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Tony/Liz, Yes it's fine.

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Amy, please can you confirm that this IC40 response is suitable for the public register.

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Liz



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# Summary of Kedrovosky coal trials at Aberthaw for Improvement Condition IC40.

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# Summary of Kedrovosky coal trials at Aberthaw for Improvement Condition IC40.

## Prepared for:

Aberthaw	
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<b>Contract No. :</b>	ETS1054

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## Summary

This report summarises the results of two sets of short duration (6 – 12 h) controlled coal trials undertaken in 2016 to assess the effect of firing bituminous coals at Aberthaw and has been produced to fulfil the requirements of Improvement Condition IC40 as part of Environmental Permit RP3133LD/V012. The report discusses the background to the trials, the trial programmes and the results of the trials.

The trials involved the handling, milling and combustion of Kedrovosky - Russian bituminous coal with a volatile matter content in excess of the Aberthaw's fuel specification and which has previously been used for blending. Kedrovosky was successfully fired on Unit 7 (in February 2016) and Unit 9 (in June 2016). Compared to operation on stock, low volatile matter content coals, reductions in NO<sub>x</sub> across both units were observed, and further reductions are achievable. Reductions in SO<sub>x</sub> emissions were also observed and are attributed to the lower sulphur content of Kedrovosky. The furnace was stable during the tests and there was no evidence of increased slagging.

The trials were performed in accordance with RWE Generation's procedures for plant modification and passed without safety, plant or environmental incident.

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## 1 Introduction

This report summarises the results of two sets of short-duration coal trials undertaken in 2016 to assess the effect of firing bituminous coals at Aberthaw. This report has been produced to fulfil the requirements of Improvement Condition IC40 as part of Environmental Permit RP3133LD/V012.

Background to the trials is given in Section 2 and the trial programme outlined in Section 3. The results of the trials are discussed in Section 4 and conclusions drawn in Section 5.

## 2 Background

Aberthaw's boilers are designed to burn exclusively coals or coal blends with a volatile matter content of between 9% and 14% (as received). In order to mitigate uncertainty in future domestic coal supplies and to manage emissions within the period covered by the Industrial Emissions Directive (IED) the feasibility of increasing the volatile matter (VM) content in Aberthaw's coal diet has been explored by RWE. It was concluded that the commercial use of bituminous coals at Aberthaw would require additional safety measures but was technically feasible.

Trials of bituminous coals at Aberthaw were therefore commissioned to give further confidence in the feasibility study conclusions.

## 3 Trial Programme

Trials were commissioned on Unit 7 and Unit 9. The latter had been retrofitted with Low NO<sub>x</sub> boiler technology supplied by Amec Foster Wheeler (AFW) in 2015. The former had been fitted with a set of modified windbox plates before the trial – a NO<sub>x</sub> reduction technology that was under assessment by RWE Generation. Both sets of trials used a staged approach, with a short duration (c. 6 hr) trial on a single mill performed in advance of the Unit trial (8 – 10 hr duration). This approach was used to confirm that the handling, milling and combustion of the test coal were satisfactory prior to its use at a larger scale.

The test coal for both sets of trials was Kedrovosky: a Russian bituminous coal with VM content of around 18.5% (a.r.). Kedrovosky has been previously used at Aberthaw as a blend coal to increase very low VM content coal to within station specification (hence detailed ash analysis has not been performed). Coal analysis for Kedrovosky is shown in Table 1 below. For each test a known stock coal (e.g. Tower) with a higher sulphur content than Kedrovosky was fired on the unit prior to, and after, the trial. The difference in sulphur content is reflected in the pre-FGD SO<sub>2</sub> indication and this was used to determine when the fuel changes occurred.

The VM content of Kedrovosky is outside of the current station specification and therefore the trials were undertaken in accordance with RWE Generation's plant modification procedure, with detailed trial plans and risk assessments for each test. In order to minimise the fire and explosion risks during the trial the high risk periods of mill operation (start-up / shut-down) were intentionally avoided and an exclusion zone was established on the relevant Unit. The requirement to minimise occupancy of the Unit, together with the lack of availability of third party contractors meant that PF and dust sampling (at precipitators) did not form part of the trials.



