Energy from Waste

Report from the NSW Chief Scientist & Engineer

May 2020

With additional advice as at November 2020

NSW GOVERNMENT | Chief Scientist & Engineer

The Hon Matt Kean MP
Minister for Energy and Environment
52 Martin Place
SYDNEY NSW 2000

Dear Minister

In December 2019 you requested that I establish a working group to undertake a review of Energy from Waste (EFW) in NSW, to ensure proposals adopt international best practice standards and controls to protect human health and the environment.

The report from this work was submitted in May 2020. The purpose of this letter is to communicate work undertaken since that time including progress on implementing recommendations. The structure follows recommendations made in the May report and as they relate to the Working Group Terms of Reference (TOR).

Recommendations 1-3: regulatory requirements and air emission limits

TOR 1: benchmarking NSW air emission limits with international best practice for EFW facilities, including an assessment of real-time monitoring approaches
TOR 4: frameworks to ensure that appropriate environmental assessments and community engagement is undertaken

The independent expert review of the draft NSW best practice air emission limits for EFW plants has been completed. Following revision, the final limits are equivalent to or more stringent than leading jurisdictions. These limits should be reviewed within three years.

The May report contained two major schematics:

- **Figure 1** sets out the assessment requirements and regulatory processes for EFW projects in NSW mapped by the Working Group. Figure 1 included draft best practice air emission limits for EFW facilities (the draft limits). The draft limits were developed by the NSW Environment Protection Authority (EPA) and reflect requirements that EFW facilities must meet both minimum air emission standards set out in law for all industrial facilities and adopt international best practice.
- **Figure 2** sets out waste inputs (fuels) that are permitted to be used in EFW facilities, limits on each type and where the waste can be sourced from.

As recommended, the draft limits were subject to an independent expert review commissioned by my office. The expert review is included as Appendix 4 to this report.

The expert review undertook a detailed comparison between the draft limits and those set in other national and international jurisdictions for EFW plants. It found that the draft limits were equal to or more stringent in eight out of ten pollutant categories. The two categories where NSW limits are higher (hydrogen fluoride and heavy metals) are relative to the European Union Best Available Technology Directive for Waste Incineration (EU BAT) which was released in December 2019.

The expert review recommended changes be implemented to ensure NSW limits are commensurate with the EU BAT, as follows:

- hydrogen fluoride 4 mg/m^3 (from proposed draft of 5 mg/m^3)

- mercury 0.04 mg/m^3 (from proposed draft of 0.05 mg/m^3)
- cadmium & thallium 0.02 mg/m^3 (from proposed draft of 0.05 mg/m^3)
- heavy metals 0.3 mg/m^3 (from proposed 0.5 mg/m^3).

I am advised by the EPA that this recommendation is accepted. Figure 1 has been updated accordingly and the best practice limits included there can be taken as final.

Given the evolving nature of technology, the expert review concluded future reductions of maximum permissible limits should be feasible. It recommended the limits be reviewed again within three years, followed by reviews at five yearly intervals. I endorse this approach.

The explanatory guide to the assessment requirements and regulatory processes for EFW projects in NSW should be made available on relevant agency websites.

At the suggestion of the Working Group, a guide to Figures 1 and 2 was prepared to support their public release. This is included as Appendix 5 to this report.

Averaging periods and exceedances are stringent but should include explicit requirements for Other Than Normal Operating Conditions (OTNOC).

The expert review concluded that the NSW approach to averaging periods for emission limits and any allowable exceedances are stringent relative to comparator jurisdictions. It noted however, that OTNOC, which relate to start up, shut down and maintenance periods should have explicit requirements for operators. This includes a management plan to control emissions during OTNOC, accompanied by monitoring and reporting. I am advised that the EPA intends to apply operating conditions in the Environment Protection Licence to any approved EFW plants and that these conditions will include start up and shut down periods.

The requirement for 100% compliance with air emission limits should be retained. Any approved facilities should be required to make emissions data publicly available in real time and online.

The expert review recommends that the NSW requirement for 100% compliance with air emissions limits be retained. Further, that emissions data be made available publicly through an online portal. I strongly support this recommendation, both in relation to EFW plants and more broadly.

Online reporting of real-time data provides transparency and information to the public about emissions and how industrial plants are operating relative to limits. More broadly it contributes to informed public discussions about the relative source and scale of pollutants from both human and natural sources.

Online real-time public reporting is not unusual. For example, the IKW Rudersdorf EFW plant in Germany provides continuous real time monitoring data online for half-hourly and daily emissions by pollutant types. The data are provided in numerical and graphical forms compared with emission limits. A recent snapshot of graphs for emissions of nitrogen oxides and sulfur dioxides is provided at Attachment 1 to this letter. The site where these data are reported also contains links to relevant legislation and agencies, including the German equivalent of the EPA (Federal Environment Agency; FEA). Similar to the EPA, ambient air quality information is provided. This includes pollutant data by network station, regional load and forecasting maps, information about exceedances recorded at stations and annual pollutant reports. Other parts of the FEA portal that the IKW website links to includes emissions information from industrial plants and diffuse sources (e.g. residential, vehicle, agriculture sources). The Dublin Covanta plant also publishes real time furnace temperature data, half hourly and weekly emissions data and results of stack tests.

Many but not all point source emissions can be reliably monitored on a continuous basis. Periodic sampling is used when continuous monitoring is not reliable or technically feasible. NSW sampling requirements are being reviewed, which will consider changes to international monitoring requirements.

While many pollutants of concern can be continuously measured, technological limitations and reliability issues mean that others are subject to periodic sampling. Periodic sampling must be undertaken in accordance with NSW regulatory guidelines. The 2019 EU BAT which was released just prior to the Working Group being convened recommended that mercury change from periodic to continuous monitoring; and that the frequency of sampling for other pollutants increase (chlorinated dioxins, furans and dioxin-like PCBs). A comparison of NSW and EU BAT standards for monitoring for EFW plants is provided in Table 2 of this report.

The expert review noted that the EU BAT did allow for periodic sampling to be used for mercury and that the EU BAT acknowledged technological challenges remain with the reliability of continuous mercury monitoring. For this reason, the expert review recommended that for the present, periodic sampling of mercury continue, paired with strategies to control waste inputs to manage mercury.

The expert review also recommended NSW sampling requirements be updated in light of international developments. The reviewer noted that the *NSW Protection of the Environment (Clean Air) Regulation 2010* (the Clean Air Regulation) and the *Approved Methods for the sampling and Analysis of Air Pollutants in NSW* (2007) (Approved Methods) are currently under review.

The EPA has commissioned advice on emission control technologies to support the Approved Methods review and that the EU BAT will be considered in the review process. Attention will be given to the detail and caveats contained in the EU BAT for continuous monitoring and sampling approaches.

Particulate emissions from industrial plants (stacks) are measured as total solid particulates (TSPs). This is consistent with international practice. Studies indicate that plants using best available technology air emissions controls generally perform well, including capture of ultrafine particles. Information about advances in emissions control and monitoring technologies and plant operating performance should be made available as part of the Approved Methods review currently underway.

On receiving the May report, you asked why the best practice air emission limits for EFW facilities in NSW (shown in Figure 1) required only total solid particulates (TSPs) to be measured in ‘stack’ monitoring. This contrasts with ambient air quality (AAQ) monitoring. You also asked about our ability to monitor and capture ultrafine particles.

For context, internationally recognised definitions of particle size relate to aerodynamic diameter and include coarse particles with a diameter of 10µm or less (PM_{10}), fine particles with a diameter of 2.5µm or less ($PM_{2.5}$) and ultrafine particles (UFP) with a diameter of 0.1µm or less ($PM_{0.1}$). I should explain that observations below about point source monitoring relate to industrial plants as a whole – EFW plants are no different in this regard.

Exposure to particulate matter (PM) can be linked to increased mortality, hospitalisations and respiratory disease. A large body of scientific evidence supports this. AAQ monitoring of airshed quality in NSW and internationally measures both PM_{10} and $PM_{2.5}$. AAQ data are used in large scale population health studies to understand better the health impacts of particulates overall as well as specific health impacts associated with coarse and fine particles. Understanding health impacts of UFP is a major area of research internationally. However, there is incomplete information about the development, size distribution and composition of UFP, and challenges remain in our ability to accurately and separately monitor these particles.

AAQ monitors are designed to capture information about overall air quality, and not from individual (point) sources. However, monitoring results are categorised into major sources of pollutants (e.g. industrial plants, cars, domestic activities, natural sources etc.). This information is used to help select interventions that will have the greatest impact on reducing pollutants from human sources and improving air quality. In Australia, this is done through the National Environment Protection (Ambient Air Quality) Measure. In NSW, improvements to the AAQ monitoring network and modelling capabilities will improve our knowledge about the scale and contribution of pollutant sources and types.

Point source emissions for particulates from industrial plants are measured as TSP, capturing all size fractions (PM_{10} and below). This is consistent with practice in leading jurisdictions, including the USA and EU. The EPA advises that measurement of sub-fractions is more complex and carries greater measurement uncertainty.

Pollution control equipment for industrial plants is commonly designed to achieve performance to a specified standard to capture and measure TSPs. Modern combustion plants use devices such as fabric filters (baghouse filters) and electrostatic precipitators (ESP) to control solid particle emissions, including fine particles. Suppliers will typically design and deliver the plant to achieve a minimum performance requirement for TSPs.

Additional advice from the expert review was sought. While the literature is relatively small, several studies have investigated the capacity and efficiency of technologies to capture UFP. Overall, most studies found that technologies used in stationary sources such as industrial plants that follow Best Available Technology Air Pollution Controls (BAT-APC), generally perform well. In the case of EFW, I understand UFP removal as high as 99% can be expected. Higher performance (removal) results from a combination of ESP, filters and absorption (scrubber and carbon injection), that collectively remove UFP from the flue gas stream. UFP removal from filters varies according to material type and operating conditions.

Issues relating to air emissions controls and monitoring requirements can be explored in more detail as part of the Approved Methods review process. Any technical advice commissioned to support the review should be released. This should assist all stakeholders, including community members, to understand current emission control and monitoring capabilities and implications for emission limits.

Conclusions about the potential health effects from EFW facilities have not changed since the May report. Risks should be able to be addressed through existing requirements, including the human health risk assessment (HHRA) process. The HHRA should consider food as an exposure pathway. Long term ambient air quality monitoring is useful for estimating health impacts. Consideration could be given to requiring approved plants contributing to the NSW AAQ network (e.g. as a condition of licence). If implemented, this should be proportionate to the level of pollutant contribution.

The Victorian EPA commissioned a review of the scientific literature on potential health effects from air emissions from EFW on local communities (EnRisks, 2018). This review identified only a limited number of papers and studies and noted that a common methodological limitation of all papers is the presence of other sources of combustion emissions. The report concluded that while effects could not be discounted, there is "*no causal evidence that health effects from incinerators emitting to EU IED standards occur*."

In May, the Working Group concluded that additional literature was likely to remain scant. I note a more recent systematic review of health impacts (Tait et al, 2020) that concludes that older incinerator technology and infrequent maintenance are linked with adverse health effects, with fewer effects associated with more modern plants. As with the EnRisks review, the authors note study limitations preclude firmer conclusions, and recommend a precautionary approach. The authors make several recommendations, including design to world's best practice standards; adherence to upgrade and maintenance schedules and avoidance of proximity to food production. The first two can be addressed through the regulatory assessment and compliance process. The latter (exposure through food) should be addressed through the human health risk assessment (HHRA) that applicants are required to prepare.

The authors also recommend that undertaking population health studies be a condition of licence. I sought the advice of NSW Health and conclude that long-term surveillance of AAQ as occurs now is the most useful and appropriate means for estimating health impacts. In this context, consideration could be given to a requirement that approved projects make a financial contribution to the NSW AAQ network. Data from this network provide important inputs to our knowledge and understanding of pollutant sources, loads and exposure. Monitoring of plant stack air emissions should continue for the purpose of compliance with limits.

Recommendation 4: work is undertaken to understand the mix of incentives influencing consumer and industry behaviours to promote adherence to the waste hierarchy

TOR 2: frameworks to ensure that energy from waste proposals align with the NSW waste hierarchy and supports economically efficient resource recovery and environmentally sustainable waste disposal

Previous reports indicate the relationship between gate fees at disposal (land fill) sites and EFW facilities are particularly important to encourage compliance with the waste hierarchy and avoid perverse outcomes. Recommendation 4 addresses this. It is understood that this work is being progressed through the 20 Year Waste Strategy.

Recommendation 6 below is relevant to TOR 2. Other (existing) requirements that promote adherence to the waste hierarchy include:

- requirements for EFW proposals to provide information about waste sources and a guarantee of supply from two sources (primary and secondary). These requirements appear in Figure 1. Supply must be in accordance with the requirements set out in Figure 2 and account for expected changes in waste streams and waste reduction and recycling requirements
- the NSW EFW policy requirement that plants to achieve at least 25% of the energy generated from the thermal treatment of waste inputs to be captured as electricity; or an equivalent level of recovery for facilities generating heat alone.

Recommendation 5: undertaking a Life Cycle Assessment is a requirement for all proposed EFW facilities, and the findings considered in the regulatory assessment process

TOR 3: contribution that energy recovery facilities may provide to achieve the NSW Government's policy of net zero emissions by 2050

NSW currently requires applicants to include greenhouse gas and energy efficiency assessments as part of the proposal Environmental Impact Statement. I am advised by planning officials that this is consistent with current practice in the European Union.

I note however that an LCA for the Western Australia Kwinana plant was a requirement of ARENA funding. The LCA was used primarily to assess risks and create a benchmark for the EFW plant based on fossil energy used, energy return on energy invested and greenhouse gasses. However, it is also used to benchmark broader environmental impacts relating to air, land and water. I note also that the report made recommendations to improve plant performance including use of waste outputs. For these reasons, and in accordance with the target of world’s best practice, Recommendation 5 should be implemented.

Recommendation 6: approved EFW proposals are required to develop a waste input sampling and monitoring program. Ideally, this requirement would form part of the SEARs. Alternatively, these plans should be required to be developed and approved prior to a plant being commissioned

TOR 2: frameworks to ensure that energy from waste proposals align with the NSW waste hierarchy and supports economically efficient resource recovery and environmentally sustainable waste disposal

Currently, the Secretary’s Environmental Assessment Requirements (SEARs) for EFW require applicants to develop plans to be developed for waste inputs and outputs and for all approved plants to have quality control processes in place. This includes waste processing and management procedures; management plans for receipt of materials not permitted under the

EFW policy; pollution risks from processing and storage and mitigation plans to manage their impacts. Environment Protection Licences (EPLs) issued by the EPA include record keeping and reporting requirements.

These are appropriate requirements. However, there is no explicit reference in the SEARs for input sampling and monitoring plans to be to be submitted as part of the Environmental Impact Assessment. The expert review made several observations about the importance of sampling and carefully monitoring waste inputs. In part this is to ensure plants respect the waste hierarchy and materials that can be reused, repurposed or recycled are. Detailed monitoring of waste inputs is also important as inputs can have a significant impact on the efficiency of plant operations.

This report does not specify how Recommendation 6 should be implemented. Ideally, it would be a standard requirement in the SEARs for EFW facilities, and therefore part of the EIS. This would ensure that plans were submitted, reviewed and subject to agency and public scrutiny prior to any approvals being issued.

Should this approach not be adopted, it is recommended that waste input sampling, monitoring and reporting plans are made a condition of Consent approval and be finalised to the satisfaction of relevant agencies prior to plant commissioning. This should be feasible given the lead time for construction. Opportunities for consultation, review and adjustment to account for feedback should be commensurate with what occurs as part of the Environmental Impact Statement (EIS) process for State Significant Developments. This approach is consistent with EFW policy requirements for substantial community engagement and that it is anticipated that EFW proposals will be classified as SSD.

Recommendation 7: a pathway is established to enable asset and process innovations to be tested and trialled

TOR 5: framework to balance the use of proven technologies and the need to encourage innovative technologies

Recommendation 7 recognises the pace of innovation in technology, products and services; matched by a strong public and investor appetite to align energy, water and resource efficiency. It proposes that assessment and compliance requirements be commensurate with the level and impact of the proposed innovation. Any innovation must align with NSW policies relating to waste, decarbonisation and the circular economy. I understand that this recommendation is being progressed by the EPA.

I would like to take this opportunity to thank agency colleagues who participated in the working group or were consulted during the process for their advice and feedback.

Yours sincerely

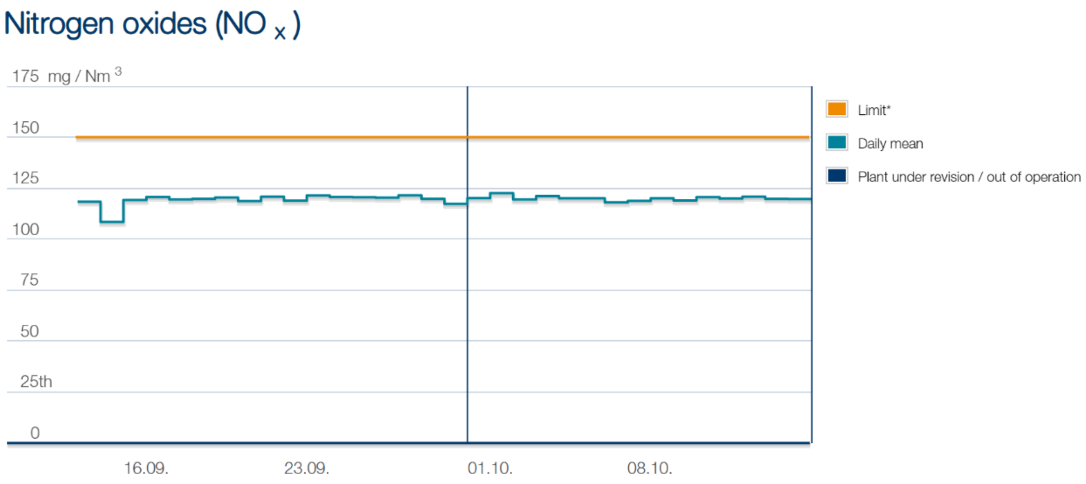
H. Durrant-Whyte.

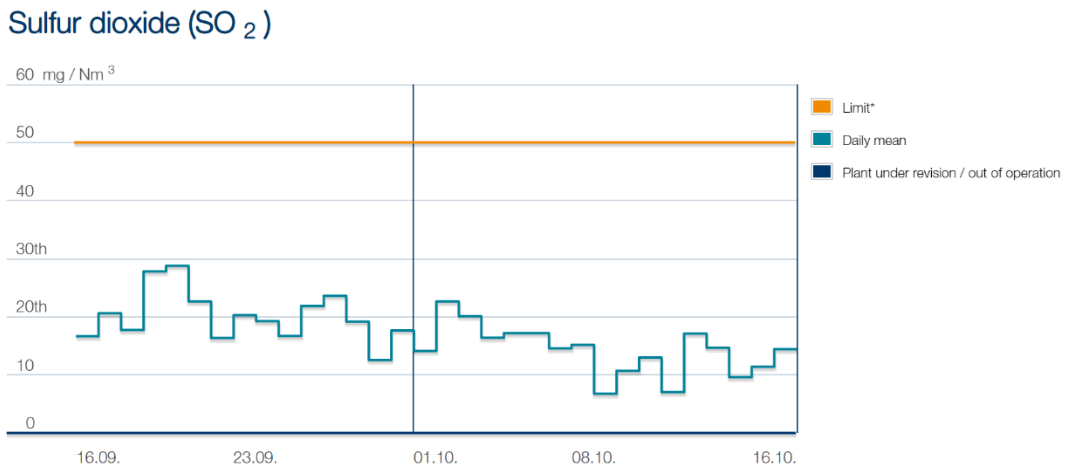
Hugh Durrant-Whyte
Chief Scientist & Engineer

13 November 2020

Attachment 1

Example graph of real time monitoring available online for the IKW Rudersdorf EFW plant





Source: https://xn--ikw-rdersdorf-0ob.de/emissionswerte.htm

Attachment 2

Summary of conclusions and recommendations from the independent expert review of the (draft) best practice air emissions limits for EFW in NSW

Complete report attached as Appendix 4

TOR	Subject	Conclusion (C) / Recommendation (R)
1	Review the *(draft) best practice air emissions limits for EFW facilities* – whether they are the most stringent and whether they are 'best practice' (the lowest emission rates technically achievable by industry)	**(C1)** In comparison to other limits nationally and internationally, and taking into account averaging periods, the *(draft) best practice air emissions limits for EFW facilities in NSW* are the most stringent in 8 out of 10 pollutant categories. The two categories where the proposed NSW best practice limits are less stringent are hydrogen fluoride and heavy metals. **(R1)** The following concentration limits are adopted by NSW to align with the world's best practice (currently expressed in the 2019 EU Directive): for (a) hydrogen fluoride 4 mg/m^3 (from currently proposed 5 mg/m^3), (b) mercury 0.04 mg/m^3 (from proposed 0.05 mg/m^3), (c) cadmium & thallium 0.02 mg/m^3 (from proposed 0.05 mg/m^3), and (d) heavy metals 0.3 mg/m^3 (from proposed 0.5 mg/m^3).
1a	Averaging periods for emissions limits – noting that NSW requires 1-hour averaging periods for most emissions, whereas other jurisdictions have 1-hour, 24-hour and other periods	(**C2**) NSW hourly averaging limits can be as stringent as jurisdictions that use dual averaging limits, provided that (1) the OTNOC (other than normal operating conditions) is accounted for and (2) hourly averaging limits are regularly reviewed and tightened as much as possible. Greater stringency comes from monitoring at more frequent (hourly) averaging of the data. However, a daily averaging limit, being lower than the hourly limit, places an EFW facility at near-optimal performance and on a trajectory of continuous improvement in terms of installing more advanced APC systems as part of continuous plant upkeep and long-term plant improvements. At the same time, introducing two averaging limits will increase reporting complexity and may introduce industry confusion, as it is accustomed to single averaging limits. (**R2**) It is recommended that (a) NSW continues to employ a single hourly averaging limit. (b) the regulator maintains the stringency of allowable emissions over time by tightening the hourly averaging limits closer to what projected secondary (lower) daily limits would be at were these in place. This should be done as part of a reviewed and well-studied schedule (using real plant data that becomes available, and in line with evolving technologies). (c) the regulator reviews the value of adopting a second tighter daily averaging limit in the future.
1b	Allowable exceedances	(**C3**) The *(draft) best practice air emissions limits for EFW in NSW* are the most stringent with its 100% requirement for compliance during NOC (normal operating conditions). However, it does not specifically address regulation relating to OTNOC. Currently, Cl 56 of the Clean Air Regulation provides exemptions relating to start-up and shutdown periods. **(R3)** NSW maintains the 100% compliance requirement for NOC, as it is the most stringent requirement possible. For the purpose of governing start-up, shutdown and maintenance periods (i.e. OTNOC), it is recommended industry be required to provide regulators with a management plan to control emissions during OTNOC periods, and to monitor and report emissions data for OTNOC periods. It is recommended industry is required to report on OTNOC periods (including reported emissions data in the OTNOC periods) and that these data are used to review allowable exceedance requirements.
	EU Directive allows flexibility in continuous monitoring by providing two concentration limits to be met, 97% or 100% of the overall recorded continuous data.	(**C4**) Flexibility in EU regulations which provide two percentile limits of 97% and 100% is believed to target small and rural EFW facilities, allowing 3% of monitored data to be omitted (in addition to allowable exceedances). It is early days to conclude whether having two emissions limits will practically support smaller and rural EFW in NSW, considering there is no history of such operations in NSW.

TOR	Subject	Conclusion (C) / Recommendation (R)
		(**R4**) With no historical experience in EFW operation in NSW, it is not possible to determine what benefits dual limits would bring to EFW facilities or communities. Hence, it is best to proceed with adopting only 100% compliance, and to undertake a review of its impacts once EFW operations in NSW have been operating for 3 years.
1c	Range of pollutants covered	(**C5**) *The (draft) best practice air emissions limits for EFW in NSW* provides a comprehensive coverage of pollutant types. The limits for smoke and opacity, required in other jurisdictions, are not mentioned in the draft, however, these are covered by the *POEO Clean Air Regulation (2010)* through monitoring of overall particulate matter and total dust. (**R5**) For completeness, the *POEO Clean Air Regulation (2010)* limits on smoke and opacity should be included in t*he (draft) best practice air emissions limits for EFW in NSW, which* is 1 Ringelmann (Smoke) and 20% Opacity.
1d	Continuous monitoring for specific pollutants	(**C6**) At the current technological state, it can be said that NSW has covered all pollutants that can be realistically continuously monitored. Emerging monitoring techniques should be continuously assessed in future reviews of the standards. For the case of mercury, it is currently more feasible to control the waste composition entering EFW facilities rather than to enforce continuous monitoring. The challenges of continuous monitoring of mercury are acknowledged by the EU in the 2019 BAT Directive, and alternates recognised. The *NSW Energy-from-Waste Policy Statement* (2015) outlines continuous monitoring for relevant pollutants. However, the *POEO Clean Air Regulation (2010)* and the *Approved Methods for the sampling and Analysis of Air Pollutants in NSW (2007)* need to be updated for consistency in relation to continuous monitoring methods for solid particles, HF, and HCl. The *'Approved Methods for NSW'* and *Clean Air Regulation* are understood to be currently under review. (**R6**) The review of the Approved Methods and Regulation take into account the EU Directive as well as other international developments. It is also recommended that: (a) emissions data from EFW facilities are required to be made publicly accessible via an online platform. (b) as reported emissions reflect actual plant performance, a rigorous evidence-based proof of performance type stack testing regime is adopted for plant commissioning.
2	Scheduling and review for EFW air emissions limits	(**C7**) Expected technology advances should enable future reductions in allowable air emissions. Emerging technology, trends in international standards and operation of local plants should be closely monitored, particularly in the initial period. (**R7**) An initial review of best practice air quality emission limits for EFW plants should be undertaken within 3 years, followed by reviews at 5-yearly intervals. The latter appears consistent with the rate of APC evolution and commercialisation. Review reports and updates should be made publicly available.
3	EFW technology and its ability to adapt to future waste variability; particularly its implications for air emissions	(**C8**) EFW facilities should not be 'over-designed' in terms of scale and material availability (feedstock). This is to minimise future feedstock competition that undermines the waste management hierarchy or lack of waste volumes that result in waste being transported over long distances. This should also help avoid unnecessary start-up and shutdown periods that can impact on air emissions. The industry should demonstrate that the waste management hierarchy is being respected during the design stage and across the operational lifetime of the asset. In terms of plant type, currently, there is no practical evidence that other EFW technology can operate at moving grate capacity. Therefore, it is expected that moving grate technology will continue to be employed, whilst improving it through operational standpoints to reduce air pollutants. Generally, understanding waste variability through periodic reviews will support plant optimisation. This includes understanding the relationship between changing waste inputs, operations and emissions. The implication of waste variability and sorting on air emissions is unclear as evidence relating feed to emissions in overseas operations is lacking. It is known moisture content carried in with waste does present a problem – while resolved through a pre-heating step (moving grate), it decreases efficiency of EFW plant In relation to waste compositions, The POEO Act outlines the eligible fuel for EFW, however, the POEO lacks reference to the NSW Waste Classification Guidelines (2014), which influence the incoming waste into EFW. The Guidelines on the other hand may require updating to reflect an emerging EFW industry especially in terms of waste quality and combustibility.

TOR	Subject	Conclusion (C) / Recommendation (R)
		It is important that the waste classification system adequately accounts for combustive technologies such as moving grate. This is to ensure the waste management hierarchy is respected, i.e. reusable and recycled materials are not used as feedstock. It is also important that the system accounts for combustible and non-combustible materials to ensure only suitable materials are used and operational efficiency optimised. (**R8**) Steps are taken to ensure only suitable feedstock is used in EFW facilities. This includes: (a) The scope and location of proposed EFW facilities are assessed relative to waste supply chains, market size and competition, and projected changes to waste streams including impacts of 'quality recycling' developments and targets. Guidelines be developed for sizing of facilities, and methods to demonstrate, as part of licensing approval and review, that the waste management hierarchy principles are followed. (b) Operators are required to provide monthly reports on the changing composition of waste streams, and data showing the relationship between waste inputs, operations and air emissions. (c) NSW EPA review the waste classification system to ensure it adequately captures materials that are suitable and not suitable for combustion. This is to help ensure the waste management hierarchy is respected, that only suitable waste inputs are used and to optimise plant efficiency. This should also assist assessment of feedstock sources and volumes. (d) Research is undertaken to support skills and technology development to manage the impact of waste variability on technology performance and emissions. (e) Collecting and publishing data on waste streams and performance. As a long-term strategy, it is recommended efforts are made to increase public awareness of waste classifications and waste stream destinations.
4	Co-location of EFW with other industry	(**C9**) In NSW, numerous opportunities for industrial symbiosis and co-location exist for EFW operations, including: (a) integration within waste management parks, (b) installation as a process heat supplier (heat networks) in industrial eco-parks for manufacturing and upcycling of waste into commodities and value-add products, and (c) integration with carbon capture and storage (CCS) and renewable energy. (**R9**) The role of EFW in special dedicated industry zones should be assessed (particularly in the Special Activation Precincts) and consideration given to co-location with existing process industry with heat intensive requirements. Programs that build research capacity in industrial symbiosis that incorporates EFW processes should be supported.
5	Other relevant matters	**(C10)** As EFW is emerging in Australia, public acceptance is a critical aspect to EFW industry. Special effort is therefore required to communicate operational performance. Review mechanisms should draw on input from technical experts from time to time, and focus on sharing of data, transparency and openness, to help inform policy and regulatory improvements. (**R10**) Industry performance should be subject to ongoing review, including mechanisms to comprehensively review and monitor air emissions data and BAT practice, which may increase public confidence in operations. Such mechanisms should: (a) include all possible aspects of air emission performance that can be used to inform decision making. (b) address modelling and governance of air emissions data collected from EFW facilities. (c) create the evidence-base for review of air emission standards and limits.

Contents

OVERVIEW

In December 2019 the Minister for Energy and Environment, the Hon Matt Kean MP requested that the NSW Chief Scientist & Engineer convene a cross-agency working group on energy from waste (EFW). The Working Group is to provide advice on environmental protection standards and frameworks to ensure that proposed EFW facilities in NSW undertake robust assessments and adopt international best practice standards and controls to ensure human health and the environment are protected. The full Terms of Reference are at Appendix 1.

The NSW Energy from Waste Policy Statement (EFW policy) and regulatory frameworks require applicants to:

- meet current international best practice techniques in process design and control; emissions control; monitoring with real-time feedback; arrangements for the receipt of waste and management of residues
- use technologies that are proven, well understood and capable of handling the expected variability and type of waste feedstock. This must be demonstrated through reference to fully operational plants using the same technologies and treating like waste streams in other similar jurisdictions
- meet technical, thermal efficiency and resource recovery criteria.

The initial focus of the Working Group was to capture and where possible, quantify assessment and environmental performance requirements and parameters for proposed EFW facilities in NSW. This is provided at **Figure 1**.

This framework (**Figure 1**) provides a summary of the current regulatory assessment process for proposed EFW facilities categorised as State significant development (SSD) and current requirements (technologies, processes, impact and risk assessments, emissions limits, data). It is anticipated EFW facilities will generally be SSD. Included are links to relevant specifications and guidelines under topic areas. In places these links take the reader to a landing page with information and further links. The assessment process requires applicants to meet with planning authorities prior to seeking the Secretary's Environmental Assessment Requirements (SEARs) and lodgement of a formal application. This is to ensure site suitability and strategic alignment; appropriate engagement and other requirements are understood; and all relevant matters are taken into consideration.

Also included in Figure 1 are proposed (draft) best practice air emission limits for EFW facilities. These draft limits reflect NSW requirements that EFW facilities must meet both minimum air emission standards set out in law for industrial facilities and adopt international best practice. It is proposed that the framework, including the draft limits, are subject to expert review, are made publicly available and updated periodically to reflect improved international standards.

The Working Group also mapped fuel types and facilities that are included and excluded from the EFW policy requirements. This is provided at **Figure 2.** Included is the type of feedstock that EFW facilities may receive under the EFW policy, the proportion of each waste stream allowed for energy recovery and waste source (processing facility) requirements.

The EFW policy requirement for an established reference facility is to provide confidence in the ability of the proposed facility to operate at known and acceptable standards, particularly in relation to air emissions. A recognised challenge is that waste inputs are never identical and may vary within and across jurisdictions as well as over time. This variation could potentially affect plant performance and therefore the type and level of air emissions or residual waste streams. Therefore, each proposal requires careful assessment on a case by case basis. Under the EFW policy, applicants are required to outline residual risks and provide plans to manage variability of waste inputs outside expected and acceptable bandwidths. It is also expected that applicants commit to continual improvement of technology and emission controls in line with international best practice.

While adherence to the framework presented at Figure 1 does not guarantee approval, closer alignment between the proposed waste inputs and the reference facility provides greater confidence in the expected performance of the proposed plant. Likewise, increasing deviation from the type or uniformity of inputs will require a proportional increase in data and information about (1) the reason for doing so, and (2) how the difference will be managed.

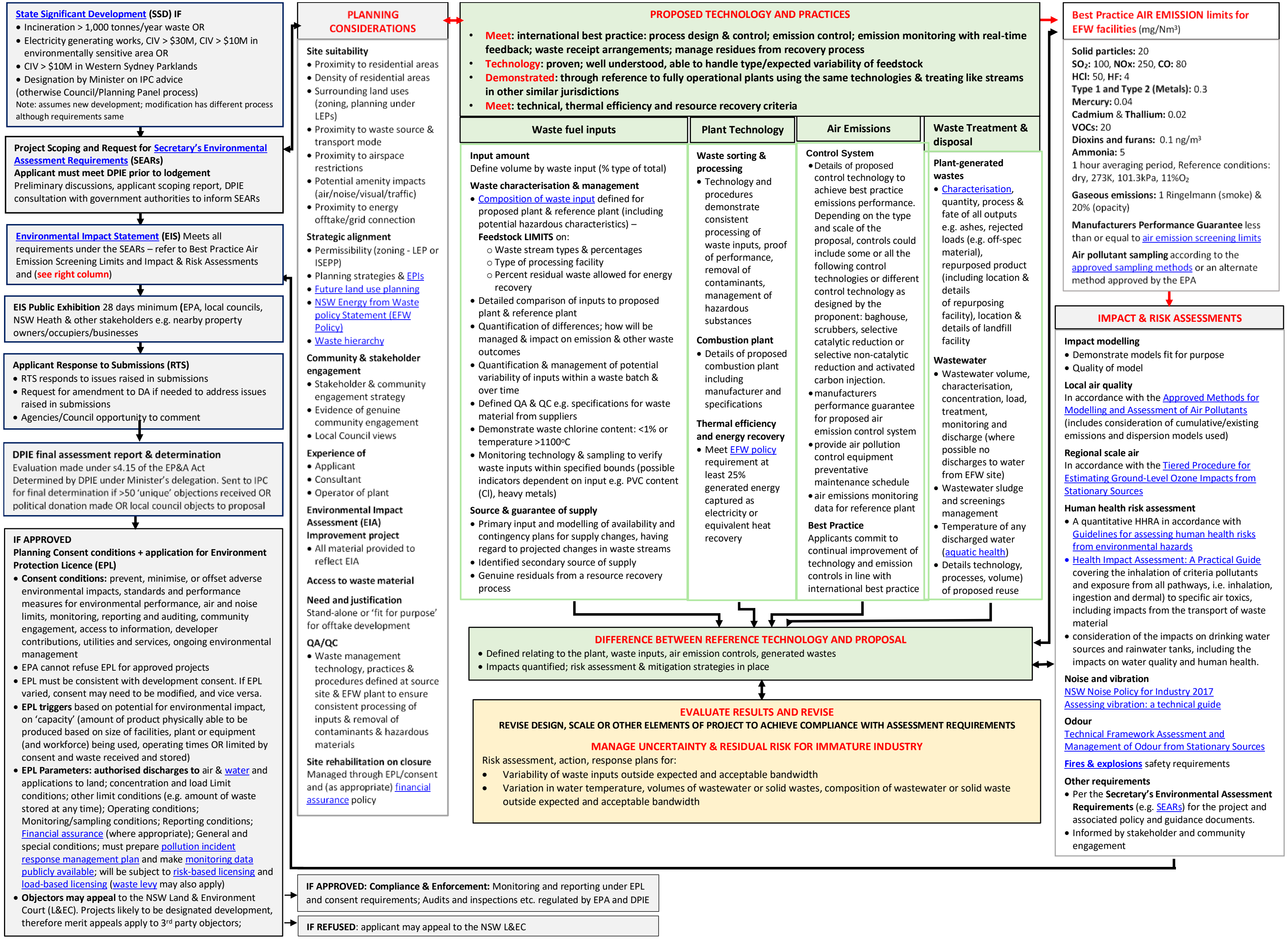
Having reviewed the requirements and process, the framework for assessing proposed EFW facilities appears sufficiently flexible in its ability to adapt to emerging best practice.

