io consulting

SUMMIT

Bacton Energy Hub Advisory

Cost & LCOH Results

October 2022

key takeaways

Bacton Energy Hub Integrated Cost Estimation and Economic Modelling

1. The overall Class 5 cost estimation basis quality is good, with the key cost blocks based on reliable technical definition and the total installed costs benchmarking well with public domain and in-house data
2. The 2030 blue hydrogen LCOH estimates are close to the BEIS 2021 equivalents (the totals at least) and scaling-up to three 350 MW plants from a single plant would be expected to provide cost efficiencies
3. The 2040 build-out is essentially two projects executed at the same time; and if the blue hydrogen cost is considered in isolation, the cost of gas (irrespective of origin) pushes the LCOH above the 2030 cases
4. Note that the LCOH analysis is based on BEIS 2021 electricity and fuel prices, derived before the Covid-19 pandemic and Russia-Ukraine war, and so do not represent potentially (much) higher long term prices
5. Future green hydrogen LCOH is highly uncertain, not just from the extent of electrolyser cost reductions and efficiencies but also, the cost of renewable power from different sources by 2040 and beyond
6. The analysis assumes green hydrogen production is powered by dedicated offshore wind but there are obviously other sources and combinations and large scale long duration energy storage implications

hydrogen scenarios

targeting blue hydrogen production start in 2030 with two stages of build-out incorporating green hydrogen

Parameter	Units	2030 (core)	2030 (build-out)	2040 (build-out)	2050 (build-out)
Gas feedstock (for blue H2)	MMscfd	30	82	356	274
Carbon capture (for blue H2)	Mtpa	0.8	2.4	10.4	8.0
Blue hydrogen plant capacity[1]	GW	0.4	1.1	4.7	3.6
Green hydrogen plant capacity[2]	GW	-	-	2.1	6.3
Total hydrogen capacity	GW	0.4	1.1	6.8	9.9
Maximum supply	TWh	3	9	57	30+54
Hydrogen blend (in NTS)	%	20%	20%	100%[3]	100%

1 Three 355 MW CCS-enabled hydrogen plants in 2030 powered by grid retired pre-2050 and addition of two 1.8 GW plants in 2040 onwards

2 One 2.1 GW electrolysers in 2040 powered from redeployed constrained wind power & green grid, then another two 2.1 GW added in 2050 from dedicated offshore wind and solar plus connection to (green) grid

3 100% hydrogen in some parts of region in 2040(?)

Cost Estimates

capital cost estimation basis quality

overall cost estimates based on estimates provided by SIG representatives to varying degrees of confidence

Capital blocks	Cost basis quality rating (green = good, red = poor)
Power connection	No basis for scope, with exception of the core 2030 estimate (from UK Power Networks)
Desalination plant	Fixed unit rate estimate (from Goal7) with uncertainties around intake scope
Blue hydrogen plant	Based on the HyNet hydrogen estimates (from Progressive) & high-level benchmarking
Green hydrogen plant	Based on 2 GW prorated for 2.1GW and benchmarked against in-house vendor data
Hydrogen export	No basis for scope or cost, 'best guess' estimate
CO2 export & sequestration[1]	Costs provided by Xodus and awaiting confirmation from OPC
Land acquisition	Based on site plot plans (by McDermott) and 'notional' £250-300k/Ha unit land cost

1 New uninsulated carbon steel pipeline 30k from shore to 4-slot wellhead platform NUI at notional offshore field

Note: the quality rating is not a measure of uncertainty but of the perceived quality of the technical definition underlying the cost estimate. There is inherent uncertainty in estimating current and future costs of hydrogen production, particularly given that certain technologies do not yet exist at scale.

capital cost rough order of magnitude estimates

capital cost estimates are dominated by the blue and green hydrogen plant cost blocks

