**Techno-Economic Evaluation of a Power-to-Methane Plant in Qatar: Levelized Cost of Methane, Financial Performance Metrics, and Sensitivity Analysis**

\*Mohammed Al-Breiki and Yusuf Bicer

Division of Sustainable Development, College of Science and Engineering,

Hamad Bin Khalifa University, Qatar Foundation, Doha, Qatar

E-mails: [\*malbreiki@hbku.edu.qa](mailto:*malbreiki@hbku.edu.qa), [ybicer@hbku.edu.qa](mailto:ybicer@hbku.edu.qa)

**Appendix A**

Mass and Energy Balance (10 MW PtG plant)

The mass and energy balance of the PtG plant was calculated for an electrolyser with a power of Pe = 10 MWe for a running time (t) of one hour. Electrical energy (Ee) used by the electrolyser was as follows:

The efficiency of the electrolyser can be used to calculate the produced heat from the electrolyzer, Eth,PEM, and hydrogen energy, Eh, HHV.

The amount of heat that is produced and can be sold from the electrolyzer, Eth,PEM,sold.

The reaction enthalpy of, ∆HH2, can be used to calculate the amounts of substances required for electrolysis per hour for water and the resulting amounts of hydrogen and oxygen.

H2O

H2

O2

The amount of carbon dioxide required for methanation and the reaction heat released in it and the amounts of methane and water can be calculated by the equation below. Note that reference state for each substance is the standard state, meaning a pressure of 1 bar and a specified temperature, typically 298.15 K or 25 °C.

CO2

CH4

Where is the percentage of benefit from the heat obtained from the heat of reaction which is about 81%.

H2O

The heat released from the condensation of water vapor formed in methanation was calculated as the product of the difference in specific enthalpy and mass. The initial values of water and saturated water temperature 25°C and an absolute pressure of 1 bar under standard conditions.

The amount of heat that is produced and can be sold from the methanation, Eth,METH. Where is the percentage of out of the heat produced by methanation into usable heat which is about 90%.

**Appendix B**

Table 1: Operating Expenses and Revenue of renewable methane plant for 20 years.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Production Capacity | | | | | | | | | | | | | | | | | | | | |
|  | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| Annual Operational Hours | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 | 8,000 |
| Projected Sales | | | | | | | | | | | | | | | | | | | | |
| CH4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Production in Kg per hour | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 | 429 |
| Annual Production | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 | 3,432,000 |
| Methane growth in sales price | $ 2.00 | 2.10 | 2.21 | 2.32 | 2.43 | 2.55 | 2.68 | 2.81 | 2.95 | 3.10 | 3.26 | 3.42 | 3.59 | 3.77 | 3.96 | 4.16 | 4.37 | 4.58 | 4.81 | 5.05 |
| Revenue from Sale of CH4 | 6,864,000 | 7,207,200 | 7,567,560 | 7,945,938 | 8,343,235 | 8,760,397 | 9,198,416 | 9,658,337 | 10,141,254 | 10,648,317 | 11,180,733 | 11,739,769 | 12,326,758 | 12,943,096 | 13,590,250 | 14,269,763 | 14,983,251 | 15,732,414 | 16,519,034 | 17,344,986 |
