



Hydrogen Integration for
Accelerated Energy Transitions



UK Research
and Innovation

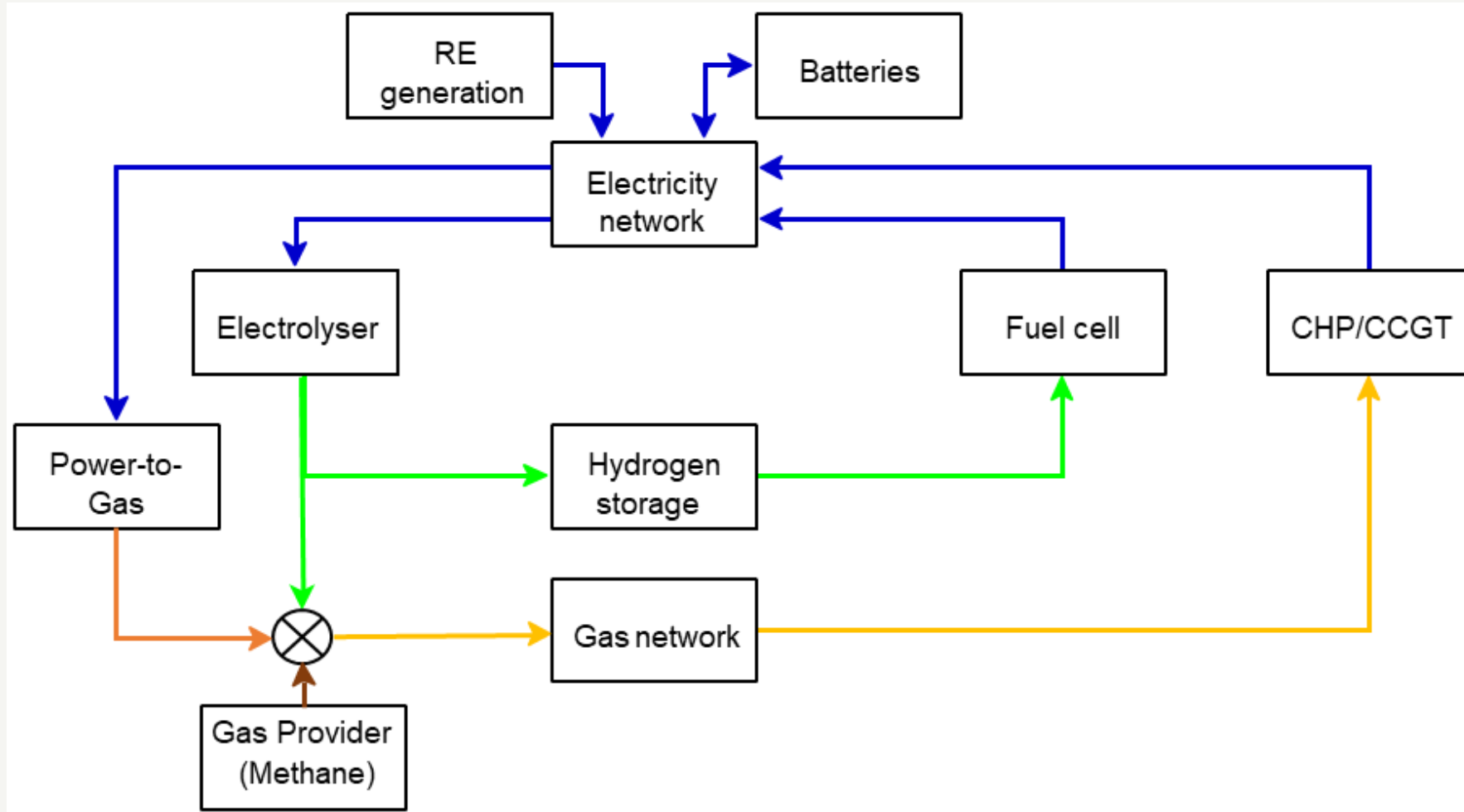


Engineering and
Physical Sciences
Research Council



Study Case of Hydrogen Blending

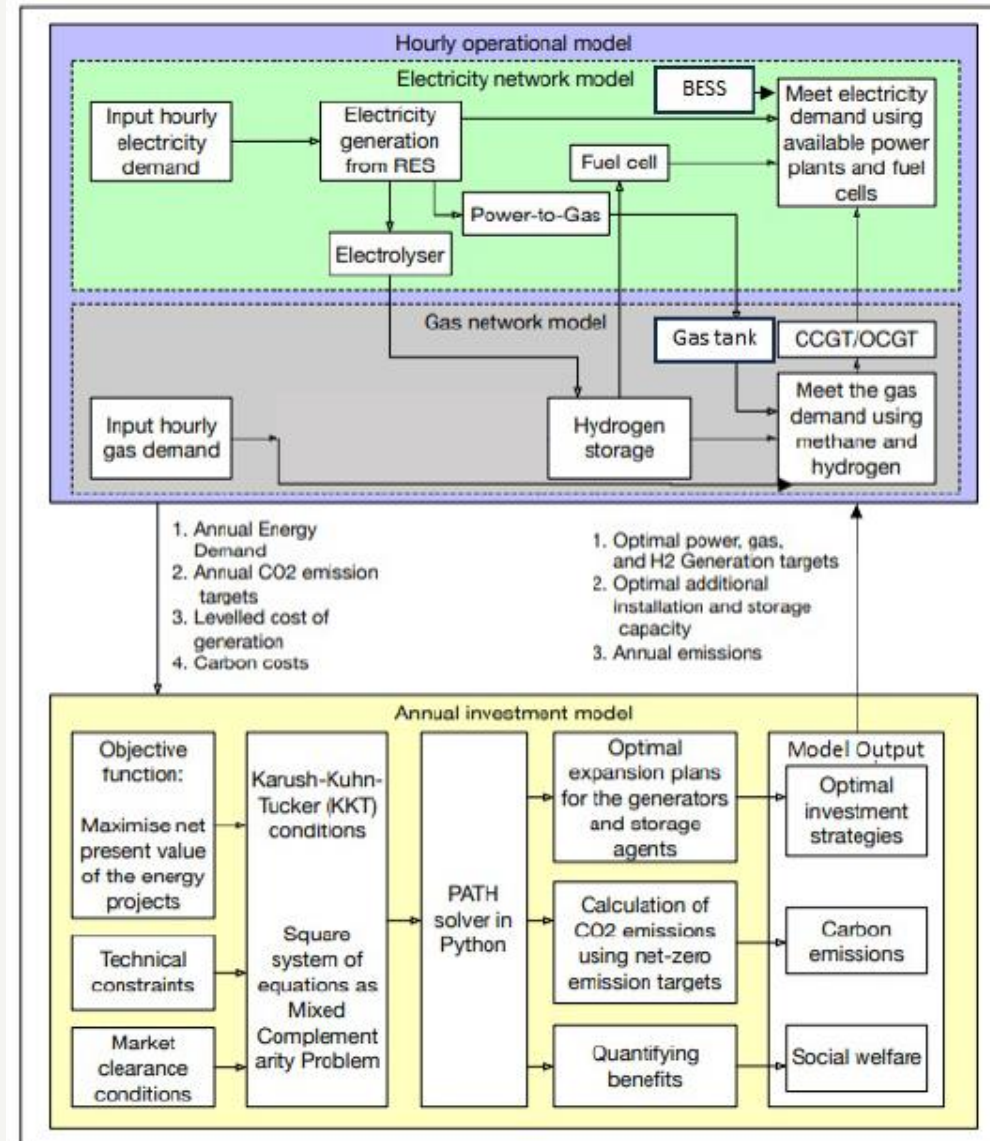
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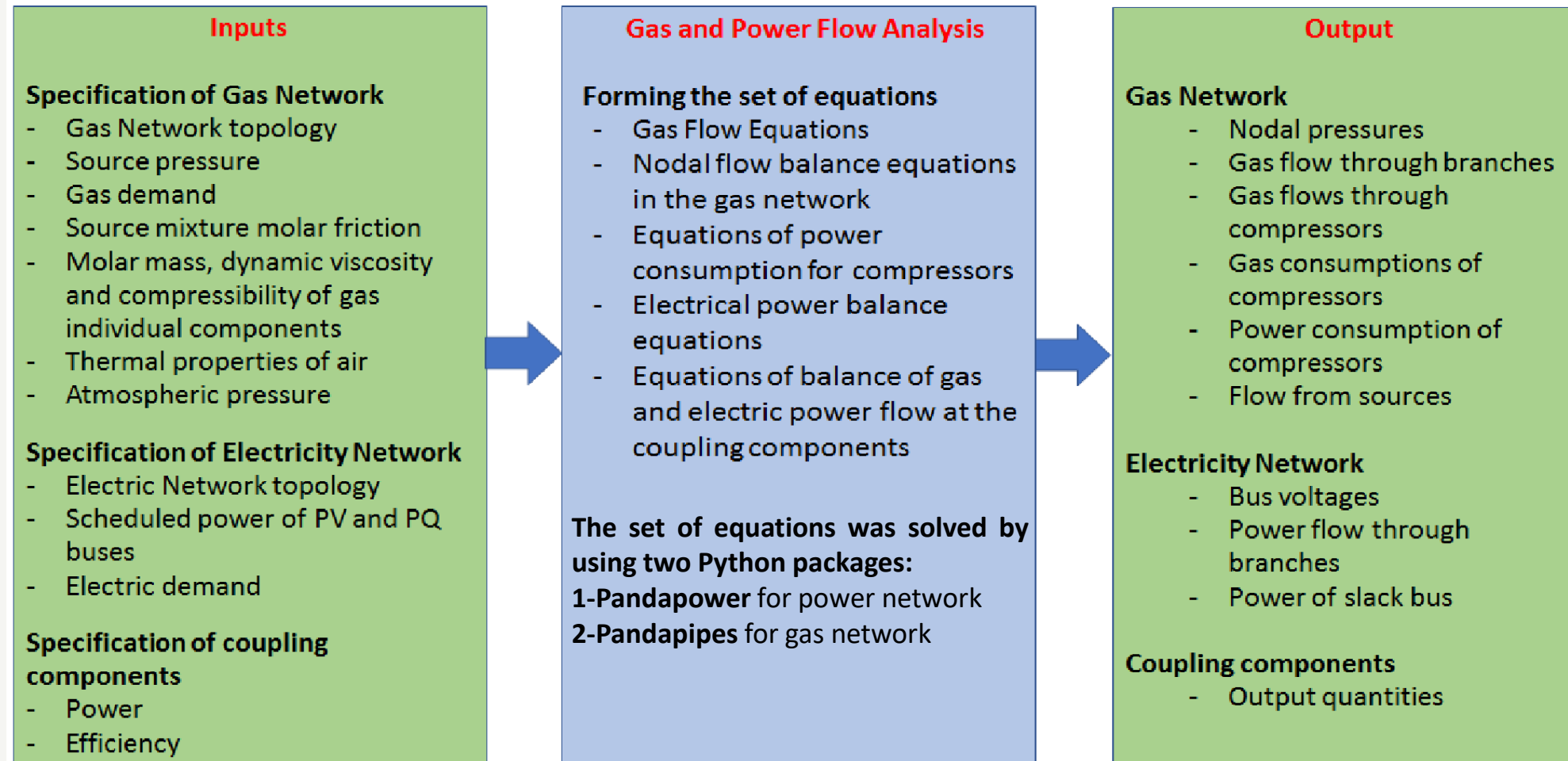
Integrated Multi-Energy System

