LCN Fund Full Submission

Supplementary Answer Form

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Project code:	WPDT205	Question Number	9
Question date	29th August	Answer date	2nd September
Submission section question relates to	2: Project Description Early Bilateral		
Topic	Commercial		
Question	Please provide the NPV of each method against the base case of an unconstrained connection.		
Notes on question			
Answer	**Model Refinement** Given the focus on the economics of the model by the panel, the financial model has been refined to move its focus from demonstrating ***'the potential to provide net financial benefits'*** to demonstrating what the potential returns would be under given relatively conservative scenarios. The model has also been updated to support the additional modelling requested by the panel. Specific refinements include: • Project cashflows have been converted to post-tax revenues. This has a negative impact on the IRR's and NPVs of the Methods • The gas price has been revised down to reflect the 2013 mid price		

	quoted in the recent DECC Fossil Fuel Price Projection rather than the potentially contentious higher future figure previously assumed. This change has a negative impact on gas injection Methods and a positive impact on Methods exploiting the gas engine • A 0.5% above inflation annual rise in energy prices has been assumed. This is considered conservative given the DECC Fossil Fuel Price Projection of a 20% increase in wholesale gas and coal prices by 2030 and the DECC sponsored Scottish Island Renewables Report which predicts onshore renewable prices in the South of England of £64/MWh by 2030. A 3% comparator was used/referenced as the example in the initial bid • Although the bid mentioned demand response opportunities would be explored by the project, an estimate of this revenue has now been included in the bid to exploit the low electrolyser utilisation • At the panels request, a comparison with a 1MW wind Farm with 1MW unconstrained connection has been included • At the panels request, the incremental cost of each Method over and above the wind farm and wind connection has been included in the results summary • At the panels request results, for Methods 1 and 5 in isolation have been included. For contrast, the combination of Methods 2 and 5 has also been included • Given the panels reference to the total value of the Methods to UK PLC, the financial value of Carbon has been included in the Method evaluation for illustration • The unconstrained connection previously referred to the unconstrained connection available for both the PV farm and the new wind farm. It has been updated now to purely reflect the connection available for the new wind farm to make it absolutely clear what this refers to Given the desire to compare the Methods with a 1MW wind farm that has a unconstrained connection (i.e. the available unconstrained availability in Wadebridge) another point needs to be made to support the evaluation that was not made explicit previously. It should be noted that the financial model was developed to demonstrate the rollout potential. As such it has not been integrated with the Wadebridge constraint model. Consequently the financial model calculates the maximum available feeder capacity to be the sum of the new wind farm unconstrained connection and the existing PV farm connection. This ignores the additional network capacity that the solution releases through active network management. This additional capacity has been excluded from the rollout model since it is site dependent. As a result the model's returns are considerably understated. No annual approximation for potential constrained capacity could be ascertained at a national level to allow us to model this.

Other opportunities excluded from the base model:

- Control system cost savings through socialising across multiple sites (it can support up to ten)
- Electrolyser cost reductions through thrashing the system (costs could be halved)
- Revenue impact of energy costs rising in line with the above quoted reports (i.e. circa 1% PA rather than the 0.5% PA assumed)

NPV Scenarios

Demonstrating the NPV of each scenario against the NPV of an unconstrained connection isn't straightforward given the flexibility of the Methods being tested. Specifically, the size/combination of Method components will be determined by the specifics of the site at which the Methods are to be rolled out – each one will be different as illustrated by the scenarios below.

Where there is a good balance of Wind and PV Method 1, the constraint scheme, provides considerable returns, as one would expect. The spark spread means that Method 2 provides a higher NPV although the gas engine is predominantly fuelled by natural gas due to the low electrolyser utilisation. The best NPV and generation results, however, are demonstrated by Methods 2 and 5 combined.

Key Assumptions	
Wind (MW):	6
PV (MW):	6
ELY (MW):	1
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	0.50%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	6.4%	14.00	0.93	7.8%	13.00	1.26
Method 0	0.00	17.05	7790.95	3.9%	17.00	3.04	5.2%	15.00	5.08
Method 1	0.40	16.96	7751.31	9.9%	11.00	8.21	11.5%	10.00	10.24
Method 2	2.31	29.12	7767.54	9.4%	12.00	8.98	10.9%	11.00	11.24
Method 3	2.00	17.01	7767.54	7.6%	13.00	6.36	9.1%	12.00	8.40
Method 4	2.91	29.12	7767.54	8.3%	13.00	7.87	9.6%	11.00	9.90
Method 5	3.15	2.28	810.55	18.3%	7.00	4.63	19.0%	7.00	4.84
Method 6	5.15	19.29	7767.54	9.1%	12.00	10.53	10.3%	11.00	12.56
Method 7	6.06	31.41	7767.54	10.3%	11.00	13.20	11.5%	10.00	15.23
Method 1+5	3.55	19.24	7751.31	11.6%	10.00	12.85	12.9%	9.00	14.87
Method 2+5	5.46	31.41	7767.54	11.0%	10.00	13.85	12.2%	9.00	15.88
ELY Utilisation:		1%							

Taking the opposite extreme with no constraint scheme potential (i.e. no PV), best returns can be achieved by providing additional electrolyser capacity to complement the available unconstrained connection as shown below.

