

TECHNICAL MEMORANDUM

To	Michael Hartley, michael.hartley@cleanaway.com.au
From	Therese Manning therese@enrisks.com.au
Client name	Cleanaway Operations Pty Ltd
Subject	Bromelton Energy and Resource Centre: Response to OCG Information Request
Date	16 July 2026

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Response to OCG Information Request

1 Background

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Cleanaway Operations to respond to OCG information requests in regard to the proposed BERC facility. The requests and responses are provided in the following pages.

No. 24	Issue: Missing scenario 4 modelling
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Information Requested

Section 4.4.5 of the HHRA report submitted as part of the application material (indicates that the risk assessment is based on three scenarios of the AQA report. These scenarios are:

- Scenario 1 - Load Point 1 (LP1) based on daily average compliance operations: This assessment includes pollutants mass emissions based on the WI BREF 2019 BREF WI, 2019 - daily average (upper) concentration limits.
- Scenario 2 - Load Point 1 (LP1) based on short-term compliance operations: This assessment includes pollutants mass emissions based on the EU IED 2010 - short-term (30-minute average) concentration limits. For this scenario, it was assumed that one line will be operating at short-term emission limits whilst the other line will be operating at the daily average (upper) concentration limit.
- Scenario 3 - Load Point 2 (LP2) based on daily average compliance operations: This assessment includes pollutants mass emissions based on the WI BREF 2019 BREF WI, 2019 - daily average and (upper) concentration limits and assuming a maximum waste throughput load of 120%.

Please note, the HHRA is missing Scenario 4 which is based on LP2 emissions considering the EU IED 2010 - short-term non-routine operation and assuming a maximum waste throughput load of 120%. Air emissions in Scenario 4 are greater than the Scenario 2. Therefore, health risk based on Scenario 2 does not represent the worst-case conditions.

The proponent is requested to submit a revised HHRA report with Scenario 4 included in the risk assessment.

Response

The Human Health Risk Assessment (HHRA) has been updated to include Scenario 4.

No. 25	Issue: Operational worst-case scenario (with both flues in operations)
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Information Requested

A short term variation in emissions is expected due to variability in mixed waste feedstock composition and/or combustion characteristics and some process upsets and non-routine operations. The Scenario 3 and Scenario 4 models are based on LP2 assuming a maximum waste throughput at 120% mechanical load for daily average and short-term average compliance operations. When both flues are operating at short-term limits, the mass emissions of air pollutants are significantly greater than the daily average limits.

The proponent is requested to submit a revised HHRA report that incorporates an analysis of the operational worst-case scenario in which both flues are operating at short-term emission limits.

Response

Refer to RFI No 14 response for discussion on worst-case scenarios.

No. 26	Issue: Operational worst-case scenario (with lines operating at short-term limits)
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Information Requested

In the AQA report, in both Scenario 2 and Scenario 4, mass emissions were modelled based on the assumption that one line operates at short-term emission limits while the other operates at daily average limits. This approach does not represent a worst-case scenario. Emissions are significantly higher when both lines (including associated flues) operate at short-term limits compared to situations where only one line is subject to short-term emission limits and the other to daily average limits. Under non-routine conditions, there is a potential for both lines to operate concurrently at short-term emission limits.

The proponent is requested to submit a revised HHRA report, incorporating an analysis of the worst-case impact health risk assessment based on mass emissions when both lines (including associated flues) operate at short-term limits.

Response

Refer to RFI No 14 response for discussion on worst-case scenarios.

No. 27	Issue: Modelled mass emission rates and final design
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Information Requested

The modelled mass emission rates were determined by multiplying the specified pollutant concentration limits by the flue gas volume flow rate. It is recognised that the project design has not yet been finalised. Consequently, stack parameters may be subject to modification following the selection of the moving grate technology provider and the completion of the detailed project design.

The proponent is requested to submit a revised HHRA report, incorporating a discussion on potential impacts the final design may have on the modelled GLCs and health risk assessment.

Response

Refer to RFI No. 15 and 17 which discuss possible changes due to technology provider selection and detailed design in relation to establishing mass emission rates.

While final stack design parameters (including flue gas flow rate, temperature, and stack configuration) may be refined during detailed design, any resulting changes are not expected to increase modelled ground level concentrations or associated health risks. This is because the assessment is based on maximum allowable emission concentrations and conservative dispersion assumptions, which together provide a conservative basis for assessing potential future operating conditions.