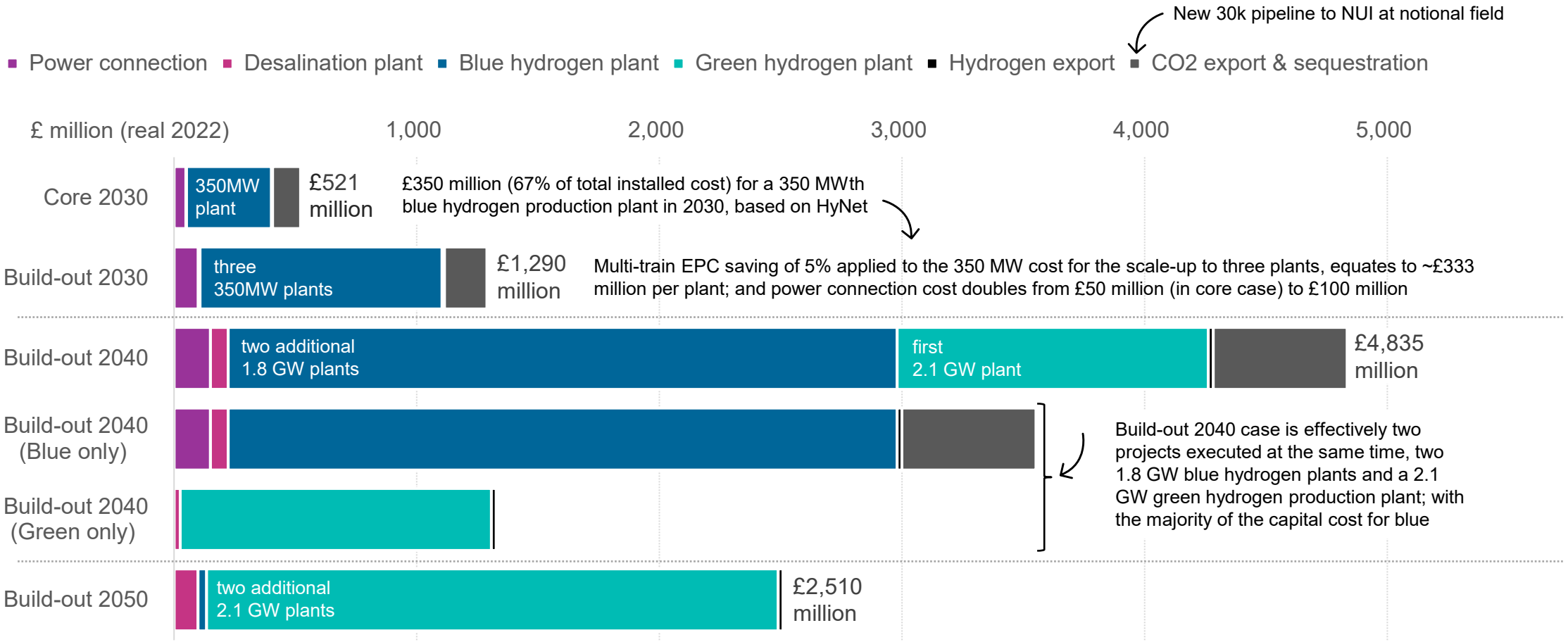
Capital cost (AACEi Class V)[1]	#	Units	2030 (core)	2030 (build-out)	2040 (build-out)	2050 (build-out)
Power connection		£ million	49	100	150	-
Desalination plant		£ million	2	7	73	99
Blue hydrogen plant		£ million	350	998	2,757	35
Green hydrogen plant[2]		£ million	-	-	1,283	2,049
Hydrogen export		£ million	5	10	20	20
CO2 export & sequestration		£ million	115	175	552	-
Land acquisition		£ million	-	4	18	33
Capital cost (incremental)		£ million	**521**	**1,294**	**4,853**	**2,543**
Capital cost (cumulative)		£ million	**521**	**1,294**	**6,147**	**8,690**

1 Costs in real terms at time of expenditure, with 2030 costs Class V ± 50% and 2040 & 2050 costs 'order of magnitude' projections with significant range of uncertainty

2 Green hydrogen plant factors in the forecast cost reduction to 2040 (40% reduction on 2022 cost) and 2050 (42% reduction)

