**Consequential life cycle assessment of carbon capture and utilization technologies within the chemical industry**

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**Electronic Supporting Information:**

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| **File name** | **Sheet name** | **Description** |
| CCU-LCI.xlsx | LCI\_CCU\_2018\_near\_term | Includes the foreground system of each alternative under analyses in the near term scenario, in a matrix format, also includes the links with the background system and the names of the ecoinvent 3 datasets used in the analysis. |
| CCU-LCI.xlsx | LCI\_CCU\_2018\_long\_term | Includes the foreground system of each alternative under analyses in the long term scenario, in a matrix format, also includes the links with the background system and the names of the ecoinvent 3 datasets used in the analysis. |
| CCU-LCIA.xlsx | LCIA | Includes the life cycle impact assessment results of the alternatives for 15 impact categories |
| CCU-LCIA.xlsx | Correlation\_Analysis | Includes an analysis of the coefficient of determination for each alternative comparing the GWP values with the values of the other impact categories |
| CCU-LCIA.xlsx | Contribution\_Analysis\_near\_term | Includes the absolute and relative contribution values for each process within the alternatives for the near term scenario |
| CCU-LCIA.xlsx | Contribution\_Analysis\_long\_term | Includes the absolute and relative contribution values for each process within the alternatives for the long term scenario |
| CCU-LCIA.xlsx | Ranking | Includes the Ranking of the alternatives in each impact category for the near and long term scenario as well as the deviation between the near and long term scenario |
| CCU-SA.xlsx | Sensitivity\_Analysis\_near\_term | Includes the results of the sensitivity analysis changing the electricity and heat supplier for each alternative in the near term scenario |
| CCU-SA.xlsx | Sensitivity\_Analysis\_long\_term | Includes the results of the sensitivity analysis changing the electricity and heat supplier for each alternative in the long term scenario |
| CCU-UA\_MCS\_nt.csv  CCU-UA\_MCS\_lt.csv |  | Includes the results of the Monte Carlo simulation (1000 runs) for each run and alternative |
| CCU-UA\_MCS\_stats\_nt.txt  CCU-UA\_MCS\_stats\_lt.txt |  | Includes the statistical data (minimum, 1st quartile, median, mean, 3rd quartile, maximum, standard deviation) from the Monte Carlo simulation (1000 runs) of each alternative for the near and long term scenario respectively |
| CCU-UA\_pairwise\_diff\_nt.txt  CCU-UA\_pairwise\_diff\_lt.txt |  | Includes the results of the pairwise differences of values obtained from each iteration of the Monte Carlo simulation. "BaseRoute" and "AltRoute" are the routes to be compared. "Percpos" "Percneg" "Percequ" indicate the percent of values that are positive, negative, equal, respectively in the distribution of pairwise differences (Where a positive value of the difference means that the base route performs worse than the alternative route). "Percscal" is calculated as median(BaseRoute) / median(BaseRoute) \* 100 and is a measure of the impact of one route compared to the impact of the other |
| CCU-UA\_Wilcoxon\_test\_nt.txt  CCU-UA\_Wilcoxon\_test\_lt.txt |  | Includes the results of the pairwise Wilcoxon test for all alternatives |

Table SI.1 Index of SI materials.

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| CO2 utilization technology | Description | Reference | TRL | Purity of CO2 | Reaction | |
| Pressure (P) | Temperature (T) |
| Methanol production | Hydrogenation of pure CO2 | 4,10,17,18-20 | 5-921-26 | High pure CO2 | 50 bar27 | 493 K27 |
| Methane production | Hydrogen + CO2 (Sabatier-synthesis) | 4,7,10,19,20,28 | 5-921-26 | Concentrated CO2 source | 8 bar29 | 280 °C29 |
| Polyol production | Propylene Oxide + glycerol + monopropylene glycol + CO2 | 3,8,30 | 6-923-26,31 | High pure CO2 | 20 bar3 | 135 °C3 |
| Ethanol production | Electrochemical reduction of CO2 | 5 | 1-521,25,26 | High pure CO2 |  | High temperature |
| Dimethyl carbonate (DMC) production | Ethylene carbonate transesterification (Asahi process) | 6,32 | 9 (commercial since 1950s) | High pure CO2 | 40 bar6 | 190 °C6 |
| Carbon monoxide production | rWGS | 4,7,10 | 7-826 | High pure CO2 | 0 bar33 | 850-950 °C33 |
| DRM | 7 | 4-721,26 | High pure CO2 | 20 bar33 | 1000 °C33 |
| Dimethyl ether (DME) production | Production from syngas | 8,20,34 | 1-326 <<725 | High pure CO2 | 50 bar8 | 160 °C8 |
| Formic acid | Electrochemical reduction of CO2 at low pressure | 9,35 | 3-721,25,26 | High pure CO2 | 3 bar9 |  |
| Hydrogenation of pure CO2 | 10,36,37 | 2-521,22,26 | High pure CO2 | 105 bar36 | 93 °C36 |
| Fisher-Tropsch products | Jet fuel production Hydrocarbons | 11,38 | 5-921,25,26,31 | High pure CO2 | 20-40 bar11 |  |
| Dimethoxymethane (DMM) production | Condensation reaction from methanol and formaldehyde Purely reductive approach | 12 | 4-5 (own assessment) | High pure CO2 | 80 bar12 |  |

Table SI.2 Detailed description of the investigated CCU technologies stating the data source, technology readiness levels, purity of CO2 needed for the conversion technology, and reaction conditions

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| Marginal mixes39 | | | | | |
| Market scenarios | Total capturable emissions [Mt/year] | CO2\_near\_term [Mt/year] | CO2\_near\_term [%] | CO2\_long\_term [Mt/year] | CO2\_long\_term [%] |
| Fermentation | 18 | 18 | 7.20% |  |  |
| Bioenergy | 66 | 66 | 26.40% |  |  |
| Hydrogen | 46 | 46 | 18.40% |  |  |
| Ammonia production | 128 | 120 | 48.00% | 8 | 0.39% |
| Iron and steel | 500 |  |  | 500 | 24.39% |
| Ethylene | 234 |  |  | 234 | 11.41% |
| Cement | 1700 |  |  | 1308 | 63.80% |
| Total | 2692 | 250 | 100.00% | 2050 | 100.00% |

Table SI.3 Composition of the marginal mix for CO2 in relative and absolute values for the near and long term scenario

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