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The CO_2 Capture tool for refineries: a new approach to analyze CO_2 capture in a multiple stack cluster

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Abstract

To achieve the long-terms goals set by the Paris Agreement, there is an urgency for the decarbonization of all sectors, including industrial sites with multiple point sources of CO_2. Post-combustion capture is one of the technologies that can help with the decarbonization of industrial clusters. Even though post-combustion CO_2 capture is energy-intensive, its application allows a significant reduction of CO_2 emissions in refineries (Johansson, 2013). There is a need to develop different strategies for refineries to decrease their CO_2 emissions. A cluster approach where multiple stacks are linked to the same CO_2 capture infrastructure seems an effective way to decrease the emissions of a cluster in a cost-effective manner.

Previous works have discussed some aspects of multi-source CO_2 capture at refineries (van Straelen et al., 2009; Nakao et al., 2021). Van Straelen et al. (2009) investigated a refinery with multiple CO_2 courses and evaluated the combination of various CO_2 sources in a joined stack, creating one point-source situation. Nakao et al. (2021) investigated the multi-absorber/single stripper concept as one of the alternatives for dealing with the multiple CO_2 sources point emissions at a refinery, compared with implementing one large absorber/stripper plant and the implementation of a single plant for each source.

Optimizing multiple CO_2 source scenarios is a complex problem, where both process design, process operation and investment and operating costs influence the results. In the EU-project REALISE, TNO and NTNU are developing the CO_2 capture tool for refineries. While the CO_2 capture tool is developed specifically for refineries, it can be used for other multiple stack scenarios if needed. The idea of the tool is that based on input parameters of different stacks in a certain cluster (e.g. flue gas flow rate, CO_2 concentration, temperature), the model can calculate the most effective CO_2 capture solution for the whole cluster based on constraints and requirements of the site.

An advantage of the tool is that it is a fast-running model, meaning that no process simulations are done in the tool itself. To achieve this, a database will be built that will contain a large number of simulation results from a standard CO_2 capture plant modelled in CO2SIM software. This database will contain numerous cases (e.g. large range of CO_2 content and solvent flow rates) so that different industrial site's scenarios can be evaluated. From the simulation database, the relevant process simulation results can be taken for the different stacks and can be used in another part of the model, where the relevant equipment can be sized, and cost calculations can be performed. This means that

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instead of the conventional energy optimization of CO_2 capture plants, the tool can also be used to optimize the CO_2 capture plants from a different perspectives, such as minimization of CAPEX or minimization of footprint, using the constraints set by the industrial cluster. This approach is schematically shown in **Figure 1**.

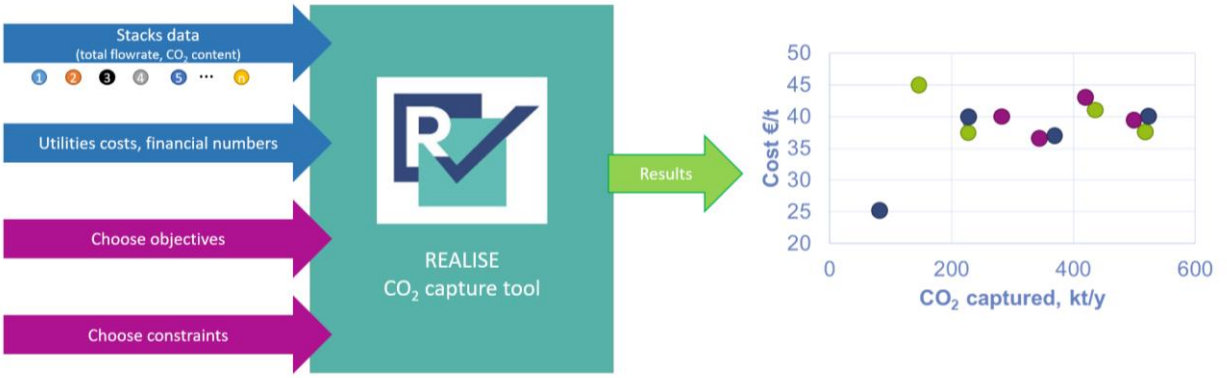

Figure 1. Conceptual visualization of the CO_2 capture tool for refineries, as created in the REALISE project.

Upon successful completion of the tool in the REALISE project, the tool will be made publically available so that refineries and industrial clusters can use it.

In the present work, the developed tool is used to evaluate cases containing up to five CO_2 point sources with different CO_2 contents (3 – 20% vol wet basis) and gas flow rates (varying from 50000 m^3/h to 500000 m^3/h). The CO_2 capture costs, the costs connected to the operation and size of the units will be presented. Based on the obtained results, recommendations will be given for each case studied, and the feasibility discussed, also considering the ease of the operation and the required area.

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