capital cost rough order of magnitude estimates – Page 2

capital cost estimates are dominated by the blue and green hydrogen plants



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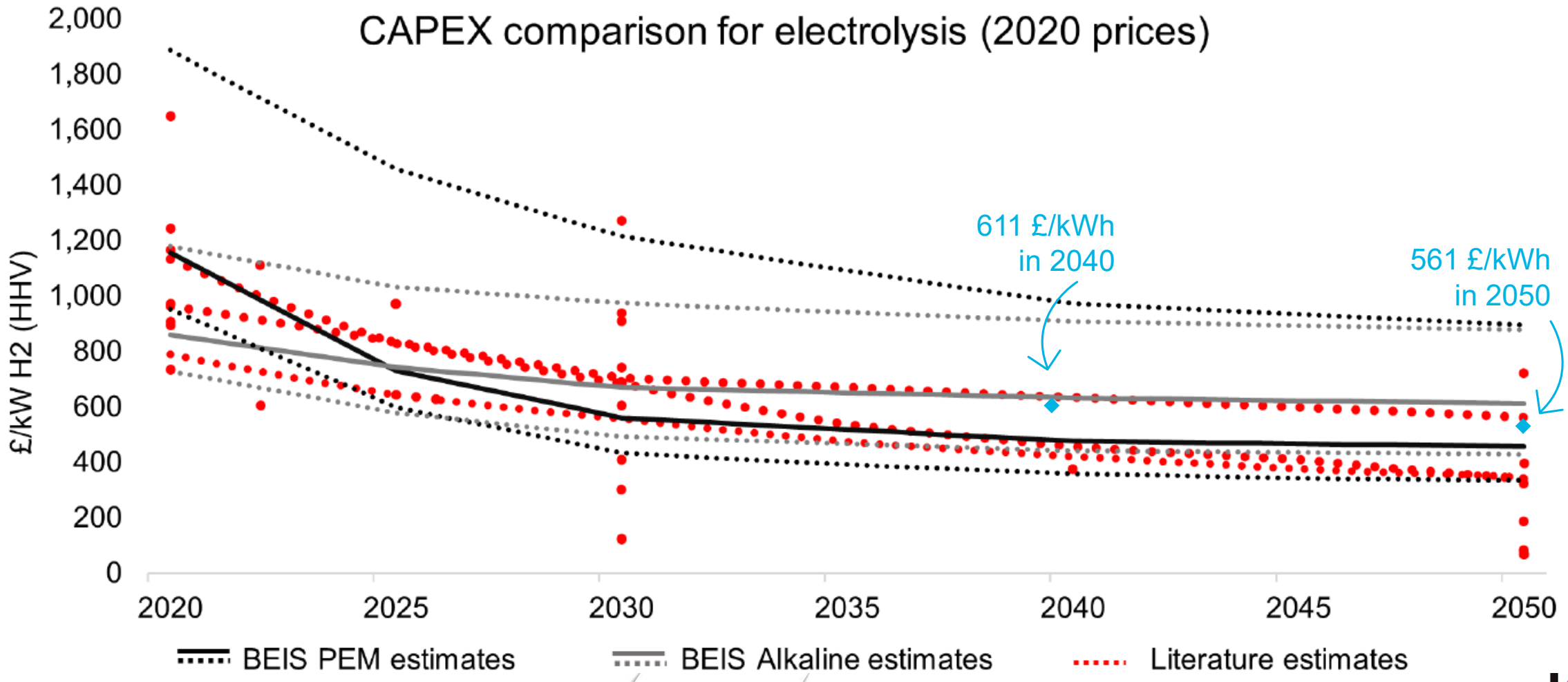
capital cost green hydrogen cost reductions

cost reductions expected from technology efficiency improvements driven by global demand for electrolysis



Levelized Cost of Hydrogen (LCOH)

LCOH adopting BEIS 2021 basis

analysis approach largely corresponds to the 'BEIS Hydrogen Production Costs August 2021'