| O2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Production in Kg per hour | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 | 1,712 |
| Annual Production | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 | 13,696,000 |
| Oxygen growth in sales price | $ 0.05 | 0.051 | 0.051 | 0.052 | 0.052 | 0.053 | 0.053 | 0.054 | 0.054 | 0.055 | 0.055 | 0.056 | 0.056 | 0.057 | 0.057 | 0.058 | 0.059 | 0.059 | 0.060 | 0.060 |
| Revenue from Sale of O2 | 684,800 | 691,648 | 698,564 | 705,550 | 712,606 | 719,732 | 726,929 | 734,198 | 741,540 | 748,956 | 756,445 | 764,010 | 771,650 | 779,366 | 787,160 | 795,032 | 802,982 | 811,012 | 819,122 | 827,313 |
| Heat |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Production in MWh per hour | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 | 2.8 |
| Annual Production | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 | 22,640 |
| Heat growth in sales price | 25.00 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Revenue from Sale of Heat | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 | 566,000 |
| Total Revenues Generated from the Plant | 8,114,800 | 8,464,848 | 8,832,124 | 9,217,488 | 9,621,841 | 10,046,128 | 10,491,345 | 10,958,536 | 11,448,794 | 11,963,273 | 12,503,178 | 13,069,779 | 13,664,408 | 14,288,462 | 14,943,410 | 15,630,795 | 16,352,233 | 17,109,425 | 17,904,156 | 18,738,299 |
| Cost of Manufacture | | | | | | | | | | | | | | | | | | | | |
| Cost of Electricity |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Per hour cost ($/MWh) | 15.7 | 16.0 | 16.3 | 16.6 | 17.0 | 17.3 | 17.6 | 18.0 | 18.4 | 18.7 | 19.1 | 19.5 | 19.9 | 20.3 | 20.7 | 21.1 | 21.5 | 21.9 | 22.4 | 22.8 |
| Consumption per hour (MWh) | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Annual CO2 consumption | 1,253,600 | 1,278,672 | 1,304,245 | 1,330,330 | 1,356,937 | 1,384,076 | 1,411,757 | 1,439,992 | 1,468,792 | 1,498,168 | 1,528,131 | 1,558,694 | 1,589,868 | 1,621,665 | 1,654,099 | 1,687,181 | 1,720,924 | 1,755,343 | 1,790,449 | 1,826,258 |
| Cost of CO2 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Per hour cost ($/kg) | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Consumption per hour (kg) | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 |
| Annual CO2 consumption | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 | 5,649,600 |
| Cost of R.O Water |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cost of Water ($/kg) | 0.0003 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| Consumption per hour (kg) | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 | 1,928 |
| Annual Water consumption | 5,321 | 5,428 | 5,536 | 5,647 | 5,760 | 5,875 | 5,993 | 6,112 | 6,235 | 6,359 | 6,487 | 6,616 | 6,749 | 6,884 | 7,021 | 7,162 | 7,305 | 7,451 | 7,600 | 7,752 |
| TOTAL COSTS | 6,905,861 | 6,930,986 | 6,956,614 | 6,982,754 | 7,009,417 | 7,036,613 | 7,064,354 | 7,092,649 | 7,121,510 | 7,150,948 | 7,180,975 | 7,211,602 | 7,242,842 | 7,274,707 | 7,307,209 | 7,340,361 | 7,374,177 | 7,408,668 | 7,443,850 | 7,479,735 |