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Schematic Diagram of
Game-Theoretic Model



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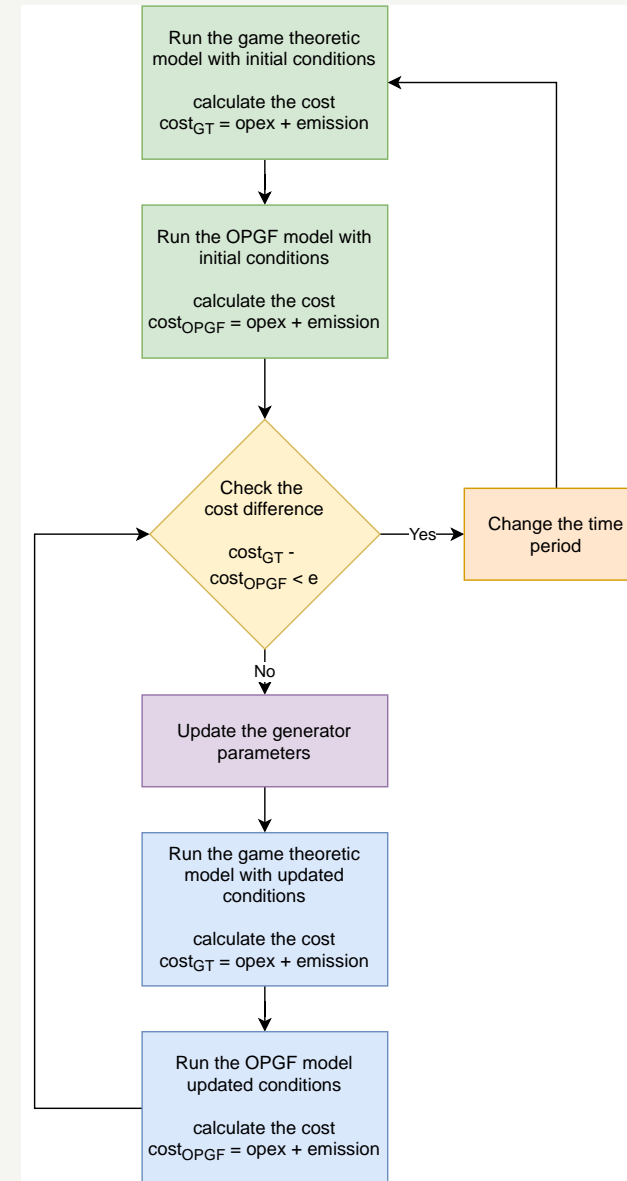
Schematic Diagram of OPGF

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Combining GT model with OPGF model

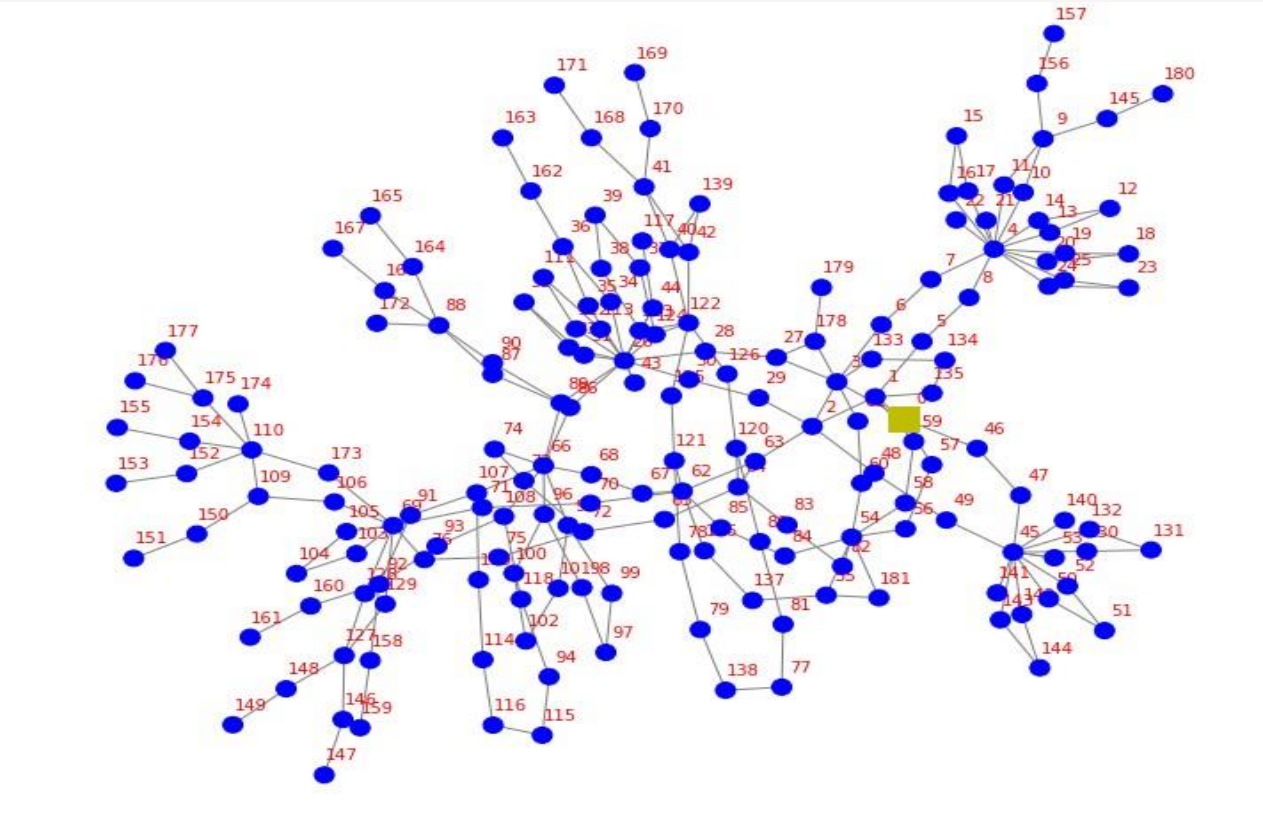
Iterative updates: GT model output → OPGF output → GT model

