Guideline

Energy from Waste

Energy from Waste Guideline

This guideline has been developed to assist proponents of energy from waste (EfW) facilities to align with Queensland's EfW Policy. It outlines matters proponents should consider in developing their EfW projects and the information applicants should provide to the Department of Environment and Science (DES) with an application for an environmental authority to conduct an EfW activity.

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Abbreviations

APCr	Air pollution control residues
ARENA	Australian Renewable Energy Agency
BAT	Best Available Techniques
BATc	Best Available Techniques Conclusions (of the BREF)
BAT-AEL	Best available Techniques associated emissions level
BOM	Bureau of Meteorology
BREF	Best Available Techniques Reference Documents
C&D	Construction and demolition waste
C&I	Commercial and industrial waste
CCF	Climate Correction Factor
DES	Department of Environment and Science
DWER	Western Australia Department of Water and Environmental Regulation
EA	Environmental authority
EIS	Environmental impact statement
EOW	End of waste
EPP Air	Environment Protection (Air) Policy 2019
ERA	Environmentally relevant activity
EU	European Union
EWC	European waste classification system
FOGO	Food organics and garden organics
GLC	Ground level concentration
HDD	Heating degree days
IAP2	International Association of Public Participation
IBA	Incinerator bottom ash
IED	Directive 2010/75/EU on Industrial Emissions (Industrial Emissions Directive)
LCA	Life cycle analysis
MRF	Material recovery facility
MSW	Municipal solid waste
NOx	Nitrogen oxides
NSW EPA	New South Wales Environment Protection Authority
PEF	Processed engineered fuel
PFAS	Per- and poly-fluoroalkyl substances
PM	Particulate matter
POEO	Protection of the Environment Operations Act 1997
RDF	Refuse derived fuel
SARA	State Assessment and Referral Agency
SIA	Social impact assessment
SLO	Social licence to operate
TEEP	Technically, environmentally and economically practicable
tpa	Tonnes per annum
TRA	Technology readiness assessment
TRL	Technology readiness level
VOC	Volatile organic compounds
WFD	European Union Waste Framework Directive
WI BREF	Waste Incineration Best Available Techniques Reference Documents
WT BREF	Waste Treatment Best Available Techniques Reference Documents

Summary

Queensland's Energy from Waste (EfW) Policy (the Policy) was released on 4 June 2020 under the Waste Management and Resource Recovery Strategy (Waste Strategy). The Policy aims to guide EfW activities in Queensland in a manner that safeguards human and environmental health, while supporting the targets and objectives of the Waste Strategy. The Policy outlines seven high-level outcomes for proponents wishing to establish facilities that recover fuels, electricity and heat from waste that is not practical to reuse or recycle.

While the Policy is non-statutory, it signals the government's preferences and policy intentions concerning the future environmental management of EfW facilities. As such, the Policy falls within the standard criteria that must be considered by the administering authority under the *Environmental Protection Act 1994* in deciding an application for an environmental authority (EA).

This guideline aims to provide proponents of EfW facilities with guidance on the scope, intention and application of the Policy. The guideline also features several EfW case studies that showcase facilities achieving outcomes in line with the Policy. This guideline may be used by proponents/applicants when planning and conducting their EfW activities; by communities wishing to better understand the Policy and associated guidance being provided to proponents, and how proponents are expected to address community and environmental concerns; and by state departments and local governments as a general reference for assessment and management of EfW facilities.

As this guideline supports the Policy, it will be considered by the Department of Environment and Science (DES) as part of assessing an EA application for an EfW activity. It is important to note that a range of other considerations and regulatory requirements may also inform a decision on any individual application.

This guideline contains four chapters. Chapter 1 provides some background on the Policy and the European Union's Best Available Techniques Reference Documents which are adopted under outcome 7 of the Policy. The guideline also outlines the purpose and scope of the guideline in terms of the types and scales of EfW facilities.

Chapter 2 of the guideline provides further details on the seven outcomes of the Policy. This information can help the applicant to further understand the strategic benefits and risks of proposed EfW facilities and where appropriate, further develop their proposed facility to deliver beneficial outcomes for Queensland in line with the Policy. Chapter 2 also outlines the relevance of specific policy outcomes to the four EfW types.

Chapter 3 of the guideline gives a high-level overview of the application process for an EA to conduct an EfW activity, including information that should be provided in an application. It also provides links to more detailed guidance to assist proponents.

Chapter 4 of the guideline contains several case studies of EfW facilities located in Australian and international jurisdictions. These case studies provide some insights into EfW facilities that have managed to achieve outcomes in line with the Policy outcomes.

1 Introduction

1.1 Background

Queensland's Energy from Waste (EfW) Policy (the Policy) was released on 4 June 2020 under the Waste Management and Resource Recovery Strategy (Waste Strategy). The Policy aims to guide EfW activities in Queensland in a manner that safeguards human and environmental health, while supporting the targets and objectives of the Waste Strategy.

The Policy outlines seven high-level outcomes for proponents wishing to establish facilities that recover fuels, electricity and heat from waste that is not practical to reuse or recycle. These outcomes relate to safeguarding the waste hierarchy; only using wastes that are not practical to reuse or recycle for energy recovery, both now and into the future; demonstrating operational performance of proposed facilities; undertaking appropriate community engagement; and pursuing appropriate standards of energy recovery and environmental protection.

It is important to note that while the Policy is non-statutory, it signals the government's preferences and policy intentions concerning the future environmental management of EfW facilities. As such, the Policy falls within the standard criteria that must be considered by the administering authority under the *Environmental Protection Act 1994* in deciding an application for an EA.

1.2 Purpose

The purpose of this guideline is to provide proponents of EfW facilities with guidance on the scope, intention and application of the Policy. The guideline also features several EfW case studies that showcase facilities achieving the Policy outcomes.

As this guideline supports the Policy, it will be considered by the Department of Environment and Science (DES) as part of assessing an EA application for an EfW activity. It is important to note though that a range of other considerations and regulatory requirements may also inform a decision on any individual application. This guideline may be used by:

- proponents/applicants when planning and conducting their EfW activities
- communities wishing to better understand the Policy and associated guidance being provided to proponents, and how proponents are expected to address community and environmental concerns
- state departments and local governments as a general reference for assessment and management of EfW facilities.

This guideline should be read together with the Policy, and guidance materials on the statutory process for EA applications and assessments published by DES, including:

- Assessment requirements for making a decision for an EA for an environmentally relevant activity – ESR/2015/1725
- Application requirements for activities with impacts to air - ESR/2015/1840
- Application requirements for activities with impacts to land - ESR/2015/1839
- Application requirements for activities with noise impacts - ESR/2015/1838
- Application requirements for activities with impacts to water - ESR/2015/1837
- Application requirements for activities with waste impacts - ESR/2015/1836.

This guideline will be reviewed and updated as needed to incorporate any learnings gained from applying the guideline to the assessment of EA applications.

1.3 Scope

This guideline, like the Policy it supports, is relevant to activities that recover energy from waste, regardless of the technology used to recover the energy. This includes energy recovered in the form of fuels (whether in solid, liquid or gas form), electricity, heat, and cooling.

The meaning of 'waste' used in the Policy and this guideline is the same as the meaning of waste in section 13 of the *Environmental Protection Act 1994*.

1.3.1 Types of EfW

The Policy broadly classifies EfW facilities into four categories (biological, chemical, mechanical, or thermal) based on processes involved in extracting the energy from the waste materials. Examples of relevant types of EfW activities are provided in Table 1. This broad classification is intended as a guide to help proponents determine where a proposed facility is likely to sit on the EfW hierarchy. However, it is acknowledged that some EfW technologies will involve multiple processes.

Table 1: Examples of EfW activities to which the Policy relates (not exhaustive)

Process	Description	Typical feedstocks	Outputs	Residues
Biological EfW				
Anaerobic digestion	Biological decomposition of organic matter by enzymes and microorganisms, in the absence of oxygen	Biosolids, food waste, green waste, agricultural residues	Biogas, electricity, heat, digestate	Liquid residues, wastewater
Fermentation	Decomposition by microorganisms, of the sugars (such as glucose, fructose and sucrose) in organic wastes	Organic waste high in sugar (e.g. sugarcane crop waste)	Alcohols (e.g. ethanol), digestate	Wastewater
Chemical				
Transesterification	Chemical reaction of fatty acids in waste with an alcohol (e.g. ethanol) in the presence of a catalyst	Waste oils/fats	Biodiesel	Wastewater, glycerol
Mechanical EfW				
Mixed waste sorting and blending for fuel production	Mechanical waste sorting to separate materials by size, density, and magnetic properties. Recyclable materials are recovered, while non-recyclable materials are blended to a consistent calorific value for use as combustion fuel	Mixed, non-putrescible waste	Refuse derived fuel, recyclable materials	
Thermal EfW				
Combustion Thermal	Waste decomposition at elevated temperatures under excess air or oxygen	Mixed residual waste, refuse derived fuels	Electricity, heat, steam	Bottom ash, air pollution control residues
Gasification	Waste decomposition at elevated temperatures in an oxygen-starved environment	Sorted homogenous feedstocks (e.g. wood, tyres from C&I and C&D waste), mixed residual waste, organic waste	Electricity, heat, steam, syngas, biochar, oil/liquid fuel	Bottom ash, air pollution control residues, tars
Pyrolysis	Waste decomposition at elevated temperatures in the absence of oxygen	Sorted homogenous feedstocks (e.g. wood, tyres from C&I and C&D waste), mixed residual waste, organic waste	Electricity, heat, syngas, char, oil/liquid fuel	Air pollution control residues, tars

1.3.2 Facility scale

The Policy and this guideline relate to several environmentally relevant activities (ERAs) associated with recovering energy from waste materials at any scale, as prescribed in Schedule 2 of the Environmental Protection Regulation 2019.

The application of the Policy and guideline to EfW research, development, and demonstration activities will be determined on a case-by-case basis.

1.3.3 New facilities

The Policy and this guideline are targeted at new EfW facilities, including those granted an EA after the Policy was released in June 2020. The Policy and guideline are non-statutory and do not override any statutory requirements or criteria relating to the EA application process. However, they do signal the government's policy intentions for the future environmental management of EfW facilities, and applicants are encouraged to consider the Policy and guidelines when developing new EfW activities.

1.3.4 Existing facilities

Facilities that were lawfully operating before the Policy commenced are encouraged to work towards achieving the Policy outcomes relevant to their activities. If existing facilities seek to amend their existing EA, the department may consider this guideline as part of that process. Further guidance on the process for amending an EA is available at https://www.business.qld.gov.au/search using the search terms 'ESR/2015/1743' and 'ESR/2015/1684'.

1.4 Best Available Techniques Reference Documents

The Policy introduces European Union (EU) Best Available Techniques (BAT) Reference Documents (BREFs) as suitable best practices to be considered in Queensland. In particular, the BREF for Waste Incineration (WI BREF), and the BREF for Waste Treatment (WT BREF) are identified as relevant guidance for the EfW sector in Queensland. These BREFs, as updated from time to time by the European Commission, are available at https://eippcb.jrc.ec.europa.eu/reference/.

Directive 2010/75/EU on industrial emissions (IED) is the main legislative instrument regulating pollutant emissions from industrial facilities in the EU. The IED is based on several pillars, one of which requires the use of BAT as the basis for establishing licence conditions. The process and work involved in determining BAT for different types of industrial facilities, results in the BREFs.

The BREFs provide reference information by bringing together real-world experiences of BAT. They are developed through a series of information exchange between various stakeholders including regulators, industry and environmental non-governmental organisations.

The WI BREF and WT BREF describe techniques and associated monitoring considered to have the potential for achieving a high level of environmental protection in biological, chemical, mechanical, and thermal EfW facilities. The BAT conclusions chapter of each BREF lays down the main findings of the BREF and is the reference used for setting licence conditions in the EU.

For certain industrial activities, e.g. waste incineration and co-incineration, the IED also sets EU wide emission limit values for selected pollutants.

It should be noted that not all techniques outlined in the BREFs are relevant to all facilities. It is recommended that proponents conduct a BAT assessment to determine which techniques in the BAT conclusions are most appropriate to their project, and consider how the proposed facility could be designed to accommodate these techniques. This will typically involve environmental, technical and economic considerations.

The BREFs should not be considered in isolation and need to be integrated with Queensland's other existing regulatory requirements. Further detail is provided at section 2.7.2.

2 Prior to making an application

This chapter provides further details on the seven outcomes of the Policy. This information can help the applicant to further understand the strategic benefits and risks of proposed EfW facilities and where appropriate, further develop their proposed facility to deliver beneficial outcomes for Queensland in line with the Policy. Table 2 outlines the relevance of specific policy outcomes to the four EfW types.

It should be noted that outcome 6 of the Policy concerns an energy recovery formula and threshold developed specifically for thermal EfW (the European Union R1 criteria) and which is not relevant to biological, chemical or mechanical EfW. However, maximising energy recovery and energy efficiency is important for all EfW types. General energy recovery guidance for all facilities is included under outcome 7 with other environmental protection guidance.

Table 2: Relevance of the Policy and guideline to different types of EfW facilities

Policy outcomes	Biological	Chemical	Mechanical	Thermal
1. Protect the waste hierarchy	✓	✓	✓	✓
2. Demonstrate operational performance	✓	✓	✓	✓
3. Engage with the community	✓	✓	✓	✓
4. Residual waste as feedstock		✓	✓	✓
5. Adapt to residual waste changes		✓	✓	✓
6. Energy recovery requirements				✓
7. Environmental protection requirements	✓	✓	✓	✓

2.1 Outcome 1: Protect the waste hierarchy

Outcome 1 of the Policy is relevant to all types of EfW activities and encourages management of waste at the highest practical level of Queensland's Waste and Resource Management Hierarchy (the waste hierarchy). In accordance with the waste hierarchy (Figure 1), every effort should be made to avoid and reduce waste generation; and maximise the reuse and recycling of any waste generated, before recovering energy, and disposal should not undermine appropriate energy recovery.

The Policy also describes an EfW hierarchy which outlines a preference for EfW facilities that recover high-value solid, liquid and gaseous fuels from waste. This preference aligns with the Queensland Biofutures 10-year Roadmap and Action Plan, which envisions a $1 billion sustainable and export-oriented industrial biotechnology and bioproducts sector for Queensland.

EfW proponents should carefully consider how their proposed facility aligns with both the waste hierarchy and the EfW hierarchy. This is important to help ensure that any EfW facilities established do not compromise the performance of higher-order reuse and recycling facilities by competing for feedstock. It is acknowledged that some EfW technologies may not fit solely into a single category (e.g. biochemical, thermochemical, and physicochemical processes).

For example, hydrothermal liquefaction of organic waste is a thermochemical process in which the waste is degraded by water at elevated temperature and pressures in the presence of chemical catalysts, to produce a crude-like oil. This example potentially sits across the chemical and thermal EfW levels of the hierarchy. If the crude oil is incinerated in a subsequent stage in the same facility to produce electricity, then the process is more aligned with the thermal EfW level of the hierarchy.

In considering alignment with the waste and EfW hierarchies, proponents should evaluate:

- the existing management fate of the proposed feedstock for the proposed EfW facility
- current and emerging programs, opportunities, and partnerships to avoid, reuse and recycle the proposed feedstock within the local government area of the proposed facility, Queensland, and other Australian jurisdictions.

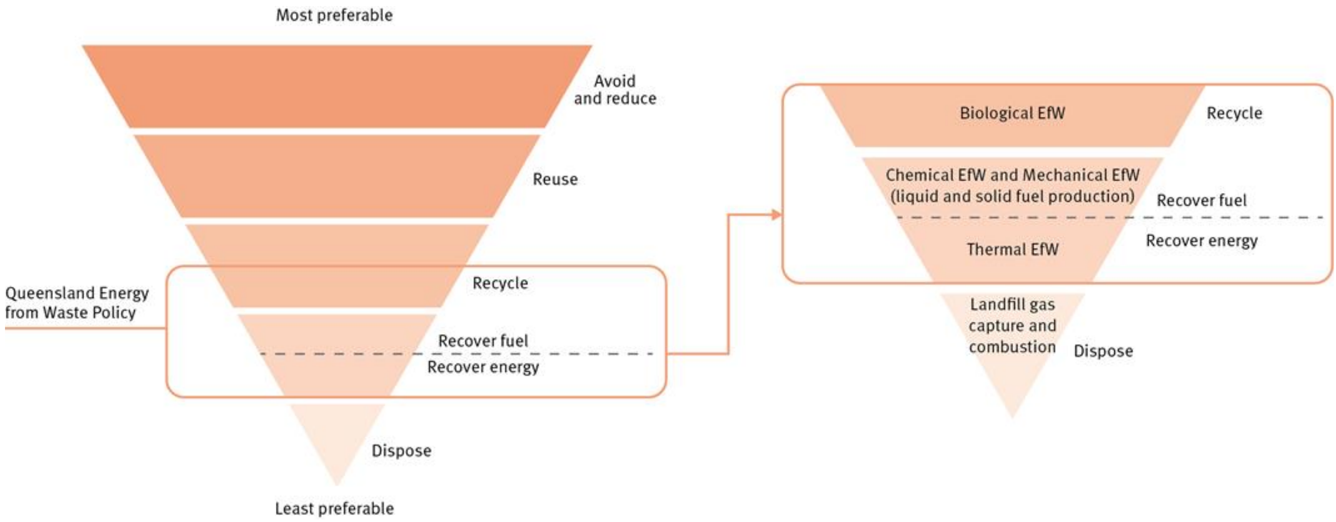


Figure 1: Queensland's waste hierarchy (left) and EfW hierarchy (right)

2.2 Outcome 2: Demonstrate operational performance

Policy outcome 2 of the Policy relates to the operational performance of a proposed EfW facility. This is relevant to all types of EfW (i.e. biological, chemical, mechanical, and thermal EfW). It is important that a facility is able to perform as intended to avoid facility failures that could cause significant environmental harm, and lead to abandoned assets. Determining operational performance depends on whether the proposed facility is based on commercial, new or emerging technology.

