

Waste To Energy Incineration – Parliamentary Inquiry Submission

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Units of Measurement Acronyms

- μg – Microgram
 - 1 millionth of a gram
- Nm^3 - Normal Cubic Metre
 - Used for measuring the volume of gas under standardised normal conditions
- mL – Millilitre
- ng – Nanogram
 - 1 billionth of a gram
- mg – Milligram
 - 1 thousandth of a gram
- m^3 - Cubic metres
- ppm – Parts per million
 - Used for measuring very small concentrations of substances in water or air
 - For water solutions, 1 ppm is the same as 1 milligram per litre (mg/L)
- ppb – Parts per billion
- pg/kg – Picograms per Kilogram
 - Used to measure the concentration of dioxins
- TEQ – Toxic Equivalency Factor
 - Not direct measurements
 - Are calculated values representing the total toxicity of a mixture of compounds, related to dioxins, furans etc
 - Really depends on which World Health Organisation framework used and whether it is specified in environmental protection legislation which is to be used as the results can vary between older and newer versions

Summary

This document seeks to explore and bring together the scientific, medical and government literature on Waste to Energy Incineration facilities and the emissions associated with its operation, for the assessment of its potential long term impacts on environmental and human health.

The Inquiry, terms of reference, criteria that are addressed in this document is as follows:

- The Suitability of Existing Waste to Energy (WtE) Infrastructure Plans and Policies, including:
 - The impact of WtE projects on residential communities and transport infrastructure
- The impact of WtE, including from
 - Separating recycling and organic material from WtE Streams
 - Nature and management of emissions waste and ash byproducts
- Alternative waste management approaches and emerging technologies that also align with circular economy principles, having regard to the recommendations of the Environment and Planning Committee's 2020 Inquiry into recycling and waste management and the role of WtE in the Victorian Government's circular economy plan, including Victoria's landfill management, capacity and strategy
- Any other related matters

The document aims to provide decision makers with a deduced assessment relating to Waste to Energy Incineration:

- Air Purification and Filtration systems
- The Emissions that are released, after all attempts at purification and filtration
- What the potential impacts of those emissions are on environmental and human health
- Whether there are suitable alternatives that support a circular economy

Though Waste to Energy Incineration is widely accepted as being the best available alternative to landfill with little risk to human and environmental health, the emerging evidence contained within this document can be deductively reasoned and appears to strongly suggest this may not be the case.

While Waste to Energy Incineration is better than landfill and there is no question there, there is reasonable doubt as to Waste to Energy Incineration businesses claims as to its safety for the surrounding environment and human population health.

The evidence, however, has not been proven conclusively, one way or the other, which leads this writer to wonder how can Waste to Energy businesses claim that it is safe when the evidence has not been proven conclusively?

There are multiple academic and scientific references in this document that suggest that the long term negative impacts of Waste to Energy Incineration are yet to be fully realised, as it simply has not been long enough for the trace elements of the toxic substances, chemicals and particulates to have caused large enough health problems (environmental or human) for studies

to have detected them; also that there are serious variables that make empirically proving this extremely difficult. [See here.](#)

Air Purification and Filtration Technology

The emerging evidence and literature from both science and industry showcases and indicates the incredible ability of modern Waste to Energy Air Purification and Filtration systems, however, in all of that documentation, there was no claim of 100% elimination and the deductive reasoning in this case suggests that there are emissions that escape all attempts to contain them; this is also supported by recent studies in Europe.

If the Air Purification and Filtration systems remove 99% of emissions, then the 1% leaves the stack and the question is, what is in that 1%?

The Emissions

The 1% of emissions greatly varies each day, depending what is being incinerated and in what quantities on a given day, though it can be made up of one or many of the following:

- Mercury
- Cadmium
- PM 2.5
- Carbon Dioxide
- Carbon Monoxide
- Nitrogen Oxide
- Sulfur Oxides
- Ammonia
- Hydrogen Chloride
- Hydrogen Fluoride
- Volatile Organic Compounds
- Dioxins and Furans

These are considered to be released at almost, near, insignificant quantities, however this is not zero and in conversation should not be minimised, as many of these substances, chemicals and particulates that are emitted from Waste to Energy Incineration facilities:

- Do not break down
- Take time to break down, increasing the chances of exposure the longer they're in the air or
- Transform by reacting with other atmospheric elements (or water) into more toxic substances

The Air Purification and Filtration systems and their associated efficiency percentages are based on optimal performance.

It stands to reason that if there were a problem with filtration, some of the limitations in the Air Purification and Filtration systems were at play or the previously mentioned Air Filtration, Purification and Monitoring systems were not maintained properly, the efficiency would reduce.

That reduction would increase the overall emissions and over time contribute to the build up of these particulates and substances in the surrounding environment; increasing the risk of contact and exposure over time.

Environmental and Human Health Impacts

There appears to be a discernible relationship, we can establish through deductive reasoning, between a build up of these substances, chemicals and particulates that can build to unsafe levels, as proven in recent studies, in areas surrounding Waste to Energy Incinerators and the impact of those substances, chemicals and particulates listed in the Human Health Impact section of this document.

There are multiple examples, in this document, of breaches of air quality and environmental safety standards by Waste to Energy Incinerators around the world; it's not the businesses who suffer the consequences of their breach, it's the flora and fauna, the people in the surrounding communities that are placed in harm's way.

The potential impacts of chronic exposure, a build up of these toxic trace substances, chemicals and particulates emitted from Waste to Energy Incineration facilities are listed in the sections below in detail. Suffice to say, exposure to these substances, chemicals and particulates over 20-30 years (the rough duration of standard Waste to Energy Incineration facilities contracts) has the potential to lower quality of life significantly, with consequences ranging from moderate to severe (see Human Health Impact section for definitions of moderate and severe).

[Human Health Impacts](#)

[Environmental Health Impacts](#)

There is no or should be no consideration greater than the safety and health of people and the environment in which they live and share with unique to the region flora and fauna.

We took 30 years to understand the dangers of PFAS, Asbestos, Lead and dioxins (just to name a few), we cannot spend another 30 years to find out all of the different combinations of dangerous substances that occur in an Waste to Energy incinerator.

Since we don't know what the dangers are, we cannot do anything but apply the principle of caution so as to provide time for incinerator companies and impartial researchers to provide a peer reviewed case to prove that all of the possible dangerous substances can be contained.

Until then it would be irresponsible to just take on faith that incinerators are not harmful, simply because they've been around a little while, when there is emerging and increasing evidence to the contrary.

The words acceptable limits should never be uttered when the cost is human health. Limits that are measured only from the direct output of the stack and not the extremely difficult and tedious task of measuring the surrounding environment, within a 10km radius of an Waste to Energy incinerator (This is due to the fact that wind gusts can carry these emissions further than the standard 5km radius (generally accepted radius however would be likely to have been measured with light winds) and water sources can carry these emissions further than that).

A zero tolerance approach to emissions of substances that impact human health should always be the first priority of any elected official.

Alternatives and circular economy

There are alternatives that Waste to Energy Incineration businesses could participate in and perhaps save money they would have spent building these facilities.

It should be noted that common solutions such as melting the plastics to make RESIN8 for concrete and asphalt, creating other construction materials such as fencing, piping etc or converting the plastics to oil and chemicals, via pyrolysis, to be reused are energy intensive and produce harmful chemicals, substances and particulates, many of those already covered in the Emissions section; so, what is the alternative?

A full list of the alternatives is available in this [section](#).

A combination of:

- Waste reduction strategies being employed by other nations
- Suggestions made in this document as to modifications to government policies to support waste reduction and elimination and
- The use of emerging science to manage, reduce and begin to eliminate the existing plastic waste presents a more health and environmentally friendly alternative to Waste to Energy Incineration, as well as supporting a true circular economy, rather than, what this writer defines Waste to Energy Incineration as, a buy and burn economy.

Evidence from the international community and in particular Denmark and Sweden, show that where Waste to Energy Incinerators is part of the waste management strategy, recycling and circular economy efforts are reduced.

This document also contains a proposal for establishing a link between households, businesses to industry led recycling and initiatives already in place; the full proposal can be found [here](#).

Final Thoughts

Current Environmental Protection Agency (EPA) mandates, legislation, powers and penalties are insufficient to hold Waste to Energy Incineration businesses to account, see [here](#) for further details.

The EPA could be given powers similar to those held and exercised by the Australian Securities and Investments Commission (ASIC) and revocation of licences should not be held as a last resort, even for minor breaches. If a strike system was implemented for minor breaches and an immediate suspension of licence for major breaches, then this would better protect the communities and environment.

Just because there is a standard does not mean the public is protected.

Unless it is enforced and monitored each and every day, by an impartial body, outside of the EPA and the business running the Waste to Energy facility, there is an unequal risk to the public vs the risk to the business breaking the emission control standards.

The business may lose their licence and worst or simply get a fine, the public may be exposed to substances that result in lifelong illnesses.

If you take energy out of the equation what you're left with is the fact an item was produced out of materials, minerals and other useful components and that item was purchased, used, discarded and burned, burning with it everything that was used to make it.

Just because the information, research or underlying data is incomplete and requires further investigation does not mean that there is no risk and further supports the reasoning that the precautionary principle should be the foremost consideration when considering these matters.

The onus can be on the Waste to Energy provider to support the research and prove beyond any doubt that the technology that is in place, the technology that is developed, prevents any harm to the environment and humans over the total contract and lifetime of the Incinerator facility.

It should be proven, beyond any reasonable doubt (which this document presents reasonable doubt), that the emissions that are released are not harmful to the environment or humans over the lifetime and total contract of the incinerator facility.

To say that Waste to Energy Incineration will not cause harm over the facility's lifetime (contracted or otherwise) when the scientific data is inconclusive either way is a reckless disregard for the "precautionary principle" and for the safety of the communities and surrounding environment where the facility will be placed.

In the face of this uncertainty, the substantial risks to the environment and human health shouldn't we be cautious?

New South Wales and the Australian Capital Territory have already banned this technology due to a similar dilemma, among other concerns; can Victoria really do any less?

Will we really abandon the precautionary principle and abandon all those people who will suffer the consequences if the decision to go ahead is wrong; are we really going to roll the dice on the quality of life of so many families?

About the Writer:

What can I say, I'm a Dad of 2, an avid reader and simply a believer in doing things right the first time, rather than waiting for the consequences of poorly thought out decisions.

Introduction

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 - Separating recycling and organic material from WtE Streams
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- Alternative waste management approaches and emerging technologies that also align with circular economy principles, having regard to the recommendations of the Environment and Planning Committee's 2020 Inquiry into recycling and waste management and the role of WtE in the Victorian Government's circular economy plan, including Victoria's landfill management, capacity and strategy
 - Known hereafter as Criteria 3
- Any other related matters
 - Known hereafter as Criteria 4

The document will provide literature with the aim of assisting decision makers with a deduced assessment of the following questions:

- How effective are the current filtration and air purification systems?
 - Waste to Energy (WtE) Incineration facilities filtration and air purification technology and its overall efficiency
- What is the typical amount of emissions these facilities produce (according to the provided references), however small?
 - What the risks of the emissions they do emit are
- What are the potential impacts of these emissions on environmental and human health?
 - What the potential impacts to human health, environment and commerce of those emissions are
- Are there suitable alternatives that will support a circular economy?
 - Alternatives to WtE that have been implemented elsewhere in the world, as well as new technologies that have a high potential to provide the commercial

benefits WtE sought to achieve

- Should waste to energy incineration facilities be considered as a waste disposal option if there is a risk to human or environmental health?

Since the literature and associated facts for environmental health continuously suggest strong links that environmental health is so entwined with human health, this writer offers the notion that when environmental health is harmed (however small) that has a flow on effect to human health.

This is not an argument in support of Landfill, quite the opposite. I sincerely and wholeheartedly agree that landfill is not the answer either. However, since the consistent argument for these Waste to Energy Incinerators is “they’re better than landfill” it would be prudent to note some key and simple facts about WtE facilities and landfill.

- Landfill does not initially produce heavy metals or dioxins into the air (this happens when they are burned or exposed to extreme heat due to Volatilization)
- Landfill can result in those toxic compounds being released in liquid form, in the form of leachate and through evaporation these chemicals, substances and particulates can be released into the air
- Landfill does produce high levels of the greenhouse gas methane, which is a threat to the environment and human health in high enough concentrations
- WtE facilities do initially and throughout their lifetime (contract or otherwise) produce heavy metals, dioxins and other harmful substances, chemicals and particulates into the air
 - These are a threat to human health if not managed to a strict control, each and every day, there can be no mistakes when the cost of the mistake is release of these substances, uncontrolled, into communities, where there is an ever increasing risk to community health the longer the problem goes on before being corrected. This is not and should never be acceptable.

WtE Incineration Designs – Criteria 2

Waste Incineration technology has come a long way since the previous generation. By the early 2000's countries around the world were or had adopted Air Quality standards, which prompted an evolution of Incineration technology. Today multi-staged air purification and filtration technologies can generally remove 99% of toxic emissions.

Modern Waste to Energy Incineration facilities (facilities built under stricter guidelines post 2006) typically utilise differing variations of these air purification and filtration technologies depending on the facility's requirements, though in some cases appear to use a handful of these technologies and not all of them.

Based on the evidence presented in the reviewed and listed references, the following information in this section and the following sections, represents typical, standard, Waste to Energy Incinerator Air Purification and Filtration Systems, the Emissions that are not removed or filtered and the impact of those emissions on Environmental and Human health.

Air Purification and Filtration Technology Sub-Section

In the sub-section below each of the air purification and filtration technologies, their benefits and limitations will be listed in bullet point form.

Bag House Filters

- A fabric filter bag used to capture the particles as they flow through
- Achieves a 99.95% reduction in PM's (atmospheric aerosols) particulate matter flowing through to the stack when operating under optimal conditions
- Filters over 95% of particles as small as 0.08 µm when operating under optimal conditions
- Typically, only operate below 350 degrees Celsius
- Not typically suitable for high moisture flue gases
 - Moisture content will cause the filters to clog more easily
 - Initial moisture content of flue gases greatly depends on the initial waste content
 - Higher moisture content greatly reduces the incineration efficiency and the filters efficiency to the point it can lead to filter failure with holes developing
- Requires regular filter maintenance to prevent build up, which reduces the filtration capability
 - If the filter builds up sufficiently the effectiveness of its filtration is greatly reduced
 - SO₃ (sulphur trioxide), S (Sulphur) and NH₃ (Ammonia) are commonly used as neutralisation chemicals (conditioning chemicals), activated carbon is also used
 - Used to increase particulate cohesiveness (improving how the waste matter clumps together in the bag filter), however they produce their own byproduct gases
- References:
 - <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/electrostatic-precipitator>

- <https://www.sciencedirect.com/topics/engineering/baghouse-filter>

Electrostatic Precipitators

- Separated into two categories
- Dry Electrostatic Precipitators (Dry ESP) and Wet Electrostatic Precipitators (Wet ESP)
 - Dry ESP
 - Can achieve 99% collection efficiency for particles 1 to 10 μm in size
 - Cannot remove toxic gases and vapours that are in those states at 204.4 degrees Celsius
 - Cannot collect small fly ash particles
 - Cannot handle moist or sticky particulate matter
 - Relies on mechanical collection methods to clean the plates that require maintenance and periodic shutdowns
 - Wet ESP
 - Used to control acid mists submicron particulates as small as 0.01 μm with 99.9% removal
 - Used to control and remove:
 - Mercury
 - Metals
 - Dioxins/furans
 - Not efficient at removing Sulfur Dioxide (SO_2) and Nitrogen Dioxide (NO_x) gases
 - High concentrations of SO_2 can lead to increased aerosol formation within the Wet ESP, reducing the overall collection efficiency
 - Evenness of the water film on the collection plates is essential to Wet ESP
 - Could result in poor cleaning and unnecessary water wastage
 - High concentrations of fine particles such as PM 2.5 may require more frequent cleaning, increasing water usage
 - The temperature and humidity of the gas stream will also significantly impact the amount of water required for proper saturation in order to operate efficiently
 - Water Usage can be broken down by three types:
 - Water saving spray ESPs, with a ratio of 0.023L per 1 kg of gas
 - Charged Droplet Electrostatic Scrubbers, with a ratio of 1.15L per 1 kg of gas
 - Electrostatic Nozzle Scrubbers, with a ratio of 1.45L per 1 kg of gas
 - Three variations in the conductive surfaces are available:
 - Stainless steel (SS)

- Ascending voltage can increase ozone concentrations
 - The stronger the current the more free electrons produced higher ozone concentrations
 - Susceptible to corrosion under long term operation
 - Original Glass
 - Low conductivity and therefore lower ozone production
 - Requires Wet ESP operation in order to function and achieve a 98% removal of toxic substances, without which they are susceptible to build up, significantly reducing their efficiency
 - Conductive Glass
 - Ascending voltage can increase ozone concentrations
 - The stronger the current the more free electrons produced higher ozone concentrations
- References:
 - [https://www.ldxsolutions.com/solutions/particular-matter-collection/wet-esp/#:~:text=A%20wet%20electrostatic%20precipitator%20\(wet%20ESP\)%20or,particles%20and%20droplets%20onto%20a%20collection%20surface](https://www.ldxsolutions.com/solutions/particular-matter-collection/wet-esp/#:~:text=A%20wet%20electrostatic%20precipitator%20(wet%20ESP)%20or,particles%20and%20droplets%20onto%20a%20collection%20surface)
 - <https://www.sciencedirect.com/science/article/pii/S2352484719303208>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0306261909000907>
 - <https://www.sciencedirect.com/science/article/abs/pii/S2213138821004616#:~:text=Factors%20affecting%20the%20removal%20efficiency%20of%20wet,of%20NO%20=%20400%20mg/m%20Operating%20parameters>
 - <https://aaqr.org/articles/aaqr-22-03-0a-0133>
 - https://en.wikipedia.org/wiki/Electrostatic_precipitator#Wet_electrostatic_precipitator
 - <https://www.electrical4u.com/advantages-and-disadvantages-of-electrostatic-precipitator/>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0378382003002686>
 - <https://www.sciencedirect.com/science/article/abs/pii/S1750583615300189>

Air Scrubbers

- Separated into two categories:
 - Dry Air Scrubbers
 - Designed to capture:
 - Dioxins
 - Acid gases such as Hydrochloric acid, hydrogen fluoride, chlorine gases and sulphur dioxide
 - Volatile Organic Compounds
 - Captured through a combination of:
 - Activated Carbon
 - Zeolites
 - Powdered Alkaline materials
 - HEPA Filters
 - 95% efficient at capturing sulfur dioxide (SO₂)
 - Limitations include:
 - Less efficient at removal of gases than wet scrubbers
 - Produces dust waste
 - Wet Air Scrubbers
 - Designed to capture:
 - Dioxins
 - Acid gases such as Hydrochloric acid, hydrogen fluoride, chlorine gases and sulphur dioxide
 - Volatile Organic Compounds
 - Uses hundreds of litres of water, per day, which is largely recycled water, to form liquid droplets of these harmful substances within a chamber containing the pollutants through impaction, diffusion, interception and chemical absorption, separating them from the rest of the flue gas
 - Has the potential for 95% to 99% efficiency of removing particulate matter, such as SO₂, depending on the scrubber design and the types of pollutants
 - Limitations include:
 - Significant water consumption (over the long term operation of the Waste to Energy Incineration facility, as the water does need to eventually cannot be recycled any further and must be disposed of)
 - Clogging due to fibrous particulate matter causing blockages
 - High pressure drops, requiring significant fan power and electricity usage
 - Generates wastewater and sludge that requires proper disposal
 - Loss of plume buoyancy
 - Can impact ground level concentrations of pollutants
 - Not an effective method at removing some Volatile Organic Compounds such as:

- <https://www.machengineering.com/blog/8-factors-that-affect-wet-scrubber-performance/>
- <https://www.machengineering.com/blog/the-major-types-of-industrial-scrubbers/>
- <https://joaairsolutions.com/systems/wet-scrubber/>
- <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/wet-scrubber>
- <https://www.sciencedirect.com/science/article/abs/pii/S0301479721024889>
- [https://www.sciencedirect.com/science/article/abs/pii/S004565351930606X#:~:text=However%2C%20it%20\(%20The%20UV/Fenton%20process%20\),case%2C%20VOCs%20mass%2Dtransfer%20enhancement%20should%20be%20respected](https://www.sciencedirect.com/science/article/abs/pii/S004565351930606X#:~:text=However%2C%20it%20(%20The%20UV/Fenton%20process%20),case%2C%20VOCs%20mass%2Dtransfer%20enhancement%20should%20be%20respected)
- <https://envigaard.com/wet-scrubber-system-manufacturer/#:~:text=Custom%20Wet%20Scrubber%20Solutions%20Industry%2DSpecific%20Design:%20Tailored,removal%20while%20minimizing%20energy%20and%20resource%20consumption>

Selective Catalytic Reduction (SCR)

- SCR can remove 70-90% and sometimes up to 98% of Nitrogen Oxides from the flue gas
 - Achieves 98% in systems using less ammonia slip (ensuring efficient use of the ammonia)
- Where as Selective Non-Catalyst Reduction can reduce Nitrogen Oxides from the flue gas by 30% - 70%, with some systems achieving 80% under optimal conditions
 - This is highly dependent on the flue gas temperatures, mixing and reagent to Nitrogen Oxides ratio
 - Temperature works between 850°C and 1100°C depending on the reagent used
 - Typically, the reagent will be ammonia or urea
 - The time the reagent spends in contact with the flue gas is also critical to efficiency
 - This method can increase the risk of ammonia slip, which can contribute to corrosion and air quality problems
- References:
 - <https://www.nature.com/articles/s41598-024-69019-w#:~:text=SCR%2C%20on%20the%20other%20hand%2C%20uses%20a,achieving%20higher%20NOx%20reduction%20efficiencies%20of%2070%E2%80%9390%25>
 - <https://www.yara.com/industrial-nitrogen/exhaust-gas-treatment-for-industrial-plants/scr-gas-exhaust-treatment/#:~:text=SCR%20system%20has%20the%20highest,C%20and%20450%20%C2%B0C>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0959652615011592>

- <https://www.krajete.com/scr-vs-sncr-and-nox-reduction-alternatives/>
- <https://www.sciencedirect.com/topics/engineering/selective-non-catalytic-reduction>
- <https://www.lechlerusa.com/en/blog/sncr-process#:~:text=The%20main%20advantage%20is%20that,and%20replacement%20of%20this%20equipment>
- <https://www.techcem.net/sncr-vs-scr-choosing-the-right-nox-reduction-technology/>
- <https://www.aidic.it/cet/17/56/320.pdf>

Plant Cooling

- Separated into two categories:
 - Wet Cooling
 - Uses significant amounts of water but keeps plant efficiency
 - With waste capacity and types of waste being burned on a given day this method of cooling has the potential to use hundreds of thousands of litres of water per day
 - Largely recycled water, however at some point that water will need to be disposed of and new water taken up
 - Dry Cooling
 - Uses significantly less water, however plant efficiency is reduced and its effectiveness is reduced in hotter climates
- References:
 - <https://www.sciencedirect.com/science/article/pii/S1364032119305994>
 - [https://www.sciencedirect.com/science/article/abs/pii/S0956053X15003554#:~:text=Waste%20incineration%20implies%20high%20water%20intakes%20mainly,an%20outstanding%20issue%20\(Ma%20et%20al.%20C%202014\)](https://www.sciencedirect.com/science/article/abs/pii/S0956053X15003554#:~:text=Waste%20incineration%20implies%20high%20water%20intakes%20mainly,an%20outstanding%20issue%20(Ma%20et%20al.%20C%202014))

Sorting

- Typically, this is not done before incineration in most Waste to Energy facilities, unless they are utilising Mechanical Biological Treatment (MBT) systems or Sorted Feedstock, prior to the waste entering the Incineration unit which at that point is known as Refuse Derived Fuel (RDF)
- These options often represent an important contribution to the Waste to Energy facility's resource recovery process and credits
- With the exception of the manual Initial Screening process, all other sorting options appear to be either after the incineration process or directly contributing towards the incineration process, rather than removing sources of harmful chemicals, substances and particulates
- There are options for sorting the waste such as:
 - Initial Screening
 - Also known as:
 - Waste Handling
 - Inspection
 - Manual Sorting

- Multi-Step Process, which appears to be visual inspection of the truck and removal of obvious open bags and non-permitted materials
 - This is a human driven, manual process, perhaps aided by camera and computer technology, in terms of weight and approved items, trucks (from specific councils, containing specific non approved materials, such as medical waste etc), however it is largely dependent on human accuracy
- Magnetic Separators
 - Such as Over-Band and Drum magnets
 - These will separate ferrous metals (like Iron) from the waste stream
 - These can, potentially, remove over 90% of the ferrous metals from the waste stream
 - Drum magnets can achieve efficiency of 95% - 99% typically in separating ferrous metals from the waste stream
 - It should be noted that Drum and Over-Band magnets are typically placed after the incineration process to recover metals from the bottom ash
- Eddy Current Separators
 - These will separate non-ferrous metals (like aluminium and copper) from the waste stream
 - These can achieve over 90% separation from the waste stream after proper treatment
 - May struggle with Stainless Steel, insulated wires or coated metals even after treatment
 - These items must be identified in the inspection phase or they risk being burned and their chemical elements made part of the flue gas
 - It should be noted that Eddy Current Separators are typically used after Magnetic Separators, after the incineration process to recover metals from the bottom ash
- Air Classifiers
 - Uses a column of air to separate lighter materials (paper and light plastic, such as loose plastic) from the waste stream
 - Its role is to not separate these materials from the those to be incinerated, but instead to identify them as a fuel source as part of the Mechanical Biological Treatment (MBT) process to create a more uniform fuel source, known as Refuse-Derived Fuel (RDF), subject to much controversy after the Basel Convention
 - Their role is to ensure that the combustion can be maintained at the required temperatures