No. 28	Issue: Health risk assessment for criteria pollutants
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Information Requested

Section 5.4.1 of the HHRA report addresses the estimation of health risks associated with criteria pollutants, including PM₁₀, PM_{2.5}, NO₂, SO₂, and CO. The assessment considered incremental changes in modelled ground level concentrations (GLCs) resulting from the proposed facility under the LP1 scenario (Load Point 1 – daily average compliance operations), as well as cumulative GLCs combining both the facility's contributions and existing ambient background levels. Modelling outcomes based on LP1 daily average emissions were compared against air quality objectives for 1-hour, 24-hour, and annual averaging periods.

It should be noted that daily average mass emission values are considerably lower than short-term (30-minute average) emission values. Consequently, modelled GLCs derived from the LP1 daily average emission scenario are significantly less than those from the LP1 short-term (30-minute average) emission scenario. As such, modelling results based on daily average emissions are not adequate for assessing risk relative to criteria pollutants with 1-hour average ambient air quality standards. The rationale for not utilising modelling results from short-term (30-minute average) emission scenarios for LP1 and LP2 when evaluating 1-hour average air quality objectives remains unclear.

The proponent is requested to submit a revised HHRA report that includes a discussion of the health risk assessment for criteria pollutants against 1-hour average air quality objectives, based on short-term (30-minute average) emission scenarios.

Response

A discussion of the health risk assessment for criteria pollutants against 1 hour average air quality objectives – even where 1 hour averages are not included in the AAQ NEPM or EPP (Air) this comparison has been added in Section 5.4 of the HHRA.

No. 29	Issue: Section 5.4.2 of HHRA report
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Information Requested

Section 5.4.2 of the HHRA report states that at the time of preparing this HHRA report (i.e. 17 February 2026) the Queensland Environmental Protection (Air) Policy 2019 ambient air quality (AAQ) objectives are not updated as the values in National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) (2021). On 1 December 2025, the Environmental Protection (Air) Policy 2019 AAQ objectives were amended to align with the AAQ NEPM standards of 2021.

The proponent is requested to submit a revised HHRA report and update information in Section 5.4.2.

Response

enRiskS acknowledges the update to the Environmental Protection (Air) Policy 2019 ambient air quality objectives, which were amended on 1 December 2025 to align with the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) 2021 standards.

Section 5.4.2 of the HHRA report has been reviewed and updated to reflect the current AAQ objectives under the Environmental Protection (Air) Policy 2019 as amended.

Information Requested

Table 5.1 of the HHRA report presents the sulfur dioxide (SO₂) AAQ objectives, as outlined in the Queensland EPP (Air) 2019 publication. Effective from 1 December 2025, the AAQ objectives within the EPP (Air) 2019 were amended to align with the standards established in the AAQ NEPM (2021) (refer to item 18 above for further information). The SO₂ air quality objectives listed in the current EPP (Air) have been substantially reduced, with the 1-hour average decreasing from 570 µg/m³ to 214 µg/m³, and the 24-hour average from 229 µg/m³ to 57 µg/m³. Notably, Table 5.1 does not provide the percentage contribution of “project + background” relative to the AAQ objectives for the various land uses.

Similarly, Table 5.2 of the HHRA report details the nitrogen dioxide (NO₂) AAQ objectives based on the Queensland EPP (Air) 2019 publication, which were superseded on 1 December 2025 (refer to item 18 above). The NO₂ air quality objectives in the current EPP (Air) have been significantly reduced, with the 1-hour average lowered from 250 µg/m³ to 164 µg/m³, and the annual average from 62 µg/m³ to 31 µg/m³. Table 5.2 does not state the percentage contribution of “project + background” in relation to the AAQ objective for the relevant land uses.

The proponent is requested to submit a revised HHRA report with updated information in Table 5.1 and in Table 5.2, add the percentage contribution of “project + background” and update risk assessment conclusions if they change.

Response

The SO₂ and NO₂ air quality objectives have been updated in the HHRA to reflect the updated values in the 2025 amendment to EPP Air 2019 publication.

Tables 5.1 and Table 5.2 have been updated to include the percentage contribution of “project + background”.

The updated assessment confirms that, despite the reduction in threshold values, predicted ground level concentrations (including background contributions) remain below the revised criteria for both SO₂ and NO₂. Accordingly, there is no change to the overall HHRA conclusions.