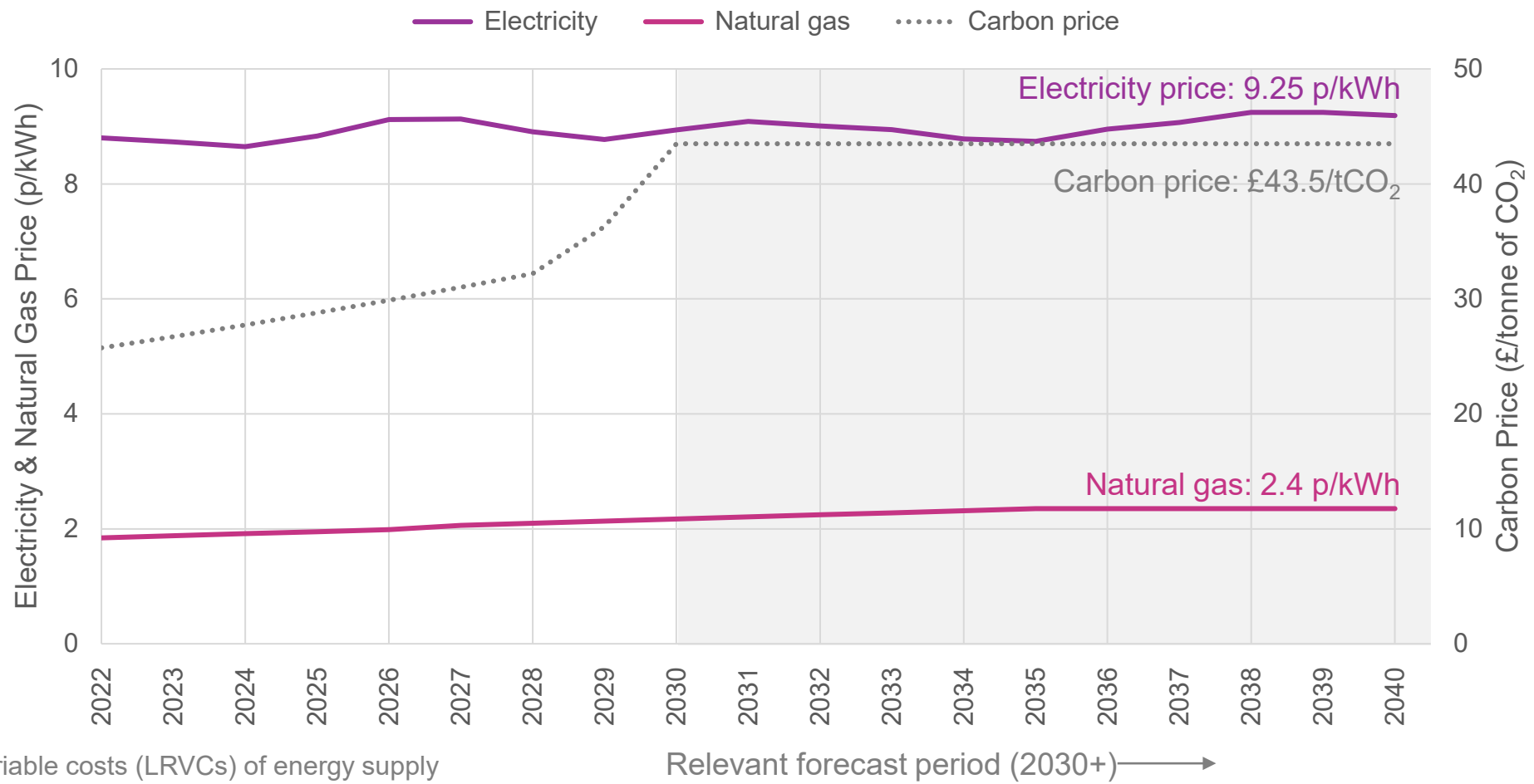
1. Levelized costs is a measure of the average cost of hydrogen produced over the full lifetime of a plant, expressed as a cost per energy unit of hydrogen produced **(£/MWh**);
2. BEIS analysis assumes a uniform build time of **three years** and excludes pre-development timings, and assumes a technical life of 30 years for electrolysis projects and 40 years for reformer projects;
3. Electricity and fuel prices are based on published BEIS data, derived **before** the Covid-19 pandemic and Russia-Ukraine war and so do not represent the gas price surge this year;
4. BEIS report Long-run variable costs of energy supply of **9.25 p/kWh** electricity price and the underlying natural gas wholesale price of **2.35 p/kWh** (with notional **20% premium** for interconnector sourced gas);
5. For offshore wind the assumption is that the electrolysis plant would face the levelized cost of offshore wind electricity generation as their electricity price (BEIS estimates offshore wind at **£40/MWh in 2040**)
6. Hurdle rates are the minimum financial return that a project developer would require over a project's lifetime, and BEIS report assumes a uniform **10% hurdle rate** to discount costs and output across time.

BEIS price forecasts

current industrial electricity & natural gas prices remain well above the level seen at the same time last year

Between Q1 2021 and Q1 2022 the average electricity price in cash terms excluding CCL in the non-domestic sector rose by 29% to: 18.14 p/kWh

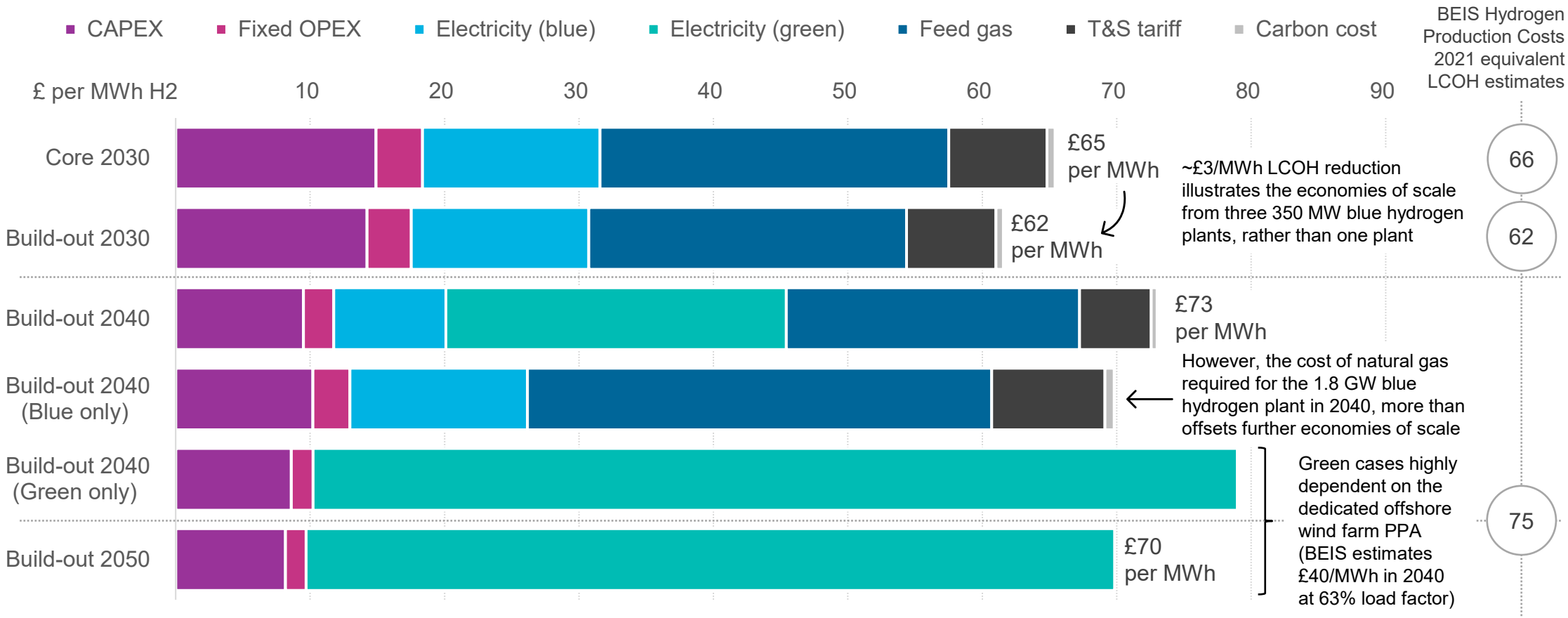
The average natural gas price over the same period in cash terms excluding CCL in the non-domestic sector rose by 71% to 3.95 p/kWh.



