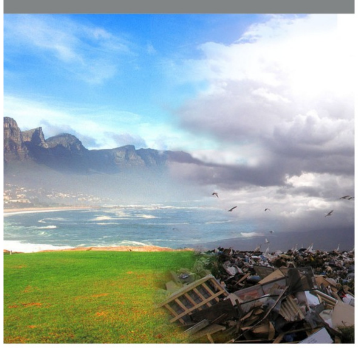
APPENDIX 6

Stopford
Energy & Environment

Stack Height Assessment for a 10 MWe Wood Gasification Facility at Barry Docks, Barry Island

for

Sunrise Renewables (Barry)



Project Number 6270

11/09/2014

Author: Mia Kett and Michael Wilkinson

michael.wilkinson@stopford.co.uk

Issue P1

Document Number: R6270-PM-0001

Stopford Energy & Environment,
a division of Stopford Projects Ltd

VAT Registration Number: 388 107 726
Company Registration Number: 1630328

Enquiries:

Stopford Energy & Environment
The Gordon Manley Building
Lancaster University
Lancaster
Lancashire
LA1 4YQ
United Kingdom

tel: +44 (0)152 451 0604

Contents

Table of Figures

Table of Tables

Stopford
Energy & Environment

Revision History

Issue	Reviewed by (date)	Approved by (date)	Comments
P01	MJW (26/09/2014)	MJW (26/09/2014)	Draft for Comment

Executive Summary

Sunrise Renewables is proposing to install a wood gasification, energy recovery facility (ERF) at Barry Docks, Barry Island, and has asked Stopford Energy and Environment to undertake a stack height assessment to support their planning application. The results for the stack height assessment will be used in subsequent dispersion modelling to support Sunrise Renewables' application to the Environment Agency for an environmental permit under the Environmental Permitting Regulations 2013.

A stack height assessment for Sunrise Renewables' proposed ERF has been completed following industry guidelines that have been prepared by the Environment Agency, EPUK and IAQM and following consultation with the Vale of Glamorgan Council.

The stack height assessment was conducted for a range of stack heights between 30 m and 55 m using ADMS, an industry standard dispersion modelling tool. Worst case emission limits for NO_2, as defined in the Industrial Emissions Directive (IED), were assumed and five years of meteorological data were used to take account of inter-annual variability in local weather conditions. It was assumed that for long term impacts, all NO_x emissions have been converted to NO_2, whereas for short term emissions, a worst case assumption was made whereby 50% of NO_x emissions have been converted to NO_2.

The impact of Sunrise Renewables' proposed ERF was assessed across a 2 km x 2 km modelling domain from which the highest modelled ground level pollutant concentrations have been extracted and used to calculate a stack height for which the impact of emissions can be described as 'NEGLIGIBLE'.

It is the conclusion of this assessment that a stack height of 43 m will be sufficient for adequate dilution and dispersion of residual emissions from the plant and it is shown that there would only be very minor appreciable benefits gained by increasing the stack height further.

1 Introduction

1.1 Background

Sunrise Renewables is proposing to install a wood gasification, energy recovery facility (ERF) at Barry Docks, Barry Island. The facility will use approximately 86,000 tonnes of recycled/recovered wood, with the syngas generated during the gasification process combusted in a boiler to generate steam. The combustion process will be fully compliant with the operational requirements specified in the Industrial Emissions Directive (IED). The operation of the ERF will be regulated by the Environment Agency in line with the requirements of the Environmental Permitting Regulations (England and Wales) 2013.

The steam generated from the combustion process will drive a turbine capable of generating approximately 10 MW_e of renewable power, sufficient to supply ca. 18,000 homes. Flue gas exiting the boiler is discharged to air via a stack, the height of which has been determined using industry best practice guidance.

This report describes the data used in the stack height assessment, the methodology applied, the assumptions that have been made and the results generated by the model. The assessment was based upon the process data supplied by Outotech (technology provider), site drawings provided by Sunrise Renewables and worst-case emission limits as defined in the IED. The site drawings are provided in Appendix I.

The objective of the assessment was to determine the stack height required to ensure that emissions to air from Sunrise Renewables' ERF do not significantly impact local air quality.

1.2 Site location

Sunrise Renewables' ERF is to be located on land at Barry Docks in Barry Island. The area is predominantly industrial with the site located at grid reference: 312617,167667. The proposed facility will be bounded to the north by a railway and residential areas; and to the east, south and west by industrial land and docks. The nearest residential properties are directly northwest of the facility across the railway and Ffordd Y Mileniwm and are approximately 300 metres from the site perimeter. The nearest school to the ERF is approximately 1 km to the north. There are several ecological receptors in proximity to the ERF, including sites with Ramsar and SSSI status. Figure 1 shows the location of the ERF relative to its surroundings.