Recommendation 1

Following expert review, Figure 1 ('the framework') and Figure 2 are finalised and are:

- recognised as a current description of the baseline assessment requirements and regulatory processes for EFW facilities in NSW
- used as working documents that are updated as required
- made publicly available, including through relevant government agency websites

The remainder of this report sets out the current state of knowledge and recommendations in relation to the Terms of Reference.



State Significant Development (SSD) IF
- Incineration > 1,000 tonnes/year waste OR
- Electricity generating works, CIV > $30M, CIV > $10M in environmentally sensitive area OR
- CIV > $10M in Western Sydney Parklands
- Designation by Minister on IPC advice

(otherwise Council/Planning Panel process)

Note: assumes new development; modification has different process although requirements same

Project Scoping and Request for Secretary's Environmental Assessment Requirements (SEARs)
Applicant must meet DPIE prior to lodgement
Preliminary discussions, applicant scoping report, DPIE consultation with government authorities to inform SEARs

Environmental Impact Statement (EIS) Meets all requirements under the SEARs – refer to Best Practice Air Emission Screening Limits and Impact & Risk Assessments and (**see right column**)

EIS Public Exhibition 28 days minimum **(**EPA, local councils, NSW Heath & other stakeholders e.g. nearby property owners/occupiers/businesses

Applicant Response to Submissions (RTS)
- RTS responds to issues raised in submissions
- Request for amendment to DA if needed to address issues raised in submissions
- Agencies/Council opportunity to comment

DPIE final assessment report & determination
Evaluation made under s4.15 of the EP&A Act
Determined by DPIE under Minister's delegation. Sent to IPC for final determination if >50 'unique' objections received OR political donation made OR local council objects to proposal

IF APPROVED
Planning Consent conditions + application for Environment Protection Licence (EPL)
- **Consent conditions:** prevent, minimise, or offset adverse environmental impacts, standards and performance measures for environmental performance, air and noise limits, monitoring, reporting and auditing, community engagement, access to information, developer contributions, utilities and services, ongoing environmental management
- EPA cannot refuse EPL for approved projects
- EPL must be consistent with development consent. If EPL varied, consent may need to be modified, and vice versa.
- **EPL triggers** based on potential for environmental impact, on 'capacity' (amount of product physically able to be produced based on size of facilities, plant or equipment (and workforce) being used, operating times OR limited by consent and waste received and stored)
- **EPL Parameters: authorised discharges to** air & water and applications to land; concentration and load Limit conditions; other limit conditions (e.g. amount of waste stored at any time); Operating conditions; Monitoring/sampling conditions; Reporting conditions; Financial assurance (where appropriate); General and special conditions; must prepare pollution incident response management plan and make monitoring data publicly available; will be subject to risk-based licensing and load-based licensing (waste levy may also apply)
- **Objectors may appeal** to the NSW Land & Environment Court (L&EC). Projects likely to be designated development, therefore merit appeals apply to 3rd party objectors;

PLANNING CONSIDERATIONS

Site suitability
- Proximity to residential areas
- Density of residential areas
- Surrounding land uses (zoning, planning under LEPs)
- Proximity to waste source & transport mode
- Proximity to airspace restrictions
- Potential amenity impacts (air/noise/visual/traffic)
- Proximity to energy offtake/grid connection

Strategic alignment
- Permissibility (zoning - LEP or ISEPP)
- Planning strategies & EPIs
- Future land use planning
- NSW Energy from Waste policy Statement (EFW Policy)
- Waste hierarchy

Community & stakeholder engagement
- Stakeholder & community engagement strategy
- Evidence of genuine community engagement
- Local Council views

Experience of
- Applicant
- Consultant
- Operator of plant

Environmental Impact Assessment (EIA) Improvement project
- All material provided to reflect EIA

Access to waste material

Need and justification
Stand-alone or 'fit for purpose' for offtake development

QA/QC
- Waste management technology, practices & procedures defined at source site & EFW plant to ensure consistent processing of inputs & removal of contaminants & hazardous materials

Site rehabilitation on closure
Managed through EPL/consent and (as appropriate) financial assurance policy

IF APPROVED: Compliance & Enforcement: Monitoring and reporting under EPL and consent requirements; Audits and inspections etc. regulated by EPA and DPIE

IF REFUSED: applicant may appeal to the NSW L&EC

PROPOSED TECHNOLOGY AND PRACTICES
- **Meet: international best practice: process design & control; emission control; emission monitoring with real-time feedback; waste receipt arrangements; manage residues from recovery process**
- **Technology: proven; well understood, able to handle type/expected variability of feedstock**
- **Demonstrated: through reference to fully operational plants using the same technologies & treating like streams in other similar jurisdictions**
- **Meet: technical, thermal efficiency and resource recovery criteria**

Waste fuel inputs

Input amount
Define volume by waste input (% type of total)

Waste characterisation & management
- Composition of waste input defined for proposed plant & reference plant (including potential hazardous characteristics) – **Feedstock LIMITS** on:
  - Waste stream types & percentages
  - Type of processing facility
  - Percent residual waste allowed for energy recovery
- Detailed comparison of inputs to proposed plant & reference plant
- Quantification of differences; how will be managed & impact on emission & other waste outcomes
- Quantification & management of potential variability of inputs within a waste batch & over time
- Defined QA & QC e.g. specifications for waste material from suppliers
- Demonstrate waste chlorine content: <1% or temperature >1100ºC
- Monitoring technology & sampling to verify waste inputs within specified bounds (possible indicators dependent on input e.g. PVC content (Cl), heavy metals)

Source & guarantee of supply
- Primary input and modelling of availability and contingency plans for supply changes, having regard to projected changes in waste streams
- Identified secondary source of supply
- Genuine residuals from a resource recovery process

Plant Technology

Waste sorting & processing
- Technology and procedures demonstrate consistent processing of waste inputs, proof of performance, removal of contaminants, management of hazardous substances

Combustion plant
- Details of proposed combustion plant including manufacturer and specifications

Thermal efficiency and energy recovery
- Meet EFW policy requirement at least 25% generated energy captured as electricity or equivalent heat recovery

Air Emissions

Control System
- Details of proposed control technology to achieve best practice emissions performance. Depending on the type and scale of the proposal, controls could include some or all the following control technologies or different control technology as designed by the proponent: baghouse, scrubbers, selective catalytic reduction or selective non-catalytic reduction and activated carbon injection.
- manufacturers performance guarantee for proposed air emission control system
- provide air pollution control equipment preventative maintenance schedule
- air emissions monitoring data for reference plant

Best Practice
Applicants commit to continual improvement of technology and emission controls in line with international best practice

Waste Treatment & disposal

Plant-generated wastes
- Characterisation, quantity, process & fate of all outputs e.g. ashes, rejected loads (e.g. off-spec material), repurposed product (including location & details of repurposing facility), location & details of landfill facility

Wastewater
- Wastewater volume, characterisation, concentration, load, treatment, monitoring and discharge (where possible no discharges to water from EFW site)
- Wastewater sludge and screenings management
- Temperature of any discharged water (aquatic health)
- Details technology, processes, volume) of proposed reuse

DIFFERENCE BETWEEN REFERENCE TECHNOLOGY AND PROPOSAL
- Defined relating to the plant, waste inputs, air emission controls, generated wastes
- Impacts quantified; risk assessment & mitigation strategies in place

EVALUATE RESULTS AND REVISE
REVISE DESIGN, SCALE OR OTHER ELEMENTS OF PROJECT TO ACHIEVE COMPLIANCE WITH ASSESSMENT REQUIREMENTS

MANAGE UNCERTAINTY & RESIDUAL RISK FOR IMMATURE INDUSTRY
Risk assessment, action, response plans for:
- Variability of waste inputs outside expected and acceptable bandwidth
- Variation in water temperature, volumes of wastewater or solid wastes, composition of wastewater or solid waste outside expected and acceptable bandwidth

Best Practice AIR EMISSION limits for EFW facilities (mg/Nm³)

Solid particles: 20
SO_2: 100, **NOx:** 250, **CO:** 80
HCl: 50, **HF:** 4
Type 1 and Type 2 (Metals): 0.3
Mercury: 0.04
Cadmium & **Thallium:** 0.02
VOCs: 20
Dioxins and furans: 0.1 ng/m³
Ammonia: 5
1 hour averaging period, Reference conditions: dry, 273K, 101.3kPa, 11%O_2

Gaseous emissions: 1 Ringelmann (smoke) & 20% (opacity)

Manufacturers Performance Guarantee less than or equal to air emission screening limits

Air pollutant sampling according to the approved sampling methods or an alternate method approved by the EPA

IMPACT & RISK ASSESSMENTS

Impact modelling
- Demonstrate models fit for purpose
- Quality of model

Local air quality
In accordance with the Approved Methods for Modelling and Assessment of Air Pollutants (includes consideration of cumulative/existing emissions and dispersion models used)

Regional scale air
In accordance with the Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources

Human health risk assessment
- A quantitative HHRA in accordance with Guidelines for assessing human health risks from environmental hazards
- Health Impact Assessment: A Practical Guide covering the inhalation of criteria pollutants and exposure from all pathways, i.e. inhalation, ingestion and dermal) to specific air toxics, including impacts from the transport of waste material
- consideration of the impacts on drinking water sources and rainwater tanks, including the impacts on water quality and human health.

Noise and vibration
NSW Noise Policy for Industry 2017
Assessing vibration: a technical guide

Odour
Technical Framework Assessment and Management of Odour from Stationary Sources

Fires & explosions safety requirements

Other requirements
- Per the **Secretary's Environmental Assessment Requirements** (e.g. SEARs) for the project and associated policy and guidance documents.
- Informed by stakeholder and community engagement

Figure 1: Assessment requirements and regulatory process for Energy from Waste projects in NSW

LEGISLATIVE FRAMEWORK

- Protection of the Environment Operations Act 1997 (POEO Act)
- Protection of the Environment Operations (Waste) Regulation 2014
- Protection of the Environment Operations (Clean Air) Regulation 2010 (POEO (Clean Air) Regulation
  Regulation of air emissions, including maximum industrial source emissions
- Protection of the Environment Operations (General) Regulation 2009
  Schedule 1 – scheduled activities that are subject to load-based licensing and relevant assessible pollutants
- Waste Avoidance and Resource Recovery Act 2001 (WaRR Act)
  Hierarchy for resource management (avoid, recover, dispose); EPA role in developing, monitoring waste strategies; extended producer responsibility schemes

ENERGY FROM WASTE POLICY STATEMENT

Objectives
- Protect human and health and environment (POEO Act);
- Meet resource management hierarchy (WaRR Act)
  (1) avoid unnecessary consumption
  (2) recover (reuse, reprocess, recycle, recover energy)
  (3) dispose

ELIGIBLE WASTE FUELS
MUST MEET OTHER REQUIREMENTS

Eligible Waste Fuels (EWF)
- Are waste/waste derived materials posing low risk of harm to the environment and human health when used as a fuel due to origin, low level of contaminants, consistency over time
- Include biomass from agriculture; forestry and sawmill residue; uncontaminated wood waste; recovered waste oil; organic residues from virgin paper pulp activities; landfill gas and biogas e.g. anaerobic digestor
- Eligible waste fuels meeting the definition of a **standard fuel** defined under the POEO (Clean Air) Regulation which meet emissions criteria still require approval for use.
- Standard Fuel is any unused and uncontaminated solid, liquid or gaseous fuel that is: (a) coal or coal-derived fuel (other than any tar or tar residues), or (b) liquid or gaseous petroleum-derived fuel, or (c) wood or wood-derived fuel, or (d) bagasse.

Requirements for Eligible Waste Fuels
- May be thermally treated using a range of treatment technologies, provided a resource recovery order and exemption has been granted by the EPA.
- Resource recovery orders and exemptions are issued by the EPA under Part 9 of the Protection of the Environment Operations (Waste) Regulation 2014 and exempt a person from the various waste regulatory requirements that apply to the use of a waste fuel (e.g. waste disposal licensing, levy payments, etc.). The exemptions apply to waste fuels determined by the EPA to be fit-for-purpose, bona-fide energy recovery opportunities.
- The origin, composition and consistency of these wastes must ensure that emissions from thermal treatment will be known and consistent over time. Facilities proposing to use eligible waste fuels must meet the following criteria:
  - ability to demonstrate to the EPA that the proposed waste consistently meets the definition of an EPA-approved eligible waste fuel
  - confirm there are no practical, higher order reuse opportunities for the waste
  - fully characterise the waste and/or undertake proof of performance
  - meet the relevant emission standards as set out in the Protection of the Environment Operations (Clean Air) Regulation 2010.

FACILITIES WITH THERMAL TREATMENT EXCLUDED

Other regulatory frameworks already apply:
- thermal processes where there is no change in the chemical composition of the waste
- transport fuels produced from waste
- autoclaving processes
- biological processes, such as anaerobic digestion and composting of waste.

Not regarded as undertaking genuine energy recovery:
- for the destruction of waste
- for the thermal treatment of contaminated soil
- proposing the thermal treatment of unprocessed mixed waste streams
- proposing the thermal treatment of waste that has been exhumed from landfills
- proposing the thermal treatment of hazardous waste materials.

ALL OTHER WASTES
MUST MEET ENERGY RECOVERY FACILITY REQUIREMENTS IN EFW POLICY STATEMENT

Wastes
- **Combination eligible and non-eligible wastes:** If the facility is proposing to thermally treat (defined in POEO Act) a combination of eligible and other waste fuels, it will be subject to the requirements of an energy recovery facility
- **Non eligible waste:** Facilities proposing to thermally treat any waste or waste-derived materials (as defined in Sch. 1 POEO Act) that are not listed as an eligible waste fuel must meet the requirements of an energy recovery facility.

Facilities
- Thermally treat waste (defined in Sch. 1 POEO Act) or waste-derived materials for the recovery of energy. Thermal treatment means the processing of wastes by combustion, thermal oxidation, thermal or plasma gasification, pyrolysis and torrefaction or other thermal treatment processes.
- Where a thermal process, such as pyrolysis or gasification, produces a gas for subsequent combustion (for example, a syngas), the facility where that gas is combusted.

Feedstock
Energy recovery facilities may only receive feedstock from waste processing facilities or collection systems that meet the criteria:

Waste stream	Processing Facility	% residual waste allowed for energy recovery
Mixed wastes		
Municipal solid waste (MSW)	LGA has separate collection for dry recyclables and food and garden waste	No limit by weight
	LGA has separate collection for dry recyclables and garden waste	Up to 40% by weight received at the processing facility
	LGA has separate collection for dry recyclables	Up to 25% by weight of waste received at the processing facility
Commercial and industrial (C&I)		Up to 50% by weight of waste received at the processing facility
	Mixed C&I where business has separate collection for all relevant waste streams	No limit by weight
Construction and demolition (C&D)		Up to 25% by weight of waste received at the processing facility
Residuals from source-separated materials		
Source-separated recyclables from MSW		Up to 10% by weight of waste received at the processing facility
Source-separated garden waste		Up to 5% by weight of waste received at the processing facility
Source-separated food +/- garden waste		Up to 10% by weight of waste received at the processing facility
Separated waste streams		
Waste stream	**Feedstock able to be used at an energy recovery facility**	
Waste wood	Residual wood waste sources directly from a waste generator e.g. manufacturing facility	
Textiles	Residuals textiles sourced directly from a waste generator	
Waste tyres	End-of-life tyres	
Biosolids	Used only in a process to produce a char for land application	
Source-separated food & garden organics	Used only in a process to produce a char for land application	

Figure 2: Waste fuels and facilities

TOR 1: Benchmarking NSW air emission limits with international best practice for energy from waste facilities, including an assessment of real-time monitoring approaches

Technology types

1.1 The most common commercially deployed EFW plants internationally use moving grate technologies. All proposed EFW facilities that have been or are currently under assessment in the NSW Planning system are moving grate proposals of some type. This is also the technology deployed in the Western Australia Kwinana plant. Kwinana is the first EFW plant being built in Australia.

1.2 Relevant reports on available technologies are summarised in Appendix 2, including the European Commission Best Available Techniques (BAT) Reference Document for Waste Incineration released in December 2019 (the 2019 EU BAT). This document, under the EU Directive 2010/75/EU, updates the previous Best Available Techniques (BAT) reference document for waste incineration, adopted in 2006, It is the most current statement on international best practice identified by the Working Group. Its conclusions provide EU states with a technical basis to set permit conditions, although countries can specify more stringent limits. Existing facilities are given four years to comply.

1.3 In the USA, national numerical emissions (performance) standards are set for stationary sources under the *Clean Air Act* (CAA). States can also set emissions limits considering technology performance and cost with some mandating a requirement for use of 'best available control technology'. To drive improvements in technologies, emission limits under the CAA can be (re)set for new and existing facilities based on the current outputs of the best performers (top 12%) within the industry, with industry allowed to determine their technologies to achieve the higher standards.

1.4 The 2019 EU BAT conclusions aim to reduce emissions from waste incineration and address other environmental considerations including energy efficiency and resource sustainability. The document encompasses emissions levels and standards on how technology, including emission control equipment, is used and the technical design, build, maintenance, operation and decommissioning of facilities. Included is information about established and emerging plant types, performance (e.g. fuel inputs, energy and water consumption, emissions and waste generation), cleaning technologies to manage pollutant streams and quality control mechanisms.

1.5 Three parameters identified as central to the selection of plant type and performance, are the chemical characteristics, the physical characteristics and the thermal characteristics of the waste (including calorific value and moisture levels). Collection (sorting and separation) and pre-treatment systems are identified as having a significant impact on the type of waste received and therefore the type of plant best suited to its management. Important also is the capacity to manage variability - "*in many cases, waste incinerators may have only limited control over the precise content of the wastes they receive. This results in the need for some installations to be designed so that they are sufficiently flexible to cope with the wide range of waste inputs they may receive. This applies to both the combustion stage and the subsequent flue-gas cleaning stages.*" (2019 EU BAT p.8)

1.6 The 2019 EU BAT sets out quality control requirements for waste feed stock to assure stable combustion occurs within a facility's design parameters, including not exceeding the capacity of the flue-gas cleaning technology. These controls, and substances identified as requiring specific management plans, are discussed in section 4.

1.7 In addition to waste composition and process design, the 2019 EU BAT sets out air emissions limits and associated monitoring methods and frequency (discussed below). Limits are designed to achieve reductions in waste incineration emissions, particularly for toxic and persistent organic pollutants (e.g. mercury, polychlorinated dioxins and furans).

1.8 The Working Group is aware of advances in less-established gasification, plasma and pyrolysis plants. The 2019 EU BAT recommends that the next review collect information on these types of facilities in operation in the EU.

Air emissions

1.9 The Heads of EPA Australia and New Zealand (HEPA) issued guidance in 2019, intended as minimum requirements for the development and operation of EFW facilities to protect the environment and human health. The guidance includes use of current international best practice in relation to abatement technologies; monitoring techniques and real time data availability. It also addresses use of municipal solid waste and/or commercial and industrial waste as inputs. NSW policies are consistent with, and (in relation to publication of data) exceed the minimum requirements.

1.10 Under the HEPA guidance, jurisdictions retain the discretion to decide the appropriateness of allowing hazardous waste as inputs to EFW facilities. In NSW, hazardous waste is classified under the Waste Classification Guidelines Part 1 (2014). Facilities proposing thermal treatment of hazardous materials are excluded from the EFW policy (Figure 2).

1.11 NSW regulations and policies set maximum emission limits and monitoring standards that industry must comply with. However, NSW also requires use of international best practice.

1.12 The NSW *Protection of the Environment Operations (Clean Air) Regulation 2010* (the Clean Air Regulation) sets out the maximum emissions permissible for an industrial source located anywhere in NSW. 'Group 6' limits, which would apply to any new EFW facilities, are the most recent and stringent emissions standards contained in the Clean Air Regulation. They are based on levels that are achievable through the application of reasonably available technology and good environmental practices.

1.13 **Table 1** summarises NSW, EU and USA limits.[1] Figure 1 and Table 1 also include draft best practice NSW emission limits for EFW facilities. The NSW EFW policy criteria state that the process and air emissions from the reference facility must satisfy, at a minimum, the requirements of the Group 6 limits.

1.14 Schedule 5, Part 2 of the Clean Air Regulation sets out the required averaging period for each regulated pollutant. The majority are an averaging period of one (1) hour. Consequently, the NSW draft best practice limits do not numerically reflect the 24-hour average emission limits set out in the 2019 EU BAT. The expert review (Recommendation 1) will consider this in the context of international best practice.

1.15 The NSW EFW policy also requires that facilities demonstrate that they will be using current international best practice control equipment. As such, the EPA may set point source emissions limits for EFW facilities in Environment Protection Licenses (EPLs) that are more stringent than the 'Group 6' emissions. The draft EFW emission limits contained in Table 1 and Figure 1 reflect this approach. The EPA advises that the draft NSW limits for EFW facilities were developed with reference to the 2010 EU limits (both 24 hour and 1 hour averaging periods) and the 2019 EU limits (24 hour averaging period) as well as local experience.

1.16 The process for establishing and updating NSW 'best practice' air emission screening limits for EFW facilities is informed by national and international standards and developments as well as local experience. However, the process is not described in policy or guidance documents.

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[1] USA emissions limits sourced from *US EPA 40 CFR Part 60 Standards of Performance for New Stationary Sources and Emission Guidelines for* Existing Sources: Large Municipal Waste Combustors; Final Rule (2006).

Recommendation 2

That the NSW EPA sets out in writing the process for establishing and updating best practice air emission limits for EFW facilities and makes this information publicly available. This process should include reference to guidance on international best practice for plant design and operation, including flue gas technologies, to achieve these limits; and clarity on the frequency with which limits are reviewed.

The draft best practice air emission limits are stated in the upper right of Figure 1.

International comparators

1.17 As noted in §1.14, care must be taken when making direct comparisons between jurisdictional limits. For example:

- Compliance with emission limits: NSW requires 100% compliance.[2] Other jurisdictions vary in how they treat compliance with emissions limits during normal operating conditions (NOC), as well as during 'other than normal operating conditions' (OTNOC)
- Averaging period: averaging periods in other jurisdictions include 1-hour, 24-hour or other periods. 24-hour average emission limits are significantly less than 1-hour averages. All NSW air emission limits for EFW facilities, including both existing and proposed, are 1-hour except for dioxins and furans (which are 6-8 hours).
- Reference conditions attached to the emission limit: concentrations of air pollutants are dependent on technical aspects including temperature, pressure, and oxygen content.
- Exceedances: the 2010 EU Directive allows waste to be burnt when limits are exceeded for up to 60 hours/year. NSW requires 100% compliance.[3]
- Treatment of continuous monitoring: EU continuous monitoring data are validated to account for a measure of uncertainty.[4] The EU practice of adjusting the monitoring framework acts to directly reduce the stringency of the numerical emission limits, which confounds comparison between the framework adopted in different jurisdictions. NSW does not use adjusted data.
- Type of plant and equipment: In the USA, emission limits may differ depending on the type of pollution control equipment installed. This also applies to the 2019 EU BAT (e.g. in relation to particulates). The emission standards in the NSW Clean Air Regulation are dependent on the type of plant or activity, and not the type of pollution control equipment installed. This reflects the NSW outcomes-based regulatory approach, which enables industry to achieve the minimum emissions performance level through the most appropriate control technology for their application.

1.18 For the spectrum of air pollutants, maximum emission levels under the 2019 EU BAT have been reduced. These include mercury and other metals, polychlorinated dioxins and furans, volatile organic compounds (VOCs), particulates, sulphur dioxide and nitrogen dioxide.

1.19 The 2019 EU BAT conclusions (BAT 25 – BAT 31) specify the technologies or combination of technologies (i.e. ESP, bag filter, scrubbers, injection, etc.) that must be applied for specific pollutants (including organic compounds like PCDD/F and PCBs) to fulfil the BAT requirements.[5] For example, there are a range of methods specified in BAT 30 to control air emissions of organic compounds (e.g. dioxins and furans), that focus on the process, including optimisation of the incineration process, control of the waste feed, on-line and off-

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[2] Cl 56 of the Clean Air Regulation provides exemptions in relation to standards of concentration prescribed in Part 5 (impurities emitted from activities and plant) relating to start-up and shutdown periods.

[3] Ibid.

[4] Brinkmann, T et al., *JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations* (2018) Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control)

[5] ESP = electrostatic precipitator; PCDD/F= Polychlorinated dibenzodioxins/dibenzofurans;' PCB = Polychlorinated biphenyls

line boiler cleaning and rapid flue-gas cooling. Treatment technologies include dry sorbent injection, carbon sorbent added to a wet scrubber, catalytic filter bags, selective catalytic reduction, fixed or moving bed adsorption in some circumstances.

Table 1: Air emission limits for EFW facilities in the USA, the EU and NSW
Includes Draft NSW best practice air emission limits as at May 2020

Air pollutant	**Averaging Period**	**US limits (mg/ standard cubic metre (CM)** [a]	**2010 EU Directive limits (mg/Nm^3)** [b]		**2019 EU BAT limits (mg/Nm^3)** [c]	**NSW Regulatory limit (mg/Nm^3)** [d]	**Draft NSW best practice** [e][f]
			100%	97%		100%	100%
Solid Particles (Total)	1 hour or less	-	30	10		50	20
	24 hours	20	10	-	<2-5 (<2-7 for existing plant w/o bag filter)	-	
TOC/ Volatile organic compounds (VOCs), as n-propane equivalent	1 hour or less	-	20	10		40	20
	24 hours	-	10	-	<3-10 (TVOC)	-	
Hydrogen Chloride (HCl)	1 hour or less	-	60	10		100	50
	24 hours	41	10	-	<2-6 (new plant <2-8 (existing plant)	-	
Fluorine (F2) and any compound containing fluorine, as total Fluoride (HF equivalent)	1 hour or less	-	4	2		50	HF 5
	24 hours	-	1	-	<1	-	
Sulphur dioxide (SO_2)	1 hour or less	-	200	50		NA [g]	100
	24 hours	86	50	-	5-30 (new) 5-40 (existing)		
Nitrogen dioxide (NO_2) or nitric oxide or both, as NO_2 equivalent	1 hour or less	-	400	200		500	250
	24 hours	308	200	-	5-120 (new) 5-150 (existing) NO_x using SCR [h]	-	
Cadmium	1 hour	-	-	-		0.2	
	24 hours	0.01	-	-		-	
Cadmium and its compounds, expressed as cadmium (Cd) and Thallium and its compounds, expressed as thallium (Tl) (in aggregate)	0.5 – 8 hours	-	0.05	-	0.005-0.02	NA	0.05 1 hour avg
Mercury and its compounds, expressed as mercury (Hg)	0.5 – 8 hours	-	0.05	-	<15-35 µg/ Nm^3 (new) <15-40 µg/ Nm^3 (existing)	0.2	0.05 1 hour avg
	24 hours	0.05	-	-	<5-20 µg/ Nm^3	-	

	2-4 weeks (long-term)				1-10 µg/ Nm^3		
Lead	24 hours	0.14	-	-		-	
Antimony, Arsenic, Lead, Chromium, Cobalt, Copper, Manganese, Nickel, Vanadium	0.5 – 8 hours	-	0.5	-	0.01-0.3	-	-
Antimony, Arsenic, Beryllium Lead, Cadmium, Chromium, Cobalt, Manganese, Mercury, Nickel, Selenium, Tin, Vanadium	1 hour	-	-	-		1	0.5
Dioxins or Furans	6-8 hours	13 ng per dry standard m^3 (total mass basis)	0.1 ng/Nm^3	-	<0.01-0.04 ng I-TEQ/Nm^3 (new) <0.01-0.06 ng I-TEQ/Nm^3 (existing)	0.1 ng/Nm^3	0.1 ng/m^3
	2-3 weeks (long-term)				<0.01-0.06 ng I-TEQ/Nm^3 (new) <0.01-0.08 ng I-TEQ/Nm^3 (existing)		
PCDD/F dioxin-like PCBs (ng WHO-TEQ/Nm^3)	6-8 hours				<0.01-0.06 (new) <0.01-0.08 (existing)		
	2-3 weeks (long-term)				<0.01-0.08 (new) <0.01-0.1 (existing)		
Carbon monoxide (CO)	1 hour or less	-	100 (30 min) 150 (10 min)	-		125	80
	4 hours	63 – 188	-	-		-	
	24 hours	125 – 313	50	-	10-50	-	
Ammonia	1 hour						5
	24 hour				2-10 (2-15 for plants with SNCR w/o wet abatement) [h]		

Notes

[a] Averaging period depends on Code of Federal Regulation or sampling method applied for compliance determination. Some emission limits were in ppmv which were converted to mg/m^3 by the NSW EPA.

[b] EU Directive provides emissions limits where 97% of the values/readings must not exceed the limit and 100% of the values/readings must not exceed the limit whereas NSW limits must always be complied with. Source: *Directive 2010/75/EU of the European Parliament and the Council of 4 Nov 2010 on industrial emissions (integrated pollution prevention and control)*

[c] Source: *Commission Implementing Decision (EU) 2019/2010 of 12 Nov 2019 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for waste incineration*

[d] Group 6 limits defined under the NSW *Protection of the Environment Operations (Clean Air) Regulation 2010* - EPL limits for new thermal treatment plant are typically lower than the Clean Air Regulation limits

[e] NSW Best Practice limits as at May 2020 – subject to review and update. Reference conditions: dry, 273K, 101.3kPa, 11% O_2

[f] The EPA advises there is no polychlorinated biphenyl (PCB) emission standard in the *Protection of the Environment Operations (Clean Air) Regulation 2010*. There is, however, a PCB impact assessment criterion in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW. Emissions of PCBs from energy recovery facilities can be assessed against the PCB impact assessment criterion on a case by case basis. Depending on the type and scale of the proposal, a PCB limit can be included in an EPL, if warranted.

[g] Determined from site specific assessment

[h] SCR = selective catalytic reduction process; SNCR = selective non-catalytic reduction process

Monitoring

1.20 The Clean Air Regulation sets out that the standards to measure air pollutants from stationary sources as set out in the Approved methods for the sampling and analysis of air pollutants in NSW (2007).[6] The document outlines approved methods for both periodic and continuous emissions monitoring from stationary sources like those from an EFW facility. The standards are based on either US EPA or Australian Standards (AS). The EPA advises arrangements are under way for a review of this document.

1.21 In 2019, the US EPA proposed some routine updates to the emissions measurement methods from stationary sources, which include updates to procedures and addition of acceptable alternative methods. It is understood these are not finalised. The 2019 BAT has also listed the European or ISO standards for measurement of air pollutants. Any updates to the NSW approved methods should have regard to changes or updates from the US and Europe.

1.22 The NSW EFW policy sets minimum monitoring requirements as follows:

1.22.1 continuous measurement of nitrogen oxides (NOx), carbon monoxide (CO), total particles, total organic carbon (TOC), hydrogen chloride (HCl), hydrogen fluoride (HF) and sulphur dioxide (SO_2). Results are to be made available to the EPA in real time, with a weekly summary of continuous monitoring data and compliance with limits published on the internet.

1.22.2 continuous emissions monitoring for operational parameters including temperature, oxygen, pressure and water vapour content of exhaust gas

1.22.3 proof of performance trials followed by at least two measurements per year and at least every three months for the first year of operation of heavy metals, polycyclic aromatic hydrocarbons, and chlorinated dioxins and furans; with continuous monitoring of these pollutants when techniques allow (**Table 2**).

1.23 The 2019 EU BAT (BAT 4) outlines the required monitoring frequency and associated standards for measuring specific air pollutants from EFW facilities, in accordance with the EU JRC Reference Report on Monitoring of Emission to Air and Water from IED Installations 2018 (the JRC report).[7] The 2019 BAT has strengthened conditions in relation to the continuous monitoring of mercury[8] and long-term sampling methods for polychlorinated dibenzo-dioxins and furans (PCDD/F) and dioxin-like polychlorinated biphenyls (PCBs). These changes appear in red text in Table 2.

1.24 Benefits of continuous measurements relative to periodic measurement include capturing all time periods and providing real-time results compared with potentially delayed results associated with lab testing. However, both continuous and periodic approaches must adhere to standards including quality assurance, accreditation and certification of equipment used.

1.25 The JRC report notes that as of 2017, there were EU certified automated monitoring systems (AMS) for NH_3, CO, particulate matter (PM), HCl, HF, Hg, NOx, and SO_2. For other heavy metals, PAHs, PCDDs/PCDFs and dioxin-like PCBs, no certified AMS systems were available. The technology is not yet at the stage where all pollutants can be measured reliably with continuous systems.

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[6] The Clean Air Regulation provides at s 3 Definitions for these to be prepared by the EPA and published in the Gazette as in force from time to time.

[7] The JRC report sets out standards for sampling of air pollutants from stationary sources, including certified automated monitoring systems (AMS) to continuously measure stack emissions and methods for periodic measurements over specified time intervals.

[8] Exceptions are allowed under certain circumstances. The continuous monitoring of mercury can be replaced with long-term sampling or periodic measurements (min 1x/6 months) under some conditions, including for plants incinerating waste with a proven low and stable Hg content (e.g. mono-streams of waste of controlled composition) (2019 EU BAT).

Recommendation 3

Technical expert advice is sought on NSW requirements as set out in Figure 1, Table 1 and Table 2, including the draft best practice air emission limits for EFW facilities; and whether these draft limits are 'best practice'. The advice should have regard to the Approved methods for the sampling and analysis of air pollutants in NSW (2007), any updates to this as they emerge, and any technical impacts or changes of note arising from the 2019 EU BAT.