Source: BEIS Long-run variable costs (LRVCs) of energy supply

LCOH analysis results

illustrates that levelized costs are dominated by the cost of natural gas and the cost of electricity



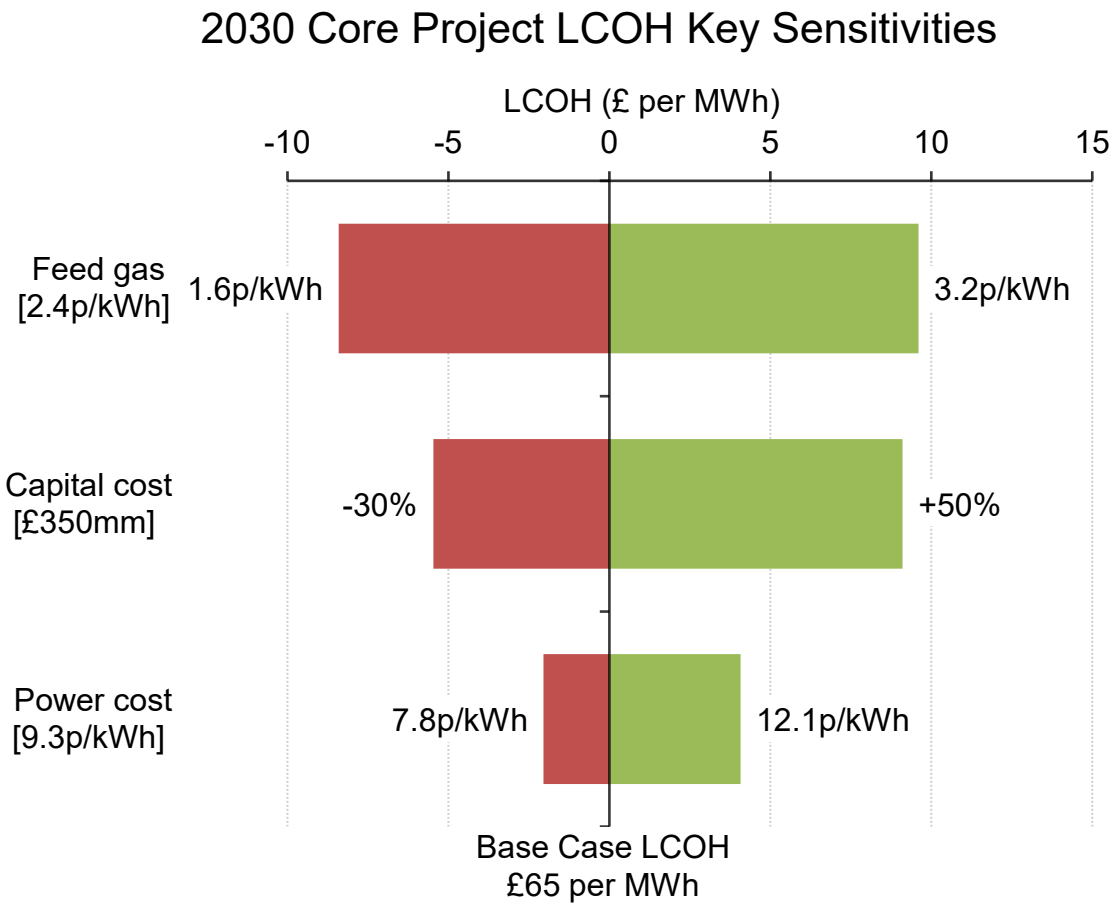
1 BEIS LRVC of energy supply of **9.25 p/kWh** electricity price & natural gas wholesale price of **2.35 p/kWh** (with notional 20% premium for interconnector sourced gas);