Table 2: Total expenses related to human capital of renewable methane plant.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Human Capital | | | | | | |
| Position | Basic Salary | Housing Allowance | Other allowances | Number | Air-tickets | Total Annual |
| General Manager | 1,968 | 1,722 | 1230 | 1 | 1148 | 60,188 |
| Production Manager | 1,312 | 1,148 | 820 | 1 | 1148 | 40,508 |
| Semi-skilled workers | 197 | 172 | 123 | 9 | 1148 | 63,468 |
| Accountant | 328 | 287 | 205 | 1 | 1148 | 10,988 |
| Total |  |  |  | 12 |  | 175,152 |

Table 3: Indirect salaries of the human capital for the renewable methane plant.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Indirect Salaries | | | | | | | | | | | | | | | | | | | | |
| Description | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| Total Salaries | 71,176 | 74,735 | 78,472 | 82,395 | 86,515 | 90,841 | 95,383 | 100,152 | 105,159 | 110,417 | 115,938 | 121,735 | 127,822 | 134,213 | 140,924 | 147,970 | 155,368 | 163,137 | 171,294 | 179,858 |
| Immigration | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 | 110 |
| End of services benefits | 1,661 | 1,744 | 1,831 | 1,923 | 2,019 | 3,028 | 3,179 | 3,338 | 2,454 | 2,576 | 2,705 | 2,840 | 4,261 | 4,474 | 4,697 | 3,453 | 3,625 | 3,807 | 3,997 | 5,995 |
| Total Salaries | 72,947 | 76,589 | 80,413 | 84,428 | 88,644 | 93,979 | 98,672 | 103,600 | 107,723 | 113,104 | 118,753 | 124,686 | 132,193 | 138,797 | 145,731 | 151,532 | 159,104 | 167,053 | 175,400 | 185,963 |

Table 4: Direct salaries of the human capital for the renewable methane plant.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Direct Salaries | | | | | | | | | | | | | | | | | | | | |
| Description | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| Total Salaries | 103,976 | 109,175 | 114,634 | 120,365 | 126,383 | 132,703 | 139,338 | 146,305 | 153,620 | 161,301 | 169,366 | 177,834 | 186,726 | 196,062 | 205,865 | 216,159 | 226,967 | 238,315 | 250,231 | 262,742 |
| Immigration | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 |
| End of services benefits | 2,426 | 2,547 | 2,675 | 2,809 | 2,949 | 4,423 | 4,645 | 4,877 | 3,584 | 3,764 | 3,952 | 4,149 | 6,224 | 6,535 | 6,862 | 5,044 | 5,296 | 5,561 | 5,839 | 8,758 |
| Total Salaries | 106,952 | 112,272 | 117,858 | 123,724 | 129,882 | 137,676 | 144,532 | 151,731 | 157,754 | 165,615 | 173,868 | 182,534 | 193,500 | 203,148 | 213,278 | 221,752 | 232,812 | 244,426 | 256,619 | 272,050 |

