## S1 - gPROMs Model Parameters

|  |  |  |
| --- | --- | --- |
| ***Parameter*** | ***Unit*** | ***Value*** |
| **GT** |
| Thermal efficiency | *%* | 43.1 |
| Compressor pressure ratio | *-* | 1:23.5 |
| Air flow rate | *kg/s* | 783 |
| Air/Fuel ratio | *-* | 35.2 |
| Fine filter ∆P | *Pa* | 1000 |
| Fuel inlet temperature | *oC* | 120 |
| Fuel inlet pressure | *Bar* | 42 |
| Turbine inlet temperature (TIT) | *oC* | 1440 |
| Turbine isentropic efficiency | *%* | 90 |
| Compressor isentropic efficiency | *%* | 90 |
| Mechanical Efficiency | *%* | 99.9 |
| Combustor ∆P | *%* | 5 |
| First stage Nozzle ∆T | *oC* | 44 |
| First stage Turbine pressure ratio | *-* | 2.1:1 |
| Second stage Nozzle ∆T | *oC* | 13 |
| Second stage Turbine pressure ratio | *-* | 2.3:1 |
| Third stage Nozzle ∆T | *oC* | 6 |
| GT Exhaust pressure | *Bar* | 1.033 |
| GT Exhaust temperature | *oC* | 629 |
| **Flue Gas Heat Recovery** |
| HP Steam temperature  | *oC* | 600 |
| HP Turbine Inlet Pressure  | *Bar* | 186 |
| Reheat Steam temperature  | *oC* | 585 |
| IP Turbine Inlet Pressure | *Bar* | 41 |
| LP Steam temperature  | *oC* | 277 |
| LP Turbine Inlet Pressure | *Bar* | 3.7 |
| Condenser pressure | *Bar* | 0.045 |
| CW water supply temperature  | *oC* | 8 |
| CW return temperature  | *oC* | 25 |
| CW supply pressure to condenser | *Bar* | 3 |
| HP, IP & LP Turbine isentropic efficiency  | *%* | 85 |
| Pump isentropic efficiency  | *%* | 70 |
| Generator efficiency  | *%* | 99 |
| Condenser thermal efficiency  | *%* | 80 |
| HRSG thermal efficiency | *%* | 99.7 |
| Economizer steam side ∆P | *%* | 2 |
| Superheat steam side ∆P  | *%* | 1 |
| HRSG gas side ∆P (per tube bank) | *%* | 0.11 |
| Mechanical efficiency (Turbine) | *%* | 99.7 |
| Mechanical efficiency (Pump & Fan) | *%* | 95 |
| Minimum Pinch Temp | *oC* | 10 |
| Booster fan Isentropic efficiency  | *%* | 85 |
| **Reforming Cycle** |  |  |
| Inlet Pressure  | *Bar* | 31 |
| Steam temperature | *oC* | 500 |
| PSA efficiency | *%* | 90 |
| Steam to Carbon Ratio  | *-* | 2.5 |
| Reformer 1 Treact  | *oC* | 913 |
| WGSR Treact   | *oC* | 420 |
| Pre-Reformer Treact | *oC* | 500 |
| Reformer unit ∆P | *%* | 10 |
| **Natural Gas** |
| Methane  | *% vol* | 89.00 |
| Ethane | *% vol* | 7.00 |
| Carbon Dioxide | *% vol* | 2.00 |
| Propane | *% vol* | 1.00 |
| Nitrogen  | *% vol* | 0.89 |
| Butane | *% vol* | 0.11 |

