IEA Bioenergy

# Implementation of bio-CCS in biofuels production

## Summary Series

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### IEA Bioenergy Task 33 special report


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## Summary


In combination with other climate change mitigation options (renewable energy and energy efficiency), the implementation of carbon capture and sequestration (CCS) will be necessary to reach climate targets. If the $CO_2$ released by bio-based processes is captured and stored in geological formation or other storage options, negative $CO_2$ emissions can be potentially achieved.

With this background, this report provides an initial overview of the potential of biomass and waste gasification to contribute to CCS through the assessment of 2 example cases set in Norway and The Netherlands. A description of these possible biofuel routes based on gasification, together with an estimation of the overall costs and potential impact of bio-CCS on greenhouse gas balances, has been presented. The study cases (600 $MW_{th}$ thermal input) have been selected to cover a representative range of gasification technologies, biofuel products and possibilities for CCS infrastructure in countries which offer particularly good opportunities for the implementation of this technology:

- Case 1: production of Fischer-Tropsch syncrude from high-temperature, entrained-flow gasification in Norway.
- Case 2: bio-SNG production from indirect gasification in The Netherlands.

The results have shown that the application of CCS in biofuel production processes can have a considerable impact on the reduction of greenhouse emissions. In both scenarios considered, the addition of CCS to a biofuel production value chain doubles the amount of avoided $CO_2$ from 0.6 to 1.1 Mton/y. This positive impact on the reduction of $CO_2$ emissions comes at a cost: the biofuel production price increases by 10-14%, as shown in Figure 1. Given the significant role of bioenergy expected in the future energy system, we conclude that with the right incentives, biofuel production coupled to CCS can be a powerful tool for $CO_2$ mitigation to reach the global climate targets. The analysis also reveals that it is necessary to modify the current $CO_2$ emission system in order to reward the negative emissions achieved by bio-CCS. If there is an economic value for negative $CO_2$ emissions, bio-CCS can significantly improve the business case with respect to the base case.

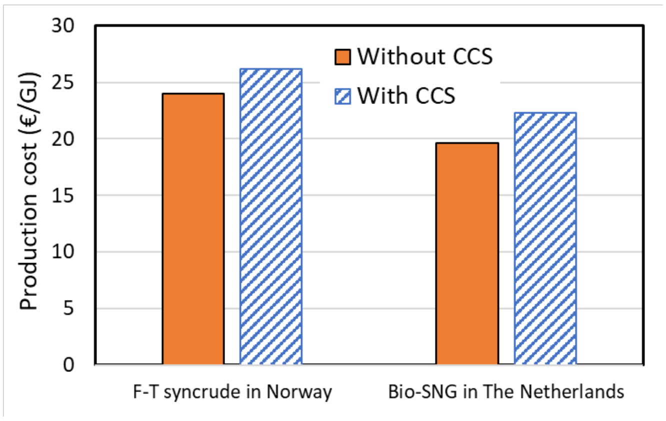


Figure 1. Summary of the effect of implementation of CCS on the production cost of biofuels as considered in this study.

The results of Case 1 show that under the conditions assumed, the cost of production of FT syncrude from woody biomass increases from 24.0 to 26.4 €/GJ, if the costs of $CO_2$ compression and cooling, transport and storage are included in the overall value chain. The analysis also shows that the economic impact of including CCS is very sensitive to the $CO_2$ transport cost, the overall FT syncrude production cost increased from 26.4 to 30.8 €/GJ (by 17%) when $CO_2$ transport cost increased from 0.09 to 0.36 €/ton/km. Possible compensation measures of the higher FT syncrude production costs resulting from the implementation of CCS include the reduction of feedstock supply costs, or the increase in the market value for bio-based LNG (which is a by-product, thus a revenue in the process), or the increase in the credits for $CO_2$ capture. The following assessments are presented: 1) 25 wt.% of the input woody biomass is replaced by sewage sludge with a gate fee of 10 €/ton; 2) the price of bio-based LNG is increased by 25%(from 20 to 25 €/GJ); or 3) the $CO_2$ credits are increased by 100% (50-100 €/ton). The results show that substitution of the wood with sewage sludge or increase of the $CO_2$ price will not improve the overall economic viability significantly, and also the price of the natural gas or $CO_2$ credits had only a minor effect on the FT syncrude costs.

As for Case 2, the results show that under the conditions assumed, the production cost of bio-SNG increases by approximately 14%, from 19.6 €/GJ to 22.3 €/GJ, when adding CCS to the bio-SNG process. Transport and storage of $CO_2$ contribute with 5.3% to the total SNG production cost. By applying pre-combustion technology (amine scrubbing in this case) to indirect gasification, approximately 1/3 of the initial carbon contained in the biomass can be captured (the rest ending up in the flue gas side of the indirect gasifier). The cost (and thus the origin) of biomass has an important effect on the production cost. Under the assumptions of this work, the threshold biomass price for the project to become financially feasible is around 8 €/GJ. Under the reference conditions considered in this study, a breakeven $CO_2$ price of approximately 30 €/ton has been determined, which indicates the need for the modification of the current $CO_2$ emission system to account for the negative emissions achieved by bio-CCS. The economic feasibility of bio-SNG + CCS is also very sensitive to the price of the bio-SNG product. The breakeven cost of bio-SNG is 17.8 €/GJ according to the assumptions taken. The investment cost has a dramatic effect on both the bio-SNG production cost and the ecomomic feasibility of the project. Under the conditions assumed, it would be necessary to reduce the investment costs below 1180 €/kW input for the project to become profitable. Thus, a significant effort needs still to be performed in the coming years for the demonstration of bio-SNG at large scale in order to reduce the capital costs.

The results of this preliminary assessment study have identified opportunities and challenges for the implementation of bio-CCS schemes. Detailed cost analyses, other locations and technological solutions other than mentioned in this exploratory study, as well as extrapolation of the results to a more global perspective and the study of the integration of the produced $CO_2$ in power to fuel/chemicals schemes (carbon utilization), are topics beyond the scope of this project which should be addressed in more detail in future work.