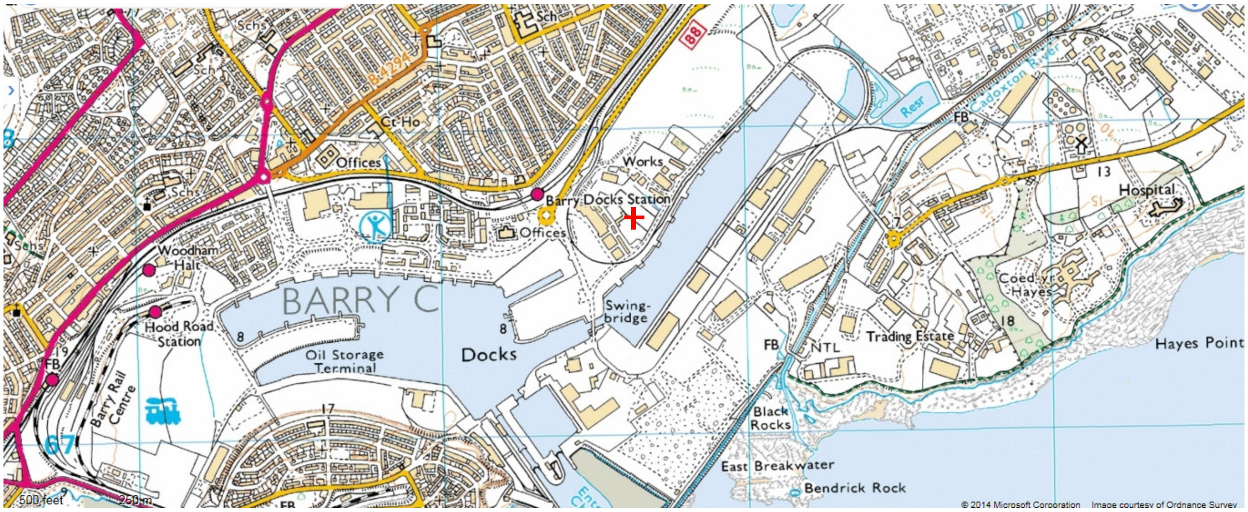


Figure 1 Location of the Energy Recovery Facility shown by the red cross

2 Stack Height Assessment

Even with the comprehensive flue gas treatment that will be in place at the proposed ERF, there will still be residual emissions which need to be discharged via an elevated stack to ensure resulting pollutant concentrations are acceptable by the time they reach ground level at sensitive receptor locations. Additionally, the stack should also be sufficiently high to ensure that the exhaust flow at stack exit is not within the aerodynamic influence of nearby buildings because downwash effects from buildings can cause poor dispersion with pollutants grounding quicker than anticipated, resulting in elevated ground level concentrations.

2.1 Stack Height Assessment Methodology

The stack height assessment was undertaken using an iterative approach for a range of stack heights between 30 m and 55 m. Impacts were quantified using ADMS, which is a "new generation" Gaussian plume dispersion model that was developed and licensed by Cambridge Environmental Research Consultants (CERC). ADMS is an industry standard tool for assessing the impact of emissions to air on human health and the wider environment. The aim of this stack height assessment was two-fold:

- To establish the minimum stack height above which emissions will have negligible impacts on local receptors; and
- To establish the height above which there will be minimal additional environmental benefit associated with the cost of increasing the stack height further.

This in accordance with Annex K of EA H1 guidance which states the following:

*"The principal consideration in whether an option represents an acceptable environmental risk is that **the costs of its implementation should not be disproportionate to the environmental benefit it realises**. Thus it may not be reasonable to implement an option of significantly higher cost which achieves only a marginal environmental improvement compared with another option."*

Two criteria have been used as a basis for determining a suitable minimum stack height as follows:

- Achieving negligible impacts on short and long term NO_2 concentrations; and
- Ensuring no ground level exceedances of short- and long-term air quality limit values for NO_2 anywhere within the modelling domain.

2.1.1 Process and Emission Data

Process data for the ERF was supplied by Outotech, Sunrise Renewables' technology supplier and is summarised in Table 1. In the absence of actual emissions data "worst case" IED emission limits have been assumed (Table 2). IED emission rates have been corrected from IED reference conditions to actual conditions of 9.7% O_2, 15% water, and 411K. In order to calculate emission rates, the IED limit values have been converted to the equivalent concentration at flue gas conditions and then multiplied by the stack exhaust volumetric flow rate at flue gas conditions (Table 3).