- They will still allow the burning of the plastics and paper releasing their chemical, particulates and substance matter into the flue gas
- Mechanical Biological Treatment System (MBT) / Sorted Feedstock
 - Replaces direct incineration with a sorting process for the waste
 - The initial step uses machinery to separate waste streams being received by the Waste to Energy business, either directly at the Waste to Energy Incinerator site or at another location before transfer to the facility
 - This can include:
 - Shredding
 - Screening
 - Using mechanical screens or trommels to separate materials by size, smaller particles fall through the holes, while larger items continue on for further processing
 - Magnetic separation
 - Using Eddy Current Separators
 - Optical sorting
 - Using optical sensors to identify and sort materials based on their colour and type, separating plastics from other materials
 - Air Classifiers
 - Manual Sorting
 - To attempt to isolate recyclable materials such as metals and plastics
 - The next stage adjusts the size and composition of the waste
 - This may be subject to Biological Treatment, which includes:
 - Reduction in volume and moisture content
 - Anaerobic digestion
 - Composting
 - Biodrying
 - A process that uses aerobic microbes to heat and rapidly dry waste, creating a more combustible material
 - Limitations can include:
 - Increased complexity and energy consumption
 - Inefficient fuel generation
 - The biological stage can be inefficient in treating mixed municipal solid waste, especially with a high moisture content or limited microbial activity
 - This stage can also produce thick rejects (materials that will either be incinerated or will go to landfill) with high moisture content, which are not ideal for incineration

- The quality of the Refuse Derived Fuel (RDF, material that will be burned in the incinerator based on its caloric value) can vary significantly depending on the waste composition in the initial input and the overall efficiency of the MBT process, making it less predictable as a fuel source (increasing the risk that combustion may not reach adequate temperatures to destroy harmful substances, chemicals and particulates)
 - Reduced energy recovery
 - Increased rejects or compost before incineration means less material available for energy recovery, potentially lowering the overall yield compared to direct incineration
 - Increased capital and operational costs
 - Higher initial investment and ongoing operational costs
 - Management of residual waste
 - The biological stage can produce by products, such as compost and rejects that require further management and disposal, likely at landfill and these still may contain hazardous substances

Air Quality Monitoring Technology

- Options include:
 - Continuous Emission Monitoring Systems (CEMS)
 - Laser Gas Analysers
 - Multi-Gas Analysers
 - Volatile Organic Compound (VOC) sensors
- CEMS
 - Used to track the facility's compliance with emissions standards.
 - Analyse levels of the following in the flue gases:
 - Carbon Monoxide
 - Carbon Dioxide
 - Nitrogen Oxides
 - Sulfur Dioxide
 - Methane
 - Oxygen
 - Limitations can include:
 - Risks of sample contamination
 - Lubricating oil from sampling equipment or other pollutants can contaminate the sample
 - Condensation can also occur in the sample line, which impacts measurements
 - Leakage
 - Leaks in the sampling system can cause inaccurate readings

- Problems with calibration
- Problems with data quality
- Readings being impacted by extreme weather conditions
 - These can impact the lifespan of the equipment
 - Predominantly high temperatures, wind and rain will skew these readings
- Human Error
 - Can occur when interpreting the data, even with highly trained staff
 - Traditional systems may not be able to foresee future patterns
- Laser Gas Analysers
 - Used within the gas stream to monitor for Mercury
 - Limitations can include:
 - Many are designed to monitor for one or two gases at a time
 - Susceptible to physical obstructions like:
 - Dust
 - Steam
 - Fog
 - Sensitive to temperature, which can compromise performance
- Multi-Gas Analysers
 - Used to monitor for:
 - Nitrogen Oxides
 - Sulfur Dioxide
 - Carbon Monoxide
 - Carbon Dioxide
 - Ammonia
 - Hydrogen Sulphide
 - Total Organic Compounds
 - Oxygen
 - Hydrogen Chloride
 - Hydrogen Fluoride
 - Mercury
 - Limitations include:
 - Sensor drift due to environmental conditions
 - Such as temperature, pressure changes or interference from other gases
 - Limited measurement ranges
 - Some sensors have a small, linear, measurement range
- Volatile Organic Compound (VOC) sensors
 - Used to monitor for:
 - Benzene
 - Toluene
 - Formaldehyde
 - Odour contributing substances
 - Limitations can include:

- Lack of selectivity
 - Measures the total presence of volatile organic compounds, rather than individual gases
 - Unsuitable for compliance monitoring
 - Sensor drift
 - Interference
 - Sensors can be impacted by non VOC gases as well as temperature and humidity, which can compromise readings
 - Broad Range
 - Should not be used in safety critical applications, where precise and specific measurements are required
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Additional Notes

- The sensor and monitoring technology will be set to current EPA guidelines and if exceeded will shut down the combustion
- The plant will be capable of running continuously, using a redundancy system for the flue gas that when the first flow path (system) requires cleaning or maintenance, the second system will be enabled
 - Informed by High Quality staff at the Sunbury Show 2025

Emissions and Risks – Criteria 2

The safety control and multi-staged air purification technologies mentioned in the previous section, largely, amount to a general 99% reduction in harmful substances emitted at the stack, on a given observation. However, this is not 100% and clearly some particulates and substances, as well as the biproducts of the agents applied to filter them, which produce their own harmful emissions, do escape the previous measures

The types of emissions and their volumes greatly depend on the type of waste being incinerated on the day and its volumes. Emissions may fluctuate day to day, however the facility will, inevitably, release almost insignificant (ranging in the submicron to low microns) amounts of these substances, chemicals and particulates per day; the key word here is almost.

This section will present the current minimum levels or amounts permissible of each emission based on the reference information (usually Government based references), where none is present this writer was unable to find any information on the level or amount or none has been defined in standards or legislation.

Based on the reported efficiency of each of the filtration methods, in the previous section and the reference materials in the Emission Details sub-section below, deductive reasoning suggests that modern Waste to Energy Incinerators will release, at some point, in near, almost, insignificant quantities:

- Mercury
- Cadmium
- PM 2.5
- Carbon Dioxide
- Carbon Monoxide
- Nitrogen Oxide
- Sulfur Oxides
- Ammonia
- Hydrogen Chloride
- Hydrogen Fluoride
- Volatile Organic Compounds
- Dioxins and Furans

Almost insignificant quantities are not zero and should not be minimised as many of these substances, chemicals and particulates that are emitted from Waste to Energy Incineration facilities:

- Do not break down
- Take time to break down, increasing the chances of exposure the longer they're in the air
or
- Transform by reacting with other atmospheric elements (or water) into more toxic substances

The technologies mentioned in the previous section and their associated efficiency percentages are clearly based on optimal performance.

It stands to reason that if there were a problem with filtration, some of the previously mentioned limitations were at play or the previously mentioned Air Filtration, Purification and Monitoring systems were not maintained properly, the efficiency would reduce.

That reduction would increase the overall emissions and over time contribute to the build up of these particulates and substances in the surrounding environment.

This is not hypothetical, as just a few examples below show, there have been long running breaches such as:

- Croydon (UK) Incinerator breaking emission standards 916 times in 2 years
- KODA Energy (US) burning material they were not approved for over 2 years
- New Jersey (US) five Incinerator facilities breaking their air permits more than 1,700 times since 2004
- Viridor, running the Runcorn Waste to Energy Incinerator facilities in the UK, breached their permitted levels by an average of 5.5, compared to 3.4 in 2019
 - In 2024 73% of UK Waste to Energy Incinerator facilities reported transgressions
 - Runcorn has breached its permit 17 times in the past 5 years
 - This operator was compelled by a court to settle a £1 million case after residents launched legal action regarding pollution and disturbances
 - The operator also required residents to sign a Non-Disclosure Agreement (NDA) as a condition of the settlement; a number of residents refused to sign and took their story to the BBC

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Of the 99% of emissions that are reduced, there is a 1% that is admittedly released, even when utilising combinations of the above safety control and multi-staged air purification technologies, based on given observations.

The BBC has also stated, in 2024, that Waste to Energy Incinerators now emit more Carbon Dioxide and other greenhouse gases than coal fired power plants for each unit of energy.

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- <https://prepp.in/news/e-492-incineration-combustion-environment-notes>
- <https://climateactionaccelerator.org/solutions/incineration/#:~:text=%23%201%20Reduce%20waste%20as%20a%20priority, toxic%20pollutants.%20Follow%20the%20Waste%20Management%20principles>
- [https://www.ncbi.nlm.nih.gov/books/NBK233627/#:~:text=The%20predominant%20reactions%20are%20between,\) %20and%20carbon%2Dcontaining%20particles.](https://www.ncbi.nlm.nih.gov/books/NBK233627/#:~:text=The%20predominant%20reactions%20are%20between,) %20and%20carbon%2Dcontaining%20particles.)
- <https://nap.nationalacademies.org/read/5803/chapter/5#52>
- https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_3_Waste_Incineration.pdf
- [https://www.sciencedirect.com/topics/engineering/waste-incinerator#:~:text=Incineration%20of%20MSW%20does%20not%20completely%20eliminate%2C, dioxins%2C%20furans%2C%20and%20others\)%2C%20heat%2C%20and%20energy](https://www.sciencedirect.com/topics/engineering/waste-incinerator#:~:text=Incineration%20of%20MSW%20does%20not%20completely%20eliminate%2C, dioxins%2C%20furans%2C%20and%20others)%2C%20heat%2C%20and%20energy)
- https://www.youtube.com/watch?v=71olHBFpG_0&t=53s
- [https://www.sciencedirect.com/science/article/abs/pii/S1352231015302910#:~:text=Abstract%20Nitrogen%20oxides%20\(NO%20x\)%20emission%20abatement, \(by%20reducing%20nitrate%20aerosol\)%20in%20the%20atmosphere](https://www.sciencedirect.com/science/article/abs/pii/S1352231015302910#:~:text=Abstract%20Nitrogen%20oxides%20(NO%20x)%20emission%20abatement, (by%20reducing%20nitrate%20aerosol)%20in%20the%20atmosphere)
- <https://www.bbc.com/news/articles/cp3wxgje5pwo>

Emission Details sub section

The following sub section is a breakdown of the:

- Typical (based on the information in the provided references), observed, particles and substances emitted in that 1%
- Their typical volumes and
- Environmental and Human Health risks

Emissions:

Mercury

- According to regulatory limits, such as those imposed by the European Union, Mercury emissions are restricted to 20 µg/Nm³
 - Measured concentrations can range between 13.38 – 18.66 µg/Nm³
- Clear signs of Mercury poisoning are Blood Mercury levels above 100 ng/mL
 - Levels can be reached over periods of chronic exposure
 - [Mercury Health Impacts](#)
- Mercury does not break down in nature
 - It can be absorbed and converted into Methylmercury, which is highly toxic and makes its way into food and water supplies
 - It can remain in the environment for years or even centuries, posing a long term threat
 - [Mercury Environmental Impacts](#)
- References:
 - <https://www.sciencedirect.com/science/article/pii/S0921344923000186>
 - <https://www.sciencedirect.com/science/article/pii/S1309104215300805>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0959652621038403>
 - <https://www.who.int/news-room/fact-sheets/detail/mercury-and-health>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC3514465/>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC4724159/>
 - https://files.dep.state.pa.us/Air/AirQuality/AQPortalFiles/Business%20Topics/Regulations/Dr_Bell_Presentation_102805.pdf
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC5336545/#:~:text=It%20is%20practically%20impossible%20to%20accurately%20determine,related%20to%20these%20sources.%20Pacyna%20et%20al>
 - <https://www.nyserda.ny.gov/All-Programs/Environmental-Research/Atmospheric-Deposition/Mercury-Human-Health-and-the-Environment>
 - <https://en.wikipedia.org/wiki/Methylmercury>
 - <https://www.atsdr.cdc.gov/toxfaqs/tfacts46.pdf>

Cadmium

- Largely controlled by the safety control and multi-staged air purification technologies mentioned in the previous section
- Where emissions occur, they do so because of dust that escapes controls
- Regulation limit examples are 3 mg, Cd/m³ (Cadmium per square metre)

- Low level exposure to Cadmium produces health risks associated with lower quality of life
 - [Cadmium Health Impacts](#)
 - These impacts could come from contaminated food or water or from the air
- Cadmium does not break down in nature
 - It can remain in the soil for decades
 - Airborne Cadmium can travel long distances before being deposited on land or in water
 - [Cadmium Environmental Impacts](#)
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S0304389413006778#:~:text=Although%20this%20includes%20Cd%20emissions%20from%20MSWIs%2C,to%20the%20increase%20in%20the%20environmental%20concentration>
 - <https://www.mdpi.com/1996-1073/15/21/8130#:~:text=It%20was%20different%20for%20the%20tested%20metals,increased%20E2%80%94Cd%2098%25%2C%20Cu%2079%25%2C%20and%20Zn%2046%25>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC11400610/>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0734242X86800350#:~:text=In%20a%20series%20of%20in%20situ%20measurements,be%20higher%20than%20E2%80%9330%20mg%20dust%20Nm%20E2%88%923>
 - <https://www.ncbi.nlm.nih.gov/books/NBK233627/#:~:text=In%20the%20modern%20systems%2C%20emissions%20created%20in,unnecessarily%20exposed%20to%20dust%20from%20the%20ash>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC10537762/>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0013935109002229>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC4780235/>
 - <https://ehp.niehs.nih.gov/doi/10.1289/ehp.0901234>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/cadmium-and-compounds>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC7147761/>

PM 2.5

- From state of the art facilities, with the safety control and multi-staged air purification technologies mentioned in the previous section, PM 2.5 concentrations can be as low (or lower) as 0.68 to 0.87 mg/m³
- Short term exposure to PM 2.5 at a dose of 10 µg/m³ can increase mortality risk, these particles can cause harm even at lower levels
 - [PM 2.5 Health Impacts](#)
- PM 2.5 can break down in nature
 - Water soluble particles are removed quickly
 - Black carbon can remain in the atmosphere for weeks to over a month before it has been removed from the air

- PM 2.5 can react with other substances in the air to form new toxic compounds
- It can contribute to acid rain and alter the chemical balance of soil and water
- [PM 2.5 Environmental Impacts](#)
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S0956053X14000993#:~:text=The%20review%20identified%20only%20a%20limited%20number,is%20lower%20than%20one%20single%20high%2Dduty%20vehicle>
 - https://www.researchgate.net/publication/291966463_Emission_of_particulate_matter_25_PM25_and_elements_from_municipal_solid_waste_incinerators
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC4740125/>
 - <https://www.health.nsw.gov.au/environment/air/Pages/particulate-matter.aspx>
 - <https://www.sciencedirect.com/science/article/pii/S2667010025001349>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC10208206/>
 - <https://community.purpleair.com/t/where-does-pm2-5-go/3090>
 - <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>

Carbon Dioxide

- Continuously emitted from the facility stack
- Flue gas concentrations typically range from 6% to 12% CO₂ but varies due to the composition of the waste day to day, particularly on the amount of plastics
 - For reference, a Coal Power plant's typical flue gas concentration of CO₂ ranges between 12% to 15%
- Low Level exposure, over time, is linked to increased health risks and impairment of cognitive function, particularly if the concentration is able to permeate a house (due to, as an example, poor window sealing)
 - [Carbon Dioxide Health Impacts](#)
- Carbon Dioxide is a well studied and confirmed source of green house gas emissions contributing to global warming
- References:
 - <https://www.sciencedirect.com/science/article/pii/S0921344924004063>
 - <https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg3-chapter10-1.pdf>
 - <https://d-nb.info/1190725908/34#:~:text=Besides%20increasing%20the%20efficiency%2C%20the%20application%20of,flue%20gas%20is%20present%20at%20atmospheric%20pressure>
 - <https://www.sciencedirect.com/topics/chemistry/flue-gas#:~:text=Typical%20flue%20gases%20from%20natural,72%2D77%25%20N2>
 - <https://www.mdpi.com/1996-1073/14/12/3582>

- <https://www.witpress.com/Secure/elibrary/papers/SDP07/SDP07088FU2.pdf>
- <https://www.sciencedirect.com/science/article/pii/S0160412018312807>
- <https://oizom.com/how-do-industrial-emissions-contribute-to-climate-change/#:~:text=FAQs%20How%20does%20the%20industry%20contribute%20to,but%20also%20from%20the%20industrial%20processes%20themselves.>
- <https://www.sciencedirect.com/science/article/pii/S0160412018312807>
- <https://www.sciencedirect.com/science/article/pii/S0013935125017542#:~:text=Over%20the%20last%20decade%2C%20numerous%20studies%20have,et%20al.%2C%202023;%20D%27Amato%20et%20al.%2C%202015>
- <https://www.thekids.org.au/projects/chronic-carbon-dioxide-exposure-an-unrecognised/>
- <https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide>
- <https://science.nasa.gov/earth/explore/earth-indicators/carbon-dioxide/>
- <https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/>

Carbon Monoxide

- This is typically the product of incomplete combustion
- The type of waste and its level of water content will influence how much Carbon Monoxide is produced
 - Should the sorting process not effectively identify and remove waste with water content this would lead to the production of Carbon Monoxide
- The Australian limit for Carbon Monoxide is 9.0 ppm
- Low level, chronic exposure to Carbon Monoxide can lead to neurological and cardiovascular problems, at best a lower quality of life, at worst serious, long term damage
 - [Carbon Monoxide Health Impacts](#)
- Carbon Monoxide is a well studied and confirmed source of green house gas emissions contributing to global warming
- Carbon Monoxide does readily break down in the environment through oxidation in the atmosphere, taking about 1 to 2 months to completely dissipate
 - [Carbon Monoxide Environmental Impacts](#)
- Sensors in the Waste to Energy Incineration facility monitor Carbon Monoxide levels and if they exceed safe limits, often between 50 and 100 ppm during normal operation, this can cause the facility to temporarily shut down until the combustion issue is corrected
- References:
 - <https://www.ncbi.nlm.nih.gov/books/NBK233627/>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC11400610/>
 - https://www.researchgate.net/publication/43345469_Carbon_monoxide_formation_and_emissions_during_waste_incineration_in_a_grate-circulating_fluidized_bed_incinerator#:~:text=The%20carbon%20to%20

[CO%20conversion%20rates%20were,emissions%20to%20satisfy%20the%20Chinese%20national%20regulations](#)

- <https://pmc.ncbi.nlm.nih.gov/articles/PMC3404310/>
- <https://my.clevelandclinic.org/health/diseases/15663-carbon-monoxide-poisoning>
- <https://ww2.arb.ca.gov/resources/carbon-monoxide-and-health#:~:text=CO%20contributes%20indirectly%20to%20climate,weak%20direct%20effect%20on%20climate>
- <https://www.clarity.io/blog/looking-beyond-co2-how-different-air-pollutants-impact-climate-change#:~:text=CO%20also%20reacts%20with%20hydroxyl%20radicals%20in,and%20warming%20potential%20of%20these%20greenhouse%20gases>
- <https://www.kane.co.uk/knowledge-centre/where-does-co-come-from>
- <https://www.osha.gov/sites/default/files/publications/carbonmonoxide-factsheet.pdf>
- <https://www.sciencedirect.com/topics/engineering/complete-combustion#:~:text=The%20quantities%20of%20products%20of%20incomplete%20combustion,carbon%20monoxide%20must%20be%20monitored%20and%20minimized>
- <https://www.reworldwaste.com/news-and-resources/blog/waste-to-energy-what-really-comes-out-of-the-stack#:~:text=Waste%20to%20Energy%20facilities%20employ%20a%20carefully%20controlled%20combustion,protective%20of%20human%20health%20and%20the%20environment>
- https://en.wikipedia.org/wiki/Carbon_monoxide
- <https://www.ncbi.nlm.nih.gov/books/NBK430740/>
- <https://soe.dcceew.gov.au/air-quality/environment/outdoor-air-quality>

Nitrogen Oxide

- Continuously emitted from the facility stack
- According to regulatory limits, such as those imposed by the European Union, Nitrogen Oxide emissions are restricted to 200 mg/ m³
 - Waste to Energy Incinerator facilities using SCR can, typically, stay below the emission limit around 100 mg/Nm³ at 11% oxygen, annually, however this does depend on the initial nitrogen oxide levels
- The regulatory limit, if exposed in full or over time (chronically) can lead to respiratory damage
 - [Nitrogen Oxide Health Impacts](#)
- Can contribute to acid rain and harm vegetation
- Can breakdown in the environment, however it can last potentially days, depending on the environmental conditions such as rain or the presence of other reactive, neutralising, chemicals in the air
 - [Nitrogen Oxide Environmental Impacts](#)
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S0956053X14005005>

- <https://www.sciencedirect.com/science/article/pii/S2666821123000686#:~:text=SCR%20is%20considered%20the%20best%20available%20technology,x%20to%20N%202%20%5B%209%2C%2010%5D>
- https://www.e3s-conferences.org/articles/e3sconf/pdf/2023/43/e3sconf_icemee2023_01014.pdf
- <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/oxides-nitrogen-0>
- <https://www.ncbi.nlm.nih.gov/books/NBK554539/>
- <https://wwwn.cdc.gov/TSP/MMG/MMGDetails.aspx?mmgid=394&toxid=69#:~:text=Low%20concentrations%20initially%20may%20cause,upper%20airway%20obstruction%2C%20and%20death>
- <https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/nitrogen-oxides>
- <https://www.unep.org/news-and-stories/press-release/rise-nitrous-oxide-emissions-endangers-pathway-15degc-ozone-layer#:~:text=Nitrous%20oxide%20is%20approximately%20270,warmin%20g%20since%20the%20industrial%20revolution.>
- <https://www.accessep.com.au/blog/environment-air-pollution-types-nitrogen-dioxide>
- [https://en.wikipedia.org/wiki/Nitrogen_dioxide#:~:text=At%20150%20%20C%20B0C%20\(302,%CE%94H%20=%2014%20kJ/mol\)](https://en.wikipedia.org/wiki/Nitrogen_dioxide#:~:text=At%20150%20%20C%20B0C%20(302,%CE%94H%20=%2014%20kJ/mol))
- <https://www.sciencedirect.com/science/article/abs/pii/S0956053X10001108>
- <https://www.sciencedirect.com/science/article/abs/pii/S0959652615011592>
- <https://www.sciencedirect.com/science/article/pii/S0959652623029359>
- <https://www.mdpi.com/2071-1050/16/1/448>

Sulfur Oxides

- Continuously emitted from the facility stack
- Minimised by safety control and multi-staged air purification technologies mentioned in the previous section but not eliminated
 - Most systems capture 92% to 99% of sulphur from the flue gases
 - Without effective controls / treatment concentrations could be as high as 150-640 mg/Nm³
 - Effective sorting is critical to reduce the amount of sulphur entering into the incineration chamber
- Health impacts at low concentrations can include mild to moderate respiratory irritation and potentially worsen conditions such as asthma
 - [Sulfur Oxides Health Impacts](#)
- Environmental impacts can include acid rain and the contribution to the accumulation of Mercury in food chains
- Sulfur Oxides can breakdown in nature in about 5-10 days, however this can vary in colder conditions to potentially 10-32 days
 - [Sulfur Oxides Environmental Impacts](#)
- References:

- <https://www.sciencedirect.com/science/article/abs/pii/S1001074218308015>
- <https://www.sciencedirect.com/topics/engineering/sulfur-emission>
- <https://www.sciencedirect.com/science/article/abs/pii/S001623612301640X>
- https://www.abigailboyd.org/greens_clean_air_bill_calls_for_strict_emissions_restrictions#:~:text=The%20use%20of%20sulphur%20oxide%20%5BSOx%5D%20or,and%20activated%20carbon%20injection%20would%20remove%20mercury
- <https://www.sciencedirect.com/science/article/abs/pii/S0269749123000234>
- <https://www.sciencedirect.com/science/article/abs/pii/S0269749124021195>
- <https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/sulfur-dioxide>
- <https://pubmed.ncbi.nlm.nih.gov/39603322/>
- <https://www.ukbiobank.ac.uk/publications/long-term-exposure-to-low-concentration-sulfur-dioxide-and-mental-disorders-in-middle-aged-and-older-urban-adults/>
- <https://www.iqair.com/au/newsroom/sulphur-dioxide>
- <https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/sulfur-dioxide>
- <https://www.epa.gov/so2-pollution/sulfur-dioxide-basics>
- <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/sulfur-dioxide#:~:text=Even%20low%20concentrations%20of%20sulfur%20dioxide%20can,adversely%20affect%20both%20land%20and%20water%20ecosystems>
- <https://ww2.arb.ca.gov/resources/sulfur-dioxide-and-health>
- https://www.health.ny.gov/environmental/chemicals/hydrogen_sulfide/
- <https://www.atsdr.cdc.gov/toxprofiles/tp116-c5.pdf>
- <https://www.sciencedirect.com/science/article/abs/pii/0004698178902172#:~:text=A%20much%20simplified%20model%20suggests,about%2005%20days%20for%20sulphur>
- <https://www.sciencedirect.com/science/article/abs/pii/0004698184903378#:~:text=The%20residence%20time%20of%20SO,10%E2%80%9319%20days%20in%20April>

Ammonia

- Occasionally emitted from these facilities
- Concentrations can range from 0.03 to 0.07 ppm though this varies significantly due to the use of SCR and the type of waste being incinerated
 - Occurs as a biproduct of other particle and substance control mechanisms
 - Such as if the SCR or SNCR system is over injected with Ammonia (ammonia slip) or the system is not optimised, unreacted Ammonia will be emitted
- Low concentrations of airborne Ammonia, 50 ppm can produce moderate to severe irritation of the eyes and upper respiratory system
 - [Ammonia Health Impacts](#)
- Can cause, eutrophication, acidification and contribute to the formation of PM 2.5 within the surrounding environment
- Ammonia can breakdown in nature within days in soil and water and approximately one week in the air
 - [Ammonia Environmental Impacts](#)
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S1309104221003561>
 - <https://www.mdpi.com/2071-1050/12/18/7309>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0959652623029682>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC7967387/#:~:text=Ammonia%20concentrations%20of%20the%20samples%20collected%20from,p pm%20and%20standard%20deviation%20of%200.72%20ppm.>
 - <https://zeroinstrument.com/understanding-ammonia-slip-causes-impacts-and-mitigation-strategies/#:~:text=Excessive%20Ammonia%20Injection:%20When%20the%20molar%20ratio,the%20stoichiometric%20requirement%2C%20surplus%20ammonia%20escapes%20unreacted>
 - <https://wwwn.cdc.gov/TSP/MMG/MMGDetails.aspx?mmgid=7&toxid=2>
 - <https://www.ncbi.nlm.nih.gov/books/NBK546677/>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC6524738/>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/ammonia-total>
 - <https://www.sciencedirect.com/science/article/pii/S0301479722018588>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/ammonia-total>
 - https://en.wikipedia.org/wiki/Ammonia_pollution
 - <https://smartfertiliserhub.org.au/publications/blogs/ammonia-abatement-in-australia-for-environmental-improvement/>
 - <https://royalsociety.org/~media/policy/projects/evidence-synthesis/Ammonia/Ammonia-report.pdf>
 - <https://www.iqair.com/newsroom/ammonia>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC7429516/#:~:text=In%20the%20atmosphere%2C%20NH%203%20reacts%20with,et%20al.%2C%202013;%20Wang%20et%20al.%2C%202020a>