2.2.1 Commercial technology

A commercial technology is considered to be one that has been in commercial operation for at least two years. A proponent of a commercial technology should provide information from a reference facility that demonstrates the proposed facility can function as intended and in accordance with the Policy. A reference facility for a commercial technology is a facility that has been in lawful commercial operation:

- at a scale (throughput) similar to the proposed facility. If a proposed facility consists of multiple modules, a suitable reference facility can be similar in scale to a single module of the proposed facility. The cumulative effects of multiple modules in the proposed facility should be considered.
  - *For example, a facility with a processing capacity of 100,000 tonnes per annum in a single processing line, can be used as a reference facility for a proposed plant processing 200,000 tonnes per annum in two processing lines.*
- using feedstock similar in composition to the proposed facility, particularly with respect to feedstock components which may have a material impact on the operational performance of the facility and its emissions or residues

- for at least two continuous years
- with a strong record of environmental compliance
- in Queensland or a jurisdiction with comparable regulatory governance to Queensland. Refer to section 2.2.4 for further information on comparable jurisdictions.

In preparing an application for a commercial EfW technology, the following information should be considered:

- Details of the reference facility to establish that it meets the criteria set out above.
- Other relevant information about the reference facility, including its location, design throughput, technologies used for emissions control and monitoring, emissions monitoring requirements (as per its environmental permit conditions), and a copy of its environmental permit.
- Two continuous years of operational data from a reference facility. Data from the design, modelling or commissioning phases alone is not appropriate. The operational data should not be more than five years old and should include the data outlined in Table 3.

Table 3: Reference facility operational data

• Waste steams (feedstocks) processed annually including definition and quantity • Electrical and/or thermal efficiency of the facility (gross and net of parasitic loading), if applicable • Electricity and/or heat produced per annum (gross and net of parasitic loading), if applicable • Products (such as fuel or oil) produced per annum, if applicable • Information and annual quantities of any other products generated • Quarterly and annual emissions reports as submitted to the regulator • Statistics on breach of licence conditions (if any), why the breach happened and how the proposed facility would be designed to avoid such breach • Statistics on emission limit value exceedances per annum (or confirmation that there was none), why the exceedance happened and how the proposed facility would be designed to avoid such exceedance • In the case of thermal EfW, statistics on furnace temperature conditions (i.e. times at which the furnace temperature decreased below 850°C, why the reduced temperature happened, and how the proposed facility would be designed to avoid this issue • Reports covering annual ash generation, ash composition, and ash disposal or recovery route • Reports about the composition and disposal of wastewater streams produced by the proposed facility • Information and annual quantity of any other wastes or hazardous materials generated at the reference facility • Information and annual quantities of relevant raw material consumed at the reference facility, such as potable water, lime, activated carbon, ammonia, oils and greases • Preferably maximum and average daily, weekly or monthly emissions (in mg/nm^3 or similar appropriate unit) for all pollutants continuously monitored, and copies of testing reports for emissions that are periodically monitored • Definition of normal operating conditions (NOC) and other than normal operating conditions (OTNOC) for the facility and if available the number of hours operated in OTNOC per year • Information on any public engagement programs, community engagement groups, requirements on public reporting of data and information on public complaints as available

2.2.2 New technology

New technology is technology that has been in commercial operation for less than two years. In the case of new technology, information from a reference facility would demonstrate that the proposed facility can function as intended and in accordance with the Policy. A reference facility for a new technology means a facility that has been in lawful commercial operation:

- at a scale (throughput) similar to the proposed facility. If a proposed facility consists of multiple modules, a suitable reference facility can be similar in scale to a single module of the proposed facility. The cumulative effects of multiple modules in the proposed facility should be considered.
  - *For example, a facility with a processing capacity of 100,000 tonnes per annum in a single processing line, can be used as a reference facility for a proposed plant processing 200,000 tonnes per annum in two processing lines.*
- using feedstock similar in composition to the proposed facility, particularly with respect to feedstock components which may have a material impact on the operational performance of the facility and its emissions or residues
- for less than two years
- with a strong record of environmental compliance
- in Queensland or a jurisdiction with comparable regulatory governance to Queensland. Refer to section 2.2.4 for further information on comparable jurisdictions.

In preparing an application involving a new technology, a proponent should consider the following details:

- Details of the reference facility to establish that it meets the criteria set out above.
- Other relevant details of the reference facility, including its location, design throughput, technologies used for emissions control and monitoring, emissions monitoring requirements (as per its environmental permit conditions), and a copy of its environmental permit.
- Operational data from the reference facility for the duration that the facility has been in operation. The operational data should include the data outlined in Table 3 to the extent available.
- The classification of the technology according to the Technology Readiness Level (TRL) index. Refer to section 2.2.5 for further information on the TRL index.

2.2.3 Emerging technology

An emerging technology is one that is still in research and development and has not yet entered commercial service. Classification of the proposed technology using the TRL index can help proponents establish the level of maturity of their proposed technology. Please refer to section 2.2.5 for guidance on determining the TRL index of a technology.

2.2.4 Comparable regulatory jurisdiction

A jurisdiction with comparable regulatory governance to Queensland is any jurisdiction that regulates EfW facilities to a standard that is similar to the standard existing in Queensland at the time an application is made. This should be determined by comparing information on the environmental standards (e.g. licence conditions, and the regulatory framework) that apply to the reference facility with the standards in Queensland. Comparable jurisdictions include other Australian jurisdictions, United Kingdom (UK), and European Union member countries.

For nominated reference facilities located in Europe, where the BREFs are the applicable environmental standard, the reference facility should show compliance with the relevant BREF BAT conclusions in force for the facility, over the period represented by the data provided. This is an acknowledgement that there is a four-year timeframe for licensed facilities to comply with any new/updated BAT conclusions. It is also acknowledged that BREF emission limit values are only applicable over a specified time averaging period and that a facility does not necessarily exceed its licensed limit for short-term deviations from the BREF emission limit value.

2.2.5 Technology readiness level (TRL)

The TRL Index is a benchmarking tool that measures technology maturity from the very early stages of scientific research through to actual application of the technology in its final intended form. In increasing order of technology maturity, the TRL Index ranges from TRL 1 to TRL 9 and can broadly be divided into three stages as depicted in Table 4. Further descriptions of each TRL are provided in Appendix 1.

Table 4: Summary of Technology Readiness Levels (TRLs)

Stage	TRL	Description
Research	TRL 1	Basic principles observed
	TRL 2	Technology concept formulated
	TRL 3	Experimental proof of concept
Development	TRL 4	Technology validated in laboratory
	TRL 5	Technology validated in relevant environment
	TRL 6	Technology demonstrated in relevant environment
Deployment	TRL 7	System prototype demonstration in operational environment
	TRL 8	System complete and qualified
	TRL 9	Actual system proven in operational environment

2.2.6 Technology readiness assessment (TRA)

The TRL rating of a specific technology can be further established by conducting a Technology Readiness Assessment (TRA). If undertaken, the TRA should assess the critical technological elements that pose major risks to the successful deployment of the EfW technology. Technology elements can include hardware, a process or a combination of the two that are vital to the performance of the larger system. A technology element is critical if it is new or novel, or used in a new or novel way; and needed for the technology to meet operational and performance requirements. For example, some critical technology elements of EfW facilities include:

- waste pre-treatment systems
- pollution control system (e.g. flue gas treatment system)
- waste reactors (e.g. combustion chamber, pyrolytic reaction chamber)
- energy transformation and recovery components (e.g. heat exchangers, turbine generator sets)
- electrical systems (e.g. control system)

A TRA should be prepared by a suitably qualified person possessing the requisite skills, knowledge and experience relevant to the technology or area of application of the technology. This may include subject matter experts in the technology, or application of the technology.

The outcomes of the TRA can be documented in a TRA report that provides information on the technology and its critical elements, the TRA methodology used, the assessment outcomes for each critical technology element, and the overall assessment outcome.

Further guidance on the TRL and TRA is available in the following document:

- US Government Accountability Office 2020, Technology Readiness Assessment Guide – Best practices for evaluating the readiness of technology for use in acquisition programs and projects, available at https://www.gao.gov/assets/710/703694.pdf.

2.3 Outcome 3: Community engagement

2.3.1 Scope

The Policy highlights the importance of EfW proponents engaging appropriately with communities potentially impacted by proposed EfW facilities. To support this engagement, the Policy sets out five key community engagement principles, which are that:

- Community engagement is authentic and transparent
- Community engagement is inclusive
- Community engagement is respectful
- Community engagement is responsive
- People have a right to participate in decisions about matters that affect them.

What is considered appropriate community engagement may be influenced by a number of factors such as:

- statutory requirements (e.g. under Queensland's planning framework)
- the size, location and type of proposed EfW facility
- sensitive receptors nearby the proposed EfW facility
- cultural values and rights, needs, and interests of the communities and stakeholders potentially impacted by the proposed facility
- the risks related to the EfW facility.

2.3.2 Demonstrating appropriate engagement

A range of published guidance materials is available outlining the steps proponents can take to build trust and mutual understanding with potentially affected communities, and deliver a robust and consistent approach to community engagement. The following publications, though not specific to the EfW sector, provide useful guidance on community engagement that can be adapted and applied to EfW projects in Queensland:

- The International Association of Public Participation (IAP2), which advances the practice of public participation globally, has published a **Quality Assurance Standard** that describes 11 steps of any engagement process that can be applied in a variety of contexts and with diverse stakeholders. Adhering to the standard while observing the Policy's community engagement principles will help to ensure a quality community engagement process. The standard is also designed to help evaluators assess the quality of a community engagement project. The standard is available at https://iap2.org.au/resources/quality-assurance-standard/.
- The **Community Engagement Toolkit for Planning** published by the Department of State Development, Infrastructure, Local Government and Planning, supports delivery of effective community engagement in making and amending local planning instruments under the state's planning and

development system. It supports local governments to meet their requirements to engage with the community on plan-making and supports community members and stakeholders in their interactions with the plan-making process. Although the toolkit is oriented towards engagement for making and amending local planning instruments, it is founded on six core principles for engagement, which align with the Policy's community engagement principles. The Toolkit is available at https://dilgpprd.blob.core.windows.net/general/community-engagement-toolkit.pdf.

- The **Community Engagement Guidelines for the Australian Wind Industry** published by the Clean Energy Council, outlines a framework for applying engagement principles to wind and other renewable energy projects. The framework provides a set of ideas, practices and tools to help the renewable energy industry earn and maintain a social licence to operate through strong community engagement. These ideas and practices can be applied to EfW projects. The guidelines are available at https://assets.cleanenergycouncil.org.au/documents/advocacy-initiatives/community-engagement/wind-community-engagement-guidelines.pdf.
- The **Stakeholder Engagement Guide – Business case development framework** published by Building Queensland, provides guidance on developing and implementing stakeholder engagement activities during the development of infrastructure proposals in Queensland. The framework is available at https://buildingqueensland.qld.gov.au/wp-content/uploads/2020/04/Stakeholder-Engagement-Guide.pdf.
- The **Community and Stakeholder Engagement Guide** published by the Metropolitan Waste and Resource Recovery Group in Victoria, was developed with significant input from industry and community representatives. It aims to assist the waste and resource recovery sector to deliver meaningful and successful community and stakeholder engagement. The guide is available at https://www.mwrrg.vic.gov.au/engagement/community-and-stakeholder-engagement-guide/.

The Policy outlines the role proponents should play in helping to ensure that communities are appropriately engaged, which may include preparing and submitting a stakeholder engagement plan, and a stakeholder engagement report with an EA application. Although encouraged, submission of a stakeholder engagement plan and report may not be required for every application.

In Queensland, all projects subject to an Environmental Impact Statement (EIS) process under the *State Development and Public Works Organisation Act 1971* or the *Environmental Protection Act 1994*, must include a social impact assessment (SIA) report as part of the EIS.

As guided by the Office of Coordinator General's SIA Guideline, the SIA covers identification, analysis, assessment, management and monitoring of the social impacts of a project, both positive and negative, and must address community and stakeholder engagement. The SIA Guideline is available at https://statedevelopment.qld.gov.au/__data/assets/pdf_file/0017/17405/social-impact-assessment-guideline.pdf. Adhering to the Policy's community engagement principles is likely to help EfW proponents deliver the requirements of the SIA.

If preparing an SIA, stakeholder engagement plan, or another similar document is not a statutory requirement, EfW proponents are encouraged to develop and maintain a community/stakeholder engagement plan. Such a plan should be based on the Policy's engagement principles and other community engagement best practices. This will send a clear signal to interested and affected parties, of the engagement program to be implemented over the life of the EfW project. This in turn will help to improve and facilitate project-related decision-making by providing opportunities for stakeholders to voice their opinions about matters that may influence project decisions.

2.3.3 Social licence to operate

Community engagement underpinned by the five community engagement principles above can play an important role in achieving a social licence to operate (SLO). SLO refers to the ongoing level of acceptance or approval by the community of a company and its operations. SLO evolved from the broader notions of corporate social responsibility and social acceptability and is based on the concept of companies obtaining 'social permission' to conduct their business in addition to 'regulatory permission'.

SLO is built on trust; it is not tangible as there is no written agreement or formal licence. Once earned, SLO is not fixed, but it varies over time in response to changes in the community and the company's behaviour and can be withdrawn at any time. For this reason, EfW operators will need to be 'good neighbours' during all stages of a project. This means taking reasonable care to avoid acts or omissions that are reasonably likely to negatively impact one's neighbour, including complying with environmental standards minimising dust, noise, odour and other nuisance issues; engaging in genuine dialogue with the community; and operating in accordance with operational and stakeholder engagement plans. EfW operators should consider negotiating good neighbour charters or agreements with potentially affected communities.

Proponents are encouraged to work towards building SLO in the communities they wish to operate in. Some guidance on SLO is provided in the Community Engagement Guidelines for the Australian Wind Industry discussed in the previous section. Additional SLO resources include the following:

- **Queensland Solar Farm Guidelines** – the guidelines aim to help industry work with community and stakeholders to achieve positive outcomes during the development of the large-scale solar sector. The guidelines include principles, frameworks and approaches which offer the tools to earn and strengthen social licence to operate through genuine community engagement. The guidelines are available at https://www.epw.qld.gov.au/__data/assets/pdf_file/0012/16122/solar-farm-guidelines-communities.pdf.
- **Establishing the social licence to operate large scale solar facilities in Australia: insights from social research for industry** – published by the Australian Renewable Energy Agency, this report sets out the preconditions and best practice principles for establishing SLO in the large scale solar energy sector. The report is available at https://resources.solarbusinesshub.com/images/reports/92.pdf.
- **Sustainability Victoria's training program on SLO**. Sustainability Victoria has announced its intention to deliver a training program on SLO to empower the waste sector to build strong, long lasting relationships with the community. Further information is available on Sustainability Victoria's website at https://www.sustainability.vic.gov.au/recycling-and-reducing-waste/delivering-waste-and-recycling-services/kerbside-recycling/educating/engaging-communities-on-waste.

2.4 Outcome 4: Only residual waste is used for energy recovery

2.4.1 Scope

Outcome 4 of the Policy states that only residual wastes should be used for energy recovery. Using residual waste helps to ensure that EfW facilities do not undermine or divert feedstock from pre-existing reuse and recycling initiatives. This outcome relates to chemical EfW, mechanical EfW, and thermal EfW. This outcome is not relevant to biological EfW, which is considered recycling under the Policy.

2.4.2 What is residual waste?

Residual waste is waste that is not technically, environmentally, or economically practicable (TEEP) to reuse or recycle. Making this determination is a stepped process as outlined in Figure 2. Applicants should first assess the technical practicability of reusing or recycling their proposed feedstock. If this is shown to be impractical, then the feedstock would qualify as residual waste under the Policy and no further analysis is recommended.

Otherwise, the next recommended step is to assess the environmental practicability of reuse/recycling. The last step, the economic practicability assessment, should be considered if reuse or recycling is shown to be environmentally practical.

If the proposed feedstock is shown to be technically, environmentally, and economically practicable to reuse or recycle, it would not qualify as residual waste.

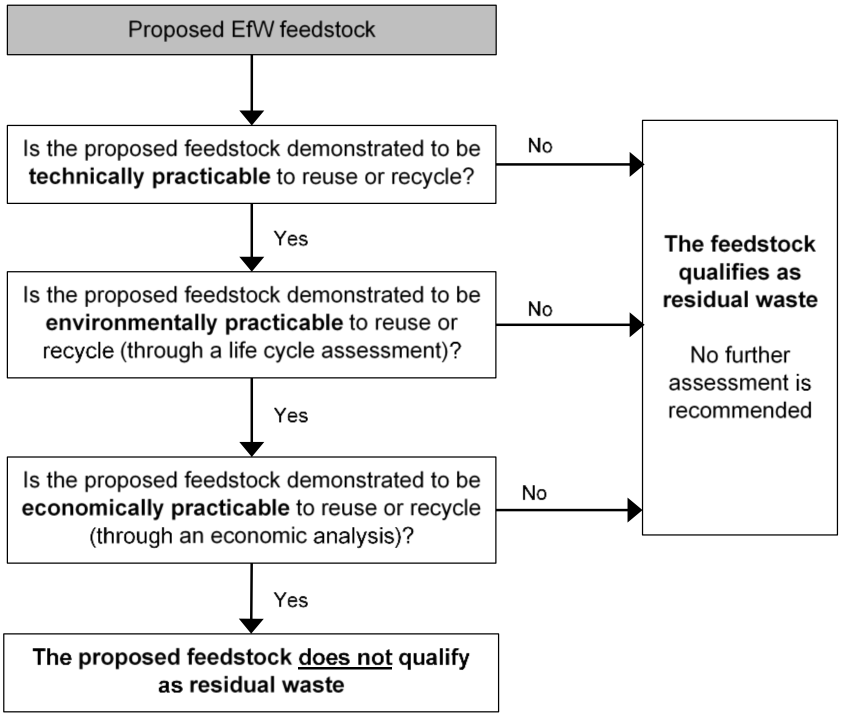


Figure 2: Recommended process to determine whether a proposed feedstock is residual waste

Technically practicable

If waste is 'not technically practicable' to reuse or recycle, it means there is no capacity or capability to legally reuse or recycle the waste. For example, this may be because:

- the infrastructure, technology or process to reuse or recycle the waste has not yet been developed or proven anywhere in the world. In this regard, proponents should be aware that new technologies are becoming available to recycle previously problematic wastes. It is important that proposed EfW facilities are able to adapt to feedstock changes resulting from the evolution and development of recycling technologies
- the feedstock has unusual or unavoidable characteristics that make reuse/recycling impracticable (e.g. waste is too degraded or contaminated and would otherwise be disposed of in landfill)
- recycling is restricted or prohibited by law (e.g. biosecurity waste, clinical and related waste)
- all reasonable efforts have been taken to divert the reusable/recyclable components from the waste. This diversion could be achieved, for example:

- through source separation of recyclable materials and/or food and garden organics (e.g. by sourcing residual MSW waste from councils with well-developed and high-performing kerbside recycling schemes)
- by pre-processing the waste stream through a material recovery facility to remove recyclable materials.