Table 1 Emission source parameters for Sunrise Renewables' energy recovery facility

Parameter	Value
Stack Diameter (m)	1.23
Efflux Temperature (K)	411
Efflux Velocity ($m.s^{-1}$)	29.6
Volumetric Flow Rate ($m^3.s^{-1}$)	35.2
Location (X,Y)	312660,167664

Table 2 IED Emission Limits for NO_2

Pollutant	Long-Term ELVs 100% output ($mg.m^{-3}$)	Short-Term ELV 100% output ($mg.m^{-3}$)
NO_x as NO_2	200	400

Table 3 Modelled pollutant emission data (9.7% O_2, 15% water and 411K)

Pollutant	Long-Term ELVs 100% output ($g.s^{-1}$)	Short-Term ELV 100% output ($g.s^{-1}$)
NO_x as NO_2	4.49	8.98

2.1.2 Atmospheric Chemistry

Nitric oxide (NO) and NO_2 are normally measured as oxides of nitrogen (NO_x), but when comparing against health standards, NO_x is usually expressed as its individual components. The principal pathway for the oxidation of nitrogen oxide (NO) to NO_2 is via reaction with ozone. With consideration to the rate of conversion of NO_x to NO_2 and the short distance the pollutant has to travel from the stack before the maximum concentration is reached at ground level, it is unlikely that more than 30% of NO_x is converted to NO_2 at ground level. However, for the purpose of this assessment, and to provide a conservative estimation of impacts, it has been assumed that 50% of NO_x is converted to NO_2 as a short term emission, whilst it has been assumed that 100% of NO_x is converted to NO_2 as a long-term emission. This is in accordance with screening criteria contained in Horizontal Guidance Note H1 Annex (f).

2.1.3 Nearby Buildings and Structures

The proximity of structures to an emission source can adversely impact plume dispersion by entraining the emissions into the turbulent wake which may draw emissions to the surface quicker and in higher concentration than would normally occur in the absence of the structure. The dimensions of the main on-site buildings were obtained following consultation with Sunrise Renewables and their technology provider, and have been included in the model. The location of the main site buildings relative to the emission source are shown in Figure 2 and their dimensions are provided in Table 4.

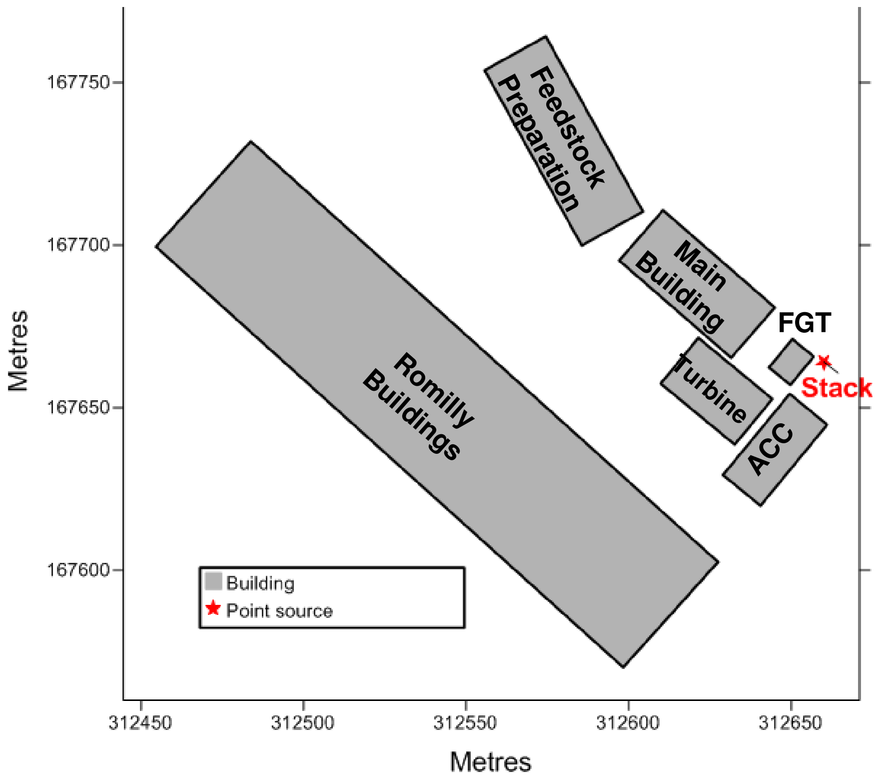


Figure 2 Location of the modelled stack relative to on-site buildings and other structures

Table 4 Modelled building data

Building	Height (m)	Length (m)	Width (m)	Angle (degrees)
Main Plant Building*	22.3	45.6	20.5	131
Feedstock Preparation	19	61.6	21.5	151
FGT	15.6	11.3	8.5	39.4
Turbine	11.3	29.5	18.2	129.5
ACC	18.2	32.3	12.9	39.4
Romilly Buildings	7.0	193.4	43.6	132

* The main plant building is considered as having the greatest affect on plume dispersion

2.1.4 Modelling Domain

When setting up a receptor grid it is necessary to ensure that there are sufficient receptor points to allow the location and magnitude of the highest ground level pollutant concentration to be predicted. If the receptor points are too widely spaced, the maximum process contribution may be underestimated. The stack height assessment was undertaken using 40 m grid spacing across a 2 km x 2 km modelling domain with the stack located at the centre of the grid (X,Y: 312660,167664).