- <https://www.intechopen.com/chapters/79308>

Hydrogen Chloride

- Frequently emitted from the facility stack
 - Concentration can vary based on the chlorine content of the waste
 - Typical concentrations without controls ranges between 770-1300 mg/ Nm³
 - With controls it can be around 60 mg/ Nm³
 - European Union regulations specify Hydrogen Chloride limits of between 2-10 mg/ Nm³
- 1.5 mg/ Nm³ is considered a low exposure
- Health risks can include respiratory irritation, chemically induced asthma and shortness of breath
 - [Hydrogen Chloride Health Impacts](#)
- Hydrogen Chloride has a half life of approximately 11 days
- It is readily dissolved in water to form hydrochloric acid
 - [Hydrogen Chloride Environmental Impacts](#)
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S1001074218308015>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0956053X07000128>
 - <https://www.envirotech-online.com/article/air-monitoring/6/environment-agency/hydrogen-chloride-emissions-monitoring-european-survey-of-practices-issues-and-opinions/3454>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0956053X07000128>
 - <https://wwwn.cdc.gov/TSP/MMG/MMGDetails.aspx?mmgid=758&toxid=147>
 - <https://www.epa.gov/sites/default/files/2016-09/documents/hydrochloric-acid.pdf>
 - <https://www.ncbi.nlm.nih.gov/books/NBK230426/>
 - <https://www.epa.gov/sites/default/files/2016-09/documents/hydrochloric-acid.pdf>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/hydrochloric-acid>
 - <https://dnr.mo.gov/water/hows-water/pollutants-sources/chloride#:~:text=Plants%20%E2%80%94%20Chloride%20in%20streams%2C%20lakes,to%20erosion%20and%20sediment%20runoff>
 - <https://hvpchemicals.oecd.org/UI/handler.axd?id=e1fe4ef3-e3d4-4f3d-9a58-8bf2f8296b61>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/hydrochloric-acid#:~:text=Hydrogen%20chloride%20released%20into%20the,processes%20that%20cause%20photochemical%20smog>

Hydrogen Fluoride

- Occasionally emitted from these facilities
- Concentrations before scrubbing range between approximately 1 to 4 mg/ Nm³, which scrubbing can lower considerably
 - However, how it is reduced depends on the efficiency of the scrubbing system
- Health impacts of exposure to Hydrogen Fluoride may cause irritation of the eyes, nose and sore throat, with possible chest tightness, headache, ataxia and confusion at concentrations as low as 1.16 mg/ m³
 - [Hydrogen Fluoride Health Impacts](#)
- Hydrogen Fluoride does not break down in nature
 - It contributes to acid rain, plant and soil damage
 - [Hydrogen Fluoride Environmental Impacts](#)
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S03043894020002X#:~:text=However%2C%20the%20emission%20limits%20vary%20from%20country,from%20the%20flue%20gas%20from%20MSW%20incinerators>
 - <https://www.ncbi.nlm.nih.gov/books/NBK597856/#:~:text=Anthropogenic%20fluoride%20emissions%20include%20the%20combustion%20of,largest%20source%20of%20anthropogenic%20hydrogen%20fluoride%20emissions>
 - https://www.nist.gov/system/files/documents/el/fire_research/R0301572.pdf#:~:text=HFC%2D125%2C%20like%20all%20fluorine%2Dcontaining%20fire%20suppression%20agents%2C,to%20the%20high%20temperatures%20of%20the%20flame
 - <https://www.sciencedirect.com/science/article/abs/pii/S0956053X14005030>
 - <https://www.gov.uk/government/publications/hydrogen-fluoride-health-effects-incident-management-and-toxicology/hydrogen-fluoride-and-hydrofluoric-acid-toxicological-overview>
 - <https://www.ncbi.nlm.nih.gov/books/NBK219903/>
 - https://www.rch.org.au/clinicalguide/guideline_index/Hydrofluoric_acid_exposure/
 - <https://www.sciencedirect.com/science/article/abs/pii/S0269749111006348>
 - [https://ww2.arb.ca.gov/sites/default/files/classic/toxics/tac/factshts1997/hydf fluor.pdf#:~:text=ATMOSPHERIC%20PERSISTENCE%20Hydrogen%20fluoride%20will%20undergo%20wet,the%20occurrence%20of%20precipitation%20events%20\(Atkinson%2C%201995\)](https://ww2.arb.ca.gov/sites/default/files/classic/toxics/tac/factshts1997/hydf fluor.pdf#:~:text=ATMOSPHERIC%20PERSISTENCE%20Hydrogen%20fluoride%20will%20undergo%20wet,the%20occurrence%20of%20precipitation%20events%20(Atkinson%2C%201995))
 - <https://www.industrialchemicals.gov.au/sites/default/files/PEC19-Hydrofluoric-acid.pdf>
 - <https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=211&toxqid=38>

Volatile Organic Compounds

- Frequently emitted from the facility stack
 - Emissions are higher during the start up and shut down phases of operation, such as for regular maintenance
 - Primarily a result of incomplete combustion
 - One study found a range between 0.07 to 0.90 mg/ m³ after flue gas cleaning
- Concentrations less than 0.3 mg/ m³ are considered to be of low concern while levels below 0.5 mg/ m³ are considered acceptable by guidelines, however above this level increases the risk of adverse impacts
 - Low level chronic exposure health risks are associated with neurological disorders, kidney damage and cancer
 - Low concentration exposure can lead to acute headaches, nausea, irritation of the eyes, nose and throat
 - [Volatile Organic Compounds Health Impacts](#)
- Volatile Organic Compounds contribute to smog, acid rain and climate change
 - [Volatile Organic Compounds Environmental Impacts](#)
- References:
 - <https://www.tandfonline.com/doi/abs/10.1080/10934529809376732>
 - <https://www.sciencedirect.com/science/article/pii/S0045653522014394>
 - <https://www.sciencedirect.com/science/article/pii/S2590162125000346#:~:text=The%20results%20indicate%20that%20the%20VOC%20composition,variations%20in%20emission%20strength%20and%20VOC%20composition>
 - <https://www.ncbi.nlm.nih.gov/books/NBK233627/>
 - <https://www.hdg.it/en/voc-all-you-need-to-know#:~:text=Outdoor%20and%20indoor%20emissions%20trends%20in%20emission,constant%20or%20irregular%2C%20and%20the%20latter%20into>
 - <https://www.sciencedirect.com/science/article/abs/pii/S1309104223002751#:~:text=The%20contribution%20of%20refinery%20emissions%20increased%20from,lead%20to%20an%20increase%20in%20VOC%20emissions>
 - <https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality>
 - <https://www.dccew.gov.au/environment/protection/npi/substances/fact-sheets/total-volatile-organic-compounds>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC5910572/>
 - <https://www.lung.org/clean-air/indoor-air/indoor-air-pollutants/volatile-organic-compounds>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC5910572/>
 - <https://cdsentec.com/tvoc-air-quality-testing-essential-facts/>
 - <https://www.environmental-expert.com/news/what-are-acceptable-voc-levels-in-the-air-814546>
 - <https://atmotube.com/blog/tvoc-monitoring-in-commercial-and-office-buildings>
 - <https://www.sciencedirect.com/science/article/pii/S277241662200153X>
 - <https://cdsentec.com/tvoc-air-quality-testing-essential-facts/>

- <https://pmc.ncbi.nlm.nih.gov/articles/PMC8700805/#:~:text=Certain%20VOCs%20were%20identified%20as%20greenhouse%20gases,the%20limited%20existing%20primary%20water%20resources%20%5B%5D.>
- <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/total-volatile-organic-compounds>
- https://www.epd.gov.hk/epd/english/environmentinhk/air/prob_solution/vocs_smog.html
- <https://pollution.sustainability-directory.com/question/what-are-the-long-term-effects-of-voc-exposure/#:~:text=Environmentally%2C%20the%20long%2Dterm%20effects%20of%20VOCs%20are,visibility%20but%20also%20damages%20vegetation%20and%20ecosystems>

Dioxins and Furans

- Emitted in varying concentrations
 - Emissions are reduced to less than 0.1 TEQ/Nm³
- Low exposure is considered to be less than 0.5 pg TEQ/Nm³
 - Low level, chronic exposure to dioxins and furans can lead to immunotoxicity, endocrine disruption, hormonal imbalance, reproductive impacts, neurodevelopmental issues in children, increased risks of certain cancers
 - [Dioxins and Furans Health Impacts](#)
- Dioxins and Furans do not break down in the environment
 - Dioxins and Furans contaminate soil, water and wildlife. They accumulate in tissues and can be spread over long distances in the atmosphere before being deposited
 - This presents a risk to food chains
 - [Dioxins and Furans Environmental Impacts](#)
- References:
 - [https://hal.science/hal-01632399/file/dioxin-emissions.pdf#:~:text=The%20composition%20of%20dioxins%20in%20the%20flue,to%20the%20environment%20\(Kulkarni%20et%20al.%2C%202008\)](https://hal.science/hal-01632399/file/dioxin-emissions.pdf#:~:text=The%20composition%20of%20dioxins%20in%20the%20flue,to%20the%20environment%20(Kulkarni%20et%20al.%2C%202008))
 - [https://www.sciencedirect.com/science/article/abs/pii/S0956053X12002863#:~:text=The%20composition%20of%20dioxins%20in%20the%20flue,to%20the%20environment%20\(Kulkarni%20et%20al.%2C%202008\).](https://www.sciencedirect.com/science/article/abs/pii/S0956053X12002863#:~:text=The%20composition%20of%20dioxins%20in%20the%20flue,to%20the%20environment%20(Kulkarni%20et%20al.%2C%202008).)
 - <https://eswet.eu/dioxins-and-waste-to-energy-plants-new-report-on-the-state-of-the-art/>
 - <https://www.eurochlor.org/wp-content/uploads/2019/04/sd3-dioxins-final.pdf>
 - <https://cwhl.vet.cornell.edu/disease/dioxin-pcb-toxicosis#:~:text=Sensitivity%20to%20dioxins%20and%20PCBs,or%20feathers%2C%20and%20enlarged%20livers>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/polychlorinated-dioxins-and-furans>
 - <https://torrentlab.com/everything-you-need-to-know-about-dioxins-and-furans/>

- <https://www.sciencedirect.com/science/article/abs/pii/S0301479718307473>
- <https://www.canada.ca/en/health-canada/services/healthy-living/your-health/environment/dioxins-furans.html>
- <https://mytapscore.com/en-au/blogs/tips-for-taps/dioxins-and-furans-toxic-chemicals-explained>
- <https://www.sciencedirect.com/science/article/abs/pii/S2214158817300624>

Potential Impact to the Environment – Criteria 1

Impacts to the Environment sub-section

Mercury

- Mercury does not readily break down in the environment
- Mercury can travel great distances and accumulate over time in the food chain
- It can contaminate air, water and soil
- Mercury can make fish and shellfish sick, kill them or accumulate in their tissues, making them unsafe for predators, including humans
- Concentrations can accumulate in plants with leaf age
- In water, Mercury is converted by bacteria into a highly toxic form known as Methylmercury, which is what will accumulate in the food chain
- Animals that eat contaminated plants, insects or animals will be impacted and have it build in their cells over time
- Mercury can persist in its Methylmercury form for decades in soil and sediments
- References:
 - <https://www.eea.europa.eu/articles/mercury-a-persistent-threat-to#:~:text=Mercury%20occurs%20naturally%20in%20the%20environment%20but,its%20way%20into%20the%20human%20food%20chain>
 - <https://www.dcceew.gov.au/environment/protection/npi/resource/student/mercury-and-compounds>
 - <https://www.dcceew.gov.au/environment/protection/chemicals-management/mercury>
 - [https://www.sciencedirect.com/science/article/abs/pii/S0048969724078768#:~:text=Ecologically%2C%20mercury%20contamination%20poses%20a%20threat%20to,organs%20\(de%20Almeida%20Rodrigues%20et%20al.%2C%202019\)](https://www.sciencedirect.com/science/article/abs/pii/S0048969724078768#:~:text=Ecologically%2C%20mercury%20contamination%20poses%20a%20threat%20to,organs%20(de%20Almeida%20Rodrigues%20et%20al.%2C%202019))
 - <https://www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/heavy-metals/mercury/mercury-general>
 - <https://enveurope.springeropen.com/articles/10.1186/s12302-020-00401-x>
 - https://www.industrialchemicals.gov.au/sites/default/files/Mercury_%20Environment%20tier%20II%20assessment.pdf
 - <https://www.eea.europa.eu/articles/mercury-a-persistent-threat-to#:~:text=Mercury%20occurs%20naturally%20in%20the%20environment%20but,its%20way%20into%20the%20human%20food%20chain>
 - <https://www.des.nh.gov/sites/g/files/ehbemt341/files/documents/2020-01/ard-28.pdf>
 - <https://www.intechopen.com/chapters/85191>
 - <https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=113&toxid=24#:~:text=Because%20mercury%20is%20a%20naturally,break%20down%20in%20the%20environment>
 - <https://www.pca.state.mn.us/pollutants-and-contaminants/mercury#:~:text=Mercury%20is%20a%20naturally%20occurring,toxic%20substances%20like%20some%20pollutants>

Cadmium

- Cadmium does not break down in the environment and is not a biodegradable heavy metal
- Cadmium can remain in soil and sediments for decades and be absorbed by plants and other organisms, leading to its accumulation in the food chain
- Cadmium is highly toxic to aquatic life
- Cadmium damages soil microfauna
- Cadmium interferes with water and nutrient uptake in plants, decreasing photosynthesis and inhibiting root growth; impacting crops
- Cadmium, in addition to the human health impacts, can also cause damage to animals organs
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S0048969717314341#:~:text=High%20Cd%20concentration%20can%20have%20toxic%20effects,and%20Navari%20Izzo%2C%202011%2C%20Zarcinas%20et%20al.%2C%202004>
 - <https://www.sciencedirect.com/science/article/abs/pii/S2468202021000176>
 - <https://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/conditions/chemicals+and+contaminants/cadmium#:~:text=Cadmium%20is%20typically%20found%20in,fertilizers%20and%20of%20sewage%20sludge>
 - <https://www.dcceew.gov.au/environment/protection/npis/substances/fact-sheets/cadmium-and-compounds>
 - <https://www.atsdr.cdc.gov/toxfaqs/tfacts5.pdf>
 - <https://www.sciencedirect.com/science/article/pii/S2405844020315346>
 - <https://www.sciencedirect.com/science/article/pii/S131961032200151X>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC7490536/>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC4427717/#:~:text=Cadmium%20distributed%20in%20the%20environment,reaching%20ultimately%20the%20human%20body>
 - <https://www.health.state.mn.us/communities/environment/risk/docs/guidance/gw/cadmiuminfo.pdf>
 - <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants/cadmium-2000>
 - <https://www.epa.gov/wqc/aquatic-life-criteria-cadmium#:~:text=Cadmium%20is%20a%20non%20essential,and%20behavior%20in%20aquatic%20organisms>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC9608472/>

PM 2.5

- PM 2.5 can contribute, significantly, to the acidification of lakes and streams, making them unsuitable for marine and other wildlife
 - In addition, this process can contribute to acid rain by reacting with sulfur dioxide and nitrogen oxides in the air and water, oxygen and other chemicals in the water

- When PM 2.5 particles settle in river basins or coastal waters, they can alter the nutrient balance
- PM 2.5 will deplete nutrients in the soil over time
- PM 2.5 particles that settle on crops, forests and other vegetation damage them and their soil over time
- PM 2.5 can contribute to increased, ground level, ozone, harmful to human and animal health
- Wind can assist PM 2.5 to travel long distances spreading the environmental impact over a large area
- PM 2.5 particles can react with other substances in the air and form secondary pollutants such as sulphates, nitrates and ozone, contributing to smog
- PM 2.5 can remain in the atmosphere for days to weeks before being deposited on the ground
- PM 2.5 can bioaccumulate in the water over time
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S1532045623001011>
 - <https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health#:~:text=PM%20can%20adversely%20affect%20ecosystems,alter%20plant%20growth%20and%20yield>
 - <https://pubmed.ncbi.nlm.nih.gov/28381823/>
 - <https://www.sciencedirect.com/science/article/pii/S1382668923000881#:~:text=Once%20in%20the%20water%2C%20these%20particles%20can,resulting%20in%20developmental%20problems%20and%20multi%20Dorgan%20toxicity>
 - <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>
 - <https://pubmed.ncbi.nlm.nih.gov/30194574/>
 - <https://www.nature.com/articles/s41598-017-00449-5>
 - <https://www.epa.gov/acidrain/what-acid-rain#:~:text=Acid%20rain%20results%20when%20sulfur,before%20falling%20to%20the%20ground>
 - <https://www.airquality.nsw.gov.au/types-of-air-pollution>
 - <https://www.transport.nsw.gov.au/system/files/media/documents/2023/130841Asubstance.pdf>
 - [https://www.meo.life/en/what-is-it-that-we-all-call-pollution/#:~:text=Ground%20level%20Ozone%20is%20a%20major%20component%20of,oxides%20\(NOX\)%20and%20volatile%20organic%20compounds%20\(VOCs\)](https://www.meo.life/en/what-is-it-that-we-all-call-pollution/#:~:text=Ground%20level%20Ozone%20is%20a%20major%20component%20of,oxides%20(NOX)%20and%20volatile%20organic%20compounds%20(VOCs))
 - [https://www.sciencedirect.com/science/article/abs/pii/S004896972208442X#:~:text=Secondary%20organic%20aerosol%20\(SOA\)%20is%20an%20important,oxidation%20products%20of%20volatile%20organic%20compounds%20\(VOCs\)](https://www.sciencedirect.com/science/article/abs/pii/S004896972208442X#:~:text=Secondary%20organic%20aerosol%20(SOA)%20is%20an%20important,oxidation%20products%20of%20volatile%20organic%20compounds%20(VOCs))

Carbon Dioxide

- Carbon Dioxide is a well documented intensification of global warming via the greenhouse effect and a leading contributor to climate change
- Causes a rise in global temperatures
- Ocean acidification
- Agricultural impact, reduced yields, loss of species
- Contributes to water scarcity
- Carbon Dioxide does not break down in the atmosphere, it instead moves between the atmosphere, oceans and land over long time scales and does not disappear readily
 - Approximately 50% can be removed in decades and another 30% in centuries
- Between 65 to 80% of emitted Carbon Dioxide is absorbed by the ocean over a period of 20 to 200 years
- References:
 - <https://www.csiro.au/en/research/environmental-impacts/climate-change/Climate-change-QA/Sources-of-CO2#:~:text=to%20the%20atmosphere-.Carbon%20naturally%20flows%20in%20and%20out%20of%20the%20land%20and%20C%20ocean,take%20up%202.2%20billion%20tonnes>
 - <https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide#:~:text=Why%20carbon%20dioxide%20matters,dropped%20from%208.21%20to%208.10>
 - <https://kunakair.com/carbon-dioxide/#:~:text=Agricultural%20yields%20will%20be%20reduced,but%20also%20on%20global%20geopolitics>
 - <https://welysis.com/blog/how-does-climate-change-affect-access-to-safe-drinking-water>
 - <https://www.socialstudies.com/blog/8-ways-weather-and-climate-impact-population-growth/#:~:text=Changes%20in%20precipitation%20patterns%20due%20to%20climate,for%20areas%20with%20more%20reliable%20water%20sources>
 - <https://news.climate.columbia.edu/2021/02/25/carbon-dioxide-cause-global-warming/#:~:text=It%27s%20like%20watering%20your%20garden,and%20oceans%20are%20rising%20quickly>
 - <https://airly.org/en/how-does-air-pollution-affect-climate-change/#:~:text=Rising%20temperatures%20are%20melting%20the%20Earth%27s%20glaciers,which%20can%20eventually%20lead%20to%20coastal%20flooding.>
 - <https://science.nasa.gov/climate-change/evidence/#:~:text=Global%20Temperature%20Is%20Rising,atmosphere%20and%20other%20human%20activities.&text=Most%20of%20the%20warming%20occurred,the%20warmest%20year%20on%20record>
 - <https://www.nature.com/articles/climate.2008.122>

- <https://cs3.mit.edu/>
- <https://www.theguardian.com/environment/2012/jan/16/greenhouse-gases-remain-air>
- <https://science.nasa.gov/earth/climate-change/greenhouse-gases/the-atmosphere-getting-a-handle-on-carbon-dioxide/>
- <https://www.earthobservatory.nasa.gov/features/CarbonCycle/page5.php>
- <https://www.iaea.org/bulletin/how-carbon-emissions-acidify-our-ocean#:~:text=It%20presents%20a%20serious%20threat,many%20biological%20mechanisms%2C%20including%20calcification.>
- <https://www.noaa.gov/education/resource-collections/ocean-coasts/ocean-acidification>
- <https://www.climatechange.environment.nsw.gov.au/impacts-climate-change/weather-and-oceans/ocean-acidification>
- <https://coastadapt.com.au/ocean-acidification-and-its-effects>

Carbon Monoxide

- Carbon Monoxide's impact is its appearing indirect effect on climate change
 - It reacts with substances in the atmosphere and increases ground level ozone
 - It also decreases the natural break down of other greenhouse gases such as methane
- Carbon Monoxide breaks down in the atmosphere over an average of 2 months as it converts into Carbon Dioxide
- Contributes to smog formation
- References:
 - <https://www.csiro.au/en/news/All/News/2023/November/3000-years-of-carbon-monoxide-records-show-positive-impact-of-global-intervention>
 - <https://www.clarity.io/blog/looking-beyond-co2-how-different-air-pollutants-impact-climate-change#:~:text=CO%20also%20reacts%20with%20hydroxyl%20radicals%20in,and%20warming%20potential%20of%20these%20greenhouse%20gases>
 - <https://ww2.arb.ca.gov/resources/carbon-monoxide-and-health#:~:text=CO%20contributes%20indirectly%20to%20climate,weak%20direct%20effect%20on%20climate>
 - <https://www.dcceew.gov.au/environment/protection/npi/resource/student/carbon-monoxide#:~:text=When%20carbon%20monoxide%20is%20emitted,causing%20other%20extreme%20weather%20events>
 - <https://kunakair.com/carbon-monoxide/>
 - <https://www.atsdr.cdc.gov/toxprofiles/tp201-c1.pdf>
 - <https://www.frontiersin.org/journals/environmental-science/articles/10.3389/fenvs.2022.822463/full>
 - [https://earthobservatory.nasa.gov/global-maps/MOP_CO_M#:~:text=In%20combination%20with%20other%20pollutants%20and%20sunshine%2C,\(%E2%80%9Cbad%E2%80%9D\)%20o](https://earthobservatory.nasa.gov/global-maps/MOP_CO_M#:~:text=In%20combination%20with%20other%20pollutants%20and%20sunshine%2C,(%E2%80%9Cbad%E2%80%9D)%20o)

Nitrogen Oxide

- Contributes to Acid Rain
 - Reacts with water, oxygen and other chemicals in the atmosphere to form acid rain, which can damage lakes, forests and soil
- Contributes to smog in the form of Nitrogen Dioxide
 - Also contributes to acid rain
- Damages vegetation
 - Leading to stunted growth, reduced crop yields
- Contributes to toxic algal blooms that harm marine life
- Contributes to the greenhouse effect
- Contributes to a loss of biodiversity, as nitrogen tolerant plants will out compete other species
- Breaks down in the atmosphere when in the form of Nitric Oxide, which is converted to Nitrogen Dioxide
 - Nitrogen Dioxide will react with hydroxyl radicals in the atmosphere to form nitric acid, which contributes to the formation of acid rain
- References:
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/oxides-nitrogen-0>
 - <https://www.epa.gov/no2-pollution/basic-information-about-no2>
 - <https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/nitrogen-oxides>
 - <https://www.sciencedirect.com/science/article/pii/S2468584421000210#:~:text=In%20other%20ecosystems%2C%20growth%20enhancement%20is%20only,also%20being%20the%20trade%2Doff%20in%20forest%20ecosystems.>
 - <https://www.unep.org/facts-about-nitrogen-pollution>
 - <https://www.unep.org/news-and-stories/press-release/rise-nitrous-oxide-emissions-endangers-pathway-15degc-ozone-layer#:~:text=Rise%20in%20nitrous%20oxide%20emissions%20endangers%20pathway,tonnes%20of%20carbon%20dioxide%20emissions%20by%202100.>
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 - <https://www.sciencedirect.com/science/article/pii/S0005272899000201>
 - <https://www.sciencedirect.com/topics/chemical-engineering/nitrogen-oxides>
 - <https://pubmed.ncbi.nlm.nih.gov/8260141/#:~:text=The%20lifetimes%20with%20respect%20to%20reactive%20processes,the%20oxidized%20nitrogen%20burden%20in%20indoor%20air.>
 - https://wtert.org/wp-content/uploads/2019/03/thesis_zhixuan-wu.pdf

Sulfur Oxides

- Sulfur Oxides contributes to acid rain
- Contributes to poor air quality by forming fine particles that cause haze and reduced visibility
- Damages vegetation by stunting growth and reducing crop yields
- Acidification of water and soil
- Sulfur Oxides, primarily sulfur dioxide, have an atmospheric lifetime of between 5 to 10 days before they're broken down and removed from the atmosphere
 - This break down results in the formation of sulfuric acid, which contributes to acid rain
 - This lowers the PH of the water, which can kill aquatic organisms
- References:
 - <https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/sulfur-dioxide#:~:text=Environmental%20effects,the%20detriment%20of%20aquatic%20life>
 - <https://www.accessep.com.au/blog/environment-air-pollution-types-sulfure-dioxide>
 - <https://www.dcceew.gov.au/environment/protection/mpi/substances/fact-sheets/sulfur-dioxide#:~:text=Even%20low%20concentrations%20of%20sulfur%20dioxide%20can,adversely%20affect%20both%20land%20and%20water%20ecosystems>
 - <https://www.epa.gov/so2-pollution/sulfur-dioxide-basics>
 - <https://www.dcceew.gov.au/sites/default/files/documents/factsheet-sulfurdioxide.pdf>
 - <https://www.nps.gov/subjects/air/humanhealth-sulfur.htm#:~:text=Sulfur%20dioxide%20can%20convert%20to,at%20our%20national%20cultural%20monuments>
 - <https://www.sciencedirect.com/science/article/abs/pii/S004698178902172#:~:text=A%20much%20simplified%20model%20suggests,about%2005%20days%20for%20sulphur>
 - https://www.epa.gov/system/files/documents/2022-08/SO2_2021.pdf
 - <https://www.sciencedirect.com/science/article/abs/pii/S004698184903378#:~:text=The%20residence%20time%20of%20SO,10%E2%80%9319%20days%20in%20April>
 - [https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020JD033220#:~:text=The%20formed%20sulfate%20in%20precipitation%20cloud%20will,of%20cloud%20droplets%20\(Xu%20et%20al.%2C%201999\)](https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020JD033220#:~:text=The%20formed%20sulfate%20in%20precipitation%20cloud%20will,of%20cloud%20droplets%20(Xu%20et%20al.%2C%201999))