Table 2: NSW and 2019 EU standards for monitoring for waste incineration plants

Parameter	NSW	2019 EU BAT under 2010 EU Directive
Abatement technology	Employ current international BP techniques[1], including with respect to EU BAT (NSW EPA)	*Best Available Techniques (BAT) Reference Document for Waste Incineration* (2019) specifies required/applicability of technologies for specific pollutants from waste incineration
Monitoring and sampling standards	*Approved methods for the sampling and analysis of air pollutants in New South Wales* (2007) Approved methods list standards (AS or US EPA) for specific parameters and pollutants	*Best Available Techniques (BAT) Reference Document for Waste Incineration* (2019) BAT lists specific and generic EN standards for continuous or periodic sampling for the range of air pollutants
Process monitoring		
Temperature (combustion chamber)	Continuous monitoring[1, 2]	Continuous monitoring[3]
Oxygen content	Continuous monitoring[1, 2]	Continuous monitoring[3]
Pressure in stack	Continuous monitoring[1, 2]	Continuous monitoring[3]
Temperature in stack/flue-gas	Continuous monitoring[2] Raised and held for duration at min temp (depending upon Cl content)[2]	Continuous monitoring[3]
Water vapour content of exhaust	Continuous monitoring[1, 2]	Continuous monitoring[3]
Flow rate of exhaust	Continuous monitoring	Continuous monitoring[3]
Emissions monitoring	Employ current international BP monitoring techniques with real-time feedback[1]	
Nitrogen oxides (NO_x)	Continuous monitoring[1, 2]	Continuous monitoring[3]
Carbon monoxide (CO)	Continuous monitoring[1,2]	Continuous monitoring[3]
Total particles	Continuous monitoring[1, 2]	Continuous monitoring[3]
Total organic compounds (TOC)	Continuous monitoring[1, 2]	Continuous monitoring[3]
Hydrogen chloride (HCl)	Continuous monitoring[1, 2]	Continuous monitoring[3]
Hydrogen fluoride (HF)	Continuous monitoring[1, 2]	Continuous monitoring (may be replaced with periodic sampling (min. 1x/6 months) under specific conditions)[3]
Sulphur dioxide (SO_2)	Continuous monitoring[1, 2]	Continuous monitoring[3]
Heavy metals	Regular monitoring[1] Min 2x/year (3 monthly in first 12 months) Continuous monitoring when appropriate measurement techniques are available [2]	1x/6 months[3]
Mercury	Regular monitoring[1] Min 2x/year (3 monthly in first 12 months) Continuous monitoring when appropriate measurement techniques are available [2]	Continuous monitoring (can be replaced with periodic sampling under specific conditions)[3]
Polycyclic aromatic hydrocarbons	Regular monitoring[1] Min 2x/year (3 monthly in first 12 months) Continuous monitoring when appropriate measurement techniques are available [2]	
Chlorinated dioxins	Regular monitoring[1] Min 2x/year (3 monthly in first 12 months) Continuous monitoring when appropriate measurement techniques are available [2]	1x/month for long-term sampling of polychlorinated dioxins (values over a sampling period of 2-4 weeks)[3] 1x/6 months for short-term sampling (sampling period of 6 – 8 hrs – avg value of 3 consecutive measurement of min 30 mins each)[3]

Furans	Regular monitoring[1] Min 2x/year (3 monthly in first 12 months) Continuous monitoring when appropriate measurement techniques are available [2]	1x/month for long-term sampling of polychlorinated furans (values over a sampling period of 2-4 weeks)[3] 1x/6 months for short-term sampling (sampling period of 6 – 8 hrs – avg value of 3 consecutive measurement of min 30 mins each)[3]
Dioxin-like PCBs	Determined on a case by case basis [5]	1x/month for long-term sampling of dioxin like PCBs (values over a sampling period of 2-4 weeks)[3] 1x/6 months for short-term sampling (sampling period of 6 – 8 hrs – avg value of 3 consecutive measurement of min 30 mins each) (Does not apply if proven stable emission levels or less than 0.01 ng WHO-TEQ/Nm_3).[3]
Benzo[*a*]pyrene	Determined on a case by case basis	1x/year[3]
NH_3 (when SNCR and/or SCR is used)[6]	Determined on a case by case basis	Continuous monitoring[3]
$N_2$0 (with fluidised bed furnace and when SNCR is operated with urea)		1x/year[3]
Data reporting		
Real time	Continuous monitoring data available to regulator in real-time consistent with international BP[1] Real-time data available for continuously monitored pollutants (exception for HF under certain conditions)[2]	JRC Reference Report on Monitoring of Emissions to air and water from IED Installations (2018) notes good practice for facilities to report on a daily, monthly and/or yearly basis, depending upon permit conditions.[4]
Public availability	Weekly summary on continuous monitoring data and compliance on internet[2]	Authority shall make results of emissions monitoring publicly available as required under permit conditions[4]

Red text: noted improvement in the December 2019 BAT (https://ec.europa.eu/jrc/en/news/new-eu-environmental-standards-waste-incineration)

Sources:

1. HEPA 2019 Guiding Principles for Government and Environmental Regulators on Energy from Waste in Australasia – Thermal (2019)
2. NSW EPA Energy from Waste Policy
3. Neuwahl, F et al., *Best Available Techniques (BAT) Reference Document for Waste Incineration* (2019) Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control)
4. Brinkmann, T et al., *JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations* (2018) Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control)
5. A PCB impact assessment criterion is included in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2007). Emissions of PCBs from energy recovery facilities can be assessed against the PCB impact assessment criterion on a case by case basis. Depending on the type and scale of the proposal, a PCB limit can be included in an EPL, if warranted.
6. SCR = selective catalytic reduction process; SNCR = selective non-catalytic reduction process

TOR 2: Frameworks to ensure that energy from waste proposals align with the NSW waste hierarchy and support economically efficient resource recovery and environmentally sustainable waste disposal

2.1 In 2017, the European Commission issued a communication on the role of EFW in the circular economy. The communication calls for careful consideration of the waste hierarchy in future EFW decisions to avoid undermining circular economy objectives and the risk of stranded assets. It warns against creating overcapacity for non-recyclable waste treatments and suggests phasing out (public) support for mixed waste incineration.

2.3.1 Countries with high landfill-low incineration capacity are encouraged to prioritise separate collection schemes, recycling infrastructure and to investigate options such as anaerobic digestion which combine material recycling and energy recovery. Export of waste for incineration should be subject to a life cycle analysis to ensure impacts (including transport) don't outweigh benefits.

2.3.2 Countries with high incineration capacity are encouraged to pair increases in landfill and incineration taxes (especially processes with low energy recovery); phase out support schemes for waste incineration, introduction of a moratorium on new facilities and decommissioning less efficient EFW plants.

2.3.3 The guidance reflected expected impacts of EU policies and targets (e.g. Circular Economy Action Plan targets and Waste Directive). It followed an infrastructure study identifying EFW overcapacity by 2030 in northern European countries (where most EFW facilities are located).

2.2 The NSW waste hierarchy is defined in the NSW Waste Resource and Recovery Act 2001, the Objects (s 3) being:
(a) to encourage the most efficient use of resources and to reduce environmental harm in accordance with the principles of ecologically sustainable development,
(b) to ensure that resource management options are considered against a hierarchy of the following order—
(i) avoidance of unnecessary resource consumption, multiple cycles of use and reuse;
(ii) resource recovery (including reuse, reprocessing, recycling and energy recovery),
(iii) disposal.

2.3 Figure 1 and Figure 2 set out the frameworks that are part of the EFW assessment process, including adherence with the NSW waste hierarchy.[9] Applicants are required to provide information about waste sources and a guarantee of supply that takes into account expected changes in waste streams and waste reduction/recycling targets. Applicants are also required to provide a secondary source of supply. If approved, conditions of Consent and the Environment Protection Licence apply these requirements. Compliance is undertaken through standard regulatory processes (monitoring, reporting, inspections, audits etc.) provided under law.

2.4 The 2019 EU BAT addresses energy and resource efficiency with conclusions directed towards alignment with circular economy objectives. This includes techniques to improve energy efficiency (BAT 20) and energy efficiency levels (BAT 21). Gross electrical efficiency for new and existing plants are set at 25%-35% for plants treating municipal solid waste (MSW) and hazardous wood waste. The NSW EFW policy requires applicants to achieve at least 25% of the energy generated from the thermal treatment of

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[9] There are separate policies that give effect to the waste hierarchy and resource recovery. These include the NSW Waste Avoidance and Resource Recovery Strategy 2014 – 2021,the NSW Circular Economy statement (2019) and the NSW issues paper, Cleaning Up Our Act: The Future for Waste and Resource Recovery in NSW (2020) which is part of the development of a NSW 20 year waste strategy.

the material to be captured as electricity; or an equivalent level of recovery for facilities generating heat alone.[10]

2.5 Consultations, including a presentation on development of policies in The Netherlands, point to the impact of incentives on consumer and industry behaviours.[11] This includes impacts of waste levies on adherence to the waste hierarchy in terms of recycling and (illegal) dumping. The level and any difference between gate fees at disposal (land fill) sites and EFW facilities can also impact. These issues, including beneficial and perverse outcomes, have been canvassed in several reports across Australian jurisdictions. Reports include, for example, the Commonwealth Senate inquiry into the waste and recycling industry (2018), the NSW Legislative Council report 'Energy from Waste' technology (2018), a NSW EPA report into illegal dumping (2015), Queensland cost-benefit analysis of landfill disposal bans. Consistent themes regarding adherence to sustainability directions relate to awareness, cost avoidance, opportunity and consequences.

Recommendation 4

Work is undertaken to understand the mix of incentives that influence consumer and industry behaviours and will promote adherence to the waste hierarchy in relation to EFW facility input streams. This could potentially be addressed through the development of the 20-Year Waste Strategy.

TOR 3: Contribution that energy recovery facilities may provide to achieve the NSW Government's policy of net zero emissions by 2050

3.1 In NSW, waste accounts for 2.4% of greenhouse gas emissions annually, mostly from landfill; with solid waste disposal on land accounting for 59% of waste emissions (Cleaning Up Our Act, 2020).

3.2 EFW facilities may have a positive or negative net effect on emissions. Relevant factors include averted versus generated emissions from inputs, the plant itself, displaced energy sources, technologies to increase energy efficiency and plant operations.

3.3 The 2019 EU BAT (BAT 1) includes implementation of environmental management systems to improve environmental performance across the life cycle (design, build, operation, maintenance and decommissioning) of facilities. The NSW EFW framework (Figure 1) addresses these elements, although is lacking in specific guidance on decommissioning.

3.4 International Standards (ISO 14040:2006 and ISO 14044) provide principles, a framework, and methodological requirements for conducting Life Cycle Assessment (LCA) studies. In 2016, the Australian Renewable Energy Agency (ARENA) published guidance for undertaking LCA of funded bioenergy projects. This guidance incorporates these ISO standards and other frameworks.[12] These methods were used by Ramboll in 2018 for an assessment of the WA Kwinana EFW project to compare performance relative to black coal energy production. That report found the Global Warming Potential (GWP) for 1 MWh of electricity for EFW was -860 kg CO_2 (benefit) versus 993 kg CO_2 for black coal. The report also identified improvements to the project where the EFW did not

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[10] In addition to air emission monitoring, the EU BAT requires monitoring emissions to water from flue gas cleaning (FGC) systems and bottom ash treatments at specified frequencies (BAT 6), monitoring content of unburnt substance in slag and bottom ash (BAT 7), ensuring the FGC system and waste water treatment plant are appropriately designed and maintained (BAT 17), and a risk based management plan to manage emissions to air and water in Other Than Normal Operating Conditions (OTNOC) (BAT 18). NSW requirements relating to emission controls, waste treatment and management of residual risk are consistent with these directions.

[11] Presentation made by Herman Huisman, Senior advisory waste management and circular economy, A4Waste, *Waste management, circular economy and the role of waste to energy* (April 2020)

[12] These include greenhouse gas emission calculation methodology (ISCC 205) and GHG audit; carbon accounting (ISO/TS 14067) bioenergy systems (ISO 13065).

perform as strongly against the BAU case (boiler ash management; waste collection and transport; plant efficiency).

3.5 A full LCA using available frameworks and drawing on the Western Australian experience could be incorporated into the assessment of EFW proposals. Consideration could also be given to growing interest in industrial ecology approaches and opportunities for co-location of facilities.[13]

Recommendation 5

A Life Cycle Assessment is made a requirement for all proposed EFW facilities and the findings considered in the regulatory assessment process.

TOR 4: Frameworks to ensure that appropriate environmental assessments and community engagement is undertaken

Environmental assessments

4.1 As outlined at point 2.3 above, Figure 1 and Figure 2 set out the frameworks that are part of the EFW assessment process. In addition to air emission limits and monitoring (TOR 1), applicants are required to undertake an air impact assessment from the proposed facility as part of the Environmental Impact Statement (EIS).[14]

4.2 The procedures for undertaking this assessment are outlined in the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016). The methods include the procedures for preparing the data; modelling methodologies, including assessment of background air quality; interpretation of results and impact assessment criteria for specific pollutants. The guidelines are reviewed and updated every five years and apply across all stationary sources across NSW, including for projects like Sydney road tunnels and other industrial facilities.

Environmental performance

4.3 The 2019 EU BAT conclusions to improve environmental performance include improvements to waste stream management (BAT 9), bottom ash treatment (BAT 10), monitoring waste deliveries (BAT 11) and techniques to manage handling and storage of waste (BAT 12).

4.4 Waste stream management techniques for MSW and other non-hazardous wastes include a testing plan to assure that waste inputs are within the suitable range for the installation design, that they are as described by the waste supplier and to identify if they require special handling or treatment. These techniques range from weighing and visual inspection to periodic sampling and full chemical analysis of the waste. The plan should be commensurate with the risk posed by the waste.

4.5 Substances and properties listed in the 2019 EU BAT that require specific management plans include mercury, alkali metals and heavy metals; iodine and bromine; chlorine and sulphur; critical organic pollutants (e.g. PCBs); variations in heat values and moisture content; physical consistency of the waste, e.g. sewage sludge; and mixability of different kinds of waste. Current waste reports identify growth in electronic and other waste containing heavy metals as an emerging issue in NSW, including in the MSW stream. The NSW Parliamentary Inquiry (2018) also focused on asbestos as an issue of concern.

4.6 The 2019 EU BAT does not specifically identify asbestos waste. However, it is recognised that asbestos is present in composite building materials in many European jurisdictions that can be present in the incineration waste streams.

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[13] The NSW Special Activation Precincts are relevant, as is the NSW EPA Industrial Ecology Program for businesses.

[14] Appendix 3 provides a more detailed explanation of the environmental assessment process.

4.7 Wang et al (2017)[15] note that asbestos can be thermally treated in waste incineration and transformed to a non-hazardous phase, but challenges exist. Thermal treatment between 1000-1250°C has been shown to entirely transform asbestos into a mixture of non-hazardous silicates (Gualtieri and Tartaglia).[16] The combustion temperature of incinerators, however, can vary, as will the resulting breakdown of the asbestos. The EFW policy specifies the flue gas must be heated to 850-1100°C for 2 seconds. The resulting asbestos can either be transferred to the slag or released into the flue gas and captured in the treatment filters (Wang et al, 2017). The report concludes further investigations may be warranted to examine the potential for asbestos in the waste stream, the transformation of asbestos during combustion or the post-combustion fate of asbestos.

4.8 The NSW framework (Figure 1) requires characterisation and management of inputs. Consistent with the 2019 EU BAT, this requirement could be strengthened to address specific wastes of concern and require quality controls including input sampling and emission monitoring to address these.

Recommendation 6

Approved NSW EFW proposals are required to develop a sampling and reporting program for waste inputs.

Human health impacts

4.9 In 2018, the Victorian Environmental Protection Authority commissioned a review of the scientific literature on potential health effects from air emissions from EFW on local communities (EnRisks, 2018). The review identified nine studies (2005-2017) relating to compounds found in the air in the vicinity of EFW facilities designed to meet EU IED or equivalent emissions standards and ten papers (six studies, four reviews) of health effects (dated 2000-2018). A common methodological limitation of all papers is the presence of other sources of combustion emissions; the report concluding "*while health effects associated with incinerator emissions cannot be fully discounted, based on the epidemiological limitations, there is no causal evidence that health effects from incinerators emitting to EU IED standards occur*."

4.10 Absent the ability to provide a list of generic chemicals of concern and emission concentrations protective of human health for all facilities, the report recommended treating chemicals nominated in the EU IED as a "bare minimum"; but understanding health implications require an understanding of the fuel mix, plant size, local meteorology and topography and land uses in the surrounding area. Additional literature since the 2018 EnRisks review is likely to remain scant.

4.11 EFW applicants in NSW are required to prepare and submit a Human Health Risk Assessment (HHRA). The Working Group reiterated the importance of this requirement; noting that the EPA, Health and DPIE jointly assess the applicant's HHRA using independent external expertise as required.

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[15] Wang, J., Schlagenhauf, L. & Setyan, A. Transformation of the released asbestos, carbon fibers and carbon nanotubes from composite materials and the changes of their potential health impacts. *J Nanobiotechnol* **15,** 15 (2017). https://doi.org/10.1186/s12951-017-0248-7

[16] Gualtieri A.F., Tartaglia A. Thermal decomposition of asbestos and recycling in traditional ceramics. J Eur Ceram Soc. 2000; 20:1409–18

Community engagement

4.12 The Heads of EPA guidance[17] on community acceptance includes consideration of social costs and benefits of a proposal and potential community responses as well as environmental and economic considerations.

4.13 The EFW policy includes public consultation and the ‘good neighbour’ principle. Applicants to provide accurate and reliable information and engage in a genuine dialogue with the community as the proposal develops from the conceptual to detailed development phase. The ‘good neighbour’ principle includes making information about emissions and resource recovery outcomes readily available; timing of waste deliveries and operating hours.

4.14 It is likely that (new) EFW proposals will be classified as State significant developments (SSD) as indicated in Figure 1. All SSD applications are listed on the Department of Planning, Infrastructure and Environment (DPIE) major projects website, as are assessment reports and determinations. There are standard consultation and public exhibition requirements for SSDs. This is described further in Appendix 3.

TOR 5: Framework to balance the use of proven technologies and the need to encourage innovative technologies

5.1 As noted previously, the requirement for an established reference facility is to provide confidence in the ability of the proposal to operate at known and acceptable standards, particularly in relation to air emissions. Closer alignment between the proposed waste inputs and the reference facility provides greater confidence in the expected performance of the proposed plant.

5.2 The Working Group concluded that the requirement for a reference facility, as well as limits in incineration itself, may mean that innovation is more likely to occur outside the EFW framework e.g. improved sensing and sorting capabilities. In addition, new approaches emerging in the fields of chemistry and synthetic biology may overtake these existing technologies. Also relevant are EU directions to adopt more circular approaches, including not commissioning new plants and decommissioning older facilities.

5.3 Notwithstanding point 5.2, a framework is needed to enable innovative developments to be tested and trialled. The requirements that applicants must meet should be proportionate to the level of change or novelty. For example, these may range from adding additional equipment to an existing asset or plant to the introduction of an entirely new process. It is important that proposed innovations align with and progress NSW policies relating to waste, decarbonisation and the circular economy. The EPA advises that work had been commenced previously on an assessment pathway for EFW proposals that use new or untested technologies (emerging technologies). This work could be revitalised.

Recommendation 7

A pathway is established and communicated to enable asset and process innovations to be tested and trialled. Requirements should be commensurate with the level and impact of the proposed innovation. Any innovation must align with NSW policies relating to waste, decarbonisation and the circular economy.

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[17] As discussed at §§ 1.9-1.10 above

APPENDIX 1: TERMS OF REFERENCE

Context

Energy recovery facilities

In NSW, government policy provides a framework by which a project that proposes to recover energy from the thermal treatment of waste (energy recovery facility) only occurs where it delivers positive outcomes for human health and the environment.

Proponents who seek to operate energy recovery facilities must comply with the 2015 NSW Energy from Waste Policy Statement, to protect the community and ensure best use is made of waste materials.

In particular, the policy statement's technical criteria for energy recovery facilities aim to ensure:

- emissions are below levels that may pose a risk of harm to the community
- current international best practice techniques are implemented, particularly with respect to process design and control, emission control equipment design and control, and emission monitoring, with real-time feedback to the controls of the process.

The policy statement also requires that energy recovery facilities use technologies that are proven, well understood and capable of handling the expected variability and type of waste feedstock. This must be demonstrated through reference to fully operational plants using the same technologies and treating like waste streams in other similar jurisdictions.

At its March 2019 meeting, the Heads of EPA Australia and New Zealand (HEPA) approved the Energy from Waste in Australasia - Thermal, Guiding Principles for Government & Environmental Regulators, for internal publication to be used as guidance for HEPA members including the NSW Environment Protection Authority (EPA). Public release is proposed later in 2019 when all jurisdictions have finalised policy positions on energy from waste. The NSW Policy Statement is consistent with the HEPA guidance.

Parliamentary Inquiry

The 2018 NSW Legislative Council's Inquiry into Energy from Waste made several recommendations to improve the energy from waste framework. The Committee recommended an expert advisory body review the 2015 Energy from Waste Policy Statement. Specifically, Recommendation 19 states:

That the NSW Government establish an expert advisory body on energy from waste chaired by the Chief Scientist to examine and report on the energy from waste regulatory framework to create certainty for the market and communities, with reference to:

- changes required to the Energy from Waste Recovery Guidelines to guarantee that New South Wales uses only world's best practices in emissions, emissions monitoring and residual waste disposal
- consent conditions required in any planning approval to guarantee that New South Wales uses only world's best practices in emissions, emissions monitoring and residual waste disposal
- the impact of energy from waste on human health
- the impact of energy from waste on recycling targets.

Purpose

To establish an Energy from Waste (EFW) Working Group to provide advice to the Minister for Energy and Environment on potential regulatory controls on air emissions resulting from energy recovery facilities.

Functions of the EFW Working Group

The EFW Working Group will provide the Minister for Energy and Environment with advice on environment protection standards and frameworks to ensure that proposed energy recovery facilities in NSW undertake robust assessments and adopt best practice standards and controls to ensure human health and the environment are protected. The advice will consider:

1. benchmarking NSW air emission limits with international best practice for energy from waste facilities, including an assessment of real-time monitoring approaches;
2. frameworks to ensure that energy from waste proposals align with the NSW waste hierarchy and supports economically efficient resource recovery and environmentally sustainable waste disposal;
3. contribution that energy recovery facilities may provide to achieve the NSW Government's policy of net zero emissions by 2050;
4. frameworks to ensure that appropriate environmental assessments and community engagement is undertaken;
5. framework to balance the use of proven technologies and the need to encourage innovative technologies; and,
6. other matters where relevant.

Operation of the EFW Working Group

1. The Chair of the EFW Working Group is the NSW Chief Scientist & Engineer (CSE).
2. The EFW Working Group will operate for three months from the date of its formation and meet fortnightly or on an as-needs basis.
3. The NSW Chief Scientist & Engineer will provide the Minister for Energy and Environment with advice in the form of a report within three months.
4. The term of the EFW Working Group can be extended by agreement between the CSE and the Minister for Energy and Environment, if required.
5. The EPA will provide secretariat support to the operation of the EFW Working Group.

Membership of the EFW Working Group

The EFW Working Group will be comprised of:

- Chair - NSW Chief Scientist & Engineer
- Deputy Chair - Director, Office of NSW Chief Scientist & Engineer
- NSW Environment Protection Authority
- Department of Planning, Industry and Environment - Planning and Assessments NSW Health

The CSE, in consultation with the Working Group, may draw on additional independent expert advice to inform the functions of the Working Group.

APPENDIX 2: MAJOR REPORTS

Year	Report	Author	Overview
2019	Best Available Techniques (BAT) Reference Document for Waste Incineration	Neuwahl, Cusano, Benavides, Holbrook and Roudier for the European Commission	The Best Available Techniques (BAT) Reference Document for Waste Incineration (BREF) under the Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control) includes: • data and information on plant, processes and performance, including emissions, raw material inputs, energy and water consumption, energy efficiency and waste generation • conclusions on BAT • comment on emerging techniques, including reheating oil scrubbers to reduce polyhalogenated aromatics and polyaromatic hydrocarbons (PAHs) from flue gasses • limited information on the cost of some air emissions monitoring systems • recommendations for future work, including collecting information on: ○ gasification, plasma and pyrolysis plants operating in the EU ○ boiler efficiency ○ short- and long- term sampling of PCDD/F emissions to inform monitoring methods ○ the composition of bottom ashes and boiler ashes and possible consequences of their mixing on the hazardousness of the resulting material and overall material recovery rates. The report comments on the difficulty of assessing compliance with emission limit values when these are set around the lower end of the BAT-AEL ranges, due to the likely increase of the relative measurement uncertainty (uncertainty as a % of measured value) with decreasing emission levels.
2019	Guiding principles for environmental regulators: Energy from Waste - Thermal	Heads of EPA Australia & New Zealand	• National principles • Intended as minimum requirements • Includes: the waste management hierarchy; community acceptance; best available technology; thermal efficiency; continuous monitoring; hazardous waste
2018	JRC Reference Report on Monitoring of Emission to Air and Water from IED Installations (Industrial Emissions Directive 2010/75/EU	Brinkman, Both, Scalet, Roudier and Sancho	• Reference document to enhance consistent application of the BAT • Guidance on general aspects of emissions monitoring, including monitoring standards, strategies and practices • Contains information about monitoring emissions to air and water • Air emissions sections includes information on air pollutants, continuous/periodic measurements, surrogate parameters, diffuse emissions, biomonitoring and costs.
2018	Tyre pyrolysis and gasification technologies: a brief guide for government and industry	Tyre Stewardship Australia	• Overview of tyre pyrolysis and gasification technologies and process steps; jurisdictional requirements and developments; and comment on the economic landscape. Early R&D stage; in NSW two pilot (proof of concept) plants
2018	Energy from Waste Technology	NSW Legislative Council Portfolio Committee No. 6 – Planning and Environment	• The report outlines merits, issues and regulation of EFW facilities, with reference to the waste hierarchy, input fuels, requirement for a reference facility, emission standards and monitoring. • The report makes specific comment on a proposal under assessment in NSW at that time.

2015	NSW Energy from Waste Policy Statement	NSW Environment Protection Authority	• Sets out requirements for EFW facilities; including technical, thermal efficiency and resource recovery criteria • Includes eligible waste fuel
2013	Review of state-of-the-art waste-to-energy technologies	WSP for the WA Department of Environment and Conservation	• Provides overview of plant technologies and flue gas cleaning systems; 14 place-based case studies of plant development, performance and operability (EU, US, Japan, UK etc.); comment on status of plasma gasification and other emerging technologies to track
2010	Directive 2010/75/EU of the European Parliament and the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)	European Parliament and Council of the European Union	• Main instrument regulating emissions from industrial facilities in the EU • Based on five pillars: ○ Integrated approach to issuing permits (licences), taking into account whole environmental performance of plant ○ Use of Best Available Techniques (BAT) and EU wide emission limit values for selected pollutants ○ Some flexibility for authorities in relation to set less strict emissions levels ○ Mandatory requirements on environmental inspections ○ Public participation

APPENDIX 3: ENVIRONMENTAL ASSESSMENT OVERVIEW

The *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (the Regulation) provide the legislative framework for assessing and determining EFW proposals in NSW, including the requirements for public participation during public exhibition. EFW proposals will generally fall under the State significant development (SSD) assessment pathway.

State Environmental Planning Policy (State and Regional Development) 2011 identifies development that is SSD. In the case of EFW proposals, the triggers for SSD are specified in Schedule 1 and Schedule 2 as follows:

- development for the purposes of electricity generating works or heat of their cogeneration that has a capital investment value (CIV) of more than $30 million or a CIV of more than $10 million and is located in an environmentally sensitive area of State significance
- development for the purpose of waste incineration that handles more than 1,000 tonnes per year of waste
- development that has a capital investment value of more than $10 million on land identified as being within the Western Sydney Parklands.

Scoping a proposal is the first step in the environmental assessment pathway for SSDs. Scoping identifies the matters and impacts that are likely to be relevant, establishes terms of reference for the Environmental Impact Statement (EIS) and the appropriate level of assessment. The scoping phase is critical to steering the remainder of the development application and EIS. An important part of scoping involves engaging with the community and other stakeholders to understand their perspectives on matters of importance to them.

Early engagement during the scoping phase develops a relationship with the community and other stakeholders, provides information about the project to the community and other stakeholders and obtains input on relevant matters to be considered in the EIS.

When an applicant has developed a development concept which allows an initial understanding of the potential impacts of the proposal and the likely interest from the community and other stakeholders, the applicant should arrange a Scoping Meeting with the Department of Planning, Industry and Environment (the Department). The Scoping Meeting provides the applicant with an opportunity to discuss the development concept with the Department and reach agreement on the approach to engaging with the community and other stakeholders prior to finalising the formal request for the Planning Secretary’s Environmental Assessment Requirements (SEARs).

The Scoping Meeting also provides an opportunity for the Department to discuss site suitability, strategic context, confirm the planning pathway and provide feedback on the information required to support the request for SEARs. At the Scoping Meeting the applicant should be able to describe what is proposed, where and when it is proposed, the strategic justification, the history of project development, alternatives considered, alignment with the planning framework, likely relevant matters and potential impacts and engagement undertaken.

The professional expertise and judgment of the applicant’s study team is key to identifying relevant matters and impacts. It is therefore critical that this team be selected carefully. Substantive consultation, early identification of issues, addressing concerns and submission of high-quality documentation prepared by a team of competent consultants has the benefit of potentially shorter assessment times arising from better community awareness of the project and a more focussed and well-prepared EIS.

The final Scoping Report is submitted to the Department in support of a request for SEARs. The Department prepares the SEARs in consultation with relevant government authorities, including the local council. The SEARs set the requirements for the preparation of the EIS and sets clear expectations on the level of assessment appropriate for each key issue.

The EIS must be prepared in accordance with the SEARS. The Department will review the EIS to make sure it addresses the SEARs prior to placing it on public exhibition for a minimum of 28 days. Once an application is received, it is subject to a detailed merit assessment process under the framework set out in the EP&A Act. The Department will assess the EFW proposal in consultation with the community and other key stakeholders, including (but not limited to) the Environment Protection Authority, NSW Health and the local council.

The public exhibition of an EIS provides a formal opportunity for the community and other stakeholders to share their knowledge and opinions by making a written submission on an EFW proposal. Applicants are expected to carefully consider the issues raised in submissions and where appropriate, change the development, the performance criteria or mitigation measures to address the issues raised. The applicant's responses to the issues are considered by the Department during its assessment of the proposal and by the consent authority when deciding whether to approve or refuse a proposal.

In determining a development application, the consent authority must consider the matters for consideration in §4.15 of the EP&A Act, which includes the likely impacts of the development, the suitability of the site, any submissions made and the public interest.

To assist with its assessment, the Department will generally engage independent experts in best practice EFW technology and human health and toxicology to advise on the consistency of the proposal with the NSW EPA's Energy from Waste Policy Statement (2015) and international best practice; and to review the Applicant's assessment of human health risk.

Approval of an EFW proposal will be subject to implementation of conditions on the development consent. These conditions are required to prevent, minimise, or offset adverse environmental impacts, set standards and performance measures for acceptable environmental performance, require regular monitoring and reporting and provide for the ongoing environmental management of the development.

To assist Applicant's with the SSD process and to improve environmental assessment, the Department has developed a set of guidance material on Scoping an EIS, Community and Stakeholder Engagement, Preparing an EIS and Responding to Submissions.

Community Engagement

One of the Objects of the EP&A Act (§1.3) is to provide increased opportunity for community participation in environmental planning and assessment. The EP&A Act and EP&A Regulation set out public exhibition and notification requirements for development applications in NSW, including requirements for public notices, the length of public exhibition periods, access to and availability of exhibition documents, and the provision, publication and response to submissions.

Participation in environmental assessment requires actions and inputs from applicants, the community, stakeholders and the Department. The SEARs for an SSD application include requirements for applicants to engage with the community and other stakeholders on a case by case basis. These requirements, which apply during the preparation of the EIS, construction and operation, recognise the importance of participation by the community and other stakeholders in the environmental assessment process.

As part of an EIS, applicants are required to prepare a Community and Stakeholder Engagement Plan (CSEP). The CSEP sets out the engagement activities undertaken during preparation of the EIS, how issues raised during community and stakeholder consultation have been addressed and whether they have resulted in changes to the proposal, details of the proposed approach to future community and stakeholder engagement based on the results of the consultation and details of how monitoring data will be communicated and made publicly accessible to the community.

During the public exhibition period, DPIE is required to provide the community with an opportunity to express their views on an EFW proposal. As part of its evaluation of the proposal, the EP&A Act requires the consent authority to consider any submissions made.

The EPA's EFW Policy Statement requires applicants to undertake public consultation and adhere to the good neighbour principle, particularly if near a residential setting but also for the workers in other nearby facilities. The 'good neighbour' principle includes making information about emissions and resource recovery outcomes readily available and consider the timing of waste deliveries and operating hours. The Policy requires applicants to engage in a genuine dialogue with the community and to obtain their acceptance to operate as the proposal develops from the conceptual to detailed development phase.

Applicants may use the Department's draft guidance on Community and Stakeholder Engagement to assist with their understanding of how the Department expects applicants to engage with the community and other stakeholders. There is an emphasis on early genuine engagement and participation throughout the preparation and assessment of the EIS.

APPENDIX 4: INDEPENDENT EXPERT REVIEW REPORT

THE UNIVERSITY OF SYDNEY

Energy-from-Waste

Independent review and expert advice

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Disclaimer

This Report was commissioned by The Office of the Chief Scientist & Engineer as independent expert advice for the Energy from Waste Review. The Report has been prepared by staff of the University of Sydney through its Waste Transformation Research Hub, School of Chemical and Biomolecular Engineering in the Faculty of Engineering. The contents of the Report are current as at November 2020.

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Executive Summary

In July 2020, the University of Sydney (USYD) through its Waste Transformation Research Hub (WTRH) was commissioned by the Office of the NSW Chief Scientist and Engineer (OCSE) to provide expert review and advice on the proposed *(draft) best practice air emissions limits for EFW in NSW* (the draft limits). Advice was also sought on technological challenges and developments in aligning EFW facilities with NSW government policies relating to waste, recycling, and net-zero emissions. This followed a review led by the Chief Scientist & Engineer to provide advice on environmental protection standards and frameworks to ensure that proposed EFW facilities in NSW undertake robust assessments and adopt international best practice standards and controls to ensure human health and the environment are protected. The full Terms of Reference (ToR) for the expert advice are at Appendix 4.

The **NSW Energy from Waste Policy Statement** (NSW EPA, 2015) sets out the policy framework and criteria that apply to proponents seeking to install and operate EFW facilities. The policy requires that EFW facilities meet both minimum air emission standards for industrial facilities contained in the **Protection of the Environment Operations (Clean Air) Regulation 2010** (the Clean Air Regulation) and adopt international best practice.

The initial expert review focused on whether the *draft limits* for EFW facilities are the most 'stringent' when compared to international 'best practice'. A detailed comparison against national and international jurisdictions has shown that the *draft limits* are the most stringent in 8 out of 10 pollutant categories. It is proposed that the two categories of pollutants, namely hydrogen fluoride and heavy metals, be revised to align with world's best practice as currently expressed in the 2019 Best Available Techniques (BAT) Reference Document for Waste Incineration (the EU Directive).

With respect to 'averaging period' for emissions limits, greater stringency comes from monitoring at more frequent (hourly) averaging of the data. NSW requires 1-hour averaging periods for most limits, whereas other jurisdictions have 1-hour, 24-hour, dual averaging, and/or other periods. The review has found that the NSW hourly averaging limits can be as stringent as jurisdictions that use dual averaging limits. It is proposed that single hourly averaging continues to be employed because it provides more frequent (hourly) averaging of the data. It is also proposed that the hourly limits are regularly reviewed and tightened to be closer to what secondary (lower) limits would be at were these in place. This should be done under a well-studied schedule (as real plant data reveals the lower emission rates technically achievable by the highest performing plants and advances in air pollution control (APC) technology), while always accounting for the other than normal operating conditions (OTNOC).

The *draft limits* are the most stringent with the 100% requirement for compliance with emissions limits during NOC. It is recommended that this 100% requirement is maintained for NOC. This however does not specifically address regulation for OTNOC. Currently, the Clean Air Regulation provides exemptions for start-up and shutdown periods. It is recommended that industry be required to provide regulators with management plans to control emissions during

OTNOC, and to monitor and report OTNOC data. It is also recommended that emissions data from EFW facilities are required to be made publicly accessible via an online platform.

The *draft limits* provide a comprehensive coverage of pollutant types when compared against other jurisdictions. The limits for smoke and opacity, required in other jurisdictions, are however not mentioned in the *draft limits*, although they are covered by the Clean Air Regulation. It is recommended that these be explicitly included. NSW has covered all pollutants that can be realistically continuously monitored. It is recommended the Clean Air Regulation and the Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (2007) are continuously reviewed, to keep them updated in terms of emerging continuous monitoring techniques of relevant pollutants. It is understood both are currently under review.

The expert review considered scheduling and review of EFW air emissions limits. Emerging technology, trends in international standards and operation of local plants should be closely monitored, particularly in the initial period. It is recommended that initial reviews are undertaken within 3 years, and on regular 5-yearly intervals after that.

The review also considered the ability of EFW technology to adapt to future waste variability. Plants must demonstrate the ability to manage both availability and variability. However, they must also demonstrate that operations will respect the waste management hierarchy. It is recommended that established feedstock sources must be demonstrated; that steps are taken to ensure only suitable feedstock is used; and that plants are not over-designed in terms of scale. This is to avoid competition with recycling transport of waste over long distances. It also helps avoid unnecessary start-up and shutdown periods, which can influence emission levels. This can be helped by adequate waste sorting and classifying material types. Ensuring only suitable materials are used also assists with the thermal efficiency of plants. For these reasons, it is recommended that operators are required to review and provide monthly reports on the composition of waste streams. These reports should be required to align with the Environment Protection Authority's (EPA) waste classifications and include an analysis of the relationship between changing waste inputs, operational changes and changes in air emissions.

The NSW EPA waste classification system should also be reviewed to reflect world's best practice. For the reasons outlined above, this includes assessing whether the classification system adequately captures materials that are suitable or not suitable for combustion and appropriate management of resultant emissions and waste (output) streams.

The review considered co-location of EFW with other industry and identified numerous opportunities in industrial symbiosis in NSW. It is recommended that these opportunities are evaluated, including the role of EFW in special dedicated industry zones (particularly Special Activation Precincts) and co-location with existing process industries with heat intensive requirements, with benefits for manufacturing and upcycling of waste into commodities and value-added products. Further extended opportunities may be attractive such as integration with carbon capture and storage (CCS) and renewable energy. EFW facilities in co-location settings can catalyse industry growth through provisions for waste treatment, energy and carbon emissions reductions opportunities, particularly for regional NSW. Programs that build research capacity in industrial symbiosis that incorporates EFW processes should be supported.

Another key aspect identified is the need for ongoing review of EFW industry performance, including all aspects related to emissions control and monitoring. Review mechanisms should be linked to emerging evidence. An emissions data platform that exploits big data, analytics and visualisation technologies will assist and help inform future policy and regulation.

Research programs can also help address waste challenges and the role of EFW in sustainable waste management, including characterising and identifying the feasible waste opportunity and industry implications. Research will help address challenges such as waste variability, technological performance, emission reduction and policy alignment.

A summary of key conclusions and recommendations is presented in Table 0-1.

Table 0-1: Summary of key conclusions and recommendation of the independent review of the (draft) best practice air emissions limits for EFW in NSW (2020).