2.1.5 Meteorological Data

The meteorological data used in the assessment was obtained from Cardiff Airport which is approximately 5.7 km west of the proposed site. Local Air Quality Management Technical Guidance (LAQM.TG(09); Defra, 2009) states that met stations within 30 km of a study site are suitable for dispersion modelling assessments.

Five years of meteorological data recorded 2009-2013 were provided by Atmospheric Dispersion Modelling Limited, an established distributor of met data within the UK. The five years of met data are summarised in Figure 3 which shows prevailing winds in the area are from the west and east. The wind roses for individual years are provided in Appendix II.

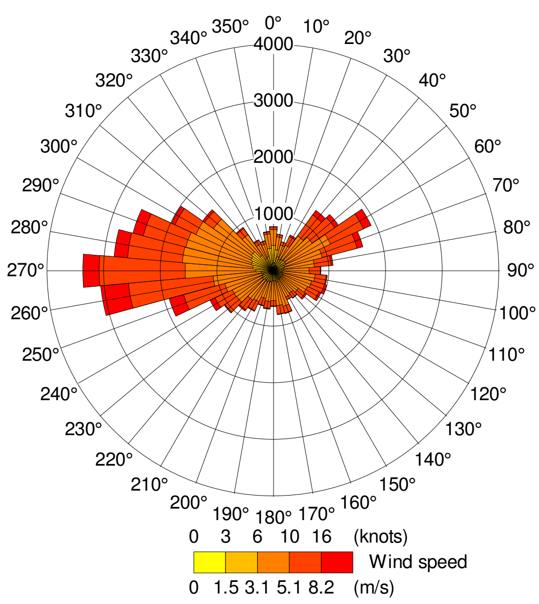


Figure 3 Cardiff Airport wind rose (2009 - 2013)

2.1.5.1 Meteorological Sensitivity Analysis

In order to ensure a worst-case scenario, a sensitivity analysis was conducted to identify which year over the period 2009-2013 produced the highest modelled ground level NO_2 concentration across the modelling domain. The maximum modelled short- and long-term NO_2 concentrations for each assessment year are presented in Table 5. These are based upon an assumed stack height of 40 m.

Table 5 Maximum Modelled NO_2 Ground Level Process Contribution for Each Assessment Year

	Maximum Modelled NO_2 Concentration ($\mu g.m^{-3}$)				
Year	**2009**	**2010**	**2011**	**2012**	**2013**
NO_2 Annual Mean	4.46	3.36	4.37	**5.07**	3.79
Maximum short-term NO_2	39.91	39.18	**39.92**	39.76	39.62

As shown in Table 5, 2012 meteorological data resulted in the highest long-term NO_2 concentration, whilst 2011 meteorological data resulted in the highest short-term NO_2 concentrations. Therefore all long-term pollutant emissions have been modelled using the 2012 meteorological data set and all short-term modelling was completed using the 2011 meteorological dataset to ensure a worst-case scenario.

2.1.6 Terrain Data

Local terrain can affect wind flow patterns, and hence affect pollutant dispersion. The effects of terrain are not normally considered significant where the gradient is less than 1:10. There is a steep incline approximately 20-30 m northwest of the proposed site boundary with a gradient exceeding 10% and resulting in a change in elevation of 26 m. In order to consider the effects of surrounding terrain, an additional 'complex terrain' file was created using data supplied by Ordnance Survey (OS) which was converted for use in the stack height assessment using ADMS' Terrain Converter facility.

2.1.7 Surface Roughness

The roughness of a surface can significantly affect the movement of air across it. Similarly, pollutant dispersion may be influenced by variations in land surface types that affect turbulence in the lower troposphere. Given that a significant fraction of the modelling domain is open coastal water, it was necessary to generate a surface roughness file to take account of the changes in surface roughness across the modelling domain. ADMS default surface roughness values of 0.5 m were applied to land-based grid points and a default value of 0.0001 m was used for coastal waters.

2.1.8 Background Air Quality

Background pollutant mapping is undertaken on a 1km by 1km grid square basis by NETCEN on behalf of DEFRA. Table 6 also shows the mapped background NO_2 concentration for the grid square containing the proposed plant for the years 2011 - 2014. The forecast annual mean NO_2 concentration for 2014 is 12.66 µg.m^{-3}.

The Vale of Glamorgan undertakes monitoring of local air quality and has provided background NO_2 concentrations recorded at Cwm Parc, Barry. Cwm Parc is the closest background monitoring site to the proposed ERF at approximately 2.4 km to the northwest of the facility. The most recent complete monitoring annual dataset recorded at Cwm Parc is for 2013 (Table 6).