Flow chart of algorithm to perform the short-term operation and long term investment simulation

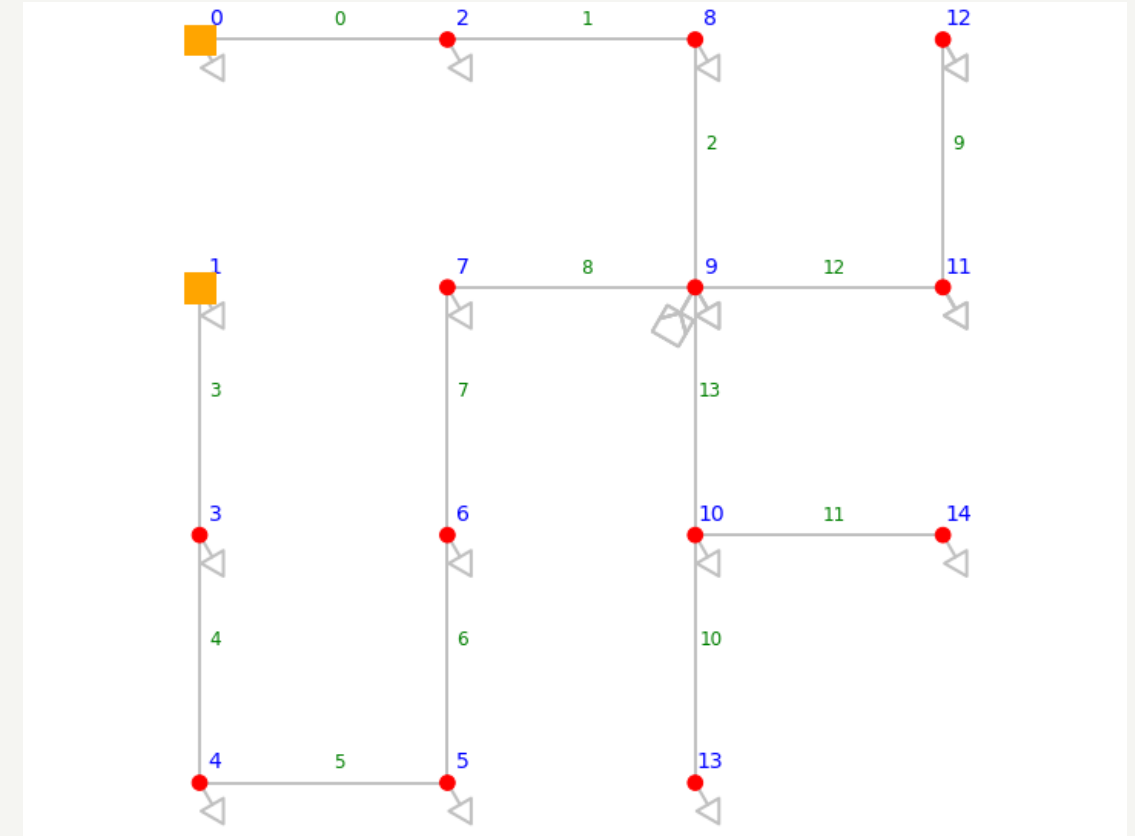


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Case study utilizes data from the North of Tyne region.