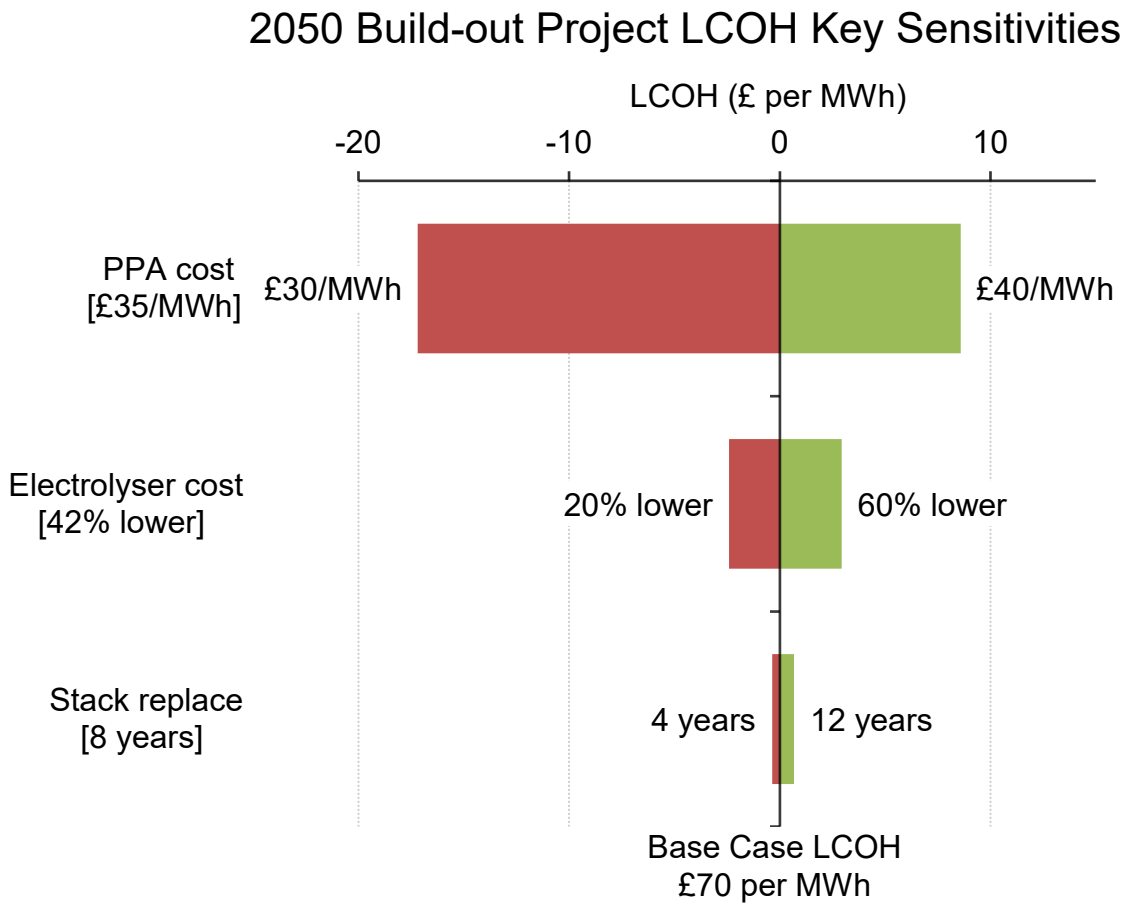
2 T&S fees based on BEIS simplified assumption of £28/tCO2 (instead of estimated CO2 export & sequestration costs at the notional field)

3 Power connection & hydrogen export costs excluded as well as CO2 export & sequestration operating cost in order to compare to BEIS LCOH; BEIS costs (1) do not cover the costs of hydrogen compression, storage, transmission or land costs and (2) the OPEX includes the electrolyser stack replacement costs annuitized.