Ammonia

- Ammonia is readily broken down in the atmosphere and water
- High ammonia levels are toxic to fish
- High ammonia levels can also contribute to the formation of particulate matter 2.5
- Ammonia contributes to eutrophication by introducing excess nitrogen into water bodies, which promotes excessive growth of algae, consuming oxygen

- High levels can contribute to acidification of water and soil
- References:
 - <https://connectsci.au/ep/article-abstract/64/2/S512/23608/Ammonia-an-assessment-of-potential-environmental?redirectedFrom=fulltext>
 - https://www.greenpeace.org/static/planet4-eu-unit-stateless/2023/06/6975a2af-ammonia-brief_en_web.pdf
 - <https://royalsociety.org/-/media/policy/projects/evidence-synthesis/ammonia/ammonia-report.pdf>
 - <https://www.rand.org/randeurope/research/projects/2018/impact-of-ammonia-emissions-on-biodiversity.html>
 - <https://royalsociety.org/-/media/policy/projects/evidence-synthesis/ammonia/ammonia-report.pdf>
 - <https://wwwn.cdc.gov/TSP/PHS/PHS.aspx?phsId=9&toxicid=2>
 - [https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-ammonia-nh3#:~:text=Ammonia%20\(NH3\)%20is%20a%20gas,and%20be%20transported%20large%20distances](https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-ammonia-nh3#:~:text=Ammonia%20(NH3)%20is%20a%20gas,and%20be%20transported%20large%20distances)
 - <https://www.mda.state.mn.us/ecological-effects-ammonia>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/ammonia-total>
 - <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants/ammonia-2000>
 - https://en.wikipedia.org/wiki/Ammonia_pollution

Hydrogen Chloride

- Environmental impacts include acid rain formation, water contamination and damage to ecosystems through corrosion
- When in the atmosphere it is readily absorbed into water droplets contributing to acid rain
- It also contributes to water pollution, as it lowers the PH of the water, making it more acidic
- It contributes to soil contamination and leads to soil acidification
- Hydrogen Chloride can break down in the environment, with a half life of 11 days
- References:
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/hydrochloric-acid>
 - <https://pubmed.ncbi.nlm.nih.gov/21288016/>
 - <https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=759&toxicid=147>
 - <https://abacus.bates.edu/acad/depts/biobook/FP-HCl.pdf>
 - <https://hpychemicals.oecd.org/UI/handler.axd?id=e1fe4ef3-e3d4-4f3d-9a58-8bf2f8296b61>

Hydrogen Fluoride

- Environmental impacts include acid rain formation, water contamination and damage to ecosystems
- When in the atmosphere it is readily absorbed into water droplets contributing to acid rain
- It also contributes to water pollution, as it lowers the PH of the water, making it more acidic
- It contributes to soil contamination and leads to soil acidification
- Hydrogen Fluoride does not break down in the environment
 - It transforms into other chemical forms by reacting with water to form hydrofluoric acid; this acid is what contributes to acid rain
- References:
 - <https://www.industrialchemicals.gov.au/sites/default/files/PEC19-Hydrofluoric-acid.pdf>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/fluoride-compounds-sources-emissions>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0269749111006348>
 - <https://www.ncbi.nlm.nih.gov/books/NBK219903/#:~:text=Hydrogen%20fluoride%20is%20a%20corrosive,is%20highly%20soluble%20in%20water>
 - <https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=211&toxqid=38>

Volatile Organic Compounds

- Volatile Organic Compounds (VOCs) contribute to smog and ground level ozone, which can harm plants and animals
 - VOCs react with sunlight to form ground level ozone
- The Smog can damage plants, inhibit seed production and hinder fertilisation
- VOCs can decrease water quality making it unsuitable for reuse like irrigation
- VOCs pollute the soil
- Depending on the specific chemical, VOCs can take hours to years to break down in the environment
- References:
 - <https://www.sciencedirect.com/science/article/abs/pii/S0045653522039820>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/total-volatile-organic-compounds>
 - https://www.epd.gov.hk/epd/english/environmentinhk/air/prob_solutions/vocs_smog.html
 - <https://www.thecmmgroup.com/vocs-impact-environment/>
 - <https://www.nature.com/articles/s41598-025-99932-7>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC8700805/#:~:text=Certain%20VOCs%20were%20identified%20as%20greenhouse%20gases,the%20limited%20existing%20primary%20water%20resources%20%5B%5D>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0168165623002304#:~:text=VOCs%20are%20used%20as%20a,shows%20biomagnific>

[ation%20in%20food%20chain](#)

Dioxins and Furans

- Dioxins and Furans contaminate the soil, water and air by bioaccumulation in the food chain, due to their fat solubility and absorption by fat tissue in animals
- They are highly resistant to degradation
- They pose a significant risk to aquatic life
 - Aquatic organisms can suffer from reduced growth, development problems or even death, particularly at early life stages
- Dioxins and furans and persist in the environment for decades
- References:
 - <https://www.dcceew.gov.au/environment/protection/npis/substances/fact-sheets/polychlorinated-dioxins-and-furans>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0301479718307473>
 - <https://www.alsglobal.eu/specialities/dioxins-testing/dioxin-testing/about-dioxins>
 - <https://www.sciencedirect.com/science/article/abs/pii/S2214158817300624>
 - <https://www.who.int/news-room/fact-sheets/detail/dioxins-and-their-effects-on-human-health>
 - <https://www.waterquality.gov.au/sites/default/files/documents/dioxins-fresh-dgvs-technical%20brief.pdf>
 - <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants/dioxins-2000>
 - <https://mytapscore.com/en-au/blogs/tips-for-taps/dioxins-and-furans-toxic-chemicals-explained>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0269749119376973>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0301479718307473>

References:

- <https://www.toxicsfreeaustralia.org.au/wp-content/uploads/2025/07/waste-incinerators-undermine-clean-energy-goals.pdf>
- <https://greens.org.au/sites/default/files/2021-09/Incinerator%20fact%20sheet%202021.pdf>
- <https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=EXH-49547220%2120221215T030220.131%20GMT>
- <https://methodrecycling.com/world/journal/the-effects-of-waste-on-your-carbon-footprint#:~:text=However%2C%20while%20waste%2Dto%2D,than%20burning%20it%20for%20energy>

- <https://www.inciner8.com/blog/waste-to-energy/ccs-can-decarbonise-waste-incineration>
- https://zerowasteeurope.eu/wp-content/uploads/edd/2019/09/ZWE_Policy-briefing_The-impact-of-Waste-to-Energy-incineration-on-Climate.pdf

Potential Impact to Human Health – Criteria 1

The Emission Details sub section indicates that small, almost, insignificant quantities of dangerous substances are released during waste incineration on a regular basis.

While the day to day emissions are not harmful themselves, in such small quantities, the emissions that:

- Don't readily break down
- React with water or other chemicals in the air to form more harmful substances
- Take a week or more to fully break down

Have a significant potential to build up in the environment; with the risk of human interaction increasing for each day the emission exists in the environment.

Human interaction has the potential to result in absorption, ingestion and build up of these harmful substances in the human body. Chronic exposure over time has the potential to lead to significant impacts to quality of life and/or serious health complications, up to and including cancer and death.

Impact to Human Health Details sub section

The following details sub section will:

- Provide further information and references on the impacts to human health caused by the regularly occurring emissions and
- Classify those impacts for both Moderate and Severe impacts
 - Moderate
 - Daily allergic reactions (respiratory or otherwise)
 - Daily use of medication to cope with symptoms
 - Lower quality of life than an otherwise healthy person
 - Severe
 - Lifelong health problems such as, but not limited to:
 - Respiratory disease (daily Ventolin usage as an example)
 - Fertility problems
 - Birth defects
 - Cardiovascular illness
 - Increased chance of certain cancers
 - Significantly lower quality of life than an otherwise healthy person

Mercury

- Mercury can be encountered in two forms:
 - Mercury and
 - Half life in the Human body is between 30 and 60 days, however the rate can change depending on where the Mercury is accumulated
 - Can remain in the brain for a half life of potentially years
 - Methylmercury
 - Half life in the Human body is 50-70 days
 - Can easily cross the blood brain and placental barriers

- Impacts of inhaling or ingesting a sufficient amount of Mercury over time, as the substance does not readily break down, are:
 - Tremors
 - Irritability
 - Memory problems
 - Respiratory failure
 - Kidney damage
 - Mild signs of mercury exposure can be seen from elemental mercury in the air of 20 $\mu\text{g}/\text{m}^3$ or more over several years
 - Difficulty sleeping
 - Impaired sensations
 - Muscle weakness
 - Breathing difficulties
 - Death
- Mercury Impact Classification: Severe
- Impacts of inhaling or ingesting an average daily intake of 3-7 $\mu\text{g}/\text{kg}$ of Methylmercury over time, as the substance does not readily break down, are:
 - Birth of babies with deformities
 - Babies with severely impaired nervous systems
 - Neurodevelopmental delay or impairment
 - Disorders in Language, visual spatial skills, gross motor skills, memory and concentration
 - Chromosomal anomalies
 - Sperm reduction
 - Testicular atrophy
 - Reduced infant survival rates
 - Probability of correlation between methylmercury exposure and cardiovascular toxicity raised consistently in some studies
 - Raised risk of Myocardial infarction
 - Minamata Disease
 - Sensory disturbances
 - Impairment of hearing
 - Equilibrium disturbance
 - Foetal Minamata Disease
 - Cerebral Infantile Paralysis because the mother is exposed during pregnancy
 - Death
- Methylmercury Impact Classification: Severe
- References:
 - <https://my.clevelandclinic.org/health/diseases/23420-mercury-poisoning>
 - <https://www.who.int/news-room/fact-sheets/detail/mercury-and-health>
 - <https://www.betterhealth.vic.gov.au/health/healthyliving/mercury-exposure-and-poisoning#sources-of-mercury-exposure>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC11188640/#sec18>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/mercury-compounds>

- <https://pmc.ncbi.nlm.nih.gov/articles/PMC3514465/>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC3514464/#:~:text=The%20biological%20half%2Dlife%20of,in%20the%20body%20%5B4%5D>
- <https://www.atsdr.cdc.gov/toxprofiles/tp46-c3.pdf>
- <https://www.sciencedirect.com/science/article/abs/pii/S0041008X13005644>
- <https://www.chp.gov.hk/en/healthtopics/content/459/8949.html>
- <https://www.env.go.jp/en/chemi/hs/minamata2002/ch3.html>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC4757939/>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC4724159/>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC7916735/>

Cadmium

- The FDA (US) toxicological reference value for the acceptable limit of cadmium ingestion range from 0.21-0.36 µg/kg (micrograms per kilogram body weight per day)
- The toxic dose of this element ranges from 3 to 330 mg and the lethal dose is from 1.5 to 9g
- Fumes of this element's toxic range from 2.600 mg/m³ per minute of exposure
- Cadmium's half life in the body is:
 - Blood: 3 to 4 months
 - Bones: 10 to 30 years
 - Kidneys: 20 years
- Accumulation over time of this element can lead to the following health impacts, even from low dose exposures:
 - Stomach irritation from consuming food or drink contaminated with high levels of cadmium can lead to the following symptoms:
 - Nausea, vomiting, diarrhea
 - Abdominal cramps and pain
 - Headaches
 - Flu like symptoms
 - Lung problems such as Bronchitis, Emphysema and loss of function
 - Kidney Damage
 - Bone problems through vitamin D metabolism interference, such as weaker or brittle bones
 - Liver problems
 - Heart problems such as cardiomyopathy (weakening of the heart muscle)
 - Increased risk of certain cancers
- Initial, General, Cadmium Impact Classification: Moderate
- Chronic Cadmium Impact Classification: Severe
- References:
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC1247384/#:~:text=In%20addition%20to%20its%20well,IPCS%201992;%20Jarup%20et%20al>
 - <https://ehjournal.biomedcentral.com/articles/10.1186/s12940-016-0113-4>
 - <https://www.tandfonline.com/doi/full/10.1080/10408444.2025.2462653>

- <https://ir.library.louisville.edu/honors/334/#:~:text=Cadmium%20exposure%20occurs%20from%20various%20sources%2C%20including,the%20gastrointestinal%20tract%2C%20respiratory%20tract%2C%20or%20skin>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC4961911/#:~:text=Cadmium%20is%20mainly%20absorbed%20by%20inhalation%20but,personal%20hygiene%20at%20the%20place%20of%20work>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC10537762/>
- <https://www.mdpi.com/1420-3049/28/18/6620>
- https://archive.cdc.gov/www_atcdr_cdc_gov/csem/cadmium/Acute-Effects.html
- <https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/cadmium-poisoning>
- <https://my.clevelandclinic.org/health/diseases/23424-heavy-metal-poisoning-toxicity>
- <https://www.betterhealth.vic.gov.au/health/healthyliving/cadmium>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC6801231/>
- <https://rarediseases.org/rare-diseases/heavy-metal-poisoning/>
- <https://www.gov.uk/government/publications/cadmium-properties-incident-management-and-toxicology/cadmium-toxicological-overview>
- <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/cadmium-poisoning>
- <https://news.miami.edu/as/stories/2025/05/how-long-do-the-toxic-effects-of-cadmium-last.html>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC11209188/>
- <https://www.sciencedirect.com/science/article/abs/pii/S0048969724078574>
- <https://www.ncbi.nlm.nih.gov/books/NBK557806/>
- <https://www.sciencedirect.com/science/article/pii/S2772416625000208>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC10537762/>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC10537762/>
- <https://www.fda.gov/food/environmental-contaminants-food/cadmium-food-and-foodwares>

PM 2.5

- There is no safe level of PM 2.5 where there is no health impact
- The World Health Organisation recommends an annual average of no more than 5 $\mu\text{g}/\text{m}^3$ and a 24 hour average not exceeding 15 $\mu\text{g}/\text{m}^3$
- Australia's national standard is 8 $\mu\text{g}/\text{m}^3$ annually and 25 $\mu\text{g}/\text{m}^3$ over a 24 hour period
- There is no single half life of PM 2.5 in the body due to its complex mixture of particles that are eliminated at different rates
 - Ultra fine particles are not easily removed and penetrate deep into the lungs
 - Some can enter the bloodstream
 - Those particles with a composition similar to heavy metals can persist for an extended period, which can have half lives of months or years, depending on the specific element

- Accumulation over time of this substance can lead to the following health impacts, even from low dose exposures:
 - Respiratory symptoms such as:
 - Irritated eyes, nose and throat
 - Persistent coughing
 - Sneezing
 - Running nose
 - Shortness of breath or difficulty breathing
 - Respiratory inflammation
 - Wheezing
 - Chest tightness
 - Worsening of pre-existing heart conditions
 - Increased risk of heart attacks or irregular heartbeats
 - Worsening of asthma and lung diseases like Chronic Obstructive Pulmonary Disease (COPD)
 - Jeopardises lung function
- PM 2.5 Impact Classification: Severe
- References:
 - <https://www.openaccessgovernment.org/air-pollution-inflammatory-lung-diseases/67352/#:~:text=However%2C%20new%20studies%20indicated%20that%20the%20real,ingested%20or%20taken%20up%20by%20other%20ways>
 - <https://acp.copernicus.org/articles/19/9399/2019/acp-19-9399-2019.pdf>
 - <https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/particle-pollution#:~:text=Our%20natural%20defenses%20help%20us,smaller%20fine%20or%20ultrafine%20particles>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC7582569/#:~:text=residential%20fuel%20combustion,-PM2.,shortly%20removed%20from%20the%20body>
 - <https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#:~:text=Some%20particles%20less%20than%2010,the%20greatest%20risk%20to%20health>
 - <https://www.sciencedirect.com/science/article/abs/pii/S0304389420318604>
 - [https://pmc.ncbi.nlm.nih.gov/articles/PMC10002561/#:~:text=Due%20to%20its%20\(%20Suspended%20particulate%20matter,harmful%20effects%20of%20PM%202.5%20%5B%203%5D](https://pmc.ncbi.nlm.nih.gov/articles/PMC10002561/#:~:text=Due%20to%20its%20(%20Suspended%20particulate%20matter,harmful%20effects%20of%20PM%202.5%20%5B%203%5D)
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC9690751/#:~:text=Another%20explanation%20was%20that%20fine%20particulate%20matter,PM%202.5%20%5B%2009%2C%2010%2C%2011%2C%2018%5D>
 - https://www.c40knowledgehub.org/s/article/WHO-Air-Quality-Guidelines?language=en_US#:~:text=By%20reducing%20air%20pollution%20levels,3%20%2D%204%20days%20per%20year
 - <https://www.theguardian.com/environment/2023/may/04/air-pollution-in-australia-how-bad-is-particulate-matter-health-effects-particles->

[facts#:~:text=5%20exposure?,respiratory%20medicine%20at%20Macquarie%20University](#)

- <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/particulate-matter-pm10-and-pm25#:~:text=Under%20the%20National%20Environment%20Protection,Workplace%20exposure%20standards>
- <https://www.health.gov.au/sites/default/files/2024-08/pm2-5-air-quality-categories-and-public-health-advice.pdf>
- <https://www.health.nsw.gov.au/environment/air/Pages/particulate-matter.aspx>
- <https://pubmed.ncbi.nlm.nih.gov/articles/PMC4740125/>
- <https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm>
- <https://www.medparkhospital.com/en-US/lifestyles/pm25>
- https://www.health.ny.gov/environmental/indoors/air/pm2_5_a.htm
- [https://www.airnow.gov/air-quality-and-health/your-health/#:~:text=Symptoms%20may%20include:%20irritation%20of,lung%20disease\)%2C%20and%20children](https://www.airnow.gov/air-quality-and-health/your-health/#:~:text=Symptoms%20may%20include:%20irritation%20of,lung%20disease)%2C%20and%20children)
- <https://www.sciencedirect.com/science/article/pii/S2666765724001212>
- <https://pubmed.ncbi.nlm.nih.gov/articles/PMC4740125/>
- <https://www.stateofglobalair.org/health/pm>
- <https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health>
- <https://www.who.int/publications/i/item/9789240034228>

Carbon Dioxide

- Waste to Energy Incinerator facilities can increase local Carbon Dioxide levels in its local radius
 - There is no single definition of a local radius, however references cite that a 5km radius is considered to be local
 - This writer asks for consideration of a 10km radius as though emissions do disperse significantly at the 10km boundary, the emissions are still present at much lower concentrations
 - However, the data on this is incomplete, as the only identified sources researched PM 10 dispersal, which is largely controlled in modern Waste to Energy Incinerators.
 - Emerging studies do appear to indicate the possibility of this radius
 - Though it stands to reason that if PM 10 was identified at these distances, similarly weighted substances and particles could also travel these distances
 - References:
 - <https://onlinelibrary.wiley.com/doi/10.1155/2013/560342>
 - <https://nap.nationalacademies.org/read/5803/chapter/6#90>
 - <https://www.sciencedirect.com/science/article/pii/S0160412025001990>

- https://www.researchgate.net/publication/300689651_Case_Study_Comparison_of_Air_Dispersion_from_Solid_Waste_Incinerator_Emission_Using_AERMOD_and_ISCS_T3
 - This radius depends on the size of the facility and the emission control technology in use
 - Carbon Dioxide levels fluctuate due to the amount of materials such as plastics, biomass being burned on a given day
 - The impacts of long term Carbon Dioxide poisoning is not well understood and more research is needed
- Increase of Carbon Dioxide levels to those sensitive to it can lead to the following health impacts:
 - Headaches
 - Dizziness
 - Nausea and vomiting
 - Weakness or fatigue
 - Shortness of breath
 - Rapid Heartbeat
 - Confusion
 - Flu like symptoms, without fever
 - Impaired cognitive function
 - Confusion or disorientation
 - Seizures
 - Chest Pain
 - Fainting
- General Symptoms Carbon Dioxide Impact Classification: Moderate
- More serious Symptoms Carbon Dioxide Impact Classification: Severe
- References:
 - <https://www.thekids.org.au/projects/chronic-carbon-dioxide-exposure-an-unrecognised/>
 - <https://www.co2meter.com/en-au/blogs/news/carbon-dioxide-indoor-levels-chart>
 - <https://www.dhs.wisconsin.gov/chemical/carbondioxide.htm>
 - https://emeritus.anu.edu.au/_resources/e-texts/co2toxicity%20EF.pdf
 - <https://www.verywellhealth.com/hypercapnia-symptoms-treatment-914862>
 - [https://www.emedicinehealth.com/wilderness_carbon_dioxide_toxicity/symptom.htm#:~:text=nausea%2C%20vomiting%2C%20dizziness%2C%20headache%2C%20rapid%20breathing%2C%20fast,\(warmth%2C%20redness%2C%20or%20tingling%20of%20the%20skin\)](https://www.emedicinehealth.com/wilderness_carbon_dioxide_toxicity/symptom.htm#:~:text=nausea%2C%20vomiting%2C%20dizziness%2C%20headache%2C%20rapid%20breathing%2C%20fast,(warmth%2C%20redness%2C%20or%20tingling%20of%20the%20skin))
 - <https://www.sciencedirect.com/science/article/abs/pii/S0956053X17309388>
 - <https://www.rts.com/blog/what-is-waste-to-energy/>

Carbon Monoxide

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 - <https://onlinelibrary.wiley.com/doi/10.1155/2013/560342>
 - <https://nap.nationalacademies.org/read/5803/chapter/6#90>
 - <https://www.sciencedirect.com/science/article/pii/S0160412025001990>
 - https://www.researchgate.net/publication/300689651_Case_Study_Comparison_of_Air_Dispersion_from_Solid_Waste_Incinerator_Emission_Using_AERMOD_and_ISCS_T3
 - This radius depends on the size of the facility and the emission control technology in use
- Standard exposure limits, over an 8 hour period for Carbon Monoxide is currently 30 ppm
- The half life of Carbon Monoxide in the body is about 4-5 hours at standard indoor room air
- Chronic exposure to Carbon Monoxide, even at low does, for those sensitive can contribute to:
 - Headaches
 - Fatigue or tiredness
 - Dizziness
 - Nausea or vomiting
 - Weakness
 - Shortness of breath
 - Confusion
 - Personality changes
 - Memory Loss
 - Poor concentration
 - Difficulty with learning
 - Balance problems
 - Difficulty with gait

- Depression
- Anxiety
- Irritability
- Hearing loss
- Vision problems
- Abdominal pain
- Long term brain injury in severe cases
- Initial, General symptoms, Carbon Monoxide Impact Classification: Moderate
- More serious symptoms Carbon Monoxide Impact Classification: Severe
- References:
 - <https://hcis.safeworkaustralia.gov.au/ExposureStandards/Document?exposureStandardID=111>
 - <https://www.ncbi.nlm.nih.gov/books/NBK430740/>
 - <https://litfl.com/carbon-monoxide-poisoning/>
 - <https://www.safework.sa.gov.au/workplaces/chemicals-and-substances/storage,-use-and-transport-of-hazardous-chemicals/carbon-monoxide>
 - <https://www.worksafe.vic.gov.au/preventing-carbon-monoxide-poisoning-lpg-powered-floor-cleaners>
 - [https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/carbon-monoxide-0#:~:text=Safe%20Work%20Australia%20sets%20the%20workplace%20exposure,\(TWA\):%2030%20parts%20per%20million%20\(34%20mg/m3\)](https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/carbon-monoxide-0#:~:text=Safe%20Work%20Australia%20sets%20the%20workplace%20exposure,(TWA):%2030%20parts%20per%20million%20(34%20mg/m3))
 - <https://pubmed.ncbi.nlm.nih.gov/10605352/>
 - <https://www.schn.health.nsw.gov.au/carbon-monoxide-poisoning-factsheet>
 - <https://www.mayoclinic.org/diseases-conditions/carbon-monoxide/symptoms-causes/syc-20370642>
 - <https://oem.bmj.com/content/59/10/708>
 - <https://www.sciencedirect.com/science/article/pii/S2214750023000732#:~:text=Parkinsonism%2C%20cortical%20blindness%2C%20mutism%2C,injury%20to%20the%20white%20matter>
 - <https://www.cognitivefxusa.com/blog/carbon-monoxide-poisoning-long-term-effects#:~:text=Physical%20and%20movement%20disorders%20can%20affect%20about,also%20a%20common%20problem%20in%20severe%20cases>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC5363978/>

