NOx BAT Options Appraisal for Aberthaw Power Station

Appendix C: Assessment of NO_x abatement options for Aberthaw for the post BREF period assessed from the 2016 baseline.

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Appendix C. Assessment of NOx abatement options for Aberthaw for the post BREF period: Sensitivity study to a revised baseline in response to Schedule 5 notice issued on 1st September 2017.

C1. Introduction

Natural Resources Wales (NRW) issued a Schedule 5 notice to RWE Generation UK on 1st September 2017 requesting the following information:

Appendix B uses the plant modifications which are subject to the current variation application (EPR/RP3133LD/V014), as the assessment baseline – i.e. station operating on High Volatile Matter Coals (HVMC) and installation of Windbox technology on Units 7 and 8.

Please provide an additional equivalent Appendix, (Appendix C) which presents the costs and benefits of LCP BREF BAT abatement techniques, based on an assessment baseline of the station operation at the time of the CJEU infraction judgement in September 2016 (i.e. station operating on Low Volatile Matter Coals (LVMC) with none of the proposed modifications described in Appendix B).

This information is required to test the sensitivity of the BAT assessment for Aberthaw Power Station against the now published LCP BREF BAT Conclusions for the proposed plant modifications compared with the baseline unmodified plant operations at the time of the CJEU infraction judgement in September 2016.

This Appendix sets out the information requested above. It references the information previously supplied[1] and therefore is not intended to be a standalone document.

C2. Methodology used to evaluate costs and benefits

C2.1. NO_x Baseline

The assessment baseline was taken to be that described in Section 5.2.1 of the BAT Options Appraisal[1] shown below in Table C2.1.

Unit	NOx (mg/Nm^3) Range	NOx (mg/Nm^3) Typical
7	940-1000	970
8	940-1000	970
9	500-530	515
Station Average	**793-843**	**818**

Table C2.1. Baseline NO_x emissions.

C2.2. Approach to assessing abatement options

The BAT Options Appraisal[1] assessed options which could be applied to operation on LVMC as well as the potential for additional abatement options to the proposed modification (HVMC conversion and Windbox technology). Similarly this cost benefit assessment (CBA) has considered both HVMC and LVMC options. The methodology used in Appendix B of the BAT Options Appraisal[1] has been used for this analysis but with adjustments to enable the assessments to be considered from the current NO_x baseline and with the assumption that the abatement measures are installed in 2017.

[1]NOx BAT Options Appraisal. Submission in response to Schedule 5 request issued on 28th June 2017.

For the HVMC options, Section 6 of the BAT Options Appraisal[1] clearly demonstrated that the HVMC conversion is the most cost effective option for reducing NOx concentrations. Therefore, to ensure that the benefits of the individual measures are quantified, the assessment of costs and benefits of potential LCP BREF abatement options has been split into two steps:

- The costs and benefits of the proposed modifications relative to the baseline
- The costs and benefits of additional further abatement to the proposed modifcation.

C2.3. Methodology

The basis of the cost benefit analysis is essentially identical to that used in Appendix B with the exception of changes to reflect the baseline and the time at which the abatement measures are deployed. These changes are as follows:

- The installation year for all options investigated was assumed to be 2017. Similar to the approach used previously for the purposes of the assessment it has been assumed that the abatement is effective from the middle of 2017, with 2017 emissions taken as the average between the baseline and that given by the abatement option.
- Financing costs were assumed to be incurred from the start of 2017.
- The NO_x baseline used reflects 2016 station operation as described in Section 5.2.1 of the BAT Options Appraisal[1].

C3. Abatement Options

C3.1. Options based on LVMC

Table C.3.1 summarises the assumptions made for the abatement options assessed from the 2016 baseline for the LVMC options. A description of the technologies and the basis of the assumed costs is given in the BAT Options Appraisal[1].