**Appendix C.**

Table 5: Breakdown costs of construction and building.

|  |  |  |  |
| --- | --- | --- | --- |
| Description | Area (m2) | Rate ($/m2) | Total ($) |
| Land space (m2) | 72000 |  |  |
| Civil & Construction Works | 23,040 | 356 | 8,206,027 |
| Mechanical work | 3600 | 137 | 493,151 |
| Electrical work | 3600 | 137 | 493,151 |
| Parking, road & harvesting area | 36000 | 27 | 986,301 |
| Gates | 720 | 137 | 98,630 |
| Boundary wall | 1440 | 301 | 433,973 |
| Administration block | 3600 | 301 | 1,084,932 |
| Total Building & Construction Cost |  |  | 11,796,164 |

Table 6: Breakdown costs of plant equipment.

|  |  |  |  |
| --- | --- | --- | --- |
| Description | Quantity | Rate ($) | Total ($) |
| Renewables | 1 | 25,726,000 | 25,726,000 |
| Seawater Desalination (RO system) | 1 | 37,056 | 37,056 |
| Electrolysis (PEM) | 1 | 5,000,000 | 5,000,000 |
| H2 storage tank | 1 | 332,500 | 332,500 |
| CO2 storage tank cost | 1 | 82,400 | 82,400 |
| Carbon dioxide compressor | 1 | 252,625 | 252,625 |
| Hydrogen compressor | 1 | 252,625 | 252,625 |
| O2 storage tank | 1 | 82,400 | 82,400 |
| Gas grid injection station | 1 | 280,000 | 280,000 |
| Methanation | 1 | 1,400,000 | 1,400,000 |
|  |  |  | 33,445,606 |

Table 7: Breakdown costs of general equipment, furniture and fixture, office equipment, computers and accessories.

|  |  |  |  |
| --- | --- | --- | --- |
| General Equipment |  |  |  |
| Description | Quantity | rate ($) | Amount |
| General Plant Equipment |  | 2% | 668,912 |
| Furniture & fixture |  |  |  |
| Description | Area (m2) | ($/m2) | Amount |
| Office furniture & decoration | 3,750 | 10 | 37,500 |
| Office Equipment |  |  |  |
| Description | Quantity | Rate ($/pic) | Amount |
| Photocopier | 2 | 514 | 1,027 |
| Phones | 4 | 41 | 164 |
| PABX Central | 1 | 326 | 326 |
| Other equipment |  |  | 2,740 |
| Total |  |  | 4,258 |
| Computer & accessories |  |  |  |
| Description | Quantity | Rate ($/pic) | Amount |
| Computer | 6 | 1,096 | 6,575 |
| Server & IT Equipment |  |  | 27,397 |
|  |  |  | 33,973 |

Table 8: Breakdown of capital expenditure.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CAPITAL EXPENDITURE | | | | | | | | | | | | | | | | | | | | | | | |
| Description | Cost | | Depreciation | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| Construction & Building | | 11,796,164 | 471,847 | 11,324,318 | 10,852,471 | 10,380,625 | 9,908,778 | 9,436,932 | 8,965,085 | 8,493,238 | 8,021,392 | 7,549,545 | 7,077,699 | 6,605,852 | 6,134,005 | 5,662,159 | 5,190,312 | 4,718,466 | 4,246,619 | 3,774,773 | 3,302,926 | 2,831,079 | 2,359,233 |
| Plant & machinery | | 33,445,606 | 1,672,280 | 31,773,326 | 30,101,045 | 28,428,765 | 26,756,485 | 25,084,205 | 23,411,924 | 21,739,644 | 20,067,364 | 18,395,083 | 16,722,803 | 15,050,523 | 13,378,242 | 11,705,962 | 10,033,682 | 8,361,401 | 6,689,121 | 5,016,841 | 3,344,561 | 1,672,280 | (0) |
| Office equipment | | 4,258 | 1,064 | 3,193 | 2,129 | 1,064 | - | 3,193 | 2,129 | 1,064 | - | 3,193 | 2,129 | 1,064 | - | 3,193 | 2,129 | 1,064 | - | 3,193 | 2,129 | 1,064 | - |
| Computer & other related accessories | | 33,973 | 11,324 | 22,648 | 11,324 | - | 22,648 | 11,324 | - | 22,648 | 11,324 | - | 22,648 | 11,324 | - | 22,648 | 11,324 | - | 22,648 | 11,324 | - | 22,648 | 11,324 |
| Furniture & fixture | | 37,500 | 7,500 | 30,000 | 22,500 | 15,000 | 7,500 | - | 30,000 | 22,500 | 15,000 | 7,500 | - | 30,000 | 22,500 | 15,000 | 7,500 | - | 30,000 | 22,500 | 15,000 | 7,500 | - |
|  | | 45,317,501 | 2,164,015 |  |  | Additions | 33,973 | 4,258 | 37,500 | 33,973 |  | 4,258 | 2,176,000 | 37,500 |  | 38,230 |  |  | 71,473 | 4,258 |  | 33,973 |  |

