**Supplemental Data for “Process Design and Techno-Economic Analysis of Biomass Pyrolysis By-Product Utilization in the Ontario and Aichi Steel Industries”**

McMaster University, 1280 Main Street West, Hamilton, Ontario, Canada, L8S 4L7

\*Corresponding Author: tadams@mcmaster.ca

Revenue gained from by-product combustion in Ontario was calculated based on a current natural gas price of 3.53 CAD2021/ GJHHV (Ontario Energy Board, 2021; Union Gas, 2017) and grade to grave life-cycle emission factor of 50.4 kgCO2e/GJHHV (Environment and Climate Change Canada, 2020b) combined with the 2022 carbon price of 50 CAD2021/tCO2e (Government of Canada, 2019). As for steam coal in Aichi, a price of 518 JPY2021/GJLHV (Agency for Natural Resources and Energy, 2020; PPS-NET, 2021), an emission factor of 89.1 kgCO2e/GJLHV (Agency for Natural Resources and Energy, 2020), and a carbon price of 289 JPY2021/tCO2e (Kojima & Asakawa, 2021) were used. Since carbon taxes will likely increase in the coming years, a future scenario in 2030 was considered for each location as well. In Ontario, a 2030 carbon price of 170 CAD2021/tCO2e was used, as this is the carbon price set by the current federal government (Environment and Climate Change Canada, 2020a). In Japan, there are no official plans to increase the carbon tax in the future, but analysts have suggested that it may increase to 11,400 JPY2021/tCO2e by 2030 (Kojima & Asakawa, 2021), and so this value was used as a projection.

In Canada, the carbon tax is based on average gate to grave emission factors of fossil fuels (ECCC, 2017). To calculate the emission factor of the natural gas in Ontario based on available data, the ReCiPe2016 midpoint values of 34 kgCO2e/kgCH4 of and 298 kgCO2e/kgN2Owere used (Huijbregts et al., 2016) for methane emissions in the data. For the Aichi case, the total emission factor was given directly in the source. It is not explained what the system boundaries are for calculating emissions for the Japanese carbon tax (Ministry of the Environment, n.d.), so it was calculated using the same system as Canada.

The values for cost savings calculations, with currencies converted to USD2021, are available in Table 1.

Table 1: Values used for cost savings calculations. Costs in USD2021

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Fuel | Heat Type | Heat Price ($/GJ) | Emission Factor (kgCO2-e/GJ) | 2022 Carbon Tax ($/t CO2-e) | 2030 Carbon Tax ($/t CO2-e) |
| Ontario NG | HHV | 2.76 | 50.6 | 39.13 | 133.03 |
| Aichi Coal | LHV | 4.73 | 89.1 | 2.64 | 104.07 |

For clarity, the cost of the vapour combustor can be converted to a levelized cost per tonne of biochar produced. Over a 20-year lifetime with 40kt of biochar produced per year, the levelized cost of the vapour combustor is given by Eq.(1). This gives a levelized cost of the vapour combustor to be 7.9 USD2021/t biochar produced. As in the main document, prices only consider future value and do not take into account discount rates.

|  |  |
| --- | --- |
|  | (1) |

Cost savings were calculated using Eq.(2), where *HP* is the Heat Price, *EF* is the Emission Factor, *CT* is the carbon tax, and *LCVP* is the levelized cost of the vapour combustor, as outlined in the main report.

|  |  |
| --- | --- |
|  | (2) |

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