Abatement Option	Abatement Range mg/Nm^3	NOx assumed for CBA	Capex £m	Opex £m/yr
Baseline	-	818 mg/Nm^3 (6702 t/yr)	-	-
LNBo on Units 7 & 8	500 - 530	515 mg/Nm^3 (4219 t/yr)	30.4	0
Sensitivity assessment Light LNBo on Units 7 & 8	520 - 615	568 mg/Nm^3 (4654 t/yr)	25.2	0.14
Sensitivity assessment OFA only on Units 7 & 8	617 - 712	664 mg/Nm^3 (5440 t/yr)	18.9	0.28
SCR on Units 7 & 8	219 - 259	225 mg/Nm^3 (1843 t/yr)	108.0	1.5
SNCR on Units 7,8 & 9	446 - 543	494 mg/Nm^3 (4047 t/yr)	54.6	1.7
Sensitivity assessment (TFTEI lower capex) SNCR on Units 7,8 & 9	446 - 543	494 mg/Nm^3 (4047 t/yr)	39.0	1.7
Hybrid SCR on Units 7 & 8	323 - 368	332 mg/Nm^3 (2720 t/yr)	72.4	1.7

Table C.3.1. Summary of costs and performance assumptions for the LVMC options used in the cost benefit analysis for the plant operating at full load for 1500 hours per annum.

C3.2. Options with HVMC Conversion

Table C.3.2 summarises the assumptions made for the abatement options assessed from the 2016 baseline for the HVMC options.

Abatement Option	Abatement Range mg/Nm^3	NOx assumed for CBA	Capex £m	Opex £m/yr
Baseline	-	818 mg/Nm^3 (6702 t/yr)	-	-
Proposed abatement				
HVMC and Windbox	435 - 543	500 mg/Nm^3 (4097 t/yr) until TNP ends 450 mg/Nm^3 (3687 t/yr) until closure[2]	6.45	-
Options for additional abatement to proposal (costs include HVMC)				
HVMC + LNBo on Units 7 & 8	305 – 370	340 mg/Nm^3 (2786 t/yr)	36.9	0
Sensitivity assessment HVMC + Light LNBo on Units 7 & 8	362 – 451	407 mg/Nm^3 (3335 t/yr)	31.7	0.14
Sensitivity assessment HVMC + OFA only on Units 7 & 8	402 – 491	447 mg/Nm^3 (3662 t/yr)	25.4	0.28
HVMC + SCR on Units 7 & 8	135 – 186	150 mg/Nm^3 (1229 t/yr)	114.5	1.16
HVMC + SNCR on Units 7,8 & 9	283 – 408	336 mg/Nm^3 (2753 t/yr)	61.1	1.5
Sensitivity assessment (TFTEI lower capex) HVMC + SNCR on Units 7,8 & 9	283 – 408	336 mg/Nm^3 (2753 t/yr)	45.5	1.5
HVMC + Hybrid SCR on Units 7 & 8	202 - 270	223 mg/Nm^3 (1827 t/yr)	78.9[3]	1.3

Table C3.2. Summary of costs and performance assumptions for the HVMC options used in the cost benefit analysis for the plant operating at full load for 1500 hours per annum.

C4. Results and discussion of the cost benefit assessment

C4.1. Options based on LVMC

The results of the cost benefit assessment for the LVMC options are detailed in Appendix C1, Table C1.1. For comparison, Table C1.2 in Appendix C1 details the equivalent information for the proposed modifications. Using these data, comparison of the lifetime NOx abated and the abatement costs indicates that, with the exception of SCR and hybrid SCR, the proposed modifications deliver a higher reduction in NOx emissions and are significantly more cost-effective than all the LVMC options. SCR and hybrid SCR are also the only options which have the capability to meet the BREF limits. Therefore, all LVMC options other than SCR and hybrid SCR can be excluded from further consideration. A summary is shown below in Table C4.1 for a plant lifetime until 2025; the results for other lifetimes show similar results.