## S2 - Economic Model Parameters

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Unit** | **Value** |
| Discount rate (David Menmuir *et al.*, 2022) | % | 7.8 |
| Interest Rate (Elliott, 2022) | % | 4.0 |
| Productive lifetime (Collodi *et al.*, 2017) | Years | 25 |
| Base year | - | 2023 |
| Year operational | - | 2026 |
| Build Time (David Menmuir *et al.*, 2022) | Years | 3 Years |
| CAPEX expenditure curve (Collodi *et al.*, 2017) | % | 20/45/35 |
| Load Factor (David Menmuir *et al.*, 2022) | % | 85% |
| Transport and storage cost (J. Murphy and S. Ferguson, 2018) | £/tCO2 | 19 |
| Natural Gas Fuel price (David Menmuir *et al.*, 2022) | £/MWh | 28 |
| Chemical Engineering Plant Index (CEPCI) (Chemical Engineering, 2022) | - | 816.3 |
| International Construction Cost Index[Netherlands/UK/Texas] (Arcadis, 2020) | - | 100/138/97 |
| USD to GBP exchange rate (2023) (Rates, 2020) | £/$ | 0.82 |
| Equipment Tax/Insurance/Freight (Donald, 2007; Elliott, 2022) | - | 1.10 |
| Civil Works factorial cost (Elliott *et al.*, 2018; Olav Falk-Pedersen *et al.*, 2019; Elliott, 2022) | - | 1.21 |
| Utilities factorial cost (Elliott *et al.*, 2018; Olav Falk-Pedersen *et al.*, 2019; Elliott, 2022) | - | 1.18 |
| Electrical factorial cost (Elliott *et al.*, 2018; Olav Falk-Pedersen *et al.*, 2019; Elliott, 2022) | - | 1.30 |
| Project management (Elliott *et al.*, 2018; Olav Falk-Pedersen *et al.*, 2019; Elliott, 2022) | - | 1.21 |
| Contractor Fee (Donald, 2007) | - | 1.03 |
| Project Contingency (Elliott *et al.*, 2018; Olav Falk-Pedersen *et al.*, 2019; Elliott, 2022) | - | 1.10 |
| Owners Costs (David Menmuir *et al.*, 2022) | - | 1.07 |
| Start-up & Spares (David Menmuir *et al.*, 2022) | - | 1.05 |
| Utility Connections (David Menmuir *et al.*, 2022) | - | 1.01 |
| Consulting Fee (David Menmuir *et al.*, 2022) | - | 1.01 |
| Maintenance (CCS) (J. Murphy and S. Ferguson, 2018) | %/Year | 1.50 |
| Labour (J. Murphy and S. Ferguson, 2018) | £/Employee/Year | 69,810 |
| Insurance/Tax/Admin (David Menmuir *et al.*, 2022) | %/Year | 1.50 |
| Regulatory (David Menmuir *et al.*, 2022) | - | 1.02 |
| MEA (Michailos and Gibbins, 2022) | £/t | 940 |
| Caustic (Gale, 2017) | £/t | 34 |
| Reclaimer disposal (Michailos and Gibbins, 2022) | £/t | 500 |
| Working Capital (J. Murphy and S. Ferguson, 2018) | - | 1 Months Consumables |

## S3 - Performance of the CO2 Capture plant

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **95% Gross** | **100% Fossil** |
| **Parameter** | ***Unit*** | **SMR** | **CCGT** | **CFP** | **SMR** | **CCGT** | **CFP** |
| Flue Gas | Kg/s | 525 | 792 | 848 | 550 | 792 | 848 |
| CO2 Concentration | % vol | 19.9 | 4.9 | 16.3 | 19.4 | 4.9 | 16.3 |
| O2 Concentration | % vol | 1 | 11 | 1 | 1 | 11 | 1 |
| Absorber(s) | # | 1 | 2 | 2 | 1 | 2 | 2 |
|  Diameter | *m* | 17.0 | 11.3 | 14.0 | 17.0 | 11.4 | 14.0 |
|  Packing Stages | *#* | 2 | 2 | 2 | 2 | 2 | 2 |
|  Packed Height | *m* | 14 | 20 | 20 | 20 | 24 | 20 |
| Stripper | *#* | 1 | 1 | 1 | 1 | 1 | 1 |
|  Diameter | *m* | 12.0 | 7.2 | 12.6 | 12.7 | 7.4 | 13.4 |
|  Packing Stages | *#* | 2 | 2 | 2 | 2 | 2 | 2 |
|  Packed Height | *m* | 16 | 20 | 20 | 16 | 20 | 20 |
| Lean Loading | mol CO2/mol MEA | 0.16 | 0.10 | 0.10 | 0.16 | 0.10 | 0.10 |
| Rich Loading | mol CO2/mol MEA | 0.47 | 0.46 | 0.49 | 0.47 | 0.44 | 0.46 |
| Reboiler Temp | oC | 125 | 136 | 136 | 125 | 136 | 136 |
| Reboiler Pressure | Kpa | 210 | 275 | 275 | 210 | 275 | 275 |
| CO2 Captured | Kg/s | 143 | 57.0 | 192 | 154 | 59.0 | 202 |
| Specific Reboiler Duty | GJ/tCO2 | 3.62 | 3.52 | 3.27 | 3.67 | 3.67 | 3.47 |
| Reboiler Duty | MJ | 516 | 200 | 628 | 566 | 217 | 701 |
| L/G | Kg/kg | 3.52 | 0.80 | 2.35 | 3.81 | 0.88 | 2.62 |