TOR	Subject	Conclusion (C) / Recommendation (R)
1	Review the *(draft) best practice air emissions limits for EFW facilities* – whether they are the most stringent and whether they are 'best practice' (the lowest emission rates technically achievable by industry)	**(C1)** In comparison to other limits nationally and internationally, and taking into account averaging periods, the *(draft) best practice air emissions limits for EFW facilities in NSW* are the most stringent in 8 out of 10 pollutant categories. The two categories where the proposed NSW best practice limits are less stringent are hydrogen fluoride and heavy metals. **(R1)** The following concentration limits are adopted by NSW to align with the world's best practice (currently expressed in the 2019 EU Directive): for (a) hydrogen fluoride 4 mg/m^3 (from currently proposed 5 mg/m^3), (b) mercury 0.04 mg/m^3 (from proposed 0.05 mg/m^3), (c) cadmium & thallium 0.02 mg/m^3 (from proposed 0.05 mg/m^3), and (d) heavy metals 0.3 mg/m^3 (from proposed 0.5 mg/m^3).
1a	Averaging periods for emissions limits – noting that NSW requires 1-hour averaging periods for most emissions, whereas other jurisdictions have 1-hour, 24-hour and other periods	(**C2**) NSW hourly averaging limits can be as stringent as jurisdictions that use dual averaging limits, provided that (1) the OTNOC (other than normal operating conditions) is accounted for and (2) hourly averaging limits are regularly reviewed and tightened as much as possible. Greater stringency comes from monitoring at more frequent (hourly) averaging of the data. However, a daily averaging limit, being lower than the hourly limit, places an EFW facility at near-optimal performance and on a trajectory of continuous improvement in terms of installing more advanced APC systems as part of continuous plant upkeep and long-term plant improvements. At the same time, introducing two averaging limits will increase reporting complexity and may introduce industry confusion, as it is accustomed to single averaging limits. (**R2**) It is recommended that (a) NSW continues to employ a single hourly averaging limit. (b) the regulator maintains the stringency of allowable emissions over time by tightening the hourly averaging limits closer to what projected secondary (lower) daily limits would be at were these in place. This should be done as part of a reviewed and well-studied schedule (using real plant data that becomes available, and in line with evolving technologies). (c) the regulator reviews the value of adopting a second tighter daily averaging limit in the future.
1b	Allowable exceedances	(**C3**) The *(draft) best practice air emissions limits for EFW in NSW* are the most stringent with its 100% requirement for compliance during NOC (normal operating conditions). However, it does not specifically address regulation relating to OTNOC. Currently, Cl 56 of the Clean Air Regulation provides exemptions relating to start-up and shutdown periods. **(R3)** NSW maintains the 100% compliance requirement for NOC, as it is the most stringent requirement possible. For the purpose of governing start-up, shutdown and maintenance periods (i.e. OTNOC), it is recommended industry be required to provide regulators with a management plan to control emissions during OTNOC periods, and to monitor and report emissions data for OTNOC periods. It is recommended industry is required to report on OTNOC periods (including reported emissions data in the OTNOC periods) and that these data are used to review allowable exceedance requirements.

TOR	Subject	Conclusion (C) / Recommendation (R)
	EU Directive allows flexibility in continuous monitoring by providing two concentration limits to be met, 97% or 100% of the overall recorded continuous data.	(**C4**) Flexibility in EU regulations which provide two percentile limits of 97% and 100% is believed to target small and rural EFW facilities, allowing 3% of monitored data to be omitted (in addition to allowable exceedances). It is early days to conclude whether having two emissions limits will practically support smaller and rural EFW in NSW, considering there is no history of such operations in NSW. (**R4**) With no historical experience in EFW operation in NSW, it is not possible to determine what benefits dual limits would bring to EFW facilities or communities. Hence, it is best to proceed with adopting only 100% compliance, and to undertake a review of its impacts once EFW operations in NSW have been operating for 3 years.
1c	Range of pollutants covered	(**C5**) *The (draft) best practice air emissions limits for EFW in NSW* provides a comprehensive coverage of pollutant types. The limits for smoke and opacity, required in other jurisdictions, are not mentioned in the draft, however, these are covered by the *POEO Clean Air Regulation (2010)* through monitoring of overall particulate matter and total dust. (**R5**) For completeness, the *POEO Clean Air Regulation (2010)* limits on smoke and opacity should be included in *the (draft) best practice air emissions limits for EFW in NSW,* which is 1 Ringelmann (Smoke) and 20% Opacity.
1d	Continuous monitoring for specific pollutants	(**C6**) At the current technological state, it can be said that NSW has covered all pollutants that can be realistically continuously monitored. Emerging monitoring techniques should be continuously assessed in future reviews of the standards. For the case of mercury, it is currently more feasible to control the waste composition entering EFW facilities rather than to enforce continuous monitoring. The challenges of continuous monitoring of mercury are acknowledged by the EU in the 2019 BAT Directive, and alternates recognised. The *NSW Energy-from-Waste Policy Statement* (2015) outlines continuous monitoring for relevant pollutants. However, the *POEO Clean Air Regulation (2010)* and the *Approved Methods for the sampling and Analysis of Air Pollutants in NSW (2007)* need to be updated for consistency in relation to continuous monitoring methods for solid particles, HF, and HCl. The '*Approved Methods for NSW*' and *Clean Air Regulation* are understood to be currently under review. (**R6**) The review of the Approved Methods and Regulation take into account the EU Directive as well as other international developments. It is also recommended that: (a) emissions data from EFW facilities are required to be made publicly accessible via an online platform. (b) as reported emissions reflect actual plant performance, a rigorous evidence-based proof of performance type stack testing regime is adopted for plant commissioning.
2	Scheduling and review for EFW air emissions limits	(**C7**) Expected technology advances should enable future reductions in allowable air emissions. Emerging technology, trends in international standards and operation of local plants should be closely monitored, particularly in the initial period. (**R7**) An initial review of best practice air quality emission limits for EFW plants should be undertaken within 3 years, followed by reviews at 5-yearly intervals. The latter appears consistent with the rate of APC evolution and commercialisation. Review reports and updates should be made publicly available.
3	EFW technology and its ability to adapt to future waste variability; particularly its implications for air emissions	(**C8**) EFW facilities should not be 'over-designed' in terms of scale and material availability (feedstock). This is to minimise future feedstock competition that undermines the waste management hierarchy or lack of waste volumes that result in waste being transported over long distances. This should also help avoid unnecessary start-up and shutdown periods that

TOR	Subject	Conclusion (C) / Recommendation (R)
		can impact on air emissions. The industry should demonstrate that the waste management hierarchy is being respected during the design stage and across the operational lifetime of the asset. In terms of plant type, currently, there is no practical evidence that other EFW technology can operate at moving grate capacity. Therefore, it is expected that moving grate technology will continue to be employed, whilst improving it through operational standpoints to reduce air pollutants. Generally, understanding waste variability through periodic reviews will support plant optimisation. This includes understanding the relationship between changing waste inputs, operations and emissions. The implication of waste variability and sorting on air emissions is unclear as evidence relating feed to emissions in overseas operations is lacking. It is known moisture content carried in with waste does present a problem – while resolved through a pre-heating step (moving grate), it decreases efficiency of EFW plant In relation to waste compositions, The POEO Act outlines the eligible fuel for EFW, however, the POEO lacks reference to the NSW Waste Classification Guidelines (2014), which influence the incoming waste into EFW. The Guidelines on the other hand may require updating to reflect an emerging EFW industry especially in terms of waste quality and combustibility. It is important that the waste classification system adequately accounts for combustive technologies such as moving grate. This is to ensure the waste management hierarchy is respected, i.e. reusable and recycled materials are not used as feedstock. It is also important that the system accounts for combustible and non-combustible materials to ensure only suitable materials are used and operational efficiency optimised. (**R8**) Steps are taken to ensure only suitable feedstock is used in EFW facilities. This includes: (a) The scope and location of proposed EFW facilities are assessed relative to waste supply chains, market size and competition, and projected changes to waste streams including impacts of 'quality recycling' developments and targets. Guidelines be developed for sizing of facilities, and methods to demonstrate, as part of licensing approval and review, that the waste management hierarchy principles are followed. (b) Operators are required to provide monthly reports on the changing composition of waste streams, and data showing the relationship between waste inputs, operations and air emissions. (c) NSW EPA review the waste classification system to ensure it adequately captures materials that are suitable and not suitable for combustion. This is to help ensure the waste management hierarchy is respected, that only suitable waste inputs are used and to optimise plant efficiency. This should also assist assessment of feedstock sources and volumes. (d) Research is undertaken to support skills and technology development to manage the impact of waste variability on technology performance and emissions. (e) Collecting and publishing data on waste streams and performance. As a long-term strategy, it is recommended efforts are made to increase public awareness of waste classifications and waste stream destinations.
4	Co-location of EFW with other industry	(**C9**) In NSW, numerous opportunities for industrial symbiosis and co-location exist for EFW operations, including: (a) integration within waste management parks,

TOR	Subject	Conclusion (C) / Recommendation (R)
		(b) installation as a process heat supplier (heat networks) in industrial eco-parks for manufacturing and upcycling of waste into commodities and value-add products, and (c) integration with carbon capture and storage (CCS) and renewable energy. (**R9**) The role of EFW in special dedicated industry zones should be assessed (particularly in the Special Activation Precincts) and consideration given to co-location with existing process industry with heat intensive requirements. Programs that build research capacity in industrial symbiosis that incorporates EFW processes should be supported.
5	Other relevant matters	**(C10)** As EFW is emerging in Australia, public acceptance is a critical aspect to EFW industry. Special effort is therefore required to communicate operational performance. Review mechanisms should draw on input from technical experts from time to time, and focus on sharing of data, transparency and openness, to help inform policy and regulatory improvements. (**R10**) Industry performance should be subject to ongoing review, including mechanisms to comprehensively review and monitor air emissions data and BAT practice, which may increase public confidence in operations. Such mechanisms should: (a) include all possible aspects of air emission performance that can be used to inform decision making. (b) address modelling and governance of air emissions data collected from EFW facilities. (c) create the evidence-base for review of air emission standards and limits.

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Abbreviations & Definitions

AAQ	Ambient Air Quality
BAT	Best Available Technology
CCS	Carbon Capture Storage
CEMS	Continuous Emission Monitoring System
CFD	Computational Fluid Dynamic
CO	Carbon monoxide
CRL	Commercial Readiness Level
EFW	Energy-From-Waste
ESP	Electrostatic precipitator
EU	European Union
FGC	Flue Gas Cleaning
GLC	Ground Level Concentration
GSP	Gross State Product
Hg	Mercury
IS	Industrial Symbiosis
LIMB	Lime absorbent injection at burner
LMWC	Large Municipal Waste Combustor
mg/m^3	Milligram per meter cube
MSW	Municipal Solid Waste
NEPM	National Environment Protection Council
NOC	Normal Operating Conditions (*Engineering Definition*) refers to the conditions at which the process operates within the regime of designed steady state operation and changes in variables are within the control design.
NOx	Nitrous oxides
NSW	New South Wales
NT	Northern Territory
OCSE	Office of the Chief Scientist & Engineer
OTNOC	Other Than Normal Operating Conditions (*Engineering Definition*) refers to the conditions at which the process operates outside the design steady state operating point due to controlled transient (non-steady state) set-point tracking in controlled ramp-up and ramp-down of the process, or due to uncontrolled abnormal behaviour in the process, or due to disturbances changes. (*EU Definition*) Defined as conditions of start-up, shutdown, leaks, malfunctions, maintenance, momentary stoppages, definitive cessation of operation (CEWEP, 2019)
PAH	Polycyclic aromatic hydrocarbons
PM	Particulate matter
POEO	Protection of the Environment Operation
QLD	Queensland
SA	South Australia
SAP	Special Activation Precinct
SCR	Selective Catalytic Reduction
SMWC	Small Municipal Waste Combustor

SNCR	Selective Non-Catalytic Reduction
SOx	Sulphur oxides
SPC	Statistical Process Control
TAS	Tasmania
TOC	Total organic carbon
tpd	Tonnes per day
tph	Tonnes per hour
TRL	Technological Readiness Level
VIC	Victoria
WA	Western Australia
WHO	World Health Organisation

1 Review of international policies

The (draft) best practice air emissions limits for EFW in NSW outlined in the NSW Framework in the Chief Scientist & Engineer report is reviewed against relevant international approaches to managing emissions from EFW. Table 1-1 lists the reviewed regulatory instruments (e.g. policies, directives and regulations), while a detailed review of pollutant limits is provided in Appendix 1.

Table 1-1: List of relevant international documents reviewed.

Title of document	Origin
- Waste Incineration Directives (EU 2000/76/EC) - Industrial Emissions Directives (EU 2010/75/EU): - BAT Reference Document for Waste Treatment (2018 PDF) - BAT Reference Document for Waste Incineration (2019 PDF) - Establishing the BAT conclusion, under Directive 2010/75/EU for Waste Incineration (Website)	European Union
- GB-18485-2014: Standard for Pollution Control on the Municipal Solid Waste Incinerator (Website) - Three-Year Action Plan: Blue-Sky War	China
- 40 Code of Federal Regulation – Standard of Performance for New Stationary Sources (Navigation Website) - Clean Air Act Guidelines and Standards for Waste Management (Various documents, Website) - Large Municipal Waste Combustors (LMWC): New Source Performance Standards (NSPS) and Emissions Guidelines (Website). - Emissions Limit for New Small Municipal Waste Combustion (SMWC) (Website).	United States
- NEA Guidelines for waste incinerator (2000 PDF) - Environmental Protection and Management (Air Impurities) Regulations (Revised in 2008) G.N. No. S 595/2000 (Website) - (For 2030 Plan) Sustainable Singapore Blueprint	Singapore
- Japan Environmental Governing Standards (PDF-2016)	Japan
- Canada-wide standards on federal incinerators: Dioxins/furans and mercury (PDF) - Canada Ambient Air Quality Standards (QAAS -2017 Website)	Canada
- National Clean Air Agreement (2015) - National Environment Protection Measure (NEPM) Ambient Air Quality (variation as recent as 2019, Website)	Australia - National
- Environmental Protection Regulations 1987 (PDF) - Environmental Protection (Kwinana) (Atmospheric Wastes) Regulations 1992 (Website)	Australia – WA

Title of document	**Origin**
- (Draft) Air emissions Guidelines (October 2019 PDF)	
- Guideline for Disposal of Waste by Incineration 2013 (PDF)	Australia – NT
- Environment Protection (Air Quality) Policy 2016 (PDF) - Enhancing resource recovery and discussing the place of energy recovery (2017 PDF)	Australia - SA
- Environment Protection (Air Quality) 2004 (PDF)	Australia - TAS
- Environmental Protection Act 1994 (PDF) - Environmental Protection (Air) Policy 2019 (PDF) - Energy from Waste Policy (2020 PDF)	Australia - QLD
- State environment protection policy (Air Quality Management) (2001 Website) - Guideline: Energy from Waste (2015 Website)	Australia - VIC
- NSW Protection of the Environment Operations (Clean Air) Regulation (2010 Website) - Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (2007 PDF) - Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016 PDF) - NSW Energy from Waste Policy Statement (2015 PDF) - The (draft) best practice air emissions limits for EFW in NSW (Draft, May 2020)	Australia - NSW

1.1 Europe Union (EU)

The ***European Union*** developed a tailored Waste Incineration Directive (2000), a comprehensive guideline for incineration that includes emissions standard, ash disposal, and monitoring techniques. The directive was adopted in Industrial Emissions Directives (2010), with modification in the compliance sector for specific emissions (Table 9-3).

Recently, the EU undertook a review of technology, limits and procedures for waste and incineration, resulting in the publication of Best-Available-Technology (BAT) for Waste Treatment (2018) and Waste Incineration (2019). Following the publication of these reference documents, EU Commission adopted the new limits and procedures as of November 2019 (European Union Directive, 2019). The limit was adopted because BAT-Air Pollution Controls (APC) and process design demonstrate the feasibility of achieving these limits. EU regulatory instruments are often adopted by other jurisdictions and were recently adopted in Western Australia for the Kwinana EFW project.

1.2 North America

The ***United States (US)*** have both federal and state environmental protection agencies. The federal Clean Air Act was established in 1963 to control air pollution at the national level. Stationary air emission sources are regulated through the Code of Federal

Regulations (CFR) part 60, whereas waste management emissions are enforced locally through:

1. National emission standards for hazardous air pollutants
2. New source performance standard
3. Waste emission rules (relevant for EFW)

The air emission standard for combustion of municipal waste is separated for large (≥ 250 tpd) and small (35-250 tpd) facilities. Although the regulations are quite rigorous, diverse, and enforced nationwide, the concentration limits are less stringent than the EU limits.

Canada has national limits for air quality index that is enforced by local authorities. Limits for dioxins and mercury emissions from incinerators have also been developed through Industrial standards. The US-Canada Air Quality Agreement (1999) was established to ensure consistent approaches to air quality management between the neighbouring region.

1.3 Asia

The ***Singapore*** National Environmental Agency have developed waste incineration standard (2000) which were updated in 2008 into a comprehensive industrial air emission standard.

In ***Japan*** the Ministry of Environment have air quality standards at the national level. For industrial emissions, a complex and convoluted reporting technique is applied, such as the K-value for SO_2 emission.

The ***Chinese*** Ministry of Environmental Protection have standards for pollution control of waste incineration. Similar to the EU and US, the standard regulates incineration performance of various sectors, including monitoring, stack height, and reporting.

1.4 Australia

The National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) developed by the National Environmental Protection Council provides a national monitoring and reporting framework for air quality standards. A comprehensive review on Australian EFW and air emissions was undertaken by WSP for the Western Australia Government (WSP Enviromental, 2013). A timeline showing the chronology of the Australian federal and NSW air emissions policy and regulation is shown in Figure 1-1.

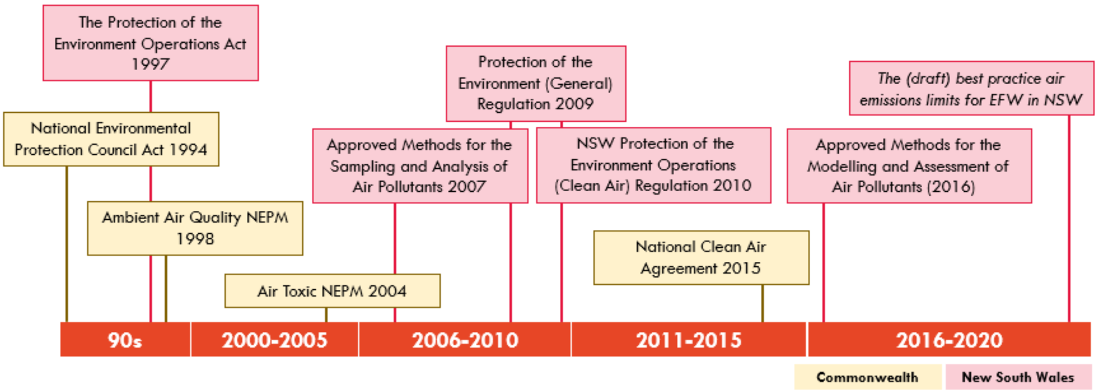


Figure 1-1: Timeline of federal and NSW air emission policy and regulation

The ***Western Australian*** Department of Waste and Environmental has developed the Air Emission Guideline (2019) which is enacted through the *Environmental Protection Regulation (1987)*. The guideline is more comprehensive than the AAQ NEPM standard with a wider range of pollutants. For the Kwinana Industrial area, *the Environmental (Kwinana) (Atmospheric Wastes) Policy (1999) and Environmental Protection (Kwinana) (Atmospheric Wastes) Regulations (1992)* were established to regulate SO_2 emissions.

The ***Northern Territory*** Environmental Protection Authority's (EPA) Waste Incineration Guideline (2013) is the first tailored guideline for waste incineration in Australia. The allowable air emissions concentration was adapted from various regulations, namely:

1. EU Waste Incineration Directive (2000)
2. Victoria State Environment Protection Policy (2001)
3. NSW *Protection of Environment and Operation Act (1997)*

The ***South Australian*** Environmental Protection Authority's (EPA) Air Quality Policy (2016) provides standards for Ground Level Concentration (GLC) and stack emissions allowable concentration.

The ***Queensland*** Department of Environment and Science also has an Air Quality Policy (2019). Their limit value of ambient air concentration is less stringent than WA's air emission guidelines.

The ***Tasmanian*** Department of Tourism, Arts and Environment's Air Quality Policy (2019) acknowledges the NEPM Ambient Air Quality standard and incorporates both design limit criteria and in stack concentration limits.

The ***Victorian*** Environmental Protection Authority (EPA) established the Air Quality Management Policy (2001). The Policy acknowledges the AAQ NEPM; however, it sets air emission limits for various types of stationary sources of air pollution including air quality in control regions (Port Phillip and Latrobe Valley).

The ***New South Wales*** government established the Clean Air Regulation (2010) and the Environment Protection Authority (EPA) released the NSW Energy from Waste Policy Statement in 2015. *The (draft) best practice air emissions limits for EFW in NSW* reflect

NSW requirements that must be met at a minimum under the Clean Air Regulation as well as use of best practice air emission controls. The NSW air emissions regulatory framework is more diverse, stringent, and comprehensive compared to other Australian states air emission management frameworks.

1.5 Commentary on set air emissions limits

Table 1-2 provides a summary comparing NSW *(draft) best practice air emissions limits for EFW in NSW)* against international limits. **In comparison to other limits nationally and internationally, and the given averaging period and compliance limits, the NSW EPA limits are the most stringent in 8 out of 10 pollutant categories.**

The EU Industrial Emission Directive (2010) limit for hydrogen fluoride (HF) is set at 4 mg/m^3 while the NSW EPA draft limit is less stringent at 5 mg/m^3. From a practical standpoint, EU Reference document reported that out of 81 monitored MSW-EFW plants, most of them monitor their HF emission at 0.6 mg/m^3, with the exception of 6 plants reporting emissions between 1 – 4 mg/m^3 (Neuwahl et al., 2019).

Compared to the EU Directive (2019), *the (draft) best practice air emissions limits for EFW in NSW* is less stringent for every type of heavy metal pollutant. The new EU limits are 0.04 for mercury, 0.02 for cadmium and thallium and 0.1 mg/m^3 for total heavy metals. From over 200 surveyed EFW lines (Neuwahl et al., 2019), the following was found:

- Mercury: All EFW emitted <0.025 mg/m^3 of mercury pollutant.
- Cadmium and thallium: 190 EFW lines generated emissions <0.02 mg/m^3, with the exception of 6 EFW lines that generated 0.02-0.1 mg/m^3, and 1 EFW line that generated more than 1 mg/m^3.
- Total heavy metal: 199 EFW lines generated emissions <0.3 mg/m^3, with exception of 6 EFW lines at 0.3- 0.5 mg/m^3.

Moreover, a comparison study has verified that new large scale EFW can swiftly adjust to the EU Directive air emission limits, including expected future amendments for more stringer environmental regulation (Neuwahl et al., 2019).

Conclusion 1 – Best practice air emissions limits

In comparison to other limits nationally and internationally, and at given averaging periods and compliance limits, the NSW EPA limits are the most stringent in 8 out of 10 pollutant categories. The two categories where the proposed NSW best practice limits are less stringent are hydrogen fluoride and heavy metals.

Recommendation 1 – Best practice air emissions limits

The concentration limits:

- 4 mg/m^3 for hydrogen fluoride (as hourly averaging) (from currently proposed 5 mg/m^3),
- 0.04 mg/m^3 for mercury (from proposed 0.05 mg/m^3),
- 0.02 mg/m^3 for cadmium and thallium (from proposed 0.05 mg/m^3), and
- 0.3 mg/m^3 for total heavy metal (from proposed 0.5 mg/m^3).

should be adopted by NSW so as to be equal to the 2019 EU Directive.

Table 1-2: The summary from Appendix 1 illustrating the best practice in air emissions limits from international jurisdictions alongside the NSW draft 2020 limits; A comparison in the right column is made in colour code: Green = NSW most stringent (or equal), Red = NSW not most stringent; Grey = no NSW standard (all limits in mg/m^3 unless stated)

Pollutant	Averaging period	EU Directive 2010 (100% compliance)	EU amendment per BAT reference document	China Waste incineration Policy 2014	US Waste combustion guidelines 2006	NSW Draft 2020	The Most stringent?
Total solid	0.5-1 hour	30	-	30	-	**20**	🟩
	24 hours	10	**2-5**	20	16*	-	▨
Gaseous organic	1 hour	-	-	-	-	**20**	🟩
	24 hours	-	**3-10**				▨
Chloride and compounds	0.5-1 hour	60	-	60	-	50	🟩
	24 hours	10	**2-7**	50	32*	-	▨
Fluoride and compounds	0.5-1 hour	**4**	-	-	-	5	🟥
	24 hours	**1**	**1**	-	-	-	▨
Mercury	0.5-8 hours	0.05	**0.01-0.04**	0.05	0.04*	0.05	🟥
Heavy metals (total)	0.5-8 hours	0.5	**0.3**	1	(lead) 0.1*	0.5	
Cadmium and thallium	0.5-8 hours	0.05	**0.02**	0.1	0.01*	0.05	
Sulphur dioxide	0.5-1 hour	200	-	100	-	**100**	🟩
	24 hours	50	**40**	80	67	-	▨
Nitrogen oxide	0.5-1 hour	400	-	300	-	**250**	🟩
	24 hours	200	**150**	250	240*	-	▨
Dioxins	6-8 hours	0.1 ng/m^3	**0.01-0.1 ng/m^3**	0.1 ng/m^3	10 ng/m^3*	0.1 ng/m^3	🟩
Carbon monoxide	10 min	150	-	-	-	-	▨
	30 min	100	-	-	-	-	
	1 hours	-	-	100	-	**80**	🟩
	4 hours	-	-	-	49-146*	-	▨
	24 hours	50	**50**	80	98-244*	-	
Ammonia	24 hours	-	2-10	-	-	**5**	🟩

* Indicate that the limit has been converted into 273 K, 101.325 kPa (1 atm), 11% O_2

2 Air emissions limits best practices

A review of *the (draft) best practice air emissions limits for EFW in NSW* is presented in this section. It covers technical aspects related to emissions monitoring including averaging periods, allowable exceedances, the range of pollutants covered, single versus dual limits, and aspects of continuous monitoring. Commentary is made in comparison with air emissions regulations and standards in other jurisdictions.

2.1 Averaging Period

By the nature of the Continuous Emission Monitoring System (CEMS), continuously generated data (at minutes or seconds intervals) is reported as averages, such as half-hourly, hourly, or daily. A ***periodical averaging (0.5 -1 hour)*** will result in a higher frequency of fluctuations. In contrast, ***daily averaging*** would dampen the fluctuation, making it feasible to adopt a lower limit. Higher limits are usually set for hourly (shorter) averaging periods as opposed to lower limits for daily (longer) averaging. Jurisdictions may adopt single or dual averaging periods as their standard. A comparison of the two averaging periods is provided in Table 2-1.

Table 2-1: Comparison of different averaging periods

Compliance at:	Advantages	Disadvantages
Periodical Averaging (1 hr)	- Captures more variance and ensures consistent reporting. - A more stringent approach. - Thorough protection against air emission. - Captures EFW performance accurately, including small short-term peaks.	- Only suitable for NOC. - The set limit has to consider short-term spikes that are negligible in daily averaging. - Requires external standard for OTNOC.
Daily Averaging	- The emission variability is dampened, allowing a lower limit to be used. - OTNOC fluctuation can be regulated as allowable discarded data. - Can be easily tightened in the future. - Encourage more advanced APC.	- Disregards more data and fluctuations. - Does not show the full performance, i.e. less accurate. - Having this as a second limit may baffle the public and industry.

An ***hourly (periodical) averaging limit*** acts as a singular protective measure to limit the emissions of an air pollutant. It is a more stringent approach than the longer daily averaging period; it incorporates shorter-term fluctuations and captures possible exceedances at narrower timeframes. However, this limit is most practical for normal operating conditions (NOC), where operational steady-state results in smaller deviations in emissions and limited '*spikes*'. During Other Than Normal Operating Condition

(OTNOC) larger deviations and more outliers will occur, making the shorter averaging limits less applicable to OTNOC.

A ***daily averaging limit*** adds a second layer of stringency. More data points are available to calculate the limit, thus dampening averaged short period 'spikes'; and a lower emission limit can be adopted, to ensure an effective APC system under NOC. This lower daily averaging limit will promote the adoption of a more advanced APC systems to meet this lower emission limit (Stantec Consulting, 2011).

The ***Chinese*** and ***EU*** standards have half-hour/hourly and daily averaging limits averaged for continuous monitoring (and at 10-minutes for carbon monoxide in the EU). Other jurisdictions (**Singapore and other Australian states)** have not adopted daily averaging limits, while others (**United States**) advise against adopting daily averaging limits alone as they are less accurate. *The (draft) best practice air emissions limits for EFW in NSW,* currently only lists the hourly averaging limit.

The effect of averaging can be demonstrated by analysing data from a facility in Dublin, Ireland. Published half-hourly averaged data (the raw continuous data was not accessible to us) was taken for one pollutant, carbon monoxide, from Boiler 1 and Boiler 2 over a 10-day period of NOC. The data is presented graphically (Appendix 2: Illustrative Emission Example, Figure 10-1), to illustrate the concept of averaging. The EU limits for both half-hourly and daily averaging limits are presented along with the NSW hourly limit as horizontal dash lines. During the example period, the EU half-hourly averaging hour limit was breached twice by the half-hourly averaged trends, but most of the half-hourly averaged data remains below even the more stringent EU daily averaging limit (50 mg/m^3). Lowering the half-hourly limit to the level of the daily limit will lead to higher frequency of short-term spikes being captured, which translate into more breaches (10 breaches for this example case).

The half-hourly data was then taken and averaged to hourly and daily periods (Appendix 2: Illustrative Emission Example, Figure 10-2). This results in the flattening of the line with less fluctuations. Therefore, the adoption of a daily averaging limit hides fluctuations that are caused by the EFW facility's performance. Daily averaged data shows that the majority of a facility's steady-state air emissions data can fall in a range lower than the more stringent daily averaging limit (accounting for existing and future APC systems), and below the hourly averaging limit being set at higher levels. The half-hourly averaging of the data reduces the magnitude of the spikes, effectively flattening the trend, but to an extent lesser than that of the daily averaging.

Setting dual limits (both hourly and daily averaging limit) addresses both NOC (steady-state) which captures the facility's performance at a higher resolution, while also creating an understanding that overall air emission should be lowered through daily limits. Only setting an hourly averaging limits at the higher level may not be the most stringent approach as it means a facility may operate near that higher limit more frequently and exploit the trend of the flattening effect of averaging. Also, having a (second) daily averaging limit creates a safeguard to limit the facility from operating more frequently near the higher hourly limit and OTNOC.

A daily averaging limit allows jurisdictions to recognise advances in technology, such as APC systems, encouraging innovation and emissions reductions on the long-term basis (in pursuit of 'zero emissions'). Since the short-term spike is dampened, it gives the opportunity for jurisdictions to employ even lower limits, while being reasonable with the OTNOC and the anticipated short-term spikes. This can be seen from EU's recent adoption of daily averaging limits, where past acknowledgement of daily averaging limit promoted the trend to install more advanced APC technology. This resulted in their recent finding that the EFW daily averaging limit can be tightened, which has been enacted as a regulation (European Union Directive, 2019).

Having a single averaging limit still allows jurisdictions to pursue stringency by tightening that single limit following a periodic review of data in conjunction with emerging APC, CEMS and statistical process control (SPC) technologies. Employing a single limit has a key advantage of being a simple measure that is easy to interpret and implement.

Conclusion 2 – Averaging periods for emissions limits

Each averaging limit serves a different purpose. The ***periodical (hourly) averaging limit*** acts as a protective measure that monitors possible breaches from EFW facilities on an hourly frequency. However, employing a low concentration limit at hourly averaging periods leads to more frequent breaches observed though short-term spikes that are resolved promptly.

The presence of a ***daily averaging limit*** will dampen the short-term spikes significantly, allowing jurisdictions to employ a lower concentration limit, promoting the notion that long-term future emissions will be at lower limits. This may create a trend within the EFW industry to install more advanced APC systems.

Moreover, jurisdictions such as EU and US utilise a daily averaging limit as a governing approach during other-than-normal operating condition (OTNOC), through allowable discarded data. This approach allows air emissions during OTNOC to be controlled and included in the regulation.

NSW hourly averaging limits can be as stringent as other jurisdictions that use dual averaging limits, provided that (1) the OTNOC is accounted for and (2) hourly averaging limits are regularly reviewed and tightened as much as possible. Greater stringency comes from monitoring at more frequently (hourly) averaging of the data. However, a daily averaging limit, being lower than the hourly limit, places an EFW facility at near-optimal performance (i.e. below the lower daily averaging limit) and on a trajectory of continuous upgrading in terms of installing more advanced APC systems as part of continuous plant upkeep and long-term plant improvements. At the same time, introducing two averaging limits will increase reporting complexity and may introduce industry confusion, as it is accustomed to single averaging limits.

Recommendation 2 – Averaging periods for emissions limits

It is recommended that

(a) NSW continues to employ a single hourly averaging limit
(b) the regulator maintains the stringency of allowable emissions over time by tightening hourly averaging limits under a reviewed and well-studied schedule (as real plant data becomes available, and in line with evolving technologies)
(c) the regulator continues to review the value of adopting a second tighter daily averaging limit in the future, to signal to the EFW proponents and operators that they must consider installing the highest performing APC technologies.

2.2 Exceedances of limits

2.2.1 Allowable Exceedances

Allowable exceedances may be incorporated to: (1) regulate exceedances due to malfunctions and emissions variability (realistic expectation to exceed) or (2) govern start-up and shutdown periods through allowable data omissions (in the case of continuous monitoring). For example, a German EFW facility explicitly acknowledges that exceedances only occur due to malfunction and start-up/shutdown (OTNOC) (Steag, 2019). This implies that OTNOC should be considered in the policy as these conditions represent the active source of BAT-APC air pollutants from EFW facilities.

Note that the definition of OTNOC may differ between jurisdiction. ***EU and US*** acknowledge malfunction, maintenance, start-up, and shutdown. ***EU*** provides flexibility for malfunction and maintenance as a discarded data, while allowing total omission during start-up and shutdown, where the cumulative duration of such condition shall be less than 60 hours per year. ***China*** follows the ***EU*** standard which requires EFW facilities to not operate for more than 4 hours uninterrupted. In contrast, ***US*** grouped malfunction, maintenance, start-up, and shutdown as an overall discarded data; however, their cumulative duration of such condition is stricter than *EU,* where only 3 hours of data omission is allowed. They also explicitly require EFW-facility to report all discarded data and the reason for discarding data to the authority. This leniency is only true for pollutants that are continuously monitored. In the case for Carbon Monoxide (CO), where it directly reflects the combustion process, significant fluctuation can be expected. Different leniency was employed, ***EU*** allows 97% percentile for CO daily average, while ***US*** allows data omission in the case of malfunction, limited to 15 hours per occurrence. ***New South Wales*** requires 100% compliance without allowing any data omissions, which stands out as the most stringent requirement internationally. However, neither *the (draft) best practice air emissions limits for EFW in NSW* nor The Clean Air Regulation (2010) highlight any technical requirement during OTNOC. While the document does not emphasize the technical requirement, Section 128(2) of POEO Act states that *any plant must carry on any activity by such practicable means as may be necessary to prevent or minimise air pollution.*

Table 2-2 shows the full comparison of approaches to managing allowable exceedances between ***EU, US***, and ***NSW*** jurisdictions. Other reviewed jurisdictions do not highlight the allowable exceedances, assuming the standard limit is entirely achieved (100%). This is possibly because the non-strict limit can be conveniently met even during OTNOC.

In general, there are no direct best practice or standardised method for OTNOC. Instead, jurisdictions employ a range of measures to allow flexibility within the established standard, including allowing '*reasonable expectation*' during OTNOC. This complexity may cause some confusion as being the 'most stringent' is not simply having the lowest emission number nor 100% compliance. The whole-package of measures must be understood when reviewing the feasibility of air emission standards and monitoring outcomes.

Conclusion 3 – Allowable exceedances

Allowable exceedances may be established to acknowledge the inevitable emissions exceedances during OTNOC. Note that some jurisdictions acknowledge maintenance and malfunction as OTNOC, while NSW only recognises start-up and shutdown.

The (draft) best practice air emissions limits for EFW in NSW is the most stringent with its 100% requirement during NOC. However, it does not specifically address regulation relating to OTNOC. Currently, Cl 56 of the Clean Air Regulation provides exemptions relating to start-up and shutdown periods.

Overseas jurisdictions provide some flexibility within their requirements for OTNOC through data omissions and different compliance techniques.