[2] *This assumption has been used as it is conservative from a cost-benefit perspective*

[3] *This number differs slightly to that used in Appendix B of the BAT Options Appraisal as a correction has been made to align with Section 5 of the BAT Options Appraisal*

Abatement	Lifetime NOx abated relative to baseline (kt)	Costs Present value (£m)	Can meet BREF limits?
Proposed Modifications HVMC + Windbox	24.4	10.0	x
LVMC Abatement Options			
Low NOx Boiler Technology on Units 7 & 8	21.1	47.2	x
Sensitivity assessment Light Low NOx Boiler Technology on Units 7 & 8	17.4	40.1	x
Sensitivity assessment OFA only on Units 7 & 8	10.7	31.4	x
SCR on Units 7 & 8	41.3	178.6	✓
SNCR on Units 7,8 & 9	22.6	97.2	x
Sensitivity assessment (TFTEI lower capex) SNCR on Units 7,8 & 9	22.6	73.0	x
Hybrid SCR on Units 7 & 8 Units 7 & 8	33.8	124.8	✓

Table C4.1 Comparison of lifetime NOx abated and costs for the LVMC options with that of the proposed modifications for a plant lifetime until 2025.

Figures C4.1 and C4.2 show graphically the results of the cost benefit analysis for the options of SCR and hybrid SCR applied to LVMC operation. For comparison purposes the costs and benefits of the proposed modifications are also shown.

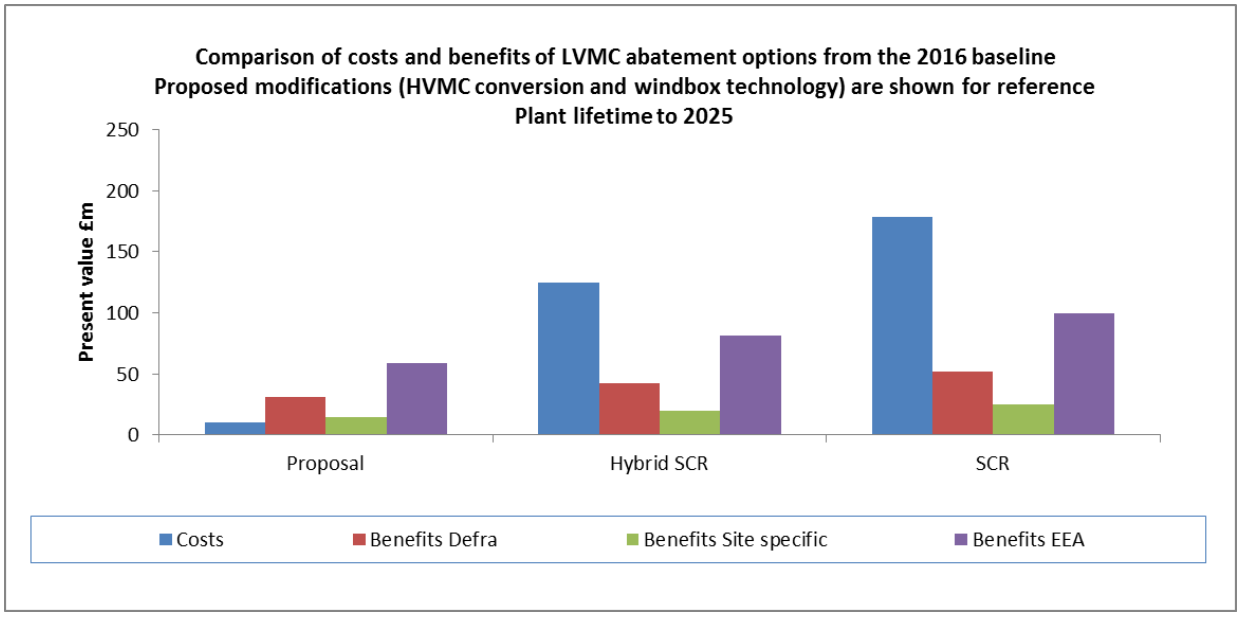

Figure C4.1. Costs and benefits of LVMC abatement options for a plant lifetime until 2025 relative to the 2016 baseline.

