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BISHOP'S CASTLE GROUP

**BISHOP'S CASTLE BIOMASS POWER PLANNING
APPLICATION: PROOF OF EVIDENCE OF
DR MARK BROOMFIELD**



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EXECUTIVE SUMMARY

My name is Dr Mark Broomfield. I am an environmental consultant with over 16 years experience as an air quality, odour and health impacts specialist.

I was commissioned by the Bishop's Castle Group to review an air quality carried out in support of the appeal for non-determination of a planning application by Bishop's Castle Biomass Power for a biomass power plant at Bishop's Castle.

The key issues identified in my review are:

- ◆ Under-estimate of emissions of fine particulate matter and dioxins and furans
- ◆ Unclear information in the emissions inventory
- ◆ Failure to model operating conditions which can be enforced via planning condition
- ◆ Failure to take account of findings of sensitivity study in interpreting results
- ◆ Reliance on fabric filtration, which is not part of the scheme design
- ◆ Use of unrepresentative meteorological data
- ◆ Inappropriate representation of local terrain
- ◆ Inappropriate representation of site buildings
- ◆ Use of superseded air quality standard for arsenic
- ◆ Failure to consider potential effects on habitat sites
- ◆ Failure to consider forecast levels of PM_{2.5}
- ◆ Apparent errors in processing of model results
- ◆ Failure to consider an appropriate stack height, and consequent selection of a stack height which was too low
- ◆ No assessment of construction phase or fugitive emissions

In view of these shortcomings, I conclude that the conclusions of the air quality assessment and the evidence of Mr Fraser are not reliable.

1. INTRODUCTION

Qualifications and Experience

- 1.1 My name is Dr Mark Broomfield. I am employed as an environmental consultant with Enviros Consulting Ltd. I am an air quality, odour and health impacts specialist with a BA in chemistry from the University of Cambridge, and a PhD in atmospheric chemistry. I have worked in these areas since 1992, both within the consultancy sector and as an industry specialist at ICI. I provide technical, strategic and research support to industry and regulatory bodies. I work closely with clients to deliver obligations under the land-use planning and local air quality management frameworks.
- 1.2 I have appeared as an expert witness on 20 occasions up to March 2009, on issues including air quality impact assessment; odours; road traffic emissions; environmental and health effects of waste management; and perception of risks to health. This work covers court hearings, planning enquiries and other forums.
- 1.3 I am a member of Environmental Protection UK (formerly the National Society for Clean Air). I contribute to seminars and conferences on air quality, health and waste-related topics. I am a Visiting Research Fellow at the University of the West of England.

Instructions

- 1.4 I was commissioned by the Bishop's Castle Group on 24 February 2009 to review an air quality carried out in support of the appeal for non-determination of a planning application by Bishop's Castle Biomass Power for a biomass power plant at Bishop's Castle. Following this review, I was commissioned to prepare this evidence and attend the Public Inquiry into the proposed development.
- 1.5 I have reviewed principally the Proof of Evidence of Mr Steve Fraser version 4 dated 3 February 2009, and the supporting document entitled "Air Quality Impact Assessment: Biomass Energy Plant, Bishop's Castle Shropshire" produced by The Airshed, version 5 dated 3 February 2009.

2. REVIEW OF AIR QUALITY IMPACT ASSESSMENT

- 2.1 I set out in this section the aspects of the air quality impact assessment with which I have identified shortcomings or apparent errors.