Examples of non-residual waste include:

- comingled recyclables from yellow lid bins
- source-separated green waste
- MSW, C&I or C&D waste that has not been source-separated.

Environmentally practicable

Waste that is ‘not environmentally practicable’ to reuse or recycle means that although the waste can technically be recycled, the negative environmental effects outweigh the environmental benefits from reusing or recycling the waste, such as:

- additional resource use from pre-processing contaminated recyclables to meet end user specifications, and management of waste resulting from pre-processing activities
- additional emissions from transporting and processing recyclable materials over long distances
- additional emissions from transporting processed materials to end-use markets.

Life Cycle Assessment (LCA), which is a methodology for assessing the environmental impacts of a system, can be used to compare the environmental impacts of reuse/recycling a proposed feedstock with energy recovery. At a minimum, environmental impacts should be compared in terms of:

- greenhouse gas emissions
- depletion of non-renewable resources
- water consumption
- Hazardous and non-hazardous waste treatment and disposal
- Primary and secondary particulate matter emissions.

It is recommended that applicants conduct an LCA in accordance with the following Australian Standards (AS):

- AS ISO 14040:2006 – Environmental management – Life cycle assessment – Principles and framework (identical to ISO 14040:2006)
- AS ISO 14044:2019 – Environmental management – Life cycle assessment – Requirements and guidelines (identical to ISO 14044:2019).

Proponents may wish to consider using an LCA software package built on these standards to compare the life cycle impact of reuse/recycling their proposed feedstock with recovering energy from the same feedstock. Examples of LCA software packages include the following:

- Environmental Assessment System for Environmental Technologies (EASETECH).
- Waste and Resources Assessment Tool for the Environment (WRATE)
- MSW Decision Support Tool (MSW-DST).

Where there is a pre-existing recycling pathway or other higher uses for a proposed feedstock in the locale of the proposed EfW facility, this environmental practicability assessment must not be used as the basis for undermining or discontinuing those pathways. It is expected that this assessment would be most relevant to regional areas that are far removed from reprocessing facilities and end-use markets. However, siting of proposed EfW facilities in similar locations far away from the proposed feedstock is unlikely to offer any environmental savings.

Economically practicable

Reuse or recycling a waste feedstock would be economically practicable if the financial cost is not excessive compared to the proposed EfW activity, or disproportionate to the benefits of recycling. This can be determined through an economic analysis of the proposed EfW activity and the reuse and recycling options available, including relevant transport costs. In some cases, the proponent may have already conducted this type of economic assessment during the feasibility or pre-feasibility stage as part of the economic justification for pursuing the EfW project.

It is not possible or appropriate to set a threshold to determine 'excessive financial costs' or 'financial costs that are disproportionate to benefits'. This should be determined on a case-by-case basis, through an economic analysis conducted by an appropriately qualified person.

It is important that proposed EfW facilities are able to adapt to feedstock changes resulting from the continuous improvement and cost-effectiveness of recycling pathways, as set out under outcome 5.

2.4.3 Roles and responsibilities

Key stakeholders including waste generators, waste service providers, and EfW operators play important roles in helping to ensure that only residual waste is used for energy recovery.

- Waste generators, such as households and businesses, should take reasonable steps to reduce waste generation, and participate fully in waste separation and diversions programs, including kerbside recycling schemes, that seek to recover recyclable and compostable materials from the waste stream.
- Waste service providers, including local government and private service providers, play an important role in providing waste collection, kerbside recycling, and landfill diversion services. This includes taking steps to encourage and incentivise maximum participation in these services. Additionally, local governments have a statutory responsibility to develop and implement waste reduction and recycling plans that consider how the Queensland's Waste Strategy goals and targets will be achieved. In entering into contracts with EfW operators for supplying residual waste, local governments should consider how they will ensure that contracts do not impede efforts to increase waste minimisation and recycling within the local government area.
- EfW operators, as receivers and processors of residual waste, are at the end of the waste management chain, and generally have less influence on waste generation and source separation behaviours, but do play a crucial role as the final gatekeepers. Operators should have regard to the Policy and this guideline when developing and operating approved EfW facilities. This includes for example, implementing feedstock acceptance and monitoring procedures to ensure only residual waste is processed for energy recovery; maintaining a feedback loop with suppliers to communicate and resolve any undesirable trends (such as the increasing presence of recyclable materials in the feedstock); and adopting flexible waste contracts that do not limit or hinder the emergence of recycling pathways and higher uses for waste materials.

2.5 Outcome 5: Adaptability to residual waste changes

The quantity and composition of residual waste in Queensland is expected to change over time as a result of implementing the Waste Strategy. Outcome 5 of the Policy highlights the importance of EfW facilities being able to adapt to these anticipated changes in residual waste. EfW facilities established now should not undermine future options or innovations in waste avoidance, reuse, and recycling. In determining a facility's adaptability to residual waste changes, it is recommended that EfW proponents consider the matters outlined in this section.

2.5.1 Feedstock variability

It is important to determine the expected variability in the quantity and composition of the residual waste feedstock over the operational life of a proposed EfW facility. This assessment should include the following:

- A baseline waste composition analysis for the current waste streams (MSW, C&I and C&D) proposed to be used by the facility.
- A year-by-year analysis of how waste composition is expected to change based on relevant policy and strategic frameworks, including:
  - the Waste Strategy
  - the Waste Reduction and Recycling Plan of the local government area(s) from which the proposed feedstock is sourced
  - any other applicable state and local government policy and strategic frameworks.
- Details of any assumptions made and linkages to studies relating to the waste streams, source(s) of waste, waste availability in the region, and the status of relevant policies.
- A sensitivity analysis based on expected implementation success of relevant policies.
- A determination on if any additional waste streams would be required to meet the capacity of the facility over time.

If the feedstock composition is not expected to change as a result of policy/strategy implementation, it is helpful to understand and document why this is the case.

2.5.2 Impact of feedstock variability on facility performance

Feedstock variability will affect different types of EfW facilities differently. It is recommended that a proponent assess and quantify the impacts of feedstock variability on a proposed facility's environmental performance (emissions), and energy products (e.g. quality of fuel produced, or quantity of heat/electricity generated). The goal of this assessment is to fully consider the impact of feedstock changes, since facilities should be able to adjust to allow feedstocks to go to higher order use (reuse, recycling) if this becomes available in the future.

This impact assessment can be supported with appropriate data and evidence from reference facilities and is recommended to include the following analysis:

- For the baseline (current) scenario, characterise all of the products, emissions and residues expected from the proposed facility, using data and information from reference facilities where appropriate. For example:
  - thermal combustion facilities could quantify the expected annual thermal and/or electrical energy output of the facility, and establish the physical and chemical characteristics of all residues including fly ash and bottom ash
  - facilities proposing to produce a liquid fuel from waste, could establish the baseline chemical composition and calorific value of the expected fuel, as well as the chemical and physical characteristics of all other residues anticipated from the process.
- Determine how the quantity and characteristics of all products, emissions, and residues; and the environmental impacts and benefits of the facility are expected to change over time in response to the

feedstock variability assessment, and how the proposed facility is designed to handle the expected changes. Document any assumptions made to support the assessment.

2.5.3 Measures to adapt

EfW proponents should ensure that the design and operation of proposed facilities incorporate appropriate administrative, technical, or process-related measures that mitigate the impacts from feedstock variability. These measures may include, for example:

- contractual arrangements with the residual waste feedstock supplier(s) that allow for variability in the quantity and quality of feedstock delivered to the proposed EfW facility
- facility and process design specifications that can cope with the projected feedstock variability, without impacting the facility's environmental performance. This should include an assessment of:
  - the design characteristics of the facility that allow it to operate as the components of the waste stream vary
  - how the emission control and abatement system can respond to changes in the feedstock
  - how the facility is able to deal with different levels of contaminants within the feedstock
  - the potential environmental impacts of a varying waste stream and how they are accounted for within the Environmental Impact Assessment.

2.5.4 Transitioning away from feedstocks over time

Over time, feedstocks once considered appropriate for EfW, may become less suitable due to the emergence and growth of technically, environmentally, and economically viable recycling pathways for previously unrecyclable wastes. EfW facilities should not undermine emerging recycling routes and should be designed and operated in a manner that enables them to transition away from using feedstocks whose recycling demand increases.

2.5.5 Review

Once operational, an EfW facility will be required to comply with the performance and reporting conditions set out in its EA. By meeting these ongoing operational performance and reporting requirements, the facility will demonstrate successful implementation of their approach to managing feedstock variability.

As part of ongoing operational management, the facility should maintain an awareness of potential or emerging changes in waste feedstocks to ensure that appropriate actions for managing this variability are implemented. Triggers for operational review could include:

- changes to waste collection and source separation systems by feedstock suppliers
- contract negotiation or supplier pre-qualification procedures for new feedstock suppliers
- changes to waste strategy, policy or frameworks at the local, state or federal level
- changes to feedstock observed through waste acceptance records and/or periodic sampling
- changes to feedstock properties observed through operational data, for example average net calorific value.

2.6 Outcome 6: Energy recovery

2.6.1 Scope

Outcome 6 of the Policy signals a preference that combustion EfW facilities maximise the energy recovered from waste by achieving a minimum level of energy recovery efficiency determined using the European Union (EU) R1 Energy Efficiency formula and the procedures set out in the EU Waste Framework Directive[1] (WFD).

It is important to note that in addition to facilities that combust waste with energy recovery, this outcome also relates to other thermal EfW facilities that produce intermediate fuels (e.g. syngas) that is then combusted onsite for heat or electricity. This includes pyrolysis, and gasification facilities.

Outcome 6 of the Policy does not relate to:

- thermal EfW facilities, where the primary output is not on-site heat, cooling or electricity generation, and that produce a product such as oil, lubricant or grease which is then sold or distributed
- thermal EfW facilities that produce a fuel product meeting an Australian fuel quality standard, which is then sold or distributed
- facilities exclusively processing wastes that are required to be incinerated under Queensland or Australian legislation, such as clinical and related waste or biosecurity waste. Any energy that these facilities can recover would be beneficial
- facilities that exclusively use biomass feedstocks for energy, for example, biomass boilers fired with bagasse or forestry residues
- co-incineration plants (i.e. plants using waste and conventional fossil fuels) and facilities that exclusively use single-stream waste feedstocks (e.g. biosolids). This recognises that the EU R1 threshold has been developed for facilities that thermally treat mixed MSW.

Whilst outcome 6 does not relate to the facilities listed above, these facilities are encouraged to adopt appropriate best available techniques to maximise energy efficiency and energy recovery (see section 2.6.3 of this guideline).

2.6.2 R1 correction factors

Proposed facilities should be able to achieve a minimum R1 threshold equal to 0.65, while existing facilities are encouraged to work towards achieving a minimum R1 threshold of 0.60. The Policy allows for the development of R1 correction factors to account for Queensland's climate and different facility sizes, which can impact the energy recovery efficiencies of combustion EfW facilities.

Due to technological improvements since the 2008 introduction of the R1 criterion in the EU, modern thermal EfW facilities should be able to meet the R1 criterion for energy recovery regardless of the climatic conditions. Recently approved combustion facilities in other Australian jurisdictions have also shown that meeting the R1 threshold is possible without correction factors. Therefore, no correction factors are recommended in this guideline for new EfW proposals in Queensland, and the R1 value should be determined in accordance with the formula set out in the Policy.

It is recognised that existing facilities, which may be based on older technology, may not be able to achieve the R1 threshold of 0.60 recommended in the Policy. For these facilities, a climate correction factor of 1.12 has been derived based on the method stipulated in Annex II of the WFD and detailed in Appendix 3 of this

[1] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, as amended by European Commission Directive 2015/1127 of 10 July 2015. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588632849355&uri=CELEX:02008L0098-20180705.

guideline. With the climate correction factor of 1.12 applied, the R1 benchmark for existing facilities is 0.54 instead of 0.60. The formula for determining the R1 value of existing thermal EfW facilities in Queensland is:

$$\text{Energy Efficiency (R1)} = \frac{E_p - (E_f + E_i)}{0.97 \times (E_w + E_f)} \times 1.12$$

where:

- E_p means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity multiplied by 2.6; and heat produced for commercial use multiplied by 1.1 (gigajoules/year)
- E_f means annual energy input to the system from fuels contributing to the production of steam (gigajoules /year)
- E_w means annual net calorific value of the waste (gigajoules /year)
- E_i means annual energy imported excluding E_w and E_f (gigajoules /year)
- 0.97 is a factor accounting for energy losses due to bottom ash and radiation
- 1.12 is the Queensland climate correction factor

2.6.3 Other energy recovery and efficiency practices

All EfW facilities are encouraged to adopt appropriate energy recovery and efficiency best practice techniques. In particular, proponents are encouraged to maximise energy recovery and efficiency in accordance with the guidance set out in the latest versions of following BREFs as updated from time to time by the European Commission and available at https://eippcb.jrc.ec.europa.eu/reference/:

- **WI BREF**, which is relevant to thermal EfW.
  - Chapter 4 describes techniques and associated monitoring considered to have the potential for achieving a high level of environmental protection in thermal EfW facilities.
  - Chapter 4.4 addresses techniques to increase energy recovery. Techniques described include both the technology used and the way in which the facilities are designed, built, maintained, operated, and decommissioned.
  - Chapter 5 outlines BAT conclusions, which are the final evaluations of BAT.
- **WT BREF**, which is relevant to biological EfW, physico-chemical EfW, and mechanical EfW, which typically produce solid, liquid or gaseous fuels.
  - Chapter 2.3 describes techniques and associated monitoring considered to have the potential for achieving a high level of environmental protection, including techniques to reduce the consumption of raw materials, water and energy.
  - BATs are also described separately for mechanical EfW (Chapter 3), biological EfW (Chapter 4), and physico-chemical EfW (Chapter 5).
  - Chapter 6 outlines BAT conclusions, which are the final evaluations of BAT.
- **BREF for Energy Efficiency (ENE BREF)**. This BREF contains guidance on techniques for energy efficiency considered to be compatible with generic BAT for a range of industrial facilities, including EfW facilities.

It is important to note that the techniques described in the BREFs are not necessarily exhaustive and other techniques may exist or may be developed which could be considered in determination of BAT for a specific facility. It is common (and recommended) to conduct a BAT assessment to determine which techniques are the most appropriate for a specific facility.

2.7 Outcome 7: Environmental protection

2.7.1 Scope

Outcome 7 of the Policy outlines the aspiration for the potential environmental impacts of EfW facilities to be managed in accordance with the relevant EU BREFs.

The Policy description of outcome 7 indicates that the outcome relates to EfW activities covered by the WI BREF and WT BREF, which are biological EfW, chemical EfW, mechanical EfW, and thermal EfW. This is contrary to Table 5 of the Policy, which indicates that outcome 7 does not relate to biological and chemical EfW.

This guideline clarifies that outcome 7 of the Policy relates to all types of EfW activities to the extent that they are also included in the WI BREF or WT BREF:

- biological EfW, including anaerobic digestion
- chemical EfW
- mechanical EfW, including refuse derived fuel production
- thermal EfW
  - thermal EfW facilities processing general and/or regulated waste, including combustion with energy recovery, pyrolysis, gasification, and plasma processes
  - co-incineration facilities whose main purpose is energy generation or production of materials and which use waste as a supplementary or substitute fuel, or in which waste is thermally treated for disposal through incineration. Examples of co-incineration facilities include cement kilns and coal-fired power plants that may replace a portion of their fossil fuel with a refuse derived fuel.

The scope outlined above considers the EU definition of waste incineration[2]. In line with the BREFs and underlying IED, outcome 7 of the Policy is not relevant to thermal EfW facilities processing only:

- vegetable waste from agriculture and forestry
- vegetable waste from the food processing industry
- fibrous vegetable waste from pulp-making
- uncontaminated wood waste and biomass waste, including forestry residues, sawmill residues and bagasse.

These waste materials pose a low risk of harm to the environment and human health due to their origin, low levels of contaminants, and consistent composition. Processing these materials will still need to comply with Queensland's environmental regulatory requirements.

[2] In the EU, the Waste Incineration BREF and associated BAT conclusions apply to 'waste incineration plants', which means plants treating waste by combustion with or without energy recovery, pyrolysis, gasification and plasma processes, if the substances resulting from the treatment are subsequently incinerated.

2.7.2 Emission limit values

The WI BREF provides guidance on techniques for a range of industrial processes regulated by the EU's Industrial Emissions Directive 2010/75/EU (IED). The IED sets EU-wide emission limits but requires industrial facilities to comply with the more stringent emission levels associated with BAT (BAT-AEL) as set out in the BREFs. The BAT-AEL reflect the capabilities of modern techniques to achieve a high level of environmental protection. The BAT-AELs are presented in the BREF as a range of values for different parameters, and different ranges may be stipulated for new and existing facilities.

Under Queensland's current regulatory framework, the emissions to air from a proposed facility must be at a level that does not cause the ambient level of contaminants in the relevant airshed to exceed the air quality objectives prescribed in Schedule 1 of the Environment Protection (Air) Policy 2019 (EPP Air). This is generally established through a process of air dispersion modelling as described in the guideline on "Application requirements for activities with impacts to air" (ESR/2015/1840).

As set out in the guideline referenced above (ESR/2015/1840), the results of any air dispersion modelling undertaken will inform the limits set in the EA. Limits applied must ensure that, where possible, emissions do not cause ambient levels of contaminants to exceed recommended levels, and must ensure that the activity generates the lowest levels of emissions practically achievable given relevant industry standards and available technology.

The Policy and this guideline identify the WI BREF as suitable best practice for Queensland and the BAT-AELs are regarded as achievable emission levels for thermal EfW facilities based on BATs drawn from real world experiences. A flow chart outlining the process for informing a facility's emission limits based on the WI BREF and EPP Air is set out in Figure 3 and described below.

The following stepwise procedure is generally followed when estimating the stack emission limits from a proposed new facility or an extension to an existing facility.