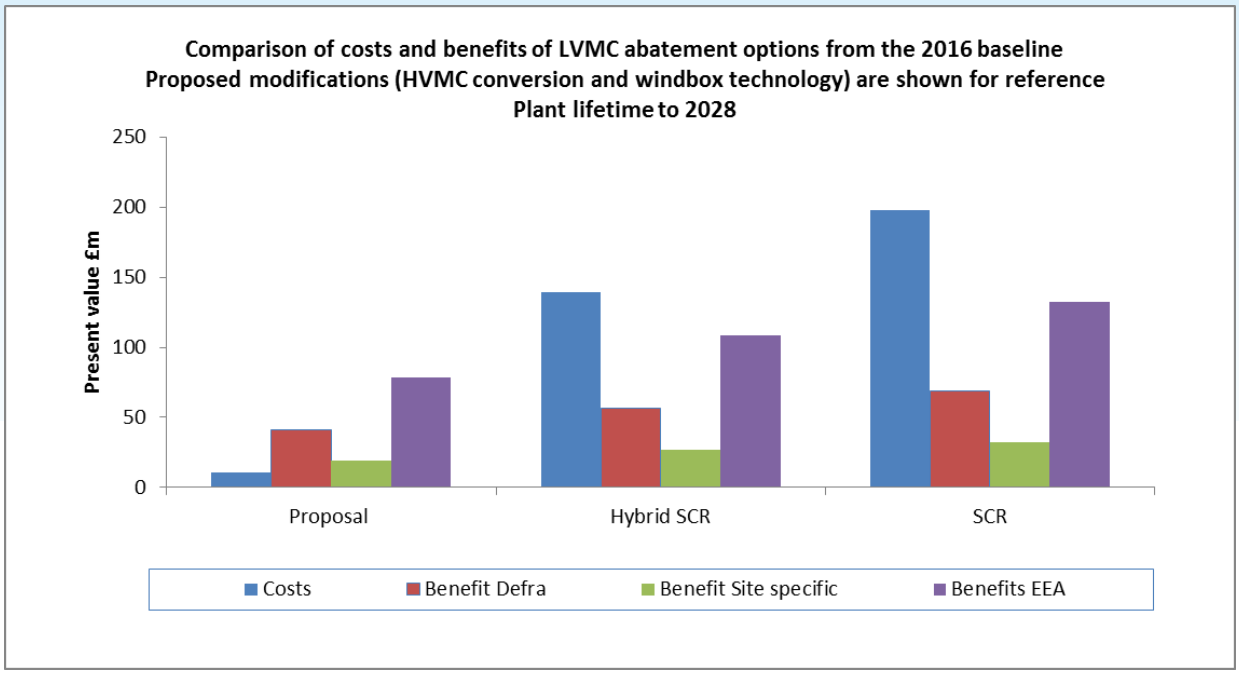

Figure C4.2. Costs and benefits of LVMC abatement options for a plant lifetime until 2028 relative to the 2016 baseline.

The CBA demonstrates that for the proposed modifications (HVMC conversion and windbox) the inferred monetised environmental benefits are significantly greater than the abatement costs. Although SCR and hybrid SCR deliver greater environmental benefits than the proposal these options are very expensive and are not justified from a cost benefit perspective, even under the very conservative assumptions underlying the assessment. For example, for a closure date of 2025 (aligned with the Government's coal phase-out proposals) the costs are a factor ~3 or greater than the benefits using the current Defra damage cost and a factor of ~6 or greater using the site specific damage cost. Using the EEA damage cost, the costs still exceed the benefits. As the site specific damage cost has been derived taking account of Aberthaw's specific dispersion pattern and local population density it is likely to give a more realistic assessment of potential benefits. Furthermore, very conservative assumptions have been made in the CBA; this is discussed in Section 4.3.