LCOH key sensitivities

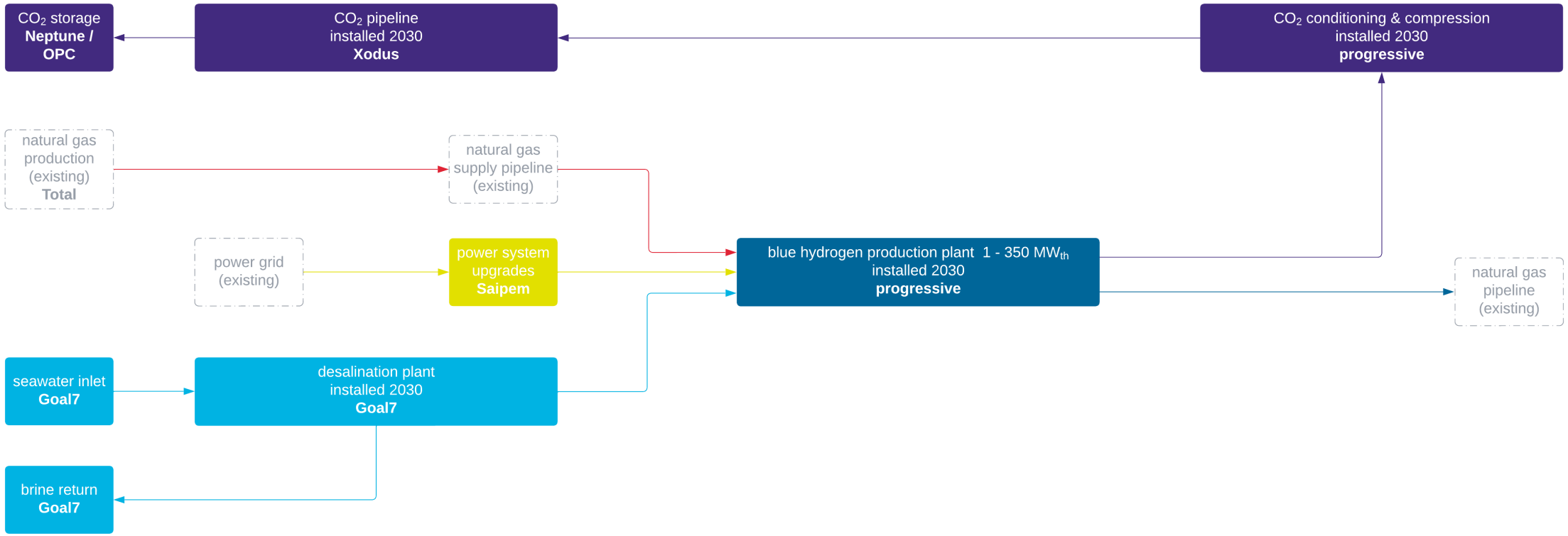
the gas price and offshore wind PPA price are the primary blue and green hydrogen respective LCOH levers