No. 31	Issue: Table 5.4
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Information Requested

Table 5.4 of the HHRA report outlines the PM_{2.5} AAQ objectives as specified in the Queensland EPP (Air) 2019 publication. The annual average PM_{2.5} EPP (Air) AAQ objective has since been updated to reflect the amended standards to align with the AAQ NEPM (2021) standards. The current EPP (Air) sets the annual average PM_{2.5} AAQ objective at 7 µg/m³. The predicted maximum cumulative (project + background) annual average concentration of PM_{2.5} at residential and commercial receptors is 6.7 µg/m³, which represents approximately 96% of the relevant objectives. Table 5.4 does not provide the percentage contribution of “project + background” relative to AAQ objectives for the respective land uses.

Additionally, modelling results in Table 5.4 indicate that the predicted annual average maximum cumulative (project + background) concentration of PM_{2.5} at residential and commercial receptors is 6.7 µg/m³, based on the LP2 daily average emission limit scenario under normal operational conditions. These findings demonstrate that PM_{2.5} is the principal contaminant for impact assessment. There remains a risk that the cumulative annual average PM_{2.5} concentration at sensitive receptors may exceed the EPP (Air) objective of 7 µg/m³.

The proponent is requested to submit a revised HHRA report with updated information in Table 5.4 to include AAQ objectives, re-run the modelling of cumulative impact (project and background) and identify a worst-case scenario applicable to the health risk assessment of PM_{2.5}. This scenario must be discussed as it relates to health risk assessment.

Response

Additional information has been added to Section 5.4.5 to address this matter. The modelling for PM_{2.5} has been conducted using a contemporaneous approach to determine cumulative concentrations. This is an intensive approach to take. The AQ assessment has not identified any additional days of exceedance of the short term or long term guideline values/objectives arising from the BERC proposal.

Information Requested

Table 5.13 of the HHRA report presents the chronic inhalation risks associated with threshold chemicals at residential receptors, based on modelled concentrations assessed under normal operating conditions (i.e., LP1). The methodology used to derive the exposure concentration, defined as the air concentration relevant to the exposure period as an annual average, is not clearly outlined. Additionally, the approach for selecting health-based criteria or tolerable concentration (TC) values for calculating risk quotients (RQs) for the identified pollutants requires further clarification.

Furthermore, Table 5.14 addresses non-threshold chronic risks for inhalation exposures within residential land use, detailing increased cancer risks calculated using adjusted exposure concentrations and inhalation unit risk values. However, the method for calculating these adjusted exposure concentrations is not specified.

The proponent is requested to submit a revised HHRA report that provides examples and demonstrates the calculation of RQs for threshold chemicals and non-threshold chemicals.

Response

The text in Section 5.5 refers to the calculations in Appendix B (how toxicity reference values were determined) and Appendix C (how the exposure concentrations were calculated).

The calculations used are the same calculations recommended for use in these types of assessment by the National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM) Schedule B7 Appendix B and in the enHealth guidance (enHealth 2012). These are the documents risk assessors are required to use by governments. In addition, most of the parameter values used in the calculations were those recommended as default values by government guidance.

Appendix B explains in detail how the health based criteria/tolerable concentrations were chosen for both short term (Section B2) and long term (Section B3) situations. A short summary of that information is provided in the relevant parts of Section 5.5. Some additional information has been added to Appendix B and Section 5.5.3.4 in relation to how values for long term exposure were determined for additional clarity.

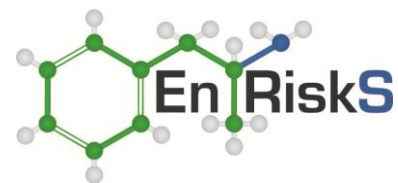
Appendix C of the HHRA provides all the equations for how the various calculations were undertaken.

In particular, Section C2 shows how the inhalation exposure concentrations are calculated. This is the equation used.

$$\text{Inhalation Exposure Concentration} = C_{\text{air}} \times \frac{ET \times FI \times RF \times EF \times ED}{AT}$$

Where:

C_{air} value is the value provided directly from the air quality modelling.



FI is the fraction from the site of interest – assumed to be 100% for this assessment (i.e. maximum possible).

RF is the dust lung retention factor – the value used in these calculations is 1 because the particles from the facility are so small (i.e. maximum possible). If an RF of 0.375 is used as per dust calculations for contaminated sites assessments, that means only 37.5% of the particles get down into the lungs. Using a value of 1 for this parameter means that all particles inhaled are assumed to reach down into the lung.

The exposure time (ET), frequency (EF) and duration (ED) for maximum off-site and maximum residential locations assumed a person could be present at that location for 24 hours per day, 365 days per year for 35 years. This was the case for threshold and non-threshold calculations. For the maximum commercial location, these values were 10 hours per day, 240 days per year for 30 years respectively. These assumptions are as per government guidance or more conservative than those used in government guideline calculations.