In order to avoid mill start-ups and shut-downs, the coal supply arrangements effected an on-load coal change; this was achieved by running the bunker(s) for the test mill(s) low before filling with Kedrovosky. The Kedrovosky was then consumed and the stock coal loaded back on top.

Test	Method Reference	Units	Results Basis			
			As Received *	As Analysed	Dry *	Dry Ash Free *
Analysis Moisture	CA2	%	-	0.8	-	-
Ash	CA3	%	16.9	18.2	18.4	-
Inherent Moisture	CA1	%	-	1.1	-	-
Loss on Air Drying	SP1	%	-	7.1	-	-
Total Moisture	SP1 & CA1	%	8.1	-	-	-
Volatile Matter	CA6	%	19.5	20.0	20.1	24.7
Sulphur	CA31	%	0.23	0.25	0.25	0.31
Gross Calorific Value	CA11	kJ/kg	26180	28260	28487	34907
Gross Calorific Value	*	kJ/kg	6253	-	-	-
Net Calorific Value	*	kJ/kg	25250	-	-	-
Net Calorific Value	*	kJ/kg	6031	-	-	-
Carbon	CA9	%	65.69	70.91	71.48	87.59
Hydrogen	CA9	%	3.43	3.70	3.73	4.57
Nitrogen	CA9	%	1.69	1.82	1.84	2.25
Fixed Carbon	*	%	56.5	61.0	61.5	75.3

**Table 1. Kedrovosky fuel analysis**

The first trial was undertaken on Unit 7; the single mill trial was performed on the 23rd February and the unit trial on the 8th March. The single mill trial on Unit 9 was performed on the 21st June and the unit trial on the 23rd June.

Due to minor plant defects, Kedrovosky was fired on 5 out of the 6 mills used in each test, with the 6th mill remaining on stock coal.

## 4 Trial Results

### 4.1 Unit 7 Trial

The single mill trial was completed successfully on 7F mill, using c. 200 tonnes of Kedrovosky. No adverse handling, milling or combustion problems were identified.

For the Unit trial 1400 tonnes of Kedrovosky were loaded from track hopper into bunkers with an additional quantity (c. 200 tonnes) reclaimed from stock as requested by test team later in the day. 7D mill remained on stock coal due to minor plant defects. No concerns were identified from the thermal camera survey which was carried out prior to transfer. No problems, spillages or fugitive dust emission at transfer points were found from the trial.

Unit 7 operated at 500MWgen through the morning and early afternoon and the load was steadily increased to 535MWgen during the afternoon. Dynamic classifier speeds remained at 105 - 110 rpm through the day. The Unit was operated with all six mills in service during the trial, however, as noted above, 7D mill remained operating on stock coal mill with four burners in service. The FGD system was in-service throughout the trial which lasted c. 12 hrs.

The furnace was stable through the test, with no concerns with steam temperatures or spray valve margins. No tube leaks were experienced and no increased slag build-up was identified. Furnace camera footage showed that the ignition point had moved slightly closer to the burners as expected with a higher volatile fuel.



A summary of trial data for operation on Kedrovosky is shown below.

Start Time	End Time	Unit Load	Mills in Service	PF Burners in Service	Average DC speed	Economiser O <sub>2</sub>
		MWgen	#	#	rpm	%
13:35	14:00	500	6	25	105 (A mill =110)	2.2
16:55	17:55	535	6	26	105 (A mill =110)	1.6

**Table 2. Unit 7 High VM Trial Data (5 mills Kedrovosky, 1 mill of Tower)**

Start Time	End Time	Pre-FGD SO <sub>x</sub>	Pre-FGD Dust	Stack CO ppm	Stack NO <sub>x</sub> (corrected)	Stack Dust (corrected)
		ppm	mg/Nm <sup>3</sup>	ppm	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>
13:35	14:00	270	37	935	721	8.4
16:55	17:55	268	48	1547	806	10.1

**Table 3. Unit 7 High VM Trial Data (5 mills Kedrovosky, 1 mill of Tower)**

Stack SO<sub>x</sub> data is not presented for the period of operation on Kedrovosky as the indications from the instruments are considered spurious. Comparison of the stack and pre-FGD SO<sub>x</sub> measurements indicates that the stack instrument was operating out of its calibrated range (as a result of the low sulphur content of the Kedrovosky: 0.3% c.f. 1% for Tower).