While it is possible to review other countries' approaches to regulate for OTNOC, it is not ideal for NSW to simply adopt their approach as this flexibility is tailored for others' specific standards.

Recommendation 3 – allowable exceedances

NSW maintains the 100% compliance requirement for NOC, as it is the most stringent requirement possible.

For the purpose of governing start-up, shutdown and maintenance periods (i.e. OTNOC), it is recommended industry be required to provide regulators with a management plan to control emissions during OTNOC periods, and to monitor and report emissions data for OTNOC periods.

It is recommended industry reports on OTNOC periods and these data are used to review allowable exceedance requirements.

Table 2-2: Summary of compliance and flexibility for the established jurisdictions.

	European Union [1]	**United States** [2]	**New South Wales** [3,4]
Normal operating condition	- (CM) Meet either limit (100% or 97% limits) for half-hourly averaging value (normal condition only) - (CM) None of the daily averaging emissions exceeds the limit (to obtain valid daily average, see next row) - None of the dioxins and heavy limits exceed. - (For CO) 97% of daily average and 95% of 10 min-average values do not exceed the limit - Not to operate for more than 4 hours uninterrupted when emission limit value is exceeded. The cumulative of exceedances shall be less than 60 hours per year.	- (CM) Meet the concentration limit. - (CM) Data must be available for ≤90% of the hours per operation/quarter year and ≥95% of the hours of operation/year - To acknowledge emission variability, they use percentile, allowing emissions variability to exceed up to one day per year (99.7%). - Flexibility in annual testing rate, providing flexibility for industry to test the facility when facing scheduled or unscheduled outage.	- (Draft) Requires 100% compliance (at NOC), meeting the limit using the approved testing method.
Start-up/ Shutdown/ Malfunction/ Maintenance	- Waste incineration shall reach and operate at >850°C - Half hour, daily, and 10 min averaging limit do not apply to start-up and shutdown (if no waste being incinerated) - (CM) To obtain a valid daily averaging, no more than 5 half-hourly data to be discarded due to malfunction or maintenance. - (CM) No more than 10 daily average value (per year) shall be discarded due to malfunction of maintenance.	- Compliance exclude start-up, shutdown, or malfunctions, but still requires monitoring and explanation to the authority of such data exclusion. These periods are limited to 3 hours per occurrence. - (For CO) malfunction results may be omitted from compliance calculation, limited to 15 hours per occurrence.	- (POEO) The standard limit of air emission does not apply to the start-up and shutdown period. - (POEO) *"the occupier of premises must operate such practicable means as may be necessary to prevent or minimise air pollution if neither of standard of concentration has been prescribed."*
Other flexibility	- Competent authorities may set less strict limits if assessment shows that the BAT limit would lead to disproportionately higher cost compared to environmental benefits due to location, local environment, and technical installation (Article 1 (15-22)) (WSP Enviromental, 2013).	- Smaller scale EFW follows less stringent limits. - USEPA recognised plant wide applicability limits, allowing a flexible air permit that is designed to accommodate rapid changes in response to market (USEPA, 2017).	*No other flexibility reported*

CM = Continuous Monitoring; CO = Carbon Monoxide.

Source:

[1] EC-European Commission. (2010). Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). *OJ EU, L*, 334(17.12), 2010. Annex IV: Technical provision relating to waste incineration plant and co-incineration plants. Part 8: Compliance

[2] US EPA (2006). Large Municipal Waste Combustors (LMWC): New Source Performance Standards (NSPS) and Emissions Guidelines. 40 CFR Part 60, 27323-27348

[3] (Draft) Energy from Waste: Report from the NSW Chief Scientist & Engineer, May 2020. NSW, Australia.

[4] NSW EPA (2010) Protection of the Environment Operations (Clean Air) Regulation 2010. *Schedule 4 – Standard of concertation for schedules premises: general activities and plant.*

2.2.2 Conditional (Percentile) Limits

The ***European Union*** is the only jurisdiction that provides 97% and 100% dual limits to be met for half-hourly averages over a year, tightening the concentration limit for the 97%. This method provides options for the industry to meet either requirement at half-hourly stage.

This approach is possibly to cater for smaller scale EFW facilities, where the inconsistency of incoming waste will result in a more severe emissions fluctuation. For example, a review study reported that MSW combustion should process at least 50,000-100,000 metric tonnes annually of combustible waste for economic feasibility; for which waste should be between 7-8 MJ/kg and should never fall below 6 MJ/kg (Qazi et al., 2018) . The high capital investment needed along with the requirement to use BAT-APC system created a trend for centralised large-scale EFW (Yassin et al., 2005).

BAT-APC may constrain breakeven costs and result in less energy to be sold to the grid. This challenges the economic feasibility of small scale EFW. This is acknowledged by EU, where authorities may set less strict limits if assessment shows that the BAT limit would lead to a disproportionately higher cost compared to environmental benefits due to location, local environment, and technical installation (WSP Enviromental, 2013). In contrast, experts believe that other 'cleaner' EFW technology such as MSW gasification may allow smaller scale EFW to be implemented as it cuts APC-related costs (Arena, 2012).

Hence, the less stringent 97% may be implemented to support smaller EFW, disregarding the 3% data while still being compliant.

Other studies viewed the 97% or 100% dual compliance limits as a 'realistic expectation' of short-term spikes and expected breaches, which are unavoidable when waste streams are constantly changing, this reasoning similar to allowable exceedances above (Stantec Consulting, 2011).

The ***United States*** acknowledges emission variability through percentiles, allowing 99% percentile for estimating emission limit while 99.7% percentile for Continuous Emissions Monitoring System (CEMS), or about one day per year. Nevertheless, USA only provides one limit and the 99.7% percentile is their flexibility for 'reasonable expectation'.

New South Wales requires 100% compliance.

Conclusion 4 – Two conditional (percentile) limits

As with two averaging period limits and allowable exceedances, conditional limits by EU provides a flexibility in the interest of OTNOC and '*reasonable expectation*'.

A study estimated that some facilities may only be able to comply to the limits 97% of the time. It is also speculated that the limit may benefit smaller and rural scale EFW due to difficulties in complying with the 100% limit, allowing 3% of monitored data to be omitted (on top of allowable exceedances).

Smaller scale EFW will process less waste, ergo less gate fee and net-energy revenue. Thus, installing a lengthy APC system may cause even more economic constraints as it will increase a plant's energy consumption, reducing available energy to be sold.

Nevertheless, EU has an established EFW industry, varying in geographical location, size, plant age, and locals' demands. Thus, EU's EFW standard evolved to provide greater flexibility to accommodate the diversity in the EFW industry.

It is too early to conclude whether having two emissions standards (percentile limits of 97% and 100%), will be practical to support smaller and rural EFW in NSW, as there is no history of such operations in NSW.

Recommendation 4 – Two conditional (percentile) limits

NSW retain the requirement of 100% compliance.

Undertake a review once EFW operations in NSW have been operating for 3 years.

2.3 Pollutant Monitoring

The (draft) best practice air emissions limits for EFW in NSW is the most comprehensive regulation in terms of type of pollutants. It acknowledges diverse types of pollutants, including uncommon heavy metals (as total metal), hydrogen fluoride, VOC, and ammonia. The NSW EPA have captured all pollutant types that have also been covered by other jurisdictions.

The (draft) best practice air emissions limits for EFW in NSW does not reference the smoke and opacity (%) of gaseous emissions, unlike the Clean Air Regulation (2010) which sets limits at 1 Ringelmann (smoke) and 20% (opacity). Nevertheless, the Clean Air Regulation limits should be met by EFW facilities if the other air emissions limits are met, as smoke and opacity are reflected through a combination of the various pollutants, such as CO and PM. Hence, it can be said that smoke and opacity limits are incorporated in monitoring the overall dust pollution, which should be addressed through continuous monitoring of total dust.

This can be seen where most tailored air emission standards do not require opacity monitoring (***EU, US (large scale***), and ***NT***), with exception of ***China*** and ***US (small scale)*** that require opacity to be monitored. Opacity monitoring requirement is often included in air emission standard that covers a wide type of stationary air emission sources. While opacity monitoring does not deliver a clear benefit as it does not address a specific pollutant, for completeness the Clean Air Regulation opacity limit should be included in *the (draft) best practice air emissions limits for EFW in NSW*.

In the case of PM, monitoring techniques (for stationary sources) that distinguish pollutant by size (PM10 and PM2.5) are riddled with technical measurement challenges. Thus, jurisdictions such as ***EU, US***, and ***China*** employ the total solid limit as Total Dust or Total PM, omitting the requirement for size monitoring (elaborated below in 2.4 Continuous Monitoring).

Conclusion 5 – Pollutant monitoring

The (draft) best practice air emissions limits for EFW in NSW is the most comprehensive standard in terms of types of pollutants covered. The limits for smoke and opacity, required in other jurisdictions, are not mentioned in the draft, however, these are covered by the *POEO Clean Air Regulation (2010)* through monitoring of overall particulate matter and total dust. The smoke and opacity limits are incorporated to monitor the overall particulate matter, which should also be addressed through total dust continuous monitoring.

Recommendation 5 – Pollutant monitoring

For completeness, the *POEO Clean Air Regulation (2010)* limits on smoke and opacity should be explicitly re-mentioned in *the (draft) best practice air emissions limits for EFW in NSW*, which is 1 Ringelmann (Smoke) and 20% (Opacity).

2.4 Continuous Monitoring

The (draft) best practice air emissions limits for EFW in NSW adopts a continuous monitoring approach for the same pollutants as those in the ***EU, US*** and ***China***. These pollutants are Total Particle (Solid), Total organic carbon (TOC), NOx, CO, HCl, HF, and SO_2. A complete review is provided in Appendix 1 (Table 9-3), and a summary is presented in Table 2-3. Emerging techniques for important pollutants are briefly discussed below.

Total Solid, HF, and HCl – While *The (draft) best practice air emissions limits for EFW in NSW* and the NSW EPA EFW Statement clearly outlined that these pollutants will be monitored continuously, the Clean Air Regulation and *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (2007)* may require updating for overall consistency.

Particulate Matter (PM) - *The (draft) best practice air emissions limits for EFW* evaluates the PM pollutants through total solid continuous monitoring. In general, stack testing only monitors PM as total solid without recognising the size distribution (PM50, PM10, or PM2.5). Although in some circumstances it is important to identify the size of PM (Brinkmann et al., 2018), difficult monitoring techniques and PM size distribution result in an inability to enact limits/standard for PM emissions from point sources according to size.

For example, ISO-23210 is a standard to identify PM size at the stack. However, the technique is not as continuous nor accurate compared to the other PM monitoring techniques. ISO-23210 is not applicable when expected flue gas is saturated with water or mostly consists of PM10, and/or to monitor total solid concentration in the stack. A comparative review of various PM monitoring devices in exhaust gases is provided by (Castellani et al., 2014). Method 201A is the USEPA methods, yet it also faces similar difficulties (USEPA, 2020).

Mercury – EU Directive notes that continuous monitoring of mercury using Atomic Absorption Spectrometry (AAS) or Atomic Fluorescence Spectrometry (AFS) is feasible. However, these methods do not detect the particulates-containing-mercury (i.e. mercury hiding in dust) and samples will need to be conditioned for mercury salt detection. Hence, it can be said that mercury continuous monitoring still requires some advancement before adoption.

While the newly established EU Directive suggests monitoring mercury continuously, it also acknowledges that EFW facilities that process mono-stream of waste with a controlled composition (i.e. proven with low and stable mercury content), may be excluded from continuous monitoring. The technical difficulty of mercury continuous monitoring is only worthwhile when EFW facilities process feedstock that are proven to have high or unknown levels of mercury, such as e-waste or multiple streams of uncharacterised waste.

Hence, considering the complexity and cost of continuous monitoring for mercury, it is advisable to retain the periodical monitoring instead. In addition, the EU Directive suggests the possibility of replacing continuous monitoring of mercury with sorbent trap sampling method, which is also able to detect particulates-containing-mercury (Brinkmann et al., 2018).

Ammonia is introduced to the flue gas stream when SCR or SNCR is installed in the plant. Where the NOx pollutants undergo the following reaction:

$$NO_x + NH_3 \rightarrow H_2O + N_2$$

Unreacted ammonia may contaminate the gas stream; hence, it is important to monitor this compound. Nevertheless, due to the SCR/SNCR being a newer process to be installed in EFW processes, the emission monitoring technique should be devised on a case-by-case basis, considering the EFW unit size and effectiveness. Continuous monitoring techniques exist for ammonia.

Dioxins – NSW EPA standard and EU Directive differ on the testing frequency, where NSW EPA allows for monitoring at a rate of 2x/year (through approved methods), while EU best practice reference recommends 1x/month of long-term sampling (using continuous sampler, ~4 weeks) and 2x/year for short-term sampling.

EU Directive studied 142 EFW lines in France and Belgium (Annex 8.9) and concluded that overall, readings of short-term vs long-term dioxins sampling do not differ significantly (Brinkmann et al., 2018). Therefore, NSW adoption of 2x/year of short-term testing is appropriate for emerging EFW industry in Australia, as it ensures strict guidelines to be complied with while allowing industry to install a simpler testing method.

Conclusion 6 – Continuous monitoring techniques

From the jurisdictions and monitoring standards reviewed, the NSW requirements include all possible pollutants that can be realistically continuously monitored at this point. Thus, it can be said that NSW monitoring techniques are well positioned to deal with continuous monitoring. Meanwhile, other emerging monitoring techniques can be reviewed in the future, namely:

- The continuous monitoring technique of NH_3.
- The continuous monitoring technique for mercury, if continuous monitoring becomes more technically and economically feasible. Currently, it is more feasible to regulate the incoming feedstock to EFW rather than requiring mercury continuous monitoring.
- A more frequent dioxin testing rate, if future monitoring of the EFW industry determines significant differences between different testing frequencies.

The *NSW Energy-from-Waste Policy Statement (2015)* requires continuous monitoring techniques for NOx, CO, Total Solid, Total Organic Compounds, HCl, HF, and SO_2 to be adopted. However, the *POEO Clean Air Regulation (2010)* and *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (2007)* need to be updated for consistency in relation to continuous monitoring methods for total solid particles, HCl, and HF. It is understood that these documents are currently under review.

Recommendation 6 – Continuous monitoring techniques

The review of the Approved Methods and Regulation takes into account the EU Directive as well as other international developments. It is also recommended that:

(a) emissions data from EFW facilities are required to be made publicly accessible via an online platform.
(b) as reported emissions reflect actual plant performance, a rigorous evidence-based performance type stack testing regime is adopted for plant commissioning.

Table 2-3: Summary of Monitoring techniques of EU Jurisdiction, BAT Refence, and NSW Best practice (Draft). **Green**: Aligned with other jurisdiction and Best practice; **Orange**: monitoring aligned with the Best practice, but approved method is not. **Red**: more superior monitoring techniques exist (does not mean it is applicable)

Pollutants	**EU [2]**	**Standard/ technique (CEN or ISO) [3]**	***The (draft) best practice air emissions limits for EFW in NSW***	**Standard/ technique (NSW by USEPA) [4]**	**NSW position**
Total Solid	CM	Light attenuation or scattering	CM	Not applicable [5] TM 15: Manual gravimetric method	🟧
Total Organic Carbon	CM	FID	CM	*CEM 9/10: FTIR (VOC)*	🟩
CO	CM	FTIR, NDIR	CM	*CEM 4 - No specific technique*	🟩
NOx	CM	Chemiluminescence, FTIR, NDIR, NDUV, DOAS	CM	*CEM 2- No specific technique*	🟩
SO_2	CM	FTIR, NDIR, NDUV, DOAS	CM	*CEM 2- No specific technique*	🟩
HCl	CM	FTIR, NDIR with GFC, TDL	CM	*TM 8: Ion Chromatography*	🟧
HF	CM	FTIR, TDL	CM	*Not applicable [5]*	🟧
Heavy Metal	2x/year	ICP-MS, ICP-OES	2x/year	AAS	🟩
Mercury	CM	AAS	**2x/year**	AAS	🟥
Dioxins	2x/year	isotope dilution GC-MS	**2x/year**	GC-MS	🟥
Ammonia	CM	FTIR, NDIR with GFC, TDL	***Determined by case***	-	🟥

CM = Continuous Monitoring; AAS = atomic absorption spectrometry; DOAS = differential optical absorption spectroscopy; FID = flame ionisation detection; FTIR = Fourier transform infrared spectrometry; GFC = gas filter correlation; NDIR = non-dispersive infrared spectrometry; NDUV = non-dispersive UV spectrometry; PID = photo ionisation detector; TDL = tuneable diode laser absorption spectrometry; GC = Gas chromatography; ICP-MS: inductively coupled plasma mass spectrometry; ICP-OES: inductively coupled plasma optical emission spectrometry

Source:

[1] (European Union Directive, 2010) EC-European Commission. (2010). Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control). *OJ EU, L, 334*(17.12), 2010. Annex IV: Technical provision relating to waste incineration plant and co-incineration plants

[2] (Brinkmann et al., 2018) - Brinkmann, T., Both, R., Scalet, B. M., Roudier, S., & Sancho, L. D. (2018). JRC Reference report on monitoring of emissions to air and water from IED Installations. *European IPPC Bureau, European Commission, Joint Research Centre: Ispra, Italy*, 155.

[3] (Neuwahl et al., 2019) - Neuwahl, F., Cusano, G., Benavides, J. G., Holbrook, S., & Roudier, S. (2019). Best Available Techniques (BAT) Reference Document for Waste Incineration. *EUR, 29971*, 2020-01.

[4] (NSW EPA, 2007) - EPA, N. S. W. (2007). Approved methods for the sampling and analysis of air pollutants in New South Wales. Sydney, Australia.

[5] (NSW EPA, 2010) - NSW EPA (2010) Protection of the Environment Operations (Clean Air) Regulation 2010. *Schedule 5 – Test methods, Averaging Periods and reference conditions for scheduled premises.*

3 Evolution of APC Best Practice

Even though air emissions have been addressed through strict air emissions control and advanced cleaning techniques, the public remains sceptical about emissions from EFW facilities. Thus, it is crucial for the requirement to undergo periodic review and to drive evolution of the use of BAT-APC in EFW. Air Pollution Control (APC) or Flue Gas Cleaning (FGC) for EFW have evolved significantly; from simple fabric filters in advanced multistage processes (Figure 3-1). A comparison of various APC technique is evaluated in Table 3-1, with different EFW facilities utilising different approaches according to their facility's objectives and jurisdictional requirements.

Facilities around the world have installed state-of-the-art APC units at high capital costs resulting in reduced net-energy produced. As such, careful design and operational optimisation of APC units is important to ensure the techno-economic feasibility of the overall EFW plant.

However, advances in APC process and techniques is resulting in better cost-optimisation for EFW facilities. These APC systems and techniques are commonly adopted in more recent and advanced facilities, ones with sufficient public and private support and at a very large scale. APC systems and techniques that are mature include:

1. Advanced combustion control/operating conditions to ensure a complete burnout, such as: pressurised furnace, staged combustion, and flue gas recirculation.
2. Utilising oxygen or oxygen-enriched air for combustion that allows the furnace to operate at high temperatures (degrading carbon pollutant) while not producing NOx.
3. SNCR or SCR (and their combinations) for NOx and possibly dioxins (installed in newer EFW facilities).
4. Flue gas condensation (Reported in Amager Bakke EFW facility).

Meanwhile, other emerging (research stage) APC systems and techniques are (Neuwahl et al., 2019; Wang et al., 2005):

1. Novel absorbents (emulsion) for dioxin scrubbing.
2. Membrane technology for VOC.
3. Photolysis UV light to clean up organic pollutants.
4. Limestone sorbent injection at burner (LIMB), have not been demonstrated in EFW.
5. Combined control method of SOx and NOx, for example gas reburning and sorbent injection (demonstrated on coal fired power plants).

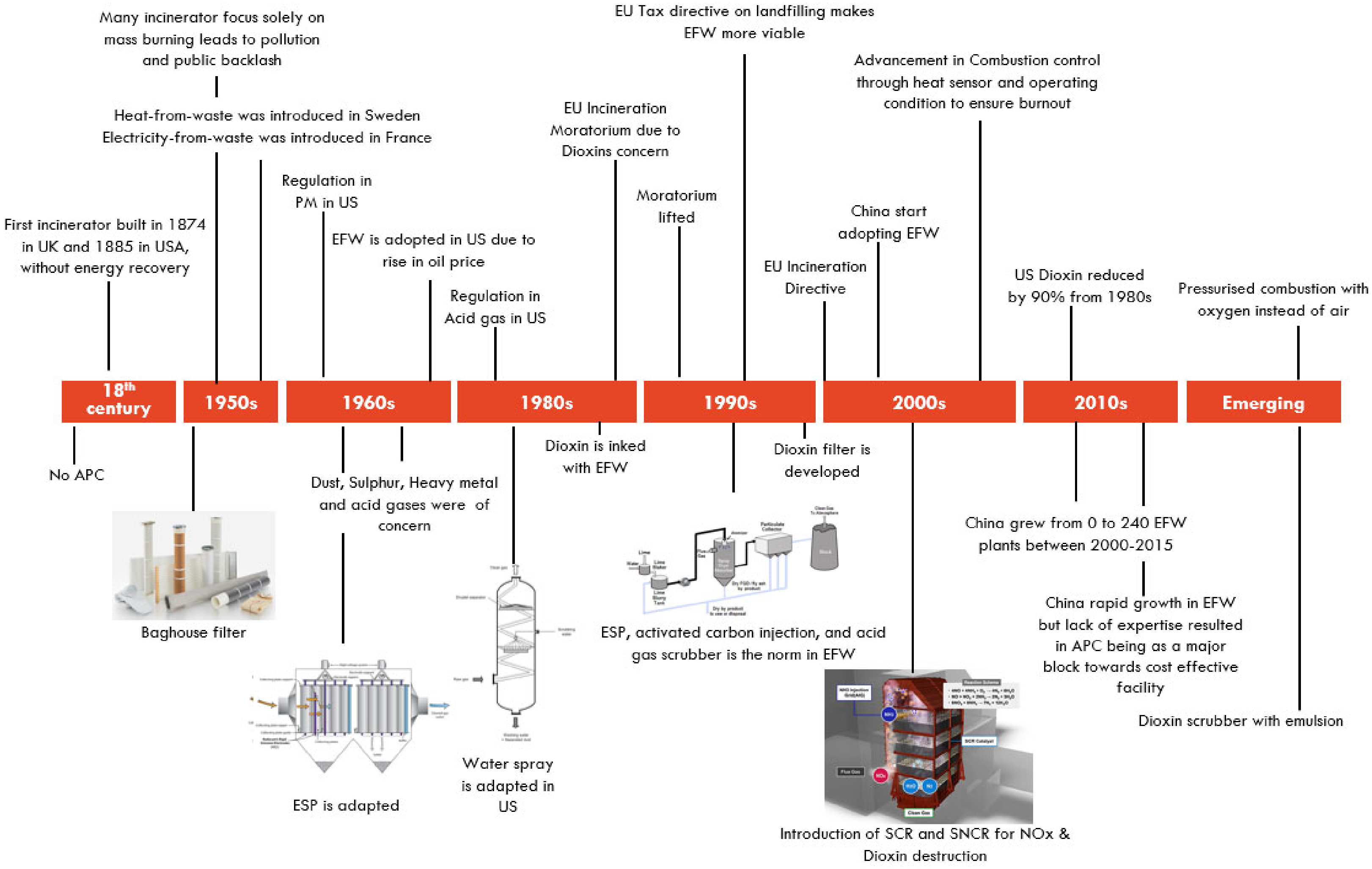


Figure 3-1: Overview of APC units adoption to EFW facility and relevant events (Correa, 2013; Makarichi et al., 2018).

Table 3-1: Overview of APC technologies (Neuwahl et al., 2019).

Objectives	**Common (Currently employed) Techniques**	**Other Techniques (less adopted)**	**More recent technologies**
Dust emission reduction	- Dry ESP - Baghouse filter	- Wet ESP - Condensation ESP - Cyclone	- Ionisation wet scrubber - Venturi Scrubber
Acid gases emission reduction (SO_2, HCl, and HF)	- Semi-wet scrubber (caustic slurry) - Wet scrubber (caustic solution)	- Dry adsorption	- Direct desulphurisation by absorbent injection to combustion chamber
Nitrogen oxide emission reduction	- At furnace: ○ Air supply restriction ○ Lower temperature ○ Homogenisation - Flue gas recirculation - Injecting ammonia to produce N_2 and H_2O; whether it is at high temperature (SNCR) or with catalyst (SCR)	- Natural gas injection (reburn) - Injection of water into flame	- Both SCR and SCNR instalment - Staged combustion - Oxygen or oxygen-enriched air for combustion
Mercury emission reduction	- Adsorption with activated carbon	- Adding oxidants (transforming elemental Hg into ionic HgS) and removed via wet scrubber	
Other metals emission reduction	- Adsorption with activated carbon - Oxides removed via dust removal		
Organic carbon emission reduction	- Adsorption with activated carbon	- Adsorption via bed filter of: Activated coke or carbon-impregnated plastic - Catalytic Filter bag	- Rapid cooling of flue gas - Emulsion based scrubber

SCR: Selective Catalytic Reduction; SNCR: Selective Non-Catalytic Reduction; ESP: Electrostatic precipitator

3.1 International comparators on policy scheduling

EU published its Incineration Directive in 2000, where the very strict limit is later updated into the Industrial Emission Directive (2010). Amendments were made to compliance requirements and the averaging technique of various pollutants. More recently, the review of Incineration Best Practice (2019) led to the implementation of a more stringent daily averaging limit for certain pollutants. The regulatory adoption (scheduling) and therefore impacts across EU nations may vary.

China The first EFW emissions regulation was introduced in 2001 and later updated with stricter limits in 2014 (Ji et al., 2016). However, there are still disparities between the EU and Chinese limits (Table 9-1). During the adoption of stricter limits, sufficient technical expertise was not available to support the rapid growth of the Chinese EFW sector. This resulted in a lack of operating experience and low energy content of waste feedstock hindered the development of cost effective APC systems (Makarichi et al., 2018).

United States Large MSW Combustor Emission Guidelines were established as early as 1991 and constantly improved until 2007. Although advances in emission guidelines for MSW combustors has ceased, US EPA continues to publish emission guidelines for other waste management approaches. For instance, Industrial Waste Incineration Guidelines (2019), Landfill emission (2020), and Sewage sludge incineration (2016).

Various novel APC technologies are still under research while others are being rolled out for implementation, with expected reductions in emissions limits, including:

1. **Carbon monoxide**, from combustion control advancement.
2. **Nitrogen oxides**, from SCR, SNCR, or N_2 controlled operating condition.
3. **Ammonia**, from SNCR and SCR instalment.
4. **Dioxin**, from SCR, dioxin filter, or dioxin scrubber.

From other regulations, EU implement new regulation at 10-year intervals, meanwhile US constantly amend their regulation every 1-4 years (depending on new ruling). These reviews are done in the interest of public and environmental health but also address technical feasibility.

In Australia, the nascent EFW industry combined with strict standards may restrict EFW implementation due to lengthy and expensive APC costs. This scenario was experienced in China. A study reported that the strict air emission standards resulted in complicated APC units. Along with low waste calorific value, and lack of technical expertise; early EFW produced minimal net energy. Thus, EFW was not an economically favourable approach.

Nonetheless, the high EFW's Technological Readiness Level (TRL) overseas combined with Australia's decades of experience in APC techniques, in regulating emissions (from industries such as coal combustion and aluminium smelting) and market ties with Europe, China, Japan, and US (leading EFW-APC countries), it is expected that Australian EFW are able to adjust and meet strict emission requirements swiftly.

Conclusion 7 – Scheduling reviews (APC review)

Various novel APC technologies are still under research while others are being rolled out for implementation. Expected technology advances should enable future reductions in allowable air emissions. Emerging technologies, trends in international standards and operation of local plants should be closely monitored, particularly in the initial period. Future tightening/lowering of concentration limits can be expected for the following pollutants:

1. Carbon monoxide
2. Nitrogen oxide
3. Ammonia
4. Dioxins

While there are no operational EFW facilities in Australia, it is expected that the industry can adjust to the strict emission guideline swiftly, considering the high Technological Readiness Level (TRL) overseas and Australia's decades of experience in APC techniques and in regulating emissions from other industries.

Recommendation 7 – Scheduling reviews (APC review)

An initial review of best practice air quality emission limits for EFW plants should be undertaken within 3 years, followed by reviews at 5-yearly intervals. The latter appears consistent with the rate of APC evolution and commercialisation. Review reports and updates should be made publicly available.

4 Adaptation of EFW technology to variability in waste streams

Currently, the world is witnessing a rapid increase of waste generation due to population growth and urbanisation. Zero-waste-to-landfill policies are being rolled out by industry very broadly. The inconsistencies and heterogeneity inherent in MSW have been proven to be major obstacles in waste management, and have led to the emergence of technology such as EFW. MSW compositions and volumes vary regionally and seasonally. This section evaluates the capabilities of EFW to cope with the future waste variability.

4.1 Waste Variability

Like any industry, feedstock security is crucial for the ongoing operation of EFW facilities. NSW data from the National Waste Report 2013-2018 (Pickin et al., 2018) was extracted and extrapolated to forecast future waste generation and destinations. Various methods of forecasting were applied (See Appendix 3). From historical data, it can be expected that overall NSW waste generation as well as recycling rates will increase, while disposal (landfill) will decrease (See Figure 4-1). It is important to note that these data and subsequent forecasts do not take into account the impact of the Chinese waste imports ban which predated the introduction of the *Circular Economy* policy by the NSW EPA (NSW EPA, 2019).

In the NSW context, it can be expected that there will be a rise in quality recycling, due to sophisticated facilities more effectively separating incoming waste. Arguably, a portion of waste will be suitable for EFW as an alternative to landfill, because not all materials are recyclable (due to theoretical recycling limit or contamination).

Thus, the rise of quality recycling may support EFW, as more consistent composition, albeit mixed and/or contaminated, will be available. However, increasing recycling capabilities will reduce the volume destined for EFW. More fluctuating volumes for EFW feedstock may result in more start-up and shutdown periods that will interfere directly with the process and possibly cause more air emission to be emitted.

Consistent with the principles of the waste management hierarchy detrimental feedstock competition should be avoided. During design stage, proponents should be required to demonstrate that their facility is not 'over-designed' throughout its expected operation time. This will avoid future waste 'lockdown' for EFW and support higher order waste management.

Broad waste classes may be used to describe waste streams including organic and inorganic, solid, liquid, hazardous and so on. Aside from waste volumes, the variable nature of waste feedstock is tracked by its composition. More homogeneity in waste results in higher predictability of waste properties. In NSW, the existing Waste Classification Guidelines (2014) have been developed to assist waste generators in classifying the waste they produce. The responsibility of classifying the waste belongs to the waste generators themselves (NSW EPA, 2017). In terms of EFW, the NSW Waste Classification Guidelines (2014) classifies MSW as non-putrescible and putrescible and does not address the combustibility nor recyclability for materials in MSW. This is important for ensuring only appropriate waste inputs are used in EFW operations.

Although the Sch 1 POEO Act defines the eligible fuel (waste) for EFW facilities, the document does not refer to the NSW Waste Classification Guidelines (2014), which influences the incoming waste into EFW. The Guidelines on the other hand may require updating to reflect on emerging EFW industry especially in terms of waste quality and combustibility. This can be done through a frequent review that maps waste classifications across the two documents in the context of EFW as a recovery method. This recognises the recyclability and quality of the material, diverting it from landfill whilst also identifying the complimentary support EFW adds to the recycling industry. This approach is taken by China and Japan where waste classification identifies the EFW opportunity (combustibility) from MSW Streams (Wen et al., 2014).

Generally, understanding waste variability through periodic reviews will support plant operational optimisation. The relationship between waste variability and sorting on air emissions is unclear as evidence for feed affecting to emissions is lacking from overseas operations. Moisture content carried in with waste presents a problem and directly influences the heating value and the combustion process, where it previously outlined that waste should be between 7-8 MJ/kg for a feasible process (Qazi et al., 2018). Thus, incoming waste into the facility should be evaluated by composition and moisture content. Moisture content has been resolved through a pre-heating step (moving grate), but causes efficiency reductions of EFW plant. Such efficiency reductions may restrict these plants from being classed as being suitably fit as a method for energy recovery. It should be the responsibility of EFW facility operator to ensure consistency of feedstock and to ensure it respects the waste management hierarchy.

The extent to which the public are aware of the NSW Waste Classification Guidelines (2014) is not clear. Increasing this awareness may result in improved public understanding of waste generation, management and treatment, and therefore, waste generating behaviours. This may also assist to ensure only materials that cannot be repurposed or recycled, and which are suitable for combustion are used in EFW facilities.

There is also a need for research to understand NSW's waste stream and composition holistically. In the long term, the combination of public awareness and research will keep the waste classification system at the contemporary level to support the EFW operations, such as to address upstream separation of PVC, mercury and other contaminating materials, which are problematic for EFW. For the moment, it is sufficient to move forward with the Sch 1 of POEO of eligible waste fuels.

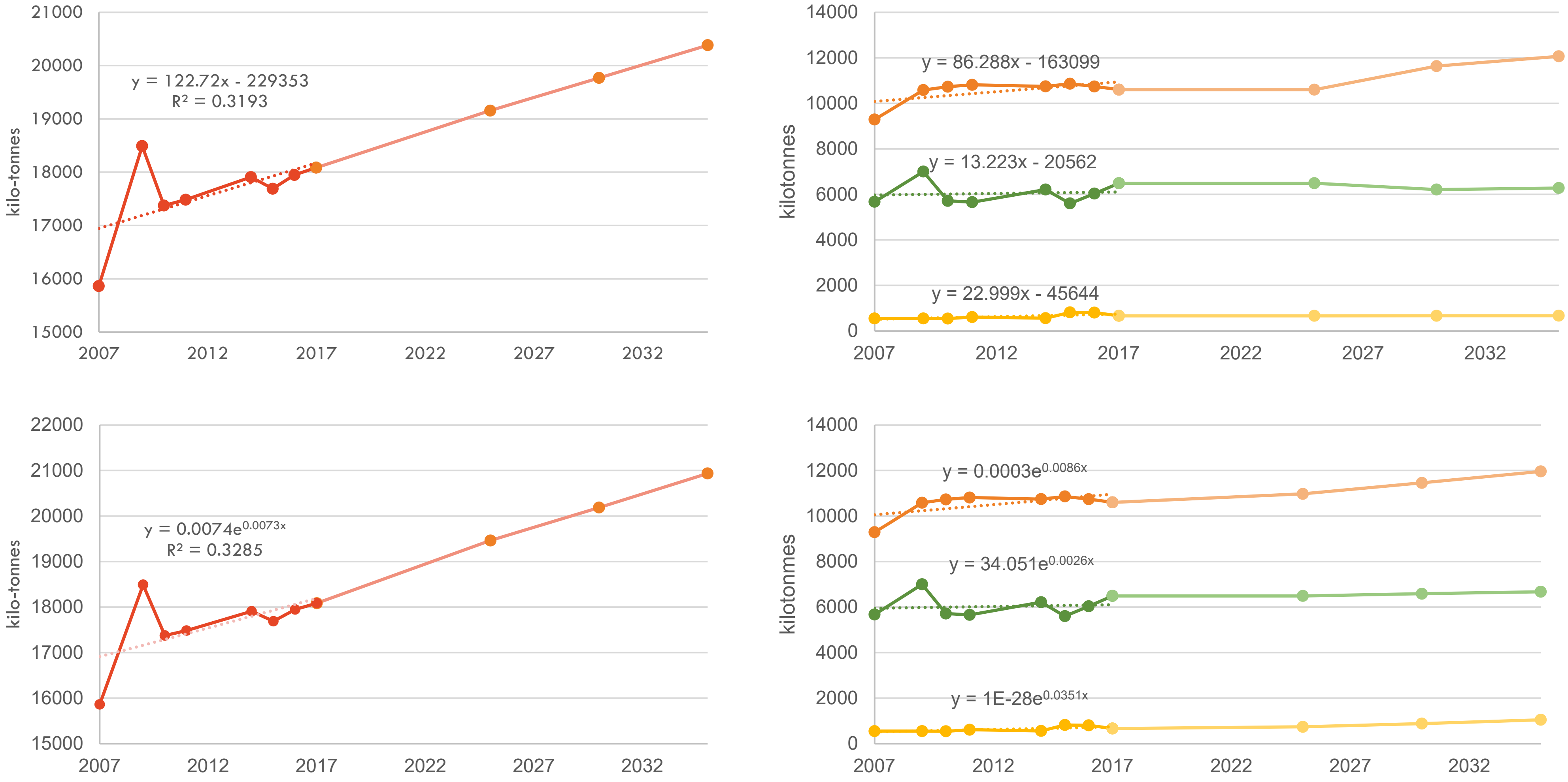


Figure 4-1: Forecast of waste generation (**left**) and destinations (**right**, Orange = Recycling; Yellow = EFW; Green = Disposal) for Linear (top) and exponential (bottom) trends in NSW (Forecasting in Appendix 3) (Pickin et al., 2018).