The parameter “exposure time” was not included in Table 5.7 – this was the table listing all the parameter values included in all the calculations. This has now been corrected. Table 5.7 is now Table 5.11 due to the addition of tables in the criteria pollutants section.

The only difference between the threshold and non-threshold calculation was the averaging time. For threshold calculation it was assumed the averaging time = exposure duration. For the non-threshold calculation, it was assumed the averaging time = 70 years (i.e. lifetime).

All of the calculations are provided in the spreadsheet images in Appendix D.

No. 33	Issue: Non-threshold chronic risks for inhalation exposures
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Information Requested

Non-threshold chronic risks associated with inhalation exposures have been assessed for PAHs and benzene. The rationale for excluding other carcinogens, such as dioxins, formaldehyde, and heavy metals, from this evaluation is unclear. For compounds classified as human carcinogens, it is widely accepted that no exposure level can be deemed entirely safe; even minimal exposure may result in genetic alterations that elevate cancer risk.

The proponent is requested to submit a revised HHRA report to include additional carcinogens in the non-threshold pollutant's risk assessment.

Response

It is not correct to say:

For compounds classified as human carcinogens, it is widely accepted that no exposure level can be deemed entirely safe; even minimal exposure may result in genetic alterations that elevate cancer risk.

This phrasing is US policy not Australian policy.

In Australia, this statement is assumed to be the case for genotoxic carcinogens only. It is a policy choice to ensure risk assessments are conservative (both in Australia and the US). It is not a statement of fact that any damage to DNA at all will definitely lead to cancer. It is a statement of policy that ensures that we do not underestimate risk because some very particular types and amounts of DNA damage may possibly lead to cancer in a lifetime especially if such damage occurs multiple times across a lifetime.

In Australia, this statement is not considered applicable for chemicals that are non-genotoxic carcinogens.

Additionally, it is a policy choice that has been subject to detailed criticism in recent years (Calabrese 2026a, 2026b; Calabrese et al. 2026). The policy arose from studies of cancer arising from radiation exposure in the 1950s and 60s. Historical review of that work has now been shown to have significant flaws.

- Calabrese, EJ 2026a, 'Hermann J. Muller's research swan song: His long-term radiation dose-rate mutation Investigations yielded no research publications, leaving questions of scientific misconduct', *Chemico-biological interactions*, vol. 433, 2026/06/25/, p. 112074.
- Calabrese, EJ 2026b, 'How the US NAS BEAR I Genetics Panel scientific misconduct could have been avoided, but was not', *Journal of Occupational and Environmental Hygiene*, 2026/05/27, pp. 1-7.
- Calabrese, EJ, Pressman, P & Selby, PB 2026, 'BEAR I Genetics Panel: An unexpected and troubling historical twist: The untold story of Hermann Muller's significant scientific confusion', *Journal of Occupational and Environmental Hygiene*, 2026/05/19, pp. 1-9.

It is clear in WHO guidance and Australian guidance that it is appropriate to consider some carcinogens genotoxic and some non-genotoxic and to treat them differently in a risk assessment.

In the US, on the other hand, there are policy requirements built into legislation that mean all chemicals that might cause cancer must be assumed to be genotoxic carcinogens.

Some additional background information about threshold vs non-threshold processes is provided below:

Most chemicals have a threshold below which there are no adverse effects. That means there is a dose or concentration below which no adverse effects are seen because there is not enough of the chemical in the body to cause enough of a change/enough damage. The threshold is determined by taking the lowest dose that did not cause effects in a study (typically from animal or human (e.g. occupational) studies) to which a number of uncertainty factors are applied (based on type of study, how many studies are available etc). This value is termed the toxicity reference value (TRV). When intakes / exposures are lower than the TRV, they are considered to not be associated with an adverse health risk (NHMRC 1999).

*Some chemicals have the potential to cause cancer by directly damaging DNA. These chemicals are described as non-threshold as it is assumed that they could cause some level of effect even at low doses. While this can be interpreted to mean that there is no safe dose, this is actually a policy choice/assumption built into the calculations to ensure risks are not underestimated. It actually means the risk of effects due to exposure to such a chemical increases with increasing dose or exposure – i.e. at low exposure, risk is low or even negligible and at high exposure, risk is much higher. The difference between threshold and non-threshold chemicals is chemicals that act via a threshold mechanism of action have **no risk** when exposure is to levels **below the threshold** and high risk at high exposures (for all types of effects include cancer) while chemicals that act via a non-threshold mechanism of action in relation to cancer have a **low risk at low exposure** and higher risk at higher exposures.*

Genotoxic carcinogens are those that directly act on DNA – they form adducts (bumps on the DNA which cause replication to not happen correctly) or they cause breaks in the DNA which again lead to incorrect replication etc – these are assessed using non-threshold approaches.