Key Assumptions	
Wind (MW):	6
PV (MW):	0
ELY (MW):	3
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	0.50%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	6.4%	14.00	0.93	7.8%	13.00	1.26
Method 0	0.00	17.05	7790.95	3.6%	18.00	2.47	4.8%	16.00	4.51
Method 1	0.40	12.34	5637.38	5.0%	16.00	2.52	6.4%	14.00	4.00
Method 2	3.91	23.27	6761.37	6.8%	14.00	5.94	8.0%	13.00	7.98
Method 3	3.60	15.50	6761.37	5.2%	16.00	3.72	6.5%	14.00	5.49
Method 4	4.51	23.27	6761.37	5.8%	15.00	4.87	7.0%	14.00	6.64
Method 5	3.15	2.28	810.55	18.3%	7.00	4.63	19.0%	7.00	4.84
Method 6	6.75	17.79	6761.37	7.1%	14.00	7.88	8.1%	13.00	9.65
Method 7	7.66	25.55	6761.37	7.5%	13.00	8.91	8.5%	12.00	10.68
Method 1+5	3.55	14.62	5637.38	7.9%	13.00	7.16	8.9%	12.00	8.64
Method 2+5	7.06	25.55	6761.37	8.7%	12.00	10.85	9.5%	12.00	12.32
ELY Utilisation:		16%							

Best NPV is again demonstrated by a combination of Methods 2 and 5 due to the spark spread. However this ignores the ability of Method 7 to react to daily electricity price variations were a more dynamic sales model adopted (something the project intends to explore), hence shifting generation between gas engine (to exploit high electricity prices) or gas inject (when electricity prices are low or potentially negative). Essentially Method 7 is carrying costs for both the Gas Inject and the Gas Engine without including the benefits derived from having both. This additional revenue potential could prove Method 7 to be an equally viable model.

It should be noted that, although electrolyser utilisation is low, this size of electrolyser provides better returns overall compared to a smaller, higher utilised electrolyser given the additional renewable generation enabled, as demonstrated below.

Key Assumptions	
Wind (MW):	6
PV (MW):	0
ELY (MW):	1
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	0.50%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	6.4%	14.00	0.93	7.8%	13.00	1.26
Method 0	0.00	17.05	7790.95	1.8%	21+	-0.25	3.2%	18.00	1.78
Method 1	0.40	12.34	5637.38	5.0%	16.00	2.52	6.4%	14.00	4.00
Method 2	2.31	21.57	6170.93	5.9%	15.00	3.96	7.1%	14.00	5.81
Method 3	2.00	13.84	6170.93	4.3%	17.00	2.12	5.6%	15.00	3.73
Method 4	2.91	21.57	6170.93	4.7%	17.00	2.85	6.0%	15.00	4.47
Method 5	3.15	2.28	810.55	18.3%	7.00	4.63	19.0%	7.00	4.84
Method 6	5.15	16.12	6170.93	6.6%	14.00	6.28	7.6%	13.00	7.89
Method 7	6.06	23.85	6170.93	7.6%	13.00	8.17	8.5%	12.00	9.78
Method 1+5	3.55	14.62	5637.38	7.9%	13.00	7.16	8.9%	12.00	8.64
Method 2+5	5.46	23.85	6170.93	8.2%	13.00	8.83	9.1%	12.00	10.31
ELY Utilisation:		23%							

Other sensitivities to consider include the unconstrained connection itself. Were the unconstrained connection to be reduced but an element of constraint scheme to remain, sufficient returns can still be obtained through a combination of Methods 2 and 5 although, once again, Method 7's performance is only slightly inferior and could potentially excess through arbitrage opportunities (and in doing so provide a smoothing service across energy vectors).