Nitrogen Oxides

- Nitrogen Oxides such as Nitric Oxide and Nitrogen Dioxide are compounds that make up Nitrogen Oxides
- Nitric Oxide
 - Can form as a result of temperatures exceeding 1300°C (often required by Medical Waste to Energy Incinerators to handle hazardous materials)
 - Can also form as a result of industrial processes using ammonia as a platinum catalyst
 - Waste to Energy Facilities typically use Ammonia as a reagent along with a catalyst which could be platinum, vanadium or zeolite) which is used to reduce Nitrogen Oxides in the SCR air purification system
 - There is no set acceptable limit for nitric oxide
 - Is a known component of smog
 - Can contribute to the formation of ozone and particulate matter in the air
 - Also used in medical and Industrial applications at low concentrations
 - Low levels of airborne nitric oxide can contribute to the following health implications over long term exposure:
 - Eye, nose, throat and lung irritation
 - Exacerbate existing respiratory conditions like asthma
 - Oxidative stress leading to chronic inflammation in the lungs
 - Some studies have begun to link nitric oxide with increased dementia risk and Alzheimer's
- Nitrogen Dioxide
 - The World Health Organization recommends a maximum annual average of 10 ppb (parts per billion) ($20 \mu\text{g}/\text{m}^3$) and a maximum 24 hour average of $25 \mu\text{g}/\text{m}^3$ or 13 ppb
 - Is a known regulated air pollutant
 - Though also emitted from cars, industrial activity, gas stoves, gas heaters and tobacco smoke, waste to energy incinerators would increase the levels of nitrogen dioxide in the ambient air
 - Low levels of nitrogen dioxide can contribute to the following health implications over long term exposure:
 - Worsen asthma symptoms
 - Exposure for children can increase their risk of respiratory illness
 - Can contribute to reduced lung function, later in life, for children constantly exposed
- Initial, General symptoms, Nitrogen Oxides Impact Classification: Moderate
- More serious symptoms, Nitrogen Oxides Impact Classification: Severe
- References:
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC10572643/>
 - <https://www.epa.gov/no2-pollution/basic-information-about-no2>
 - <https://wwwn.cdc.gov/tsp/ToxFAQs/ToxFAQsDetails.aspx?faqid=396&toxqid=69>
 - <https://pmc.ncbi.nlm.nih.gov/articles/PMC2933573/>

- <https://www.sciencedirect.com/science/article/abs/pii/B9780323898577000207>
- <https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/nitrogen-oxides>
- <https://sites.ndtv.com/breathe-clean/indoor-pollution-the-silent-killer>
- <https://document.airnow.gov/air-quality-guide-for-nitrogen-dioxide.pdf>
- <https://www.epa.gov/no2-pollution/basic-information-about-no2#:~:text=Health%20effects&text=Such%20exposures%20over%20short%20periods,and%20visits%20to%20emergency%20rooms>
- <https://www.intechopen.com/chapters/87028>
- <https://environment.govt.nz/facts-and-science/air/air-pollutants/nitrogen-dioxide-effects-health/#:~:text=Effects%20on%20health,-The%20main%20health&text=Inhalation%20of%20nitrogen%20dioxide%20by,hospital%20admissions%20for%20respiratory%20disease.>
- [https://pmc.ncbi.nlm.nih.gov/articles/PMC6976917/#:~:text=In%20the%20short%20term%2C%20exposure,causes%20airway%20disease%20\(e8\)](https://pmc.ncbi.nlm.nih.gov/articles/PMC6976917/#:~:text=In%20the%20short%20term%2C%20exposure,causes%20airway%20disease%20(e8))
- <https://www.inbiot.es/wikinbiot/nitrogen-dioxide>
- <https://www.sciencedirect.com/science/article/abs/pii/S1438463905000672>
- [https://www.clarity.io/blog/air-quality-measurements-series-nitrogen-dioxide#:~:text=Globally%2C%20the%20World%20Health%20Organization%20\(WHO\)%20sets,10%20%CE%BCg/m3%20for%20the%20annual%20mean%20level](https://www.clarity.io/blog/air-quality-measurements-series-nitrogen-dioxide#:~:text=Globally%2C%20the%20World%20Health%20Organization%20(WHO)%20sets,10%20%CE%BCg/m3%20for%20the%20annual%20mean%20level)
- <https://www.epa.gov/no2-pollution/primary-national-ambient-air-quality-standards-naaqs-nitrogen-dioxide>
- <https://www.ncbi.nlm.nih.gov/books/NBK554539/>
- <https://www.aeroqual.com/blog/meet-the-nitrogen-oxide-family>
- <https://en.wikipedia.org/wiki/NOx>
- <https://www.britannica.com/science/nitric-oxide>
- https://en.wikipedia.org/wiki/Nitric_oxide
- <https://en.wikipedia.org/wiki/NOx#:~:text=In%20atmospheric%20chemistry%2C%20NO%20x%20is%20shorthand,rain%2C%20as%20well%20as%20affecting%20tropospheric%20ozone>
- https://en.wikipedia.org/wiki/Biological_functions_of_nitric_oxide
- <https://www.mdpi.com/2073-4344/14/11/766>
- <https://d-nb.info/1354493370/34>
- [https://www.cleanenergywire.org/factsheets/waste-energy-controversial-power-generation-incineration#:~:text=Activated%20carbon%20\(charcoal%20treated%20with%20oxygen%20to,exposing%20flue%20gases%20to%20very%20high%20temperatures](https://www.cleanenergywire.org/factsheets/waste-energy-controversial-power-generation-incineration#:~:text=Activated%20carbon%20(charcoal%20treated%20with%20oxygen%20to,exposing%20flue%20gases%20to%20very%20high%20temperatures)
- <https://www.sciencedirect.com/science/article/abs/pii/S0920586111000265>
- <https://encyclopedia.pub/entry/14875>
- <https://encyclopedia.pub/entry/14875>
- <https://www.mdpi.com/1420-3049/27/23/8578>

- [https://www.sciencedirect.com/science/article/abs/pii/S030451029085154A#:~:text=The%20main%20limitations%20are%20\(i,the%20synthesis%20of%20bulky%20molecules](https://www.sciencedirect.com/science/article/abs/pii/S030451029085154A#:~:text=The%20main%20limitations%20are%20(i,the%20synthesis%20of%20bulky%20molecules)
- https://www.researchgate.net/post/What_are_the_limitations_of_zeolites_as_a_catalyst#:~:text=In%20the%20organic%20synthesis%2C%20the%20zeolites%20as,of%20heavy%20secondary%20products%20found%20with%20zeolites
- <https://www.sciencedirect.com/topics/engineering/platinum-catalyst#:~:text=A%20platinum%20catalyst%20is%20defined,the%20reduction%20of%20nitrogen%20oxides>
- <https://www.sciencedirect.com/science/article/abs/pii/S030451029085154A>
- https://www.researchgate.net/publication/369050240_Structure_sensitivity_of_alumina-_and_zeolite-supported_platinum_ammonia_slip_catalysts

Sulfur Oxides

- The World Health Organization states that 40 $\mu\text{g}/\text{m}^3$ of sulfur oxides concentration in the air are the acceptable limits for a 24 hour period
 - Australia sets workplace limits at 2 ppm or 5.2 $\mu\text{g}/\text{m}^3$ over an 8 hour time-weighted average
 - Ambient outdoor air standards for sulfur oxides, on a 1 hour average, is 0.075 ppm and 0.02 ppm over 24 hours
 - In New Zealand in the short term exposure to sulfur dioxide is assessed against the National Environmental Standards for Air Quality (NESAQ) 1 hour average standard of between 350 $\mu\text{g}/\text{m}^3$ and 570 $\mu\text{g}/\text{m}^3$
 - As well as the World Health Organization 2005 standard of 20 $\mu\text{g}/\text{m}^3$ in 24 hours
 - It should be noted that in 2021 New Zealand advised against adopting the less stringent air quality guideline of 40 $\mu\text{g}/\text{m}^3$ from the World Health Organization
 - Can react with other chemicals in the air to form particulate matter
- A Sulfur Oxide, sulfur dioxide, at low levels, can contribute to the following health implications over long term exposure:
 - Irritation of the nose, throat and lungs
 - Coughing, wheezing and increased mucus secretion in the airways
 - Increased risk of respiratory tract infections
 - Can worsen asthma, chronic bronchitis symptoms
 - Negative effects are more pronounced while exercising
 - Potential link with low level exposure over time and cardiovascular disease
 - Fine particles can penetrate deep into the lungs and cause similar health effects to those caused by gaseous sulfur dioxide
- New information has emerged suggesting a potential link between long term exposure to sulfur dioxide in the ambient air and an increased risk of Amyotrophic Lateral Sclerosis (ALS)
 - The article and associated research states that:

- Long term exposure to sulfur dioxide, which is a component of oil based fuel (which plastic is developed from) has been linked to increased risk of ALS, based on higher reported rates near mining operations where the study was conducted in Canada
 - The study, however, did only focus on association, not causation
 - Quotes from the article:
 - “High levels of SO₂ (Sulfur Dioxide) can be created during “anything that has to do with mining activities” as well as the use of fossil fuels for energy, such as the burning of coal or diesel-operated equipment.”
- Initial, General symptoms, Sulfur Oxides Impact Classification: Moderate
- References:
 - <https://abcnews.go.com/Health/exposure-mining-fossil-fuel-linked-als-new-research/story?id=126254429>
 - <https://www.sciencedirect.com/science/article/pii/S0013935125014835?via%3Dihub>
 - [https://www.nps.gov/subjects/air/humanhealth-sulfur.htm#:~:text=High%20concentrations%20of%20SO₂%20can%20affect%20lung%20function%2C%20worsen,and%20cause%20similar%20health%20effects](https://www.nps.gov/subjects/air/humanhealth-sulfur.htm#:~:text=High%20concentrations%20of%20SO2%20can%20affect%20lung%20function%2C%20worsen,and%20cause%20similar%20health%20effects)
 - <https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/sulfur-dioxide#:~:text=Sulfur%20dioxide%20affects%20the%20respiratory,as%20asthma%20and%20chronic%20bronchitis>
 - <https://environment.govt.nz/facts-and-science/air/air-pollutants/sulphur-dioxide-and-effects-on-health/#:~:text=Sulphur%20dioxide%20can%20cause%20respiratory,been%20linked%20to%20cardiovascular%20disease>
 - <https://www.iqair.com/newsroom/2021-who-air-quality-guidelines#:~:text=Nearly%20all%20sulfur%20dioxide%20emissions%20come%20from,interval%20weren%27t%20re%2Devaluated%20and%20remain%20the%20recommendation>
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/sulfur-dioxide>
 - [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)
 - <https://environment.govt.nz/publications/our-air-2021/indicator-findings/#:~:text=We%20also%20assess%20against%20the%20less%20stringent,a%2024%2Dhour%20average%20of%2040%20%CE%BCg/m%203>

Ammonia

- There does not appear to be a single acceptable daily level for ammonia in the ambient air for the general public
 - Guidelines are currently focused on where this is predominantly encountered, in industrial workplaces
 - Australia sets workplace airborne concentration levels at 25 ppm (17 mg/m³) over 8 hours at a maximum
- Ammonia, at low airborne levels can contribute to the following health implications over long term exposure:
 - Irritation to the eyes, nose and throat
 - Coughing
 - Runny nose
 - Narrowing of the airways
 - Repeated or prolonged exposure can lead to lung damage and may cause an asthma like allergy
 - People with asthma may be more sensitive to ammonia and their condition may be aggravated with increased concentrations
- Initial, General symptoms, Ammonia Impact Classification: Moderate
- More serious symptoms, Ammonia Impact Classification: Severe
- References:
 - <https://www.cdc.gov/chemical-emergencies/chemical-fact-sheets/ammonia.html#:~:text=Abdominal%20pain%2C%20nausea%2C%20or%20vomiting,%2C%20tastes%2C%20or%20looks%20unusual>
 - https://www.ccohs.ca/oshanswers/chemicals/chem_profiles/ammonia.html
 - [https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=10&toxid=2#:~:text=as%20on%20farms\).- ,How%20can%20ammonia%20affect%20my%20health?,cause%20burns%20and%20even%20blindness](https://wwwn.cdc.gov/TSP/ToxFAQs/ToxFAQsDetails.aspx?faqid=10&toxid=2#:~:text=as%20on%20farms).- ,How%20can%20ammonia%20affect%20my%20health?,cause%20burns%20and%20even%20blindness)
 - <https://nj.gov/health/eoh/rtkweb/documents/fs/0084.pdf>
 - <https://wwwn.cdc.gov/TSp/MMG/MMGDetails.aspx?mmgid=7&toxid=2#:~:text=Inhaling%20ammonia%20causes%20rapid%20onset,serious%20corrosive%20burns%20on%20contact>
 - <https://www.gov.uk/government/publications/ammonia-properties-incident-management-and-toxicology/ammonia-general-information#:~:text=Breathing%20in%20low%20levels%20of,burns%20throughout%20the%20digestive%20tract>
 - [https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/ammonia-total#:~:text=Safe%20Work%20Australia%20sets%20the,\(24%20mg/m3 \)](https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/ammonia-total#:~:text=Safe%20Work%20Australia%20sets%20the,(24%20mg/m3))

Hydrogen Chloride

- The European Union (EU) and United States (US) Centre for Disease Control (CDC) appear to agree on an occupational exposure limit for Hydrogen Chloride at 5 ppm for an 8 hour time-weighted average
- For the ambient air, concentrations typically range much lower, between 0.4 and 4 µg/m³
 - The odour threshold typically is 0.77 ppm, however it may be higher for some people and is not a reliable indicator for safety
- Hydrogen Chloride at low airborne levels can contribute to the following health implications over long term exposure:
 - Irritation to the eyes, nose and throat
 - Irritation of the respiratory tract
 - In some cases leading to the inflammation of the lungs and pulmonary edema (fluid on the lungs)
 - The full, long term, implications of long-term, low-level exposure are not yet fully understood, however due to the corrosive nature of Hydrogen Chloride long term exposure to tissue can be harmful
- Initial, General symptoms, Hydrogen Chloride Impact Classification: Moderate
- More serious symptoms, Hydrogen Chloride Impact Classification: Severe
- References:
 - <https://www.ncbi.nlm.nih.gov/books/NBK230426/#:~:text=Acute%20exposure%20to%20high%20concentrations%20might%20produce,the%200eyes%2C%20it%20has%20good%20warning%20properties>
 - <https://www.atsdr.cdc.gov/toxfaqs/tfacts173.pdf>
 - <https://www.epa.gov/sites/default/files/2016-09/documents/hydrochloric-acid.pdf>
 - <https://www.acmt.net/news/vinyl-chloride/>
 - <https://www.gov.uk/government/publications/hydrogen-chloride-properties-incident-management-and-toxicology/hydrogen-chloride-toxicological-overview#:~:text=General%20toxicity,with%20moisture%20in%20the%20air>
 - <https://nj.gov/health/eoh/rtkweb/documents/fs/1012.pdf>
 - <https://www.ncbi.nlm.nih.gov/books/NBK424680/>
 - <https://www.cdc.gov/TSP/MMG/MMGDetails.aspx?mmgid=758&toxid=147>

Hydrogen Fluoride

- The United Kingdom (UK) guidelines for Hydrogen Fluoride for general public exposure in the ambient air states the amount should not exceed 0.2 ppm (0.16 µg/m³) over a 1 hour period
- The USA CDC states that in non-industrial areas, ambient air fluoride levels are typically 1 µg/m³
- Hydrogen Fluoride in the air can cause the following health implications over long term exposure, even at low levels:
 - Irritation to the eyes, nose, throat
 - Coughing

- Chest pain
- Can be absorbed into the body and as it doesn't readily break down it can lead to systematic toxicity, impacting the heart, kidneys and liver
- Chronic and or prolonged exposure at low levels can lead to:
 - Respiratory problems
 - Sinus disorders
- Initial, General symptoms, Hydrogen Fluoride Impact Classification: Moderate
- More serious symptoms, Hydrogen Fluoride Impact Classification: Severe
- References:
 - <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/fluoride-compounds-sources-emissions>
 - <https://www.industrialchemicals.gov.au/sites/default/files/PEC19-Hydrofluoric-acid.pdf>
 - https://www.safeworkaustralia.gov.au/system/files/documents/1702/hydrogenfluoride_1989pdf.pdf
 - <https://www.ncbi.nlm.nih.gov/books/NBK597858/>
 - <https://www.ncbi.nlm.nih.gov/books/NBK219903/>
 - https://uk-air.defra.gov.uk/assets/documents/reports/cat11/0805151602_Halogen_and_Hydrogen_Halides_Addendum.pdf
 - <https://wwwn.cdc.gov/TSP/PHS/PHS.aspx?phsid=210&toxid=38>
 - https://www.safeworkaustralia.gov.au/system/files/documents/1702/hydrogenfluoride_1989pdf.pdf

Volatile Organic Compounds

- Total Volatile Organic Compounds (VOCs) guidelines state that the total level for VOCs should be below 500 g/m³ (0.5 µg/m³) or 0.25 ppm; this also appears to be acceptable for indoor levels
- The compounds themselves are:
 - Propane
 - Butane
 - Methane
 - Isoprene
 - Benzene
 - Toluene (derivative of Benzene)
 - Ethylbenzene (derivative of Benzene)
 - Xylenes (derivative of Benzene)
 - Ethanol
 - Formaldehyde
 - Butanone
 - Methylene Chloride
 - Carboxylic acids and esters
- VOCs in the air can cause the following health implications over long term exposure, even at low levels:
 - Respiratory irritation
 - Headaches
 - Dizziness

- Nausea
- Memory loss
- Learning difficulties
- Personality changes
- Worsen symptoms for people with asthma
- Chronic irritation of the nose and throat
- Damage to the liver, kidneys and Central Nervous System
- Initial, General symptoms, Volatile Organic Compounds Impact Classification: Moderate
- More serious symptoms, Volatile Organic Compounds Impact Classification: Severe
- References:
 - <https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality>
 - <https://www.lung.org/clean-air/indoor-air/indoor-air-pollutants/volatile-organic-compounds>
 - <https://www.dcceew.gov.au/environment/protection/npis/substances/fact-sheets/total-volatile-organic-compounds>
 - <https://www.tremco.com.au/buildsmarterblog/hot-topics/understanding-volatile-organic-compounds#:~:text=One%20of%20the%20most%20pressing%20concerns%20regarding,pre%20existing%20health%20conditions%20are%20especially%20at%20risk>
 - <https://pubmed.ncbi.nlm.nih.gov/articles/PMC5910572/>
 - <https://www.cdc.gov/niosh/docs/87-104/default.html>
 - <https://www.health.state.mn.us/communities/environment/air/toxins/voc.c.htm>
 - <https://www.sciencedirect.com/science/article/pii/S0147651325003380>
 - <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/volatile-organic-compound>
 - <https://pubmed.ncbi.nlm.nih.gov/articles/PMC6748254/>
 - <https://www.pressac.com/insights/what-are-volatile-organic-compounds-and-why-to-monitor-them/>
 - https://en.wikipedia.org/wiki/Volatile_organic_compound
 - <https://www.eea.europa.eu/help/glossary/eea-glossary/volatile-organic-compound-voc>
 - <https://tsi.com/indoor-environments/learn/volatile-organic-compounds-guide#:~:text=Safe%20levels%20of%20VOCs%20can,m3%20can%20be%20considered%20acceptable>
 - [https://atmotube.com/blog/tvoc-monitoring-in-commercial-and-office-buildings#:~:text=VOC%20ppm%20from%20200.20%20to,considered%20a%20dangerous%20TVOC%20level.&text=Acceptable%20indoor%20VOC%20levels%20\(in,ppm%20or%20400%20%20C2%B5g/m3](https://atmotube.com/blog/tvoc-monitoring-in-commercial-and-office-buildings#:~:text=VOC%20ppm%20from%20200.20%20to,considered%20a%20dangerous%20TVOC%20level.&text=Acceptable%20indoor%20VOC%20levels%20(in,ppm%20or%20400%20%20C2%B5g/m3)
 - <https://learn.kaiterra.com/en/resources/understanding-tvoc-volatile-organic-compounds>

Dioxins and Furans

- Dioxins
 - The half life of Dioxins in the human body is estimated to be between 7 and 11 years, though this can vary depending on the specific type of dioxin and individual factors, such as age and body fat
 - Despite their potency and persistent nature there does not appear to be a universal standard for dioxin concentrations in the air. Instead, their impact is, typically, measured in Tolerable Daily Exposure (TDI)
 - The World Health Organization recommends a TDI of 1-4 pg/kg body weight per day from all sources combined, which is 70 to 280 pg/day for a 70 kg person
 - The health impacts for dioxins, even at low levels, over time (as they bioaccumulate) can be:
 - Nausea
 - Vomiting
 - Diarrhea
 - Liver damage
 - Increased risk of cancer
 - Damage to the immune system
 - Hormonal disruptions
 - Low testosterone levels in men
 - Reproductive and developmental problems
 - Decreased fertility
 - Immune system impairment
 - Impaired learning and intelligence
 - Liver damage
 - Thyroid damage
 - Cardiovascular damage
 - Dioxins Impact Classification: Severe
- Furans
 - Furans also have an estimated half life in the human body between 7 to 11 years
 - Furans accumulate in the body fat and do not break down readily, because they are stable and fat soluble
 - The health impacts for furans, even at low levels, over time can be:
 - Headache
 - Light headedness
 - Dizziness
 - Passing out
 - Muscle weakness
 - Difficulty concentrating
 - Difficulty with memory
 - Liver damage
 - Kidney damage
 - Furans Impact Classification: Severe
- References:

- <https://www.saveamericasforests.org/Forests%20-%20Incinerators%20-%20Biomass/Documents/Briefing/Presentations/Dioxin%20References.pdf>
- <https://nj.gov/health/eoh/rtkweb/documents/fs/0952.pdf>
- <https://environment.govt.nz/facts-and-science/air/air-pollutants/dioxins-furans-pcbs-effects-health/>
- <https://www.epa.gov/dioxin/learn-about-dioxin>
- <https://pubs.rsc.org/en/content/articlelanding/2025/ay/d4ay01767f/una-uth>
- <https://www.healthandenvironment.org/resources/environmental-hazards/chemicals-and-materials/dioxins>
- <https://www.alsglobal.eu/specialities/dioxins-testing/dioxin-testing/about-dioxins>
- <https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/polychlorinated-dioxins-and-furans>
- <https://www.healthdirect.gov.au/pesticides>
- <https://torrentlab.com/lets-understand-how-dioxins-and-furans-are-harmful-to-human-health/>
- <https://nj.gov/health/eoh/rtkweb/documents/fs/0952.pdf>
- <https://www.waxlawfirm.com/blog/2018/february/understanding-the-long-term-effects-of-toxic-exp/#:~:text=Stomach%20and%20digestive%20problems%2C%20organ,to%20some%20of%20these%20symptoms.>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC9227754/#:~:text=The%20half%2Dlife%20of%20dioxins,2%2C9%2C44%5D>
- <https://www.niehs.nih.gov/health/topics/agents/dioxins#:~:text=Dioxins%20are%20mainly%20byproducts%20of,such%20as%20wildfires%20and%20volcanoes>
- <https://respiratory-research.biomedcentral.com/articles/10.1186/s12931-022-01983-1#:~:text=Relative%20risk%20estimates%20from%20air%20pollution%20studies,increment%20units%20and%20target%20groups%20for%20analysis>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC10143573/>
- [https://www.nepc.gov.au/publications/archive/ephc-archive/ephc-archive-ambient-air-quality-nepm#:~:text=the%20standard%20setting%20process%20used%20\(including%20the,on%20a%20case%2Dby%2Dcase%20basis%20for%20each%20pollutant](https://www.nepc.gov.au/publications/archive/ephc-archive/ephc-archive-ambient-air-quality-nepm#:~:text=the%20standard%20setting%20process%20used%20(including%20the,on%20a%20case%2Dby%2Dcase%20basis%20for%20each%20pollutant)
- <https://www.agriculture.gov.au/sites/default/files/documents/report-12.pdf>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC2898056/>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC10246344/#:~:text=Lastly%2C%20we%20did%20not%20examine%20dietary%20exposure,unlikely%20to%20be%20confounded%20by%20dietary%20exposures>
- <https://www.who.int/news-room/fact-sheets/detail/dioxins-and-their-effects-on-human->

[health#:~:text=Once%20dioxins%20enter%20the%20body,be%207%20to%2011%20years](#)

- <https://www.gov.uk/government/publications/dioxins-properties-incident-management-and-toxicology/dioxins-toxicological-overview>
- https://www.fao.org/uploads/media/FAO_Fact_Sheet_020408.pdf
- <https://arctic-council.org/news/5-facts-to-know-about-dioxins-one-of-the-most-toxic-compounds-on-earth/>
- <https://www.gov.uk/government/publications/dioxins-properties-incident-management-and-toxicology/dioxins-toxicological-overview>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC2661912/>
- <https://pubmed.ncbi.nlm.nih.gov/30721813/>

Alternative Approaches – Criteria 3

With the apparent and emerging evidence that can be deduced from the references and points in the above sections it appears that Waste to Energy Incineration will:

- Produce harmful chemicals, substances and particulates across the lifetime of the facility (contracted or otherwise) that build up over time (regardless of the amount of these chemicals, substances and particulates) and/or
- Increase the overall risk of human and environmental health impacts as exposures occur (when compared to otherwise healthy populations and locations not near one of these facilities)

Noting this, alternative approaches are needed to:

- Manage and potentially find an alternative use for the non-recyclable waste we already have
- Significantly reduce and eliminate the non-recyclable waste from being produced and made available to consumers
- Better manage and find uses for the recyclable waste we already have, ensuring that any barriers to participation by households and businesses are reduced to their lowest possible level

This section will cover the following points in their relevant subsections:

- Possible alternative uses for mixed plastic waste
- Waste reduction strategies being currently employed or developed around the world
- Suggestions for consideration of future Government policies regarding waste reduction and elimination
- A proposal regarding waste sorting and establishing a link between households and businesses to industry led recycling initiatives already in place

Possible Alternative Uses for Mixed Plastic Waste

Mixed plastic waste can be comprised of:

- Bottles (any recycling grade)
- Soft plastic packaging
- Hard plastic packaging
- Loose plastic bags
- Certain recyclable consumer goods

Each of these present a significant issue when considering sorting and end markets for any single given business, however new research is showing promising investment opportunities for a product that doesn't generate harmful gases and reuses plastics instead of burning them.

Common solutions such as melting the plastics to make RESIN8 for concrete and asphalt, creating other construction materials such as fencing, piping etc or converting the plastics to oil and chemicals, via pyrolysis, to be reused are energy intensive and produce harmful chemicals, substances and particulates, many of those already covered in the Emissions section; so, what is the alternative?