## References

Arcadis (2020) *International Construction Costs 2020*, *International Construction Costs*. https://connect.arcadis.com/: The Organisation. Available at: https://www.arcadis.com/en/knowledge-hub/perspectives/global/international-construction-costs.

Chemical Engineering (2022) *THE CHEMICAL ENGINEERING PLANT COST INDEX [Internet]*. chemengonline.com: Chemical Engineering. Available at: https://www.chemengonline.com/pci-home.

Collodi, G. *et al.* (2017) ‘Techno-economic Evaluation of Deploying CCS in SMR Based Merchant H2 Production with NG as Feedstock and Fuel’, *Energy Procedia*, 114, pp. 2690–2712. Available at: https://doi.org/10.1016/j.egypro.2017.03.1533.

David Menmuir *et al.* (2022) *Review of next generation carbon capture technology for industrial, waste and power sectors*. Glasgow: Department for Business, Energy & Industrial Strategy. Available at: https://www.gov.uk/government/publications/review-of-next-generation-carbon-capture-technology-for-industrial-waste-and-power-sectors.

Donald, R.W. (2007) ‘Rules of Thumb’, in *Rules of Thumb in Engineering Practice*. Wiley, pp. 1–44. Available at: https://doi.org/10.1002/9783527611119.ch1.

Elliott, B. *et al.* (2018) *Retrofitting an Australian Brown Coal Power Station With Post-Combustion Capture -  A Conceptual Study*. Bechtel Infrastructure and Power Corporation.

Elliott, B. (2022) *Front-End Engineering Design (FEED) Study for a Carbon Capture Plant Retrofit to a Natural Gas-Fired Gas Turbine Combined Cycle Power Plant (2x2x1 Duct-Fired 758-MWe Facility With F Class Turbines)*. Reston: Bechtel. Available at: https://ukccsrc.ac.uk/open-access-sherman-feed/.

Gale, J. (2017) *Evaluating the Costs of Retrofitting CO2 Captured in an Integrated Oil Refinery: Technical Design Basis and Economic Assumptions*. IEA Greenhouse Gas R&D Programme. Available at: https://ieaghg.org/publications/technical-reports/reports-list/10-technical-reviews/923-2017-tr5-evaluating-the-costs-of-retrofitting-co2-captured-in-an-integrated-oil-refinery-technical-design-basis-and-economic-assumptions.

J. Murphy and S. Ferguson (2018) *Assessing the Cost Reduction Potential and Competitiveness of Novel (Next Generation) UK Carbon Capture Technology*, *Benchmarking State-of-the-art and Next Generation Technologies*. Amec Foster Wheeler Group. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/864688/BEIS\_Final\_Benchmarks\_Report\_Rev\_4A.pdf.

Michailos, S. and Gibbins, J. (2022) ‘A Modelling Study of Post-Combustion Capture Plant Process Conditions to Facilitate 95–99% CO2 Capture Levels From Gas Turbine Flue Gases’, *Frontiers in Energy Research*. 24 May 2022, 10. Available at: https://doi.org/10.3389/fenrg.2022.866838.

Olav Falk-Pedersen, M. *et al.* (2019) *CO2 Capture Facility at Kårstø, Norway: Front-End Engineering and Design (FEED) Study Report*. 1st edn. GASSNOVA.