Key Assumptions	
Wind (MW):	6
PV (MW):	3
ELY (MW):	1
Firm Connection (MW):	1
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	0.50%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	6.4%	14.00	0.93	7.8%	13.00	1.26
Method 0	0.00	17.05	7790.95	2.6%	19.00	0.88	3.9%	17.00	2.92
Method 1	0.40	13.66	6242.86	6.5%	14.00	4.15	7.9%	13.00	5.79
Method 2	2.31	23.49	6669.80	7.0%	14.00	5.45	8.3%	12.00	7.43
Method 3	2.00	14.86	6669.80	5.4%	16.00	3.45	6.8%	14.00	5.19
Method 4	2.91	23.49	6669.80	5.8%	15.00	4.34	7.1%	14.00	6.09
Method 5	3.15	2.28	810.55	18.3%	7.00	4.63	19.0%	7.00	4.84
Method 6	5.15	17.15	6669.80	7.4%	13.00	7.61	8.5%	13.00	9.36
Method 7	6.06	25.77	6669.80	8.4%	12.00	9.66	9.4%	12.00	11.40
Method 1+5	3.55	15.94	6242.86	9.0%	12.00	8.79	10.1%	11.00	10.42
Method 2+5	5.46	25.77	6669.80	9.1%	12.00	10.32	10.0%	11.00	11.96
ELY Utilisation:		18%							

Optimum overall performance however can be achieved by having a combination of firm, constraint and electrolyser operation, maximising carbon benefits alongside financial returns.

Key Assumptions	
Wind (MW):	6
PV (MW):	2
ELY (MW):	2
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	0.5%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	6.4%	14.00	0.93	7.8%	13.00	1.26
Method 0	0.00	17.05	7790.95	3.8%	17.00	2.90	5.1%	15.00	4.94
Method 1	0.40	15.44	7055.77	8.3%	12.00	6.34	9.9%	11.00	8.18
Method 2	3.11	26.87	7446.07	8.4%	13.00	7.91	9.7%	11.00	10.11
Method 3	2.80	16.54	7446.07	6.7%	14.00	5.51	8.1%	13.00	7.46
Method 4	3.71	26.87	7446.07	7.3%	13.00	6.82	8.6%	12.00	8.77
Method 5	3.15	2.28	810.55	18.3%	7.00	4.63	19.0%	7.00	4.84
Method 6	5.95	18.82	7446.07	8.3%	13.00	9.68	9.4%	12.00	11.62
Method 7	6.86	29.16	7446.07	9.1%	12.00	11.51	10.2%	11.00	13.46
Method 1+5	3.55	17.72	7055.77	10.4%	10.00	10.98	11.6%	10.00	12.82
Method 2+5	6.26	29.16	7446.07	10.1%	11.00	12.80	11.1%	10.00	14.64
ELY Utilisation:		8%							

A further scenario that the project plans to test, is the ability to essentially thrash the electrolyser. It is believe its capacity could effectively be doubled for short periods, in essence halving the effective price. In this instance a larger electrolyser providers better returns despite the lower utilisation.

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	6.4%	14.00	0.93	7.8%	13.00	1.26
Method 0	0.00	17.05	7790.95	3.9%	17.00	3.06	5.2%	15.00	5.10
Method 1	0.40	15.44	7055.77	8.3%	12.00	6.34	9.9%	11.00	8.18
Method 2	2.71	27.41	7482.15	9.3%	12.00	9.12	10.7%	11.00	11.32
Method 3	2.40	16.64	7482.15	7.6%	13.00	6.58	9.0%	12.00	8.54
Method 4	3.31	27.41	7482.15	8.2%	13.00	8.02	9.5%	11.00	9.98
Method 5	3.15	2.28	810.55	18.3%	7.00	4.63	19.0%	7.00	4.84
Method 6	5.55	18.92	7482.15	9.1%	12.00	10.74	10.2%	11.00	12.70
Method 7	6.46	29.70	7482.15	9.6%	12.00	12.08	10.6%	10.00	14.03
Method 1+5	3.55	17.72	7055.77	10.4%	10.00	10.98	11.6%	10.00	12.82
Method 2+5	5.86	29.70	7482.15	10.9%	10.00	14.00	11.9%	10.00	15.85
ELY Utilisation:		6%							

Scernario & Rollout Carbon Saving	
Wind (MW):	6
PV (MW):	2
ELY (MW):	3
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	0.5%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55
Co2 Saved (Tonnes PA):	7,482
Number of eqivalent sites	500
Co2 Saved (Million Tonnes PA):	3.74

As can be seen, although a combination of Methods 2 and 5 have the best NPV, both end-to-end Methods have healthy NPVs also.

A similar consideration is if the costs of the control system could be socialised. It is capable of supporting up to 10 instances. Hence costs could reduce considerably from those quoted. The model below assumes a modest 50% decrease in price although a more substantial decrease is obviously possible if shared across 10 sites.