Table 6 Annual mean NO_2 concentrations

	Background NO_2 (µg.m^{-3})			
Source	2011	2012	2013	2014
Cwm Parc	16.42	16.75	16.62	---
DEFRA background maps	13.27	13.07	12.86	12.66

The data collected from the monitoring site at Cwm Parc was used as the background concentration for subsequent calculations as it is higher than that predicted by the DEFRA background maps and provides a conservative estimate of impacts. For the purposes of this assessment, and in accordance with LAQM.TG(09), the short-term background NO_2 concentration has been assumed to be twice the mapped annual mean background.

2.2 Stack Height Assessment Results

Potential impacts have been quantified using matrix tables contained within Environmental Protection UK and Institute of Air Quality Management guidance documents (Table 7 and Table 8). The significance of an impact is defined using an impact descriptor scale which ranges from "Negligible" to "Substantial Adverse". The guidance states that an imperceptible change in air quality would be described as Negligible. The impact descriptor is a function of the change in ambient air quality relative to the annual mean NO_2 air quality limit value (AQLV) of 40 µg.m^{-3} (process emissions only - Table 7) and the impact this has on the predicted environmental concentration (PEC - Table 8).

Table 7 Generic Basis of Definition of Impact Magnitude for Changes in Ambient Pollutant Concentrations as Percentage of Objective/Limit Value/Environmental Assessment Level.

Magnitude of Change	Annual Mean
Large	Increase/decrease >10%
Medium	Increase/decrease 5 - 10%
Small	Increase/decrease 1 - 5%
Imperceptible	Increase/decrease <1%

Table 8 Air Quality Impact Descriptors for increases to the Annual Mean Nitrogen Dioxide Concentration at a Receptor

Absolute Concentration in Relation to Objective/Limit Value	Change in Concentration		
	Small	Medium	Large
Increase in NO_2 with Scheme			
Above Objective/Limit Value With Scheme (>40 µg.m^{-3})	Slight Adverse	Moderate Adverse	Substantial Adverse
Just Below Objective/Limit Value With Scheme (36-40 µg.m^{-3})	Slight Adverse	Moderate Adverse	Moderate Adverse
Below Objective/Limit Value With Scheme (30-36 µg.m^{-3})	Negligible	Slight Adverse	Slight Adverse
Well Below Objective/Limit Value With Scheme (<30 µg.m^{-3})	Negligible	Negligible	Slight Adverse

Table 9 contains the maximum predicted annual mean NO_2 concentrations at ground level locations surrounding the proposed plant based upon stacks heights assessed between 30 m and 55 m.

Table 9 Maximum Modelled Annual Mean NO_2 Concentrations and Predicted Impacts

Stack Height (m)	Max predicted Increase in Ground Level Annual Mean NO_2 (µg/m3)	Magnitude of Change	PEC (Process Contribution + Background) with Scheme	Impact on Annual Mean NO_2 Concentration
30	15.88	Large	32.48	Slight Adverse
32	13.33	Large	29.93	Slight Adverse
34	9.73	Large	26.33	Slight Adverse
36	7.82	Large	24.42	Slight Adverse
38	6.19	Large	22.79	Slight Adverse
40	5.07	Large	21.67	Slight Adverse
42	4.24	Large	20.84	Slight Adverse
42.5	4.06	Large	20.66	Slight Adverse
43	3.93	Medium	20.53	Negligible
44	3.93	Medium	19.89	Negligible
46	2.81	Medium	19.41	Negligible
48	2.44	Medium	19.04	Negligible

Stack Height (m)	Max predicted Increase in Ground Level Annual Mean NO_2 (µg/m3)	Magnitude of Change	PEC (Process Contribution + Background) with Scheme	Impact on Annual Mean NO_2 Concentration
50	2.16	Medium	18.76	Negligible
55	1.60	Small	18.20	Negligible

As shown in Table 9, a minimum stack height of 43 m will have "Negligible" impacts on resulting ground level annual mean NO_2 concentrations. Table 9 also shows that the largest benefits in terms of increased dilution and dispersion of emissions occurs as the stack is increased in height to 43 m and that there are no appreciable additional benefits gained above this height.

Table 10 contains the maximum modelled 1-hour mean NO_2 concentrations, based upon stack heights between 30 m and 55 m. In accordance with EA H1 guidance, if the short term process contribution is <10% of the AQLV, impacts can be screened as insignificant.