C4.2. Options with HVMC Conversion

The results of the cost benefit assessment for the HVMC options are detailed in Appendix C1, Tables C1.2 and C1.3, and are shown graphically below in Figures C4.3 & C4.4. This assessment differs from that submitted in Appendix B of the BAT Options Appraisal[1] in that the abatement options are assumed to be applied earlier, increasing the environmental benefits.

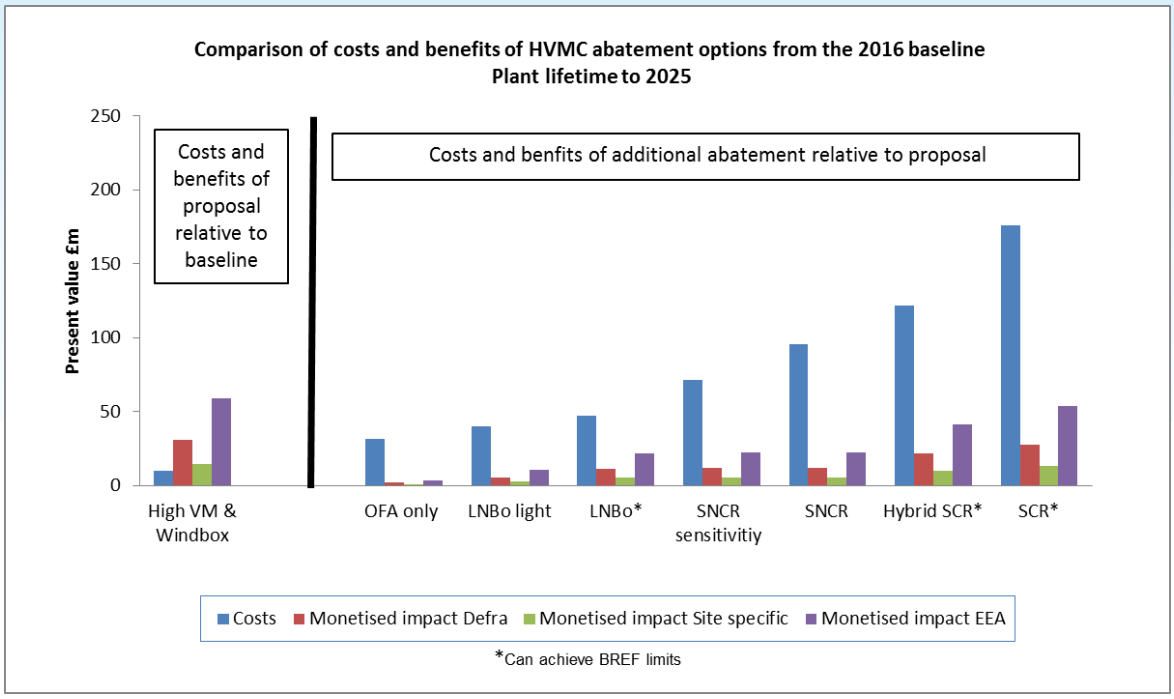

Figure C4.3. Costs and benefits of HVMC abatement options for a closure date of 2025 relative to the 2016 baseline.