Identification of expected air pollutants from proposed facility

Determine the accurate description of the activity carried out on the site and expected release of pollutants. This must include:

- A process flow diagram clearly showing all unit operations to be carried out on the premises
- a description of all pollution control equipment and pollution control techniques for all processes on the premises
- operational parameters of all potential emission sources, including all operational variables including release type (e.g. stack, volume or area source) and release parameters (e.g. stack height, stack diameter, exhaust velocity, temperature, emission rate)
- a list of air pollutants of concern expected to be released from premises based on a review of the existing data for the site and/or relevant literature.

Determine whether the project involves thermal EfW

This must be based on the definition of thermal EfW set out in this guideline. If the project does not involve thermal EfW, then stack emission limits can be selected from the NSW POEO Regulation or similar emission standards prescribed in other jurisdictions comparable to Queensland. Where the project involves thermal EfW, the stack emission limits can be selected either from the WI BREF or estimated based on the dispersion modelling exercise.

Categorised air pollutants

Identify the chemical characteristics of the pollutants emitted from the facility and categorise them according to their characteristics. In order to estimate emission limits, air pollutants can be categories as follows:

1. Pollutants listed in the WI BREF such as: SOx, NOx, CO, VOC, particulates, heavy metals, dioxins, hydrogen chloride (HCl) and hydrogen fluoride (HF).
2. Pollutants not listed in the WI BREF such as: polycyclic aromatic hydrocarbons and odour.
3. Hazardous substances that may have carcinogenic, mutagenic or highly persistent characteristics.

It is important to categorise the air pollutants in the above groups as the stack emission limit estimation techniques are different for each categories of pollutants.

Determine pollutant mass emission rate

Determine the pollutants mass emission rate based on the flue gas volume flow rate (taking into account the stack parameters) and the selected stack concentration limit selected from the NSW POEO Regulation or the WI BREF. The modelled mass emission rate must be based on the worst case (hourly average maximum) emission rate. An air emission inventory must be developed for all potential point sources and diffuse sources. This information will be used in the air pollution modelling studies.

Estimate ground level concentration and dilution factors

Undertake an impact assessment with relevant inputs of emissions and local meteorology to an air dispersion model to provide estimates of the likely impacts on the surrounding environment. The impact assessment modelling results includes ground level concentrations (GLC) at each of the existing and likely future sensitive receptors. This information will be used to compare against the EPP (Air) objectives and to calculate the dilution factors. The dispersion modelling results also include the concentration contour plots and frequency contour plots. The former shows the spatial distribution of concentrations at a given percentile level around a source and are useful in showing where worst-case impacts occur. The latter shows the spatial distribution of frequencies with which a given level of concentration is exceeded.

The dilution factor at the nearest sensitive receptor is equivalent to stack emission value divide by the GLC at that receptor. These values estimated from the air pollution modelling results, could be used in the estimation of stack emission limits for the pollutants not listed in the WI BREF. Different averaging periods might be used in this analysis depending on the ambient air quality standards. Based on the air pollution modelling results estimate dilution factors at the nearest sensitive receptor(s) for 1-hour, 24-hour and annual averages values.

Compare the estimated GLC with the EPP (Air) objectives

In cases where impact assessment modelling is conducted using NSW POEO Regulation, WI BREF or emission factors, the modelling results must be compared against the EPP (Air) objectives. To ensure compliance, the GLC at a sensitive receptor should be less than the ambient air quality objectives prescribed in EPP (Air). If the GLCs are greater than these objectives, then the proponent must consider reducing the air emissions. Allowance for future development in the area and background ambient air concentration must also be considered in this estimation.

To provide further certainty that emissions generated from the facility would meet the air quality objective, the proponent must conduct a human health risk assessment. The assessment must consider the likely cumulative health risks from the proposed facility air emissions. The GLC estimated from the modelling exercise will be used to estimate the health risk at the sensitive receptors. Health risk assessment process and criteria must be based on the Environmental Health Australia (enHealth, 2012[3]) guidelines.

Finalising Environmental Authority limits

The stack emission limits of the pollutants will be selected based on the procedure discussed above. These limits will demonstrate compliance not only with the best practice emission standards (e.g. WI BREF) but also with the ambient air quality standards (e.g. EPP (Air)) and with the health risk assessment criteria (e.g. enHealth guidelines).

[3] enHealth 2012, *Environmental health risk assessment guidelines for assessing human health risks from environmental hazards*. Commissioned by the enHealth Council, http://www.eh.org.au/documents/item/916.

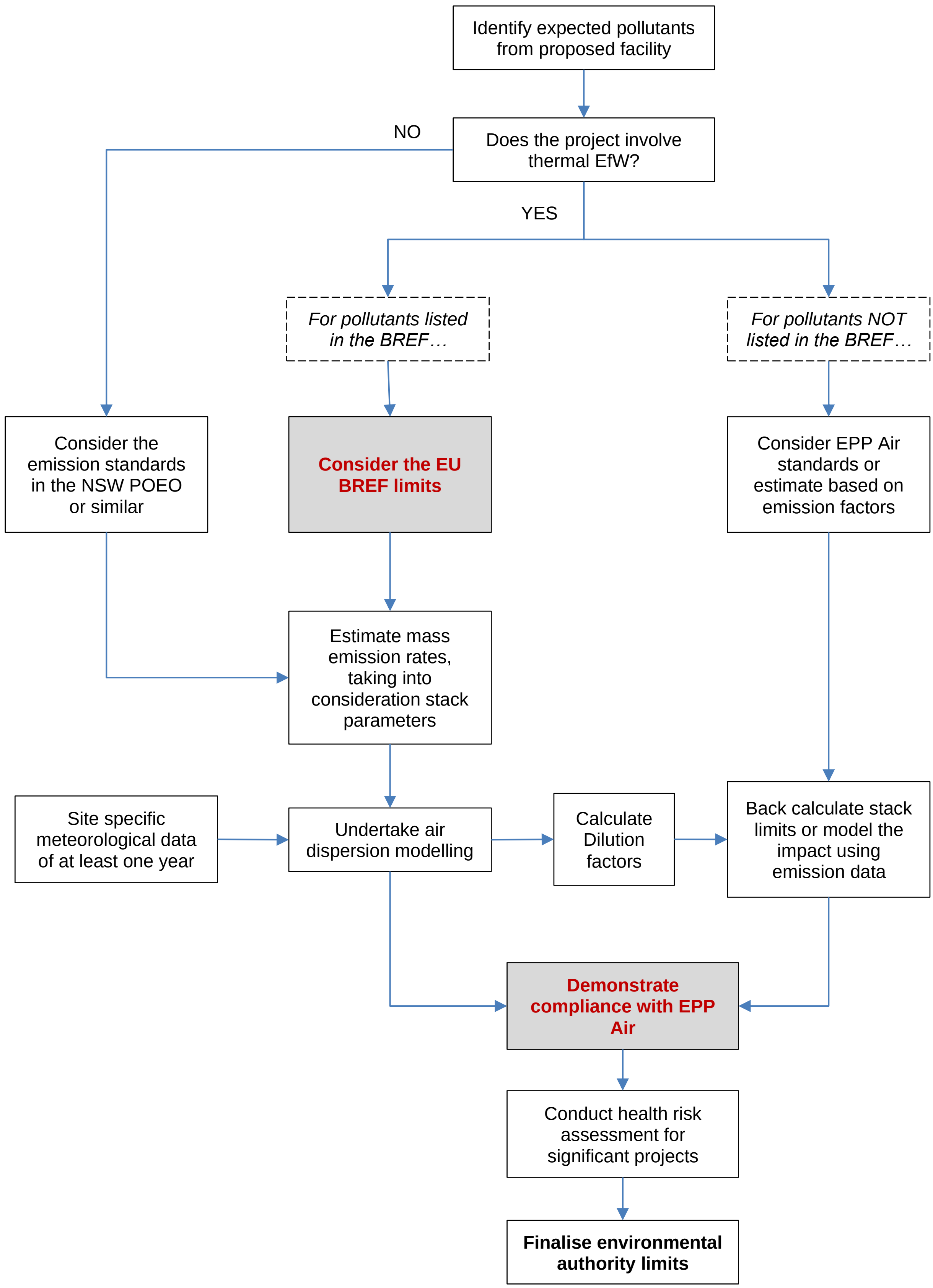


Figure 3: Process for informing a facility's emission limits based on the WI BREF and EPP Air

2.7.3 Waste Treatment BREF

The BAT conclusions chapter of the WT BREF addresses 53 BATs across several waste treatment processes and sub-processes (Table 5). As the WT BREF includes waste treatment and energy recovery processes, it is unlikely that all BATs would apply to any given EfW project. It is recommended that Proponents conduct a BAT assessment to determine which techniques in the BAT conclusions are most appropriate to their project and consider how the proposed facility could be designed to accommodate these techniques. This will typically involve environmental, technical and economic considerations

Table 5: Waste treatment processes and sub-processes covered by the BAT conclusions for waste treatment

Waste treatment process	Waste treatment sub-process (not all are relevant to EfW)
Mechanical treatment	• Treatment of waste electrical and electronic equipment (WEEE) containing volatile fluorocarbons and/or volatile hydrocarbons • Mechanical treatment of waste with calorific value • Mechanical treatment of WEEE containing mercury • General
Biological treatment	• Aerobic treatment of waste • Anaerobic treatment of waste • Mechanical biological treatment of waste
Physico-chemical treatment	• Physico-chemical treatment of solid and/or pasty waste • Rerefining of waste oil • Physico-chemical treatment of waste with calorific value • Regeneration of spent solvents • Thermal treatment of spent activated carbon, waste catalysts and excavated contaminated soil • Water washing of excavated contaminated soil • Decontamination of equipment containing PCBs
Treatment of water-based liquid waste	-

3 Making an application

3.1 Pre-lodgement

The Department of Environment and Science (the department) encourages applicants to request a pre-lodgement meeting prior to submitting a formal application. Pre-lodgement meetings are a service made available by the department to discuss early concepts (pre-design) to determine the feasibility of the proposed project or to seek direction and advice on whether a proposed application will meet the legislative application requirements. This service can improve the quality of applications and may reduce delays and un-anticipated problems associated with applications.

To request a pre-lodgement meeting complete the Application for pre-lodgement services ESR/2015/1664 and return to the details provided at the bottom of the form. This form should not be used for pre-lodgement relating to development applications proposed to be made under the *Planning Act 2016*. Pre-lodgement for these applications must be arranged through the State Assessment and Referral Agency (SARA), for further information go to www.business.qld.gov.au using 'ESR/2015/1664' as a search term.

3.2 Summary of application process

Queensland has an integrated development application, assessment and decision-making system. Most development applications are lodged with, and assessed by, the relevant local government. However the Planning Regulation 2017 may require that certain development applications be referred to the state through SARA.

Environmentally relevant activities (ERA) are listed in Schedule 2 and Schedule 3 of the Environmental Protection Regulation 2019 (EP Reg). Carrying out an ERA will require an operator to apply for an EA to conduct the activity. If the ERA is a concurrence ERA then the application will need to be lodged through SARA, for further information go to https://www.business.qld.gov.au/running-business/environment/licences-permits/applying.

Depending on the scale and complexity of the individual proposal, a proponent may seek to undertake an Environment Impact Statement (EIS) under the *State Development and Public Works Organisation Act 1971 (the SDPWO Act)*. In this case, the Coordinator-General would coordinate the assessment, with input from relevant agencies including DES. Advice from DES would include consideration of the EfW Policy and Guideline. By completing an EIS under the SDPWO Act, the Coordinator-General can suggest conditions, or impose specific conditions that must be attached to an approval (including an EA). Any EA for a project that has completed an EIS would still be required to be issued by DES taking into account the recommendations by the Coordinator-General.

Prior to holding an EA the operator is required to be a registered suitable operator (RSO). If an operator is not a current RSO then they can apply for the EA and RSO at the same time. An application process can look different depending on particular processes, i.e. standard application has a different process and timeframes to site specific application. Figure 4 details a quick outline of the assessment process.

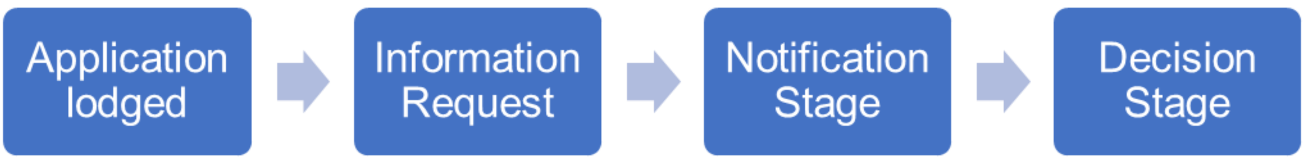


Figure 4: Application outline

For further information on the application process please refer to the departments guideline on Approval processes for environmental authorities or further information can also be found at https://www.business.qld.gov.au/running-business/environment/licences-permits/applying.

3.3 Relevant information to provide in your application

When making an application for an ERA the department requires information to assess the activity against the legislative requirements. The first step is to identify the environmental values of the site and surrounding areas including any nearby sensitive places. Once the environmental values have been identified then the applicant needs to determine the possible impacts and associated risks. The final step is to identify mitigation strategies that the applicant will implement to address the risks.

When deciding an application, the department will assess the application against requirements stipulated in the *Environmental Protection Act 1994*, including considerations stated in the Environmental Protection Regulation 2019 and any relevant Environmental Protection Policy, including the Environmental Protection (Air) Policy 2019 (EPP (Air)). Each EfW project will be assessed individually based on the proposed technology, characteristics of the feedstock, sensitivity of the receiving environment and location of the proposed project. The best practice national and international source emission standards, as specified in the EU BREFs, NSW POEO Regulation or similar standards, and the assimilated capacity of the airshed will be considered for evaluating the application. The applicant needs to demonstrate compliance against both the best practice source emission standards (e.g. NSW POEO Regulation and EU BREFs) and relevant ambient air quality standards (e.g. EPP Air objectives). Air dispersion modelling is generally required if there is a risk that emissions from the proposed activity may cause levels of contaminants to meet or exceed:

- Air quality objectives prescribed in Schedule 1 of the EPP (Air) for applicable environmental values
- Other recognised criteria, standards or guidelines relevant to protecting the identified environmental values of the receiving environment (e.g. human health and wellbeing, health and biodiversity of ecosystems, aesthetics of the environment, and agricultural land uses).

The assessment and supporting information provided by the applicant must be sufficient for the administering authority to decide whether an approval should be granted and to make a decision about the approval conditions. The information required for an air impact assessment of an EfW project is provided in detail in **Appendix 2** of this document.

In addition to impacts to air, an important environmental consideration for EfW facilities is the potential for the facility to cause an environmental nuisance. As part of the application process, applicants must outline how they will deal with any environmental nuisance matters, including dust, smoke, noise and odour. Environmental nuisance is considered an unreasonable interference with an environmental value caused by aerosols, fumes, light, noise, odour, particles or smoke. It may also include an unhealthy, offensive or unsightly condition because of contamination. For activities that need an EA, the most common causes of environmental nuisance are dust, noise and odour.

Another consideration is the potential to release prescribed water contaminants to waters. Prescribed water contaminants include a wide variety of contaminants from inert substances such as earth, clay, gravel and sediment to substances such as chemicals, contaminants with a high or low pH, construction and building waste, and oil. The applicant must outline how they will ensure that prescribed water contaminants are not left in a place where they could enter a waterway roadside gutter or stormwater drain and to make sure that they do not actually get into one of those places. This includes making sure that stormwater falling on or running across a site does not leave the site contaminated. Where stormwater contamination occurs an application must demonstrate that it will be treated to remove contaminants. The applicant should also demonstrate where and how material will be stored onsite to reduce the chance of water contamination.

To assist in the preparation of an application, the department has developed a guideline for each environmental value which details all the above steps and aspects to consider. When preparing your supporting information and impact assessment, you should refer to the:

- application requirements for activities with impacts to air - ESR/2015/1840
- application requirements for activities with impacts to land - ESR/2015/1839
- application requirements for activities with noise impacts - ESR/2015/1838
- application requirements for activities with impacts to water - ESR/2015/1837
- application requirements for activities with waste impacts - ESR/2015/1836.

4 Case Studies

4.1 Case study: Urban Utilities, QLD

4.1.1 Facility summary

Company	Urban Utilities
Location	Luggage Point and Oxley Creek Resource Recovery Centres, QLD
Technology	Wet anaerobic digestion
Scale	Luggage Point: Approximately 400,000 tonnes/year wet feedstock Oxley Creek: Approximately 100,000 tonnes/year wet feedstock
Waste hierarchy alignment	Recycling
EfW hierarchy alignment	Biological
Waste feedstock	Biosolids from sewage treatment Co-digestion of high-strength liquid trade waste such as liquid waste from soft drink manufacturing and fats, oils and grease
Energy output	Biogas, combusted on-site through co-generation facilities
Other outputs	Stabilised soil conditioner – reduced weight and biological activity compared to raw sewage treatment biosolids
Consumables	n/a
Regulatory agency	Department of Environment and Science
Environmental authority	EPPR00521513 https://storagesolutiondocsprod.blob.core.windows.net/register-documents-ea/EPPR00521513.pdf
Licenced activities	ERA 63 Sewage treatment works – (1g) operating sewage treatment works with a total daily capacity of more than 100,000 EP. Anaerobic digestion not specifically discussed within the Environmental Authority.

4.1.2 Anaerobic digestion for biosolids

Urban Utilities has been using anaerobic digestion to help manage the biosolids from its major wastewater treatment plants for more than a decade. Anaerobic digestion reduces the quantity of solids which need to be transported off-site and improves their biological stability so that they can be recovered as an agricultural resource under the End of Waste Code for biosolids.[4] Biogas is used to generate electricity, and heat from the biogas combustion is captured and used to warm the digesters and accelerate the anaerobic digestion process.

4.1.3 Exploring drivers for investment

Outcome 1: Protect the waste hierarchy
Outcome 6: Energy recovery requirements does not apply to biological energy recovery

Sewage treatment is the core business at Urban Utilities wastewater treatment plants. Urban Utilities has an active research and development program investigating opportunities for improved efficiency, performance and

[4] https://environment.des.qld.gov.au/__data/assets/pdf_file/0029/88724/wr-eowc-approved-biosolids.pdf

cost savings across multiple aspects of wastewater treatment. However, translating projects from a trail phase to larger scale investment requires a robust business driver.

