solids and liquids), energy and reagents consumptions. These variables are direct inputs for the LCI foreground modelling. In the case of the IMP@CT project, process simulation is used to calculate data on the MMP operations at industrial scale. To complete the foreground modelling, experimental data as well as experts judgments and literature data are used. Given the particularity of modularity of IMP@CT technologies, the LCI foreground modeling must adapt to the type of treated mineral ores and take into account the geographical context. In the case of the project, the process simulation is performed using USIM PACTM software, the ecoinvent v3.4 database is used for the LCI background modelling and the LCA calculation is performed using Simapro v8.5 with the ILCD impact assessment method.

3. Results and discussion

To link the different LCI foreground modelling specific to the treatment of 1 ton of ore using the MMP while keeping the adaptability to assess different scenarios of MMP deployment, a coupling between process simulation outputs and LCI inputs is proposed in a specific Excel tool. The tool's architecture is presented in Figure 1. It allows to take into account all the necessary information for LCI foreground modelling in separate

¹ <http://impactmine.eu/>

sheets as well as all information concerning the goal and scope of each scenario to assess (type of treated ore, amount treated, geographical context...).

A complete LCI for the foreground is then compiled, calculated and converted into ecoinvent nomenclature, in a specific sheet of the tool that can directly be imported within Simapro to perform LCA calculations.

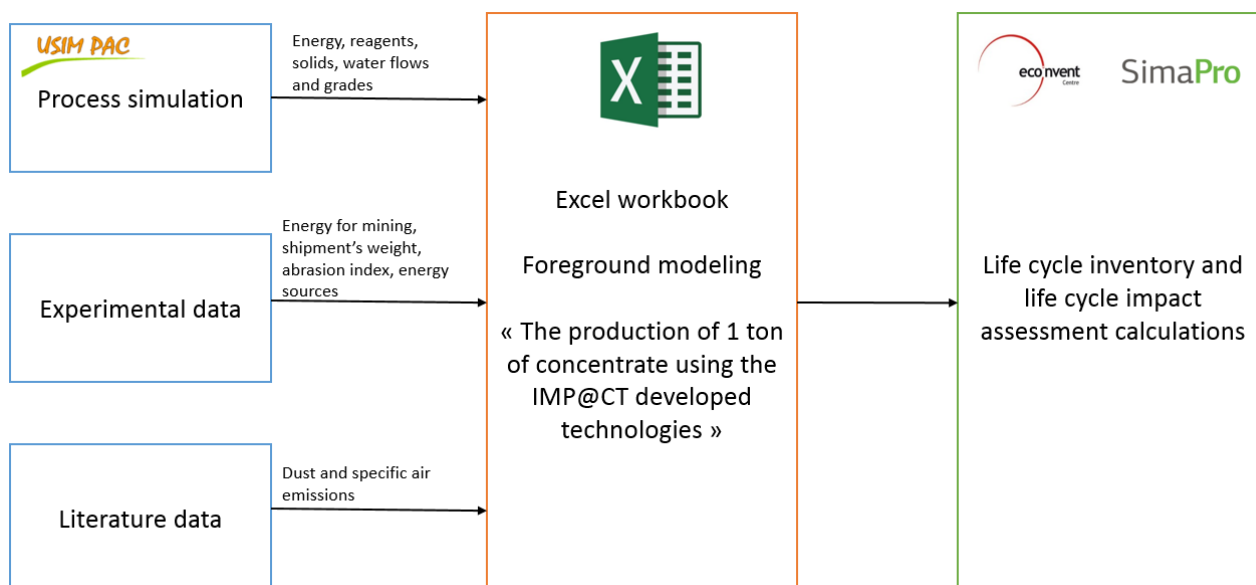


Figure 1: Description of the coupling concept

4. Conclusions

To use mineral processing simulation alongside LCA allows the environmental assessment of emerging technologies to be built on more reliable data notably when upscaling effects arise. This coupling is here illustrated using the raw material sector but could be used in any other field where process design is used to develop emerging technologies. Finally, the developed tool gives the ability to assess different kinds of scenarios specific to the IMP@CT project. At the end, by answering the challenges of upscaling effects and adaptability, results obtained can be used by decision makers for both eco-design approaches and benchmark assessments.

5. References

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