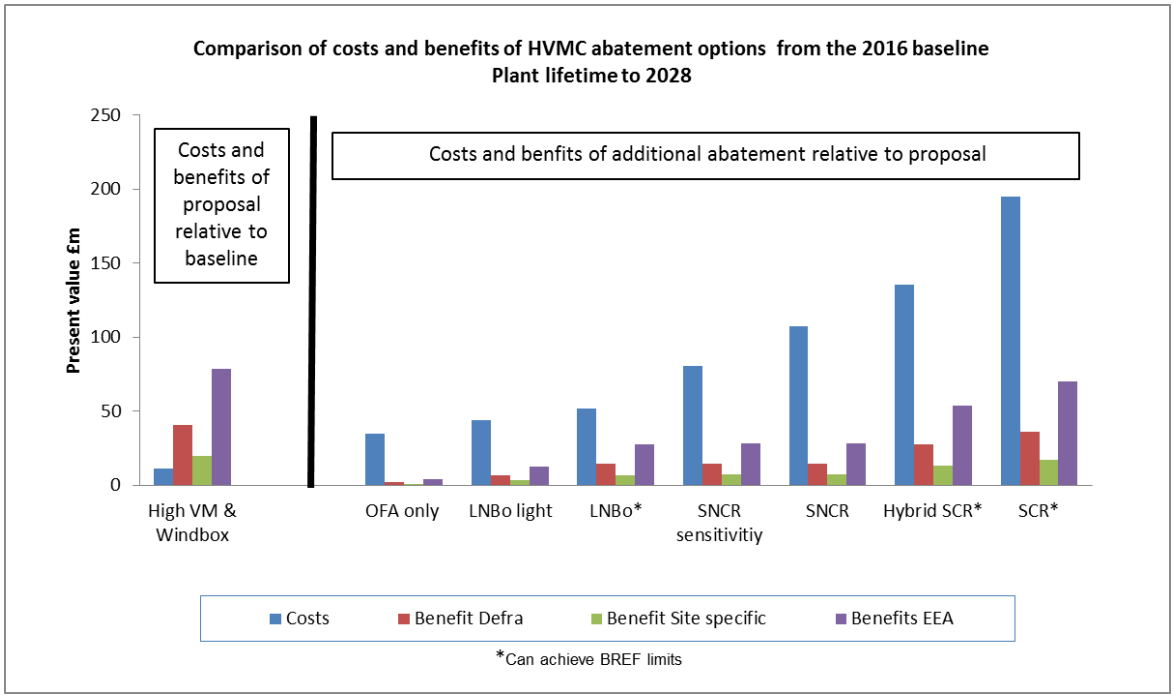

Figure C4.4. Costs and benefits of HVMC abatement options for a closure date of 2028 relative to the 2016 baseline.

The assessment of HVMC options demonstrates that while for the proposed modifications the inferred benefits significantly exceed the costs, the costs of additional abatement beyond the proposal are very disproportionate compared to the additional environmental benefits. For a closure date of 2025 (aligned with the Governments coal phase out proposals) the marginal costs are a factor of ~4 or greater than the marginal benefits using the current Defra damage cost and ~9 or greater using the site specific damage cost. Using the EEA damage cost as a sensitivty the costs still exceed the

benefits by a factor of ~2 or greater for 2025 closure. For the latest closure date investigated, the costs still exceed the benefits by a significant margin.

C4.3. Further discussion of results

The assumptions underlying the CBA have been very conservative and therefore the actual disproportionality of the costs and benefits of additional abatement is likely to be substantially greater. In particular:

- No account has been taken of the installation time in the analysis. This is a very pessimistic assumption for complex technologies where the installation time could be a significant fraction of Aberthaw's remaining lifetime.
- It has also been simplistically assumed that all the abatement options could be performed in the same outage period. In practice the lead time for this to be achievable (development of the design & installation programme as well as contractual negotiations) is longer than the timescale over which the changes in emissions regulation for Aberthaw (infraction and BREF finalisation) have occurred, necessitating a separate outage for installation of any additional abatement options to the proposal. A separate installation of additional abatement would require additional site establishment costs and this is estimated to be in the range £2-3m per unit. Complex technologies would also incur availablility risks for existing contractual committments relating to security of supply (Capacity Market).
- Conservative assumptions have been made about Aberthaw's future generation levels, and in practice actual generation may be significantly lower than the assumed 1500 hours per annum.
- As noted in the BAT Options Appraisal[1] the achievable abatement from SNCR is likely to be much lower than that assumed, due to the technical difficulties with targeting the temperature window associated with Aberthaw's unusual design as well as the intermittent nature of future generation.

Finally, as the site specific damage cost has taken into account Aberthaw's specific dispersion pattern and local population pattern this is likely to give a much more realistic representation of the benefits assessment. All the assessments using this damage cost show very high levels of disproportionately between costs and benefits for all abatement options other than the proposal.