**Appendix D**

Table 9: Profit and loss statement of power to renewable methane.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Description | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| Revenue | - | 8,114,800 | 8,464,848 | 8,832,124 | 9,217,488 | 9,621,841 | 10,046,128 | 10,491,345 | 10,958,536 | 11,448,794 | 11,963,273 | 12,503,178 | 13,069,779 | 13,664,408 | 14,288,462 | 14,943,410 | 15,630,795 | 16,352,233 | 17,109,425 | 17,904,156 | 18,738,299 |
| OPERATING EXPENSES | | | | | | | | | | | | | | | | | | | | | |
| Salaries & related Staff cost - Direct | 3,039 | 72,947 | 76,589 | 80,413 | 84,428 | 88,644 | 93,979 | 98,672 | 103,600 | 107,723 | 113,104 | 118,753 | 124,686 | 132,193 | 138,797 | 145,731 | 151,532 | 159,104 | 167,053 | 175,400 | 185,963 |
| Cost of Manufacturing | 575,488 | 6,905,861 | 6,930,986 | 6,956,614 | 6,982,754 | 7,009,417 | 7,036,613 | 7,064,354 | 7,092,649 | 7,121,510 | 7,150,948 | 7,180,975 | 7,211,602 | 7,242,842 | 7,274,707 | 7,307,209 | 7,340,361 | 7,374,177 | 7,408,668 | 7,443,850 | 7,479,735 |
| Utilities and plant overheads | 2,000 | 24,000 | 25,200 | 26,460 | 27,783 | 29,172 | 30,631 | 32,162 | 24,000 | 25,200 | 26,460 | 27,783 | 29,172 | 30,631 | 32,162 | 24,000 | 25,200 | 26,460 | 27,783 | 29,172 | 30,631 |
| Total Operating Expenses | 580,528 | 7,002,807 | 7,032,774 | 7,063,486 | 7,094,965 | 7,127,233 | 7,161,223 | 7,195,188 | 7,220,249 | 7,254,433 | 7,290,511 | 7,327,511 | 7,365,460 | 7,405,666 | 7,445,666 | 7,476,940 | 7,517,094 | 7,559,740 | 7,603,504 | 7,648,422 | 7,696,329 |
| Gross Profit / (Loss) | (580,528) | 1,111,993 | 1,432,074 | 1,768,638 | 2,122,524 | 2,494,608 | 2,884,906 | 3,296,158 | 3,738,287 | 4,194,362 | 4,672,761 | 5,175,667 | 5,704,319 | 6,258,742 | 6,842,796 | 7,466,470 | 8,113,701 | 8,792,493 | 9,505,921 | 10,255,734 | 11,041,970 |
| GENERAL & ADMINSTRATIVE EXPENSES | | | | | | | | | | | | | | | | | | | | | |
| Lease rental | 65,753 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 | 197,260 |
| Salaries & related Staff cost - Indirect | 3,039 | 72,947 | 76,589 | 80,413 | 84,428 | 88,644 | 93,979 | 98,672 | 103,600 | 107,723 | 113,104 | 118,753 | 124,686 | 132,193 | 138,797 | 145,731 | 151,532 | 159,104 | 167,053 | 175,400 | 185,963 |
| Communication Expenses | 274 | 6,575 | 7,890 | 9,468 | 11,362 | 13,635 | 16,362 | 19,634 | 6,575 | 7,890 | 9,468 | 11,362 | 13,635 | 16,362 | 19,634 | 6,575 | 7,890 | 9,468 | 11,362 | 13,635 | 16,362 |
| Marketing Expenses |  | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 | 2,740 |
| Courier & Stationery | 548 | 6,575 | 6,773 | 6,976 | 7,185 | 7,401 | 7,623 | 7,851 | 6,575 | 6,773 | 6,976 | 7,185 | 7,401 | 7,623 | 7,851 | 6,575 | 6,773 | 6,976 | 7,185 | 7,401 | 7,623 |
| Repair & Maintenance | - | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 | 870,710 |
| Pre-operating expenses |  | (69,615) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total general expenses | 69,615 | 1,087,192 | 1,161,961 | 1,167,567 | 1,173,685 | 1,180,389 | 1,188,673 | 1,196,867 | 1,187,461 | 1,193,096 | 1,200,258 | 1,208,010 | 1,216,431 | 1,226,887 | 1,236,992 | 1,229,591 | 1,236,905 | 1,246,258 | 1,256,310 | 1,267,145 | 1,280,657 |
| Net Operating income / EBITA | (650,143) | 24,800 | 835,072 | 1,674,496 | 2,479,881 | 3,257,117 | 4,009,801 | 4,746,462 | 5,498,240 | 6,218,898 | 6,933,333 | 7,647,363 | 8,364,584 | 9,085,842 | 9,819,352 | 10,594,031 | 11,363,193 | 12,148,953 | 12,957,017 | 13,790,214 | 14,647,736 |
| Finance cost | | | | | | | | | | | | | | | | | | | | | |
| Depreciation | - | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 |
| NET PROFIT | (650,143) | (2,139,215) | (1,893,903) | (1,562,944) | (1,215,177) | (849,796) | (467,782) | (64,725) | 386,811 | 837,250 | 1,308,488 | 1,803,641 | 2,323,873 | 2,867,840 | 3,441,789 | 4,072,863 | 4,712,780 | 5,382,220 | 6,085,595 | 6,824,573 | 7,597,298 |

