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# $CO_2$ Biomethanation as an enabling process for carbon recycling and utilisation – critical review of gaps and opportunities for future scale-up in the UK

# Biomethanation-CRU

## INTRODUCTION

$CO_2$ Biomethanation is the biological conversion of carbon dioxide and hydrogen to biomethane via the action of hydrogenotrophic methanogens and can be used as part of a carbon capture and utilization scheme as shown in figure 1. In this work a biomethanation integration scenario was developed with four carbon intensive industries: cement, steel, distillery (for potable distilled spirits) and pulp and paper. For each, an exemplar **baseline** process was chosen, which was extended to produce a high-level design of the integration scenario. Relevant mass and energy flows were quantified based on reaction stoichiometry and literature data. Subsequently this data used to estimate the carbon footprint, using an approach summarized in figure 2, as well as additional costs, associated with the process integration only considering the differences between the **baseline** and **decarbonised** processes.

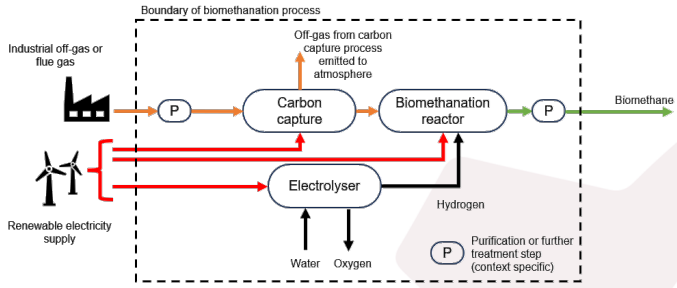


*Figure 1. The biomethanation process.*

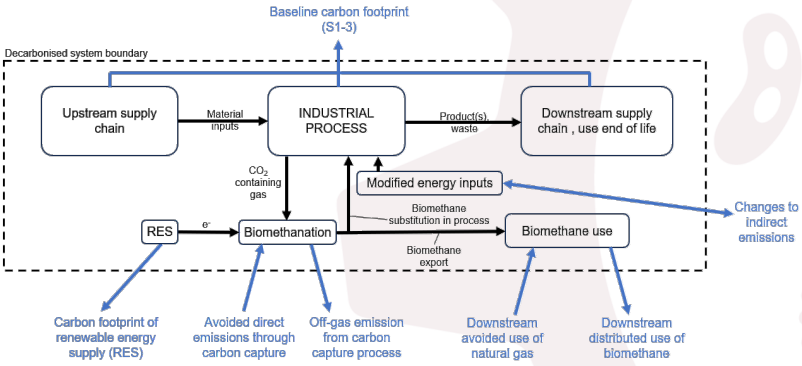


*Figure 2. Generalised methodology for carbon footprint calculation.*

## RESULTS

For the other four industries considered, it was found that biomethanation can result in substantial decarbonisation, ranging from 0.70-2.87 $tCO_{2e}$/ $t_{product}$ as shown in figure 3. Where the carbon source was biogenic (pulp and paper, distillery) the decarbonisation replaced all direct fossil emissions with equivalent biogenic emissions. It was found to be critical to achieve decarbonisation that electricity be renewable and ideally to be from the lowest carbon options e.g. wind, solar.

The decarbonisation was mainly driven by the substitution of natural gas with biomethane, both in the industrial process and exported to downstream applications. For industries where the carbon source was biogenic (distillery, pulp and paper) this effect was more pronounced such that decarbonisation via biomethanation could be more effective than direct electrification (i.e. removal of direct fossil GHG emissions).

Economic assessment predicted significant increases in production cost for (+37-1070%) which , due to uncertainties involved, should be treated as indicative. Additional costs are dominated by hydrogen production which is predicted to remain high into the future even where curtailed electricity is targeted.

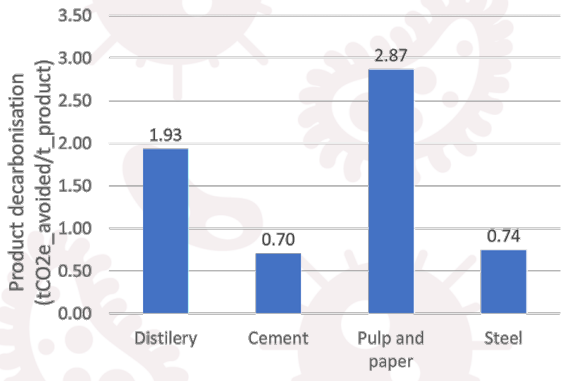


*Figure 3. Product decarbonisation results for the four industries considered*