Table 10 Modelled maximum 1-Hour Mean NO_2 Concentrations and the percentage contribution it makes to the short-term Air Quality Limit Value of 200 µg.m^{-3}

Stack Height (m)	Predicted Process contribution to 1-Hour Mean NO2 Concentrations (99.8^{th} percentile) (micrograms/m3)	Total Concentration (Process Contribution + Background)	Percentage Contribution of Process to AQLV
30	32.30	65.5	16.2
32	28.68	61.9	14.3
34	23.50	56.7	11.7
36	19.97	53.2	10.0
38	16.51	49.7	8.3
40	13.17	46.4	6.6
42	10.79	44.0	5.4
44	9.52	42.7	4.8
46	8.42	41.6	4.2
48	7.50	40.7	3.7
50	6.78	40.0	3.4
55	6.24	39.4	3.1

As indicated by Table 10, for stack heights greater than 36 m the maximum modelled process contribution to the 1-hour mean AQLV for NO_2 is <10% at ground level locations. Therefore, a stack height of 43 m or more will not have a significant impact on the 1-hour mean NO_2 AQLV in accordance with EA H1 guidance.

3 Stack Height Assessment Conclusion

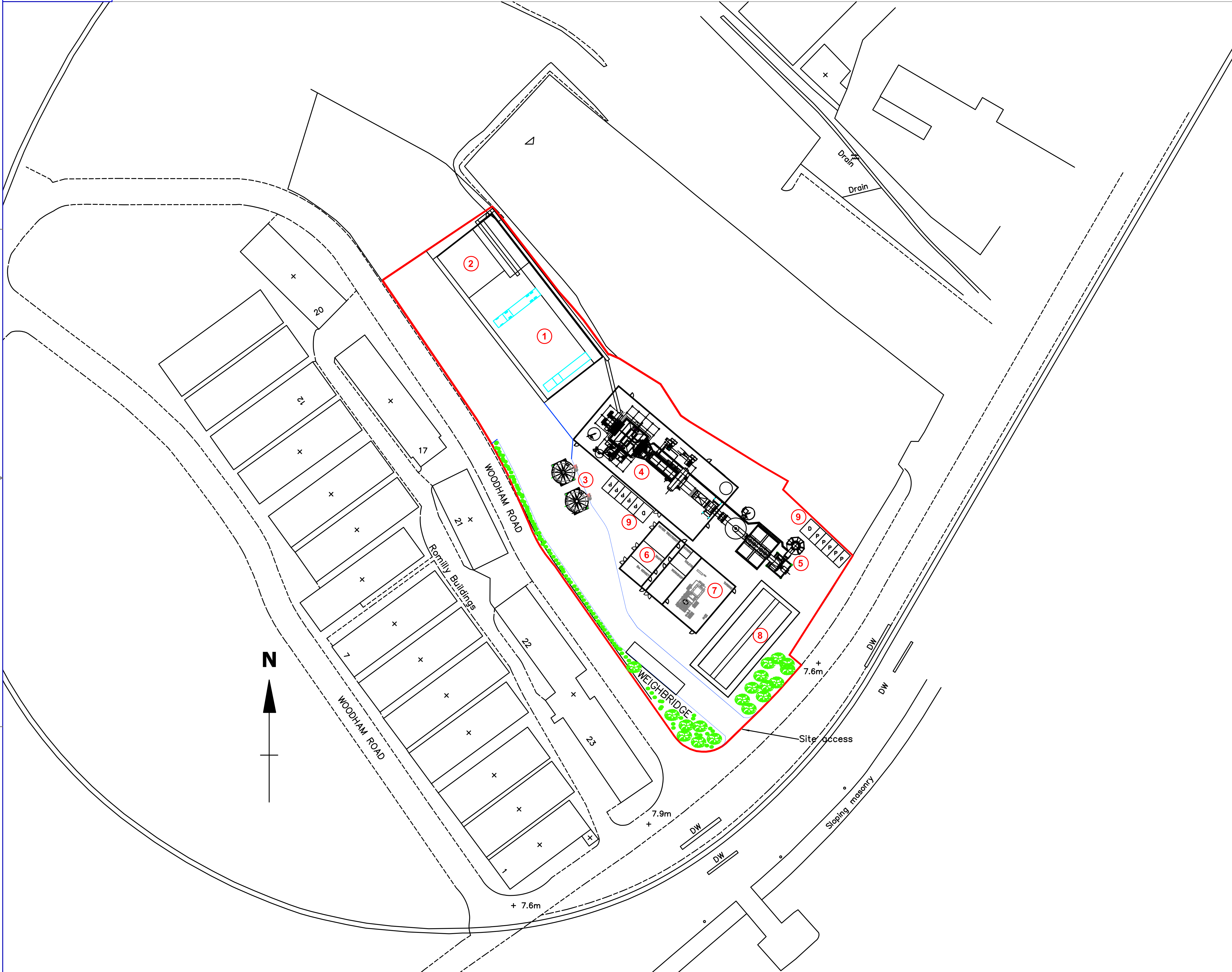
With consideration to the above, the proposed stack height of 43 m has been assessed to be sufficient for adequate dilution and dispersion of residual emissions from the plant and it is shown that there would only be very minor appreciable benefits gained by increasing the stack height further. It should be noted that this assessment is conservative, as worst case assumptions have been made for background pollutant concentrations, NO_x to NO_2 conversion rates, emission rates and worst case meteorology from 5 years of data. Given that the assessment was based on site specific dispersion modelling, confidence in a stack height of 43 m not having a significant impact on local air quality is high.