Mixed Plastic Waste Alternative Options

1. Researchers at the University of Southern Queensland are working with Australia Sunlight Group, one of Queensland's largest plastic recycling companies, to develop a method of transforming mixed plastic waste into graphene and green hydrogen
 - a. They have also created an improved system that can convert plastic waste into multi-walled carbon nano tubes and single-walled carbon nano tubes (SWNT) (often referred to, in the industry, as "Black Gold")
 - b. SWNT at high purity, can sell for between \$50 and \$1,000 per gram, making it more valuable than gold
 - c. Green hydrogen is also produced during the process and is isolated using a method of advanced gas separation developed by Dr Aaron Li of the University of Melbourne
 - d. They plan on a Pilot Program in 2 years and are calling for Government support to bridge the gap between proof of concept and full commercialisation
 - i. Reference:
 1. [From plastic waste to "Black Gold": A recycling breakthrough | UniSQ](#)
2. Self-Healing Concrete
 - a. Through production of Polyhydroxyalkanoate (PHA) from plastic waste where the waste is unsuitable for thermoplastic applications
 - b. Developed to address the inevitable issue of aging concrete and crack formation
 - c. Increases the service life of constructions
 - d. Decreases maintenance costs
 - e. Consequently, reduces the enormous amount of carbon dioxide emitted by the concrete industry, simply because demand will reduce
 - f. Field trials have demonstrated this technology at a larger scale
 - g. Large scale implementation is still limited by initial costs and cost of the production of the healing agent
 - i. Lack of distribution channels is one of the major hurdles to cost reduction
 - ii. Purification costs also are a barrier to full commercialisation
 1. Reference:
 - a. [From waste to self-healing concrete: A proof-of-concept of a new application for polyhydroxyalkanoate - ScienceDirect](#)
3. Toys
 - a. Soft plastics can be recycled into new children's toys
 - b. References:
 - i. [Australian toys made from recycled plastic – Happy Planet Toys](#)
 - ii. [A Sustainable Australian Success Story. Introducing Resoftables and Recyclings by Headstart | The Toy Universe](#)
 - iii. [Best recycled eco-friendly and sustainable bags from plastic waste. – Ploys](#)
 - iv. [Green Toys Australia | Recycled Plastic Toys | Little Earth Nest](#)

- v. [Toy recycling program to reduce plastics in landfill launched by Big W and TerraCycle - ABC News](#)
4. Furniture
- a. Companies are producing chairs, tables and outdoor furniture using recycled plastic materials
 - b. References:
 - i. [Replas | Australia's Leading Recycled Plastic Products](#)
 - ii. [Top 100 Recycled Plastic Furniture Manufacturers in Australia \(2025\) | ensun](#)
 - iii. [Soft Plastic Recycling Solutions Melbourne – APR Plastics](#)
 - iv. [Recycled Furniture – DESIGN BY THEM](#)
 - v. [Plastic Forests – Recycling Soft Plastics into Sustainable Products](#)
5. Shopping Bags
- a. Retailers are beginning to sell and promote durable and reusable bags made from soft plastics
 - b. References:
 - i. [NSW facility takes on large-scale recycling of Australian household soft plastics - ABC News](#)
 - ii. [Plastic Bag Recycling Australia 🇦🇺 – How To Recycle Soft Plastics](#)
 - iii. [Soft plastic recycling is back in supermarkets! - The Australia Institute](#)
 - iv. [Coles offers shopping bags made from marine waste and recycled plastic](#)
6. Clothing
- a. Some brands are now creating clothing items using recycled plastic fibres
 - b. References:
 - i. [A Game-Changer for Sustainable Fashion & E-commerce: Better Packaging Co. & RYCL Partner for Dual Recycling Impact - AFC](#)
 - ii. [UPPAREL Clothing Collection Pick Up Australia](#)
 - iii. [Samsara Eco – infinitely recycled plastics and textiles.](#)
 - iv. [From plastic to fantastic](#)
 - v. [BlockTexx®](#)
7. New plastic wrappers
- a. Companies like Nestle have methods of recycling their wrappers into new wrappers for their products
 - b. Reference:
 - i. [The wrap on soft plastics | Nestlé Australia](#)
8. Each of the above points from 3-6 can largely be recycled due to research from the University of NSW, Sydney (UNSW) using a low energy method that is already at industrial scale
- a. The process removes the need for extensive cleaning of the waste
 - b. It can separate the polymer from the additives, such as dyes, which further reduces cost
 - c. Completely tolerant of mixed plastic waste being received

- d. Reference:
 - i. [Can Australian innovation turn the tide on soft plastic waste? - AIPS](#)

- 9. Even with the above solutions, as well as the less desirable construction and building applications, the amount of plastic being produced will exceed any recycling or circular economy efforts. Measures must be taken to significantly reduce or eliminate completely the amount of plastic being manufactured and sold to consumers

- 10. Investment and support for research initiatives such as biodegrading plastic through the use of bacteria, fungi and insects, being carried out at universities and research institutions across the world, locally at the University of Sydney, may also present methods to dispose of the current stocks of plastic while Government measures to significantly reduce or eliminate single use plastics take effect
 - a. References:
 - i. [Fungi makes meal of hard-to-recycle plastic - The University of Sydney](#)
 - ii. [Insects for plastic biodegradation – A review - ScienceDirect](#)
 - iii. [Using Insect Larvae and Their Microbiota for Plastic Degradation - PMC](#)
 - iv. [Plastic-Eating Insects | United Nations Development Program](#)
 - v. [Microbial recycling of plastics: An annotated selection of World Wide Web sites relevant to the topics in microbial biotechnology - PMC](#)
 - vi. [Superworms: how plastic-eating larvae sparked a scientific breakthrough](#)

- 11. Plastic alternatives are being researched all the time and one such example is from the South Dakota State University (SDSU) where they are researching the possibility of converting grapevine remnants into a biodegradable plastic-like film
 - a. It can break down in the soil in as little as 17 days
 - b. It is as transparent and flexible as plastic
 - c. Can be stronger than traditional plastic bags, in terms of tensile strength
 - d. References:
 - i. [Can grapevines help slow the plastic waste problem? | South Dakota State University](#)
 - ii. [Scientists turn grapevine waste into clear, strong films that vanish in days | ScienceDaily](#)
 - iii. [Valorization of grapevine agricultural waste into transparent and high-strength biodegradable films for sustainable packaging - Sustainable Food Technology \(RSC Publishing\)](#)

- 12. Additional References:
 - a. [Soft plastic recycling has changed again – here’s what you need to know - Australian Marine Conservation Society](#)
 - b. [What Are Soft Plastics Recycled Into? These Are 6 Surprising Products Made from Soft Plastics! - Rubbish Removal Sydney | Sydney City Rubbish Removal](#)
 - c. [How to manage soft plastic recycling - CSIRO](#)
 - d. [A new soft plastics scheme is ramping up, but can it solve our recycling problem? - ABC News](#)
 - e. [Is There A Practical Way To Utilize Mixed “Plastic Waste?”](#)

- f. [Chemists tackle the tough challenge of recycling mixed plastics | Colorado State University](#)
- g. [Upcycling mixed plastic waste as a replacement for natural aggregates in concrete: A critical review - ScienceDirect](#)
- h. [Recycling of multi-material multilayer plastic packaging: Current trends and future scenarios - ScienceDirect](#)
- i. [State of Bioplastics in Australia report – Ending Plastic Waste](#)
- j. [CSIRO report reveals the state of bioplastics in Australia - CSIRO](#)
- k. [State of bioplastics in Australia](#)

Waste Reduction Strategies

According to this writer’s search efforts, New Zealand appears to be leading the way in terms of Waste Reduction Strategies that don’t include incineration.

Some of the measures New Zealand are using are as follows:

- Phasing out certain types of plastic packaging
- Extending a ban on PVC and polystyrene food and drink packaging
- Mandating that produce labels, including the adhesive, must be home compostable by July 1st 2028
- Setting up the Waste Minimisation Fund to support infrastructure and other initiatives (often community led) that help to divert waste from landfills
- Standardising (in 2022) household recycling with regard to the collected materials
- Introducing kerbside food scrap collection
- Partnering and collaborating with businesses to reduce and manage commercial waste
- Funding councils to remediate contaminated sites they own or on behalf of the other landowners through the Contaminated Sites and Vulnerable Landfills fund to reduce the risk to human health and the environment posted by legacy contaminated sites and vulnerable landfills
 - These are funded through the Waste Disposal Levy
- References:
 - [Update on waste policies | Ministry for the Environment](#)
 - [Government announces new waste and resource efficiency strategy and work Program | Ministry for the Environment](#)
 - [Government waste work Program | Ministry for the Environment](#)
 - [Waste disposal levy expansion | Ministry for the Environment](#)
 - [waste-and-resource-efficiency-work-Program-2024-26.pdf](#)
 - [A Circular Economy | Air New Zealand – Australia](#)

Other methods of waste reduction are being considered such as from the Australian Senate Standing Committees on Environment and Communications, Waste and Recycling Industry in Australia 2024, Chapter 8:

- Recommends that producers take responsibility for the end of life management of their products to encourage waste prevention at the source
- Other methods are:

- Mandates to require manufacturers and retailers to minimise the amount of packaging material used for consumer goods
- Making programs mandatory for certain products such as e-waste, tyres and mattresses to improve their end of life management
- Setting strict green criteria for public procurement, governments purchasing items determined by high environmental standards and circular economy benefits
- Ensuring that the full cost for ecological and waste management costs are borne by the producer, not the public

There are additional measures Governments could consider adopting to actually have a measurable impact on waste reduction, which will be listed in the next sub section

In addition to the measures the Government could consider adopting, existing plastic waste could be managed, reduced and begin to be eliminated through the use of emerging research into plastic breaking down: bacteria, fungus and worms (wax worms, mealworms, Superworms (being researched by the University of Queensland)).

This could be a measure to eliminate existing plastic, while using the recycling and circular economy options in the next section.

References:

- [Chapter 8 – Parliament of Australia](#)
- [Beyond Waste | Greens WA](#)
- [Six ways that governments can drive the green transition | EY - Australia](#)
- [7 inspiring government food waste campaigns foodservice can learn from](#)
- [Reduce food waste at your business | Environment, land and water | Queensland Government](#)
- <https://www.bbc.com/news/science-environment-68927816>
- <https://one5c.com/plastic-eating-bacteria-136931563/>
- <https://www.nsf.gov/news/genetically-modified-bacteria-break-down-plastics-saltwater>
- <https://www.theguardian.com/environment/2022/feb/05/how-super-enzymes-that-eat-plastics-could-curb-our-waste-problem>
- <https://www.theguardian.com/environment/2023/sep/28/plastic-eating-bacteria-enzyme-recycling-waste>
- <https://www.abc.net.au/news/science/2016-03-11/plastic-eating-bacterium-can-break-down-pet/7238614>
- <https://www.abc.net.au/news/2023-04-15/plastic-eating-fungi-discovery-raises-hopes-for-recycling-crisis/102219310>
- https://www.sydney.edu.au/news-opinion/news/2023/04/14/fungi-makes-meal-of-hard-to-recycle-plastic.html#:~:text=According%20to%20a%20study%20published%20in%20*npj:,of%20incubation%20*%2025%2D27%25%20over%2090%20days
- <https://www.hawaii.edu/news/2025/02/26/marine-fungi-plastic-pollution/#:~:text=Hungry%20marine%20fungi%20may%20be%20the%20key,pollution%20%7C%20University%20of%20Hawai%CA%BBi%20System%20News.>
- <https://theconversation.com/plastic-eating-insect-discovered-in-kenya-242787>

- <https://www.sciencedirect.com/science/article/pii/S0957582024003744>
- <https://one5c.com/plastic-eating-worms-136931560/>
- <https://en.wikipedia.org/wiki/Plastivore>
- https://www.csiro.au/en/news/All/Articles/2022/March/insect-digestion-of-waste#:~:text=CSIRO%20researchers%20are%20investigating%20the%20digestive%20processes,**Poly%20lactic%20acid**%20Used%20by%203D%20printers
- <https://www.undp.org/serbia/stories/plastic-eating-insects>
- <https://www.bbc.com/future/article/20240419-the-worms-that-eat-through-plastic>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC11856541/>

Suggestions for consideration of future Government policies regarding waste reduction and elimination

Further suggestions, in addition to those previously mentioned, could be:

- Providing tax or utility incentives for businesses that participate in recycling their own products either through Government lead or Community lead initiatives, passing the used or discarded product back to the producer
 - Perhaps in the form or in addition to the “green credits” Waste to Energy Incinerator facilities would have received
- Setting a mandate for Government purchases to preference products that are created by recycling or are from recycling manufacturers
- Setting guidelines for producers to use cardboard, paper and plastic alternatives (such as the recycled bags mentioned previously)
 - As an example, children’s toys could be packaged in a cardboard box with a picture of the toy as it was at the time of manufacture
 - Achieved through the use of Camera’s on the conveyor belt that capture each individual toy product as it passes through the production line, matching the figure picture with the corresponding box
 - This could also be applied to other items currently sold in clear plastic boxes or backed with cardboard
 - Supermarkets could also be mandated to use cardboard boxes, paper or provide re-usable bags for consumers to place their fruit and vegetables in to purchase, instead of the loose plastic bags they currently provide
 - Other examples include:
 - Transparent film, made from grapevine, as mentioned above in the Possible Alternative Uses for Mixed Plastic Waste section, point 11
 - Reusable silicone bags
 - Beeswax wraps
 - Packaging made from cornstarch or mycelium (mushrooms)
 - Bamboo, stainless steel, paper or silicone utensils and straws
 - Which has already seen great success in supermarkets across Australia
 - Sugarcane fibre
 - Measures such as this have already been taken by the United States, State of California in:
 - SB-707

- Responsible Textile Recovery Act of 2024
 - https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202320240SB707
 - SB-54
 - Solid Waste: reporting, packaging, and plastic food service ware
 - https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB54
 - SB-1383
 - Short-Lived climate pollutants: methane emissions: dairy and livestock: organic waste: landfills
 - https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=201520160SB1383
-
- Public Education campaigns on new recycling and circular economy systems
 - Investing in waste recycling infrastructure, such as the next sub sections proposal
 - The government requiring the onus to be on the Waste to Energy provider to support the research and prove beyond any doubt that the technology that is in place, the technology that is developed, prevents any harm to the environment and humans over the total contract and lifetime of the Incinerator facility.
 - It should be proven, beyond any reasonable doubt (which this document presents reasonable doubt), that the emissions that are released are not harmful to the environment or humans over the lifetime and total contract of the incinerator facility.

In addition, each level of Government has a role to play, such as:

- The Federal Government setting a target for a nation wide ban on the production of single use plastics and soft plastic usage
 - Including the recycled plastic bags for grocery items such as fruits and vegetables
 - State Governments ratifying these targets in legislation
 - The Federal Government could also assist through the provision of research grants where gaps in alternative products exist to meet consumer needs
 - The Federal and State governments could also require all new plastic, cardboard and glass items to have a specific percentage of recycled materials
 - To assist with the uptake of recycled materials and ensure the market has a stable income source
- State Governments could then encourage the use alternative products and ensure where gaps exist research is funded, either from the manufacturers or by the Government itself
 - This could be offset through the introduction of new taxes for the waste transition
 - This would be the draconian version of a more permanent solution; however, the point is to stop the production and provision of these plastics and begin using or finding alternatives
 - We proved we could do it with plastic bags in 2019

- In addition, funding could be allocated for new waste sorting Programs to ensure the stability of the circular economy
 - Such as the proposal in the next sub section
- Local Governments could assist communities to ensure that the waste is sorted correctly, through education Programs, as well as waste and recycling collection

Proposal for an alternative to managing waste and supporting a circular economy in Victoria

The following is a proposal regarding waste sorting and establishing a link between households and businesses to industry led recycling initiatives already in place.

A significant portion of the cost of recycling initiatives is the waste sorting.

Waste sorting largely starts with households and businesses sorting their waste from their recycling in terms of their council provided or industry provided bins.

These bins, however, don't account for all types of waste and as previous references in the Alternatives section of this document have alluded to, not all recycled materials get recycled due to the lack of available markets for the recycled products.

What if there was a way to link available markets and/or original packaging producers with consumers disposing of waste and recycling?

Well, there are already many initiatives started by individual businesses that request the consumer send their discarded products back to them for re-use, a true representation of the circular economy.

The problem is that this process places the onus on the consumer and creates a barrier to participation, as the process is not always straightforward, convenient or cost effective for the consumer to handle.

Often consumers are forced to pay or work out where they can take the products they wish to recycle, which has a byproduct of creating a storage issue for the consumer. This results in the process becoming difficult for the consumer, which then produces the effect of the otherwise recyclable or reusable product being discarded as part of the general waste stream.

It is often not a lack of desire to recycle, on the part of the consumer, but a lack of easy accessibility to the process.

That is where this proposal comes in; it's sort of like Amazon but for waste recycling.

- Creation of a 17-18 bin system (more if I missed any) for all types of materials
 - These bins need not be strictly household (residential) located
 - For larger items, such as metals, polystyrene, E-waste, hazardous household or automotive waste (etc) community bins, at convenient, centralised, collection points (such as supermarkets, shopping centres etc), per suburb, could be used
 - Though there is some travel involved, it is significantly lower friction, lower effort, on the part of the consumer, as they don't need to work out which company they can use and then travel to their inconvenient, possibly far away, collection points, saving

hours for everyday people and significantly reducing landfill waste

- Existing plastic waste could be managed, reduced and begin to be eliminated through the use of emerging research into plastic breaking down: bacteria, fungus and worms (wax worms, mealworms, Superworms (being researched by the University of Queensland)).
 - This could be a measure to eliminate existing plastic, while using the recycling and circular economy options
 - This option has the potential to drastically reduce the sorting complexity requirement
- The recyclable materials and the businesses that already handle them are as follows:
 - Paper and Cardboard (clean)
 - Businesses that recycle these materials are:
 - Veolia
 - Cleanaway
 - AB Recycling
 - KS Environmental
 - REMONDIS Coolaroo
 - BINGO Industries
 - Waarec
 - CSC Waste and Recycling
 - Glass (recyclable)
 - Hard Plastics (bottles, recyclable boxes etc)
 - Soft Plastics (food coverings, packaging etc)
 - Currently the Supermarkets are taking these for recycling as part of the Soft Plastics Taskforce trial
 - Coles
 - Woolworths
 - Aldi
 - Soiled soft plastics, such as children's yogurt pouches and other hard to recycle items such as used and soiled soft plastic can be recycled by businesses such as:
 - Replas
 - Cleanaway (can handle soiled and packaged food waste, such as difficult to recycle items such as those with heavy food residue, though it is currently not accessible to the general public for small consumer items)
 - Veolia
 - REMONDIS
 - Wanless Waste Management
 - APR Plastics
 - Plasgain
 - There would be a requirement to split the soft plastics into clean and soiled

- Some councils, Brimbank and Greater Dandenong, also have drop off points for this material
- Ferrous Metals
 - Steel (carbon and mild steel)
 - Stainless steel
 - Cast iron and wrought iron
 - Could be in items such as:
 - Skillets, pans and pots
 - BBQ Plates
 - Gardening equipment
 - Car parts
 - Tools
 - Businesses that recycle these materials are:
 - Albon Metals and Recycling
 - Base Metal Recyclers
 - Future Recycling Metals
 - AX Recycling
 - SRS Metals
 - Scrappy's Metal Recycling
 - InfraBuild
 - JJ Scrap Metals
 - United Metal Recycling
- Non-Ferrous Metals
 - Aluminium
 - Copper
 - Zinc
 - Lead
 - Nickel
 - Tin
 - Brass
 - Bronze
 - Could be in items such as:
 - Electrical wiring
 - Cans
 - Roofing and guttering
 - Cookware
 - Taps
 - Door handles
 - Some plumbing fittings
 - Die-cast products
 - Businesses that recycle these materials are:
 - Albon Metals and Recycling
 - Base Metal Recyclers
 - Future Recycling Metals
 - AX Recycling
 - OZ Metal Recycling
 - United Metal Recycling

- Galaxy Metals
- Evelyn Recycling
- Best Way Scrap Metal
- Electronic Waste (E-Waste)
 - Businesses that recycle these materials are:
 - Officeworks
 - The Good Guys
 - A Tech Computer Recycling
 - Mobile Muster (non for profit)
 - JB Hi-Fi
 - Bunnings Warehouse
 - PhoneCycle
 - B-Cycle
 - Australia Post
 - National Television and Computer Recycling Scheme (non company, drop off points should be centralised)
 - Drop off points that should be centralised being provided by some local councils
 - Bayside
 - City of Melbourne
 - Mornington Peninsula Shire
 - Boroondara
- Textiles and shoes (could also include shopping bags in addition to clothing and shoes)
 - Businesses with recycling schemes include:
 - Adidas
 - Nike
 - Patagonia
 - Allbirds
 - Rothy's
 - Havaianas
 - Upparel
 - Limitless
 - Textile Recyclers Australia
 - Worn Up
 - H&M
 - Uniqlo
 - Sheridan
 - Macpac
 - Zara
 - Shred-X (their division called Textura)
 - Rebel Sport (shoes)
 - Sports Power (shoes)
 - Shoes and Sox
 - Anyone in the TreadLightly program
 - Charities

- California introduced the passed bill SB-707 Responsible Textile Recovery Act in 2024 to achieve something very similar to what is proposed here and below
 - This shifted the costs of clothing waste management from the state taxpayers to clothing companies
 - Not what is proposed below for Victoria, preference would be for businesses to be incentivised and opt in with a tax to cover the management, transport and transfer facilities costs
 - <https://pirg.org/california/articles/what-is-california-doing-to-reduce-waste/>
 - https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=202320240SB707
- Beauty products
 - Businesses with recycling schemes include:
 - Lush
 - Kiehl's
 - bareMinerals
 - Zoya
 - Gillette
 - Mecca
 - David Jones
 - Sephora
 - Priceline
 - Banish Recycling
 - TerraCycle
 - MAC Cosmetics
- Hazardous Household Waste (hard) (such as batteries, light bulbs, sharp edges such as from broken glasses)
 - Businesses with recycling schemes include:
 - Bunnings Warehouse (batteries)
 - B-Cycle drop off points that need to be centralised (batteries)
 - KS Environmental (batteries)
 - ReSource (batteries)
 - Future Recycling (batteries)
 - Battery Specialists (car batteries)
 - EcoBatt (most types of batteries)
 - Any business participating in the Ecocycle or E-Cycle solutions (light bulbs)
 - Crushed Glass Concepts (broken glass)
 - All Glass Recycling (broken glass)
- Hazardous Household Waste (liquid) (unused cleaning chemicals, cooking oil, beauty products (not the bottle), paint etc)
 - Businesses with recycling schemes include:

- Greencare Environmental Solutions (unused cleaning chemicals)
- Cleanaway (unused cleaning chemicals)
- Envirostore Chemical Consulting (unused cleaning chemicals)
- Paintback
- Revive Oils
- Argus Waste Recycling (cooking oils)
- Scanline (cooking oils)
- Environmental Oils
- Your Oil Man
- Greensprout Oil
- Auscol (cooking oils)
- J.J. Richards & Sons (cooking oils)
- Banish (beauty products)
- Automotive Waste (fuel, oil, rags, chemicals)
 - Businesses with recycling schemes include:
 - National Resource Recovery
 - Ace Waste
 - Cleanaway
 - J.J. Richards & Sons
 - Nationwide Waste Solutions
 - RPM Automotive Group
 - Currently developing a tyre recycling program
- Books and Toys
 - Businesses with recycling schemes include:
 - Big W's Toys for Joy program
 - Websites like Givit
 - Local Council Recycled goods shops
 - Charities
- Polystyrene
 - Businesses with recycling schemes include:
 - Foamex
 - Unipod
 - REMONDIS Australia
 - Veolia
 - Local council drop off points that should be centralised
 - Moonee Valley
 - Yarra
 - Monash
 - Brimbank
- PVC
 - Businesses with recycling schemes include:
 - CryoGrind Australia
 - Emmans
 - JR Hammer
 - NWC Recycling
 - Flash 1 Metal

- Ezi-Metal Recycling
- Melbourne Copper
- Vanden Recycling
- Corex Plastics
- AluPlast
- Precious Plastics Melbourne
- Organic Waste (food scraps etc)
 - Can also include paper and cardboard (soiled) – food containers, pizza boxes etc
 - Can be placed as part of Food Organics and Garden Organics (FOGO) for composting
 - Businesses with recycling schemes include:
 - Goterra
 - Reground (coffee grounds)
 - Eco Guardians
 - Repurpose It
 - Gaia EnviroTech
 - Delorean Corporation
 - Pavilion Farms
 - Corio Waste Management
 - Veolia
 - Cleanaway
 - Council provided FOGO services:
 - Banyule
 - Hepburn Shire
 - Hume
 - Melton
 - Moonee Valley
 - Whitehorse
 - City of Melbourne
 - City of Port Phillip
 - City of Stonnington
 - Wellington Shire
 - Wyndham
- Used Nappies (dead serious)
 - Businesses with recycling schemes include (I couldn't believe it either):
 - DiaperRecycle
 - Melbourne based
 - The Nappy Loop
 - Led by the CSIRO and Kimberly-Clark Australia
 - Waster
- Commercial Recycling Programs Mixed Materials (such as Coffee Pods by Nespresso)
 - These could be linked with organisations such as:
 - Nespresso

- Nestle
- TerraCycle
- Broken Crockery
 - Separate to the bin system
 - Currently there is no recycling effort for this material
 - It currently is required to be sent to landfill
- The Red Bin (General Waste)
 - As current recycling initiatives stand (based on this writer's findings, more are welcome) there will still be a requirement for a General Waste (landfill) bin
 - However, that bin should only contain items that cannot be recycled by any of the above mentioned or additionally discovered business initiatives
 - Additionally, this writer strongly recommends that the General Waste bin be a community 'skip bin' and no longer located with residential properties, to encourage the thought for proper recycling and ensure uptake of the new circular economy recycling effort
- None of these of course prevent any consumer from engaging in the services of scrap metal yards or similar businesses, however for those consumers with neither the time nor the money to utilise these services it would prevent these items from being disposed of in the general waste
 - Those scrap metal yards could participate in the sections below to ensure they received the recycled products they can then on sell
- These materials could be picked up as part of the regular and expected council waste and recycling truck Programs
 - Some of the waste and recycling materials above could have community skip bins located, in a tight cluster all together, in central hubs of suburbs, lowering the barrier to participation
 - This system could be modified to also account for Hard Rubbish type items
- They can then be stored and sorted, according to their type and shipped to the relevant, interested industry
 - In terms of sorting and cleaning (because this should not be on the consumer)
 - With the already proven concept of image recognition, used in supermarkets to identify products at the checkout and further utilised (in some capacity) in the Victorian Container Deposit scheme surely this could be implemented at sorting facilities to:
 - Identify particular containers
 - Send those containers onto the relevant conveyer belt that leads to a purpose designed cleaning station for that type of container
 - The initial cost would be a one time cost and the only incurred cost would be maintenance

