SYNERGETICS
ENVIRONMENTAL ENGINEERING

Draft addendum report: Air quality impact assessment of the proposed waste gasification power station in East Rockingham, Western Australia

for

New Energy Corporation

4 September 2013

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1 Introduction

This report is an addendum to the report "Air quality impact assessment of the proposed waste gasification power station in East Rockingham, Western Australia" (Synergetics 2012) and addresses two questions raised by Western Australia Department of Environment and Conservation (WA DEC) in an email to Synergetics dated 20 August 2013 (included as Attachment 1) in relation to the need for a sensitivity analysis of alternate TIBL height assumptions and some questions in relation to the modelled emission values:

1. Sensitivity Analysis – WA DEC requested a sensitivity analysis investigating the effects of substituting TIBL height for mixing height.
2. Emission Values - WA DEC suggested that there may be discrepancies between emissions rates reported in the appendix of Synergetics (2012) and as reported in other documents.

This document provides a description of the methodology and results of the sensitivity analysis. It also investigates any potential issues with configuration file emission factors as given in the appendix of the previous report.

2 Sensitivity analysis

2.1 Methodology

Calculations of the TIBL height in Synergetics (2012) are based on the Garratt (1992) model:

$$h_T(\mathrm{s}) = \sqrt{\frac{2(1+2\beta)\mathrm{H}_0}{\gamma\rho c_\mathrm{p}\mathrm{u}}\mathrm{s} + \mathrm{h}_{\mathrm{T0}}^2}$$

where: $h_T(s)$ = TIBL height (m)

h_{T0} = TIBL height at start of sub-step (m)

H_0 = surface sensible heat flux (W/m^2) over land

s = distance from the coast (m)

ρ = average air density at the surface (kg/m^3)

u = average wind speed over the TIBL height (m)

γ = potential temperature gradient above the mixed layer assumed as a value of $\gamma = 9.76 \times 10^{-3}$ (°K/m)

β = ratio of the downward heat flux at the TIBL height to the upward heat flux at the surface

c_p = specific heat at constant pressure (J/kg.°K).

Garratt reports that $\beta = 0.2$ is supported by the bulk of experimental data, however in our modelling to provide a conservative low value it was assumed that $\beta = 0$. Similarly it is conservative to assume that the value of $h_{T0} = 0$. These substitutions conveniently reduce the Garratt model to a simpler and more conservative form referred to as the Weisman (1976) model (Earth Tech, 2000).

As a means for testing the sensitivity of calculated GLCs when the TIBL height is changed to alternate values, two additional runs were conducted assuming that the calculated parameters were in error by an aggregate of half and double the true value. This effect can be conveniently achieved by approximately doubling and halving the potential temperature gradient as shown in Table 1 and recalculating the GLCs.

Table 1 - Potential temperature lapse rate scenarios tested in the sensitivity analysis.

Scenario	**γ (°K/m)**
Original modelling	9.76×10^{-3}
Doubled potential temperature lapse rate	2.0×10^{-2}
Halved potential temperature lapse rate	5.0×10^{-3}

In other respects the same modelling parameters as Synergetics (2012) were employed. GLCs were then compared with the equivalent results reported in Synergetics (2012).

2.2 Results

Maximum ground level concentrations (GLCs) were found to be unaffected by the changes in TIBL height for all averaging times. Table 2 shows these results.

Table 2 - GLC results ($\mu g/m^3$) for the worst-case off-site gridded receptor.

γ (°K/m)	Averaging time					
	10-min	15-min	30-min	1-hour	8-hour	24-hour
9.76×10^{-3}	13.1	12.8	12.4	12.0	6.37	5.91
2.0×10^{-2}	13.1	12.8	12.4	12.0	6.37	5.91
5.0×10^{-3}	13.1	12.8	12.4	12.0	6.37	5.91

GLCs were only affected for some of the top 100 concentrations (see spreadsheet "Peak GLC concentration comparisons" supplied separately). For example the Kwinana beach sensitive receptor was unaffected with the changes to TIBL height for all averaging times as shown in Table 3.

Table 3 - GLC results for the Kwinana beach discrete receptor.

γ (°K/m)	Averaging time					
	10-min	15-min	30-min	1-hour	8-hour	24-hour
9.76×10^{-3}	1.16	1.10	9.99×10^{-1}	8.98×10^{-1}	6.52×10^{-1}	5.67×10^{-1}
2.0×10^{-2}	1.16	1.10	9.99×10^{-1}	8.98×10^{-1}	6.52×10^{-1}	5.67×10^{-1}
5.0×10^{-3}	1.16	1.10	9.99×10^{-1}	8.98×10^{-1}	6.52×10^{-1}	5.67×10^{-1}

However at the Leda Primary school, sensitive receptor GLCs were affected by the changes in TIBL height. However, increases in GLCs only occurred for the larger potential lapse rate ($\gamma = 2.0 \times 10^{-2}$ °K/m) for averaging times of 10-min, 15-min, 30-min and 1-hour as shown in Table 4.

