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Environmental and Techno-economic Feasibility of a BCCUS project:
the CO2SERRE case study in Centre-Val de Loire (France)

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Abstract

The setting up of negative emissions appears more and more as a means to achieve the ambitious objectives of future GHG emissions reductions. Capturing, storing and/or valorising CO₂ issued from biomass is a promising way to obtain these negative emissions. With this objective, the CO2SERRE project studies the techno-economic and environmental feasibility of implementing an innovative “BCCUS” pilot in France (Centre-Val de Loire). The concept consists in capturing CO₂ from a biomass cogeneration plant in Orléans, valorizing it in local greenhouse farms, and storing the unused CO₂ in geological reservoirs in the region.

To feed the techno-economic and environmental feasibility assessment, each stage of the CCUS chain has been considered and assessed: capture, transport, geological storage, and use in greenhouses. This paper presents the CO2SERRE project's final outcomes on the technical feasibility of the process, as well as on its viability on both economic and environmental sides.

Dalkia Biomasse Orléans (DBO) facility emits around 80 kt of CO₂ per year. Data on the plant process and its emissions have been collected. A post-combustion capture by chemical absorption with monoethanolamine (MEA) is considered. The different options for transporting the captured CO₂ have been studied, mapped and optimized. The use of pipelines (with CO₂ in supercritical phase) is considered for transport to the storage site, while the truck option is considered for transport of liquefied CO₂ to the greenhouses. Based on the current practice of CO₂ consumption in greenhouses and the needs of the producers of the region, the potential for captured CO₂ use in greenhouse in the Orléans region has been estimated to 10 kt/year. Finally, the underground storage capacity in the geological formations of the Paris Basin has been studied through modelling of reservoir behaviour according to well location and injection rate. The targeted reservoir would be able to store over 1 Mt/year, which is almost equivalent to the total annual emissions of the region Centre-Val de Loire.

An environmental assessment has been carried out on the whole capture – transport – storage – utilization chain, using Life Cycle Analysis (LCA). The system with CCUS has been compared to the actual situation without CCUS, and different scenarios has been considered according to the source of energy for capture process (steam from DBO or from a gas-fired power plant; with or without energy valorization of the DBO exhaust gases). The analysis shows that, globally, implementing CCUS in our case study avoids more environmental impacts than it generates. Avoided

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impacts are higher when the energy for capture comes from DBO, but it generates a gain loss for the operator. Also, valorising the exhaust gases energy is interesting especially when using energy from the gas-fired plant. Concerning valorisation of the CO₂ in greenhouses, the outcomes show that the highest the share of valorization compared to storage, the lowest are the environmental impacts.

The technico-economic analysis (TEA) of the project assesses the economic viability of the whole concept, in which carbon is considered as an input for growing plants. The TEA values the overall carbon capture, transport and storage costs of the project, and compares this avoided carbon price with the actual price already paid by local greenhouse operators. While both TEA and LCA take account of a sole carbon source, biomass burning, the CO₂SERRE concept could be extended to other sources of carbon coming from biomass use, like beetroot fermentation in sugar refineries. An evaluation of the sensibility of the LCA results from the value of its different parameters is performed: compared time profile and volume of carbon emission by biomass burning and use by greenhouse, transport options, and reservoir types.

Keywords: CCUS, BCCS, biomass energy, negative emissions, CO₂ valorization, circular economy, techno-economic evaluation, LCA, environmental evaluation