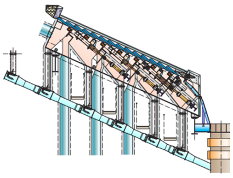
4.2 Moving grate technology

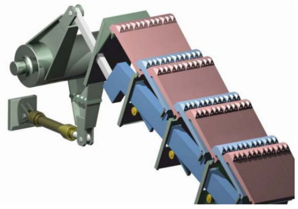
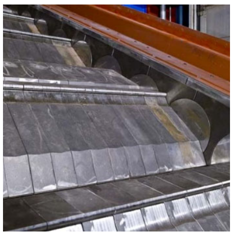
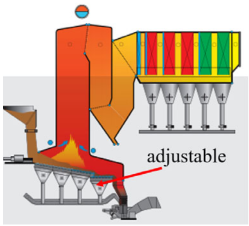
Moving grate technology is widely used due to its high feeding capacity and over time the technology has been developed and matured to meet the performance targets and regulatory requirements. Compared to other EFW technology, moving grate is superior in terms of handling large bulky, mixed, and contaminated waste without prior sorting or shredding. Its ability to handling mixed waste and variations in calorific value, allows for a stable combustion process. Moving grate advancement continues, with the goal to achieve even more reliable technology. A summary of various commercial moving grate design can be found in Table 4-1.

In general, advances in design optimisation and controlling the combustion process are achieving a more complete combustion, increasing the efficiency of energy recovery and reducing air pollutants. Nevertheless, there are still challenges around moving grate, namely:

1. Maintaining supply and demand balances. Overseas, successful EFW facilities are often supported with high landfill tax and adequate sorting of combustible portions. Without consistent flowrates and appropriate compositions, more other-than-normal operating condition can be expected, ergo, more chance of air pollutant emissions.
2. Incomplete combustion due to ash, incombustible portion, and high moisture content, resulting in more CO and TOC.
3. An increase in plastic portion may result in more dioxins, acid gases, and PAHs production.
4. Finding optimum operating conditions: High temperatures degrade dioxins and other organic pollutants but may generate more NOx and elemental heavy metals.

Table 4-1: Summary of various commercial moving grate.

Grate type	Diagram/picture	Description
Horizontal grate (Germany) (Martin GmbH, 2013a)		Independent neighbouring grate bars move alternately, producing a counter movement that transport waste during combustion. The grates are placed horizontally (all transportation done mechanically, no gravity (slope) assistance unlike reverse acting grate). The grate's air nozzle can be sized depending on the desired bottom ash and over fire controller.
Reverse acting grate – Vario (Germany) (Martin GmbH, 2013c)		**Vario** grate is an optimised version of a typical reverse grate. Three different combustion zones can be controlled individually depending on the waste fluctuation, this allows good mixing without compromising the residence time. The constant grate movement mixes the waste and controls the combustion process through five different air nozzles (internal temperature up to 1200°C). The unique design omits the requirement for cooling water.

Grate type	Diagram/picture	Description
Reverse acting grate – SITY 2000 (Germany) (Martin GmbH, 2013b)		**SITY 2000** is claimed to be designed for Asian waste (high moisture content), the grate is divided into 2 drive units and 4 under grate air zones, which can be controlled independently.
DynaGrate® (Esbjerg, Denmark) (Babcock and Wilcox Volund, 2019)		A novel grate design that claims to be state-of-the-art reverse acting grate. There is no contact between independent rotating grates, resulting in high waste agitation and low maintenance. Uniform and high conversion can be guaranteed. In high calorific value waste combustions, cooling water can be integrated into the grate.
Vølund grate (Esbjerg, Denmark) (Babcock and Wilcox Volund, 2019)		An older grate design created in1930. The grate is stair-like, and the movement is termed as 'Walking floor', equipped with under-grate air nozzle. Each section of the furnace can be controlled independently. The new grate is claimed to be free of melted fused aluminium problems (unlike previous design).
Von Roll Inova® (Osaka, Japan) (Hitachi Zosen INOVA)		Principally similar to reverse acting grate, the furnace provides drying, ignition, combustion, and burnout of waste, which can be controlled independently. The four-level grate can be adjusted in three different configurations to optimise the burnout. This allows a more flexible operation and lowers the operating cost.
Air/Water-cooled Grate (Singapore) (Keppel Segher, 2011)		Integration of reverse acting grate with air cooling for low-medium calorific value waste, claiming to be the only grate that has separate and independent control. The grates incorporate horizontal and vertical movement of multistage to adapt with feed fluctuations. For high calorific waste, air can be substituted with water to cool the grate, focusing the air for combustion optimisation.
Modular Grate System (Steinmueller-babcock Environment GmbH, 2019)		The modular grate system allows the grates to operate individually, multiple tracks can be installed on one furnace. The furnace can be controlled independently allowing high degree of flexibility. The grate composed of bar rows that overlap each other and move alternately.

4.3 Other EFW Technologies

From the various thermal waste processing technologies reviewed (Table 4-2), plasma gasification appears to be the cleanest EFW technology in terms of air pollutants production. In plasma gasification, the high-temperature treatment degrades dioxins and tar, while the partial oxidation reaction inhibits the production of NOx. The extreme nature of plasma also ensures a high conversion of waste (Fabry et al., 2013).

Table 4-2: Summary of various thermal EFW technologies and their implications on emissions

Technology	Suitable for	Implication on Emissions control	Drawbacks
Fluidised bed combustor	Shredded MSW, RDF	- Less NOx production	- Pre-treatment requirement
Rotary kiln combustor	Hazardous waste.		- Small scale - Longer residence time
Pyrolysis	Sorted Waste, Tyre, Plastic	- Less NOx production - Tar and organic pollutants production	- Small scale
Gasification	RDF	- Less NOx production - Tar and organic pollutants production	- Smaller scale than moving grate - Require pre-treatment
Plasma Gasification	RDF	- Low NOx production - Degrade tar and dioxins	- Emerging technology

RDF = Refuse Derived Fuel; MSW=Municipal Solid Waste.

Currently, there is no available commercial plasma gasification technology at a moving grate capacity. The technology may benefit with improvements in cost optimisation and long-term reliability. Details of various plasma gasification companies are provided in (Wood et al., 2013) – *Case Study 15*.

On the other hand, a study argues that plasma gasification has already achieved a high TRL; however, the low CRL hindered the adoption of the technology (Munir et al., 2019). Plasma gasification is deemed to be at moderate CRL due to its safety concerns and lack of plasma EFW awareness. The major challenges in plasma gasification are (Munir et al., 2019):

1. Accommodating the high energy requirement for plasma generation.
2. Providing investors with clear evidence of successful pilot scale testing.
3. Public awareness of plasma gasification importance.

4.4 Moving grate optimisation

For EFW, the ideal goal is to design a thermal process that is resilient to feedstock changes while maintaining high performance. While technology such as plasma gasification may be able to do so, the impeding cost and technological immaturity hinder the implementation.

Therefore, the more ideal approach for the industry is to adopt the proven technology (moving grate) while optimising it from the operational standpoint. Such optimisation can be done through:

- Adequate sorting and regulation of waste. The composition, volume, and heating content should be made as homogenous as possible. This can be done through waste sorting, moisture removal, and mixing.
- Staged combustion will allow a more complete combustion through temperature and air supply control (e.g. Von Roll Inova® Hitachi Zosen Inova).
- Water cooling grate to reduce the extreme temperatures, inhibiting NOx production. (e.g. DynaGrate® by Babcock & Wilcox).
- Utilising oxygen enriched air to inhibit NOx production.
- Utilising Computational Fluid Dynamics (CFD) design to estimate pollutant generation and flow (e.g. VoluMix™ overfire air system by Babcock & Wilcox, claim to reduce CO and TOC).

4.5 Other APC

While optimisation and installing a clean technology is beneficial, designing APC processes that can accommodate the emission fluctuations is equally crucial. Chapter 3 has summarised APC evolution and ongoing trend in APC for EFW.

In addition, Table 4-3 lists the various APC methods of some advanced EFW facilities. More recently installed facilities utilise complex APC sequences to ensure pollution reduction. Newer APC processes include:

1. Installing catalytic reduction to reduce NOx pollutants (e.g. SUS-Ningbo EFW Plant, Amager Bakke-Copenhagen).
2. Installing specific units to expand the plant's objective (e.g. Amager Bakke water scrubber/condenser for heat pump energy recovery).

Conclusion 8 – EFW and future waste variability

Waste inconsistency has been a significant obstacle in waste management. In NSW, it can be expected that the recycling industry will increase, which may produce a more consistent composition of feedstock destined to EFW processing. This together with market competition, will reduce feedstock volume for EFW, which may result in more start-up and shutdown periods due to lack of feedstock. Therefore, EFW facilities must not be 'over-designed' so as not to compete with successful quality recycling.

In relation to waste compositions, The POEO has outlined the eligible fuel for EFW, however, the POEO lacks reference to the NSW Waste Classification Guidelines (2014), which arguably influence the incoming waste into EFW. The Guidelines on the other hand may require updating to reflect on emerging EFW industry especially in terms of waste quality and combustibility.

In general, various approaches can be done to ensure EFW's resilience towards changes in the feedstock, which includes understanding waste variability through periodic review and reporting on changing composition of waste streams. Generally, understanding waste variability through periodic reviews will support plant operational optimisation. The implication of waste variability and sorting on air emissions is unclear based on overseas operations as evidence relating feed to emissions is lacking. Moisture content carried in with waste present a problem resolved through a pre-heating step (moving grate) causing efficiency reductions of EFW plant.

For emerging EFW technology, plasma gasification appears most promising in terms of air pollution reductions; nevertheless, only a handful of companies are able to demonstrate the technology commercially as a practical EFW, however research on this front continues to advance.

A more ideal approach is to adopt emerging advanced techniques to support moving grate efficiency including air pollutants reduction. This support can be done through:

- Feedstock homogenisation.
- Controlled combustion through air and cooling supply.
- The utilisation of computational modelling to optimise air emissions reduction.

Currently, there is no practical evidence that other EFW technology can operate at moving grate capacity; hence, it is currently more ideal to employ moving grate whilst improving it through operational standpoints to reduce air pollutants.

Recommendation 8 – EFW and future waste variability

Steps are taken to ensure only suitable feedstock is used in EFW facilities. This includes:

(a) The scope and location of proposed EFW facilities are assessed relative to waste supply chains, market size and competition, projected changes to waste

Recommendation 8 – EFW and future waste variability

streams including impacts of 'quality recycling' developments and targets. Guidelines be developed for sizing of facilities, and methods to demonstrate, as part of licensing approval and review, that the waste management hierarchy principles are followed.

(b) Operators are required to provide monthly reports on the changing composition of waste streams, and data showing the relationship between waste inputs, operations and air emissions.

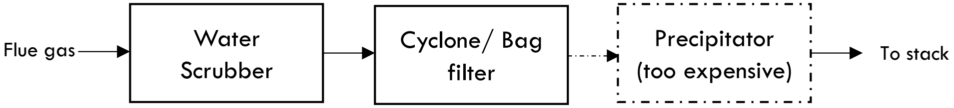
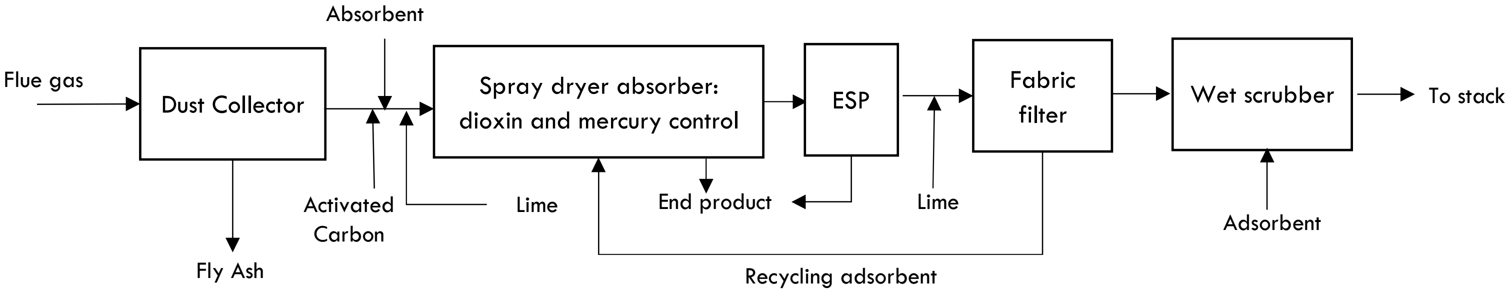
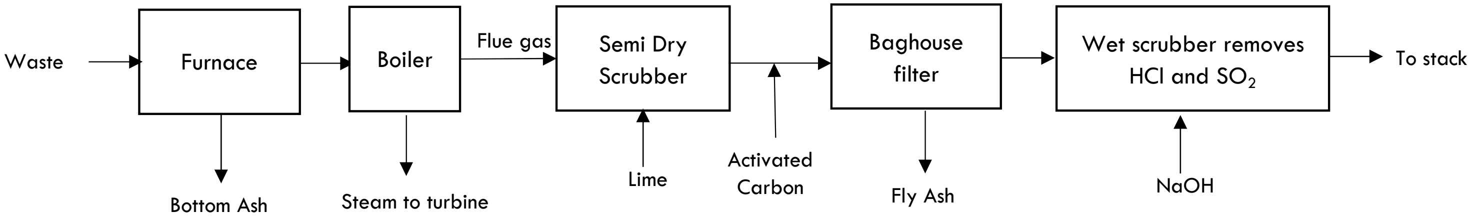
(c) NSW EPA review the waste classification system to ensure it adequately captures materials that are suitable and not suitable for combustion. This is to help ensure the waste management hierarchy is respected; that only suitable waste inputs are used and to optimise plant efficiency. This should also assist assessment of feedstock sources and volumes.

(d) Research is undertaken to support skills and technology development to manage in the impact of waste variability on technology performance and emissions.

(e) Collecting and publishing data on waste streams and performance.

As a long-term strategy, it is recommended efforts are made to increase public awareness of waste classifications and waste stream destinations. Appreciation of the importance of waste classifications, together with increased understanding of waste properties will result in increased producer responsibility. Other benefits include classification and sorting systems and improved behaviours for the upstream separation of problematic EFW feeds such as PVC, mercury and other contaminating materials.

Table 4-3: Summary of various EFW Air Pollution Control systems.

<table>
<tr><th>Facility</th><th>APC technology configurations</th></tr>
<tr><td><i>Older technique (for references)</i>
<i>(Lenehan, 1962)</i></td><td>
</td></tr>
<tr><td><i>GEA NIRO SDA System</i> <i>(German APC Supplier)</i> (GEA Process Engineering).</td><td>
</td></tr>
<tr><td>Covanta EFW (Dublin, Ireland)
2017-now
Up to 2260 tpd
<i>(Covanta, 2019)</i></td><td>
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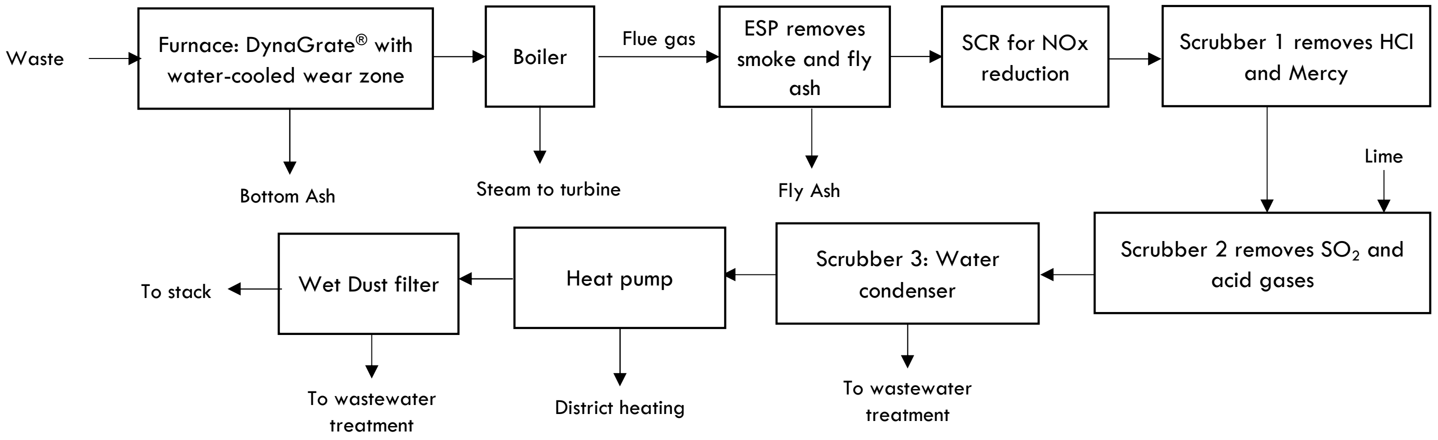
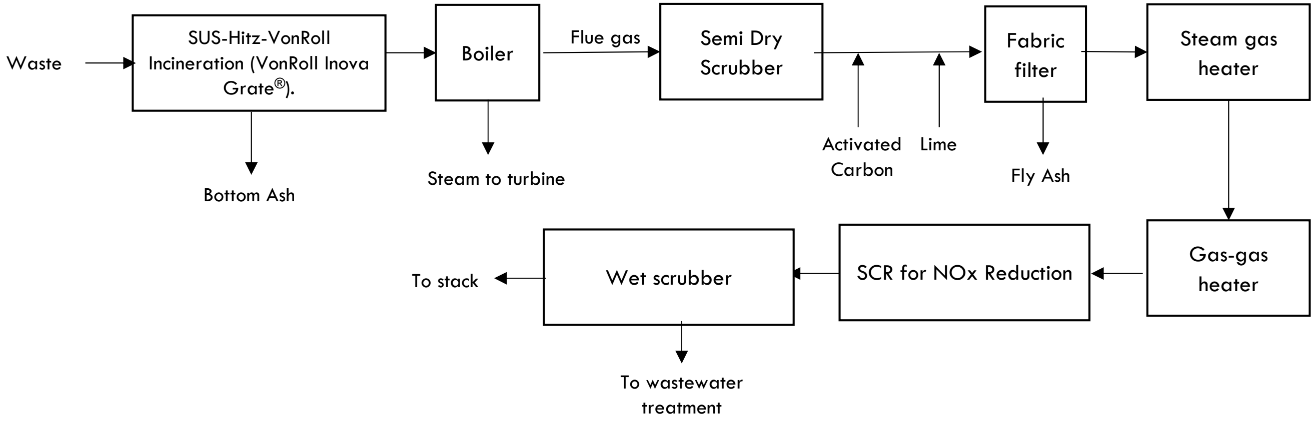
Facility	APC technology configurations
Amager Bakke, Copenhagen, Denmark [4] 2019-now 840 tpd (Amager ressourcecenter , 2019).	
SUS EFW Facility Plant (Ningbo, China)[5] 2018-now 2250 tpd (CITICPE & Environment, 2019)	

5 Co-location of EFW facilities

EFW is well established overseas with various examples of industrial symbiosis and co-location with other industry. This section provides some insights on EFW process integration and potential industry co-location opportunities with reference to the NSW context. The summary and review of these integrations are provided in Table 5-1.

5.1 Waste management parks

Waste management parks represent an industry precinct focused on the waste process industry. An example is the SUS Ningbo EFW (China) precinct, designed as part of the Eco-Industrial Parks (EIP). It processes various types of waste including medical waste, organic waste (kitchen and food), e-waste, and industrial waste. The possibilities of integrating with construction waste and wastewater treatment facilities are under consideration. This EIP also has an on-site museum and sports recreational centre, which together with local employment aims to enhance public engagement and acceptance (CITICPE & Environment, 2019).

Waste management parks work to eliminate competition between recycling and EFW, where energy recovered from waste may be used to operate the recycling facility, creating a symbiotic relationship. Victoria's first EFW project was installed in an industrially symbiotic setting by integrating it with a paper recycling facility (Whittaker & Kendall, 2019). Numerous other examples of industrial symbiosis which do not specifically focus on EFW have been established internationally and provide useful lessons for EFW co-location, deriving economic, environmental and social benefits (Gibbs & Deutz, 2005; Jacobsen, 2006; Roberts, 2004; Zhu et al., 2007).

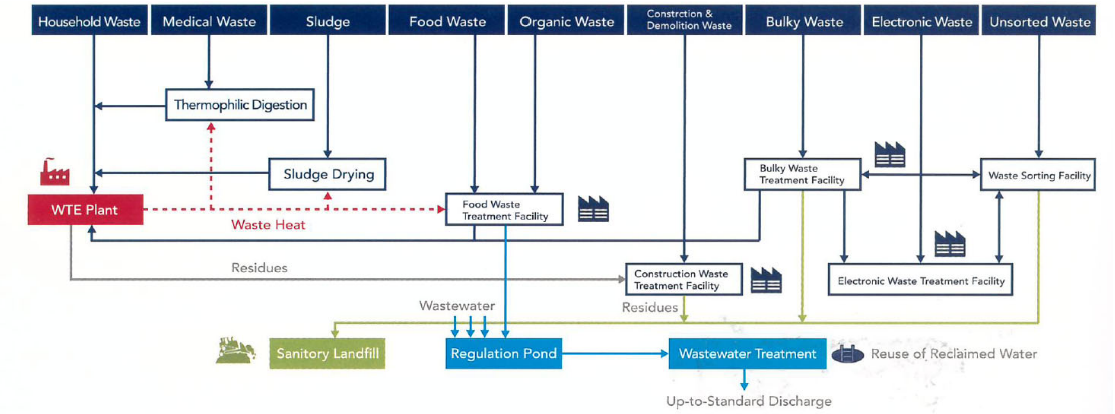


Figure 5-1: Eco-Industrial Park that sorts various type of waste for different best possible treatment (CITICPE & Environment, 2019).

For NSW, Waste management parks are best located near an established resource recovery facility that is close to a disposal site, primarily to avoid further carbon emissions from the transportation of waste.

The NSW EPA has identified this opportunity by introducing Circulate, a NSW Industrial Ecology Program (NSW EPA, 2020). Relevant examples of such industrial symbiosis are discussed next.

5.2 Heat networks

An industrial park in Waasland Port, Belgium, utilises ECLUSE steam network, where the steam is provided by Indaver/SLECO EFW through a closed loop steam exchange. Five energy-intensive chemical facilities whose previously energy source was natural gas, utilise the steam generated, including an acetone production plant, thus decreasing their carbon dioxide emissions.

The EFW Steam network commenced only recently in 2019, after four years of design and construction. The owners acknowledge that this industrial symbiosis was made to happen because of 'Green Heat Action Plan' in 2011 from the Flemish Government, providing industry support for the heating network strategy (ECLUSE, 2011, 2018).

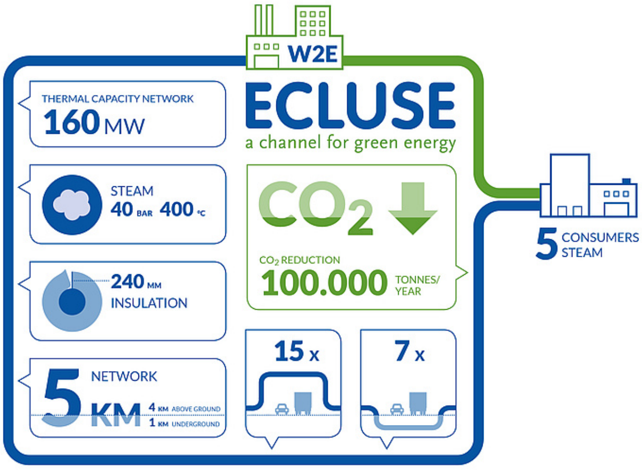


Figure 5-2: Ecluse Infographic(ECLUSE, 2018).

For NSW, various industrial parks may be suitable for EFW integration similar to ECLUSE. The more industrial symbiosis is promoted and embraced in the area, the easier EFW can be integrated. With significant energy-intensive mining and smelting facilities in NSW, steam networks are a potential alternative to their current energy supply, although this is yet to be demonstrated. Support from government would be required for such an initiative. The regionally-based Special Activation Precincts (SAPs) are suitable candidates for EFW, with resource recovery being identified as a preferred industry within the Parkes SAP (NSW Government, 2020). The co-location and industrial symbiosis within SAPs should carry a circular economy and low emissions design emphasis (Tumilar et al, 2020).

5.3 Upcycling of by-products

While bottom ash and fly ash contain heavy metal and other pollutants, under proper treatment, the material can be upcycled into concrete and other constructions products. Various commercial processes and trademarked products exist, such as:

1. Plasmarok® (UK) for building aggregates, collected from vitrified ash from plasma gasification process (Advanced Plasma Power, 2019).
2. Eco-Cement Production (Japan), processing ash from waste combustion into cement (Tokyo Enviromental Public Service Corporation).
3. Granova® (Germany), crushed aggregates from EFW bottom ash (REMEX Mineralstoff GmbH, 2019).
4. Kwinana EFW claims that their bottom ash will be upcycled for brick production using Pittsburgh Mineral & Environmental Technology, Inc. (PMET) Brixx™ process (Pheonix Energy, 2014).
5. Early discussions with NSW EFW proponents' points to the interest in upcycling bottom and fly ash from proposed EFW facilities.

Other EFW facilities have shown recovery of other materials including valuable metal recovery. Such processes include the slagging gasification technology operating at temperatures near 1600°C, and currently being tested by Nanyang Technological University in Singapore at demonstration scale.

5.4 Carbon Capture and Storage (CCS)

Carbon capture and storage (CCS) is the action of taking emitted carbon dioxide and storing it underground to avoid increases in greenhouse gases and mitigating against climate change. Carbon capture requires large amounts of energy and is currently commercially challenging mainly due to the high costs of the technology. Integrating EFW with carbon capture may offer potentially feasible solutions such as:

1. Utilising the energy generated from EFW to capture the emitted carbon; Climework (Switzerland) installed a carbon capture plant integrated with waste combustion (Figure 5-3), which captures 2.5 tpd of CO_2. They claim that the plant captures more emission than it produces. The facility is at demonstration scale and has been operated for three years (Morris, 2017).
2. Utilising carbon capture to reduce the EFW process carbon emission:
    a. Klemetsrud EFW facility (Oslo, Norway) is planning to remove 90% of produced CO_2 (~414,200 tpa). Currently, it is at the design stage (Stuen, 2017).
    b. Amager Bakke (Copenhagen, Denmark) is planning to capture the non-renewable portion of the carbon emission, aiming to become carbon neutral by 2025 (Amager ressourcecenter, 2019).

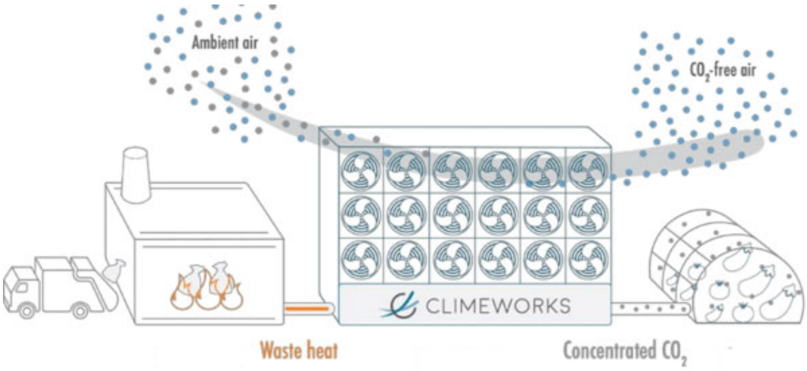


Figure 5-3: Infographic of CCS from EFW by Climeworks (Morris, 2017).

For NSW, the significant research in post-combustion carbon capture in the power industry may be translated for EFW, allowing NSW to install CCS-EFW in the future. Research and development in this field is still required particularly to address technical challenges like optimal heat integration but also the identification of suitable geological storage sites in NSW. It is also worthy to note that renewable energy may be used to augment the CCS process (Carbon Capture & Storage Association, 2019; Mokhtar et al., 2012; Qadir et al., 2013). Other opportunities include the utilisation of captured carbon in for example the integration of CCS-EFW with chemical synthesis.

5.5 Co-combustion of MSW

Power plants that are retrofitted or built with co-firing capabilities for MSW and other biomass streams may offer further economic and environmental advantages. Co-firing typically would consume MSW at low co-firing fractions of around 10%. NSW coal-fired power plants may not all be suitable for such co-firing, and those which are will require close examination of the power plant's existing location with reference to waste generation centres and waste availability. Integrating co-combustion of biomass and the renewable combustible fraction of MSW with CCS (aka as Bioenergy with CCS or BECCS for short) add carbon emissions reductions potential but key factors to consider include changes in emissions profiles due to co-firing with MSW. While CO_2 emissions are likely to be reduced, emissions of heavy metal elements may increase (The University of Sydney, 2020).

5.6 Renewable Energy

While facilities such as Shenzhen EFW are installing solar panel roofs to feed the grid with more renewable energy (SHL Architecture, 2019), renewable energy may be integrated with EFW as a process intensification method. Some examples of renewable energy integrated with EFW include:

1. Pilot scale packed bed solar gasifier in Almeria Spain (Piatkowski et al., 2011).
2. Modelling of solar assisted tyre pyrolysis for fuel production (Zeaiter et al., 2018; Zeng et al., 2017).

3. Solar farm coupled with Swanbank EFW in Queensland to complement each other during electricity peak (Peterseim et al., 2012).

There is currently no renewable energy integrated EFW facilities due to operational complexity and energy demand fluctuation challenges. Solutions used in power hybridisation of renewable energy and other conventional power generators have been proposed and can offer lessons to EFW power hybridisation (Mokhtar et al., 2012; Parvareh et al., 2014).

Conclusion 9 – Co-location of EFW facilities

In NSW, numerous opportunities for industrial symbiosis and co-location exist for EFW operations, including:

- integration within waste management parks.
- installation as process heat supplier (heat networks) in industrial eco-parks for manufacturing and upcycling of waste into commodities and value-add products.
- integration with CCS and renewable energy.

EFW facilities in co-location settings can catalyse industry growth through provisions for waste treatment, energy and carbon emissions reductions opportunities, particularly for regionally based Special Activation Precincts (SAPs).

Recommendation 9 – Co-location of EFW facilities

Assess the role of EFW in special dedicated industry zones (particularly SAPs) and consider co-location with existing process industry with heat intensive requirements.

Support research programs that build research capacity in industrial symbiosis that incorporates EFW processes.

Table 5-1: Summary of possible EFW industrial co-location.

EFW co-process	**Status**	**Benefits**	**Challenges**	**NSW context**	**Examples**
IS- Waste management park	Available	- Sorting waste for best possible treatment - Minimising competition between recycling and EFW - Applies the waste management hierarchy	- Waste heterogeneity - Centralised waste management - Require an effective waste transport and network	- Existing waste management facilities may be suitable	- SUS Ningbo Eco-Industrial Park
IS-Energy	Available	- Close loop system of energy requirement - Highly efficient.	- Heat integration and optimisation - Collaboration of multiple private entities	- Existing industrial parks or areas may be suitable	- Wassland Port, Belgium,
IS-Feedstock	Available	- Metal recycling - Concrete production	- Proper regulation for ash recycling (e.g. heavy metal leachability)	- *Any facility*	- Kwinana – Brixx^{TM} - Plasmarok ® - Eco-cement - Granova ®
Carbon capture	R&D stage	- Reducing carbon emission - Mitigate GHG emissions	- High cost and 'first of a kind' - Lack of CO_2 market. - Less energy sold to the grid	- Utilising research in CCS for power plant to EFW in the future	- Klemetsrud Norway - Amager Bakke, Denmark
Renewable Energy	R&D stage	- Diverse stream of energy being fed to the grid. - May complement each other (EFW as baseload)	- Complex interaction - Waste and renewable energy inconsistency - Potential fluctuations in energy supply	- Require strong connection between renewable and grid energy - More complex regulation	- *No commercial example*

6 Other Matters

This section provides a discussion around international direction of EFW.

6.1 Ambient Air Impact

From a monitoring perspective, some jurisdictions focus on Ground Level Concentration (GLC), including the AAQ NEPM, WA's Air Emission Guideline (2010), and QLD's Environmental Protection Air Quality (2019). The review of these is provided in (Appendix 1). For NSW, the ambient air standard applies during licensing stage, through *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016).*

It would be expected, that if a state-of-the-art EFW facility is built in NSW, it would exist near urban areas due to operational benefits (e.g. shorter waste transport trips and integration of heat and power). Examples of urban EFWs are:

1. Amager Bakker (Copenhagen, Denmark), 1.6 km away from the Danish Royal Palace.
2. Spittelau (Vienna, Austria), acting as city's architectural landmark.
3. Toshima Plant (Tokyo, Japan), constructed with large a fitness centre and heated pool to enhance public engagement and acceptance.

6.2 Facility size

While having a specific EFW standard is an excellent starting point, it is wise to note that in some countries, the relevance of EFW have resulted in flexibility in the standards to take into account industry differences. Should the industry grow in Australia, future revisions of the standards may need to be considered.

The most common standard flexibility revolves around the capacity of the facility, i.e. its scale. To meet the strict air emissions guidelines, industry is required to install lengthy APC units. This may result in mega combustor and centralised waste management (discussed elsewhere in this report). Installing extensive APCs for a small combustor would be economically restraining. Some examples of flexibility within standards include:

1. ***US*** – Municipal solid waste combustor standard differ for large (≥ 250 tpd) and small (35-250 tpd) scale.
2. ***EU*** – Standards for NOx and NO_2 for new or large (>6tph) incineration is 200 mg/m^3, while for smaller scale incineration is 400 mg/m^3.
3. ***China*** – EFW standard for dioxin differ with capacity, for >100 tpd limit is 0.1 ng TEQ/m^3; 50-100 tpd 0.5 ng TEQ/m^3 and <50 tpd 1.0 ng TEQ/m^3

US air emission standards for waste treatment is rigorously diverse, encompasses different types of waste incineration, landfill, and feedstock (sewage sludge, medical, and industrial waste). In ***EU***, different standards apply for rotary kiln and co-combustion process (pyrolysis, gasification, etc.), possibly due to the prominence of high thermal hazardous waste treatment (for rotary kiln) and smaller scale EFW.

In contrast in ***Australia***, coal combustion may offer a convenient transformation to EFW, reducing its impact and capital cost. Thus, a specific standard for retrofitted thermal plants may be required to ensure high performance in terms of emissions from these facilities.

The NSW EPA acknowledges that a 'one size fits all' approach for all industry types and scales is not desirable. This is reflected in the NSW EPA's licencing framework that allows different limits to be set tailored to the individual development. Section 10 of the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016)* provides the principles used by the NSW EPA in setting these limits applying them on a case-by-case basis.

6.3 Community engagement

The authors of this report are not experts in community engagement, however, are able to make the following observations:

- EFW projects face difficulties with social acceptance due to the perception that EFW facilities cause health and environmental hazards. This is despite the wide deployment of the technology globally, with more than 500 such plants in EU alone.
- EFW projects require close community engagement throughout all stages of the project. Overseas plants have included architectures and facilities (Figure 6-1A) that positively adds to and fits in with the local community.
- The change in paradigm in the model of EFW is to consider technology that is complementary to circular economy principles with integration of EFW as a multi-functional technology solution ('polygeneration'). This would include considering them within SAPs or industrial symbiosis parks where the most benefit of EFW may be reaped in the context of circular integrated waste cycles (Figure 6-1B), enhancing and linking resources and energy efficiency improvements.
- Public acceptance may be enhanced by viewing waste as a resource, promoting the role of EFW in the waste management hierarchy, supporting re-use, recycling, recovery, zero-waste-to-landfill.
- Proponents of EFW projects engage with the local community to incorporate facilities such as educational centres, recreational facilities, and museums as part of the project (Figure 6-1C-H). Essentially, the EFW facility would work closely with government to create precincts that offers multiple benefits for a community.
- Making air emissions from EFW facilities publicly available (Figure 6-1F) to provide a high level of transparency to the community.