Emissions data

- 2.2 The model results presented throughout the study are based on an assumed discharge temperature of 180°C (equivalent to 453 degrees Kelvin). The Air Quality Impact Assessment report makes clear that the planned discharge temperature is 150°C. The sensitivity analysis makes clear that this will result in an underestimate of levels of airborne pollutants. The sensitivity analysis is discussed in more detail below.
- 2.3 The air quality impact assessment study assumes an emission concentration of particulate matter of 100 mg/Nm³ (Scenario 1) or 50 mg/Nm³ (Scenario 2). This in turn is based on the assumption that "*Emissions from the process will be treated by fabric filtration*" (Air quality impact assessment, page 6 paragraph 1.4). Table 3-2 also comments that the emission concentration of 50 mg/Nm³ is "*based on experience elsewhere.*" We understand that the reference plant at Eccleshall has consistently exceeded these emission levels for particulate matter, and the Eccleshall plant does not have fabric filtration. In view of the absence of alternate pollution control regimes, the reliance of this technique in the air quality assessment, and experience at the Eccleshall plant, it is recommended that the use of fabric filtration should be made the basis of a planning condition. The appellant should indicate where on the plans provided to the inquiry the filtration plant will be located
- 2.4 Alternatively, if an alternative technology without these guaranteed emissions is to be relied on, then the air quality assessment should be revised. The data on which "*experience elsewhere*" is based should also be provided to the inquiry to allow it to be properly tested.
- 2.5 The assessment of dioxins and furans is based on an assumed emission concentration of 0.1 ngTEQ/m³, taken from the Waste Incineration Directive (Air quality impact assessment table 3.3). Using this emission concentration gives an estimated emission rate of 1.16 × 10⁻⁹ grams TEQ per second. However, there are significant differences in fuel and pollution control measures between the proposed biomass plant, and plant covered under the Waste Incineration Directive. More relevant data is provided by Defra under the National Atmospheric Emissions Inventory¹ quoting United States Environmental Protection Agency data. This indicates an emission rate of 0.6 – 13 ngTEQ per kg dry fuel burnt. Applying this more relevant figure indicates an emission rate of dioxins and furans of up to 8.2 × 10⁻⁹ grams TEQ per second – up to 7 times higher than the figure used in the air quality impact assessment. It is of concern that the assessment has not used appropriate data on which to base the estimate of emissions of dioxins and furans.
- 2.6 The assessment of plume visibility is based on three values for the plume moisture content. These values are not substantiated. These values should be based on calculations of the moisture content of the fuel, together with moisture formed during the combustion process. I understand that local residents are concerned

¹ Defra, "A Review of the Current Source Inventories for Dioxin and Dioxin-like PCBs for Air, Soil, & Water with view to updating Emission Factors/Estimates and Inclusion of New Sources," Final Report prepared by AEA Technology Environment, Ref. CPEC51 Netcen/ED48412/R1, 2006

about the possibility of formation of an extended visible plume. Without a properly based evaluation of plume visibility, it is not possible to discount these concerns.

- 2.7 The study may have carried out an incorrect calculation in evaluating emissions from the facility. Tables 3-1 and 3-2 provide a calculated correction for converting the volume flow rate from actual discharge oxygen levels to the reference oxygen levels at which emissions limits were set (11%). The actual discharge oxygen level is given as 9% in the column headed "O₂ actual⁽⁶⁾." However, in the seventh column, the heading "volume release at 453K wet 6% O₂⁽⁴⁾" suggest that the discharge oxygen level may be 6%.
- 2.8 The conversion factor is given by the following formula:

$$\text{Conversion factor} = (21\% - O_{2,\text{discharge}}\%) / (21\% - O_{2,\text{reference}}\%)$$

- 2.9 The factor of 1.2 given in the table is the appropriate factor for converting from an actual discharge oxygen level of 9% to a reference oxygen level of 11%. However, if the figure of 6% is correct, then the conversion factor is $(21\% - 6\%) / (21\% - 11\%) = 1.5$. Depending on the correct interpretation of Tables 3-1 and 3-2, emissions may have been under-estimated by a factor of 25%. Based on the data provided, it is not possible to be confident which figure is correct. Further difficulties are presented by the quoted efflux velocity which does not appear to be consistent with any value quoted for the volume release rate.

Other model inputs

- 2.10 The study uses a wide range of meteorological data sets. It is surprising that the study does not make use of the most representative available meteorological data sets. A preliminary review of Meteorological Office weather stations identified three meteorological stations which could potentially be used – Shawbury, Lake Vyrnwy and Shobdon. I made a preliminary enquiry to the Meteorological Office regarding appropriate meteorological data for the Bishop's Castle area. In reply, the Meteorological Office gave the following preliminary advice:

"Shawbury is the only nearby location which can provide a full ADMS dataset. However, most of the parameters required can be supplied from either of the two alternatives you mention. So we could provide ADMS dataset from either Shobdon or Lake Vyrnwy with just the cloud cover data supplied from Shawbury in either case."