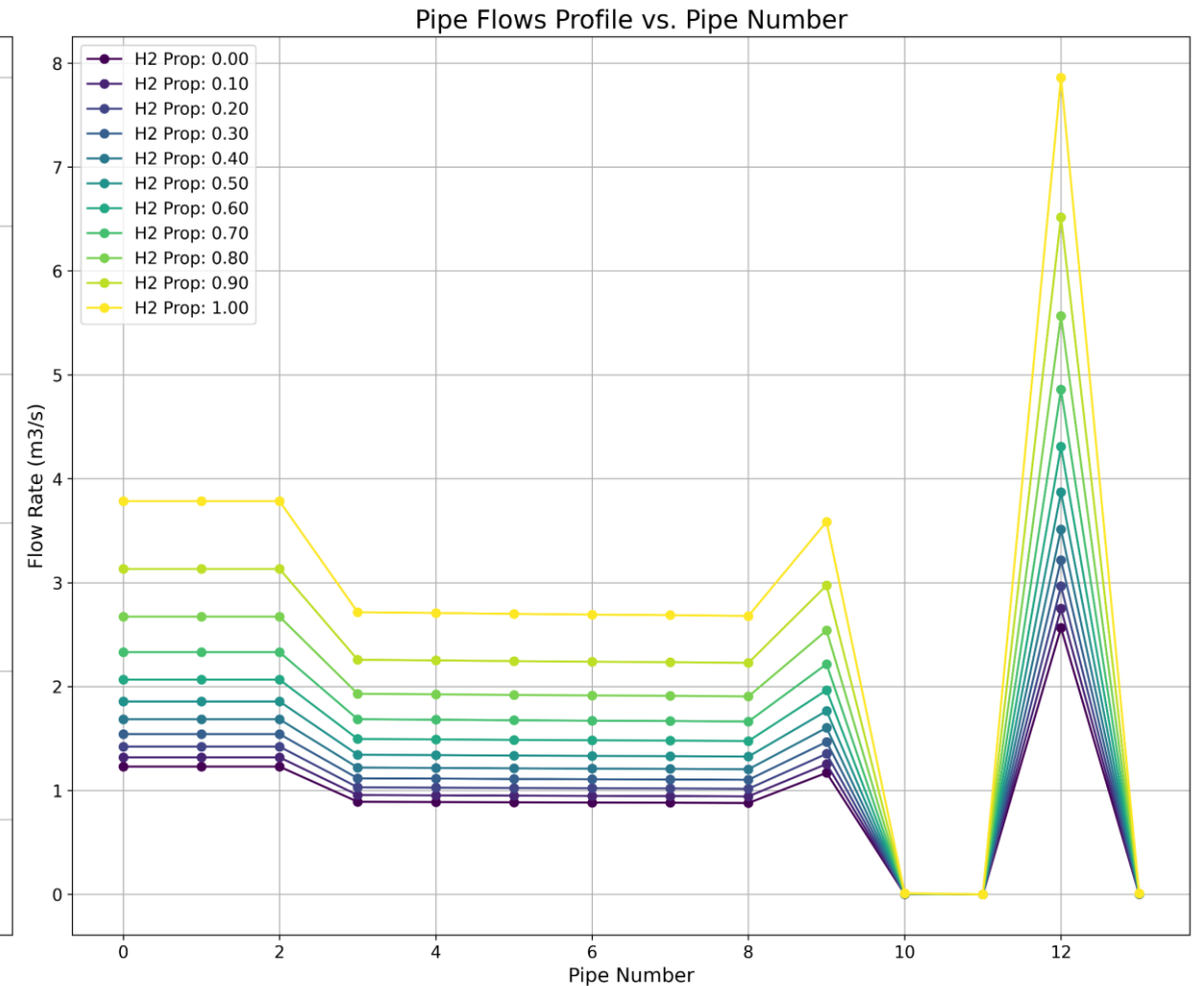
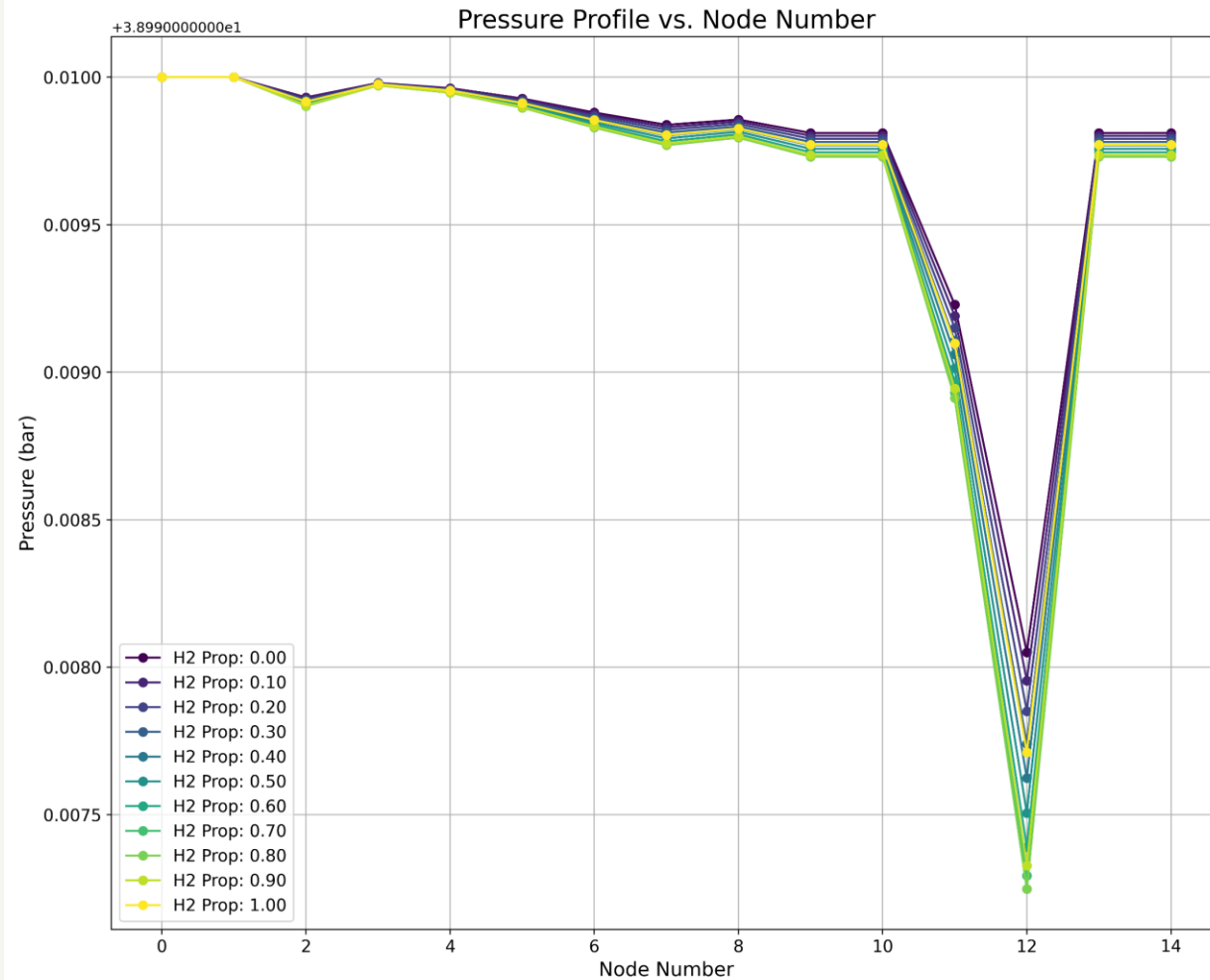
Power Network



Gas Network

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Results



Study Case of Hydrogen Blending

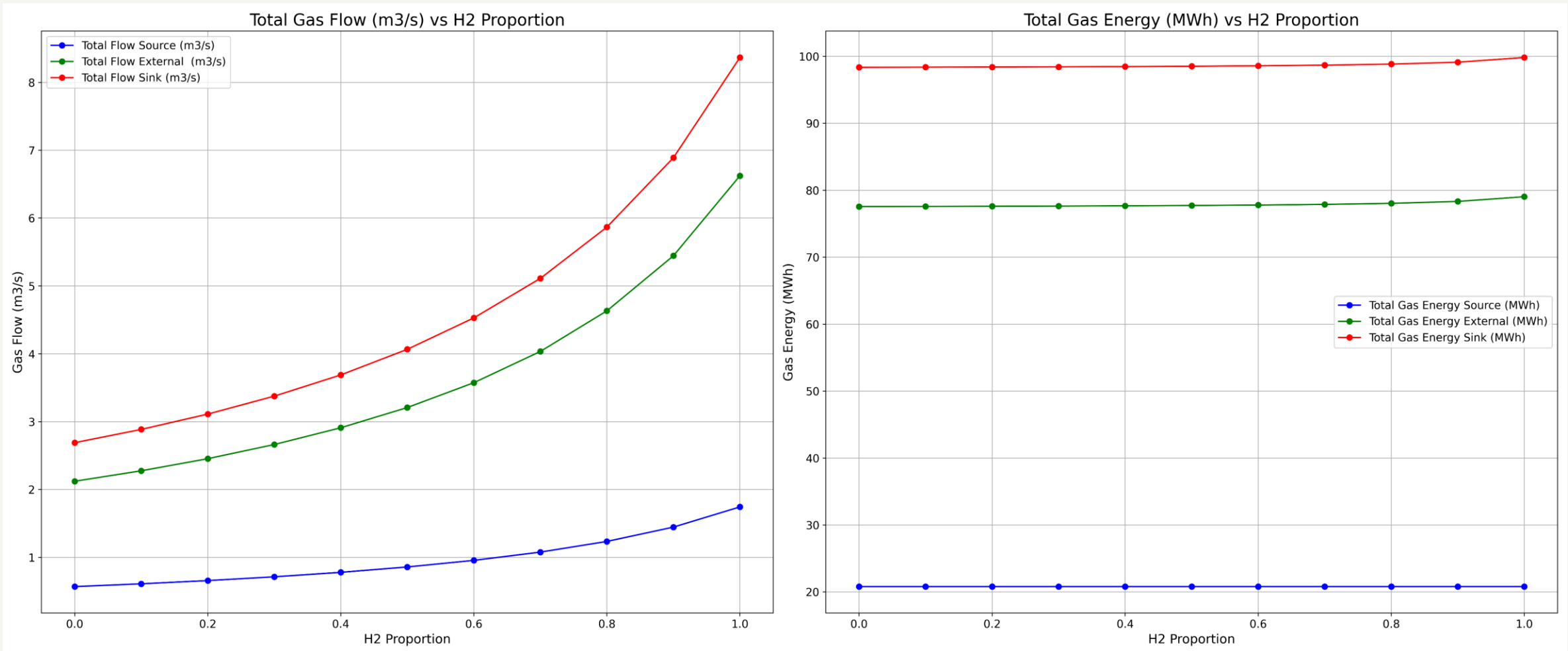
Results

OPGF

| H2_prop | Total Cost | Total Gas Energy Sinks | Total Gas Energy Sources | Total Gas Energy External | Total Flow Rate Sinks | Total Flow Rate Sources | Total Flow Rate External |
|---------|------------|------------------------|--------------------------|---------------------------|-----------------------|-------------------------|--------------------------|
| | (£) | (MWh) | (MWh) | (MWh) | (m3/s) | (m3/s) | (m3/s) |
| 0 | 8881.084 | 98.365 | 20.797 | 77.568 | 2.690 | 0.569 | 2.122 |
| 0.1 | 8881.559 | 98.385 | 20.797 | 77.588 | 2.886 | 0.610 | 2.276 |
| 0.2 | 8882.135 | 98.409 | 20.797 | 77.611 | 3.112 | 0.658 | 2.454 |
| 0.3 | 8882.849 | 98.438 | 20.798 | 77.640 | 3.376 | 0.713 | 2.663 |
| 0.4 | 8883.756 | 98.475 | 20.798 | 77.678 | 3.689 | 0.779 | 2.910 |
| 0.5 | 8884.948 | 98.524 | 20.798 | 77.726 | 4.066 | 0.858 | 3.208 |
| 0.6 | 8886.583 | 98.591 | 20.798 | 77.793 | 4.529 | 0.956 | 3.574 |
| 0.7 | 8888.963 | 98.689 | 20.798 | 77.891 | 5.112 | 1.077 | 4.035 |
| 0.8 | 8892.752 | 98.845 | 20.799 | 78.046 | 5.868 | 1.235 | 4.633 |
| 0.9 | 8899.721 | 99.132 | 20.799 | 78.332 | 6.890 | 1.446 | 5.444 |
| 1 | 8916.779 | 99.833 | 20.800 | 79.033 | 8.367 | 1.743 | 6.624 |