The elevated CO levels observed during the trial are as a consequence of the design of the modified windbox plates; such levels were also observed during operation with stock coal as shown in Table 4. This design of windbox plate has since been removed from the Unit.

A comparison of plant and emissions data for operation on Kedrovosky and operation on Tower before the trial is shown below. Key differences are the reduction in NO<sub>x</sub> and Carbon in ash, driven by the increased volatility of the Kedrovosky and the reduction in SO<sub>x</sub> emissions, driven by the lower sulphur content of the Kedrovosky.

	Tower Coal - High CO operational period	Tower Coal - Low CO operational period	Kedrovosky
Unit Load (MWgen)	502	503	500
Mills in Service	5	6	6
PF Burners in Service	24	25	25
Average DC speed (rpm)	110	110	106
Economiser O <sub>2</sub> (%)	1.7	1.8	2.2
Average Platen Steam Temperature (°C)	516	502	523
Average Spray Valve Position (%)	27	23	27
Carbon in ash (%)	12.1		6.7
Pre-FGD SO <sub>x</sub> (ppm)	676	675	270

	Tower Coal - High CO operational period	Tower Coal - Low CO operational period	Kedrovosky
Pre-FGD Dust (mg/Nm <sup>3</sup> )	58	33	37
Stack CO (ppm)	1335	515	935
Stack NO <sub>x</sub> (mg/Nm <sup>3</sup> )	832	865	721
Stack SO <sub>x</sub> (mg/Nm <sup>3</sup> )	50	192	Out of range
Stack Dust (mg/Nm <sup>3</sup> )	8.8	8.3	8.4

**Table 4. Unit 7 Performance Comparison at 500MWgen**

#### 4.2 Unit 9 Trial

The single mill trial was completed successfully on 9C mill, using c. 175 tonnes of Kedrovosky. No adverse handling, milling or combustion problems were identified.

For the Unit trial 1400 tonnes of Kedrovosky were loaded from the stockpile into bunkers. 9A remained on Tower coal due to minor plant defects.

The Unit was operated at 490MWso (505MWgen) throughout the day, with an increase to 510MWso (525MWgen) in the evening on transition from Kedrovosky back to stock coal. Dynamic classifier speeds were reduced to 95rpm through the day on the mills processing Kedrovosky to manage mill outlet temperatures and throughputs (as 9A remained on stock coal it was operated with a DC speed of 115rpm). The FGD system was in-service throughout the trial which lasted c. 10 hours.

Throughout the day several tests were carried out by modulating the various dampers. The largest effect on NO<sub>x</sub> was achieved by reducing the number of burners in service – this increased mill pressure and pushed the flame further down into the furnace. The furnace was stable through the test and there were no concerns with steam temperatures, no tube leaks and no indications of increased slagging.

At 506MWgen (and 5 mills of Kedrovosky) CO was very low and dust levels were approximately 25 mg/Nm<sup>3</sup>. Indicative NO<sub>x</sub> performance at that load (with 3 – 4 burners of Tower) was just over 350 mg/Nm<sup>3</sup> during the afternoon optimisation period.

A summary of trial data for operation on Kedrovosky is shown below. Stack dust data is not presented for the period of operation on Kedrovosky due to faults with the instrument during the trial.

