Capture and storage of CO₂ from fossil fuel combustion is gaining attraction as a mean to tackle climate change. This technology can contribute to a large reduction of the atmospheric greenhouse gases (GHG) concentration. In this study, we are dealing with a variant CCS system where the stored CO₂ comes from biomass instead of fossil fuels. Several industrial sectors could be investigated like the paper industry, the electric sector, or the biofuel sector. According to (Kheshgi and Prince, Energy, 2005), this last option called BCCS (Biomass & Carbon Capture and Storage) may be considered as a relatively cheap solution, in favourable conditions, which can potentially contribute to a net GHG emission reduction, seeing that CO₂ from biomass is considered neutral. Moreover, although the amount of CO₂ that is emitted most biofuel distilleries is small (about hundred times lower than steel works for example), the IEA CCS Roadmap (2009), emphasizes that this system has the global potential to store about 2 Gt of CO₂ by 2050, assuming that biofuels account for 26% of the total transport fuel demand (BLUE map scenario).

Based on these qualitative observations, the CPER Artenay project presents a real study case to quantify the environmental benefits and study of the technico-economic feasibility of the application of BCCS systems in the biofuel sector.

The study is located within an area of 900 km² south of Paris - France. This zone is highly attractive because of the particularly favourable capability to match sources and sinks. Two sugar beet distilleries, which produced more than 100 000 m³ of bio-ethanol (~200 000 t CO₂ all processes included) in 2005, are located right above two major deep aquifers (the Dogger and the Keuper deep saline aquifers) that might be used for CO₂ storage.

**Geological and Technical issues:** CCS systems design obviously depends on the geology of the CO₂ storage. The first step of the study was to build up a conceptual geological model with a particular challenge for ‘deep aquifer’ storage due to the scarcity of available data. The approach used is based on the interpretation of 300km of seismic lines combined with a sedimentological study and analysis of 50 existing wellbores data. In the area of interest, a sequential stratigraphic analysis and geostatistical simulations. Three major normal faults crossing the area were identified, among which the Sennely Fault which affects all formations from the basement to the Lower Cretaceous. The layers on the study area are nearly sub-horizontal, except close to the faults where bends (drag folds) can be observed. The geological model is used to elaborate a flow model to estimate the injectivity and the extension of the overpressure within the open aquifer and the CO₂ plume after 30 years of
injection. The injection strategy and pattern is optimized to ensure the safest operational conditions. Furthermore, the main migration scenarios are investigated following the risk assessment.

To ensure safety and cope with public acceptance, the relevant risks are assessed and a risk management plan is developed for the site. The methodology used has been developed within CRISCO2 project (O. Bouc et al., GHGT-9, 2008). It is based on the assessment of the potential effects of risk events judged relevant by an expert panel, given the results of the previous geological characterisation, the results of the dynamic simulations and the analysis of a number of maps of the site showing the vulnerability of the environment, external hazards, etc. The potential exposure of vulnerable assets resulting from these risk events is estimated and safety requirements are deduced from its comparison to critical thresholds. This methodology focuses on simple, but realistic physically-based modelling and addresses uncertainty management. It is worth underlining that risk assessment for a BCCS system needs to take account of the associated compounds in the flue gas, which are significantly different from the case of fossil fuels CCS, ie Votatil Oil Components, acetaldehydes, and oxygen.

**Life Cycle Analysis and Economics:** To quantitatively assess the interest of BCCS, a Life Cycle Analysis (LCA) and an economical analysis were performed on this real case study with CO₂ capture either on the fermentation process alone, or on all the involved processes (fermentation, power production, steam generation). There are peak of energy needs and CO₂ flow rates (fermentation and combustion) during sugar beet harvests. The size of installation providing steam and electricity in bioethanol production and CO₂ capture process is a key driver for project profitability. An optimization analysis was proposed between installations size and CO₂ volume captured during the harvest (some CO₂ might be not captured during harvest to limit energy and investment requirements).

The major results of this study show that even though the size of Artenay sugar beet distillery is limited, reasonable profitability with about 60% GHG reduction compared to base case (no CCS) can be achieved when CO₂ is captured on the fermentation process only. In that case stored CO₂ generates EU Allowances (EUA) which compensate for credit buying for combustion process. Economical balance is harder to achieve without subsidies considering CCS on the whole process (CO₂ from combustion is considered non-emitted and fermentation EUA are sold on markets). However, in that case a net carbon sink can be created resulting in the storage of CO₂ from the atmosphere (about 5% of the fossil fuel CO₂ emitted without CCS).

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