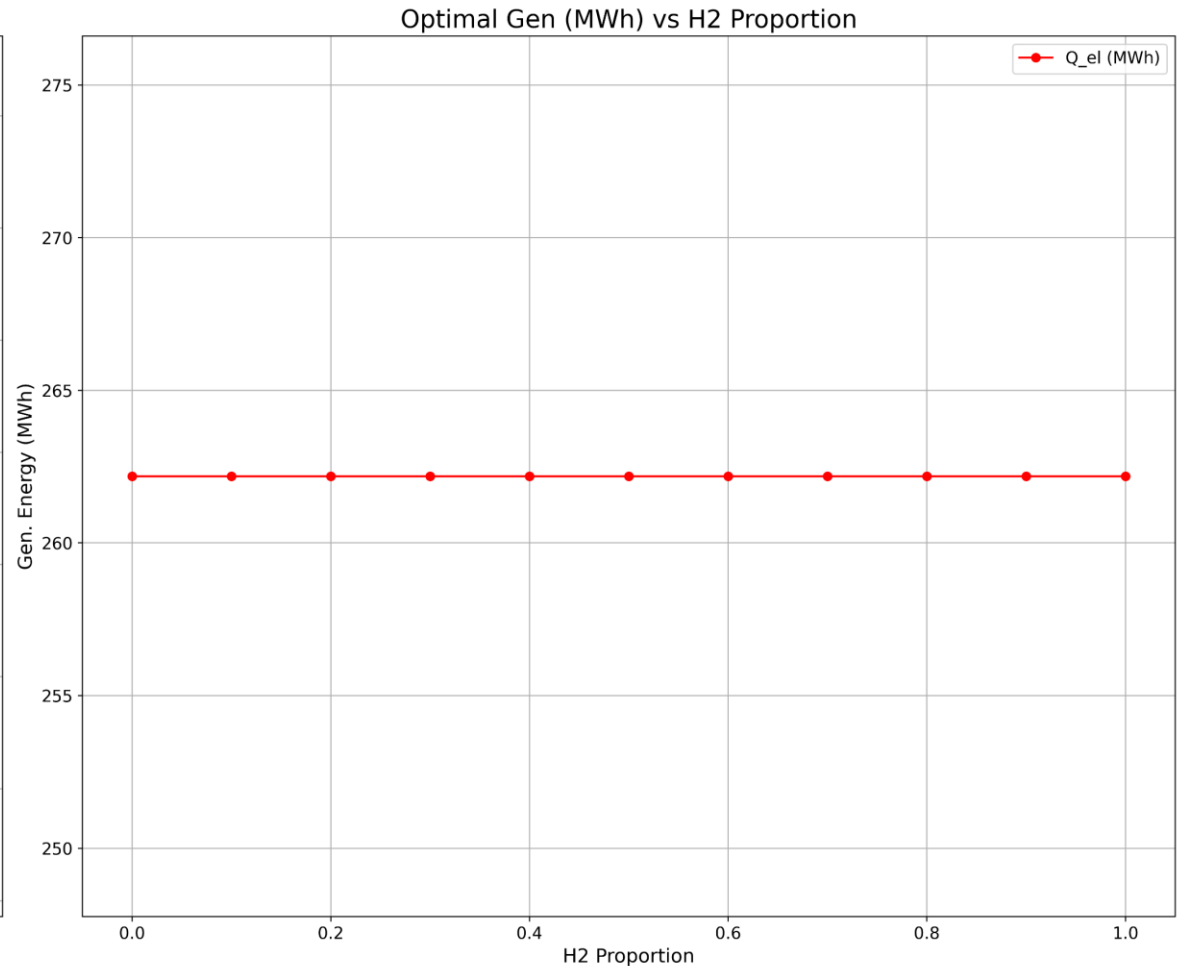
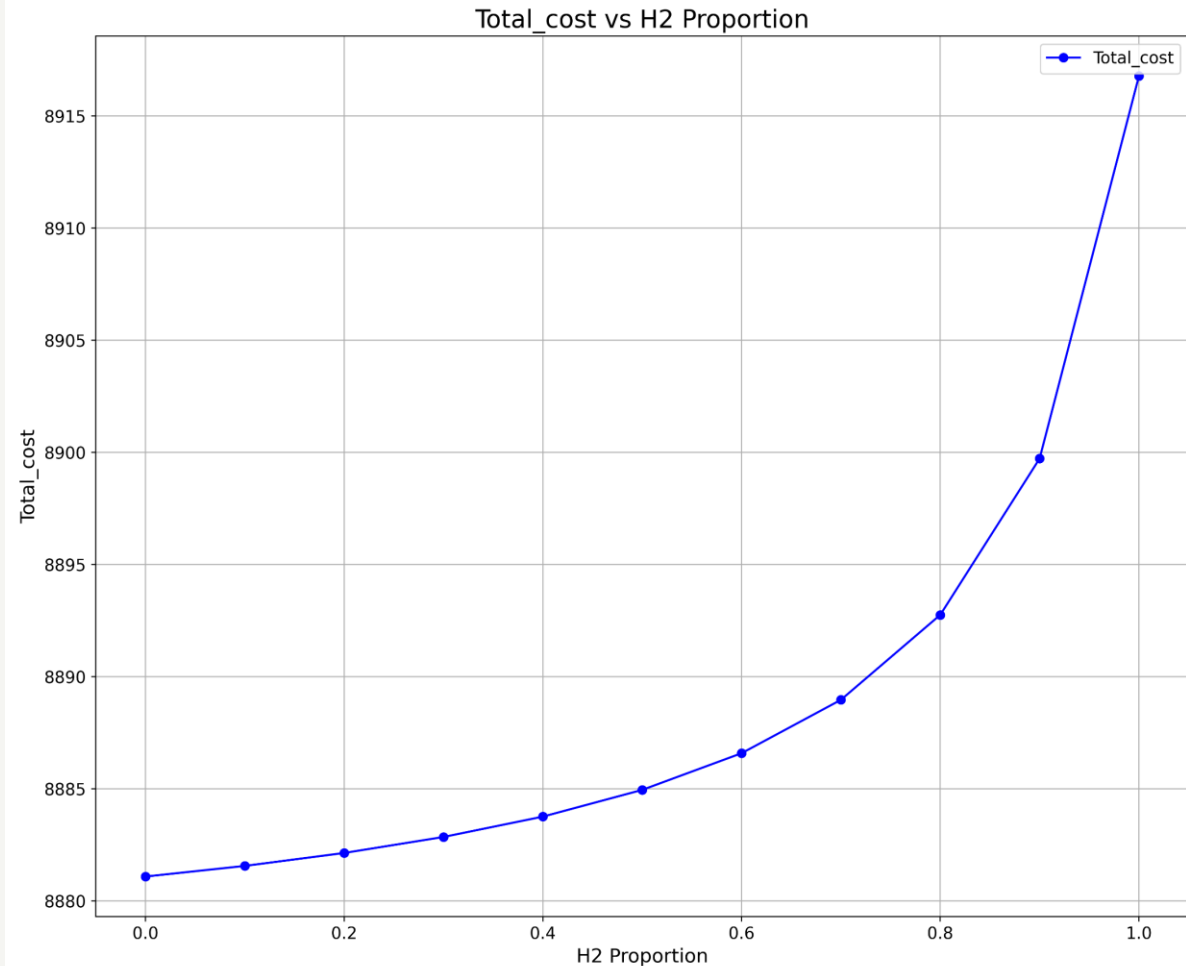
Study Case of Hydrogen Blending