Urban Utilities uses gas engines to generate electricity from their anaerobic digesters. At Luggage Point, biogas production exceeds the generating capacity of these engines, and excess biogas is flared without energy recovery. Urban Utilities is a major electricity user. They pay a low price for electricity from the grid, so investing in additional biogas engines to produce electricity from the current excess biogas would be more expensive than purchasing electricity from the grid.

Urban Utilities has investigated various options and pathways for emissions reduction. The Urban Utilities energy strategy includes a range of actions, including energy efficiency, installation of more than 1000 solar panels across 13 sites and use of energy from the anaerobic digestors.[5]

The digester units at Luggage Point have spare capacity which is not currently needed for biosolids. Co-digestion of other liquid waste streams improves the utilisation of the existing digester assets, without any need for capital works upgrades. Urban Utilities accepts liquid waste from the beverage industry for co-digestion with biosolids, and is investigating co-digestion of fats, oils and greases. These are high-energy feedstocks, which increases the methane yield from the anaerobic digestion process compared to digestions of biosolids only. They are source-separated streams with a low contamination risk.

4.1.4 Thermal energy recovery for future-proofing

Outcome 1: Protect the waste hierarchy

Urban Utilities is investigating new thermal treatment options for biosolids, to provide resilience against emerging contaminant issues such as the growing understanding of per- and poly-fluoroalkyl substances (PFAS). In the future, emerging contaminants may restrict or prevent the application of biosolids to land, including biosolids which have been processed through anaerobic digesters. If Urban Utilities is required to dispose of biosolids to landfill to protect the environment from PFAS contamination, this may increase operational costs compared to current land application practices.

Thermal treatment options create resilience and avoid landfill disposal while protecting the environment. Urban Utilities is actively trialling:

- Biosolids drying and pelletisation for co-combustion in existing coal fire power stations. The End of Waste Code for coal combustion products was updated in March 2021 to include testing and product usage requirements for the co-combustion of biosolids with coal. This enables co-combustion to be undertaken for PFAS destruction, while still allowing ash from coal combustion to be used in soil conditioner and construction applications.[6] Under this pathway, Urban Utilities is responsible for biosolids drying and handling as part of its existing operations while energy recovery stage occurs at an existing coal fired power station.
- Pyrolysis of biosolids to produce solid char. The EA at Urban Utilities' Oxley wastewater treatment site is currently being amended to enable it to conduct this energy recovery activity.

4.1.5 Communities as customers

Outcome 3: Engage with the community

Urban Utilities uses its existing sewerage treatment sites to carry out energy recovery processes. Sewage treatment remains the major activity at these sites, and odour control is the primary concern for neighbouring

[5] https://urbanutilities.com.au/about-us/what-we-do/our-energy-strategy#:~:text=Solar,sewage%20treatment%20with%20renewable%20energy.
[6] https://environment.des.qld.gov.au/__data/assets/pdf_file/0032/89816/wr-eowc-approved-coal-combustion-products.pdf

communities and businesses. In this context, trials and/or implementation of new energy recovery processes is not a topic for community interest or engagement from a health, amenity or environmental impact perspective.

For Urban Utilities, willingness to pay is the key engagement topic for energy recovery projects. As a regulated water and sewerage utility, Urban Utilities has a strong focus on the cost to serve each year, and the impact of infrastructure decisions on customers' utility bills. Urban Utilities uses an internal customer reference group to test new proposals, and publishes high-level summary information online about its established anaerobic digestion facilities as part of Urban Utilities' energy strategy and sustainability commitments.

4.2 Case study: Northern Oil, Gladstone QLD

4.2.1 Facility summary

Company	Northern Oil
Location	Gladstone, Queensland
Technology	Fractional distillation, solvent extraction, thermal oxidation
Scale	100 million litres per year capacity being the entire annual consumption of lube oils in Queensland. Currently operating at 70% due to feedstock availability
Waste hierarchy alignment	Recycling
EfW hierarchy alignment	Liquid fuel production
Waste feedstock	Oil and water mixtures or emulsions, or hydrocarbons and water mixtures or emulsions, mineral oils, lubricating greases, coolants and organic solvents.
Energy output	Liquid fuels – Industrial grades of light fuel oil, heavy fuel oil and gas oil (diesel cut)
Other outputs	Base oil for lubricant manufacturing, bitumen/asphalt
Consumables	Natural gas, electricity, solvent and caustic
Regulatory agency	Department of Environment and Science
Environmental Authority	https://apps.des.qld.gov.au/public-register/pages/ea.php?id=52200
Licenced activities	ERA 62 - Resource recovery and transfer facility operation - category 2 regulated waste ERA 61 - Thermal waste reprocessing and treatment - category 2 regulated waste ERA 61 - Thermal waste reprocessing and treatment- general waste ERA 55 - Other waste reprocessing or treatment- category 2 regulated waste ERA 08 - Chemical Storage - chemicals that are liquids ERA 08 - Chemical Storage - chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods

Northern Oil facility and typical feedstock delivery vehicle. Image courtesy of Northern Oil.

Aerial view of the Northern Oil site. Image courtesy of Northern Oil.

4.2.2 A recycling business with energy recovery

Policy outcome 1: Protect the waste hierarchy
Policy outcome 4: Use only residual waste as feedstock

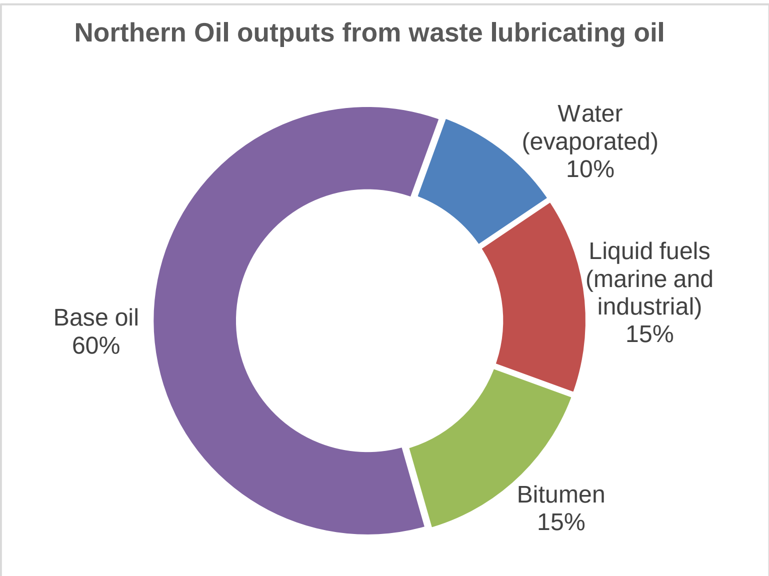
Waste lubricating oil and other hydrocarbons are generated in mechanical workshops and industrial operations throughout the country. Over time, lubricating oils become less effective as they are contaminated with metals, particulates, fuels and moisture and product additives become degraded. However, the base oil can be recycled back into new lubricating products. The Northern Oil facility uses fractional distillation to separate waste lubricating oil back into useful products.

Through use and collection waste oil becomes contaminated with various materials especially water, fuels, coolants and solvents. Approximately 60% of the waste oil feedstock received by Northern Oil is the original lubricant fraction and is refined back into base oil and sold to lubricant manufacturers. The recovery of the lubricant contained in the waste oil site at 99%. This closed-loop recycling is the primary business driver for the Northern Oil operation.

The fractional distillation process also separates and refines other fractions which are sold as industrial fuels. Together, these energy products make up approximately 15% of the input feedstock.

The remaining waste oil feedstock is separated into water, which is thermally oxidised at high temperature on site to ensure emissions control (10%), and re-refined bitumen (15%) used in road manufacture. The site has no trade waste connection and therefore all input either leaves as a product or is oxidised onsite.

The Northern Oil process is a good example of the TEEP framework presented in Policy outcome 4: Use only residual waste as feedstock. It is technically practicable to separate the waste lubricating oil into multiple components through fractional distillation. The Northern Oil facility separates and recycles base oil back into lubrication products, which is a positive outcome that protects the waste hierarchy. The energy recovery aspect of the Northern Oil operation applies to 15% of the feedstock which cannot be recycled, but can be sold as liquid fuel.



Multiple products recovered through the fractional distillation process. Image courtesy of Northern Oil.

4.2.3 Recovering value from problem waste

Policy outcome 1: Protect the waste hierarchy
Policy outcome 4: Use only residual waste as feedstock

If improperly managed, waste oil has the potential to cause environmental damage. Controlled storage, handling and tracking of waste oil through the Northern Oil supply chain prevents environmental damage, while the refining process undertaken by Northern Oil is an example of closed-loop recycling.

Waste oil is aggregated at individual mechanical workshops, then in depots in most population centres of approximately 20,000 people or more, and is transported to the Northern Oil facility in Gladstone using B-double tanker vehicles. This enables workshops to responsibly dispose of their waste oil to encourage responsible disposal and environmental protection. Northern Oil pays for the waste oil feedstock supply chain and generates revenue primarily from recovered base oil.

The Northern Oil facility is also supported by the Product Stewardship (Oil) Act 2000 (PSO), which is a national framework to support responsible management and environmentally and economically sustainable recycling options for used oil. This scheme imposes an up-front levy on every litre of lubricating oil sold, and the funds are used to support responsible management and recovery of used oil. The re-refining process undertaken by Northern Oil receives the highest rate of incentive under the PSO, at 50 cents per litre in 2020[7], because it recycles approximately 60% of the waste oil feedstock back into waste base oil for lubricant manufacture.

The PSO also provides incentives, at a lower rate, to operations which clean waste oil to a lower standard for use as a fuel in some industrial burners. This EfW pathway delivers energy recovery only, as the base oil is burned rather than refined back into lubricating products.

4.2.4 Operational experience and environmental protection

Policy outcome 2: Demonstrate operational performance

Northern Oil is a joint venture between Southern Oil, which has operated a waste oil refining facility in Wagga Wagga for more than 20 years using similar fractional distillation technology, and JJ Richards, a major waste collection and waste management company.

[7] https://www.environment.gov.au/protection/used-oil-recycling/product-stewardship-oil-program/benefits

The fractional distillation process and emissions control at the Northern Oil facility are flexible enough to manage fluctuations in the proportions of oil, water and fuel within the waste feedstock without encountering operational performance issues. Waste oil from over 70,000 individual collections is combined at local consolidation depots, in transport tankers and in on-site receival and storage at the Northern Oil facility. This helps to homogenise the waste feedstock before processing.

Given the scale of the supply chain, a risk-based spot testing regime is in place for waste oil consignments. This is primarily intended to control risks within the transport supply chain from potential inappropriate blending of waste oil with more flammable liquid fuels.

Conditions within the facility's environmental authority have a strong focus on spill-prevention, containment and monitoring to prevent contamination of stormwater or ground-water, as this is a key environmental risk for handling liquid waste.

Air emissions are also a significant concern when processing mixed hydrocarbons such as waste oil. The thermal oxidiser unit operates continuously and processes all refinery streams that do not become products i.e.: off gases, VOCs, light ends, vacuum vapours and sour water. Detailed emissions monitoring and quarterly sampling is required on the unit to ensure emissions from the stack are acceptable.

The site also operates a hot oil heater that provides energy for the re-refinery and this unit is fuelled only by quality controlled natural gas, sourced from the adjacent Queensland Gas Pipeline

4.2.5 Facility siting facilitates project development

Policy outcome 3: Engage with the community

The Northern Oil facility is located in the priority industrial development area at Yarwun, Gladstone. This means the site was pre-approved for heavy industry and is located alongside other heavy industrial activities. The environmental controls specified in the Northern Oil EA are typical of large industrial operations. No additional conditions were imposed to cater for sensitive receptors, and the project did not have to undertake a community consultation process during the project development.

4.3 Case study: ResourceCo, Wetherill Park NSW

4.3.1 Facility summary

Company	Cleanaway ResourceCo Resource Recovery Facility
Location	Wetherill Park, NSW
Technology	Mechanical waste sorting and solid fuel production
Scale	Material input (approved capacity): 250,000 tpa Processed engineered fuel (PEF) production (approved capacity): 150,000 tpa
Waste hierarchy alignment	Resource Recovery and Energy recovery
EfW hierarchy alignment	Mechanical
Waste feedstock	Mixed residual waste including, dry commercial and industrial waste and mixed construction and demolition waste.
Energy output	Up to 150,000tpa of PEF with elevated calorific value compared to unprocessed waste (Gross calorific value >15 MJ/kg and moisture content <15%) Energy recovery occurs at customer facilities, primarily cement kilns.

Other outputs	Recovered metals, recovered soils and aggregates for recycling
Consumables	Electricity for facility operation and liquid fuel for mobile plant
Regulatory authority	NSW EPA
Environmental Protection Licence	20937 https://apps.epa.nsw.gov.au/prpoeoapp/ViewPOEOLicence.aspx?DOCID=206184&SYSUID=1&LICID=20937
Licenced activity	Recovery of general waste Waste storage – other types of waste

Mechanical sorting equipment at Wetherill Park prior to commissioning. Image courtesy of ResourceCo.

Mechanical sorting of mixed waste feedstocks. Image courtesy of ResourceCo.

Processed engineered fuel produced to customer specifications including calorific value. Image courtesy of ResourceCo.

4.3.2 Producing fuel for industrial decarbonisation and landfill diversion

Policy outcome 1: Protect the waste hierarchy

Note: Policy outcome 6: Energy recovery does not apply to this facility, as it is a mechanical process and energy recovery only occurs at separate facilities which use the PEF.

The Cleanaway ResourceCo Resource Recovery Facility at Wetherill Park accepts commercial and industrial (C&I) and construction and demolition (C&D) waste from selected sources which would otherwise be disposed to landfill. The facility sorts and processes up to 250,000 tonnes of dry, raw material per annum into processed engineered fuel (PEF) and reusable commodities such as metal, concrete, bricks, rubble and soil. It targets waste from three different feedstock streams:

- Light residual waste from C&D recycling operations such as plastics and wood
- C&D waste from skip bin operators who would otherwise have disposed directly to landfill
- Dry C&I waste.

Materials are inspected on receival, shredded, and then passed through a series of screens, drum separators, ballistic separators and an optical separator to sort the feedstock by size and density, with magnets used to extract metals. The PEF is used as a substitute for fossil fuels by industrial facilities, reducing their reliance on coal or gas for heating.

The Wetherill Park facility supplies the Boral Berrima cement kiln in NSW and exports PEF to cement kilns in Asia, replacing up to 100,000 tonnes of coal usage per year. In terms of greenhouse gas emissions, this is equivalent to taking up to 20,000 cars off the road in terms.

The existing kilns and air pollution control systems at cement kilns are generally suitable for controlling emissions from PEF combustion, and are subject to their own approval processes. Cement kilns could not use unprocessed waste as fuel. The PEF production process unlocks thermal EfW opportunities for existing industrial facilities which would otherwise have remained reliant on fossil fuels.

4.3.3 Landfill levy and recycling revenue drive PEF business

Policy outcome 3: Only residual waste and feedstock.

The PEF material is not a significant revenue-generating stream for the facility. The business model is based on selling recyclable materials, primarily metals, and charging a competitive gate fee for accepting mixed waste. Waste generators use the Wetherill Park facility to avoid disposing waste to landfill, including incurring the NSW landfill levy, and to achieve higher order sustainability and resource recovery outcomes.

The landfill levy in NSW provides a financial driver for waste generators to use the facility, and for it to maximise resource recovery and minimise residual waste disposal. The facility also offers shorter transport distances compared to landfill disposal, with fully sealed roads and a smooth delivery process.

C&D recyclers are key customers for the Wetherill Park PEF facility. Their recycling businesses focus on recovering inert material such as soils, recovered concrete and masonry for construction markets. Further resource recovery from their light residual fraction, including plastics and wood, is not economically practical for C&D recyclers, as it does not align to their core business and supply chains and they have no market for the products. However, the additional processing undertaken at Wetherill Park is commercially viable due to the combination of the high landfill diversion achieved through PEF production and the sale of recyclables, primarily metals.

During the approvals process, the NSW Environment Protection Authority (EPA) requested information in order to understand the resource recovery performance, including compliance with prescriptive EfW eligibility limits which form part of the NSW EfW policy. At the approvals stage, the facility provided[8]:

- summary information on the expected composition and resource recovery and PEF recovery rates from different feedstock streams
- information about target tonnages, target customers and business model provided to NSW EPA (redacted in publicly available documents)
- commitment to require resource recovery mass balance assurances from C&D recyclers
- details of the sorting stages used to recover different material types
- a commitment to “ensure that new technologies are implemented in relation to resource recovery and environmental management of the Waste and Resource Management Facility throughout its life”.

The facility is also required to submit mass balance reporting to the NSW EPA as part of the NSW levy liability and mass balance reporting framework for all waste and resource recovery facilities, to monitor stockpiling and resource recovery outcomes throughout the industry.

4.3.4 Demonstrating performance

Policy outcome 2: Demonstrate operational performance

ResourceCo has operated a similar facility in South Australia since 2006, producing PEF for the Adelaide Brighton cement kiln. This reference facility provided confidence and credibility during the design and approvals process for the Wetherill Park facility.

At the approvals stage, the key performance issues for the Wetherill Park facility were traffic, dust, noise and fire risk, all of which are controlled through facility design and licencing. Odour is not a key issue for this type of waste facility as it only accepts dry waste which has low odour generating potential.

During the approvals process, the NSW EPA requested information in order to understand the controls in place to exclude unacceptable and potentially dangerous or polluting wastes. The facility demonstrated an acceptable approach to avoiding, removing and managing non-target waste, including:

- Supplier pre-qualification, including details of waste composition and source separation or resource recovery practices and quality assurance/quality control procedures to determine the waste eligibility and suitability for energy recovery.
- Visual inspection points upon waste receival, waste tipping and removal of large items and manual picking lines.
- Optical sensing applied to the PEF product output to provide real-time information about moisture content and some chemical parameters.
- Periodic sampling and laboratory testing of the PEF product against customer specifications.

[8] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7256%2120190227T102658.511%20GMT

The PEF specification provided by confirmed customer Lafarge Holcim Kanthan Cement kiln (Malaysia) during the project development phase.[9] It includes limits on calorific value, ash, moisture particle size and chemical composition, all of which are relevant to the performance of the fuel in the kiln.[10]

4.3.5 Planning, permitting and consultation

Policy outcome 3: Engage with the community

The facility was classified as a State Significant Development in NSW and required to prepare an environmental impact statement (EIS). Documentation of this process is published in the NSW Government Major Projects website.[11] The planning and approvals process under the State Significant Development Pathway took approximately 18 months. ResourceCo submitted its request for environmental assessment requirements to be addressed in the EIS in September 2015. Development consent for the facility was granted in April 2017.