Start Time	End Time	Unit Load	Mills in Service	PF Burners in Service	Average DC speed	Economiser O <sub>2</sub>
		MWgen	#	#	rpm	%
12:10	12:55	506	6 (5 Kedrovosky)	29	95 (A mill =115)	6.1
15:00	16:00	506	6 (5 Kedrovosky)	28	95 (A mill =115)	5.9
16:00	17:00	506	6 (5 Kedrovosky)	28	95 (A mill =115)	5.9

**Table 5. Unit 9 High VM Trial Data (5 mills Kedrovosky, 1 mill of Tower)**

Start Time	End Time	Pre-FGD SO <sub>x</sub>	Pre-FGD Dust	Stack CO ppm	Stack NO <sub>x</sub> (corrected)	Stack SO <sub>x</sub> (corrected)
		ppm	mg/Nm <sup>3</sup>	ppm	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>
12:10	12:55	232	33	85	457	64
15:00	16:00	258	24	236	360	59
16:00	17:00	262	25	174	357	61

**Table 6. Unit 9 High VM Trial Data (5 mills Kedrovosky, 1 mill of Tower)**

Earlier on in the trial (around midday) the unit was not fully optimised and the NO<sub>x</sub> was c. 450 mg/Nm<sup>3</sup>. By reducing the number of burners in service and hence increasing the mill pressure, this had the effect of concentrating the PF firing and driving the flame further into the furnace, resulting in a reduced NO<sub>x</sub> emission of c. 350 mg/Nm<sup>3</sup>. Dust was low throughout the trial however there was an increase in CO corresponding to the reduction in NO<sub>x</sub>, this however was reduced with further optimisation.

Operation with Kedrovosky was at lower loads than the preceding set-up period on Tower and therefore directly comparable data was not obtained. Results from tests performed by RWE during commissioning and optimisation of Unit 9's retrofitted combustion system show that stack NO<sub>x</sub> emissions of 500 mg/Nm<sup>3</sup> are to be expected for operation at 500 MWgen on Tower under comparable conditions.

#### 4.3 Comparison of Unit 7 and 9 results

The unit operating data during the trial are compared below:-

	Kedrovosky Unit 7	Kedrovosky Unit 9
Unit Load (MWgen)	500	506
Mills in Service	6	6
PF Burners in Service	25	28
Average DC speed (rpm) (on Kedrovosky mills)	105	95
Economiser O <sub>2</sub> (%)	2.2	2.1
Average Platen Steam Temperature (°C)	523	508
Average Spray Valve Position (%)	27.5	36.5
Stack CO (ppm)	936	174
Carbon in Ash (%)	6.73	11.5
Pre-FGD SO <sub>x</sub> (ppm)	270	262
Pre-FGD Dust (mg/Nm <sup>3</sup> )	37	25
Stack NO <sub>x</sub> (mg/Nm <sup>3</sup> )	721.5	357
Stack SO <sub>x</sub> (mg/Nm <sup>3</sup> )	Out of range	60

	Kedrovosky Unit 7	Kedrovosky Unit 9
Stack Dust (mg/Nm <sup>3</sup> )	8.3	In error

**Table 7. Unit Performance Comparison**

As can be seen from the Table above, the main differences in the sets of data are CO and NO<sub>x</sub> emissions and carbon in ash figures. Unit 9 was able to operate at much lower NO<sub>x</sub> levels due to its retrofitted combustion system which resulted in better air staging compared to the modified windbox plate design fitted to Unit 7, resulting in lower CO emissions. The higher carbon in ash figures for Unit 9 are attributed to the higher moisture content of the test coal and the consequent reduction in DC speeds to maintain milling plant temperatures and throughputs.

For both trials further reduction in NO<sub>x</sub> would be expected if Kedrovosky had been supplied to all 6 mills, rather than 5.

## 5 Conclusion

Controlled trials were undertaken in February and June 2016 to assess the effect of firing a bituminous coal at Aberthaw. The trials involved the handling, milling and combustion of Kedrovosky - a Russian bituminous coal previously used by Aberthaw for blending.

The trials showed reductions in NO<sub>x</sub> emissions from the Units compared to operation on a known stock coal. Due to minor plant defects some stock coal was fired at the same time as the Kedrovosky in both unit trials – further NO<sub>x</sub> reductions are expected from the exclusive firing of bituminous coal.

Reductions in SO<sub>x</sub> emissions were observed and are attributed to the sulphur content of the Kedrovosky. The furnace was stable during the tests and there was no evidence of increased slagging; no tube leaks were experienced.

The trials were performed in accordance with RWE Generation's procedures for plant modification and passed without safety, plant or environmental incident.

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