Non-genotoxic carcinogens are those that cause other types of damage which may (or may not) eventually lead to DNA changes which can result in cancer – these are assessed using threshold approaches. There are many carcinogens that do not cause cancer until there is enough damage to the organ that the cells are dying. For example, liver damage from excess alcohol can eventually lead to liver cancer if there is sufficient damage.

In addition, there are chemicals that are initiators of cancer, ones that are initiators and promoters and others that are only promoters. Promoters of cancer can increase the effect of another chemical that is an initiator but they cannot initiate cancer themselves.

There was a specific discussion in Appendix B (section B3 – approach) about why a number of chemicals that have been identified as carcinogens relevant to this assessment should be considered as threshold chemicals rather than non-threshold ones. This summary information is repeated here:

- Arsenic – the mechanism by which cancer is caused does not appear to be mutagenic with a threshold mode of action identified for the assessment of cancer (where damage to cells and sufficient exposure to result in cancer proliferation required) (NEPC 1999 amended 2013). Hence the threshold TRV adopted is protective of all health effects including carcinogenicity.

- Cadmium – the available data suggests only weak evidence of genotoxicity and review by NEPC indicates that a threshold mode of action is relevant for the assessment of cancer. Hence the threshold TRV adopted is protective of all health effects including carcinogenicity.
- Chromium VI – the available data suggests the compound may have some genotoxic potential, however, review by NEPC (NEPC 1999 amended 2013) indicates that carcinogenicity is likely to act on the basis of a threshold mode of action. Hence the threshold TRV adopted is protective of all health effects including carcinogenicity.
- Formaldehyde – the available data suggests that it may be weakly genotoxic, however, where cancer has been observed it occurs at the point of contact (e.g. nose) and only occurs where exposure is sufficient for cytotoxicity occurs (i.e. cell death) (IARC 2006; UNEP 2002; WHO 2002). A threshold mode of action is, therefore, considered appropriate. Hence the threshold TRV adopted is protective of all health effects including carcinogenicity.
- Nickel – the available data indicates that the compound may be genotoxic, however, the mechanism of action is not well understood. WHO (WHO 1991) indicates that very high concentrations of nickel are required to produce genotoxic effects (after cell damage/death) and hence a threshold mode of action is considered appropriate (NEPC 1999 amended 2013). Hence the threshold TRV adopted is protective of all health effects including carcinogenicity.
- Dioxin-like compounds (as 2,3,7,8-TCDD) – review of carcinogenicity by NHMRC (NHMRC 2002) and WHO (FAO/WHO 2018; WHO 2019) indicates that TCDD is not genotoxic and hence a threshold approach is considered appropriate. Hence the threshold TRV adopted is protective of all health effects including carcinogenicity. In addition, dioxin-like compounds have been identified as promoters but not initiators. The mode of action by which they act is via the Ah receptor. When they connect with that receptor that turns the receptor on triggering a whole bunch of actions including the promotion of some types of cancer. Such promotion can only occur if initiating events for those types of cancer have occurred previously. In addition, there needs to be a sufficient number of molecules of the dioxin-like chemicals attaching to sufficient numbers of the Ah receptor in multiple cells in a relevant organ or organs for sufficient metabolic processes to be kicked off to do the promotion type effects. This definitely indicates a threshold exists.

No. 34	Issue: Non-threshold risk assessment of As and Ni
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Information Requested

For heavy metals such as arsenic (As) and nickel (Ni), which may contribute to cancer risk via inhalation or ingestion, the cancer risks based on the non-threshold approach have not been estimated. The risk assessment for arsenic and nickel was limited to the threshold approach. Arsenic is an established human carcinogen; however, there is ongoing debate regarding its classification as a genotoxic carcinogen. Some research indicates that arsenic is a potent genotoxic carcinogen capable of inducing DNA damage, including chromosomal breakage and numerical chromosomal alterations. A similar concern may apply to the assessment of carcinogenic effects stemming from nickel exposure. Consequently, there is a potential for the cancer risk associated with arsenic and nickel to be underestimated when employing the threshold methodology.