The State Significant Development process includes obligations to consult with relevant agencies and stakeholders, and complete public exhibition of the EIS for comments followed by a formal response to submissions.

The site is located in an industrial area. A letter was distributed to neighbouring businesses and/or landowners. One request for further detail about the proposed site layout was received as a result of this approach, and ResourceCo was able to provide this information. The proposal did not receive any community submissions following the EIS exhibition. ResourceCo-Cleanaway consulted with various local and State Government agencies while developing the proposal and responded to agency submissions as part of the EIS process[12].

4.4 Case study: Pyrocal, Loganholme QLD

The Logan Water biosolids gasification project received funding from the Australian Renewable Energy Agency (ARENA) as part of ARENA's Advancing Renewables Program. The views expressed herein are not necessarily the views of the Australian Government, and the Australian Government does not accept responsibility for any information or advice contained herein.

4.4.1 Facility summary

Company	Pyrocal
Location	Loganholme, Queensland
Technology	Gasification
Scale	600 kg/hr demonstrations scale (biosolids only) 1210 kg/hr full scale (biosolids only)
Waste hierarchy alignment	Waste treatment
EfW hierarchy alignment	Thermal
Waste feedstock	Biosolids
Energy output	Heat
Other outputs	Solid char

[9] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7256%2120190227T102658.511%20GMT
[10] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7256%2120190227T102727.406%20GMT
[11] https://www.planningportal.nsw.gov.au/major-projects/project/5016
[12] https://www.planningportal.nsw.gov.au/major-projects/project/5016/submissions/12931/3251

Consumables	Diesel for start-up heating Dosing agents for flue gas treatment – magnesium hydroxide and urea
Regulatory Authority	Department of Environment and Science
Environmental Authority	Loganholme wastewater treatment plant https://apps.des.qld.gov.au/public-register/pages/ea.php?id=56384
Licenced activities	The pilot biosolids processing facility is located at the Loganholme wastewater treatment plant and licenced within the EA for Logan City Council's wastewater treatment operations. This EA also includes ERA 63 – Sewage treatment activities across multiple sites. ERA 61: Thermal waste reprocessing and treatment – category 2 regulated waste

Demonstration plant located at Loganholme wastewater treatment plant, showing full processing system. Image courtesy of Pyrocal.

Demonstration plant located at Loganholme wastewater treatment plant, showing heat recovery system. Heat recovery unit and biosolids feed equipment are visible in the background. Image courtesy of Pyrocal.

Demonstration plant located at Loganholme wastewater treatment plant, showing the hearth unit where biosolids are thermally treated. Image courtesy of Pyrocal

4.4.2 New technology solution for emerging contaminants

Policy outcome 1: Protect the waste hierarchy

The Pyrocal technology uses heating in with restricted amounts of air to gasify the volatile fraction of waste feedstocks. This includes persistent contaminants such as per- and poly-fluoroalkyl substances (PFAS) and microplastics within waste feedstocks. Gases are burned in a thermal oxidiser, releasing heat, and flue gases are cleaned prior to release into the atmosphere. The non-volatile fraction of waste becomes a solid char, which can be partially or wholly recovered, depending on the waste feedstock and char composition.

Pyrocal technology is primarily intended to offer a solution for problematic and contaminated wastes by destroying high-risk contaminants and greatly reducing the volume of material which must be transported for reuse or disposal.

Pyrocal has completed pilot scale trial processing at around 500-600 kg per hr at the Loganholme wastewater treatment plant. The pilot scale trial was supported by ARENA funding and detailed results are publicly available.13 Development of a full-scale facility on the site is progressing and will be capable of 1210 kg per hour of feedstock.

For biosolids, PFAS are key emerging contaminants of concern because they are highly persistent in the environment and can accumulate in the food chain. Wastewater treatment operators expect that growing understanding and regulation is likely to disrupt established biosolids practices and require more active treatment. The Pyrocal biosolids trials reduced the volume of dried biosolids by up to 90% and found an average PFAS destruction of 94%. The solid char from processed biosolids contains fixed carbon and phosphorus content which is high enough to be attractive as a fertiliser product.

[13] https://arena.gov.au/assets/2021/03/loganholme-wastewater-treatment-plant.pdf

4.4.3 Identifying energy recovery opportunities

The process generates energy in the form of heat. Pyrocal has a plant in South Australia which uses this heat to create steam and generate electricity. However, the revenue from electricity generation is typically low and management of problem wastes remains the primary driver for the technology.

At the full-scale Loganholme wastewater treatment plant, heat will be used on-site to dry biosolids in preparation for processing. This is a productive, self-contained use of the thermal energy but does not involve net export of energy from the operation. One of the objectives of the trial was to demonstrate that the integration of biosolids drying and gasification is energy neutral and will not require additional fuel consumption for the drying stage. The demonstration was successful but identified the need for an additional heat exchanger stage to increase energy recovery efficiency in the full-scale plant.

4.4.4 Air emissions testing and performance

Policy outcome 2: Demonstrate operational performance
Policy outcome 7: Environmental protection requirements

The Pyrocal example demonstrates how technology development, demonstration, refinement and scale up has occurred in Queensland, including the importance of on-going technology refinement and provision of information to provide confidence for the licencing of subsequent operations.

The technology development commenced in 2008. Over this time, Pyrocal has tested each of the components of its technology and reached the testing stage for the fully integrated system (Technology Readiness Level 9). It continues to make refinements for performance and efficiency. For example, the pilot testing showed that processing biosolids generated a much higher load of fine particulate matter than other organic biomass feedstocks, and initially exceeded emission limits. The emissions control system was adjusted to include a wet electrostatic precipitator to better control PM2.5 emissions and successfully met emissions limits for particulates in subsequent runs.

During the Loganholme biosolids trials, continuous emissions monitoring was required for basic parameters (O_2, NO_x, CO, and SO_x) during every test run. Full air emissions analysis including particulates, heavy metals and emerging contaminants of concern was performed for two runs (24-hour run and 100-hour run). Some exceedances were reported and adjustments were made and tested in subsequent runs, such as altering the chemical dosing agent for SO_x control, and proposed changes were identified to avoid emissions issues in the full-scale facility.[14]

The biosolids pilot also demonstrated that a single oxidation stage was adequate to meet licenced emissions limits, including PFAS destruction, and the secondary oxidiser could be removed resulting in higher energy efficiency. These lessons and adjustments demonstrate the importance of a trial phase in refining and demonstrating the performance of new technology.

The stack emissions limits set in the EA are bespoke. In Queensland, the Environmental Protection (Air) Policy (EP Air) takes an airshed approach to managing air pollution. Air pollution and dispersion modelling is used to back-calculate acceptable stack emission limit for the airshed where the facility is located. The department is also able to set emissions limits which are more stringent than the EP Air requirements, considering the NSW environmental regulations or the EU Industrial Emissions Directive and Best Available Technique reference documents. It is important to note that differences in reference oxygen concentration, emissions averaging periods and absolute compliance vs percentage compliance requirements need to be taken into account when adopting or translating emissions limits from other regulatory frameworks.

[14] https://arena.gov.au/assets/2021/03/loganholme-wastewater-treatment-plant.pdf

Outcome 7: Environmental Protection of the EfW Policy sets the aspiration for EfW facilities to be operated in accordance with relevant EU Best Practice Reference documents (BREF). It should be noted that a full scale Pyrocal biosolids gasification facility would be unlikely to fall within the scope of the EU Waste Incineration BREF because:

- Sludge from urban waste water treatment is not classified as hazardous waste (EWC code 19 08 05)
- The IED requirements only apply to non-hazardous thermal treatment plants processing more than 3 tonnes of waste per hour
- The full scale biosolids gasification facility proposes to treat 1.2 tonnes per hour.

The Queensland EfW Policy encourages all proponents to review the best practice techniques set out in the relevant BREF document and Best Available Techniques conclusions (BATc). However, for proposals which do not fall within the scope of the BREF and BATc, some techniques may not be applicable due to limitations of scale or technology types.

4.5 Case study: Avertas Energy, Kwinana WA

4.5.1 Facility summary

Company	Avertas Energy (previously Phoenix Energy)
Location	Kwinana, WA
Technology	Moving grate
Scale	400,000 tpa
Waste hierarchy alignment	Energy recovery
EfW hierarchy alignment	Thermal
Waste feedstock	Mixed residual waste including municipal solid waste under 20-year waste supply contracts with Rivers Regional Council, Kwinana City Council and Southern Metropolitan Regional Council
Energy output	38 MW electricity exported to the grid
Other outputs	Incinerator Bottom Ash (IBA) Air Pollution Control residue (APCr)
Consumables	Natural gas for start-up heating Dosing agents for flue gas treatment – urea, activated carbon and quick lime
Regulatory agency	Environmental Protection Authority (EPA), Department of Water and Environmental Regulation (DWER)
Environmental permit	W5911/2015/1 https://der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/Decisions_/W5911_Works_Approval_Kwinana_WtE_Amendment_November_2019.pdf Ministerial approval https://www.epa.wa.gov.au/sites/default/files/Ministerial_Statement/Statement%20No.%201016_1.pdf https://www.epa.wa.gov.au/sites/default/files/1MINSTAT/1623%20Kwinana%20Statement%201093%20for%20publishing.pdf

Licenced activities	52 – Electric power generation 60 – Incineration 61 (A) – Solid waste facility 67 – Fuel burning

Facility under construction June 11 2021. Image courtesy of Avertas Energy.

Visualisation of the completed facility. Image courtesy of Avertas Energy.

4.5.2 Regulatory Framework in Western Australia

The Avertas Energy project was the first major thermal EfW project to be approved in Australia. Construction of the facility commenced in 2019 and it is scheduled to begin commissioning in 2021.[15]

Western Australia (WA) has a multi-stage approvals and licencing process. The key stages for the Avertas Energy from Waste project were the EPA assessment, culminating in Part 4: Ministerial Approval and Part 5: Works Approval issued by the Department of Water and Environmental Regulation (DWER). DWER is also responsible for the licence for the facility to allow for emissions and discharges.

Construction, environmental commissioning and time limited operation of the facility will occur under the Works Approval. Once this has been completed and the facility has been successfully commissioned, Avertas Energy can ask for a licence, which then will regulate emissions and discharges during the operation of the facility.[16]

Prior to the submission of any EfW proposals, the Western Australian Government identified that Part 5 approvals would only be able to regulate direct environmental impacts, such as emissions to air or land. The Part 5 licencing process would not be able to impose any conditions with the sole purpose of regulating the role of EfW technology within the waste hierarchy or requiring application of best practice technologies. These additional expectations for the EfW sector were set through EPA research culminating in a Ministerial

[15] https://avertas.com.au/2019/03/08/construction-underway-for-australias-first-thermal-waste-to-energy-facility/
[16] DWER Guide to Licencing: https://www.der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/licensing%20guidelines/Industry%20Regulation%20Guide%20to%20licensing%20%20June%202019.pdf

Statement, which was subsequently refreshed within the WA Energy from Waste Position Statement.[17, 18,19] It focuses on issues of suitable technologies, waste feedstocks and locations for EfW developments.

4.5.3 Demonstrated performance

Policy outcome 2: Demonstrate operational performance

The project proponent, Phoenix Energy selected an established EfW technology supplier, Martin GmbH as part of the project development team. This gave the project access to the technical experience of a reputable supplier and helped the approvals documentation to demonstrate that the proposed EfW technology was mature and reliable.

Martin GmbH provided a list of 407 operating reference sites, showing its track record as a well-established technology supplier. The proposal then narrowed down to a single reference facility, the Tokyo-Kita plant. This was selected because it utilises a moving-grate technology of a similar scale which has a similar air pollution control system as the Kwinana proposal, and air emissions data is available in the public domain.[20]

After the project received initial approval in 2017, the technology provider Martin GmbH left the project. The Ministerial Statement was amended to remove the specific reference to the Martin GmbH and include a definition of "Proven Grate Combustion Technology - Technology provided by a supplier with a track record in providing grate combustion systems to waste to energy resource recovery facilities, which recover energy from municipal solid waste at a similar scale to the proposal, and which is consistent with the Environmental and Health Performance of Waste to Energy Technologies under section 16(e) of the EP Act, April 2013." This enabled the project to involve another established and reputable supplier and proceed with the development.

Prior to financial close, the project was sold to Avertas Energy and another established technology provider, Keppel Seghers, was confirmed. This change in technology supplier was not a major hurdle because the developer demonstrated to the regulatory authority that Keppel Seghers is a Proven Grate Combustion Technology supplier with a track record using reference projects and operational data. Keppel Seghers have more than 100 projects globally, including various facilities operating in the UK and EU which are subject to EU IED regulatory requirements. Summary data demonstrating performance in line with these requirements is publicly available under the regulatory frameworks in these jurisdictions.

The original reference facility and supplier involvement in the approvals process established regulatory and community confidence in the project, and the change in technology provider did not alter the core commitments to moving grate combustion and key flue gas treatment stages. Operating conditions set in the approvals remain binding for the final design and technology provider.

4.5.4 Protecting the waste hierarchy

Policy outcome 1: Protecting the waste hierarchy
Policy outcome 4: Use only residual waste as feedstock

In 2019, WA Waste and Resource Recovery Strategy 2030 was published. It set recycling targets, committed to food and garden organics collection (FOGO) across the Perth and Peel regions and introduced a definition of "residual waste" for the first time.[21] It defined residual waste as:

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[17] https://www.epa.wa.gov.au/sites/default/files/EPA_Report/Report%20and%20Recommendations%20-%20WTE%20Residual%20Waste%20-%2017%20October%202018_0.pdf
[18] https://www.wasteauthority.wa.gov.au/images/resources/files/2020/Position_statement_on_waste_to_energy.pdf
[19] https://www.wasteauthority.wa.gov.au/publications/view/miscellaneous/waste-to-energy
[20] https://www.epa.wa.gov.au/sites/default/files/PER_documentation/Phoenix-Energy-Kwinana-WTE-PER-Document-FINAL.pdf
[21] https://www.wasteauthority.wa.gov.au/images/resources/files/Strategic_Direction_Waste_Avoidance_and_Resource_Recovery_Strategy_2030.pdf

- "Waste which remains following the application of a better practice source separation and recycling system", as defined by the WA Government; or
- Where a better practice guideline is not available, material recovery performance needs to meet or exceed the relevant stream target for MSW, C&I and C&D waste streams" as set out in the strategy.

Under the strategy, only residual waste should be directed to energy recovery.

Adoption of better practice source separation and higher recycling rates is a transition involving changes to services and behaviour across multiple councils, businesses and service providers in the waste and resource recovery sector. WA Government recognised that EfW facilities are unable to directly control the source-separation systems of their customers, particularly the timing of decisions to introduce new systems and services.

In 2019, the regulator incorporated new conditions within the Ministerial Statement.[22] Each year facilities are required to prepare and submit a Waste Acceptance System Plan including:

- A description of waste that the facility could accept, if it only accepted residual waste. This could change over time as new source separation or recycling options become accepted in WA.
- A description of the waste streams actually accepted at the facility, including information about source separation systems as provided by the waste generators.
- Details and justification of measures and procedures that have been implemented to ensure that the project has the ability to accept only residual waste.

The first Waste Acceptance Sampling Plan must be submitted prior to commissioning.

Under this new condition, the facility must continue to demonstrate that the sizing and technical capabilities can accommodate changes in waste feedstock supply due to improved recycling, but the EfW facility is not responsible for achieving those changes.

Meanwhile, the WA Government is encouraging increasing source separation and recycling, including FOGO adoption under the Better Bins program and funding and recycling infrastructure investment through the Recycling Modernisation Fund. The definition of residual waste and ongoing reporting requirements prevents over-capacity in the EfW sector, while allowing flexibility to introduce future improvements in resource recovery.

4.5.5 Air emissions

Policy outcome 7: Environmental protection requirements

The Avertas Energy facility is located in the Kwinana Industrial Area. This meets the expectations set by the WA Government and formalised in the EfW Position Statement that in the early stages of establishing EfW in WA, facilities should be located in industrial areas with long-term buffer zones to residential development.

The Kwinana Industrial Area is a well-established heavy industrial zone. It has a dedicated air quality policy at the airshed level, which is the key instrument for controlling the environmental impact of emissions to air under WA regulations. The Part 4: Ministerial Approval for the EfW facility also directs stack emissions to be set in line with the EU Industrial Emissions Directive, and enacted through the Part V works approval and facility licence. The airshed emissions requirements under existing WA regulations must be met, and the regulator also has the power to set more stringent controls on stack emissions using the EU Industrial Emissions Directive (IED) emission limits.

[22] https://www.epa.wa.gov.au/sites/default/files/1MINSTAT/1623%20Kwinana%20Statement%201093%20for%20publishing.pdf

The stack emissions limit set within the Works Approval matches the IED, indicating that it was the more stringent instrument for all pollutants. Monitoring conditions in the works approval, including averaging periods, stack emissions value and use of tiered percentage compliance requirements rather than single absolute limit, are framed to match the IED regulatory framework and support adoption of IED limit values. The testing methods continue to reference the DWER Guidelines and US EPA methods which are established in the WA market, rather than introducing unfamiliar EU-standard stack test methodologies.[23]

Once constructed, the Avertas facility will need to demonstrate proof of performance during commissioning and provide detailed emissions monitoring data to the regulator via a Commissioning Report. The facility will also undertake ongoing emissions monitoring, reporting and compliance for the life of the project, as set out in the operational licence.

4.6 Case study: Kemsley, UK

4.6.1 Facility summary

Company	Enfinium *Acquired the EfW facility from Wheelabrator Technologies UK in 2021*
Location	Kemsley, UK. Postcode ME10 2TD, adjacent to the DS Smith paper mill
Technology	Moving grate technology (two lines)
Scale	657,000 tpa
Waste hierarchy alignment	Energy recovery
EfW hierarchy alignment	Thermal
Waste feedstock	Mixed residual waste including municipal solid waste, commercial and industrial waste and paper residues from the adjacent paper mill
Energy output	Electricity and steam 45MW electricity and 55MW steam when demand from the paper mill operating at maximum capacity, or up to 75 MW electricity with lower steam demand.
Other outputs	Ash Flue gas treatment residue
Consumables	Diesel for start-up heating Dosing agents for flue gas treatment – urea, activated carbon and hydrated lime
Regulatory agency	Environment Agency, UK
Environmental permit	https://www.gov.uk/government/publications/me10-2td-k3-chp-operations-limited-environmental-permit-issued-eprjp3135dkv004
Licenced activities	Scheduled activity: Incineration of non-hazardous waste in a waste incineration plant with a capacity of 3 tonnes per hour or more. Directly associated activity: Generation of electrical power using a steam turbine from energy recovered from the flue gases.