Table 10: Cash flow sheet of power to renewable methane.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| DESCRIPTION | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| OPERATING ACTIVITIES | | | | | | | | | | | | | | | | | | | | | |
| Net Profit | (270,098) | (2,139,215) | (1,893,903) | (1,562,944) | (1,215,177) | (849,796) | (467,782) | (64,725) | 386,811 | 837,250 | 1,308,488 | 1,803,641 | 2,323,873 | 2,867,840 | 3,441,789 | 4,072,863 | 4,712,780 | 5,382,220 | 6,085,595 | 6,824,573 | 7,597,298 |
| Adjustment for: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Depreciation |  | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 | 2,164,015 |
| Provision for End of Services |  | 4,087 | 4,291 | 4,506 | 4,731 | 4,968 | 7,451 | 7,824 | 8,215 | 6,038 | 6,340 | 6,657 | 6,990 | 10,485 | 11,009 | 11,560 | 8,496 | 8,921 | 9,367 | 9,836 | 14,753 |
| Operating Cash flow before changes in Working Capital | (270,098) | 28,887 | 274,403 | 605,578 | 953,570 | 1,319,187 | 1,703,685 | 2,107,115 | 2,559,041 | 3,007,304 | 3,478,843 | 3,974,313 | 4,494,878 | 5,042,340 | 5,616,813 | 6,248,438 | 6,885,292 | 7,555,156 | 8,258,978 | 8,998,424 | 9,776,066 |
| Working Capital Changes | | | | | | | | | | | | | | | | | | | | | |
| Accounts receivable |  | (676,233) | (29,171) | (30,606) | (32,114) | (33,696) | (35,357) | (37,101) | (38,933) | (40,855) | (42,873) | (44,992) | (47,217) | (49,552) | (52,005) | (54,579) | (57,282) | (60,120) | (63,099) | (66,228) | (69,512) |
| Prepayments & other receivables |  | (16,667) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Accounts Payable |  | 575,488 | 2,094 | 2,136 | 2,178 | 2,222 | 2,266 | 2,312 | 2,358 | 2,405 | 2,453 | 2,502 | 2,552 | 2,603 | 2,655 | 2,709 | 2,763 | 2,818 | 2,874 | 2,932 | 2,990 |
| Accrued Expenses & Provisions |  | 12,158 | 607 | 637 | 669 | 703 | 889 | 782 | 821 | 687 | 897 | 942 | 989 | 1,251 | 1,101 | 1,156 | 967 | 1,262 | 1,325 | 1,391 | 1,761 |
| Net Cash flow from operating activities | (270,098) | (76,367) | 247,933 | 577,744 | 924,304 | 1,288,416 | 1,671,483 | 2,073,107 | 2,523,288 | 2,969,541 | 3,439,320 | 3,932,765 | 4,451,203 | 4,996,643 | 5,568,565 | 6,197,723 | 6,831,739 | 7,499,116 | 8,200,078 | 8,936,520 | 9,711,305 |
| INVESTING ACTIVITIES | | | | | | | | | | | | | | | | | | | | | |
| Acquisition of property & equipment | (3,334,222) | (45,317,501) | - | - | (33,973) | (4,258) | (37,500) | (33,973) | - | (4,258) | (2,176,000) | (37,500) | - | (38,230) | - | - | (71,473) | (4,258) | - | (33,973) | - |
| Net cash used in investing activities | (3,334,222) | (45,317,501) | - | - | (33,973) | (4,258) | (37,500) | (33,973) | - | (4,258) | (2,176,000) | (37,500) | - | (38,230) | - | - | (71,473) | (4,258) | - | (33,973) | - |
| FINANCING ACTIVITIES | | | | | | | | | | | | | | | | | | | | | |
| Share Capital | 1,815,200 | 46,751,218 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Net cash used in financing activities | 1,815,200 | 46,751,218 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Net Increase/ (decrease) in Cash & Cash Equivalent | (1,789,121) | 1,357,351 | 247,933 | 577,744 | 890,331 | 1,284,158 | 1,633,983 | 2,039,135 | 2,523,288 | 2,965,284 | 1,263,320 | 3,895,265 | 4,451,203 | 4,958,412 | 5,568,565 | 6,197,723 | 6,760,267 | 7,494,859 | 8,200,078 | 8,902,547 | 9,711,305 |
| Cash at the beginning of the year |  |  | 1,357,351 | 1,605,284 | 2,183,029 | 3,073,360 | 4,357,518 | 5,991,501 | 8,030,635 | 10,553,923 | 13,519,207 | 14,782,528 | 18,677,793 | 23,128,995 | 28,087,408 | 33,655,973 | 39,853,696 | 46,613,963 | 54,108,822 | 62,308,900 | 71,211,447 |
| Cash & Cash Equivalent at the end | (1,789,121) | 1,357,351 | 1,605,284 | 2,183,029 | 3,073,360 | 4,357,518 | 5,991,501 | 8,030,635 | 10,553,923 | 13,519,207 | 14,782,528 | 18,677,793 | 23,128,995 | 28,087,408 | 33,655,973 | 39,853,696 | 46,613,963 | 54,108,822 | 62,308,900 | 71,211,447 | 80,922,752 |