[20steel%2C,boards%2C%20connectors%2C%20and%20wiring%20from%20outdated%20devices](#)

- <https://premier-metals.com.au/hidden-value-non-ferrous-metals/>
- <https://www.cohenusa.com/blog/35-most-commonly-recycled-ferrous-metal-items/>
- <https://ecoscrapmetal.com.au/things-you-need-to-know-about-scrap-metal-in-sydney/>
- <https://www.geelongaustralia.com.au/bins/article/item/8cb963227c7b661.aspx>
- <https://evolvewaste.co.uk/top-10-everyday-items-you-didnt-know-could-be-recycled/#:~:text=Clothes%20that%20are%20worn%20out%20or%20no,new%20products%20like%20insulation%20or%20cleaning%20rags>
- <https://www.melbourne.vic.gov.au/news/guide-recycling-and-waste-city-melbourne>
- <https://www.alburycity.nsw.gov.au/services/waste-and-recycling/albury-recycling-centre#:~:text=Electronic%20waste%20is%20any%20item%20with%20a,be%20removed%20before%20they%20harm%20the%20environment>
- <https://www.abcrubbishremovalmelbourne.com.au/types-of-rubbish/>
- <https://www.recyclingtoday.org/blogs/news/top-10-things-to-recycle-and-reuse>
- <https://greenskipbinsadelaide.com.au/waste-types-for-mixed-heavy-skips/#:~:text=Furniture%20&%20appliances%20Furniture%20&%20appliances%20are,such%20as%20TVs,%20refrigerators%20and%20water%20heaters>
- <https://www.repsol.com/en/energy-move-forward/energy/types-of-waste/index.cshtml>
- <https://www.bbc.com/news/science-environment-68927816>
- <https://one5c.com/plastic-eating-bacteria-136931563/>
- <https://www.nsf.gov/news/genetically-modified-bacteria-break-down-plastics-saltwater>
- <https://www.theguardian.com/environment/2022/feb/05/how-super-enzymes-that-eat-plastics-could-curb-our-waste-problem>
- <https://www.theguardian.com/environment/2023/sep/28/plastic-eating-bacteria-enzyme-recycling-waste>
- <https://www.abc.net.au/news/science/2016-03-11/plastic-eating-bacterium-can-break-down-pet/7238614>
- <https://www.abc.net.au/news/2023-04-15/plastic-eating-fungi-discovery-raises-hopes-for-recycling-crisis/102219310>
- https://www.sydney.edu.au/news-opinion/news/2023/04/14/fungi-makes-meal-of-hard-to-recycle-plastic.html#:~:text=According%20to%20a%20study%20published%20in%20*npj:,of%20incubation%20*%2025%2D27%25%20over%2090%20days
- <https://www.hawaii.edu/news/2025/02/26/marine-fungi-plastic-pollution/#:~:text=Hungry%20marine%20fungi%20may%20be%20the%20key,pollution%20%7C%20University%20of%20Hawai%CA%BBi%20System%20News.>
- <https://theconversation.com/plastic-eating-insect-discovered-in-kenya-242787>
- <https://www.sciencedirect.com/science/article/pii/S0957582024003744>
- <https://one5c.com/plastic-eating-worms-136931560/>
- <https://en.wikipedia.org/wiki/Plastivore>
- https://www.csiro.au/en/news/All/Articles/2022/March/insect-digestion-of-waste#:~:text=CSIRO%20researchers%20are%20investigating%20the%20digestive%20processes,**Poly%20lactic%20acid**%20Used%20by%203D%20printers
- <https://www.undp.org/serbia/stories/plastic-eating-insects>

- <https://www.bbc.com/future/article/20240419-the-worms-that-eat-through-plastic>
- <https://pmc.ncbi.nlm.nih.gov/articles/PMC11856541/>
- <https://www.csiro.au/en/news/All/News/2022/December/New-nappy-recycling-trial-launches-in-Australia>
- <https://www.csiro.au/en/news/All/Articles/2022/December/nappy-loop-project>
- <https://diaperrecycle.com/#:~:text=DiaperRecycle%20is%20a%20disposable%20nappy%20recycling%20program,notified%20of%20start%20date%20and%20payment%20fe>
e
- <https://greater-shepparton.com.au/whats-happening/news/news-article/!/456/post/the-nappy-and-incontinence-aid-collection-service-turning-waste-into-products>
- <https://waster.com.au/nappy-waste-collection/>

Discussion – Criteria 4 and Summary and Assessment of Criteria’s 1, 2 and 3

This section will present and link to information provided in the previous sections to provide a consolidated overview of the findings.

It will address the following subsections:

- Air Purification and Filtration Systems and their Emission Efficiency
- Environmental and Human Health Safety Standards and the Criticality of Accurate Adherence and Reporting
- Summary

Air Purification and Filtration Systems and their Emission Efficiency

This document, hopefully, has shown the impressive capabilities of Air Purification and Filtration Systems used in Waste to Energy Incineration, with most options capturing over 95% of toxic substances, chemicals and particulates up to generally 99%. This document has also presented some of the limitations of such systems and noted where ratings require the optimum of conditions in order to be achieved.

In short, this is not 100% capture of all substances, chemicals and particulates.

Is it fair to expect 100% capture and no mistakes in the handling of the highly and well documented toxic byproducts produced by Waste to Energy Incineration operation?

Taking into account:

- The expected lifetime of the Waste to Energy Incineration facilities
- The number of vulnerable people (children and the elderly, as well as those who are unwell or allergic) in the surrounding communities and consequences to them if these emissions are allowed to build up in their bodies or be in contact with them for years
- The results of the filtration and air purification systems, their byproducts (toxic bottom and fly ash, as well as water contaminated with toxic substances, chemicals and particulates from wet scrubbing and similar methods), will need to be sent to landfill or storage facilities anyway, creating an arguably more toxic substance to transport, store and control at landfill, than the original items
- The fact that the environmental and human health are so intrinsically linked (as discussed earlier in this document) and
- The fact that many of these emissions (substances, chemicals and particulates) either do not break down in nature (becoming far more toxic by mixing with other elements in the atmosphere or surrounding environment) or take time to break down, further increasing the risk of human interaction and harm

By those criteria, yes, 100% capture and no mistakes over the lifetime of the operation of the Waste to Energy facilities is imperative; to do otherwise would be irresponsible and dangerous to the health of the people and environment surrounding the facility.

It should be noted that a predominant claim made by Waste to Energy providers and supporters is that all that is emitted from the stack is water vapour, carbon dioxide and oxygen. While this is technically true the devil is in the details (as the saying goes) and though 99% of all emissions are significantly reduced, they are not eliminated and there is a 1% that is released. Contained

within that 1% are the substances, chemicals and particulates [below](#); the air purification and filtration systems simply do not catch it all.

Further exacerbating the issue is the sorting process. Multiple references (including one from HiQ) states that the “Material processed through the facility will have already been through separation processes before they reach us, in line with Total Economic and Environmental Potential (TEEP) principles.”

What this fails to mention is how TEEP appears to work at a practical level.

According to the following references TEEP in Victoria works through the standard waste and recycling system we’re all already familiar with, the:

- Red Bin – General Waste
- Yellow Bin – Mixed recycling
- Green Bin – Garden and in some cases Food, Garden and Organic (FOGO)
- Purple Bin – Where applicable, for separate glass recycling

What this does not specify is the fact that no additional sorting, other than by the residents, is carried out on the Red Bin waste. Therefore, stating that materials have already been processed through TEEP is, essentially, an empty statement other than the obviously recyclable material, however this is reliant on residents sorting their waste correctly, which is known to not occur.

The sheer amount of educational materials produced each year and programs run each year to educate residents about what goes into which bin and the fact it is run regularly each year shows the message is not getting through; an inspection at most large landfill sites will confirm this.

Furthermore, the general criteria of the TEEP test, suggests that operators need only show that there is no technical or reasonable way to carry out separate collection of waste and that separate collection would incur excessive and disproportionate costs – even when the value of the materials are considered, to allow them to be burned.

In this sense, the TEEP test does not appear to prevent materials that when burned produce toxic substances, chemicals and particulates, from entering the Waste to Energy Incinerator.

<https://www.slideshare.net/slideshow/teep-and-lessons-learned-from-uk-approach-to-eu-compliance/54163369>

<https://hunterwaste.com/teep/>

Data Points

Air Purification and Filtration Technology:

- Bag House Filters
- Electrostatic Precipitators
- Air Scrubbers (wet and dry)
- Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction
- Sorting
- Air Quality Monitoring Technology

The Emissions:

- Mercury
- Cadmium
- PM 2.5
- Carbon Dioxide
- Carbon Monoxide
- Nitrogen Oxide
- Sulfur Oxides
- Ammonia
- Hydrogen Chloride
- Hydrogen Fluoride
- Volatile Organic Compounds
- Dioxins and Furans

Details

Air Purification and Filtration Technology:

- Bag House Filters
 - 0.5% release of Particulate Matter (PM 2.5) under optimal conditions
 - 5% release of other particles as small as 0.08 μm under optimal conditions
 - Not suitable for high moisture levels in the flue gas
 - Neutralisation chemicals (conditioning chemicals) produce their own harmful byproducts
- Electrostatic Precipitators
 - Dry ESP has 1% release of particles 1 to 10 μm
 - Unable to remove toxic substances, chemicals and particulates that are in gaseous or vapour forms at 204.4 degrees Celsius
 - Unable to handle moist or sticky matter
 - Wet ESP has a 0.01 release of particulates as small as 0.01 μm
 - Not efficient at removing sulfur dioxide or nitrogen dioxide gases
 - High concentrations of sulfur dioxide can lead to increased aerosol formation within the wet ESP, reducing the overall collection efficiency
- Air Scrubbers
 - Dry Air Scrubber
 - 5% release of sulfur dioxide
 - Produces toxic dust waste
 - Less efficient at removal of gases than wet air scrubbers
 - Wet Air Scrubber

- Potential for 1% to 5% release of particulate matter, such as sulfur dioxide, depending on the design
 - Prone to clogging
 - High pressure drops, requiring significant fan power and electricity usage
 - Generates wastewater (sludge) requiring disposal at landfill
 - Usage can result in the loss of the buoyancy of the stack emitted total flue gas, impacting and increasing concentrations of pollutants at the ground level
 - Not effective at removing some Volatile Organic Compounds
- Selective Catalytic Reduction (SCR)
 - SCR
 - 10% to 30% release of Nitrogen Oxides
 - Can achieve 2% release, however, requires careful usage of high levels of ammonia and a system designed to reduce (key word) ammonia slip (ammonia emission)
 - Selective Non-Catalytic Reduction
 - 30% to 70% release of Nitrogen Oxides
 - Some systems can achieve 20% release of Nitrogen Oxides under optimal conditions
 - Requires ammonia or urea usage
 - Can increase the risk of ammonia slip
- Sorting
 - Typically, not done before the waste is incinerated
 - Largely, human driven or human required to observe the waste entering the storage silo and being picked up by the crane (observed by the crane operator) before incineration
 - This will not catch items under large textiles or plastic sheeting or in boxes or smaller items such as thermometers, containing mercury
 - All other forms of sorting, such as for metals, are done after the incineration process is completed and the toxic substances, chemicals and particulates have been released
- Air Quality Monitoring Technology
 - Risks of sample contamination impacting readings
 - Calibration problems
 - Data quality problems
 - Impacts of extreme weather
 - Human error
 - Relies on the operator for accurate raw data on the emissions at the stack (however small) on a daily basis
 - The public and enforcement agencies will rely on non-redacted, non-omitted, raw data (data not calculated by mean, median, percentage or average)

The Emissions:

- Mercury
 - Does not break down in nature

- Can be converted into Methylmercury, highly toxic and makes its way into food and water supplies due to its composition
- Can remain in the environment for years or even centuries, posing a long term threat
- According to regulatory limits, such as those imposed by the European Union, Mercury emissions are restricted to $20 \mu\text{g}/\text{Nm}^3$
 - Measured concentrations can range between $13.38 - 18.66 \mu\text{g}/\text{Nm}^3$
- [Health Impacts](#)
- [Environmental Impacts](#)
- Cadmium
 - Emission sources are not at the stack but rather in the mishandling (accidental or otherwise) of the toxic dust byproducts of the Air Purification and Filtration systems
 - Regulation limit examples are $3 \text{ mg, Cd}/\text{m}^3$ (Cadmium per square metre)
 - Low level exposure to Cadmium produces health risks associated with lower quality of life
 - What would be the community control measure, to prevent the inhalation of the airborne dust, should such a mishandling event occur?
 - Will be required to go to landfill
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- PM 2.5
 - From state of the art facilities, with the safety control and multi-staged air purification technologies mentioned in the previous section, PM 2.5 concentrations can be as low (or lower) as 0.68 to $0.87 \text{ mg}/\text{m}^3$
 - Short term exposure to PM 2.5 at a dose of $10 \mu\text{g}/\text{m}^3$ can increase mortality risk, these particles can cause harm even at lower levels
 - PM 2.5 can break down in nature
 - Can remain in the atmosphere for weeks to over a month before it has been removed from the air
 - PM 2.5 can react with other substances in the air to form new toxic compounds
 - It can contribute to acid rain and alter the chemical balance of soil and water
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Carbon Dioxide
 - Continuously emitted from the facility stack
 - Flue gas concentrations typically range from 6% to 12% CO_2 but varies due to the composition of the waste day to day, particularly on the amount of plastics
 - For reference, a Coal Power plant's typical flue gas concentration of CO_2 ranges between 12% to 15%
 - Low Level exposure, over time, is linked to increased health risks and impairment of cognitive function, particularly if the concentration is able to permeate a house (due to, as an example, poor window sealing)
 - Carbon Dioxide is a well studied and confirmed source of green house gas emissions contributing to global warming
 - [Health Impacts](#)

- [Environmental Impacts](#)
- Carbon Monoxide
 - Typically, the product of incomplete combustion
 - The type of waste and its level of water content will influence how much Carbon Monoxide is produced
 - Should the sorting process not effectively identify and remove waste with water content this would lead to the production of Carbon Monoxide
 - It is ironic that Waste to Energy Incineration businesses claim that the majority of their incinerated waste is organic material, which would contain a significant moisture content
 - This claim, this writer suspects, is based on a measurement of weight, rather than volume, which, if measured by volume the majority of the waste would likely be plastic
 - The Australian limit for Carbon Monoxide is 9.0 ppm
 - Low level, chronic exposure to Carbon Monoxide can lead to neurological and cardiovascular problems, at best a lower quality of life, at worst serious, long term damage
 - Carbon Monoxide is a well studied and confirmed source of green house gas emissions contributing to global warming
 - Carbon Monoxide does readily break down in the environment through oxidation in the atmosphere, taking about 1 to 2 months to completely dissipate
 - Sensors in the Waste to Energy Incineration facility monitor Carbon Monoxide levels and if they exceed safe limits, often between 50 and 100 ppm during normal operation, this can cause the facility to temporarily shut down until the combustion issue is corrected
 - However as mentioned previously these sensors have limitations
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Nitrogen Oxide
 - Continuously emitted from the facility stack
 - According to regulatory limits, such as those imposed by the European Union, Nitrogen Oxide emissions are restricted to 200 mg/ m³
 - Waste to Energy Incinerator facilities using SCR can, typically, stay below the emission limit around 100 mg/Nm³ at 11% oxygen, annually, however this does depend on the initial nitrogen oxide levels
 - The regulatory limit, if exposed in full or over time (chronically) can lead to respiratory damage
 - Can contribute to acid rain and harm vegetation
 - Can breakdown in the environment, however it can last potentially days, depending on the environmental conditions such as rain or the presence of other reactive, neutralising, chemicals in the air
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Sulfur Oxides
 - Continuously emitted from the facility stack
 - Minimised by safety control and multi-staged air purification technologies mentioned in the previous section but not eliminated
 - Most systems capture 92% to 99% of sulphur from the flue gases

- Without effective controls / treatment concentrations could be as high as 150-640 mg/Nm³
 - Effective sorting is critical to reduce the amount of sulphur entering into the incineration chamber
 - Environmental impacts can include acid rain and the contribution to the accumulation of Mercury in food chains
 - Sulfur Oxides can breakdown in nature in about 5-10 days, however this can vary in colder conditions to potentially 10-32 days
 - Health impacts at low concentrations can include mild to moderate respiratory irritation and potentially worsen conditions such as asthma
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Ammonia
 - Occasionally emitted from these facilities
 - Concentrations can range from 0.03 to 0.07 ppm though this varies significantly due to the use of SCR and the type of waste being incinerated
 - Occurs as a byproduct of other particle and substance control mechanisms
 - Such as if the SCR or SNCR system is over injected with Ammonia (ammonia slip) or the system is not optimised, unreacted Ammonia will be emitted
 - Low concentrations of airborne Ammonia, 50 ppm can produce moderate to severe irritation of the eyes and upper respiratory system
 - Can cause, eutrophication, acidification and contribute to the formation of PM 2.5 within the surrounding environment
 - Ammonia can breakdown in nature within days in soil and water and approximately one week in the air
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Hydrogen Chloride
 - Frequently emitted from the facility stack
 - Concentration can vary based on the chlorine content of the waste
 - Typical concentrations without controls ranges between 770-1300 mg/ Nm³
 - With controls it can be around 60 mg/ Nm³
 - European Union regulations specify Hydrogen Chloride limits of between 2-10 mg/ Nm³
 - 1.5 mg/ Nm³ is considered a low exposure
 - Health risks can include respiratory irritation, chemically induced asthma and shortness of breath
 - Hydrogen Chloride has a half life of approximately 11 days
 - It is readily dissolved in water to form hydrochloric acid
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Hydrogen Fluoride
 - Occasionally emitted from these facilities
 - Concentrations before scrubbing range between approximately 1 to 4 mg/ Nm³, which scrubbing can lower considerably

- However, how it is reduced depends on the efficiency of the scrubbing system
 - Health impacts of exposure to Hydrogen Fluoride may cause irritation of the eyes, nose and sore throat, with possible chest tightness, headache, ataxia and confusion at concentrations as low as 1.16 mg/ m^3
 - Hydrogen Fluoride does not break down in nature
 - It contributes to acid rain, plant and soil damage
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Volatile Organic Compounds
 - Frequently emitted from the facility stack
 - Emissions are higher during the start up and shut down phases of operation, such as for regular maintenance
 - Though facilities running redundancy systems will not require these phases as often
 - Primarily a result of incomplete combustion
 - One study found a range between 0.07 to 0.90 mg/ m^3 after flue gas cleaning
 - Concentrations less than 0.3 mg/ m^3 are considered to be of low concern while levels below 0.5 mg/ m^3 are considered acceptable by guidelines, however above this level increases the risk of adverse impacts
 - Low level chronic exposure health risks are associated with neurological disorders, kidney damage and cancer
 - Low concentration exposure can lead to acute headaches, nausea, irritation of the eyes, nose and throat
 - Volatile Organic Compounds contribute to smog, acid rain and climate change
 - [Health Impacts](#)
 - [Environmental Impacts](#)
- Dioxins and Furans
 - Emitted in varying concentrations
 - Emissions are reduced to less than 0.1 TEQ/Nm^3
 - Low exposure is considered to be less than 0.5 pg TEQ/Nm^3
 - Low level, chronic exposure to dioxins and furans can lead to immunotoxicity, endocrine disruption, hormonal imbalance, reproductive impacts, neurodevelopmental issues in children, increased risks of certain cancers
 - Dioxins and Furans do not break down in the environment
 - Dioxins and Furans contaminate soil, water and wildlife. They accumulate in tissues and can be spread over long distances in the atmosphere before being deposited
 - This presents a risk to food chains
 - [Health Impacts](#)
 - [Environmental Impacts](#)

However, for all types of incinerators, there is a need to be alert to off-normal (upset) conditions that might result in short-term emissions greater than those usually represented by typical operating conditions or by annual national averages. Such upset conditions usually occur during incinerator startup or shutdown or when the composition of the waste

being burned changes sharply. Upset conditions can also be caused by malfunctioning equipment, operator error, poor management of the incineration process, or inadequate maintenance.

<https://www.ncbi.nlm.nih.gov/books/NBK233633/#:~:text=UNCERTAINTY%20AND%20VARIABILITY%20Incineration%20facilities%20vary%20with,of%20contaminants%2C%20and%20frequency%20of%20process%20upsets>

Environmental, Human Health, Circular Economy Impacts and the Criticality of Accurate Adherence and Reporting

The importance of this section cannot be overstated enough; there is no or should be no consideration greater than the safety and health of people and the environment in which they live and share with unique to the region flora and fauna.

The contract lifetimes of Waste to Energy Incineration are long; even 5 years of continuous operation, based on the previous sub section, would be enough to produce impacts in the surrounding environment and in vulnerable people in the surrounding communities, whether it is reported, observed, visible or not. Each year of operation increases the risk of chronic, low-level exposure and lowers the quality of life for those impacted.

Reporting and Enforcement Sub-Section

The data points in the previous sub section reference the Air Purification and Filtration technology operating under the optimum of conditions, however, it is not always going to be possible to operate under the optimum conditions with no mistakes for a variety of reasons (such as tiredness of operators, disgruntled employees, operators just having an 'off' day etc). It stands to reason then that in 5-30 years (depending on the contract length) there will be emissions of toxic substances, chemicals and particulates exceeding safe limits.

This then requires the accurate, honest and timely reporting of such events and community action plans to ensure exposure is limited.

This is not possible under the current Environmental Protection Agency (EPA) mandates, legislation and penalties.

The current legislation requires, mostly, self-reporting by operators with limited to no specification as to the time frame as it states the report must be made to the EPA "as soon as you become aware of it or reasonably should have been aware." This creates the possibility and high potential for deliberate delay in an attempt to rectify the problem 'in house', while the community is unknowingly exposed to toxic substances, chemicals and particulates.

This is not helped by the EPA's current on site compliance assessments, which appear to be conducted based on:

- Risk
 - Determined by the risk profile of the facility
- Immediate risk
 - As determined by the EPA if there is an immediate risk to environmental or human health
 - This would rely on other data points other than EPA findings or reporting by the operators and likely would have to be community driven and reported to the EPA, a responsibility the community should not have to bear
- Reasonable Time
 - EPA Officers can enter and inspect a facility at any reasonable time
 - This process, if not consistently applied each day, would miss key data, as what is being incinerated and the emissions being produced greatly depends on the waste content of the day

In addition, data on precisely what emissions and the exact amounts (not calculated by mean, median, averages or percentages) of those emissions being created on a daily basis is either non-existent, extremely difficult to find or heavily edited and redacted. The emissions vary each and every day, depending on what has found its way into the waste incineration unit, so irregular checks or reliance on self reporting will produce inaccurate data in terms of what the public is being exposed to each day and what substances, chemicals and particulates are building up in the air, surrounding environment or in humans.

This creates an impossible situation for enforcement agencies to protect the public and the environment.

This has recently (January 2025) been identified and successfully proposed to the United States EPA to require their nations municipal waste incinerators to monitor for dangerous air emissions; monitoring that was not done previously and yet Waste to Energy Incinerators (modern or old) were seen as safe with little to no daily monitoring (by a third party) to provide the evidence that it was so.

<https://www.theguardian.com/environment/2025/jan/09/epa-waste-toxic-air-emissions>

In addition to the impossible situation, above, enforcement agencies are further hamstrung by the enforcement penalties they currently have at their disposal, which can consist of:

- Infringement Notices
- Clean-up or Response Orders
- Court-Imposed Penalties
- Criminal proceedings
 - Such as prison time, seldom used

These largely equate to fines and are calculated based on the number of breaches and their associated penalty units:

- For the 2025-2026 financial year a penalty unit is set at the value of \$203.51
- For 20 penalty units the total cost to the business would be \$4,070
 - Some may say the cost of doing business

Fines are not enough and do nothing to discourage businesses from breaching controls; examples supporting this statement are below.

The human cost of breaching these controls is in the Human Health Impacts section of this document.

The EPA could be given powers similar to those held and exercised by the Australian Securities and Investments Commission (ASIC) and revocation of licences should not be held as a last resort, even for minor breaches. If a strike system was implemented for minor breaches and an immediate suspension of licence for major breaches, then this would better protect the communities and environment.

Examples of recent breaches for Waste to Energy Incineration facilities around the world include but are not limited to:

- Croydon (UK) Incinerator breaking emission standards 916 times in 2 years
- KODA Energy (US) burning material they were not approved for over 2 years

- New Jersey (US) five Incinerator facilities breaking their air permits more than 1,700 times since 2004
- Viridor, running the Runcorn Waste to Energy Incinerator facilities in the UK, breached their permitted levels by an average of 5.5, compared to 3.4 in 2019
 - In 2024 73% of UK Waste to Energy Incinerator facilities reported transgressions
 - Runcorn has breached its permit 17 times in the past 5 years
 - This operator was compelled by a court to settle a £1 million case after residents launched legal action regarding pollution and disturbances
 - The operator also required residents to sign a Non-Disclosure Agreement (NDA) as a condition of the settlement; a number of residents refused to sign and took their story to the BBC

The operators in the Victorian Waste to Energy Incineration market, Veolia, Cleanaway and HiQ (formerly High Quality Bulla) are not exempt from EPA breaches of their own, examples include but are not limited to:

- Veolia
 - Fined over \$1 million for breaches of operating licence and failure to comply with the general environmental duty
 - Fined in 2023 for \$30,000 for a minor breach relating to failure to cover waste cells, have sufficient litter controls and failure to limit the size of the tipping face
 - Fined in 2025 for \$9,880 for a minor breach relating to pallets of dairy waste being stored without an EPA permit or licence at the site
 - Fined in 2017 for \$7,773 for allowing stockpiles of material to catch fire due to poor site practices
 - Refused application, by the EPA, for a Waste Transfer station in Hampton Park based on the unacceptable risk to human health and the environment
- Cleanaway
 - 8 workers have died on Cleanaway premises since 2022 due to safety breaches
 - Fined in 2020 for \$8,261 for an incinerator bypassing standard air emission controls, with which Cleanaway did not report the breach to the EPA until 9 days after the incident
 - Fined \$20,000 in 2021 for failure to notify the EPA of a non-compliance and breaches of licence at the site
 - Fined \$45,000 to fund a local environmental project due to pollution of wood fibres raining down on residential properties more than 1.5 kms away; the charge was found proven, without conviction
 - Fined \$30,000 in 2023 for failing to properly log its transporting of waste hand sanitizer
 - Fined \$15,000 in 2021 for missed deadlines and failure to manage waste stockpiles
- HiQ
 - Fined a total of \$55,000 in 2024 for:
 - Improper leachate management
 - Failure to implement a rehabilitation plan
 - Improper waste cover
 - Operation of more than one tipping face per cell

- Not establishing a proper risk-based monitoring program
- Failure to conduct an independent annual survey and
- Improper disposal of asbestos waste
- Fined a total of \$17,000 in 2025 for beginning construction of a new waste cell without written approval from the authority

Just because there is a standard does not mean the public is protected.