[23] https://der.wa.gov.au/images/documents/our-work/licences-and-works-approvals/Decisions_/W5911_Works_Approval_Kwinana_WtE_Amendment_November_2019.pdf

Facility under construction in 2019, with the DS Smith paper mill visible in the background. Image published by Wheelabrator Technologies

Completed K3 facility in 2020. Image published by Wheelabrator Technologies

4.6.2 Solving a waste problem

Policy outcome 1: Protect the waste hierarchy
Policy outcome 2: Use only residual waste as feedstock

The Kemsley K3 facility is the first fully-merchant EfW facility in the UK. This means that it does not have any direct waste supply contracts with local government authorities. Instead, the facility sought and secured waste supply from private waste management companies in the market. Long term certainty remains important to underpin the infrastructure investment, and the K3 facility secured 10-15 year long contracts with multiple national waste management companies.

The facility processes a mixture of residual MSW and C&I waste which waste management companies collect from generators and deliver to the K3 facility. The environmental permit for the facility lists wastes which can be accepted using the European Waste Classification (EWC) system. This includes a wide range of waste materials from specific industries which are potentially acceptable[24]. Materials which were separately collected for recycling, but subsequently found to be unrecyclable, are specifically permitted. This enables the facility to accept rejected feedstock from the paper mill. Waste generators and waste management companies remain responsible for separating recyclable materials.

The K3 facility provides a robust, flexible and responsible solution for managing mixed, non-recyclable waste, but is not responsible for implementing or verifying waste collection or recycling systems. Overall residual waste availability is considered as part of the facility permitting process, but is not translated into any operational requirements.

Both bottom ash and air pollution control residues (APCr) are sent offsite to other facilities where they are treated and recovered in the UK, resulting in zero waste to landfill. Management of the APCr is undertaken by OCO Technology, which operates a proprietary carbon-negative process that immobilises contaminants within a “manufactured limestone” product. This enables APCr to be recycled as aggregate in the construction industry. The initial contract for incinerator bottom ash (IBA) recovery was awarded to Fortis IBA. At the Fortis IBA site, bottom ash is matured and undergoes a curing process which helps to immobilise potential contaminants within the ash. Matured IBA is graded by size and processed to recover ferrous and non-ferrous metals, including a specific magnetic drum which targets AA and AAA batteries which may be present in the ash.[25] The remaining IBA material is an inert clinker which is recycled as aggregate products for earth works, road construction and other construction products.[26,27]

4.6.3 Providing energy benefits

Policy outcome 6: Energy recovery requirements

The K3 facility is located adjacent to an existing paper mill, operated by DS Smith, and supplies it with approximately 70 tonnes per hour of steam. This reduces the need for the paper mill to use energy from fossil fuel sources, including on-site combined heat and power (CHP) gas turbines. The K3 EfW facility which is designed to generate up to 75MW of electricity and once the parasitic load is utilised it can export up to 63MW of electrical power to the national grid during low steam demand from the paper mill.

The DS Smith paper mill produces a wide range of recycled paper and cardboard products and is the second-largest recovered fibre paper operation in the UK and Europe. The paper mill provided land for the K3 EfW

[24] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/921939/Amended_Variation_Notice_JP3135DK-V004.pdf
[25] https://fortisiba.com/about-us/processing/
[26] https://fortisiba.com/ibaa-applications/
[27] https://consult.environment-agency.gov.uk/psc/me10-2td-k3-chp-operations-limited/supporting_documents/190919%20R%20JER1247%20AG%20Kemsley%20GS%20Variation%20Final.pdf

project, and benefits from cheaper and more sustainable energy for its paper milling operations. The co-location of thermal EfW technology with an industrial paper mill operation enables both steam and electrical power from the EfW facility to be utilised, unlocking more efficient energy recovery and enabling it to easily meet the R1 threshold for distinguishing energy recovery from waste disposal.

4.6.4 Recognising renewable energy

Approximately 45% to 50% of the energy supplied by the facility comes from renewable, organic materials such as food waste, garden waste or soiled paper and cardboard. The UK government operates a Contracts for Difference (CfD) scheme which provides electricity revenue certainty to support low-carbon electricity generation.[28] The K3 facility participates in this scheme and receives CfD payments for the renewable portion of the electricity that it generates. This is calculated using the Bioma software system, based on a range of continuously monitored operational parameters from the energy recovery process and flue gas continuous monitoring system.

4.6.5 Planning and permitting in the UK

The project development journey for the K3 facility spans more than a decade. The initial project application was made in 2010. The K3 facility was originally designed and approved to accept 550,000 tpa of waste and produce 49.9MW of electricity. At this scale, the facility was assessed and approved for development by the local Kent County Council in 2012. Construction commenced in 2016 and the facility was commissioned in 2020.

In 2017, enfinium subsequently identified continuing demand from the waste management market for energy recovery to manage non-recyclable waste. enfinium was able to secure an additional 107,000 tpa of residual waste, and process this without any changes to the external layout or design of the facility. However, at this increased throughput, the facility crossed the 50MW threshold to become a Nationally Significant Infrastructure Project under the UK Planning Act 2008. As a result, the project undertook a second development consent process. This included preparation and publication of an Environmental Impact Assessment and formal consultation with local authorities, neighbouring businesses and the local community and undertaking formal public notification and submissions processes.

The increased throughput and energy production was approved in February 2021. A full permit history is provided within the Environmental Permit.[29]

4.6.6 Community consultation

Policy outcome 3: Engage with the community

The consultation approach was developed to make people living, working and moving through the application site and further afield aware of the project and give them an opportunity to comment. Summarised in the Statement of Community Consultation report,[30] it included the following:

- Informal engagement with specific local stakeholders such as local members and parish councils ahead of the formal consultation process.
- Three public exhibitions where members of the community could discuss, ask questions and complete a questionnaire.

[28] https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference
[29] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/921939/Amended_Variation_Notice_JP3135DK-V004.pdf
[30] https://www.wtikemsley.co.uk/site/assets/files/1318/k3_wkn_dco_socc_final.pdf

- Leaflet mailing, posters in community halls and facilities and media releases with information about the proposal and the consultation process. This targeted an area within a 5km radius of the project site and involved mailing 15,000 leaflets.
- Targeted mailing of information to local interest and action groups (for example the Sittingbourne Society, the Swale Locality Board, Swale Community Empowerment Network and the Swale Senior Forum) which might not otherwise have been aware of the proposal or the consultation process.
- A project website providing project details, documentation and a portal to submit a response during the consultation period.

Locating the K3 EfW facility adjacent to the existing DS Smith Paper mill and within an established industrial area has helped to minimise the impact of the development, and the facility has not experienced issues with amenity impacts since commencing operations.

4.7 Case study: Lakeside Energy from Waste, Slough UK

4.7.1 Facility summary

Company	Lakeside Energy from Waste Ltd, joint venture between Grundon Waste Management and Viridor
Location	Slough, UK. Postcode SL3 0FE
Technology	Moving grate incineration
Scale	Design capacity: 411,000 tpa Nominal permit capacity: 400,000 tpa. This is not an upper limit and the facility has processed around 450,000 tpa of waste in some years, when the average calorific value of received waste was lower than the nominal design value.
Waste hierarchy alignment	Energy recovery
EfW hierarchy alignment	Thermal
Waste feedstock	Mixed residual waste including municipal solid waste, commercial and industrial waste.
Energy output	40MW electricity
Other outputs	Ash Flue gas treatment residue
Consumables	Fuel oil for start-up heating Dosing agents for flue gas treatment – ammonia, activated carbon and lime
Regulatory agency	Environment Agency, UK
Environmental permit	VP3690EL/V004. Permit documents not publicly available but can be requested from the UK Environment Agency.
Licenced activity	Scheduled activity: Incineration of non-hazardous waste in a waste incineration plant with a capacity of 3 tonnes per hour or more.

Lakeside facility. Image available at: https://www.viridor.co.uk/siteassets/images/erf/lakeside-efw/lakeside03.jpg

Lakeside facility aerial view. Image available at: https://www.viridor.co.uk/siteassets/images/erf/lakeside-efw/lakeside02.jpg

4.7.2 A local solution to waste

Policy outcome 1: Protect the waste hierarchy

The key purpose of the Lakeside EfW facility is to provide a permanent solution to managing mixed residual waste from councils and businesses in the London region. Landfill capacity in the region is highly constrained and transporting waste to neighbouring areas for disposal is an unpopular and unsustainable option. The Lakeside EfW facility was recognised in 2017 as one of first EfW plants to achieve 100% diversion from landfill when it entered an agreement with Carbon8 Aggregates Ltd to treat the air pollution control residues from the facility and recycle them into lightweight, carbon-negative aggregates for use in building blocks, precast and ready mixed concrete.

In 2019, Carbon8 was rebranded as OCO Technology. Grundon is a major investor in OCO Technology and waste recovery operations, in addition to the Lakeside EfW facility and other waste collection and management activities.

The Lakeside EfW facility is a privately-funded commercial facility, and one of the key financial drivers for the project was the landfill disposal tax. This was originally introduced into the UK in 1996 at a rate of £7/tonne for putrescible waste disposed to landfill. The tax has increased over time, reaching £94.15/tonne in 2020 and driving continuing reductions in the tonnages of waste disposed to landfill. At the time of the facility opening, this tax sat at £40/tonne.

The UK waste and recycling system is driven by financial mechanisms such as the landfill tax, landfill bans on biodegradable waste and other policies and programs to promote recycling and does not place direct responsibility on the Lakeside EfW facility for achieving recycling targets. Dry comingled recyclable materials are cheaper for councils and businesses to send to the MRF for recovery, while mixed putrescible waste is directed to energy recovery. The Lakeside EfW facility can accept non-recoverable residual material from sorting operations at the MRF, as its licenced waste acceptance criteria include a wide range of specific commercial and industrial wastes as potential feedstocks, including EWC code 19 12 – “waste from mechanical treatment of waste (for example sorting, crushing, compacting, pelletising)”.

4.7.3 Managing variability in waste feedstock

Policy outcome 4: Adapt to residual waste changes over time

The facility is licenced to accept non-hazardous municipal, commercial and industrial waste under European Waste Catalogue Chapter 20 (i.e. all non-hazardous waste codes 20 XX XX, including mixed municipal waste). The facility is designed and operated to accommodate the inherent variability of mixed residual waste. For example, the design throughout the facility is 411,000 tonnes per year of waste, producing 40MW of electricity. However, if the calorific value of the mixed waste feedstock is higher or lower than the nominal design value, the waste feed rate is adjusted to maintain complete combustion and efficient energy recovery.

The facility is capable of operating on waste with calorific values in the range 7 MJ/kg to 12 MJ/kg. If the average calorific value over a year is in the lower end of this range, the overall throughput of the facility increases. This operational flexibility is part of the facility design and does not negatively impact overall environmental performance, as noted in facility annual reports. Waste deliveries are tipped into the waste bunker, and waste is mixed in the bunker to homogenise short-term variability between individual loads. The waste bunker is designed to hold around four days of waste supply. It is designed for waste storage, including fire detection and suppression, an impermeable barrier to groundwater and negative pressure as the odorous air is from the waste bunker is drawn into the combustion chamber.

The track record of waste throughput, and odour and emissions performance summarised in Table 6 illustrates that the facility has been able to flexibly accommodate waste with a lower average calorific value than the waste information adopted during the original design process prior to 2009. The facility has been able to identify and rectify occasional operational issues without any repeated pattern of emissions exceedances, which is acceptable from a regulatory compliance perspective. A monthly summary of emissions reporting compared to emissions limit values is provided on the Lakeside EfW facility website.[31]

Table 6: Summary of waste throughput and operational performance from available annual reports

Year	Waste throughout		Odour complaints	Emissions exceedances
	Tonnes per annum	As % of design throughput		
2014	453,552	110.4%	None	None
2016	435,845	106%	None	Two instances of short-term volatile organic compounds (VOC) exceedance on start-up. The average daily limit of 10mg/m^3 was not breached on either day.
2017	455,692	110.9%	None	Three short term dust exceedances were notified to the agency, but in each case the facility was able to temporarily reduce load and fix the issue, so that daily emissions limits were not breached.
2018	431,278	104.9%	None	One instance of air emissions exceedances for CO and NOx was notified to the agency on August 12th. This was caused by very wet waste creating poor burning conditions, and rectified by slowing the grate speed to allow waste to dry on the grate.

4.7.4 Working with waste suppliers

The Lakeside EfW facility receives mixed residual waste from both private waste collection contractors and council waste collections. Making the switch from landfill disposal to energy recovery highlighted that some collection rounds picked up bulky waste items such as mattresses, shopping trolleys and vehicle parts along with general mixed residual waste. While these items are not hazardous or problematic from a combustion perspective, the metal components pass through to the ash-handling system and cause blockages or maintenance issues. Rather than increasing efforts to identify and separate unwanted items after they had been delivered, the Lakeside EfW facility operator focused on engaging directly with suppliers and delivering waste education sessions for the delivery drivers, which helped to change the waste collection practices and avoid inappropriate bulky items from being delivered.

4.7.5 Planning and permitting in the UK

The Lakeside EfW facility holds a permit from the UK Environment Agency which implements requirements of the EU Industrial Emissions Directive through UK regulations and processes. The Lakeside EfW facility first applied for and received a permit in 2003. This was varied in 2009 and the facility has been fully operational since 2010. In 2014, the permit was varied in order to bring the new requirements from the EU Industrial Emission Directive into force. In 2019, updated Best Available Techniques Conclusions (BATc) documents were published for waste incineration, and the UK Environment Agency will go through another permit variation process to bring these into force for Lakeside EfW within the 4-year transition timeframe. Following the UK exit

[31] https://www.lakesideefw.co.uk/

from the EU, the UK has committed to maintain current EU IED and BATc requirements, with the power to adopt future EU BATc or develop UK-specific BATc in the future.[32]

4.7.6 Improving over time

Large-scale thermal energy from waste infrastructure is a long-term asset, with a design life of around 25 years, which can be lengthened to around 40 years with refurbishment. Over this length of time, both technology and environmental standards improve, and amendments to operating requirements, such as a timetable for adoption of new BAT conclusions, is expected. Similarly, carbon capture for stack emissions is an area of emerging technology which is not yet required or commercially established. The Lakeside EfW facility operators are already monitoring developments in this space, with the expectation that their plant may be expected to justify whether carbon capture is technically and economically feasible in the future.

4.7.7 Community consultation

Policy outcome 3: Engage with the community

The Lakeside EfW facility conducted community engagement during the development phase of the scheme. They focused on early engagement with immediate neighbours, including Heathrow Airport and the local community. The Grundon waste management business had established frameworks in place for talking with the community, and used these during the project development for the Lakeside EfW Facility. This included consulting directly with key stakeholders at a local authority level and holding meetings to explain the facility and answer questions. Parish Councils are an existing local institution which proved useful for reaching community spokespeople at a very local level. This strong focus on the immediate local community aligned to the IAP2 principle of involving people in decisions which affect them and helped to avoid vocal objections to the proposal.

5 Further guidance and references

If you are unsure whether your activity requires an EA then head to https://www.business.qld.gov.au/running-business/environment/licences-permits/form-fees-finder. This will also develop a report which details information that will need to be considered in an application.

https://environment.des.qld.gov.au/management/activities details on the department external web page.

https://www.business.qld.gov.au/running-business/environment/licences-permits/applying details on the QLD Business Portal.

[32] https://www.gov.uk/guidance/industrial-emissions-standards-and-best-available-techniques

6 Definitions

Anaerobic digestion means the biological breakdown of organic matter by microorganisms and enzymes, in the absence of oxygen to produce biogas and digestate (a nutrient rich residue).

Biogas means gas produced from anaerobic digestion, which is a mixture of methane and carbon dioxide.

Biological EfW means technologies or processes that use microorganisms and enzymes to breakdown waste materials in the absence of oxygen to produce a biogas and a fertiliser-like residue. Anaerobic digestion, and fermentation of waste materials are examples of biological EfW.

Chemical EfW means the production of energy (fuel) from waste materials using chemical agents. An example of this is transesterification, which involves reacting waste fats and oils which an alcohol (methanol) in the presence of a catalyst (sodium hydroxide) to produce biodiesel.

Combustion means the breakdown of waste at elevated temperatures under excess air or oxygen to produce heat, ash, and flue gas.

Commercial technology means a technology that has been in commercial operation for at least two (2) years.

Commercial operation means operation of the technology or facility, in return for financial gain or other valuable consideration, and which is available to the public, or performed under a contract between the technology or facility operator and a customer with no control over the operator.

Comparable jurisdiction means a jurisdiction that imposes requirements similar to those imposed in this policy and in applicable Queensland legislation, including the *Environmental Protection Act 1994* and its subordinate legislation, and the *Waste Reduction and Recycling Act 2011* and its subordinate legislation.

Emerging technology means a technology one that is still going through the research and development process as determined against the Technology Readiness Level Index.

End of waste (EOW) code means a code that sets out the requirements for a particular waste to be reclassified into a resource for one or more specified end uses.

Energy from waste (EfW) means the extraction of energy from waste materials. The energy can be extracted in the form of solid, liquid or gaseous fuels, heat, or electricity generated using the former.

Fermentation means the breakdown by microorganisms, of the sugars such as glucose, fructose and sucrose, in waste organic matter, into ethanol and carbon dioxide.

Gasification means the breakdown of waste at elevated temperatures under oxygen-reduced conditions to produce a syngas comprising mainly of carbon monoxide, hydrogen, carbon dioxide, nitrogen, and methane.

Incineration means the destruction of waste using heat, for the primary purpose of disposal.

New technology means a technology that has been in commercial operation for less than two (2) years.

Pyrolysis means the breakdown of waste at elevated temperatures in the absence of oxygen to produce char, pyrolysis oil, and syngas.