Results



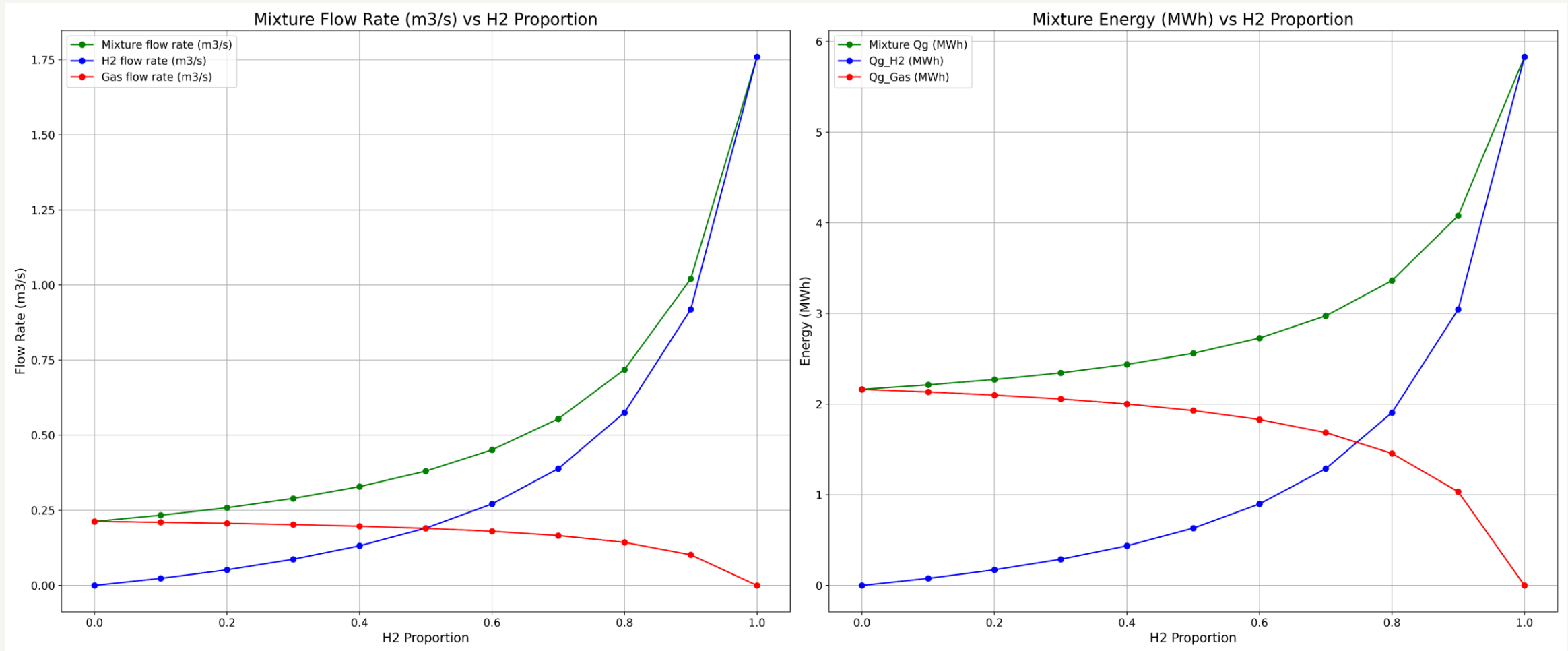
Study Case of Hydrogen Blending

Results



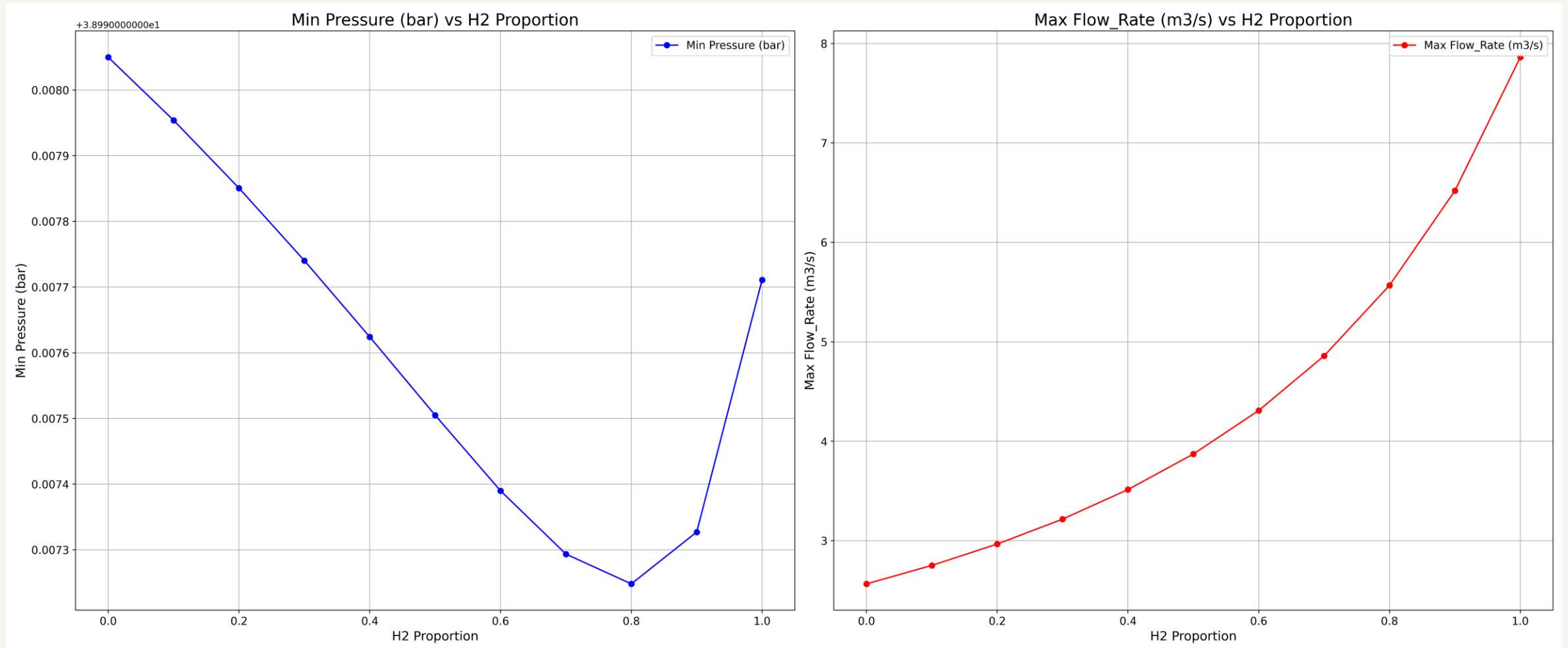
Study Case of Hydrogen Blending

Results



Study Case of Hydrogen Blending

Results



Study Case of Hydrogen Blending

Techno-economic Analysis

| H2 Proportion | Cost GT | Cost_OPGF | Cost Difference | NPV | Total Supply | Total Demand | Emissions GT | Emissions OPGF |
|---------------|----------|-----------|-----------------|-----------|--------------|--------------|--------------|----------------|
| 0 | 75366.44 | 120621.69 | -45255.26 | 57623.59 | 557.96 | 557.96 | 318.76 | 965.21 |
| 0.1 | 73690.35 | 118156.95 | -44466.60 | 59818.51 | 558.38 | 558.38 | 308.17 | 931.48 |
| 0.2 | 71750.16 | 115990.18 | -44240.02 | 62360.21 | 558.88 | 558.88 | 296.27 | 901.71 |
| 0.3 | 69546.65 | 112388.24 | -42841.59 | 65256.56 | 559.51 | 559.51 | 282.65 | 850.54 |
| 0.4 | 66886.52 | 108210.15 | -41323.63 | 68791.39 | 560.31 | 560.31 | 265.66 | 792.96 |
| 0.5 | 63705.12 | 103817.32 | -40112.20 | 72991.18 | 561.35 | 561.35 | 246.07 | 731.25 |
| 0.6 | 59801.56 | 97921.71 | -38120.15 | 78246.06 | 562.79 | 562.79 | 221.32 | 649.45 |
| 0.7 | 54923.81 | 90998.50 | -36074.70 | 84798.73 | 564.88 | 564.88 | 190.89 | 552.43 |
| 0.8 | 48403.73 | 82064.51 | -33660.78 | 92795.86 | 568.20 | 568.20 | 149.84 | 427.13 |
| 0.9 | 39334.12 | 68683.05 | -29348.93 | 101445.73 | 574.32 | 574.32 | 92.54 | 240.05 |
| 1 | 28758.90 | 53208.43 | -24449.53 | 114073.17 | 589.29 | 589.29 | 23.35 | 23.20 |