Key Assumptions	
Wind (MW):	6
PV (MW):	2
ELY (MW):	1
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	0.5%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	6.4%	14.00	0.93	7.8%	13.00	1.26
Method 0	0.00	17.05	7790.95	3.5%	18.00	2.27	4.7%	16.00	4.31
Method 1	0.40	15.44	7055.77	8.3%	12.00	6.34	9.9%	11.00	8.18
Method 2	2.01	26.21	7310.82	8.7%	12.00	7.66	10.1%	11.00	9.80
Method 3	1.70	16.16	7310.82	7.0%	14.00	5.40	8.5%	12.00	7.32
Method 4	2.61	26.21	7310.82	7.5%	13.00	6.54	8.8%	12.00	8.46
Method 5	3.15	2.28	810.55	18.3%	7.00	4.63	19.0%	7.00	4.84
Method 6	4.85	18.44	7310.82	8.7%	12.00	9.56	9.8%	11.00	11.48
Method 7	5.76	28.50	7310.82	9.8%	11.00	11.87	10.9%	10.00	13.78
Method 1+5	3.55	17.72	7055.77	10.4%	10.00	10.98	11.6%	10.00	12.82
Method 2+5	5.16	28.50	7310.82	10.4%	10.00	12.52	11.5%	10.00	14.37
ELY Utilisation:			11%						

A further consideration is the impact on results if prices increase in line with the DECC Fuel Price Projection and Scottish Island Renewables Reports. As one would expect, the models viability improves still further.

Key Assumptions	
Wind (MW):	6
PV (MW):	2
ELY (MW):	1
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	1.0%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	7.0%	14.00	1.10	8.3%	12.00	1.43
Method 0	0.00	17.05	7790.95	4.0%	17.00	3.26	5.2%	15.00	5.30
Method 1	0.40	15.44	7055.77	9.0%	12.00	7.27	10.5%	11.00	9.11
Method 2	2.31	26.21	7310.82	9.1%	12.00	8.76	10.5%	11.00	10.91
Method 3	2.00	16.16	7310.82	7.4%	13.00	6.15	8.8%	12.00	8.06
Method 4	2.91	26.21	7310.82	8.0%	13.00	7.65	9.3%	12.00	9.57
Method 5	3.15	2.28	810.55	18.9%	7.00	5.01	19.6%	6.00	5.22
Method 6	5.15	18.44	7310.82	9.1%	12.00	10.69	10.2%	11.00	12.60
Method 7	6.06	28.50	7310.82	10.2%	11.00	13.35	11.3%	10.00	15.26
Method 1+5	3.55	17.72	7055.77	11.0%	10.00	12.28	12.2%	9.00	14.13
Method 2+5	5.46	28.50	7310.82	10.9%	10.00	14.01	11.9%	10.00	15.85
ELY Utilisation:			11%						

Taking the DECC price projections, trashing the electrolyser and socialising the control system result in the following.

Key Assumptions	
Wind (MW):	6
PV (MW):	2
ELY (MW):	1
Firm Connection (MW):	3
Gas Engine (MW):	1.4
uCHP Numbers (K):	1
Energy price rise PA:	1.0%
Gas Price (£/MW):	22
Electricity Price (£/MW):	55

Methods/ Outcomes	Non-Wind Cost (£m)	GWh/ Anum	Tonnes C02/ Annum saved	Developer (No Carbon)			UK PLC (Inc Carbon)		
				20 Year IRR	Pay Back Year	20 Year NPV (£m)	20 Year IRR	Pay Back Year	20 Year NPV (£m)
1MW/1MW	0.00	2.76	1260.95	7.0%	14.00	1.10	8.3%	12.00	1.43
Method 0	0.00	17.05	7790.95	4.0%	17.00	3.26	5.2%	15.00	5.30
Method 1	0.40	15.44	7055.77	9.0%	12.00	7.27	10.5%	11.00	9.11
Method 2	1.61	26.21	7310.82	9.9%	12.00	9.35	11.3%	10.00	11.48
Method 3	1.30	16.16	7310.82	8.1%	13.00	6.72	9.6%	12.00	8.64
Method 4	2.21	26.21	7310.82	8.7%	12.00	8.23	10.0%	11.00	10.14
Method 5	3.15	2.28	810.55	18.9%	7.00	5.01	19.6%	6.00	5.22
Method 6	4.45	18.44	7310.82	9.7%	12.00	11.26	10.8%	10.00	13.17
Method 7	5.36	28.50	7310.82	10.9%	10.00	13.93	11.9%	10.00	15.84
Method 1+5	3.55	17.72	7055.77	11.0%	10.00	12.28	12.2%	9.00	14.13
Method 2+5	4.76	28.50	7310.82	11.6%	10.00	14.58	12.6%	9.00	16.43
ELY Utilisation:			11%						

A final consideration is the potential further expansion of this model from a community perspective. The core drive for communities, such as WREN, is to provide lower cost energy to the local community. Currently the modelling assumes energy generated is sold at wholesale prices. Obviously were the solution operator to undertake a wider supply role then the potential to drive down energy prices for the community whilst providing low-carbon energy security is considerable.

Attachments

Verbal Clarifications (Consultants)	