C5. Conclusions

The costs and benefits of all potential abatement options from the 2016 baseline have been assessed assuming Aberthaw operates for 1500 hours per year. Both HVMC and LVMC options have been considered with the assessment of costs and benefits assuming that the modifications are made in 2017. The assessment has demonstated that the proposed modifications (HVMC and Windbox) deliver a greater environmental benefit than most of the LVMC abatement options at a significantly lower cost. Only SCR and hybrid SCR might offer greater environmental benefits, but at a cost that is disproportionate to the environmental benefits and is therefore not justified from a cost-benefit perspective. This is particularly the case in the context of Aberthaw's limited and uncertain lifetime. For the HVMC options, the costs and benefits of additional abatement to the proposed modification have also been considered. The analysis has demonstrated that the additional costs are very disproportionate to the additional benefits. This is the case even under conservative asumptions relating to generation levels, installation timescales, plant lifetime and abatement potential.

Appendix C1.

Table C1.1. Costs and benefits of abatement options applied to the LVMC baseline.

Abatement	Plant lifetime after abatement installed Yrs (date)	Lifetime NOx abated relative to baseline (kt)	Present Values of Costs & Benefits (£m)			
			Costs	Benefits derived from damage costs		
				Defra	EEA	Site specific
Low NOx Boiler Technology Units 7 & 8	8.5 (~end 2025)	21.1	47.2	26.5	51.0	12.6
	9.5 (~end 2026)	23.6	48.7	29.4	56.6	14.0
	10.5 (~end 2027)	26.1	50.2	32.2	62.0	15.3
	11.5 (~end 2028)	28.6	51.7	35.0	67.4	16.6
Sensitivity assessment Light Low NOx Boiler Technology Units 7 & 8	8.5 (~end 2025)	17.4	40.1	21.8	42.0	10.4
	9.5 (~end 2026)	19.4	41.5	24.2	46.6	11.5
	10.5 (~end 2027)	21.5	42.9	26.6	51.2	12.6
	11.5 (~end 2028)	23.6	44.2	28.9	55.6	13.7
Sensitivity assessment OFA only Units 7 & 8	8.5 (~end 2025)	10.7	31.4	13.4	25.8	6.4
	9.5 (~end 2026)	12.0	32.6	14.9	28.7	7.1
	10.5 (~end 2027)	13.2	33.7	16.4	31.6	7.8
	11.5 (~end 2028)	14.5	34.8	17.8	34.3	8.5
SCR Units 7 & 8	8.5 (~end 2025)	41.3	178.6	51.8	99.7	24.6
	9.5 (~end 2026)	46.2	185.2	57.4	110.5	27.3
	10.5 (~end 2027)	51.0	191.7	63.0	121.3	29.9
	11.5 (~end 2028)	55.9	197.9	68.6	132.1	32.6
SNCR Costs and abatement from TFTEI Units 7,8 & 9	8.5 (~end 2025)	22.6	97.2	28.3	54.5	13.4
	9.5 (~end 2026)	25.2	101.3	31.4	60.5	14.9
	10.5 (~end 2027)	27.9	105.2	34.4	66.2	16.3
	11.5 (~end 2028)	30.5	109.0	37.5	72.2	17.8
Sensitivity assessment SNCR TFTEI lower capex Units 7,8 & 9	8.5 (~end 2025)	22.6	73.0	28.3	54.5	13.4
	9.5 (~end 2026)	25.2	76.3	31.4	60.5	14.9
	10.5 (~end 2027)	27.9	79.4	34.4	66.2	16.3
	11.5 (~end 2028)	30.5	82.5	37.5	72.2	17.8
Hybrid SCR Units 7 & 8	8.5 (~end 2025)	33.8	124.8	42.4	81.6	20.1
	9.5 (~end 2026)	37.8	129.8	47.1	90.7	22.4
	10.5 (~end 2027)	41.8	134.6	51.7	99.6	24.6
	11.5 (~end 2028)	45.8	139.2	56.2	108.2	26.7

Table C1.2. Costs and benefits of the proposed modifications relative to the baseline.