The proponent is requested to submit a revised HHRA report to include non-threshold risk assessment for exposure to arsenic (As) and nickel (Ni).

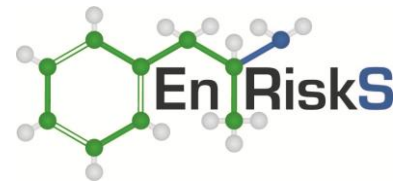
Response

As discussed above, the mode of action by which exposure to a chemical is thought to possibly lead to cancer is important for determining what approach to adopt.

For both arsenic and nickel, it has been determined by national authorities that a threshold approach is relevant and appropriate, particularly for oral type exposure. Full details supporting this choice are provided in the relevant part of Appendix B in the HHRA.

The following general points are noted for nickel:

- For nickel
 - WHO recommends assessment using threshold approaches for oral exposure (WHO 2022)
 - TCEQ provides a long term air guideline value based on a threshold approach of $0.23 \mu\text{g}/\text{m}^3$. TCEQ also provides a long term air guideline value based on a 1 in 100,000 increased risk of cancer. This value is $0.059 \mu\text{g}/\text{m}^3$. This was the value used in this assessment. Using this value is equivalent to a non-threshold calculation.
 - Nickel fume from a refinery or smelter is the form of nickel that has been linked with cancer.
 - Because a WtE facility combusts the waste and then puts the gases through various air pollution control equipment, the form of nickel that can be present in the exhaust gases is only as attached to particles not as fume. This limits the potential for cancer – regardless the inhalation tolerable concentration used in this assessment is one designed to be protective for cancer based on occupational studies of fume related sources of nickel.
- For arsenic
 - TCEQ does not provide a long term guideline value for inhalation based on a threshold approach as there was not sufficient information about other effects. TCEQ do provide a long term air guideline value based on a 1 in 100,000 increased risk of cancer. This value is $0.067 \mu\text{g}/\text{m}^3$ and this is the value that was used in this assessment. This value was derived from occupational studies reporting respiratory and lung cancers. Using this value is equivalent to a non-threshold calculation.



- o In regard to the oral exposure route, it is still not agreed as to whether arsenic acts via a genotoxic mechanism or not. Recently updated assessments for arsenic by WHO (as part of JECFA) and EFSA, have continued to recommend a threshold type approach for both carcinogenic and non-carcinogenic effects (EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain) et al. 2024; WHO 2026).

Information Requested

The AQA and HHRA uses formaldehyde and benzene as the benchmark for all VOCs, complying with relevant health guideline levels (for example, the air pollution assessment criteria highlighted in the Victorian EPA - Guideline for assessing and minimising air pollution in Victoria). This may not be accurate, and further assessment is needed to determine the levels of other VOCs (for example, acrolein and acetone) that may be released.

The proponent is requested to submit a revised air quality assessment and human health risk assessment, including assessment against all other VOCs that will be released through emissions. If any VOCs are found to be released beyond the health investigation guideline levels, provide mitigation measures to ensure that they will be released at levels in line with relevant health guidelines.

Response

There is limited published data on the full speciation of VOCs from energy-from-waste facilities, primarily due to the complexity and variability of combustion processes, the diversity of waste feedstocks and the functional purpose of TVOC measurements—which is generally to indicate combustion efficiency rather than to characterise individual compounds.

The following response outlines the basis for assessing VOCs emissions from the proposed BERC, drawing on available literature, best available techniques (BAT) guidance, reference facility data and established regulatory practice for managing complex emission mixtures.

Best Available Techniques (BAT) Reference Document for Waste Incineration (BREF)

The Best Available Techniques (BAT) document for waste incineration notes the following about total volatile organic carbon:

This parameter includes a number of gaseous organic substances, the individual detection of which is generally complex or not possible. During the incineration of organic waste, a large number of chemical reactions take place, some of which are incomplete. This leads to an extremely complex pattern of compounds in trace amounts. A complete account of every substance within the TVOC parameter is not available; however, incineration generally provides high destruction efficiencies for organic substances.

TVOC is measured continuously. Low TVOC levels are key indicators for the quality of combustion in an incineration process. (BAT- Section 3.2.1 Substances emitted to air)

VOCs in the Context of Energy from Waste

During combustion, VOCs present in the waste are primarily destroyed. VOCs can also be formed through incomplete combustion of large organic chemicals, thermal breakdown of complex hydrocarbons and the transformation of trace organic compounds present in the waste stream. Secondary formation can occur through recombination reactions in the cooling flue gas stream.