(A)

(B)

(C)

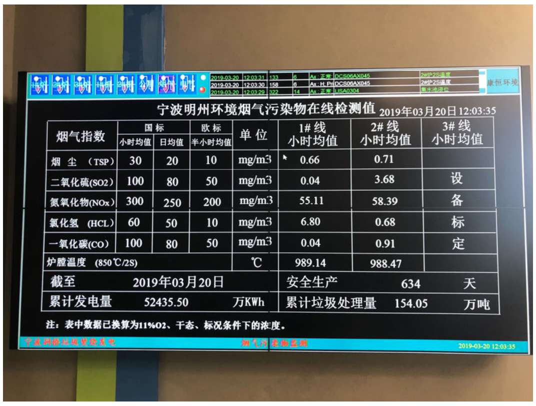
(D)

(E)

(F)

(G)

(H)



宁波明州环境烟气污染物在线检测值 2019年03月20日 12:03:35

烟气指数	国标		欧标	单位	1# 线 小时均值	2# 线 小时均值	3# 线 小时均值
	小时均值	日均值	半小时均值				
烟 尘 （TSP）	30	20	10	mg/m3	0.66	0.71	
二氧化硫(SO2)	100	80	50	mg/m3	0.04	3.68	设
氮氧化物(NOx)	300	250	200	mg/m3	55.11	58.39	备
氯化氢 (HCL)	60	50	10	mg/m3	6.80	0.68	标
一氧化碳(CO)	100	80	50	mg/m3	0.04	0.91	定
炉膛温度 (850℃/2S)				℃	989.14	988.47	

截至	2019年03月20日		安全生产	634	天
累计发电量	52435.50	万KWh	累计垃圾处理量	154.05	万吨

注：表中数据已换算为11%O2、干态、标况条件下的浓度。

2019-03-20 12:03:35

(I)

Figure 6-1. Various aspects of the Ningbo China EFW facility.

(A) Attractive architecture
(B) Neighbouring biogas plant
(C) Entry to the EFW Museum
(D) An exhibition in the EFW Museum
(E) Educational centre
(F) Sport centre with heated swimming pool with free access to the public
(G) Fountain using water recycled from the plant and a temple in the distance
(H) View of one of the units in the APC line availble for vieweing during industrial tourism trips to the plant
(I) Real-time online data reporting to the public of key emissions

Conclusion 10 – Other matters

Based on the global EFW industry, it is probable that EFW operations will be located near urban areas. Currently, in NSW emitted pollutants must be demonstrated to be at safe levels through *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2016)*.

Clearly, and while recognising the newness of EFW industry to NSW, public acceptance is a critical aspect to EFW industry. Special effort is therefore required to communicate operational performance. Review mechanisms should draw on input from technical experts from time to time, and focus on sharing of data, transparency and openness, to help inform policy and regulatory improvements.

Recommendation 10 – Other matters

Adopt a mechanism that comprehensively reviews and monitors data from EFW air emissions, that will achieve the best possible outcomes with respect to keeping the emissions regulations at best practice and also achieving public confidence in the EFW technology and industry. Such mechanism will:

(a) address all aspects of emissions control and monitoring and consisting of policy and technical experts with engineering and data science backgrounds, to inform future policy and regulation amendments through an evidence-based emissions data platform that exploits big data, analytics and visualisation technologies.

(b) focus on management, modelling and governance of all data generated from the compulsory monitoring of EFW facilities.

(c) propose review mechanisms that will track EFW industry's progress and provide regular reports and detailed scientific studies and assessments of the impacts of air emissions from EFW facilities.

(d) Create the platform for periodical evidence-based reviews of the standards to ensure it remains world leading in terms of stringency and also achieving an efficient EFW industry.

7 Conclusions

This report aims to address the TORs by OSCE in respect to providing independent expert advice on process engineering and air emissions for Energy from Waste. *The (draft) best practice air emissions limits for EFW in NSW* can be said to be one of the most stringent set of requirements to be currently internationally for air emissions from EFW.

The complexity of regulatory requirements for air emissions from EFW facilities resulted in diverse approaches across different jurisdictions around the world. Generally, having the most stringent requirements relies on more than just applying the lowest possible concentration limit for identified air pollutants. In addition, *the (draft) best practice air emissions limits for EFW in NSW* should recognise that being the most stringent is a '*whole package*' which includes a strict approach to emissions' reporting and monitoring to manage and meet industry expectations.

Following our review, we have made 10 critical conclusions and 10 recommendations (all summarised in Table 0-1), which includes a proposal to adopt several proposed measures and make changes to others. Our recommendations were made with a view for NSW to continue to have a world leading and stringent framework for air emissions requirements for EFW facilities. The recommendations critically focus on having the requirements continuously reviewed and updated while capturing bottom-up learning as the EFW industry evolves in NSW.

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9 Appendix 1: Independent Standard Review

Table 9-1: Comprehensive review of standard and policy in EFW air emissions (Stack Testing)

/Jurisdiction/Standards			EU 2000 [a] [1]	EU 2010 EID[a] [2]	EU BAT Ref. Doc. (2019)[3]	China[4]	USA Clean Air Guidelines and Standard for Waste Management [c]		Singapore Regulation[7]	SA EPA[8]	TAS EPA[9]	NT EPA[10]	VIC EPA[11]	NSW EPA	
Pollutants	**Expressed as**	**Averaging Period**	**2000/76/EC**	**2010/75/EU (IED) (Annex VI)**	**for Waste Incineration BAT- 5.1.5 Conclusion pg. 491**	**GB-18485-2014[d]**	**New Large Municipal Waste Combustor 2006[5]**	**New Small Municipal Waste Combustor[6]**	**The Schedule**	**Air Quality Policy 2016 – Schedule 4: Stack Emission**	**Environmental Protection Policy 2004 – In-stack concentration**	**Guideline of disposal of waste by Incineration**	**EPP: Air Quality Management: Schedule E New Stationary Limit**	**Clean Air Regulation 2010 (General)[c][12]**	**Draft NSW Best Practice[a][13]**
Total Solid	Total Dust	0.5 hours	30 mg/m^3 (100%) 10 mg/m^3 (97%)	30 mg/m^3 (100%) 10 mg/m^3 (97%)											
		1 hour												36 mg/m^3 *	20 mg/m^3
		24 hours	10 mg/m^3	10 mg/m^3	<2-5 mg/m^{3†} <2-7 mg/m^3 (w/o bag filter)										
	PM	-							50 mg/m^3	100 mg/m^3	71 mg/m^3 *		250 mg/m^3		
		1 hour				30 mg/m^3									
		24 hours				20 mg/m^3	15.6 mg/m^3 *	19 mg/m^3 *							
	TSP	-										36 mg/m^3 *			
Gaseous organic substance	TOC	0.5 hours	20 mg/m^3 (100%) 10 mg/m^3 (97%)	20 mg/m^3 (100%) 10 mg/m^3 (97%)											
		24 hours	10 mg/m^3	10 mg/m^3											
		-													
	TVOC	1 Hour												29 mg/m^3 *	20 mg/m^3
		24 hours			<3-10 mg/m^{3†}										
Chloride and compounds	HCl	0.5 hours	60 mg/m^3 (100%) 10 mg/m^3 (97%)	60 mg/m^3 (100%) 10 mg/m^3 (97%)											
		1 hour				60 mg/m^3								71 mg/m^3 *	50 mg/m^3
		24 hours	10 mg/m^3	10 mg/m^3	2-6 mg/m^3 (New)† 2-7 mg/m^3 (Existing)†	50 mg/m^3	32 mg/m^3 *	32 mg/m^3 *							
		-							200 mg/m^3		71 mg/m^3 *	71 mg/m^3 *			

/Jurisdiction/Standards			EU 2000 [a] [1]	EU 2010 EID[a] [2]	EU BAT Ref. Doc. (2019)[3]	China[4]	USA Clean Air Guidelines and Standard for Waste Management [c]		Singapore Regulation[7]	SA EPA[8]	TAS EPA[9]	NT EPA[10]	VIC EPA[11]	NSW EPA	
Pollutants	Expressed as	Averaging Period	2000/76/EC[	2010/75/EU (IED) (Annex VI)	for Waste Incineration BAT- 5.1.5 Conclusion pg. 491	GB-18485-2014[d]	New Large Municipal Waste Combustor 2006[5]	New Small Municipal Waste Combustor[6]	The Schedule	Air Quality Policy 2016 – Schedule 4: Stack Emission	Environmental Protection Policy 2004 – In-stack concentration	Guideline of disposal of waste by Incineration	EPP: Air Quality Management: Schedule E New Stationary Limit	Clean Air Regulation 2010 (General)[c][12]	Draft NSW Best Practice[a][13]
	Cl	-							32 mg/m^3	200 mg/m^3	143 mg/m^3 *		200 mg/m^3	143 mg/m^3 *	
Fluoride and compounds	HF	0.5 hours	4 mg/m^3 (100%) 2 mg/m^3 (97%)	4 mg/m^3 (100%) 2 mg/m^3 (97%)					10 mg/m^3			36 mg/m^3 *			
		1 hour												36 mg/m^3 *	5 mg/m^3
		24 hours	1 mg/m^3	1 mg/m^3	<1 mg/m^3†										
		-								50 mg/m^3	36 mg/m^3 *	36 mg/m^3 *	50 mg/m^3		
Cadmium and its compound	Cadmium (Cd)	0.5- 8 Hours	0.05 mg/m^3 (total) [b]	0.05 mg/m^3 (total)	0.005-0.02 mg/m^3 (total)†	0.1 mg/m^3	0.01 mg/m^3 *	0.02 mg/m^3 *	0.05 mg/m^3	3 mg/m^3	1 mg/m^3 *	0.14 mg/m^3 *	3 mg/m^3	0.1 mg/m^3 *	0.05 mg/m^3
Thallium and its compound	Thallium (Tl)	0.5- 8 Hours								<10 mg/m^3 total		0.05 mg/m^3			
Mercury and its compound	Mercury (Hg)	0.5- 8 Hours		0.05 mg/m^3	<15-35 µg/m^3 (new)† <15-40 µg/m^3 (exist)†	0.05 mg/m^3	0.04 mg/m^3 *	0.06 mg/m^3 *			1 mg/m^3 *	0.05 mg/m^3		0.1 mg/m^3 *	0.05 mg/m^3
		24 hours			5-20 µg/m^3										
		Long term			1 – 10 µg/m^3				0.05 mg/m^3	3 mg/m^3					
Antimony and its compound	Antimony (Sb)	0.5 – 8 Hours	0.5 mg/m^3 [b]	0.5 mg/m^3 (total)	0.01-0.3 mg/m^3 † (total)	1 mg/m^3			5 mg/m^3	10 mg/m^3	<4 mg/m^3 total*	0.5 mg/m^3	10 mg/m^3	0.7 mg/m^3 *	0.5 mg/m^3
Arsenic and its compound	Arsenic (As)								1 mg/m^3	10 mg/m^3		0.5 mg/m^3	10 mg/m^3		
Lead and its compound	Lead (Pb)						0.1 mg/m^3 *	0.02 mg/m^3 *	0.5 mg/m^3	10 mg/m^3		0.5 mg/m^3	10 mg/m^3		
Chromium and its compound	Chromium (Cr)									<10 mg/m^3		0.5 mg/m^3			
Cobalt and its compound	Cobalt (Co)											0.5 mg/m^3			
Copper and its compound	Copper (Cu)								5 mg/m^3			0.5 mg/m^3			
Manganese and its compound	Manganese (Mn)											0.5 mg/m^3			
Nickel and its compound	Nickle (Ni)											0.5 mg/m^3	10 mg/m^3		
Vanadium and its compound	Vanadium (V)											0.5 mg/m^3			

/Jurisdiction/Standards			EU 2000 [a] [1]	EU 2010 EID[a] [2]	EU BAT Ref. Doc. (2019)[3]	China[4]	USA Clean Air Guidelines and Standard for Waste Management [c]		Singapore Regulation[7]	SA EPA[8]	TAS EPA[9]	NT EPA[10]	VIC EPA[11]	NSW EPA	
Pollutants	**Expressed as**	**Averaging Period**	**2000/76/EC[**	**2010/75/EU (IED) (Annex VI)**	**for Waste Incineration BAT- 5.1.5 Conclusion pg. 491**	**GB-18485-2014[d]**	**New Large Municipal Waste Combustor 2006[5]**	**New Small Municipal Waste Combustor[6]**	**The Schedule**	**Air Quality Policy 2016 – Schedule 4: Stack Emission**	**Environmental Protection Policy 2004 – In-stack concentration**	**Guideline of disposal of waste by Incineration**	**EPP: Air Quality Management: Schedule E New Stationary Limit**	**Clean Air Regulation 2010 (General)[c][12]**	**Draft NSW Best Practice[a][13]**
Selenium, Tin, Beryllium	Total														
Sulphur oxide	SO$_2$	0.5 hours	200 mg/m^3 (100%) 50 mg/m^3 (97%)	200 mg/m^3 (100%) 50 mg/m^3 (97%)	5-30 mg/m^3 (New) † 5-40 mg/m^3 (Existing) †										
		1 hour				100 mg/m^3									100 mg/m^3
		24 hours	50 mg/m^3	50 mg/m^3		80 mg/m^3	67 mg/m^3 *	69 mg/m^3 *							
		-							1700 mg/m^3			150 mg/m^3			
	SO$_3$	-								100 mg/m^3	71 mg/m^3 *	71 mg/m^3 *	200 mg/m^3		
Nitrogen oxides	NO$_2$	0.5 hours	400 mg/m^3 (100%) 200 mg/m^3 (97%)	400 mg/m^3 (100%) 200 mg/m^3 (97%)											
		1 hour												64-357 mg/m^3 *	250 mg/m^3
		24 hours	200 mg/m^3 (new or >6 tph) 400 mg/m^3 (<6 tph)	200 mg/m^3 (new or >6 tph) 400 mg/m^3 (<6 tph)											
		-							400 mg/m^3	357 mg/m^3 *	357 mg/m^3 *	250 mg/m^3 *	357 mg/m^3 *		
	NOx	1 Hours				300 mg/m^3									
		24 hours			50-120 mg/m^3 (w SCR) † 50-150 mg/m^3 (w/o SCR) †	250 mg/m^3	240 mg/m^3 *	240-800 mg/m^3 *							
Dioxins and Furans	Toxic Equivalence Factor (TEQ)	6 – 8 hours	0.1 ng/m^3 [b]	0.1 ng/m^3	<0.01-0.04 ng I-TEQ/Nm^3 (new) † <0.01-0.06 ng I-TEQ/Nm^3 (existing) †	0.1 ng/m^3	10 ng/m^3	10 ng/m^3	1 ng/m^3	0.1 ng TEQ/ m	0.0037 ng/m^3 (as design criteria)	0.1 ng TEQ/mg		0.1 ng/m^3 *	0.1 ng/m^3
		Long term			<0.01-0.06 ng I-TEQ/Nm^3 (new) † <0.01-0.08 ng I-TEQ/Nm^3 (existing) †										
PCDD/F + dioxins like PCBs	Toxic Equivalence Factor (TEQ)	6 – 8 hours			<0.01-0.06 ng WHO-TEQ/Nm^3 (new) † <0.01-0.08 ng WHO-										

/Jurisdiction/Standards			EU 2000 [a] [1]	EU 2010 EID[a] [2]	EU BAT Ref. Doc. (2019)[3]	China[4]	USA Clean Air Guidelines and Standard for Waste Management [c]		Singapore Regulation[7]	SA EPA[8]	TAS EPA[9]	NT EPA[10]	VIC EPA[11]	NSW EPA	
Pollutants	Expressed as	Averaging Period	2000/76/EC[	2010/75/EU (IED) (Annex VI)	for Waste Incineration BAT- 5.1.5 Conclusion pg. 491	GB-18485-2014[d]	New Large Municipal Waste Combustor 2006[5]	New Small Municipal Waste Combustor[6]	The Schedule	Air Quality Policy 2016 – Schedule 4: Stack Emission	Environmental Protection Policy 2004 – In-stack concentration	Guideline of disposal of waste by Incineration	EPP: Air Quality Management: Schedule E New Stationary Limit	Clean Air Regulation 2010 (General)[c][12]	Draft NSW Best Practice[a][13]
		2-3 weeks			TEQ/Nm³ (existing) † <0.01-0.08 ng WHO-TEQ/Nm³ (new) † <0.01-0.1 ng WHO-TEQ/Nm³ (existing) †										
Carbon Monoxide	CO	10 min	150 mg/m³	150 mg/m³											
		30 min	100 mg/m³	100 mg/m³											
		1 hour				100 mg/m³								89 mg/m³ *	80 mg/m³
		4 hours					49-146 mg/m³ *	49-146 mg/m³ *							
		24 hours	50 mg/m³	50 mg/m³	10-50 mg/m³†	80 mg/m³	98-244 mg/m³ *	98-244 mg/m³ *							
		-							250 mg/m³	1000 mg/m³			2500 mg/m³		
Ammonia		24 hours			2-10 mg/m³† 2-15 mg/m³ w/ SNCR & w/o wet abatement technique	-			30 mg/m³						5 mg/m³
Colour/Smoke	Ringelmann	-				1			1		1		1	1	
	Opacity	6 mins						10%						20%	

Notes:

- **Tph:** Tonne per hour; **-:** Averaging period is not specified; - : No Limit value (No need for monitoring); **PM**: Particulate Matter
- (*) the concentration limit has been converted into 273 K, 101.325 kPa (1 atm), 11% O_2
    - $C(mg/m^3) = C(ppm) \times (MW/22.4)$; Where, C = pollutant concentration; MW = Molecular Weight; 22.4 = the volume of 1 L of 1 atm and 273 K
    - $C_{(\text{at reference oxygen\%})} = C_{(\text{at measured oxygen\%})} \times \frac{(21-\text{reference oxygen\%})}{(21-\text{measured oxygen\%})}$
    - (at 273K)= V(at measured) $\times \frac{273}{(273+\text{gas meter temperature in celcius})}$; where, V = Volume of measured air (Assume 1 m^3 for conversion)
- (†) the reported Best-Available limit has is selected and established as regulation per Directive, C. (2010). Directive 2010/75/EU of the European Parliament and of the Council. *Off. J. Eur. Union L*, *334*, 17-119.
- Long term indicates sampling is done for weeks (usually 2 – 3 weeks)
- X ppm = Y mg/m^3 x (24.45 / Molecular Weight), *indicate unit conversion `

Sources:

[1] Directive, E. U. (2000). Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste. *Official Journal of the European Communities L*, *332*, 91-111.

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[7] Singapore National Environment Agency (2015), Environmental Protection Division Annual report 2015, Appendix 7.
[8] South Australia EPA (2016). Environment Protection (Air Quality) Policy 2016 *under section 28 of the Environment Protection Act 1993*. Version: 9.4.2020
[9] Department of Tourism, arts and the Environment, Environment Division (2005) Environment Protection Policy (Air quality) 2004. *Schedule1 In-Stack Concentration*
[10] Northern Territory Environment Protection Authority (2013) Guideline for Disposal of Waste by Incineration Version 2.0.
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[12] NSW EPA (2010) Protection of the Environment Operations (Clean Air) Regulation 2010. *Schedule 4 – Standard of concertation for schedules premises: general activities and plant.*
[13] From the provided draft report.

Table 9-2: Review of Ground Level Concentration (GLC, or Ambient Air Quality AQI) Standard and limit (on Selected pollutants, in µg/m³ at 273 K, 101.325 kPa)

Pollutants	**Averaging Period**	**WHO Europe Guideline Value** [1]	**WHO Global Guideline** [2]	**Australia NEPC: National Environment Protection Measure for Ambient air**[3]	**WA Air emission Guideline** [4]	**QLD Environment department** [5]	**SA EPA**[6]	**NSW EPA**[7]
Particulate Matter ($PM_{2.5}$)	24 hours		25	25	25	25	25	25
	Annual		10	8	8	8	8	8
Particulate Matter (PM_{10})	24 hours		50	50	50	50	50	50
	Annual		20	25	25	25		25
Hydrogen chloride (HCl)	3 min						270	
	1 hour				153			153*
Hydrogen fluoride (HF)	24 hours				3.2*	2.9	3.4	1.5
	7 days				1.9*		2	0.8
	30 days				0.9*	0.84		0.4
	90 days				0.5*	0.5	1	0.25
Nitrogen Dioxide (NO_2)	1 hour	200	200	246*	246	250	250	246
	Annual	40	20	61*	62	62	60	62
Ozone (O_3)	1 hour			214*	214	210	210	214
	4 hours			171*	171	171	170	171
	8 hours	120	100					
Sulphur Dioxide (SO_2)	10 min	500	500					712
	1 hour			571*	570	570	570	570
	24 hours	125	20	229*	228	229	230	228
	Annual	50		57*	60	57	60	60
Carbon Monoxide (CO)	15 min	100,000						100,000
	30 min	60,000						
	1 hour	30,000			32,747*		31,240	30,000
	8 hours	10,000		11,250*	10,916*	11,000	11,250	10,000
Lead (Pb)	Annual	0.5		0.5	0.5	0.5	0.5	0.5
Mercury (Hg)	3 min						0.36	
	1 hour				0.6			0.20*
	Annual	1			0.2	1.1		
Cadmium (Cd)	3 min						0.036	
	1 hour				0.0196*			0.002*
	Annual	5 ng/m³				5 ng/m³		

Pollutants	Averaging Period	WHO Europe Guideline Value [1]	WHO Global Guideline [2]	Australia NEPC: National Environment Protection Measure for Ambient air[3]	WA Air emission Guideline [4]	QLD Environment department [5]	SA EPA[6]	NSW EPA[7]
Manganese (Mn)	1 hour				0.15			19.6*
	Annual	0.15				0.16		
Chromium (Cr(VI))	3 min					0.19		
	1 hour				0.098*			0.098
	Annual	2.5 ng/m^3						
Copper (Cu)	3 min					36		
	1 hour				20*			4.03*
	Annual				1*			
Cobalt (Co)					0.1			
Dioxins (PCDDs/PCDFs)	1 hour				0.000002*			0.000002*

Notes:

- (*) the concentration limit has been converted into 273 K, 101.325 kPa (1 atm)
  - C(mg/m^3) = C(ppm) x (MW/22.4); Where, C = pollutant concentration; MW = Molecular Weight; 22.4 = the volume of 1 L of 1 atm and 273 K
  - V(at 273K)= V(at measured) x$\frac{273}{(273+\text{gas meter temperature in celcius})}$; where, V = Volume of measured air (Assume 1 m^3 for conversion)

Source:

[1] World Health Organization. (2000). Air quality guidelines for Europe. *Chapter 3: Summary of the guidelines*

[2] World Health Organization. (2006). WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide: global update 2005: summary of risk assessment (No. WHO/SDE/PHE/OEH/06.02). World Health Organization.

[3] National Environment Protection *Council (2015)* Variation to the National Environment Protection (Ambient Air Quality) Measure. *Schedule 2: Standards and Goal*

[4] Department of Water and Environmental Regulation (2019). Guideline: Air emissions, regulated under Environmental protection act 1986. *Government of Western Australia. Appendix A: Ambient air quality guideline values @ 25°C*

[5] Queensland Department of Environment and Science. Environmental Protection (Air) Policy 2019. Subordinate Legislation 2019 No. 153. *Schedule 1: Air quality Objective*

[6] South Australia EPA (2016). Environment Protection (Air Quality) Policy 2016 *under section 28 of the Environment Protection Act 1993*. Version: 9.4.2020. Schedule 2: Ground Level Concentration

[7] NSW EPA (2016). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. *Environment Protection Authority*. ISBN 9781760395650. Assessment Criteria

Table 9-3: Comprehensive monitoring and reporting regulation

Standards	**EU 2000/76/EC**	**EU 2010/75/EU (IED)** **(Annex VI)**	**BAT References Document for Waste Incineration (2019)** **5.1.2 Monitoring, pg. 479**	**NSW Regulatory Limit** **NSW EPA EFW Policy**
Sampling method	CEN or ISO standard	CEN or ISO standard	EN Standards	Approved Method for Sampling and Analysis of Air Pollutants (NSW – 2006) US EPA (United State)
Process monitoring				
Monitoring point	Permit issued by competent authority	Permit issued by competent authority	-	-
Temperature in stack	Continuous	Continuous	Continuous monitoring	Continuous monitoring
Boiler Temperature	Continuous, determined by authority	Continuous, determined by authority	Continuous monitoring	Continuous monitoring
Water vapour	Continuous, at exhaust point	Continuous, at exhaust point	Continuous monitoring	Continuous monitoring
Flowrate	-	-	-	Continuous monitoring
Oxygen Content	Continuous, at exhaust point	Continuous, at exhaust point	Continuous monitoring	Continuous monitoring
Pressure	Continuous, at exhaust point	Continuous, at exhaust point	Continuous monitoring	Continuous monitoring
Pollutant monitoring method				
NOx	Continuous monitoring (provided the limit values are set)	Continuous monitoring (provided the limit values are set)	Continuous monitoring	Continuous monitoring
CO	Continuous monitoring	Continuous monitoring	Continuous monitoring	Continuous monitoring
Total particles/dust	Continuous monitoring	Continuous monitoring	Continuous monitoring	Continuous monitoring
TOC	Continuous monitoring	Continuous monitoring	(TVOC) Continuous monitoring	Continuous monitoring
HCl	Continuous monitoring	Continuous monitoring	Continuous monitoring	Continuous monitoring
HF	Continuous monitoring, may be omitted if HCl limit is not being exceeded	Continuous monitoring, may be omitted if HCl limit is not being exceeded	Continuous monitoring, may be omitted if HCl limit is not being exceeded, No EN Standard	Continuous monitoring
SO_2	Continuous monitoring	Continuous monitoring		Continuous monitoring
Heavy Metals	2x/year; 3x monthly in the first 12 months; may be reduced to 1x/year	2x/year; 3x monthly in the first 12 months; may be reduced to 1x/year	Once every six months	Min 2x/year (3x monthly in first 12 months) Continuous monitoring when appropriate measurement techniques are available
Mercury			Continuous, can be reduced to once a month	
Polycyclic aromatic carbon				
Chlorinated dioxins	2x/year; may be reduced to 1x/year	2x/year; may be reduced to 1x/year	Once a month for long term-sampling, Once every six months for short-term sampling	
Furans	2x/year; may be reduced to 1x/year	2x/year; may be reduced to 1x/year		
Dioxins line PCB				
Benzo[a]pyrene			Once every year	
NH_3			Continuous	
N_2O			Once every year	

Standards	EU 2000/76/EC	EU 2010/75/EU (IED) (Annex VI)	BAT References Document for Waste Incineration (2019) 5.1.2 Monitoring, pg. 479	NSW Regulatory Limit NSW EPA EFW Policy
Reporting				
Data presentation	"Recorded, processed and presented in an appropriation fashion… to be decided by those authorises"		See: JRC Reference Report on Monitoring of Emissions to air and water from IED Installations	
Daily Emission limit value	95% confidences internal of daily measured result shall not exceed the emissions limits: CO (10%); SO_2 (20%) NO_2 (20%); Total dust (30%); TOC (30%); HCl (40%); HF (40%). No more than five half-hourly data to be discharged due to malfunction (Exemption apply).	95% confidences internal of daily measured result shall not exceed the emissions limits: CO (10%); SO_2 (20%) NO_2 (20%); Total dust (30%); TOC (30%); HCl (40%); HF (40%). No more than five half-hourly data to be discharged due to malfunction (Exemption apply).		100% below the limit
Public availability	Application to new permits for incinerations to local authority. Annual report to competent authority, which shall be made available to the public.	Public participation in decision making	Information will be made public by authority	Information will be published to the internet
Comply if (in short)	- None of the daily average exclude the limit values. Or 97% of daily average over a year does not exceed the limit set.	- None of the half-hour average exclude the limit values. Or 97% of half-hour average over a year does not exceed the limit set. - No average value of dioxins exceeds the limit - For CO, 97% of the daily average over the year do not exceed the limit and 95% of 10-minutes average in any 24 hours do not exceed the limit.		Hourly average is 100% below the limit

10 Appendix 2: Illustrative Emission Example

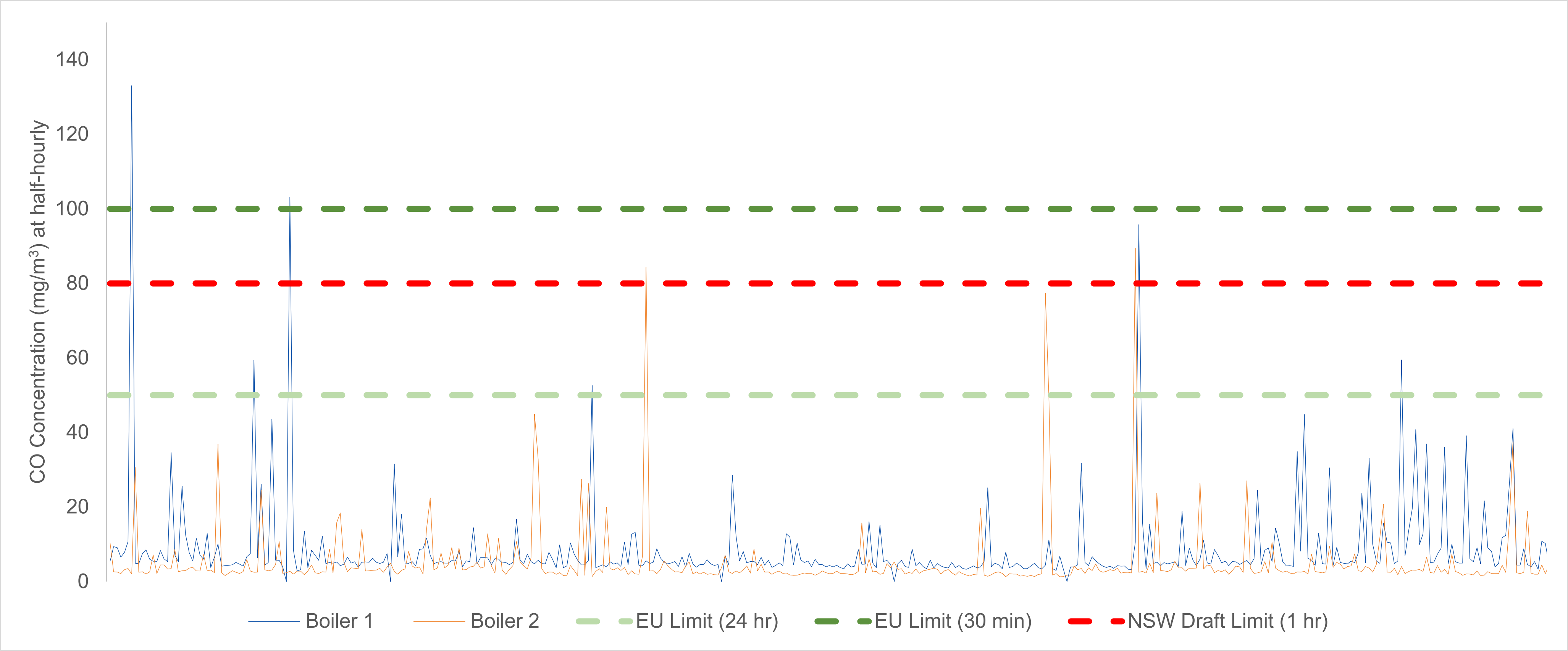


Figure 10-1: The CO emission record of EFW Covanta (Website) at half-hourly average including respective emission level

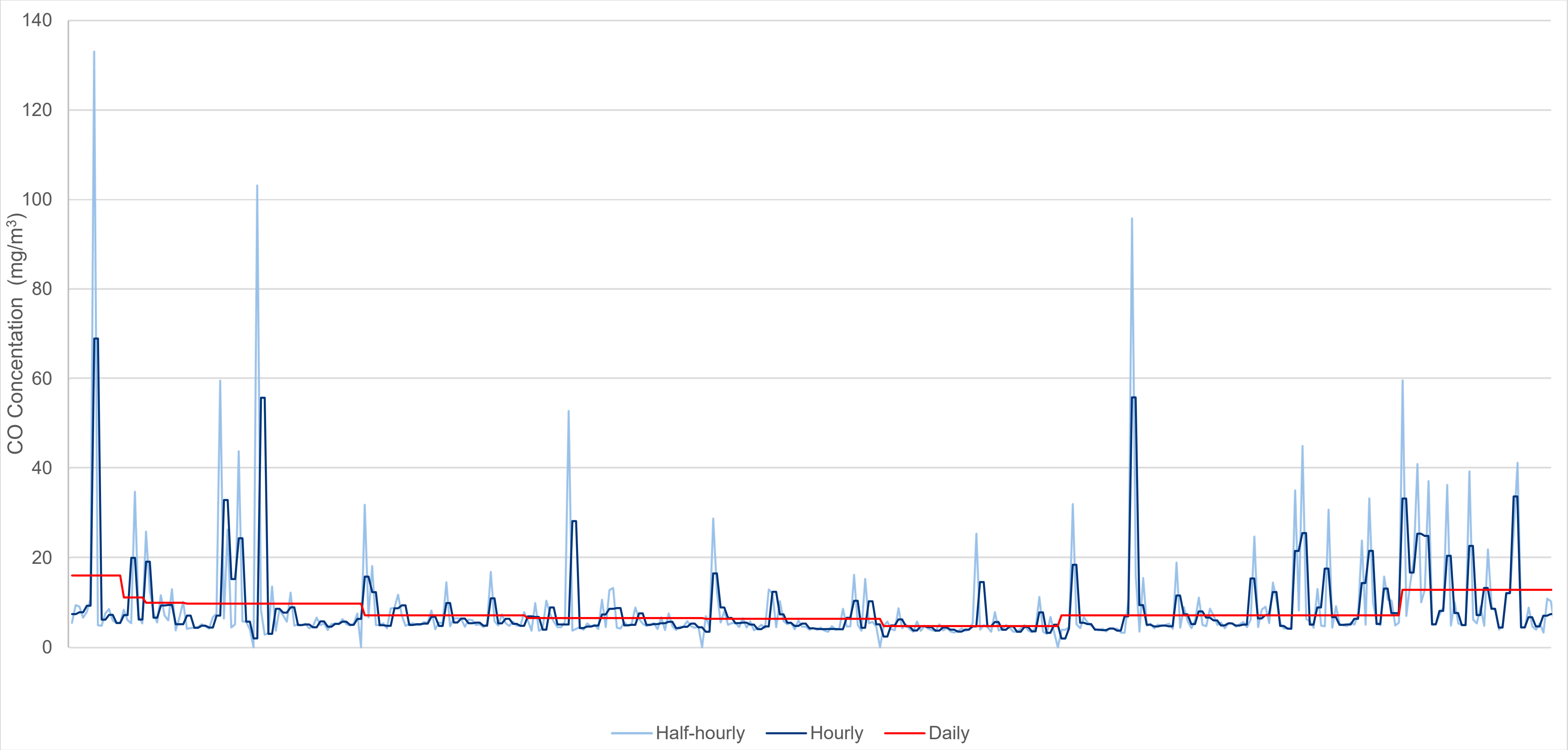


Figure 10-2: The CO emission record in boiler 1 when data is presented as hourly and daily to illustrate the dampen effect

11 Appendix 3: NSW Waste Forecast

Table 11-1: Summary of historical waste generation in NSW and forecasting (kiloton).

Overall Waste generation						
Year	**Historical**	**CAGR**	**Linear**	**Exponential**	**Population CAGR**	**GSP CAGR**
		1.54%	y = 122.72x -229353	y=0.0074 e ^(0.0073x)	1.40%	2.43%
2007	15863					
2009	18490					
2010	17374					
2011	17484					
2014	17908					
2015	17690					
2016	17948					
2017	18086					
2025		18184	19155	19462	18175	18240
2030		18309	19769	20186	18265	18330
2035		18435	20382	20936	18355	18420
Recycling						
Year	**Historical**	**CAGR**	**Linear**	**Exponential**	**Population CAGR**	**GSP CAGR**
		1.33%	y = 86.288x -163099	y=0.0003e ^(0.0086x)	1.40%	2.43%
2007	9291					
2009	10583					
2010	10731					
2011	10814					
2014	10743					
2015	10860					
2016	10741					
2017	10603					
2025		10661	11634	10974	10655	10693
2030		10734	12066	11456	10708	10746
2035		10808	12497	11959	10760	10799
EFW						

Year	Historical	CAGR	Linear	Exponential	Population CAGR	GSP CAGR
		1.92%	y = 22.999x -45644	y=1E-28 e ^(0.0351x)	1.40%	2.43%
2007	550					
2009	550					
2010	542					
2011	613					
2014	559					
2015	819					
2016	806					
2017	665					
2025		669	669	739	668	671
2030		673	673	881	672	674
2035		678	678	1050	675	677

Disposal						
Year	Historical	CAGR	Linear	Exponential	Population CAGR	GSP CAGR
		1.35%	y = 13.233x -20562	y=34.051 e ^(0.0026x)	1.40%	2.43%
2007	5674					
2009	7000					
2010	5716					
2011	5657					
2014	6214					
2015	5602					
2016	6035					
2017	6489					
2025		6524	6215	6587	6521	6544
2030		6569	6281	6673	6553	6577
2035		6614	6347	6761	6585	6609

12 Appendix 4: Terms of Reference by OCSE

Services	
Name	**Description of Milestones/Deliverables**
Provision of Independent expert advice in process engineering/air emissions for Energy from Waste	To provide written expert technical advice to the Office of the NSW Chief Scientist & Engineer (OCSE) on Energy from Waste facilities, including, 1. Review the (draft) best practice air emissions limits for energy from waste facilities outlined in the NSW framework in the CSE report (upper right corner of Figure 1 and Table 1) and comment on whether these limits are internationally the 'most stringent' and reflect technical best practice (i.e. are the lowest achievable emission rates that can be met by industry). Aspects of the review may consider, but are not confined to: a. Averaging periods Current NSW legislation stipulates 1-hour averaging periods for most emissions. It is also understood that the 2010 EU Directive limits include both 1-hr (or less) and 24-hr values and the 2019 BREF, operating in parallel to the 2010 Directive, has tightened the 24-hr values. Comment on implications for air emissions limits differences between averaging periods across jurisdictions (i.e. 1-hour vs 24-hour or other averaging periods) for the range of pollutants, including advantages/disadvantages of different approaches. b. Allowable exceedances Comment on the practical implications (benefits and disbenefits) of the different approaches across jurisdictions around: • allowable exceedances e.g. treatment of compliance during normal operating conditions or other than normal operating conditions or allowable periods or timeframes for exceedances of limits • conditional limits e.g. EU 97% limits where 97% of readings must fall below the limit). c. Pollutants monitoring Comment on range of pollutants covered in draft NSW EFW limits and any potential omissions in comparison with pollutants captured by other jurisdictions d. Continuous monitoring Comment on any jurisdiction that you are aware of that undertakes continuous monitoring for specific pollutants that NSW requires to be monitored on a periodic basis and any benefits/disbenefits and how they are managed, including sensitivity of equipment.