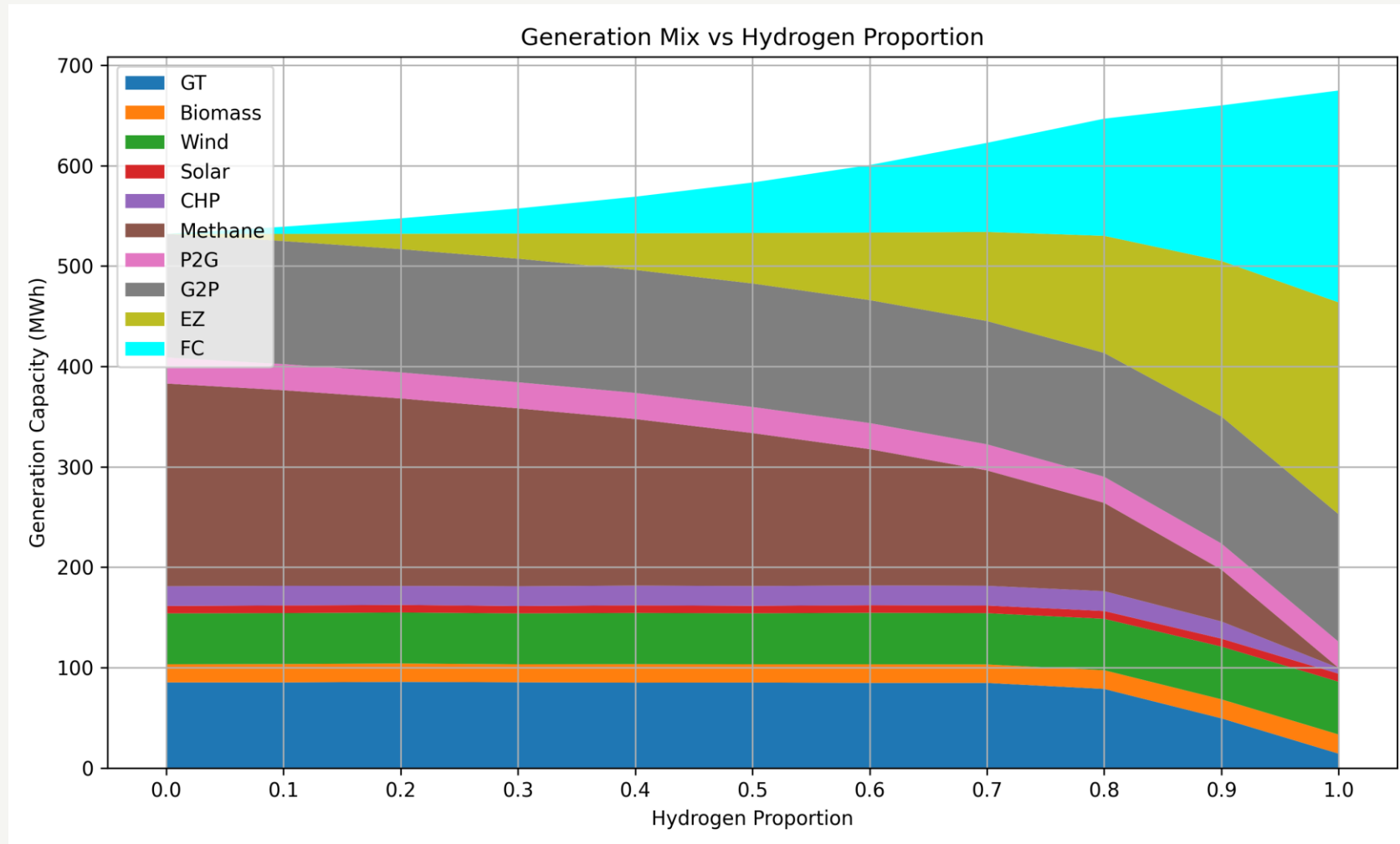
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Techno-economic Analysis

| Player Type | Generation Capacity (MWh) vs. H2-Prop | | | | | | | | | | |
|-------------|---------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
| CHP | 19.70 | 19.57 | 18.94 | 19.71 | 19.64 | 19.72 | 19.65 | 19.70 | 19.77 | 17.16 | 5.76 |
| EZ | 0.00 | 7.12 | 15.36 | 25.00 | 36.44 | 50.26 | 67.26 | 88.72 | 116.69 | 154.92 | 211.06 |
| FC | 0.00 | 7.12 | 15.36 | 25.00 | 36.44 | 50.26 | 67.26 | 88.72 | 116.69 | 154.92 | 211.06 |
| G2P | 122.93 | 122.59 | 122.73 | 123.12 | 122.53 | 123.01 | 122.47 | 122.82 | 123.32 | 126.55 | 127.05 |
| GT | 85.30 | 85.28 | 85.83 | 85.40 | 85.06 | 85.18 | 84.82 | 84.79 | 78.81 | 49.50 | 14.31 |
| P2G | 26.00 | 26.00 | 26.00 | 26.00 | 26.00 | 26.00 | 26.00 | 26.00 | 26.00 | 26.00 | 26.00 |
| Biomass | 18.06 | 18.34 | 18.31 | 17.95 | 18.43 | 18.14 | 18.50 | 18.40 | 18.65 | 18.97 | 19.11 |
| Meth | 201.88 | 194.84 | 186.71 | 177.20 | 165.94 | 152.39 | 135.78 | 114.92 | 87.94 | 51.64 | 0.00 |
| Solar | 7.42 | 7.63 | 7.58 | 7.34 | 7.62 | 7.46 | 7.63 | 7.59 | 7.77 | 7.90 | 8.00 |
| Wind | 50.68 | 50.71 | 50.77 | 50.69 | 50.99 | 50.80 | 51.29 | 51.08 | 51.23 | 52.51 | 52.54 |