Table 4 - GLC results for the Leda Primary school discrete receptor. Cells highlighted grey show increases in GLC.

γ (°K/m)	Averaging time					
	10-min	15-min	30-min	1-hour	8-hour	24-hour
9.76×10^{-3}	1.23	1.17	1.06	9.50×10^{-1}	6.19×10^{-1}	4.14×10^{-1}
2.0×10^{-2}	1.54	1.42	1.24	1.08	5.86×10^{-1}	4.14×10^{-1}
5.0×10^{-3}	1.21	1.12	9.77×10^{-1}	8.82×10^{-1}	4.62×10^{-1}	3.87×10^{-1}

The Leda Primary school's increases in GLC concentrations have been investigated. When the GLC emissions of the Leda Primary school receptor are scaled for each pollutant, as shown in Table 5, it was found that all GLC + background (b/g) concentrations still fall well within relevant acceptance criteria.

Table 5 – GLC results for the Leda Primary School discrete receptor with larger potential lapse rate ($\gamma = 2.0 \times 10^{-2}$).

Pollutant	Averaging time	Assessment criteria ($\mu g/m^3$)	b/g ($\mu g/m^3$)	GLC + b/g ($\mu g/m^3$)	CF
CO	15-min	100000	1650	1651	61
CO	30-min	60000	1440	1441	42
CO	1-hour	30000	1250	1251	24
CO	8-hour	11249	870	870	13
NO_2	1-hour	246	49	51	4.8
NO_2	1-year	61.6	4.0	4.1	15
TSP	1-year	90	-	2.5×10^{-3}	>100
PM_{10}	24-hour	50	25	25	2.0
$PM_{2.5}$	24-hour	25	13	13	2.0
$PM_{2.5}$	1-year	8	2.5	2.5	3.2
SO_2	10-min	500	10	10	49
SO_2	1-hour	572	20	20	28
SO_2	24-hour	229	3.0	3.1	75
SO_2	1-year	57.2	1.0	1.0	57
HCl	1-hour	100	-	2.7×10^{-2}	>100
HF	1-hour	100	-	3.1×10^{-3}	>100
TOC (as benzene)	1-hour	29	-	3.3×10^{-2}	>100
Dioxins and furans	1-hour	1×10^{-6}	-	8.8×10^{-10}	>100
As	1-hour	0.09	-	3.0×10^{-5}	>100
As	1-year	3×10^{-3}	-	1.0×10^{-6}	>100
Cd	1-hour	1.8×10^{-2}	-	8.3×10^{-5}	>100
Cd	1-year	5×10^{-3}	-	2.9×10^{-6}	>100
Co	24-hour	0.1	-	6.6×10^{-6}	>100
Cr (VI)	1-year	2×10^{-4}	-	2.1×10^{-7}	>100
Cr (III)	1-hour	10	-	6.0×10^{-5}	>100
Cu	1-hour	1	-	3.3×10^{-4}	>100
Hg	1-hour	1.8	-	7.5×10^{-6}	>100
Hg	1-year	1	-	2.6×10^{-7}	>100
Mn	1-hour	18	-	3.3×10^{-4}	>100
Mn	1-year	0.15	-	1.1×10^{-5}	>100
Ni	1-hour	0.18	-	2.3×10^{-5}	>100
Ni	1-year	3×10^{-3}	-	7.9×10^{-7}	>100
Pb	1-year	0.5	-	6.1×10^{-5}	>100
Sb	1-hour	9	-	3.3×10^{-4}	>100
Tl	1-hour	1	-	1.2×10^{-5}	>100
Tl	1-year	0.1	-	4.1×10^{-7}	>100
V	24-hour	1	-	1.8×10^{-5}	>100

3 Emission factors in Ausplume file

WA DEC suggested that there may be a discrepancy in the emission rates reported in the configuration files appended to the previous report.

The emission rates were checked and no discrepancies were found. To assist WA DEC better understand the emission rates, details of the emission rates used in this assessment are described in the report "13028 Addendum Report AQ impact assessment of gasification facility at East Rockingham CD03.docx". The intermediate calculations are included in the detailed spreadsheet "NEC12029_GLC_processing_option2_v1.xlsx". A separate tab has been used in the spreadsheet for each receptor (worst case, Kwinana beach, Leda primary) for both the main stack (M) and emergency shutdown stack (E).

