ERECTION OF A BIOMASS POWER PLANT

AND ALTERATIONS TO EXISTING VEHICULAR ACCESS

EVIDENCE ON BEHALF OF

THE APPELLANTS

BY

Professor Bernard M. Gibbs BSc (Tech), PhD, (Sheffield), CEng, FInstE, MIChemE

With Professor Gordon E Andrews BSc, PhD (Leeds), CEng, MIMechE, MASME, FInstE, FInstDGTE
and with Energy and Resources Research Institute, University of Leeds, School of Process, Environmental and Materials Engineering

PINS Ref: APP/K3225/A/08/20860117

LPA Ref: 1/08/20502/F

January 2009

Authorised By …………………………………………

1. Introduction

1.1. I have been requested to submit evidence on behalf of the appellant, Bishops Castle Biomass Power Limited, on combustion matters in relation to an appeal against non-determination of a planning application to develop a Biomass Power Plant on an area of land located on the Bishop's Castle Business Park, Bishop's Castle, South Shropshire.

2. Professional Background

2.1. I am Professor in Applied Combustion and Energy Technology, with 25 years tenure at the University of Leeds with research interests summarised below:

2.2. Fluidisation. Combustion and gasification in fluidised beds.
Hydrodynamics of bubbling and circulating fluidised beds at elevated temperatures. High aspect ratio fluidised beds. Application of CFD to predict hydrodynamics. Heat transfer in fluid beds. Coal and biomass combustion in bubbling and circulating fluidised bed. Control of NOx and N2O emissions. Modelling NOx and ammonia emissions from commercial biomass fired circulating fluidised bed boilers and gasifiers. Trace element emissions. Research equipment includes fully instrumented pilot scale high temperature (900ºC) circulating and bubbling fluidised beds

2.3. Pulverised coal combustion.
Fundamental studies of the influence of coal rank on reburning for the reduction of NOx emissions. Selective non catalytic reduction of NOx. Advanced reburning techniques. Simultaneous insitu reduction of NOx and SOx. Carbon in ash losses - measurement and prediction. Co-firing of coal and biomass. Combustion of pulverised coal in high CO2 atmospheres – influence of CO2 concentration of flame temperature, flame radiation and NOx emissions. CFD modelling of combustion in high CO2 atmospheres - prediction of burning behaviour and heat transfer in large-scale boiler plant. Measurement and reduction of trace element emissions. Spontaneous ignition of coal and biomass. Two down-fired pulverised coal combustion rigs (30kW and 150kW), a drop tube furnace, flat flame burner and TGA are utilised for experimental studies.

2.4. Corrosion in combustion, gasification and incineration.
The corrosion of boiler steels is a continuing problem, which has been exacerbated by the increasing reliance on imported coals, utilisation of low NOx burners and the increasing use of biomass and waste as fuels. In addition the development of super critical plant leads to the need for new corrosion resistant alloys for boiler plant. Fundamental corrosion studies are carried out on purpose built rigs that are capable of reproducing 'plant corrosion conditions'. The importance of operating stoichiometry, metal temperature and heat flux, fuel chlorine and sulphur levels, trace element content have been established for candidate materials. Current research is focussed on biofuels, co-firing and low NOx burners.

2.5. Reduction of NOx and particulates from diesel engine exhausts
Catalytic reduction of NOx. Diesel particulate traps using fibre-based systems with large mass particle storage and low-pressure loss capability.

2.6. Gas filtration

A purpose built gas filtration rig has been developed for the controlled addition of particulates to a gas stream for the measurement of filtration characteristics of selected filter material.

3. Scope and purpose of Evidence

3.1. In January 2009 Bishops Castle Biomass Power requested the University of Leeds to consider the combustion characteristics of a proposed biomass power plant and the related emissions. The purpose of the evidence is to describe in a generalised manner the combustion of biomass materials in the context of the scale and type proposed in this planning application.

4. Combustion characteristics

5. Discussion of combustion for this specific plant

5.1. Reference is made to the Summary of Technical Details for Planning Expert Witnesses. This gives a generic description of the fuels, combustion, air pollution control, stack, emissions monitoring, steam raising, power generation and cooling. Numerous technology suppliers are available for provision of plant operating within the parameters set out here.

5.2. The performance of the technology specific to Bishops Castle Project; with particular consideration for compliance with the planning conditions is summarised below with reference to the generic project parameters.

6. Emissions

6.1. NOx

6.1.1. NOx is produced from combustion through two processes, fuel NOx and Thermal NOx.

6.1.2. Fuel NOx is generated through the partial oxidation of Nitrogen in the fuels with most of the fuel nitrogen being emitted as molecular nitrogen. The referenced fuels are low in Nitrogen limiting fuel NOx generation. Fuel NOx is further reduced by limiting the oxygen available for oxidation of the Nitrogen (sub-stoichiometric conditions) and low grate temperatures.

6.1.3. Thermal NOx is the oxidation of nitrogen in the air. The generation of thermal NOx is a function of the combustion temperature and stoichiometry (oxygen levels). Thermal NOx increases rapidly above 950°C; holding grate temperatures below 950°C ensures reduced thermal NOx production. Sub-stoichiometric primary combustion assisted by the use of lowered oxygen from flue gas recirculation further limits thermal NOx production.

6.1.4. The combination of plant specification, air –staged combustion and fuel characteristics would lead to low NOx generation.

6.2. SOx

6.2.1. SOx generation is the result of oxidiation of the sulphur in the fuel. The sulphur content of woody fuels is inherently low as referenced, resulting in low SOx generation; and in addition a large proportion of the sulphur is bound or captured in the ash as sulphates at the operating temperatures of the grate (850-950°C).

6.3. Chlorine

6.3.1. Chlorine (and fluorine) is inherently very low in these woody biomass fuels at under 0.1%. The limited chlorine is released to form mainly HCl and chlorides which condense in the ash or on the heat exchange surfaces and are removed as ash and clinker. This removal of chlorine is most complete when alkalis (Na and K) are high which is the case with most biomass fuels.

6.3.2. Dioxins are formed with high chlorine fuels, coupled with carbonaceous products of incomplete combustion (PICs) predominantly in the temperature range 200-500°C in the presence of oxygen and a catalyst (copper). Dioxin generation is limited by low chlorine levels in the fuels, low amount of fly ash particles in the combustion products, high alkali levels preferentially reacting with the chlorine, the absence of a catalyst (copper) in the ash, a 2 second combustion time at over 850°C giving low PICs and efficient cooling in the 200-500°C range.

6.4. Polycyclic Aromatic Hydrocarbons (PAH)

6.4.1. The use of second stage combustion at temperatures of 850 to 950°C for a period of 2 seconds in the presence of excess oxygen will ensure that any unburnt hydrocarbon emissions as PAH will be minimal and below regulatory emission limits.

6.5. Particulates

6.5.1. The combination of a multicyclone and high efficiency bag filtration (best available technology for this type of plant) can be expected to result in particulate emissions of dust and PM10 sized particulates to be well below permitted levels.