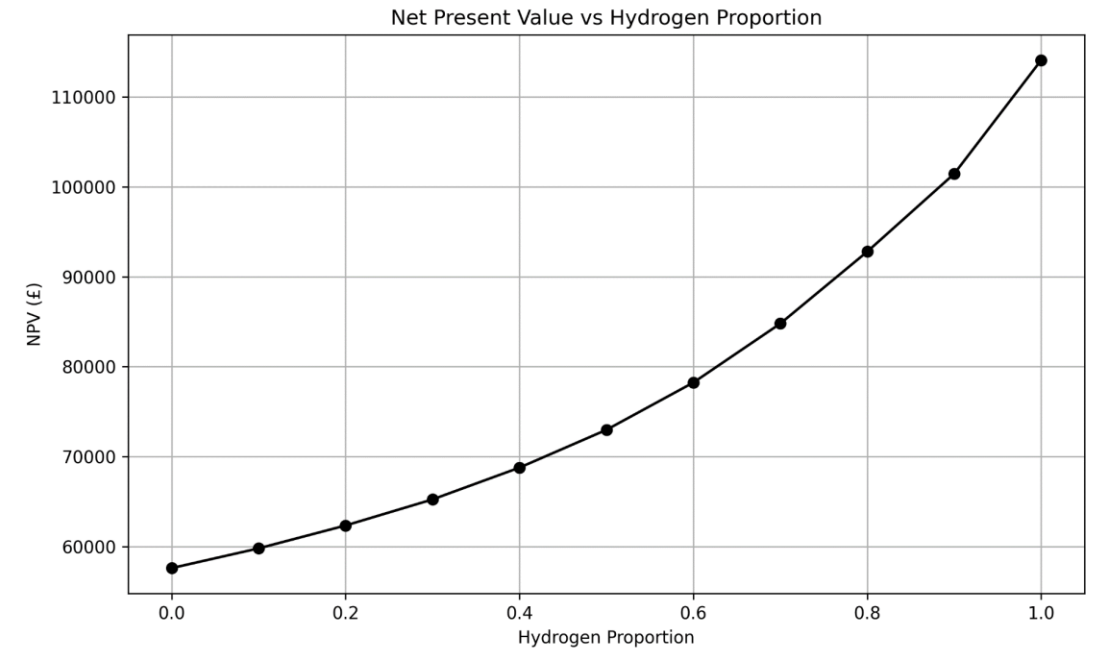
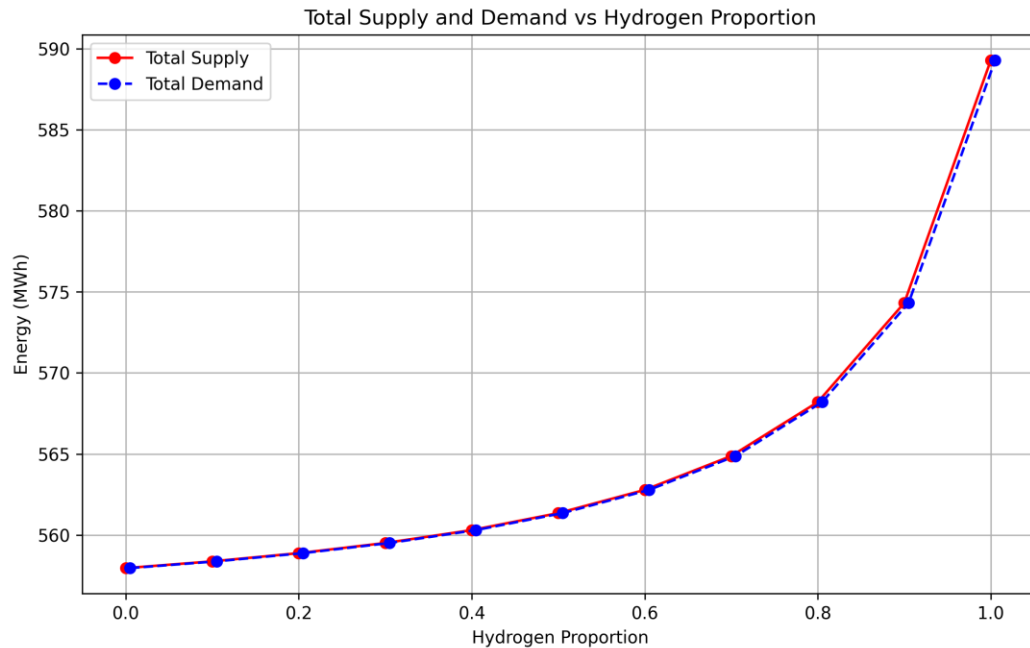
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Techno-economic Analysis



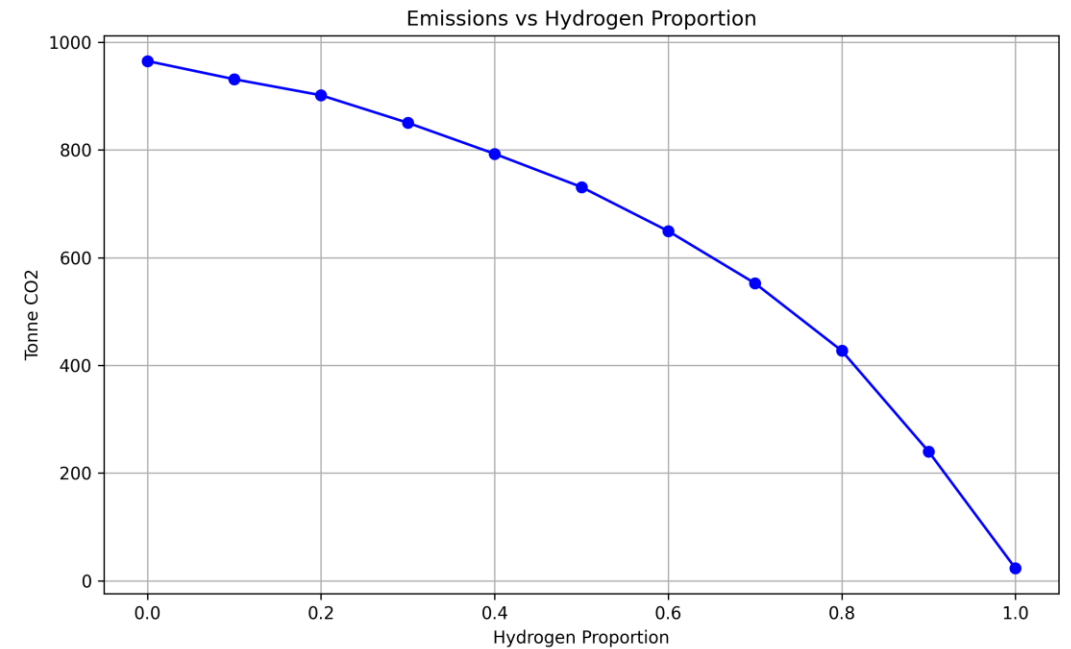
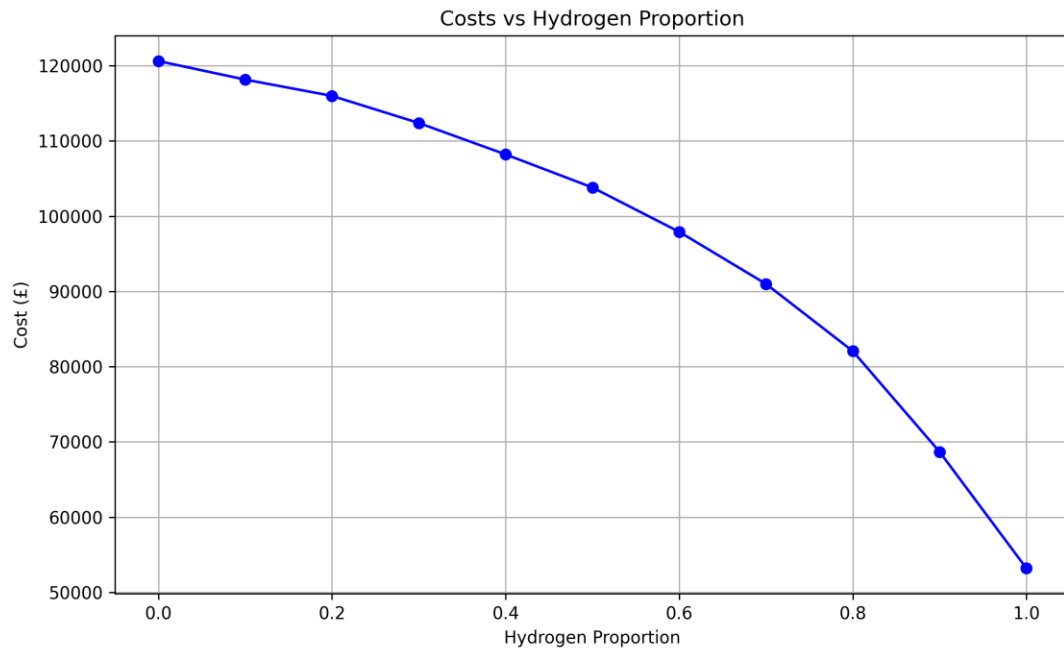
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Techno-economic Analysis



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Techno-economic Analysis



Thank you for your attention