Appendices

Appendix I. Site drawings

Drawing number
E1627–2002

ORIGINAL SHEET SIZE A1 - DO NOT SCALE



General notes

Legend

1. FEEDSTOCK RECEPTION
2. FEEDSTOCK FEED SYSTEM
3. ASH SILOS
4. MAIN PROCESS BUILDING
5. FGT AND EXHAUST (EXTERNAL)
6. WELFARE & ANCILLIARIES
7. TURBINE
8. ACC
9. CAR PARKING

1:500 — 10 0 10 20m

Rev	Revision details	Drn	Chk	App	Date
C					
B					
A	ISSUED FOR DISCUSSION	JW	KD	KC	30.07.14

Imtech
Imtech House
5 Newlands Court
Attwood Road
Burntwood
Staffordshire
WS7 3GF
Tel: 01543 496600
Fax: 01543 496601

Customer: SUNRISE RENEWABLES

Project: BARRY ACT

Title: SITE LAYOUT

Drawn by:	JW	30.07.14	Checked:	KC	30.07.14	Scale 1:500
Designed:	KD	29.07.14	Approved:	KC	30.07.14	

Drawing number: E1627–2002 — Rev. A

DISCUSSION/COMMENT

IPL–A1–(AUG 2008)
File Name - T:\E1627 Barry\04 Drawing-Document Registers\E1627-2001-2002 Traffic & Site Layout.dwg , CAD Operator - Wilkinson, John, Saved - 07 August 2014 15:07:02, Plotted - 07 August 2014 15:47:07