"I'm not familiar with the area myself, so it is hard to say which would be most representative. If your location is hilly, then I suppose getting the data from a similarly hilly location would be better than from the middle of a plain. Looking at the map I would guess that Shobdon (with cloud data from Shawbury) might be the best. Lake Vyrnwy seems to be right in the Cambrian mountains, which I would expect to mean the conditions there are somewhat different. However, I'm not an expert so I can't guarantee my advice is the best."

- 2.11 While this is no more than preliminary advice, the Meteorological Office has made no reference to weather stations at Coleshill (near Birmingham Airport), Hereford or Manchester Ringway as providing data that could be representative of conditions at the Bishop's Castle site. The most representative available meteorological data should have been used in the assessment. It is not good practice to carry out an air quality assessment using however wide a range of non-representative meteorological data, and to conclude that the study results are representative or conservative.

- 2.12 The study highlights the importance of incorporating terrain effects in the study. The terrain area covers a significantly wider area than the immediate study area (see first figure in Appendix 2 of the air quality impact assessment). Depending on the exact approach used in the ADMS modelling study, the terrain file used in the modelling study had a grid interval of 170 metres or 340 metres. This is too wide to give a reliable representation of terrain effects in the near field. The sensitivity study appears to indicate that inclusion of terrain data can result in modelled concentrations over 8 times greater than if terrain data is included (Appendix 3.2 page 3 final two columns of data). While this seems extreme, it underlines the importance of a reliable representation of terrain effects in the modelling study.
- 2.13 The study has correctly taken account of the potential effect of site buildings on dispersion. However, as well as considering the main process building, the study should include consideration of the potential effect of the pelletiser building on dispersion. This would be expected to adversely affect the dispersion of emissions from the proposed facility and could readily be taken into account using the ADMS dispersion model.
- 2.14 The study uses an outdated air quality guideline for arsenic (Table 7). This may arise from the use of an outdated version of the Environment Agency's H1 guidance note (reference 12 of the air quality impact assessment). This note was re-issued in March 2008.² The updated air quality guideline for arsenic is $0.006 \mu\text{g}/\text{m}^3$ (Ref. 2 page 54; the updated value is also specified in Reference 10 of the air quality impact assessment). The updated guideline is approximately 33 times more demanding than the value used in the air quality report.

Sensitivity analysis

- 2.15 The sensitivity analysis provided by the Operator is very hard for a layman to follow. For example, the use of the ADMS output file headers as table column headings in Appendix 3.2 is extremely difficult to interpret for anyone who is not familiar with ADMS model outputs. The second table of data headed "s2" appears to be incorrectly labelled as "no chemistry" – I consider that this should be labelled "with chemistry."
- 2.16 A key aspect of a sensitivity analysis is to return to the model results to check what effect the sensitivity analysis has on the study conclusions. This does not appear to have been done. Our analysis of the sensitivity analysis indicates that the choice of study inputs could have a significant effect on the study outputs. The analysis below is based on modelled levels of oxides of nitrogen:
- ◆ Selection of a different value of surface roughness could increase model forecasts by 9% - 37% of those presented.
 - ◆ Selection of a different value of efflux velocity could increase model forecasts by 21% - 38% of those presented. Measurements from the Eccleshall facility indicate that efflux velocity could well be at or below the lower levels used in the sensitivity study.
 - ◆ Selection of a different value of discharge temperature could increase model forecasts by 9% - 16% of those presented. As discussed above, the design temperature is lower than that used in the modelling study, which indicates that

² Environment Agency, Guidance Note EPR - H1, "Environmental Risk Assessment Part 2, "Assessment of point source releases and cost-benefit analysis," March 2008

the study results are likely to be under-estimates of the values likely to occur in practice.