**Appendix E**

Table 11: Balance sheet of power to methane

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Description | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| NON-CURRENT ASSETS | | | | | | | | | | | | | | | | | | | | |
| Property, plant & equipment - *Gross Book Value* | 3,334,222 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 | 45,317,501 |
| *less: Accumulated Depreciation* | - | 2,164,015 | 4,328,031 | 6,492,046 | 8,622,089 | 10,781,847 | 12,908,363 | 15,038,405 | 17,202,421 | 19,362,179 | 19,350,194 | 21,476,710 | 23,640,725 | 25,766,511 | 27,930,526 | 30,094,541 | 32,187,084 | 34,346,842 | 36,510,858 | 38,640,901 |
| *Net Book Value* | 3,334,222 | 43,153,485 | 40,989,470 | 38,825,454 | 36,695,411 | 34,535,653 | 32,409,138 | 30,279,095 | 28,115,080 | 25,955,322 | 25,967,306 | 23,840,791 | 21,676,775 | 19,550,990 | 17,386,974 | 15,222,959 | 13,130,416 | 10,970,658 | 8,806,643 | 6,676,600 |
| Total Non-Current Assets | 3,334,222 | 43,153,485 | 40,989,470 | 38,825,454 | 36,695,411 | 34,535,653 | 32,409,138 | 30,279,095 | 28,115,080 | 25,955,322 | 25,967,306 | 23,840,791 | 21,676,775 | 19,550,990 | 17,386,974 | 15,222,959 | 13,130,416 | 10,970,658 | 8,806,643 | 6,676,600 |
| Accounts Receivable |  | 676,233 | 705,404 | 736,010 | 768,124 | 801,820 | 837,177 | 874,279 | 913,211 | 954,066 | 996,939 | 1,041,931 | 1,089,148 | 1,138,701 | 1,190,705 | 1,245,284 | 1,302,566 | 1,362,686 | 1,425,785 | 1,492,013 |
| Prepayments & other receivables |  | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 | 16,667 |
| Cash & Bank | 933,679 | 1,357,351 | 1,605,284 | 2,183,029 | 3,073,360 | 4,357,518 | 5,991,501 | 8,030,635 | 10,553,923 | 13,519,207 | 14,782,528 | 18,677,793 | 23,128,995 | 28,087,408 | 33,655,973 | 39,853,696 | 46,613,963 | 54,108,822 | 62,308,900 | 71,211,447 |
| Total Current Assets | 933,679 | 2,050,251 | 2,327,355 | 2,935,706 | 3,858,151 | 5,176,005 | 6,845,345 | 8,921,581 | 11,483,801 | 14,489,940 | 15,796,134 | 19,736,391 | 24,234,810 | 29,242,775 | 34,863,345 | 41,115,647 | 47,933,196 | 55,488,175 | 63,751,352 | 72,720,127 |
| Total Assets | 4,267,901 | 45,203,736 | 43,316,825 | 41,761,160 | 40,553,562 | 39,711,658 | 39,254,483 | 39,200,676 | 39,598,881 | 40,445,262 | 41,763,440 | 43,577,182 | 45,911,586 | 48,793,765 | 52,250,319 | 56,338,606 | 61,063,612 | 66,458,833 | 72,557,995 | 79,396,727 |
| EQUITY & LIABILITIES | | | | | | | | | | | | | | | | | | | | |
| Capital/Equity | 1,815,200 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 | 46,751,218 |
| Retained Earnings | (270,098) | (2,139,215) | (4,033,119) | (5,596,062) | (6,811,239) | (7,661,035) | (8,128,817) | (8,193,542) | (7,806,731) | (6,969,481) | (5,660,993) | (3,857,352) | (1,533,479) | 1,334,361 | 4,776,150 | 8,849,013 | 13,561,793 | 18,944,013 | 25,029,608 | 31,854,182 |
| Total Equity | 1,545,102 | 44,612,003 | 42,718,100 | 41,155,156 | 39,939,979 | 39,090,183 | 38,622,401 | 38,557,676 | 38,944,487 | 39,781,737 | 41,090,225 | 42,893,866 | 45,217,739 | 48,085,579 | 51,527,368 | 55,600,231 | 60,313,011 | 65,695,231 | 71,780,827 | 78,605,400 |
| NON-CURRENT LIABILTIES | | | | | | | | | | | | | | | | | | | | |
| Staff termination benefits | 4,087 | 8,378 | 12,884 | 17,615 | 22,583 | 30,034 | 37,858 | 46,073 | 52,111 | 58,452 | 65,109 | 72,099 | 82,584 | 93,593 | 105,152 | 113,649 | 122,570 | 131,937 | 141,773 | 156,526 |
| Total Non-current Liabilities | 4,087 | 8,378 | 12,884 | 17,615 | 22,583 | 30,034 | 37,858 | 46,073 | 52,111 | 58,452 | 65,109 | 72,099 | 82,584 | 93,593 | 105,152 | 113,649 | 122,570 | 131,937 | 141,773 | 156,526 |
| CURRENT LIABILITIES | | | | | | | | | | | | | | | | | | | | |
| Accounts payable |  | 575,488 | 577,582 | 579,718 | 581,896 | 584,118 | 586,384 | 588,696 | 591,054 | 593,459 | 595,912 | 598,415 | 600,967 | 603,570 | 606,226 | 608,934 | 611,697 | 614,515 | 617,389 | 620,321 |
| Accrued Expenses |  | 12,158 | 12,765 | 13,402 | 14,071 | 14,774 | 15,663 | 16,445 | 17,267 | 17,954 | 18,851 | 19,792 | 20,781 | 22,032 | 23,133 | 24,289 | 25,255 | 26,517 | 27,842 | 29,233 |
| Total Current Liabilities | - | 587,646 | 590,347 | 593,120 | 595,967 | 598,892 | 602,048 | 605,141 | 608,321 | 611,413 | 614,763 | 618,207 | 621,748 | 625,602 | 629,358 | 633,223 | 636,952 | 641,032 | 645,231 | 649,554 |
| Total Equities & Liabilities | 1,545,102 | 45,203,736 | 43,316,825 | 41,761,160 | 40,553,562 | 39,711,658 | 39,254,483 | 39,200,676 | 39,598,881 | 40,445,262 | 41,763,440 | 43,577,182 | 45,911,586 | 48,793,765 | 52,250,319 | 56,338,606 | 61,063,612 | 66,458,833 | 72,557,995 | 79,396,727 |