Wind Roses

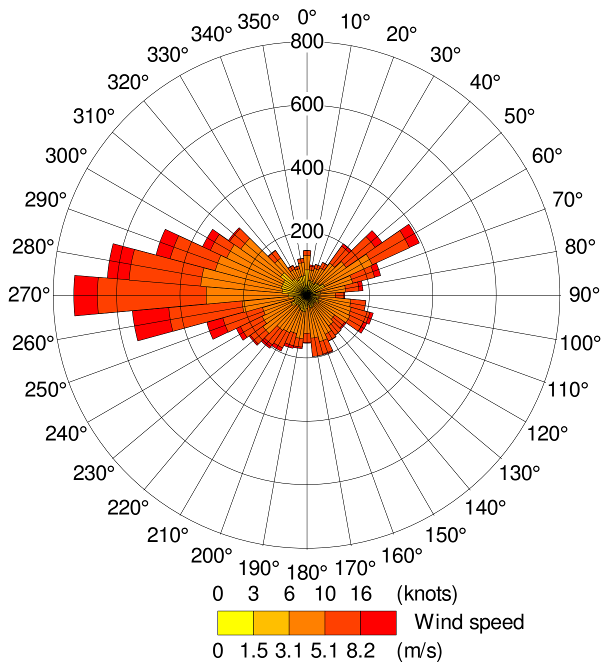


Figure 4: Cardiff Airport Wind Rose - 2009

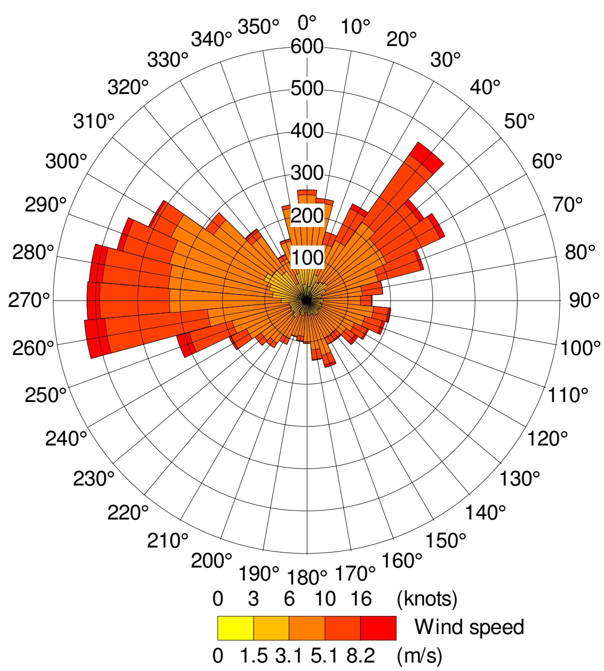


Figure 5: Cardiff Airport Wind Rose - 2010

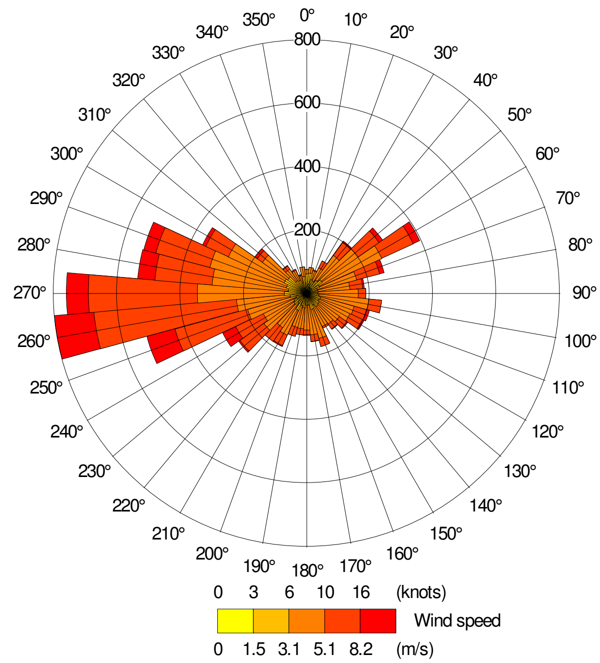


Figure 6: Cardiff Airport Wind Rose - 2011

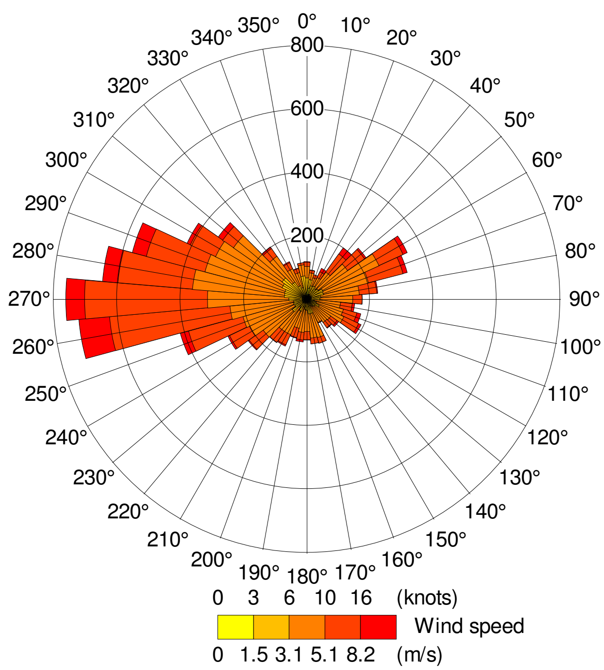


Figure 7: Cardiff Airport Wind Rose - 2012

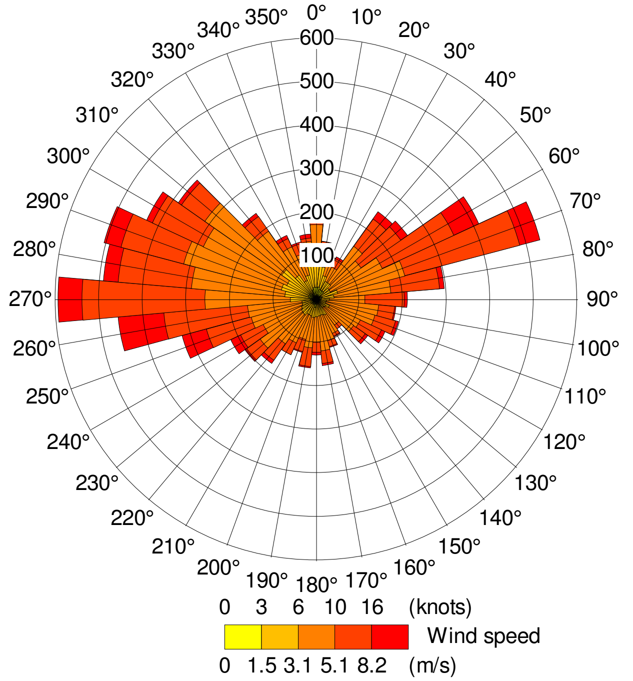


Figure 8: Cardiff Airport Wind Rose - 2013

Stack Height Assessment for a 10 MWe Wood Gasification Facility at Barry Docks, Barry Island for Sunrise Renewables (Barry)

11/09/2014

Project 6270

Document Number: R6270-PM-0001

Stopford Energy & Environment
The Gordon Manley Building
Lancaster Environment Centre
Lancaster University
Lancaster
LA1 4YQ
United Kingdom

+44(0) 1524 510604