- ◆ Selection of a different value of receptor height could increase model forecasts by 2% - 4% of those presented.
- ◆ The study results for Scenario 2 are based on "expected emissions." However, the proposed conditions would permit higher emissions of oxides of nitrogen. Unless the appellant is prepared to accept lower emissions limits based on the emissions concentrations set out for Scenario 2, then the assessment should be based on the concentration limits set out in the proposed conditions. We have seen no evidence to suggest that lower emissions limits have been proposed as conditions by the Appellant. Consequently, emissions of oxides of nitrogen could be 50% higher than those used in the sensitivity analysis.

2.17 Taking all of these considerations together, modelled levels of oxides of nitrogen could be 273% - 278% of those set out in the report (e.g. in Figures 1 to 4). Taking into account the possible calculation error described in Sections 2.7 to 2.9 above means that modelled levels of oxides of nitrogen could be 342% - 347% of those set out in the report. I have not considered in detail the implications of this for the scheme design. However, this does provide a strong indication that the conclusions of the air quality study based on much lower model results are not reliable.

Data processing

2.18 The model study indicates that modelled levels of carbon monoxide and sulphur dioxide are zero or low relative to modelled levels of nitrogen dioxide and PM₁₀ (Table 8). This is not plausible in the light of the emission rates for these substances relative to other substances specified in Tables 3-1 and 3-2. This indicates that the study results have not been interpreted correctly, and reduces the confidence that can be placed in the study results.

Results interpretation

2.19 The air quality assessment highlights the attention now being paid to the finer fraction of particulate matter, PM_{2.5} (paragraph 2.7). However, no interpretation of the model results in terms of levels of PM_{2.5} is provided.

2.20 The air quality assessment indicates that the ecological Limit Value for nitrogen dioxide should apply to the project (section 2.15) (this should in fact refer to oxides of nitrogen rather than nitrogen dioxide). However, the report does not give any evaluation against this limit value, and concludes without further discussion that "*the proposed installation is unlikely to affect any sensitive ecological receptor*" (Section 7.5). In view of the lack of any discussion of modelled levels of oxides of nitrogen, and the potential under-estimates identified as part of the sensitivity analysis, I consider that this conclusion cannot be relied on.

Other air quality issues

2.21 So far as I am aware, no assessment of construction phase impacts or of potential fugitive emissions has been carried out in the air quality assessment. Anecdotal evidence indicates that odours from fuel storage, fuel processing/handling, and stack emissions at the Eccleshall facility can be significant. These assessments should be provided to enable a full assessment of environmental effects to be carried out. Based on the information presently available, it would not be possible to be confident that these issues could be satisfactorily addressed.

- 2.22 So far as I am aware, no assessment of stack height has been carried out. The current proposed stack height of 16 metres is relatively low in view of its location adjacent to a 12 metre high building.
- 2.23 I have carried out a preliminary assessment of stack height using the well established D1 guidelines, which are familiar to all local authority environmental health departments.³ The calculations are set out in Appendix 1 of this Proof of Evidence. This preliminary assessment indicated that an initial stack height of 27 metres should be used as a starting point for the process design. It is recommended that any planning application should be supported by a proper explanation of how the stack height has been arrived at, possibly supported by a D1 calculation, and/or an evaluation of different stack heights using a dispersion modelling technique. The substantially lower stack height used at the Eccleshall facility could possibly explain observations of poor dispersion of emissions from this facility.

Confidentiality

- 2.24 Enviro understands that access to the air quality assessment work carried out by the appellant has previously been restricted on the grounds of commercial confidentiality. In my experience, this would be very rare – an air quality study of this nature would not normally contain information which would make it commercially sensitive. I have seen nothing in the information now presented to this inquiry which could be considered commercially confidential.

³ Her Majesty's Inspectorate of Pollution, Technical Guidance Note (Dispersion) D1, "Guidelines on Discharge Stack Heights for Polluting Emissions," 1993



3. CONCLUSIONS

- 3.1 In view of the shortcomings set out in Chapter 2, I conclude that the conclusions of the air quality assessment and the evidence of Mr Fraser are not reliable.