Recycling means extracting materials from waste and converting them into useful products. For example, concrete may be extracted from the construction and demolition waste stream and converted into recycled aggregate suitable for use in road base as a virgin material substitute. Recycling includes biological energy-from-waste processes.

Refuse derived fuel (RDF) means a fuel produced from waste, typically by shredding to reduce particle size, dehydrating to remove moisture, and removal of non-combustible materials such as metals.

Residual waste means waste that is not technically, environmentally, and economically practicable to reuse or recycle.

Social licence means the informal approval or endorsement of a project granted by a community.

Stakeholder engagement plan means a plan developed by the proponent of an EfW facility that provides details about project stakeholders, how they will be engaged over the life of the facility and the associated communication activities, and mechanisms to address stakeholder grievances.

Syngas (or synthesis gas) means a fuel gas mixture containing methane, hydrogen, carbon monoxide, carbon dioxide and nitrogen.

Technology Readiness Level (TRL) Index means a method of estimating the maturity level of a particular technology. It is used by the Australian Renewable Energy Agency (ARENA) to measure the technical readiness of renewable energy solutions.

Thermal EfW means the decomposition of waste at high temperatures to produce heat or release the energy contained in the waste. Combustion with energy recovery, pyrolysis and gasification are examples of thermal EfW.

Appendix 1: Technology readiness levels

Stage	TRL and definition	Description	Supporting information
Basic technology research	TRL 1: Basic principles observed and reported	Scientific research begins to be translated into applied research and development. Examples include paper studies of a technology's basic properties or experimental work that consists mainly of observations of the physical world.	Published research or other references that identify the principles that underlie the technology.
	TRL 2: Technology concept and/or application formulated	Invention begins. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies. The idea moves the ideas from pure to applied research. Most of the work is analytical or paper studies with the emphasis on understanding the science better. Experimental work is designed to corroborate the basic scientific observations made during TRL 1 work.	Publications or other references that outline the application being considered and provide analysis to support the concept.
Research to prove feasibility	TRL 3: Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory-scale studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative tested with simulants. The work has moved beyond the paper phase to experimental work that verifies that the concept works as expected on simulants. Components of the technology are validated, but there is no attempt to integrate the components into a complete system. Modelling and simulation may be used to complement physical experiments.	Supporting information includes results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems.
Technology developme nt	TRL 4: Component and/or system validation in laboratory environment	The basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of ad hoc hardware in a laboratory and testing with a range of simulants and small scale tests on actual waste. TRL 4 is the first step in determining whether the individual components will work together as a system. The laboratory system may be a mix of on hand equipment and a few special purpose components that may require special handling, calibration, or alignment to get them to function.	Results of the integrated experiments, and estimates of how the experimental components and experimental test results differ from the expected system performance goals.
	TRL 5 - Laboratory-scale, similar system validation in	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in	Results from the laboratory scale testing, analysis of the

Stage	TRL and definition	Description	Supporting information
	relevant environment	almost all respects. Examples include testing a high-fidelity, laboratory- scale system in a simulated environment with a range of simulants and actual waste. The major difference between TRL 4 and TRL 5 is the increase in the fidelity of the system and environment to the actual application. The system tested is almost prototypical.	differences between the laboratory and eventual operating system/ environment, and analysis of what the experimental results mean for the eventual operating system/ environment.
Technology demonstration	TRL 6: Engineering/ pilot-scale, similar (prototypical) system validation in relevant environment	Engineering-scale models or prototypes are tested in a relevant environment. Examples include testing an engineering scale prototypical system with a range of simulants. True engineering development of the technology as an operational system begins. The major difference between TRL 5 and TRL 6 is the step up from laboratory scale to engineering scale and the determination of scaling factors that will enable design of the operating system. The prototype should be capable of performing all the functions that will be required of the operational system. The operating environment for testing should closely represent the actual operating environment.	Results from the engineering scale testing and analysis of the differences between the engineering scale, prototypical system/environment, and analysis of what the experimental results mean for the eventual operating system/ environment.
System commissioning	TRL 7: Full-scale, similar (prototypical) system demonstrated in relevant environment	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning. Final design is virtually complete.	Results from the full-scale testing; analysis of the differences between the test environment; and analysis of what the experimental results mean for the eventual operating system/ environment.
	TRL 8: Actual system completed and qualified through test and demonstration	The technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of development. Examples include developmental testing and evaluation of the system with actual waste in hot commissioning.	Results of testing the system in its final configuration under the expected range of real world environmental conditions. Assessment of whether it will meet its operational requirements. What problems were encountered? What are/were the plans, options or actions to resolve problems before finalising the design?
System operations	TRL 9: Actual system operated over the full range of expected conditions	The technology is in its final form and operated under the full range of operating mission conditions. Examples include using the actual system with the full range of wastes in hot operations.	Operational test and evaluation reports.

Appendix 2: Information required for an air impact assessment of an EfW project

In order to assess the impact from the proposed EfW facility the following information must be provided:

- The accurate description of the activities carried out on the site and the surrounding environment.
- Process flow diagram clearly showing all unit operations to be carried out on the premises, detailed discussion of combustion/incineration technology and lists of all process inputs and outputs.
- Describe the pollution control equipment and pollution control techniques employed on the premises and the features of the proposal designed to suppress or minimise emissions, including dusts and odours.
- Describe the backup measures to be incorporated that will act in the event of failure of primary measures to minimise the likelihood of plant upsets and adverse air impacts.
- Provide air emission inventory of the proposed facility for all potential point, area and volume sources including fugitive emissions of dusts and odours. Provide a complete list of emissions to the atmosphere including SOx, NOx, VOC, CO, CO2, particulates, PM10, PM2.5, heavy/trace metals, hydrogen chloride (HCl), hydrogen fluoride (HF), and toxic/hazardous substances such as polycyclic Aromatic Hydrocarbons (PAH) and dioxin and furan.
- For point sources, present the flue gas concentrations at standard temperature and pressure and relevant oxygen reference level. Also, provide the mass emission rate and the flue gas temperature, exit velocity and volume flow rate and stack height.
- Estimation of emission rates should be based on actual measurements on samples taken from similar facilities, either full-scale facilities operating elsewhere, or experimental or demonstration-scale facilities (see section 2.2 of this guideline). Where this is not possible, use published emission factors and/or data supplied by manufacturers of process and control equipment.
- The proposed level of emissions must be compared with the best practice national and international source emission standards such as:
  - NSW Protection of the Environment Operations (Clean Air) Regulation 2010: http://www.legislation.nsw.gov.au/sessionalview/sessional/sr/2010-428.pdf.
  - European Commission Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010, on industrial emissions (integrated pollution prevention and control).
  - European Commission's Best Available Techniques Reference Documents (BREFs) that provide guidance on best available techniques for a range of industrial processes regulated by the Industrial Emissions Directive 2010/75/EU. The BREFs are available from the European Commission's website at: https://eippcb.jrc.ec.europa.eu/reference/.
- Describe the nearby sensitive receptors and provide locations of these sensitive receptors on a map and in a table.
- Discuss how the site specific meteorological data is prepared for the dispersion modelling. Provide Windrose diagrams indicating the prevailing wind direction and speed at the proposed site.
- Undertake an impact assessment with relevant inputs of emissions and local meteorology to an air dispersion model to provide estimates of the likely impacts on the surrounding environment. The model inputs should be as detailed as possible, reflecting any variation of emissions with time and including at least a full year of representative hourly meteorological data. The model input parameters must be based on the actual stack conditions for the licence.

- Estimate ground level concentration (GLC) at the nearest sensitive receptor(s) based on 1-hour average for the maximum or 100 percentile values. Results of the dispersion modelling must be presented as concentration contour plots and concentrations at the sensitive receptors. The predicted GLC should be made for both normal and expected maximum emission conditions and the worst-case meteorological conditions should be identified. Ground level predictions should be made at any residential, industrial and agricultural developments believed to be sensitive to the effects of predicted emissions. The techniques used to obtain the predictions should be referenced, and key assumptions and data sets explained. The limitations and accuracy of the atmospheric dispersion models should be discussed.
- Describe the background ambient air concentration from the existing sources in the airshed and evaluate the cumulative impact on the receiving environment. Address both acute and cumulative impacts by considering the project in conjunction with existing and known future emission sources within the region.
- The assessment of proposed levels of emissions of dust, fumes and odours should include emissions during both normal and upset conditions. Consideration should be given to the range of potential upset condition scenarios and the air emissions that may be generated as a result.
- Where odour is an issue, conduct odour impact assessment using the criteria described in the Queensland Guideline of "Odour Impact Assessment from Developments". The guideline sets out various approaches to assess potential impacts from developments proposals. Guidance provides the use of air dispersion modelling as a tool to predict ground level odour concentrations and comparison must be made with guideline values to determine the likelihood of adverse odour impacts.
- Where a number of toxic and carcinogenic air pollutants are emitted, assess the potential cumulative health impacts of emissions holistically rather than only for individual contaminants—for example, assess whether two or more contaminants that have a similar toxic effect on organisms would synergistically impact on the health of the organisms even though their individual amounts might be below objectives. The risk and hazard index criteria as specified in the NSW EPA "Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, must be used for this assessment. https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/approved-methods-for-modelling-and-assessment-of-air-pollutants-in-nsw-160666.pdf?la=en&hash=D4131297808565F94E13B186D8C70E7BD02B4C3D
- Modelled air quality concentrations at the "most exposed existing or likely future off-site sensitive receptors" must be compared with the appropriate national and international ambient air quality standards including *Environmental Protection (Air) Policy 2019* and *National Environmental Protection Measure (NEPM) Air*.
- Select air dispersion model based on the industry best practice and it should be appropriate for the local topographical and meteorological conditions. Please note AUSPLUME model which was a Victorian EPA regulatory model has been withdrawn by the Vic EPA in 2014. This model was replaced by a US EPA regulatory model known as AERMOD. DES also encouraging the industry to use CALPUFF or AERMOD model and does not support the use of AUSPLUME model in Queensland.
- Air dispersion modelling shall be undertaken in accordance with NSW EPA *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*. For CALPUFF modelling, consider the guidance provided in the NSW guideline entitled: "Generic Guidance and Optimum Model Setting for the CALPUFF Modelling System…": http://www.epa.nsw.gov.au/resources/air/CALPUFFModelGuidance.pdf.
- A summary of the model's input data file must be provided with the report.

- Discuss the regular Isokinetic (grab) stack monitoring program and the Continuous Emissions Monitoring System (CEMS) that would be implemented to monitor key emissions including particulates, carbon monoxide, sulphur dioxide, nitrogen oxides, and volatile organic compounds, hydrogen chloride, hydrogen fluoride, cadmium, thalium, mercury, antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, vanadium, dioxins and furans.

Appendix 3: Derivation of the R1 climate correction factor for Queensland

Overview

Outcome 6 of the Queensland Energy from Waste (EfW) Policy is for a proposed thermal EfW facility to meet a stipulated energy recovery efficiency threshold, determined using the R1 Energy Efficiency Formula (R1 formula) and the procedures set out in the European Union (EU) Waste Framework Directive[33] (WFD). This requirement applies only to combustion EfW (incineration) and excludes pyrolysis, gasification, and other advanced thermal EfW processes.

The EfW Policy further stipulates that correction factors will be developed (through a guideline) to take into account Queensland's climate and different facility sizes, which can impact the energy recovery efficiencies of thermal EfW facilities. The Queensland R1 formula is therefore to be calculated as follows:

$$\text{Energy Efficiency (R1)} = \frac{E_p - (E_f + E_i)}{0.97 \times (E_w + E_f)} \times \text{CCF}$$

where:

- E_p means annual energy produced as heat or electricity. It is calculated with energy in the form of electricity multiplied by 2.6; and heat produced for commercial use multiplied by 1.1 (gigajoules/year)
- E_f means annual energy input to the system from fuels contributing to the production of steam (gigajoules /year)
- E_w means annual net calorific value of the waste (gigajoules /year)
- E_i means annual energy imported excluding E_w and E_f (gigajoules /year)
- 0.97 is a factor accounting for energy losses due to bottom ash and radiation
- CCF means a climate correction factor

Proposed EfW facilities in Qld are expected to meet the stipulated minimum R1 threshold of 0.65, while facilities in operation when the EfW Policy should move towards achieving 0.60 within five years.

The R1 formula considers the EfW plant's effectiveness in recovering the energy embodied in the waste feedstock, as well as the effective uses of the recovered energy as electricity, heating, cooling or steam. The R1 formula therefore promotes the efficient use of energy recovered from waste materials.

Article 38.1 of the WFD enables the R1 formula to be adjusted for local climatic conditions insofar as they influence the amounts of energy that can technically be used or produced in the form of electricity, heating, cooling or processing steam. This consideration is based on technical evidence that warmer climates have a negative effect on the efficiency of electricity production. When it is also considered that facilities in warmer climates tend to favour electricity production over heat production, due to the lower demand or use for heat, then EfW facilities that produce electricity in a warmer climate face an energy recovery disadvantage compared to EfW facilities that produce heat.

The CCF will help to maintain a level playing field by compensating for situations where heating demand is low, and where there are no, or very limited, opportunities to use industrial heat.

This Appendix sets out the derivation of a CCF for Queensland using the method specified in the WFD.

[33] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, as amended by European Commission Directive 2015/1127 of 10 July 2015. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588632849355&uri=CELEX:02008L0098-20180705.

Methodology

Annex II of the WFD sets out the method for determining the CCF. The method is based on a Heating Degree Day (HDD) parameter determined at the plant's location, and the date the plant was permitted (Table 7). The CCFs which came into effect for facilities permitted after 31 August 2015 (last column of Table 7) have been applied to determine the CCFs for Queensland.

HDD is a measure of the energy input required to maintain a building at a comfortable (or base) temperature. It represents the number of degrees that the day's outdoor mean temperature (T_{MEAN}) is less than the base temperature (15°C in the WFD). If T_{MEAN} drops below the base temperature, then heating is required.

In Table 7, lower HDD values are indicative of warmer climates, and result in a higher CCF, which provides a greater level of compensation for the lower heat demand and fewer opportunities to reuse heat in warmer climates.

Table 7: Climate Correction Factors (CCFs) as set out in the Waste Framework Directive

Average annual Heating Degree Days for previous 20 years (HDD_{20})	CCF for facilities permitted before 1 Sep 2015	CCF for facilities permitted after 31 Aug 2015 (see Note)
$HDD_{20} \geq 3350$	1	1
$2150 < HDD_{20} < 3350$	$\left(\frac{0.25}{1200} \times HDD_{20}\right) + 1.698$	$\left(\frac{0.12}{1200} \times HDD_{20}\right) + 1.335$
$HDD_{20} \leq 2150$	1.250	1.12

Note: The CCFs in this column only have been applied to determine the CCFs for Queensland.

The CCF is determined using the annual HDDs averaged over the previous 20 years (HDD_{20}, Table 8), noting that:

- the annual HDD is the sum of the daily HDD over the year
- the daily HDD is calculated as shown in Table 8, where T_{MEAN} is the average of the minimum and maximum temperatures for the day.

Table 8: Value for daily HDD based on mean outdoor temperature (T_{MEAN})

Average outdoor temperature (T_{MEAN})	Daily HDD
T_{MEAN} >15°C	0
$T_{MEAN} \leq$ 15°C	18°C - T_{MEAN}

To determine where Queensland sits in Table 7, the HDD_{20} for Queensland's coldest location was determined. Climate summaries for Queensland, published by the Bureau of Meteorology[34] (BOM), indicate that the lowest annual mean temperatures routinely occur in the Darling Downs Region of Qld, specifically in Applethorpe and Stanthorpe, which are roughly 6km apart. The BOM's temperature dataset for the previous 20 years (2000–2019) is more complete for Applethorpe than for Stanthorpe[35], therefore Applethorpe was selected for this calculation.

The daily minimum and maximum temperature for Applethorpe (Bureau Station number 041175) between 2000 and 2019 were obtained from the BOM's Climate Data Online website.[36] This data was used to determine the daily T_{MEAN}, daily HDD, and annual HDD according to the procedures described above. Where the BOM dataset

[34] http://www.bom.gov.au/climate/current/statement_archives.shtml?region=qld&period=annual
[35] No temperature data is available for Stanthorpe between 2000 and 2004.
[36] http://www.bom.gov.au/climate/data/index.shtml

lacked values for the day's minimum or maximum temperature (e.g. due to equipment malfunction), the previous day's value was used.

The resulting annual HDDs, and the HDD_{20} are summarised in Table 9. The HDD_{20} for Applethorpe is approximately 1,300—well below the lowest HDD_{20} threshold of 2,150 in Table 7. This means that the R1 CCF for a proposed EfW facility in Applethorpe would be 1.12.

As Applethorpe is routinely one of the coldest places in Queensland, no other location in Queensland is likely to reach temperatures low enough to result in an HDD_{20} greater 1,300. Locations that are warmer than Applethorpe will generate an HDD_{20} that is less than 1,300. This means that all of Queensland sits below the lowest HDD_{20} threshold ($HDD_{20} \leq 2150$) shown in Table 7, and the corresponding CCF of 1.12 can be applied to Queensland.

Table 9: Annual HDD (2000–2019) for Applethorpe, Qld (Bureau Station number 041175)

Year	Annual HDD	Number of missing temperature values estimated (see note)
2000	1,400	16
2001	1,403	10
2002	1,295	3
2003	1,435	7
2004	1,385	4
2005	1,228	10
2006	1,356	10
2007	1,247	0
2008	1,391	5
2009	1,212	5
2010	1,301	3
2011	1,475	1
2012	1,364	0
2013	1,162	1
2014	1,232	1
2015	1,286	1
2016	1,187	1
2017	1,240	1
2018	1,235	2
2019	1,145	8
HDD_{20}	**1,299**	**-**

Note: Any missing data points for BOM's daily minimum or maximum temperature were estimated as the previous day's value.

Disclaimer

While this document has been prepared with care it contains general information and does not profess to offer legal, professional or commercial advice. The Queensland Government accepts no liability for any external decisions or actions taken on the basis of this document. Persons external to the Department of Environment and Science should satisfy themselves independently and by consulting their own professional advisors before embarking on any proposed course of action.

Approved:
2 December 2021

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Version history

Version	Date	Description of changes
1.0	2 December 2021	First publication. This is a new guideline to assist proponents of energy from waste (EfW) facilities to align with Queensland's EfW Policy. It outlines the information applicants should provide to the Department of Environment and Science (DES) with an application for an environmental authority to conduct an EfW activity.