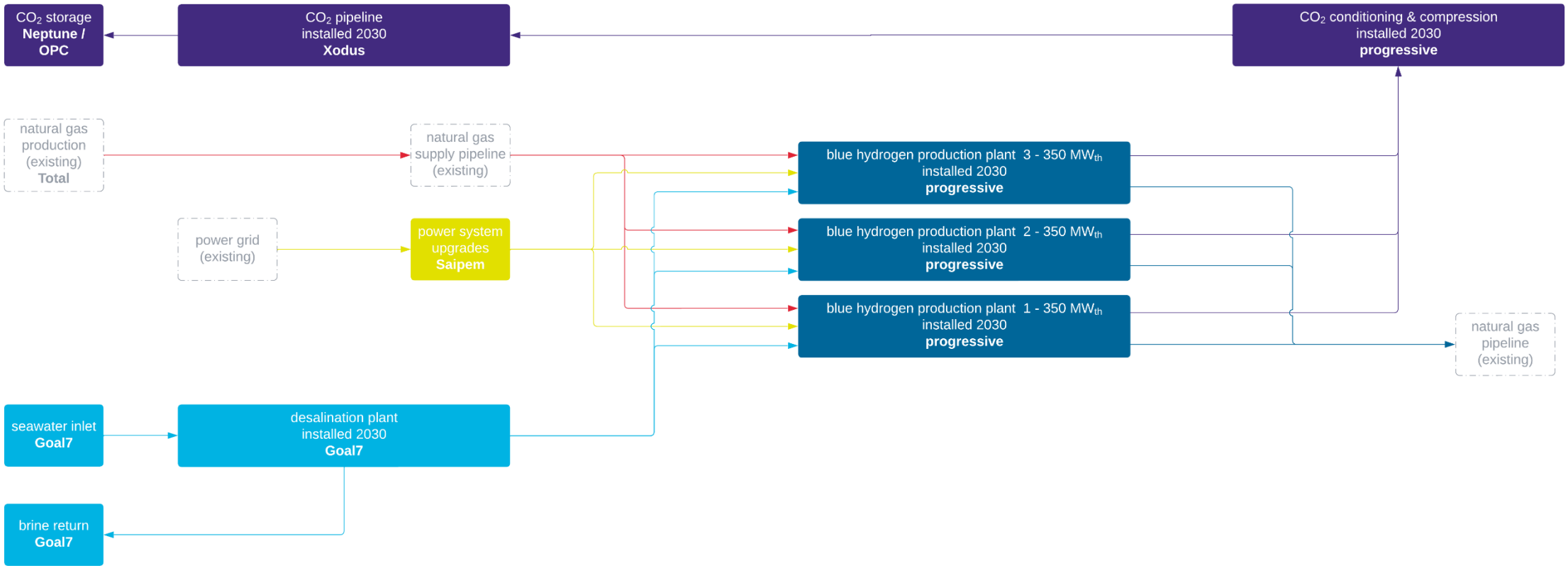


Annex A: BFDs

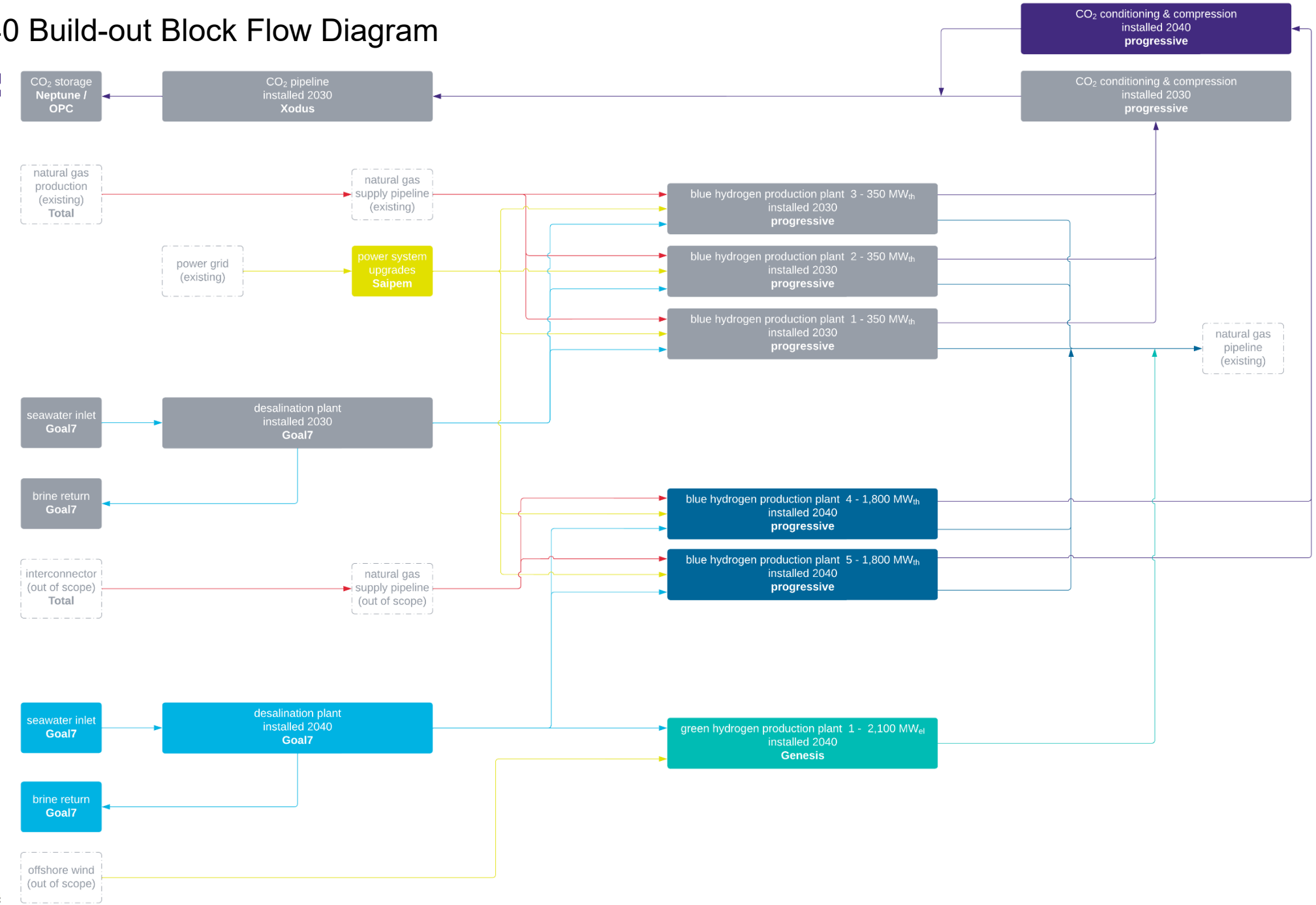
2030 Core Block Flow Diagram



2030 Build-out Block Flow Diagram



2040 Build-out Block Flow Diagram



2050 Build-out Block Flow Diagram