APPENDICES



1. PRELIMINARY STACK HEIGHT CALCULATION

<u>Release Parameters</u>					
Temperature	°C	150			
Oxygen content	%	9			
Moisture content	%	15			
Stack area	m ²	0.785			
Efflux Velocity (w)	m/s	17.68			
Volumetric flow (V)	m ³ /s	13.89			
Volumetric flow	m ³ /hr	50,000			
Stack diameter	m	1.00			
<u>Release Rate</u>		PM	CO	NO2	SO2
Discharge Rate (D)	g/s	1.0770	0.81	3.23	0.54
Guideline Conc or EAL (Gd)	mg/m3	0.050	10	0.20	0.266
Background conc (Bc)	mg/m3	0.028		0.011	0.025
Pollution Index (Pi)	m ³ /s	48080	81	17064	2236
Maximum value of Pollution Index	m ³ /s	48080			
<u>Uncorrected Discharge Stack Heights</u>					
Heat Release from Stack (Q)	MW	1.59			
Uncorrected Discharge Height based on Buoyancy (Ub)	m	14.48	$U_b = 10^a \cdot P_i^b$ (eq 6)		
Must be ≥ 1m			Limits: (Ub min 1m max 200m) (Q min 0.03 max 100) (Pi min 50 max 10 ⁷)		
			Constants		
			for Q ≤ 1MW	a =	-1.15
				b =	0.49
			for Q > 1MW	a =	-1.16
				b =	0.495
Discharge momentum (M)	m4/s2	164.32			
Uncorrected Discharge Height based on Momentum (Um)	m	36.64	$\log_{10} U_m = x + (y \cdot \log_{10} P_i + z)^{0.5}$ (eq 15)		



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Limits: (Um min 1m max 200m) (Discharge momentum min 1 max 2.1e4) (Pi min 50 max 10⁷)

Constants

x = -1.65
y = 4.517
z = -10.80
Min Um = 4.196

Calculation of final discharge stack height, corrected for nearby buildings (C)

Uncorrected discharge height (U)	m	14.48
A		2.53
Building Height (H)	m	12.0
Building width (B)	m	20.0
K	m	12
Height of disturbed flow over building (T)	m	30.0
Are there any buildings within this distance of the release point?	m	183.2
Is correction for buildings required?		YES

Correction for single wide buildings

Final Discharge Stack Height (C)	m	26.96
Final Discharge Stack Height (C)	m	27



2. REFERENCE DOCUMENTS

A Review of the Current Source Inventories for Dioxin and Dioxin-like PCBs for Air, Soil, & Water with view to updating Emission Factors/Estimates and Inclusion of New Sources

Final Report



Netcen/ED48412/R1

April 2006

Title | **A Review of the Current Source Inventories for Dioxin and Dioxin-like PCBs for Air, Soil, & Water with view to updating Emission Factors/Estimates and Inclusion of New Sources**

Customer | Department for Environment, Food and Rural Affairs

Customer reference | CPEC51

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	Name	Signature	Date
Authors			
Reviewed & approved by			