**Appendix F**

Table 12: NPV and financial performance

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Description | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 |
| PV Factor | 10.0% | 0.909090909 | 0.826446281 | 0.751314801 | 0.683013455 | 0.620921323 | 0.56447393 | 0.513158118 | 0.46650738 | 0.424097618 | 0.385543289 | 0.350493899 | 0.318630818 | 0.28966438 | 0.263331254 | 0.239392049 | 0.217629136 | 0.197844669 | 0.17985879 | 0.163507991 | 0.148643628 |
| Net Cashflow from Operations |  | (76,367) | 247,933 | 577,744 | 924,304 | 1,288,416 | 1,671,483 | 2,073,107 | 2,523,288 | 2,969,541 | 3,439,320 | 3,932,765 | 4,451,203 | 4,996,643 | 5,568,565 | 6,197,723 | 6,831,739 | 7,499,116 | 8,200,078 | 8,936,520 | 9,711,305 |
| Total Cash Inflow |  | (76,367) | 247,933 | 577,744 | 924,304 | 1,288,416 | 1,671,483 | 2,073,107 | 2,523,288 | 2,969,541 | 3,439,320 | 3,932,765 | 4,451,203 | 4,996,643 | 5,568,565 | 6,197,723 | 6,831,739 | 7,499,116 | 8,200,078 | 8,936,520 | 9,711,305 |
| Total Cash Outflow | (45,317,501) | - | - | - | (33,973) | (4,258) | (37,500) | (33,973) | - | (4,258) | (2,176,000) | (37,500) | - | (38,230) | - | - | (71,473) | (4,258) | - | (33,973) | - |
| Net Cash flow | (45,317,501) | (76,367) | 247,933 | 577,744 | 890,331 | 1,284,158 | 1,633,983 | 2,039,135 | 2,523,288 | 2,965,284 | 1,263,320 | 3,895,265 | 4,451,203 | 4,958,412 | 5,568,565 | 6,197,723 | 6,760,267 | 7,494,859 | 8,200,078 | 8,902,547 | 9,711,305 |
| PV of Net Cashflow | (45,317,501) | (69,424) | 204,904 | 434,068 | 608,108 | 797,361 | 922,341 | 1,046,398 | 1,177,133 | 1,257,570 | 487,065 | 1,365,267 | 1,418,290 | 1,436,275 | 1,466,377 | 1,483,686 | 1,471,231 | 1,482,818 | 1,474,856 | 1,455,638 | 1,443,524 |
| Net Present Value | (23,954,016) | | | | | | | | | | | | | | | | | | | | |
| IRR | -5% | | | | | | | | | | | | | | | | | | | | |

Appendix G

Table 13: Breakdown of initial investment costs for the power-to-methane plant.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Capital Cost | Tire 1 | Tire 2 |
| Construction & Building | Civil & Construction Works | $ 11,796,164 | $ 8,206,027 |
| Mechanical work | $ 493,151 |
| Electrical work | $ 493,151 |
| Parking, road & green areas | $ 986,301 |
| Gates | $ 98,630 |
| Boundary wall | $ 433,973 |
| Administration block | $ 1,084,932 |
| Plant & Machinery | Renewables | $ 33,445,606 | $ 25,726,000 |
| Seawater Desalination | $ 37,056 |
| Electrolysis | $ 5,000,000 |
| H2 storage tank | $ 332,500 |
| CO2 storage tank cost | $ 82,400 |
| Carbon dioxide compressor | $ 252,625 |
| Hydrogen compressor | $ 252,625 |
| O2 storage tank | $ 82,400 |
| Gas grid injection station | $ 280,000 |
| Methanation | $ 1,400,000 |
| Others | Furniture and fixture | $ 1,509,448 | $ 37,500 |
| Office Equipment | $ 4,258 |
| Computer & other related accessories | $ 33,973 |
| Pre-operating Expenses | $ 336,081 |
| Working Capital | $ 192,801 |
| Provision for Contingencies | $ 904,835 |

Table 14: Breakdown of OPEX for the power-to-methane plant.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Capital Cost | Tire 1 | Tire 2 |
| Cost of manufacturing | Cost of Electricity | $ 6,905,861 | $ 1,253,600 |
| Cost of CO2 | $ 5,649,600 |
| Cost of Water | $ 2,661 |
| Repair and Maintenance | Solar unit 2 %CAPEX/a | $ 870,710 | $ 514,520 |
| Desalination 4 %CAPEX/a | $ 1,482 |
| Electrolysis 4 %CAPEX/a | $ 200,000 |
| H2 storage tank 2 %CAPEX/a | $ 4,988 |
| CO2 storage tank cost 4 %CAPEX/a | $ 2,884 |
| O2 storage tank 2 %CAPEX/a | $ 1,236 |
| Gas grid injection station 2% CAPEX/a | $ 5,600 |
| Methanation 10 %CAPEX/a | $ 140,000 |
| Others | Salaries and related Staff cost - Direct | $ 383,044 | $ 72,947 |
| Utilities and plant overheads | $ 24,000 |
| Lease rental | $ 197,260 |
| Salaries & related Staff cost - Indirect | $ 72,947 |
| Communication Expenses | $ 6,575 |
| Marketing Expenses | $ 2,740 |
| Courier & Stationery | $ 6,575 |