Abatement	Plant lifetime after abatement installed Yrs (date)	Lifetime NOx abated relative to baseline (kt)	Present Values of Costs & Benefits (£m)			
			Costs	Benefits derived from damage costs		
				Defra	EEA	Site specific
Proposal HiVM + Windbox	8.5 (~end 2025)	24.4	10.0	30.6	58.9	14.5
	9.5 (~end 2026)	27.4	10.3	34.0	65.5	16.2
	10.5 (~end 2027)	30.4	10.7	37.5	72.2	17.8
	11.5 (~end 2028)	33.4	11.0	40.9	78.8	19.4

Table C1.3. HVMC Options: Change in costs and benefits of additional abatement abatement options relative to the proposal.

Abatement	Plant lifetime after abatement installed Yrs (date)	Lifetime NOx abated relative to proposal (kt)	Present Values of Costs & Benefits (£m)			
			Costs	Benefits derived from damage costs		
				Defra	EEA	Site specific
HiVM + Windbox Low NOx Boiler Technology Units 7 & 8	8.5 (~end 2025)	8.9	47.2	11.2	21.6	5.3
	9.5 (~end 2026)	9.8	48.7	12.3	23.7	5.8
	10.5 (~end 2027)	10.7	50.2	13.3	25.6	6.3
	11.5 (~end 2028)	11.6	51.7	14.3	27.5	6.8
HiVM + Windbox Sensitivity assessment Light Low NOx Boiler Technology Units 7 & 8	8.5 (~end 2025)	4.2	40.1	5.4	10.4	2.6
	9.5 (~end 2026)	4.6	41.5	5.8	11.2	2.8
	10.5 (~end 2027)	4.9	42.9	6.2	11.9	2.9
	11.5 (~end 2028)	5.3	44.2	6.6	12.7	3.1
HiVM + Windbox Sensitivity assessment OFA only Units 7 & 8	8.5 (~end 2025)	1.4	31.4	1.9	3.7	0.9
	9.5 (~end 2026)	1.5	32.6	1.9	3.7	0.9
	10.5 (~end 2027)	1.5	33.7	1.9	3.7	0.9
	11.5 (~end 2028)	1.5	34.8	2.0	3.9	1.0
HiVM + Windbox SCR Units 7 & 8	8.5 (~end 2025)	22.1	176.1	27.8	53.5	13.2
	9.5 (~end 2026)	24.6	182.5	30.7	59.1	14.6
	10.5 (~end 2027)	27.0	188.7	33.5	64.5	15.9
	11.5 (~end 2028)	29.5	194.6	36.3	69.9	17.2
HiVM + Windbox SNCR Costs and abatement from TFTEI Units 7,8 & 9	8.5 (~end 2025)	9.2	95.8	11.6	22.3	5.5
	9.5 (~end 2026)	10.1	99.7	12.6	24.3	6.0
	10.5 (~end 2027)	11.0	103.4	13.7	26.4	6.5
	11.5 (~end 2028)	12.0	107.1	14.8	28.5	7.0
HiVM + Windbox Sensitivity assessment SNCR TFTEI lower capex Units 7,8 & 9	8.5 (~end 2025)	9.2	71.6	11.6	22.3	5.5
	9.5 (~end 2026)	10.1	74.7	12.6	24.3	6.0
	10.5 (~end 2027)	11.0	77.7	13.7	26.4	6.5
	11.5 (~end 2028)	12.0	80.6	14.8	28.5	7.0
HiVM + Windbox Hybrid SCR Units 7 & 8	8.5 (~end 2025)	17.0	122.0	21.4	41.2	10.2
	9.5 (~end 2026)	18.9	126.6	23.6	45.4	11.2
	10.5 (~end 2027)	20.8	131.2	25.7	49.5	12.2
	11.5 (~end 2028)	22.6	135.5	27.8	53.5	13.2

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