Data Source	UNEP Toolkit 2005	BREF	US EPA	UNEP Toolkit	European Dioxins Inventory	Review of UK releases to land and water	UNEP Toolkit	European Dioxins Inventory	Review of UK releases to land and water	UNEP Toolkit	UNEP Toolkit	UNEP Toolkit
Potential release route											Residues	
Source Categories	Air	Air	Air	Water	Water	Water	Land	Land	Land	Products	Fly Ash	Bottom Ash
Shale oil fired power plants (µg TEQ/TJ)	1.5			ND			NA			NA	ND	
Light fuel oil/natural gas fired power boilers (µg TEQ/TJ)	0.5		0.2 ng TEQ/L oil	ND			NA			NA	ND	
Biomass Power Plants												
1. Mixed biomass fired power boilers (µg TEQ/TJ)	500			ND			NA				ND	
2. Clean wood fired power boilers (µg TEQ/TJ)	50		0.56-13.2 ng TEQ/kg	ND			NA	1.94-21.95 µg TEQ/t	22.3 ng TEQ/kg (bottom ash), 722-7620ng TEQ/kg (filter ash)	NA	ND	
									0.23-1.12ng TEQ/kg (bottom ash), 117-372 ng TEQ/kg (filter ash)	NA	15	
Landfill and biogas combustion												
Biogas/ landfill gas-fired boilers, motors/turbines and flaring (µg TEQ/TJ)	8			ND			NA			NA	NA	
Household heating and cooking - Biomass												
Contaminated wood/biomass fired stoves (µg TEQ/TJ)	1,500			ND			NA			NA	2000 ng TEQ/kg Ash	
Virgin wood/biomass fired stoves (µg TEQ/TJ)	100		0.5 ng TEQ/kg	ND			NA	0.27-19.21 µg TEQ/t	75-500 ng TEQ/kg ash, 500-9000 ng TEQ/kg soot	NA	20 ng TEQ/kg Ash	
Domestic heating - Fossil fuels												
High-chlorine coal fired stoves (µg TEQ/TJ)	15000			ND			NA	41.21-5802.65 µg TEQ/t		NA	30000 ng TEQ/kg Ash	
Coal fired stoves (µg TEQ/TJ)	100			ND			NA		***	NA	5000 ng TEQ/kg Ash	
Oil fired stoves (µg TEQ/TJ)	10			ND			NA			NA	NA	
Natural gas fired stoves (µg TEQ/TJ)	1.5			ND			NA			NA	NA	
Production of Mineral Products												
Cement kilns												

Environmental Risk Assessment

Part 2

Assessment of point source releases and cost-benefit analysis

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Record of changes

Version	Date	Change
080328	28/03/08	Issued for launch of EPR

Polycyclic aromatic hydrocarbons (PAH)

	Statutory Air Quality Standards		Non-Statutory Objectives and guidelines (i.e. objectives not in UK Regulation)	
Measured as	EC Air Quality Framework Directive & Daughter Directives	UK Air Quality Regulations & The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	WHO Guidelines
	^h Target Value ^{8,9}	Objectives	Objectives ^{1,2}	Guidelines
Annual mean	1 ng/m ³ benzo[a]pyrene by 31 Dec 2012 (For the total content within the PM10 fraction)		0.25 ng/m ³ benzo[a]pyrene by end of 2012	

^h'Target Value' see footnote⁴.

Arsenic

	Statutory Air Quality Standards		Non-Statutory Objectives and guidelines (i.e. objectives not in UK Regulation)	
Measured as	EC Air Quality Framework Directive & Daughter Directives	UK Air Quality Regulations & The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	WHO Guidelines
	^h Target Value ^{8,9}	Objectives	Objectives	Guidelines
Annual mean	6 ng/m ³ by 31 Dec 2012 For the total content within the PM10 fraction			

^h'Target Value' see footnote

Cadmium

	Statutory Air Quality Standards		Non-Statutory Objectives and guidelines (i.e. objectives not in UK Regulation)	
Measured as	EC Air Quality Framework Directive & Daughter Directives	UK Air Quality Regulations & The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	WHO Guidelines
	^h Target Value ^{8,9}	Objectives	Objectives	Guidelines ¹¹
Annual mean	5 ng/m ³ by 31 Dec 2012 For the total content within the PM10 fraction			5 ng/m ³

^h'Target Value' see footnote

Nickel

	Statutory Air Quality Standards		Non-Statutory Objectives and guidelines (i.e. objectives not in UK Regulation)	
Measured as	EC Air Quality Framework Directive & Daughter Directives	UK Air Quality Regulations & The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	The Air Quality Strategy for England, Scotland, Wales and Northern Ireland	WHO Guidelines
	^h Target Value ^{8,9}	Objectives	Objectives	Guidelines
Annual mean	20 ng/m ³ by 31 Dec 2012 For the total content within the PM10 fraction			

^h'Target Value' see footnote

⁴ 'Target Value' means a concentration in the ambient air fixed with the aim of avoiding, preventing or reducing harmful effects on human health and the environment as a whole, to be obtained where possible over a given period. The Directive specifies that meeting the target values "would not" involve measures beyond application of best available techniques (BAT), and in particular "would not lead to the closure of installations"