In the process of checking these emission rates, a few minor typographical amendments were made to the results tables. In all but one instance these amendments consisted of reductions in the concentration. No changes to conclusions or analysis were required. These amendments are noted as footnotes in the respective tables of "13028 Addendum Report AQ impact assessment of gasification facility at East Rockingham CD03.docx" and are summarised below.

Table 6 – Summary of minor amendments to results tables.

Table No.	Page No.	Pollutant	Conditions	Averaging time	Value in version 2 of report ($\mu g/m^3$)	Value in version 3 of report ($\mu g/m^3$)
16	30	CO	b/g	30-min	1440	1435
16	30	SO_2	b/g	24-hour	3.0	2.9
17	31	CO	b/g	30-min	1440	1435
17	31	CO	GLC + b/g	30-min	1430	1436
18	32	CO	b/g	30-min	1440	1435
18	32	SO_2	b/g	24-hour	3.0	2.9
19	33	CO	b/g	30-min	1440	1435
19	33	CO	GLC + b/g	30-min	1439	1435

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4 Conclusions

WA DEC has requested that Synergetics review several items from the previous report, "13028 Addendum Report AQ impact assessment of gasification facility at East Rockingham CD03.docx" (Synergetics 2012). It was found that:

1. A sensitivity analysis conducted by doubling and halving the potential temperature gradient to generate a broad range of alternate TIBL heights was modelled from which it was concluded that all GLCs still fall well within relevant acceptance criteria for all scenarios.
2. The calculations and report were checked and no discrepancies were identified. A few minor typographical amendments were identified and made during the checking.

5 References

Earth Tech 2000. *A User's Guide for the CALPUFF Dispersion Model (v5)*. Earth Tech, Inc. PA, USA.

Garratt JR 1992. *The Atmospheric Boundary Layer*. Cambridge University Press, Great Britain.

Synergetics 2012. Air quality impact assessment of the proposed waste gasification power station in East Rockingham, dated 10 December 2012, Western Australia, Synergetics Pty Ltd, 490 Spencer Street, Melbourne, 3003, Victoria saved as file "13028 Addendum Report AQ impact assessment of gasification facility at East Rockingham CD03.docx".

Attachment 1 – Email from Western Australia Department of Environment and Conservation

From: Blockley, Adrian [mailto:Adrian.Blockley@DER.wa.gov.au]
Sent: Tuesday, 20 August 2013 1:18 PM
To: Dave Collins
Subject: FW: Phone call follow-up

Hi Dave,

I've included some annotations on the list below – some of items don't require further action but there are a couple of issues that require a response.

WA DEC Comments on Air Quality **NEC East Rockingham**

Air Quality

1. The model used in the assessment, Ausplume, is an old model which has a number of limitations. While these limitations usually result in the model being more conservative this is not always the case. No response required
2. Ausplume has no built in mechanism for simulating the effects of coastal fumigation which is a significant factor affecting ground level concentrations from stack emissions in the Kwinana Industrial strip. The proponent has attempted to work around this limitation by setting the mixing depth equal to the TIBL height. The partial plume penetration formulation within Ausplume is rudimentary and does not work with building wakes or gradual plume rise. The proponent should do multiple runs to undertake sensitivity tests of these configurations. They should refer to the Ausplume help files and documentation for further information. Please provide evidence to document treatment of potential coastal fumigation (East Rockingham is closer to the coast than Boodarie – fumigation still might not be an issue but conclusion needs appropriate supporting evidence).
3. The DEC does not usually specify which model a proponent must use but requires that a proponent is able to demonstrate that a selected model is appropriate for a specific task. Main concern here is probably fumigation. This was addressed in the previous comment.
4. We advise the proponent that any modelling should conform to the DEC Air Quality Modelling Guidance notes. They should take note especially regarding requirements for modelling files as AQMB cannot begin review of the modelling for final PER if the required files are not provided with the PER. This can result in delays in the assessment. This is a statement of DER's requirements to undertake an assessment. If the modelling files were subsequently provided then further response is not required.
5. Some simple checking of emissions calculations seems to indicate discrepancies between emissions rates reported in the modelling appendix and as reported in other documents. It may be beneficial for the proponent to check through the emission rate calculations and also provide a spreadsheet which contains details of the emissions calculations with the final PER. Air Quality Branch recommends reviewing emissions calculations to ensure no inconsistencies.

Regards, Adrian