The BERC's design and pollution control systems ensure that the formation and release of VOCs are minimised through the following mechanisms:

- High-temperature combustion
Waste is combusted at temperatures of at least 850°C, which breaks down volatile organic

compounds into simpler, less harmful substances. This means only very small amounts of VOCs remain post-combustion.

- **Activated carbon treatment**
Activated carbon is injected into the flue gas stream downstream of the combustion chamber. Residual VOCs that pass through combustion can adsorb onto the activated carbon and are subsequently removed in the baghouse filter, further reducing VOC emissions.
- **Efficient particulate filtration (baghouse):**
The baghouse filter captures activated carbon along with adsorbed compounds, ensuring that remaining VOCs and semi-volatile compounds are removed before emissions are released to the atmosphere.
- **Monitoring approach (TVOC measurement)**
Continuous monitoring using photoionisation detectors (PIDs) detects a broad range of hydrocarbons, including low-toxicity aliphatic compounds (e.g. methane, ethane, propane). These are expected to make up a significant proportion of measured TVOC and have much lower health risk compared to benzene or formaldehyde.
- **Atmospheric dispersion and breakdown**
Once emitted, VOCs disperse at height and undergo further breakdown in the atmosphere, particularly through reactions driven by sunlight (UV). This reduces the likelihood of sustained exposure at ground level.

Reference Facility – Greatmoor, UK

Data from the Greatmoor Energy from Waste facility in the UK shows that, over the past six years, the highest monthly daily average TVOC concentration has been 10% or less of the BREF emission limit of 10 mg/Nm³ (at 11% O₂).

As shown in Figure 1, the measured values (blue bars) consistently sit well below the BREF limit (green line at 100%), with most results around or below 10% of the limit. Periods where no data are recorded correspond to non-detectable concentrations, indicating that VOC levels were below the limit of detection.

This demonstrates that, in practice, total VOC emissions are significantly lower than the emission limit. In addition, emissions cannot reasonably comprise 100% of any individual compound, any single compound would represent only a fraction of this total.

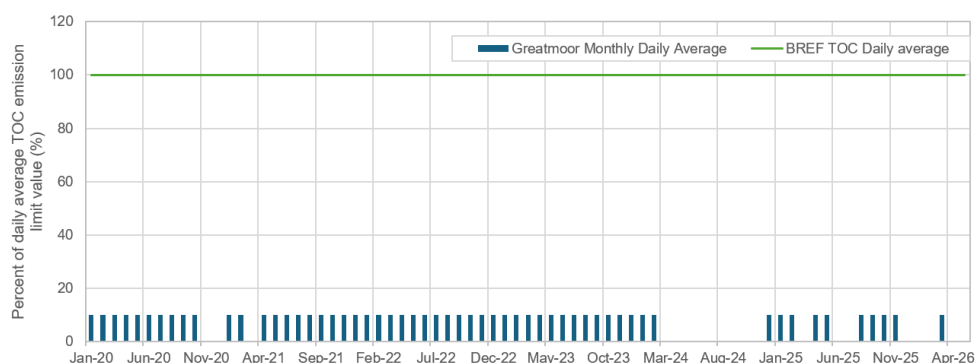


Figure 1: Greatmoor average TOC emissions

Review of the Literature

A review of relevant literature has also been undertaken, including the study *“Impact of Air Pollution Control Devices on VOC Profiles and Emissions from Municipal Waste Incineration Plant¹”* (Liu, 2025), which examined VOC emissions across full-scale municipal waste incineration facilities in China. The study undertook comprehensive multi-point sampling across the flue gas treatment train. The results showed that halogenated hydrocarbons were the dominant VOC group, accounting for 56.2% of total VOCs, followed by alkanes/alkenes (16.6%), oxygenated VOCs (15.5%) and aromatic hydrocarbons (11.7%). It is recognised that Chinese facilities may have different feedstock compositions and operate under different emission limits; however, for the purpose of understanding the relative distribution of VOC species across the four broad categories, the findings are considered applicable.

Approach to complex emissions in other industries

The inability to identify and assess every individual chemical within complex emissions to air, water or land is a well-established limitation in environmental risk assessment and has been addressed through accepted regulatory practice for decades. Rather than attempting full chemical characterisation, it is standard practice to assess representative (surrogate) chemicals that conservatively indicate the behaviour and risk of the broader mixture.