Services	
Name	**Description of Milestones/Deliverables**
	2. It is intended that air emission limits for EFW facilities will be reviewed on a periodic basis, particularly in consideration of evolving best practice. Comment on technology changes that might impact on scheduling of these reviews, including observations on the rate of change of technologies that would impact on emissions limits or other requirements. 3. NSW policy directions are moving toward increased recycling and reuse and net zero emissions, which may have implications on the types and volumes of future waste streams for EFW facilities. a. With the predominant technology being moving grate, comment on any challenges going forward in this technology's ability to adapt and manage variable and diverse waste streams, particularly implications for controlling emissions b. Are there emerging technologies that are better able to manage these challenges? If so, describe the technologies and their state of technological and commercial readiness, and provide relevant international examples in this regard. EFW Technology or APC Technology? 4. Comment on potential benefits and any technical challenges to co-location of EFW with other industry in the NSW context, including optimal candidates and requirements (regulatory, industry, infrastructure, etc). 5. Any other matters deemed relevant

APPENDIX 5: GUIDE TO THE NSW ENERGY FROM WASTE FRAMEWORK

The NSW Energy from Waste (EFW) framework provides a summary of the requirements and regulatory assessment process for proposed EFW plants in NSW. This is presented at **Figure 1**.

The framework was developed as part of a review of EFW undertaken by the NSW Chief Scientist & Engineer (CSE) at the request of the Minister for Energy and Environment, the Hon Matt Kean MP. A cross-agency working group was established to provide advice on environmental protection standards and frameworks to ensure that proposed EFW facilities in NSW undertake robust assessments and adopt international best practice standards and controls to ensure human health and the environment are protected.

Numerous statutes, regulations, policies, plans and other documents underpin the assessment and approval process for any major development. The framework was developed to capture the complete process and requirements for proposed EFW plants in NSW. It assisted the working group to assess and make comparisons with requirements in other jurisdictions, both in Australia and internationally. It also provides a tool for stakeholders to understand the entirety of requirements. This Guide was developed to orient the reader to the framework and to highlight major elements of the process.

Figure 1 includes hyper-links to relevant policies and guidelines for each topic area. When multiple documents are involved, these links take the reader to a landing page with information and further links. In addition to requirements, the documents include details of modelling and risk assessment processes that the applicant must follow as part of their application.

An overview of the planning assessment process for EFW plants appears on the left side of **Figure 1**. It is anticipated that EFW plants will generally be categorised as State significant developments (SSD). Developments are categorised as SSD due to their size, economic value or potential impacts. Information about how SSDs are assessed can be found here. This webpage in turn links to the major projects website which contains information and reports about all SSD applications, including proposed EFW.

Under the NSW Energy from Waste Policy Statement (EFW policy), proposals must:

- meet current international best practice techniques, including emissions controls
- use technologies that are proven, well understood and capable of handling the waste inputs. This must be demonstrated through reference to fully operational plants using the same technologies and treating similar waste streams to the proposed plant
- meet technical, thermal efficiency and resource recovery criteria
- undertake monitoring with real-time feedback.

The centre and right side of **Figure 1** sets out technical requirements relating to allowable waste inputs, plant technology, air emissions and waste treatment and disposal. The upper right corner of **Figure 1** includes best practice air emissions limits for EFW plants. These limits are the maximum emissions for different pollutant types permitted for any approved EFW plants. The limits were developed by the NSW Environment Protection Authority (EPA) and reviewed by an independent expert commissioned by the CSE. The limits as they appear reflect the advice from this expert review.

The lower right quadrant of **Figure 1** sets out the impact and risk assessments that must be undertaken. These assessments must include detailed consideration and account for all parts of the proposed plant, technology and practices from the point of design to the build and operations. The suitability of models used to assess local and regional air quality impacts must be demonstrated. All assessments, including a human health risk assessment, must be undertaken in accordance with the methods specified in the Secretary's Environmental Assessment Requirements for the SSD project.

As a result of the various assessments, the design, scale or other elements of the proposal may need to be revised to achieve compliance with all requirements (lower centre quadrant of **Figure 1**). Applicants must also develop risk assessment, action and response plans to manage any variability in waste inputs and to appropriately manage water and solid waste outputs.

1. The Planning process – how EFW proposals are assessed

Applicants must meet with NSW planning officials before any proposals are lodged. This is to ensure there is a complete understanding of the entirety of all requirements and processes. In addition to technical matters, the proposed location of the site and consistency with the EFW policy are discussed. Other matters discussed include:

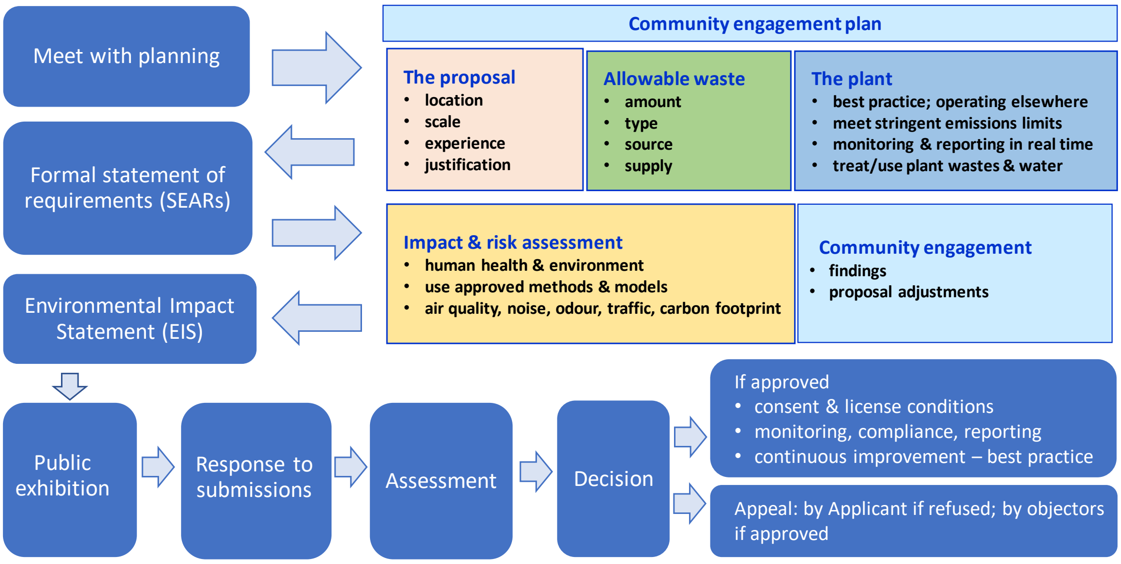
- a description and justification for the scope of the proposal, the waste inputs and volumes, the type of plant and its expected operational performance
- an overview of identified stakeholders and proposed community engagement activities
- likely risk assessments that will be required to understand possible environmental and human health impacts based on the plant, waste inputs and local environmental and community conditions.

Following the initial meeting(s) with planning officials, and once the scope and design of the proposed plant have been established and described in a scoping report, a formal statement of requirements is issued - called the Secretary's Environmental Assessment Requirements (SEARs). The SEARs set out all the issues that must be addressed and studies undertaken for the proposal to be considered. The SEARs are developed in consultation with and on advice from stakeholders including local councils and state government agencies.

Applicants are required to prepare an Environmental Impact Statement (EIS) addressing all requirements included in the SEARs. Once a development application is lodged, the EIS is put on public display for a minimum period of 28 days. Nearby residents and businesses are notified of the proposal; and submissions are invited from the community, local council and government agencies. The applicant then prepares a response to issues raised.

The assessment by planning officials considers all relevant law, policy and plans; specialist advice from government agencies or other technical experts; feedback and submissions made by stakeholders; and the applicant's response. A report on the assessment of key potential impacts and a recommendation is prepared by planning officials.

If approved, the planning consent and Environment Protection Licence (EPL) set out the conditions for operation, monitoring and reporting. The EPL can require additional studies or programs of work be undertaken.



Process and requirements overview

2. What is an EFW plant

EFW plants thermally treat certain types of waste materials for the purposes of energy recovery. The EFW policy requires that a minimum amount of energy generated (25%) is captured as electricity, or an equivalent amount of heat is recovered. This requirement is to ensure waste isn’t simply burned. Thermal treatment includes combustion, thermal oxidation, gasification and pyrolysis.

There are strict limits about what waste can be used in NSW EFW plants. Hazardous wastes are not allowed – they require special treatment. There are also limits about the amount (proportion) of different waste types that can be used. These limits are designed to align with the waste hierarchy and to encourage recycling and reuse.

The CSE review mapped fuel types and facilities that are included (or excluded) from the EFW policy requirements. This is provided at **Figure 2.**

Included in **Figure 2** is the type of feedstock that EFW facilities are permitted to receive under the EFW policy; the proportion of each waste stream allowed for energy recovery; and requirements about where waste can be sourced from.

It is expected that the amount and type of waste produced will change over time. This will be influenced by development of new materials and expected changes in patterns of recycling, reprocessing and reuse. Proposals must demonstrate that the plant can accommodate these changes and that they have both a primary and a secondary source of supply.

The EFW policy requires waste inputs be characterised. The CSE review made recommendations to reinforce oversight of waste inputs and to ensure proposals are consistent with the waste hierarchy and NSW policies relating to sustainability, circular economy and net-zero emissions. These include that:

- work is undertaken to understand the mix of incentives that influence consumer and industry behaviours to promote adherence to the waste hierarchy. This includes the impact of gate fees at landfill sites and EFW facilities
- approved proposals are required to develop a sampling and reporting program for waste inputs
- a Life Cycle assessment (LCA) is required and the findings considered in the regulatory assessment process.

3. Use of Best Practice Technology and requirement for a reference plant

The EFW policy requires projects to use international best practice techniques, including in:

- process design and control
- emission control equipment
- emissions monitoring
- receipt and management of waste
- management of residues.

To provide confidence in the ability of the proposed plant to operate at known and acceptable standards, particularly in relation to air emissions, an established reference facility is required (**Figure 1**).

A recognised challenge is that waste inputs are never identical and may vary within and across jurisdictions as well as over time. This variation could potentially affect plant performance and therefore the type and level of air emissions or residual waste streams. Therefore, each proposal requires careful assessment on a case by case basis, taking into account expected performance under local conditions, including efficiency and ability to manage the proposed waste stream.

Under the EFW policy, applicants are required to outline residual risks and provide plans to manage variability of waste inputs outside expected and acceptable bandwidths. It is also expected that applicants commit to continual improvement of technology and emission controls in line with international best practice.

While adherence to the framework presented at **Figure 1** does not guarantee approval, closer alignment between the proposed waste inputs and the reference technology provides greater confidence in the expected performance of the proposed plant. Likewise, increasing deviation from the type or uniformity of inputs will require a proportional increase in data and information about (1) the reason for doing so, and (2) how the difference will be managed.

Having reviewed the requirements and process, the CSE review concluded that the framework for assessing proposed EFW facilities appears sufficiently flexible in its ability to adapt to emerging best practice.

4. Emissions limits

NSW regulations and policies set maximum air pollutant emission limits and monitoring standards that industry must comply with. The EFW policy states that the process and air emissions from the facility must satisfy, at a minimum, the requirements of the requirements of Group 6 Limits under the *Protection of the Environment Operations (Clean Air) Regulation* 2010 (the Clean Air Regulation).

The NSW EFW policy also requires that facilities demonstrate that they will be using current international best practice control equipment. Consequently, the emissions limits set for EFW facilities in Environment Protection Licences (EPLs) are likely to be more stringent than 'Group 6' emissions.

Section 45 of the *Protection of the Environment Operations Act* (POEO Act) sets out matters regulators are required to take into account when exercising licensing functions. This includes environmental protection policies; the pollution likely to be caused by the activities; and practical measures that can be taken to prevent, control or mitigate pollution and protect the environment from harm. These statutory requirements, together with the principles and requirements described in the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW 2016 (Approved Methods for Modelling) are applied by the EPA when setting emissions limits for industrial activities. This includes the best practice air emission limits for EFW facilities (best practice limits) set out in the top right corner of **Figure 1**.

The principles applied by the EPA include setting emission limits that:

- reflect reasonably available control technology and good environmental practice
- reflect proper and efficient operation
- protect the health and amenity of the surrounding community
- are consistent with minimising toxic air pollutants to the maximum extent achievable through the application of best practice process design and/or emission controls.

Information considered when emission limits are set in NSW includes:

- emission control performance information available from other jurisdictions such as the European Union
- knowledge and information gained from assessments included in recent EFW development applications in NSW and elsewhere in Australia
- air quality impact assessments.

This approach is consistent with ongoing policy and technology reviews undertaken in comparable jurisdictions, including for example, the USA and EU.

In NSW, a local air quality impact assessment of emissions from the proposed plant must be undertaken as part of the Environmental Impact Statement (EIS). Assessment and modelling must be undertaken in accordance with the statutory methods set out in the Approved Methods for Modelling. This includes preparation of an emissions inventory, use of meteorological data and technical requirements for the air quality impact assessment. These include how background concentrations of pollutants are accounted for; how the chemical transformation of pollutants is modelled; methods for modelling dispersion of emissions; how dispersion modelling results are interpreted and impact assessment criteria for specific pollutants.

The expert review recommended that the best practice air emission limits are reviewed within three years. The EPA advise the review will consider emissions data obtained for any established EFW facilities and that the EFW policy will be reviewed at the same time.

5. Monitoring

Methods for both periodic and continuous emissions monitoring to demonstrate compliance with air emission limits are set out in the Approved Methods for sampling and analysis of air pollutants in New South Wales (2007). These methods are currently being reviewed, including an assessment of advances in plant emissions control and monitoring technologies.

Where technology permits reliable measurement, continuous monitoring is required. The NSW EFW policy requires continuous, real time measurements of nitrous oxide (NOx), sulfur dioxide (SO_2), carbon monoxide (CO), total particles, total organic carbon (TOC), hydrochloric acid (HCl) and fluorhydric acid (HF). The EPA also required periodic measurement of other pollutants such as metals and dioxins.

For any approved facility, the EPA will require operators to undertake proof of performance campaign monitoring after construction has been completed. This is to demonstrate compliance with air emissions standards. Monitoring requirements set out in Environment Protection Licences are tailored to each project. The licences detail pollutants to be monitored, monitoring methods, monitoring frequency and reporting requirements. Licence reviews consider improvements in monitoring technologies, individual project risk factors identified during the planning process and the plant’s operating and compliance history over time.

6. Human Health Risk Assessment (HHRA)

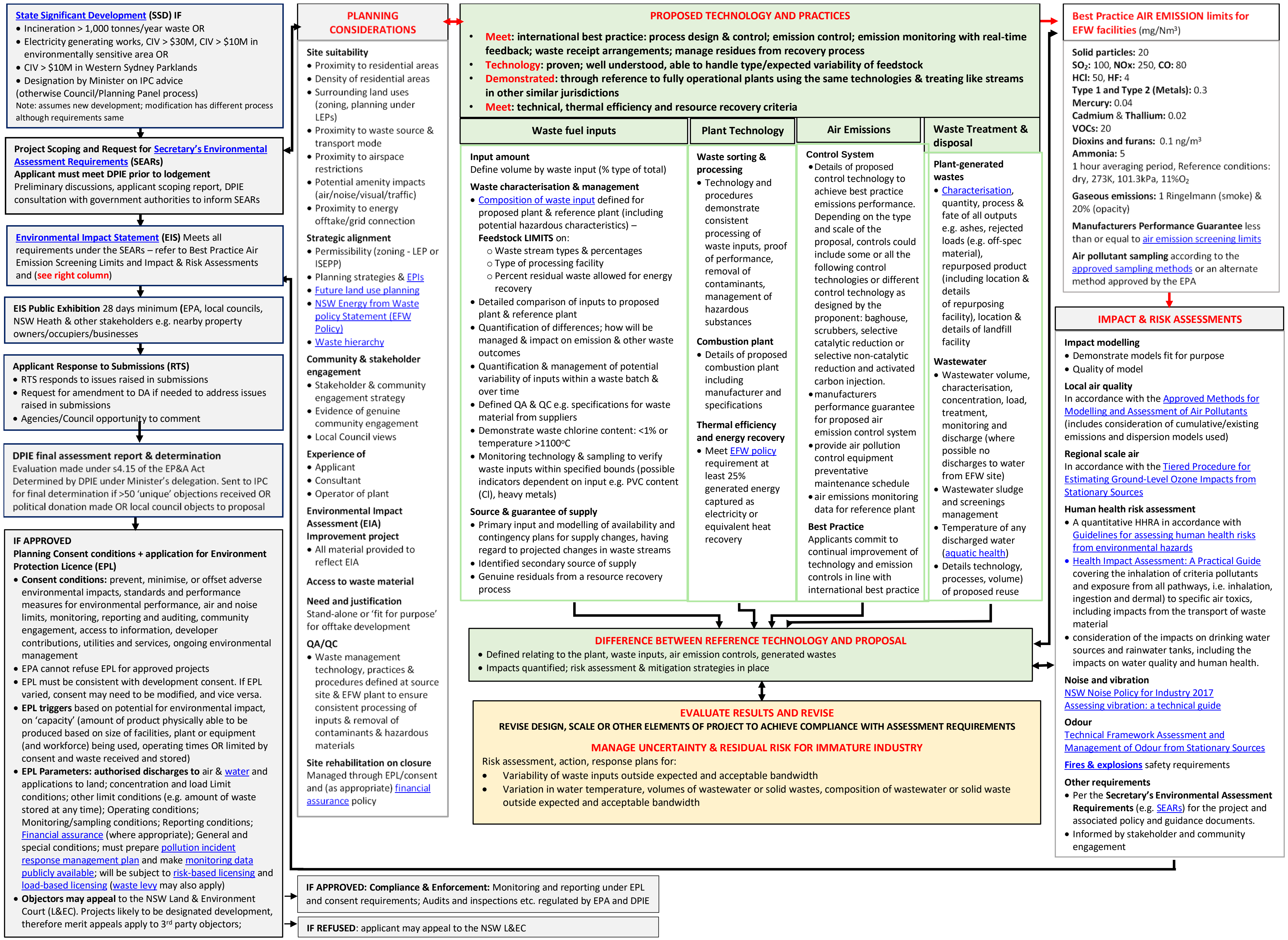
Applicants are required to prepare and submit a detailed Human Health Risk Assessment (HHRA). The HHRA must be undertaken in accordance with the Australian ‘Guidelines for assessing human health risks from environmental hazards’ (enHealth, 2012). The HHRA is reviewed by technical experts in NSW government agencies. Independent external experts may also be engaged to assess complex proposals such as EFW plants.

The enHealth guidance provides a nationally consistent approach to environmental health assessment. Emphasis is given to appropriate scoping in the design phase of risk assessment and consultation with all stakeholders and decision makers to ensure the conceptual models and methodologies used are adequate.

The general methodology of a HHRA involves issue identification, hazard identification and dose-responses assessment, exposure assessment and risk characterisation. This information is considered in the context of available literature from laboratory, animal and human health studies about exposure to and impacts of pollutants on human health. Actual and derived (modelled) data as well as expert opinion is used. More specific information, e.g. the location of the proposed plant, atmospheric and geographic conditions that will influence the dispersal of any emissions and population demographics, including vulnerable groups, are included in the assessment.

An important input to the HHRA is the air quality impact assessment. This assessment, as well as performance data from the reference plant, helps to identify pollutants of concern and potential exposure levels. This information helps to ensure the HHRA focuses on the main contributors to health risk. Potential exposure pathways for these pollutants is considered, including inhalation, contact with soil, contact and ingestion of groundwater, drinking water (water from rainwater tanks or water reservoirs) or ingestion of home-grown food. Risks from multiple exposure pathways are also assessed. For each pollutant, both acute and chronic exposure is assessed. Safety margins are usually applied to threshold values to ensure those most sensitive are protected.

It is important to recognise that the exposure risks in the HHRA are associated with ambient air quality as it relates to whole populations and not the individual. Currently, there is no means of assessing the impact that a single source of emissions (e.g. a specific plant) will have on an individual.



State Significant Development (SSD) IF
- Incineration > 1,000 tonnes/year waste OR
- Electricity generating works, CIV > $30M, CIV > $10M in environmentally sensitive area OR
- CIV > $10M in Western Sydney Parklands
- Designation by Minister on IPC advice

(otherwise Council/Planning Panel process)

Note: assumes new development; modification has different process although requirements same

Project Scoping and Request for Secretary's Environmental Assessment Requirements (SEARs)
Applicant must meet DPIE prior to lodgement
Preliminary discussions, applicant scoping report, DPIE consultation with government authorities to inform SEARs

Environmental Impact Statement (EIS) Meets all requirements under the SEARs – refer to Best Practice Air Emission Screening Limits and Impact & Risk Assessments and (**see right column**)

EIS Public Exhibition 28 days minimum **(**EPA, local councils, NSW Heath & other stakeholders e.g. nearby property owners/occupiers/businesses

Applicant Response to Submissions (RTS)
- RTS responds to issues raised in submissions
- Request for amendment to DA if needed to address issues raised in submissions
- Agencies/Council opportunity to comment

DPIE final assessment report & determination
Evaluation made under s4.15 of the EP&A Act
Determined by DPIE under Minister's delegation. Sent to IPC for final determination if >50 'unique' objections received OR political donation made OR local council objects to proposal

IF APPROVED
Planning Consent conditions + application for Environment Protection Licence (EPL)
- **Consent conditions:** prevent, minimise, or offset adverse environmental impacts, standards and performance measures for environmental performance, air and noise limits, monitoring, reporting and auditing, community engagement, access to information, developer contributions, utilities and services, ongoing environmental management
- EPA cannot refuse EPL for approved projects
- EPL must be consistent with development consent. If EPL varied, consent may need to be modified, and vice versa.
- **EPL triggers** based on potential for environmental impact, on 'capacity' (amount of product physically able to be produced based on size of facilities, plant or equipment (and workforce) being used, operating times OR limited by consent and waste received and stored)
- **EPL Parameters: authorised discharges to** air & water and applications to land; concentration and load Limit conditions; other limit conditions (e.g. amount of waste stored at any time); Operating conditions; Monitoring/sampling conditions; Reporting conditions; Financial assurance (where appropriate); General and special conditions; must prepare pollution incident response management plan and make monitoring data publicly available; will be subject to risk-based licensing and load-based licensing (waste levy may also apply)
- **Objectors may appeal** to the NSW Land & Environment Court (L&EC). Projects likely to be designated development, therefore merit appeals apply to 3rd party objectors;

IF APPROVED: Compliance & Enforcement: Monitoring and reporting under EPL and consent requirements; Audits and inspections etc. regulated by EPA and DPIE

IF REFUSED: applicant may appeal to the NSW L&EC

PLANNING CONSIDERATIONS

Site suitability
- Proximity to residential areas
- Density of residential areas
- Surrounding land uses (zoning, planning under LEPs)
- Proximity to waste source & transport mode
- Proximity to airspace restrictions
- Potential amenity impacts (air/noise/visual/traffic)
- Proximity to energy offtake/grid connection

Strategic alignment
- Permissibility (zoning - LEP or ISEPP)
- Planning strategies & EPIs
- Future land use planning
- NSW Energy from Waste policy Statement (EFW Policy)
- Waste hierarchy

Community & stakeholder engagement
- Stakeholder & community engagement strategy
- Evidence of genuine community engagement
- Local Council views

Experience of
- Applicant
- Consultant
- Operator of plant

Environmental Impact Assessment (EIA) Improvement project
- All material provided to reflect EIA

Access to waste material

Need and justification
Stand-alone or 'fit for purpose' for offtake development

QA/QC
- Waste management technology, practices & procedures defined at source site & EFW plant to ensure consistent processing of inputs & removal of contaminants & hazardous materials

Site rehabilitation on closure
Managed through EPL/consent and (as appropriate) financial assurance policy

PROPOSED TECHNOLOGY AND PRACTICES
- **Meet: international best practice: process design & control; emission control; emission monitoring with real-time feedback; waste receipt arrangements; manage residues from recovery process**
- **Technology: proven; well understood, able to handle type/expected variability of feedstock**
- **Demonstrated: through reference to fully operational plants using the same technologies & treating like streams in other similar jurisdictions**
- **Meet: technical, thermal efficiency and resource recovery criteria**

Waste fuel inputs

Input amount
Define volume by waste input (% type of total)

Waste characterisation & management
- Composition of waste input defined for proposed plant & reference plant (including potential hazardous characteristics) – **Feedstock LIMITS** on:
  - Waste stream types & percentages
  - Type of processing facility
  - Percent residual waste allowed for energy recovery
- Detailed comparison of inputs to proposed plant & reference plant
- Quantification of differences; how will be managed & impact on emission & other waste outcomes
- Quantification & management of potential variability of inputs within a waste batch & over time
- Defined QA & QC e.g. specifications for waste material from suppliers
- Demonstrate waste chlorine content: <1% or temperature >1100°C
- Monitoring technology & sampling to verify waste inputs within specified bounds (possible indicators dependent on input e.g. PVC content (Cl), heavy metals)

Source & guarantee of supply
- Primary input and modelling of availability and contingency plans for supply changes, having regard to projected changes in waste streams
- Identified secondary source of supply
- Genuine residuals from a resource recovery process

Plant Technology

Waste sorting & processing
- Technology and procedures demonstrate consistent processing of waste inputs, proof of performance, removal of contaminants, management of hazardous substances

Combustion plant
- Details of proposed combustion plant including manufacturer and specifications

Thermal efficiency and energy recovery
- Meet EFW policy requirement at least 25% generated energy captured as electricity or equivalent heat recovery

Air Emissions

Control System
- Details of proposed control technology to achieve best practice emissions performance. Depending on the type and scale of the proposal, controls could include some or all the following control technologies or different control technology as designed by the proponent: baghouse, scrubbers, selective catalytic reduction or selective non-catalytic reduction and activated carbon injection.
- manufacturers performance guarantee for proposed air emission control system
- provide air pollution control equipment preventative maintenance schedule
- air emissions monitoring data for reference plant

Best Practice
Applicants commit to continual improvement of technology and emission controls in line with international best practice

Waste Treatment & disposal

Plant-generated wastes
- Characterisation, quantity, process & fate of all outputs e.g. ashes, rejected loads (e.g. off-spec material), repurposed product (including location & details of repurposing facility), location & details of landfill facility

Wastewater
- Wastewater volume, characterisation, concentration, load, treatment, monitoring and discharge (where possible no discharges to water from EFW site)
- Wastewater sludge and screenings management
- Temperature of any discharged water (aquatic health)
- Details technology, processes, volume) of proposed reuse

DIFFERENCE BETWEEN REFERENCE TECHNOLOGY AND PROPOSAL
- Defined relating to the plant, waste inputs, air emission controls, generated wastes
- Impacts quantified; risk assessment & mitigation strategies in place

EVALUATE RESULTS AND REVISE

REVISE DESIGN, SCALE OR OTHER ELEMENTS OF PROJECT TO ACHIEVE COMPLIANCE WITH ASSESSMENT REQUIREMENTS

MANAGE UNCERTAINTY & RESIDUAL RISK FOR IMMATURE INDUSTRY

Risk assessment, action, response plans for:
- Variability of waste inputs outside expected and acceptable bandwidth
- Variation in water temperature, volumes of wastewater or solid wastes, composition of wastewater or solid waste outside expected and acceptable bandwidth

Best Practice AIR EMISSION limits for EFW facilities (mg/Nm³)

Solid particles: 20
SO_2: 100, **NOx:** 250, **CO:** 80
HCl: 50, **HF:** 4
Type 1 and Type 2 (Metals): 0.3
Mercury: 0.04
Cadmium & **Thallium:** 0.02
VOCs: 20
Dioxins and furans: 0.1 ng/m³
Ammonia: 5
1 hour averaging period, Reference conditions: dry, 273K, 101.3kPa, 11%O_2

Gaseous emissions: 1 Ringelmann (smoke) & 20% (opacity)

Manufacturers Performance Guarantee less than or equal to air emission screening limits

Air pollutant sampling according to the approved sampling methods or an alternate method approved by the EPA

IMPACT & RISK ASSESSMENTS

Impact modelling
- Demonstrate models fit for purpose
- Quality of model

Local air quality
In accordance with the Approved Methods for Modelling and Assessment of Air Pollutants (includes consideration of cumulative/existing emissions and dispersion models used)

Regional scale air
In accordance with the Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources

Human health risk assessment
- A quantitative HHRA in accordance with Guidelines for assessing human health risks from environmental hazards
- Health Impact Assessment: A Practical Guide covering the inhalation of criteria pollutants and exposure from all pathways, i.e. inhalation, ingestion and dermal) to specific air toxics, including impacts from the transport of waste material
- consideration of the impacts on drinking water sources and rainwater tanks, including the impacts on water quality and human health.

Noise and vibration
NSW Noise Policy for Industry 2017
Assessing vibration: a technical guide

Odour
Technical Framework Assessment and Management of Odour from Stationary Sources

Fires & explosions safety requirements

Other requirements
- Per the **Secretary's Environmental Assessment Requirements** (e.g. SEARs) for the project and associated policy and guidance documents.
- Informed by stakeholder and community engagement

Figure 3: Assessment requirements and regulatory process for Energy from Waste projects in NSW

LEGISLATIVE FRAMEWORK

- Protection of the Environment Operations Act 1997 (POEO Act)
- Protection of the Environment Operations (Waste) Regulation 2014
- Protection of the Environment Operations (Clean Air) Regulation 2010 (POEO (Clean Air) Regulation
  Regulation of air emissions, including maximum industrial source emissions
- Protection of the Environment Operations (General) Regulation 2009
  Schedule 1 – scheduled activities that are subject to load-based licensing and relevant assessible pollutants
- Waste Avoidance and Resource Recovery Act 2001 (WaRR Act)
  Hierarchy for resource management (avoid, recover, dispose); EPA role in developing, monitoring waste strategies; extended producer responsibility schemes

ENERGY FROM WASTE POLICY STATEMENT

Objectives

- Protect human and health and environment (POEO Act);
- Meet resource management hierarchy (WaRR Act)
  (1) avoid unnecessary consumption
  (2) recover (reuse, reprocess, recycle, recover energy)
  (3) dispose

ELIGIBLE WASTE FUELS
MUST MEET OTHER REQUIREMENTS

Eligible Waste Fuels (EWF)

- Are waste/waste derived materials posing low risk of harm to the environment and human health when used as a fuel due to origin, low level of contaminants, consistency over time
- Include biomass from agriculture; forestry and sawmill residue; uncontaminated wood waste; recovered waste oil; organic residues from virgin paper pulp activities; landfill gas and biogas e.g. anaerobic digestor
- Eligible waste fuels meeting the definition of a **standard fuel** defined under the POEO (Clean Air) Regulation which meet emissions criteria still require approval for use.
- Standard Fuel is any unused and uncontaminated solid, liquid or gaseous fuel that is: (a) coal or coal-derived fuel (other than any tar or tar residues), or (b) liquid or gaseous petroleum-derived fuel, or (c) wood or wood-derived fuel, or (d) bagasse.

Requirements for Eligible Waste Fuels

- May be thermally treated using a range of treatment technologies, provided a resource recovery order and exemption has been granted by the EPA.
- Resource recovery orders and exemptions are issued by the EPA under Part 9 of the Protection of the Environment Operations (Waste) Regulation 2014 and exempt a person from the various waste regulatory requirements that apply to the use of a waste fuel (e.g. waste disposal licensing, levy payments, etc.). The exemptions apply to waste fuels determined by the EPA to be fit-for-purpose, bona-fide energy recovery opportunities.
- The origin, composition and consistency of these wastes must ensure that emissions from thermal treatment will be known and consistent over time. Facilities proposing to use eligible waste fuels must meet the following criteria:
  - ability to demonstrate to the EPA that the proposed waste consistently meets the definition of an EPA-approved eligible waste fuel
  - confirm there are no practical, higher order reuse opportunities for the waste
  - fully characterise the waste and/or undertake proof of performance
  - meet the relevant emission standards as set out in the Protection of the Environment Operations (Clean Air) Regulation 2010.

FACILITIES WITH THERMAL TREATMENT EXCLUDED

Other regulatory frameworks already apply:

- thermal processes where there is no change in the chemical composition of the waste
- transport fuels produced from waste
- autoclaving processes
- biological processes, such as anaerobic digestion and composting of waste.

Not regarded as undertaking genuine energy recovery:

- for the destruction of waste
- for the thermal treatment of contaminated soil
- proposing the thermal treatment of unprocessed mixed waste streams
- proposing the thermal treatment of waste that has been exhumed from landfills
- proposing the thermal treatment of hazardous waste materials.

ALL OTHER WASTES
MUST MEET ENERGY RECOVERY FACILITY REQUIREMENTS IN EFW POLICY STATEMENT

Wastes

- **Combination eligible and non-eligible wastes:** If the facility is proposing to thermally treat (defined in POEO Act) a combination of eligible and other waste fuels, it will be subject to the requirements of an energy recovery facility
- **Non eligible waste:** Facilities proposing to thermally treat any waste or waste-derived materials (as defined in Sch. 1 POEO Act) that are not listed as an eligible waste fuel must meet the requirements of an energy recovery facility.

Facilities

- Thermally treat waste (defined in Sch. 1 POEO Act) or waste-derived materials for the recovery of energy. Thermal treatment means the processing of wastes by combustion, thermal oxidation, thermal or plasma gasification, pyrolysis and torrefaction or other thermal treatment processes.
- Where a thermal process, such as pyrolysis or gasification, produces a gas for subsequent combustion (for example, a syngas), the facility where that gas is combusted.

Feedstock

Energy recovery facilities may only receive feedstock from waste processing facilities or collection systems that meet the criteria:

Waste stream	Processing Facility	% residual waste allowed for energy recovery
Mixed wastes		
Municipal solid waste (MSW)	LGA has separate collection for dry recyclables and food and garden waste	No limit by weight
	LGA has separate collection for dry recyclables and garden waste	Up to 40% by weight received at the processing facility
	LGA has separate collection for dry recyclables	Up to 25% by weight of waste received at the processing facility
Commercial and industrial (C&I)		Up to 50% by weight of waste received at the processing facility
	Mixed C&I where business has separate collection for all relevant waste streams	No limit by weight
Construction and demolition (C&D)		Up to 25% by weight of waste received at the processing facility
Residuals from source-separated materials		
Source-separated recyclables from MSW		Up to 10% by weight of waste received at the processing facility
Source-separated garden waste		Up to 5% by weight of waste received at the processing facility
Source-separated food +/- garden waste		Up to 10% by weight of waste received at the processing facility
Separated waste streams		
Waste stream	**Feedstock able to be used at an energy recovery facility**	
Waste wood	Residual wood waste sources directly from a waste generator e.g. manufacturing facility	
Textiles	Residuals textiles sourced directly from a waste generator	
Waste tyres	End-of-life tyres	
Biosolids	Used only in a process to produce a char for land application	
Source-separated food & garden organics	Used only in a process to produce a char for land application	

Figure 4: Waste fuels and facilities