This approach is routinely applied across a range of regulated activities. For example, sewage treatment plant effluents contain thousands of chemicals but are regulated using key indicator parameters rather than full speciation (which would not be possible); vehicle, service station and road project emissions are assessed using a small number of VOC indicators such as benzene and formaldehyde; and petroleum hydrocarbon contamination at contaminated sites is assessed using surrogate compounds (e.g. BTEX and naphthalene) or fraction-based methods linked to worst-case representative chemicals. These approaches recognise that complex mixtures cannot be fully characterised and instead focus on the components that drive risk.

The same principle is also applied to defined chemical groups. For example, PAHs are assessed using a limited set of priority compounds, and dioxin-like compounds are assessed using a subset of toxicologically relevant congeners, rather than all possible compounds. For VOC mixtures, the use of benzene or formaldehyde as conservative surrogates is aligned with established international practice and is directly analogous to assuming total VOCs behave as a representative worst-case compound.

Approach adopted in this assessment

This assessment has assumed that all of the TVOC for short-term and long-term inhalation exposures will be either 100% benzene or 100% formaldehyde. These substances were selected because they represent well-known, higher-risk compounds. Using this approach ensures the assessment does not underestimate potential health risks and provides a protective, precautionary basis for evaluating impacts on the community.

In reality, emissions would not consist of 100% of any single VOC such as benzene or formaldehyde. Instead, they would be made up of a mixture of different compounds at much lower proportions. In addition, the facility would not operate continuously at the maximum emission limit of

¹ [Impact of Air Pollution Control Devices on VOC Profiles and Emissions from Municipal Waste Incineration Plant](#)

10 mg/m³ all day, every day – but this is the concentration assumed to be emitted all day every day in the modelling. Monitoring data from comparable facilities, such as the Greatmoor example, shows that actual emissions are typically only around 10% of this limit.

Review of additional VOCs

An additional review of acrolein and acetone has been undertaken. When conservatively assuming these compounds constitute 100% of total emissions (an unrealistic scenario), predicted annual concentrations at the nearest commercial and residential receptors are shown in Table 1.

Table 1: Review of additional VOCs

Compound	Criteria (annual)	Residential	Commercial	Commentary
Acrolein	0.02 µg/m ³ (Note 1)	Unrealistic scenario (assuming 100% acrolein) 89%	99%	Information about acrolein can be found at: https://www.dcceew.gov.au/environment/npis/substances/acrolein-2-propenal
		More realistic scenario 1.4%	1.5%	Because of the nature of this chemical, it is not likely that it would be present in waste material entering the facility nor is it likely to remain intact through the combustion chamber. Given its instability, it is unlikely to be one of the VOCs that could reform in the gases leaving the chamber if the conditions allow such chemicals to form instead of CO ₂ , H ₂ O, SO ₂ , NO ₂ , HCl etc. While acrolein may form when smoking cigarettes or in vehicle emissions, this is combustion that is occurring under much lower temperatures and non-optimal combustion conditions. This is why it is unlikely to be formed in an EfW facility. A more realistic scenario is that actual emissions are significantly lower, with total VOC emissions operating at around 10% of the emission limit based on comparable facility data and any individual compound represents only a fraction of this (for example, approximately 15.5% based on the <i>Impact of Air Pollution Control Devices on VOC Profiles and Emissions from</i>

				<i>Municipal Waste Incineration Plant (Liu, 2025) Study.</i> This would equate to around 1.55% of the conservative assumption used in the assessment. This would indicate that if acrolein is formed and passes through all stages in the pollution control process, the resulting concentrations would represent approximately 1.4% at the maximum residential location and 1.5% for the maximum commercial location. This demonstrates that the assessment approach is highly conservative and is likely to substantially overestimate real-world exposures.
Acetone	16,000 µg/m3 (Note 1)	Unrealistic scenario (assuming 100% acetone)	0.00011% 0.00012%	

Note 1: Table 3 Guideline for Assessing and Minimising Air Pollution in Victoria, Victorian Government, EPA Victoria Publication 1961.2 EPA Victoria, 2025.

2 Limitations

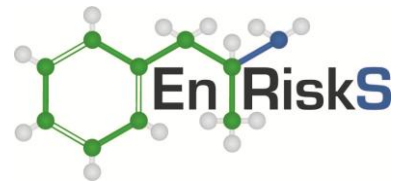
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The methodology adopted and sources of information used are outlined in this report. Environmental Risk Sciences Pty Ltd has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information provided for use in this assessment was false.

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3 Closure

If you require any additional information, please do not hesitate to contact Therese on (02) 9614 0297 or 0487 622 551.

Yours sincerely,

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