Unless it is enforced and monitored each and every day, by an impartial body, outside of the EPA and the business running the Waste to Energy facility, there is an unequal risk to the public vs the risk to the business breaking the emission control standards.

The business may lose their licence and worst or simply get a fine, the public may be exposed to substances that result in lifelong illnesses.

Human and Environmental Health and Circular Economy Impacts Sub-Section

The health impacts of waste incinerators and the build up of the harmful substances they produce, no matter how small at the stack, can be likened to the development of skin cancer melanoma, as an example of how risk accumulation increases based on the duration of exposure over long periods of time. Skin cancer melanoma develops based on exposure to the sun between 0 and 15 years, after which time the risk of a fully developed melanoma being present in the body, increases with every sun exposure and no measures to decrease that risk.

New Zealand, Denmark, South Korea and Sweden all acknowledge, in one form or another that Waste to Energy Incineration either produces adverse impacts for environmental and human health and/or impacts and discourages recycling and circular economy efforts.

It has already been acknowledged by Sweden and Denmark that Waste to Energy Incineration is harming their recycling and circular economy efforts, with recycling rates stagnating in Sweden (and an acknowledgement that more reusable and recyclable materials need to be diverted away from waste incineration) and Denmark decommissioning Waste to Energy Incinerators to improve recycling and reduce emissions.

France has launched a major study of the pollutants that are commonly emitted from these Waste to Energy facilities, in June 2025 and their impacts on human health.

ToxicoWatch Foundation, with support from Zero Waste Europe conducted a study that identified high levels of dioxins, PFAS and heavy metals in environments surrounding Waste to Energy Incinerators in Spain, France and The Netherlands; these were found in drinking water, in chicken eggs and heavy metals were identified close to homes, parks and schools.

These facilities are banned in metropolitan Sydney (due to the New South Wales (NSW) Government applying the “precautionary principle” as a result of the deemed unacceptable risk to human health and air quality) and in the Australian Capital Territory (ACT) (due to concerns about environmental and human health and its potential to undermine recycling efforts).

The United States, State of California, is shifting away from Waste to Energy Incineration, with their last facilities closing in 2024, due to disproportionate negative health impacts on low-income communities and communities of colour located near these facilities, as well as a desire to invest in a more sustainable, zero waste, future. This also ended due to the state’s decision to end “diversion credit” support for these facilities to better align with zero waste goals.

If there was no reason for concern, if the danger was so minimal, then it is highly unlikely that these studies would be conducted at all, the fact that they are and the fact that Waste to Energy Incinerators are known to emit the pollutants that are the focus of the study in France, strongly suggests a reason for concern and reasonable doubt as to the community’s and environment’s true safety.

It is important to reiterate that these emissions, while small at a single observation, if allowed to continuously produce will:

- Never break down and build up in waterways, drinking water, flora, fauna and humans, ultimately leading to a level which health impacts are felt, lowering quality of life or
- Take days, weeks, months or years to break down. The longer they’re present the greater the risk to the environment and human health or

- Transform into more toxic substances, chemicals or particulates when exposed to other elements in the atmosphere or water

True measures to tackle plastic waste and the impact on circular economic policies are described in the article below:

<https://www.plasticpollutioncoalition.org/blog/2019/4/29/six-times-more-plastic-waste-is-burned-in-us-than-is-recycled>

- Quotes from the article above:
 - “First, incineration is not material recovery, it is material destruction. The plastic waste material is burned into CO₂ and water and the heat generated is used to make steam which generates power. While the facilities are called “Waste to Energy”, their primary purpose is to destroy material and decrease the volume of waste sent to landfills. But a significant volume of toxic ash containing heavy metals remain when municipal waste is burned – about 10% - 15% of the original volume of waste – and it must be managed and disposed of as hazardous waste.”
 - “From a climate change perspective, burning plastic is not a smart way to make power. Since a large amount of energy was used and carbon was emitted to make the plastic resin in the first place, the power generated from burning plastic has a higher lifecycle carbon footprint than renewable energy or power generated from natural gas combustion.”

If these substances, chemicals and particulates are not identified early the risk of adverse health impacts that lower the quality of life or outright threaten it grows with each year of operation of the Waste to Energy facility; as the evidence is starting to suggest for Denmark, France and Spain. These impacts are outlined in the sections:

[Environmental Impacts](#)

[Human Health Impacts](#)

Alternatives Sub-Section

The short answer is, there really are alternatives to Waste to Energy Incineration. Alternatives that actually support a circular economy and reuse materials rather than destroy them.

Government Policy Suggestions

Proposal for an alternative to managing waste and supporting a circular economy in Victoria

Take a buy and burn economy and transform it into one that really means what it says when it says we're doing everything possible, putting your money where your mouth is, as the saying goes.

Will these alternatives be possible overnight, of course not, it's silly to say such things. However, is it possible to get these alternatives far down the planning and Proof of Concept path in a year, absolutely yes.

In 2019 and 2023 Victoria proved it could stand up to the misinformation, such as the complaining and quite frankly bullying that went on in the community during the removal plastic shopping bags from retail and grocery stores; with the same resolve we could finally start to move towards the eventual end of the landfill problems and waste production cycle and be a world leader in circular economic waste reduction and repurposing.

The statement touted by supporters of Waste to Energy Incineration is that "Waste to Energy has a roll to play", this writer asks the question, does it really? Is it truly necessary, when there are other options on the table ([Alternatives section](#)) that either don't produce or produce significantly less of the harmful substances, chemicals and particulates mentioned in the [Emissions section](#)?

- Quotes from a Polycarbin article (below):
 - https://polycarbin.com/blogs/news/from-waste-to-energy-to-a-circular-future-a-new-opportunity-for-the-life-science-industry?srltid=AfmBOorqS1z3hY8HRkJFQfKuyQ2qD4Hhya_BuloPcB-oB9ltck1apXtY
 - "However, the industry is evolving. WTE, while once seen as a necessary solution, is increasingly being viewed as a last resort for waste management. These facilities emit greenhouse gases, leave behind toxic ash, and if utilized indiscriminately as a material disposal outlet also destroy potentially valuable resources."
 - "Plastics, in particular, are a prime example. With their high BTU (energy) – e.g., HDPE contains over 18,000 BTUs per pound – they have historically been used as fuel in incinerators. But this ignores their long term value as recyclable materials."
 - "Studies confirm that excessive calorific value from high BTU materials like plastics can destabilize combustion and increase NOx (Nitrogen Oxides) emissions."
 - "Additional research highlights that recycling these plastics is both more environmentally and economically sound, displacing more fossil fuels while generating more jobs than incineration."

There are, of course, other measures that other countries have taken in an attempt to reduce (not eliminate nor having an effective plan to eliminate in the immediate future) greenhouse gas

emissions, through incrementally increasing tax thresholds on companies as they produce these emissions.

However, Sweden and Denmark have already proved that taxing Carbon Dioxide and greenhouse gases does nothing to improve recycling and circular economy efforts, if Waste to Energy Incineration is already in place. All this measure achieves is a boost to Government coffers with no regard for any health implications to the environment or people in the surrounds of the Waste to Energy facility, which, by the evidence beginning to emerge on this subject, would be a complete betrayal of public trust and a failure of proper governance for the people.

Each level of Government has a role they can play to see alternative measures succeed; please see [here](#).

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Final Thoughts – Criteria 4

It appears that there is increasing evidence that the claim made by Waste to Energy Incineration facilities and their parent company's that the emissions released from Waste to Energy Incineration facilities are insignificant and safe, contains significant reasonable doubt, when evaluated over the lifetime of the incineration facility.

The claim that the only emissions are water vapour, carbon dioxide and oxygen is not entirely accurate. While technically true, the content of the water vapour and surrounding gases appear to contain trace elements of chemicals, substances and particulates that do not or take time to break down in nature (forever chemicals), further increasing the risk of human interaction and increasing the risk of impacts to human and environmental health.

The argument stating that there's more background substances, chemicals and particulates (emissions) in the ambient air then comes out of the Waste to Energy Incinerator stack. While technically true, what timeframe does this relate to? Is it by day, by month, by year or is it just a point in time measurement that has been observed on a given day?

If this is just an average of point in time measurements, not each and every day, then this writer's answer is duh. Obviously there would be more of some of these substances in the background ambient air, that's not the concern, the concern is why add to it when a build up of these emissions is what causes the environmental and human health impacts mentioned in their given sections.

If the claim of a majority or predominantly organic waste was true then you wouldn't have the majority of these emissions, which are largely associated with plastic, metals, chemicals and failure to burn other waste (creation of highly toxic substances, chemicals and particulates).

Failure to burn, ironically, is largely due to high moisture content, which the source is, generally, organic waste.

This claim (this writer suspects) is based on a measurement of the organic wastes weight, vs other wastes weight, rather than volume, which may point towards a different source (plastic) as the predominant source of waste for these Waste to Energy facilities.

The fact is landfill's do emit high levels of methane and other greenhouse gases as well as contain toxic substances and chemicals, this document does not advocate for them.

The fact is that Waste to Energy Incineration just makes a different type of pollution, the impact of which creates a different issue but the outcome is the same, people suffer needlessly.

Waste to Energy emissions and the subsequent pollution don't just impact the atmosphere like landfill, they'll also impact the environment and humans at the ground level, over the course of 20-30 years, as opposed to greenhouse gases and global warming, which has been observed and steadily increasing to potentially catastrophic consequences, since at least the 1970s.

There is a different price to be paid by the surrounding communities for, what amounts to, a marginal to moderate drop in energy prices, temporarily, until those savings are absorbed by 'market forces' (energy companies raising prices over 10 years). In return Waste to Energy Incineration releases and builds up toxic substances, chemicals and particulates, slowly, over 30+ years, eventuating in moderate to severe impacts (see Human Health Impacts section for ratings description) to human health and the environment.

The waste from these facilities, the bottom ash, waste water (full of toxic substances, chemicals and particulates removed during the wet scrubbing processes) all need to be disposed of in landfill, arguably creating a more toxic substance to be handled by landfill than the original source material.

The risk of impacts to the environmental and human health and the level of severity of those impacts appear to increase with each year of operations; often, if not always, continuous operation.

It appears that the emissions that cause these impact risks to increase, despite all the best, modern, air purification and filtration technology, as reviewed in the WtE Incineration Designs sub-section, are not entirely contained, as those technologies, while incredibly impressive and do filter the vast majority of the emissions, have their own limitations.

This health evidence is, currently, difficult to prove empirically due to the following factors:

- Movement of people over the lifetime of the Waste to Energy Incineration facility
- Lack of centralised tracking for the diseases and conditions mentioned in the Impacts to Human Health section to monitor and correlate any emissions with health impacts over the lifetime of the Waste to Energy Incineration facility
- Lack of transparency from Waste to Energy Incineration facility company's regarding the precise amounts of those emissions mentioned in the Emissions section, no matter how small or perceived insignificance (this writer was unable to locate any daily, weekly, monthly or yearly data from any Waste to Energy Incineration facility where emissions are tracked to the micron scale, all evidence comes from independent scientific studies)
- Lack of regular monitoring by regulatory bodies, such as the Environmental Protection Agency (EPA), with monitoring or inspections limited to days, weeks, if not months in between checks
 - Over reliance on self-reporting by the Waste to Energy Incineration facility company's
- Lack of a centralised database to track emissions reporting in real time.
 - The database could be used by policymakers and enforcement agencies to shut down emissions problems before they become a serious threat
- No standard unit of measurement for the substances, chemicals particulates and other emissions for monitoring devices and reporting in scientific or otherwise papers/articles

Just because the information, research or underlying data is incomplete and requires further investigation does not mean that there is no risk and further supports the reasoning that the precautionary principle should be the foremost consideration when considering these matters.

The reason evidence is starting to emerge at all, appears to be from some of the longest running Waste to Energy Incinerators, such as in Norway, Sweden, Denmark and France; simply because it takes time (nearly 20 years) for the substances, chemicals and particulates to build to levels that border concern, if not outright cause it (as seen in the Zero Waste Europe study).

Despite the small, yet growing, stack of empirical evidence, the smoking gun if you will, through deductive reasoning, based on the Waste to Energy Incineration facility company's own admission and the independent scientific studies, a reasonably astute individual could reach the conclusion that for each year a Waste to Energy Incineration facility is in operation, the risk of significant harm to the surrounding environment and communities increases and likely

occurs; just without the reporting, collation and comparison of evidence and analysis by a centralised body.

The risks are clearly a concern, earlier this year (June 2025) France launched a national study to investigate the health implications of the substances, chemicals and particulates that are commonly emitted from Waste to Energy Incinerators. In Australia, while the Kwinana facility in Western Australia commenced operation, the New South Wales (NSW) Government banned Waste to Energy Incinerators in metropolitan Sydney; with a similar ban by the Australian Capital Territory (ACT) Government for Canberra.

These facilities are being shut down in California, and the European Union has restricted the opening of new facilities by tightening financial support criteria and cutting funding.

We took 30 years to understand the dangers of PFAS, Asbestos, Lead and dioxins (just to name a few), we cannot spend another 30 years to find out all of the different combinations of dangerous substances that occur in an incinerator. Since we don't know what the dangers are, we cannot do anything but apply the principle of caution so as to provide time for incinerator companies and impartial researchers to provide a peer reviewed case to prove that all of the possible dangerous substances can be contained. Until then it would be irresponsible to just take on faith that incinerators are not harmful, simply because they've been around a little while, when there is emerging and increasing evidence to the contrary.

The words acceptable limits should never be uttered when the cost is human health. Limits that are measured only from the direct output of the stack and not the extremely difficult and tedious task of measuring the surrounding environment, within a 10km radius of an incinerator. A zero tolerance approach to emissions of substances that impact human health should always be the first priority of any elected official.

Having a Waste to Energy Incinerator at all vastly increases the risk of regular, daily, release of substances, chemicals and particulates harmful to environmental and human health that do not break down, take time to break down or become worse toxic substances, chemicals or particulates after release from the Waste to Energy facility's stack.

There are not enough measures to discourage and prevent businesses from committing breaches. A fine after the fact, does nothing to protect the environment or the people in the impacted communities, the damage has already been done.

The debate around the production (recovery) of energy vs the energy it took to produce the waste items being used as fuel for these facilities confuses and dilutes the core issue. The core issue is and subsequent questions we must ask is what is produced by these facilities, in its entirety and in that is there any risk to human or environmental health? If there is risk, if what is produced are known contaminants, pollutants and toxins (or can form other toxins, pollutants and contaminants on release over the lifetime of the facility) and if there are alternatives to waste management, then this measure to incinerate our waste simply should not be done.

Waste to Energy facilities, their core function (primary or first function) is to obtain waste from their silo (pile etc) and place it into the incinerator to be burned, producing the byproducts of heat, steam and highly toxic gases (vapours) that require serious purification and filtration to get anywhere close to safe (not close enough), all to produce enough heat and gas movement to turn a turbine to produce electricity.

Electricity, just like the toxic chemicals, substances and particulates, is a byproduct, not the core function (primary or first function) of waste to energy facilities, despite their branding as waste to energy; they are, first and foremost a waste disposal system that happens to produce electricity in its operation.

There are many other options that do produce electricity as their core function, (heat and steam are not the only things that can turn turbines) such as the simple movement of natural cascades or rushing of water (there are research and proof of concepts that show how to do this without causing undue harm to flora and fauna, however that is beyond the scope of this document). This, among other options, has the nice byproduct of not producing toxic airborne substances, chemicals and particulates, as well as landfill occupying and potentially mishandled and then released ash.

So, what do we know?

Waste to Energy Incinerators commonly emit trace elements, substances, chemicals and particulates (see all references in the above sections)

In these trace elements are substances, chemicals and particulates where:

- Some never break down in nature
- Some mix with other elements, substances, chemicals and particulates either in the incineration unit, in the atmosphere or in water on release and form new highly toxic substances, chemicals and particulates
- Some take weeks to months to break down on release and have the potential to cause harm in that time
- Some are released if control measures fail, whether that be by an equipment failure or failure to follow proper procedures by staff. Upon release these substances, chemicals and particulates are highly toxic and dangerous to the surrounding environment and communities and are easily made airborne

We know these substances, chemicals and particulates, despite all of the current technology to filter them, will be emitted in small quantities each day, depending on what is burned.

We know is these substances, chemicals and particulates are toxic, they build up and or cause serious harm if mishandled.

The onus could be on the Waste to Energy provider to support the research and prove beyond any doubt that the technology that is in place, the technology that is developed, prevents any harm to the environment and humans over the total contract and lifetime of the Incinerator facility.

It should be proven, beyond any reasonable doubt (which this document presents reasonable doubt), that the emissions that are released are not harmful to the environment or humans over the lifetime and total contract of the incinerator facility.

You will hear 2 claims from pro waste to energy incineration groups and businesses:

- The first that Waste to Energy Incineration has not been definitively, scientifically, linked to adverse human or environmental health impacts with the currently available body of scientific evidence (though growing, as provided in this document).

And

- That Waste to Energy Incineration poses negligible, little, insignificant (and many more variations on these words) risk to the surrounding environment and communities.

This writer poses the question:

How can Waste to Energy businesses state that Waste to Energy Incineration poses negligible, little, insignificant (and many more variations on these words) risk if the scientific evidence is inconclusive, not definitive?

Scientific evidence does not take sides, it is or it isn't, proven with data. Studies assessing human and environmental health impacts can provide evidence that Waste to Energy Incineration is safe or it isn't.

There are studies supporting the position of Waste to Energy Incineration businesses and there are studies that are beginning to suggest that position requires re-evaluation.

The fact that Waste to Energy Incineration businesses claim it is safe or the risk is negligible, in the face of inconclusive evidence either way (by their own admission) is risky, if not outright dangerous.

To say that Waste to Energy Incineration will not cause harm over the facility's lifetime (contracted or otherwise) when the scientific data is inconclusive either way is a reckless disregard for the "precautionary principle" and for the safety of the communities and surrounding environment where the facility will be placed.

When it comes to the air we breathe, the water we drink, the food we eat, are words like acceptable risk, negligible risk, little risk, harmless (in the short term, based on a daily measurement at the stack, which may not accurately show what is being incinerated over the course of the week or longer) really acceptable?

The fact that the controls over what is to be incinerated requires human observation, significantly increases the risk of incineration of items that further increase the amount of pollutants that air quality and purification systems have to attempt to remove; they don't remove everything.

If you don't really know what is being incinerated and you don't really know that it is safe but you're doing it anyway then you are acting on, not data, but an instinct, a feeling, a theory.

To then put a theory into practice is, by definition, a test, an experiment; one that changes the air quality for the surrounding communities and environment.

By changing the quality of the surrounding air (however small) that people have no choice or control over when or what they're breathing in and you don't know what the results of those changes will be, over the lifetime of the facility, then the experiment is being conducted on

unwitting and unwilling people and that could be considered (interpreted) as against the Charter of Human Rights, which Australia and the State of Victoria are signatories to.

Is it really the best solution, our only solution or is it just the cheapest? Should the cheapest solution be the one selected when the consequences of mistakes in that solution are so harmful to human and environmental health?

We are not talking about toxic particles that are emitted and an hour later they're gone. We are talking about particles that: never go away, take days, weeks, months, years to disappear or be diffused into the air and that is just those particles that were emitted that particular minute when the reading was taken; not taking into account the volumes emitted over the course of the lifetime of these facilities.

These facilities can and do operate 24 hours a day, 7 days a week, with minimal disruption for maintenance due to redundant systems; a fact they're often applauded for. These facilities can and do operate over these times for 5, 10, 15, 20 and 30 years, non stop.

The evidence is only growing and the deductive reasoning of the evidence so far is objectively suggesting that Waste to Energy Incineration is not as safe or good an option as once thought.

To say this is too complicated to think about, too many points to go through, let's just burn it all, it's good enough, is lazy and irresponsible in the face of evidence that this may not be safe.

The argument that the likelihood of enough substances, chemicals and particulates falling in an area over the lifetime of the Waste to Energy Incinerator facility is so low that we should just go ahead, build and operate it, is a complete disregard for humanity and the environment.

With that, you're stating that if someone or a few someone's, (remembering these are real human beings, with lives and families and futures) gets sick, has their quality of life lowered so that life, that future slips away from them and has such bad luck that they're sick as a result of the Waste to Energy Incineration facility (when it is proven and it will eventually be, the evidence is already starting to mount) being operated (when they wouldn't have been otherwise) then it's just tough luck, an acceptable outcome to power 50,000 homes? That is disgraceful, inhuman, thinking. One person's life should never be seen as acceptable to lose (whether that is deceased or life as they knew it is forever changed, no matter how small) over something as mundane as providing energy to homes and businesses; think harder, design a better solution.

We once thought and produced papers stating that mercury, lead, asbestos, cigarettes and PFAS were all safe, the smart and cost effective solutions and in some cases even beneficial to human health, which were all disproven in their entirety as false and misleading claims, sometimes deliberately placing people in harm's way for the sake of corporate and investor profit.

Is this something we're willing to roll the dice on? That in 20-25 years there will be no consequence for continuously emitting these substances?

This of course only accounts for the standard emissions that come out each day in the 1% average and commonly observed emissions, it says nothing about if there were an accident and fly ash or biproducts became uncontrolled. It may be an accident and a rare occurrence, but the odds are not zero. Would there be a community warning not to go outside? Would there be a wide scale clean up operation if it became airborne? Any risk of this scenario, though the odds

may be small, is a risk to a life potentially ruined through accidental exposure to a substance they had no means of protecting themselves against.

It could take 30+ years for the full extent of chronic exposure at such low levels to start to become apparent in human health and by then the data will be difficult to tie together due to the extremely high chance of people moving away from where the Waste to Energy Incineration facility is located

Evidence such as this article support this:

[The health impacts of waste incineration: a systematic review - ScienceDirect](#)

The current, modern, Waste to Energy Incinerators have only been around, in the numbers they currently are, in Europe for no more than 22 years and the environmental impact is only now starting to be observed by science, such as the recent Zero Waste Europe study

[The True Toxic Toll - Zero Waste Europe](#)

These facilities do not contribute to and in fact do nothing for a true circular economy, they're only for a buy and burn economy.

If you take energy out of the equation what you're left with is the fact an item was produced out of materials, minerals and other useful components and that item was purchased, used, discarded and burned, burning with it everything that was used to make it.

Are there better alternatives? Yes

Are these alternatives the quickest, easiest most affordable option today? Not always, they come with their own set of challenges, the largest being having never been done before.

Are the alternatives better for human health and the environment? The evidence presented in this document, a presentation of the collective evidence in the reference materials, would suggest, yes, they are.

The alternative proposal in this document, some by now have likely pointed out, will still have to send some items to landfill, this is true. However, the types of items that will need to be landfilled will be drastically reduced with the reception and uptake of the proposal and the primary driver of the methane concern at landfills will likely be addressed through the FOGO recycling methods proposed. The alternative proposal has the added benefit of not poisoning surrounding flora, fauna and humans

We must ask ourselves is our argument based on the notion that incineration is currently better than landfill and is our most economical (bang for buck) alternative? Or is our argument based on what is best for human and environmental health and alternatives that can reasonably replace landfill and be sustainable for years to come, creating a true circular economy that in time, will show it's worth in the investment.

Burning our way out of the landfill problem is not going to solve the problem while protecting the environment and the people, it simply makes the problem smaller and airborne, spreading the problem into sensitive and important waterways, as well as fauna and vulnerable people.

Conclusion

This document attempted to bring together the scientific, medical and government literature on Waste to Energy Incineration facilities and the emissions associated with its operation, for the assessment of its potential, long term impacts on environmental and human health.

It has provided literature with the aim of assisting decision makers with a deduced assessment of the following questions:

1. How effective are the current filtration and air purification systems?
2. What is the typical amount of emissions these facilities produce, however small?
3. What are the potential impacts of these emissions on environmental and human health?
4. Are there suitable alternatives that will support a circular economy?

The Inquiry, terms of reference, criteria that has been addressed in this document is as follows:

- The Suitability of Existing Waste to Energy (WtE) Infrastructure Plans and Policies, including:
 - The impact of WtE projects on residential communities and transport infrastructure
 - Known as Criteria 1
- The impact of WtE, including from
 - Separating recycling and organic material from WtE Streams
 - Nature and management of emissions waste and ash byproducts
 - Known as Criteria 2
- Alternative waste management approaches and emerging technologies that also align with circular economy principles, having regard to the recommendations of the Environment and Planning Committee's 2020 Inquiry into recycling and waste management and the role of WtE in the Victorian Government's circular economy plan, including Victoria's landfill management, capacity and strategy
 - Known as Criteria 3
- Any other related matters
 - Known as Criteria 4

The emerging evidence strongly indicates significant doubt on the claims made by Waste to Energy Incineration providers that the emissions are insignificant.

The evidence suggests a correlation between substances, chemicals and particulates emitted in sub-micron volumes from the Incinerator stack and a build up of same substances, chemicals and particulates that are known to cause harm, in the surrounding environment and population in proximity to the Waste to Energy Incineration facility; the evidence also suggests that these substances, chemicals and particulates take time to diffuse into the air or never disappear, further adding to the risk of incremental, chronic exposure over the lifetime of the Waste to Energy facility.

There appears to be a discernible relationship, we can establish through deductive reasoning, between a build up of these substances, chemicals and particulates that can build to unsafe levels, as proven in recent studies, in areas surrounding Waste to Energy Incinerators and the impact of those substances, chemicals and particulates listed in the Human Health Impact section of this document.

Health impacts on the environment and humans range from minor to severe (as defined in the Human Health Impacts section of this document) as a result of contact with these substances, chemicals and particulates over a prolonged period of time; evidence is only now starting to emerge as that prolonged period of time can be 20 years or more.

In that time the most vulnerable of the communities are placed directly in harm's way, the elderly and infants, with far reaching consequences that are easily misattributed and/or misdiagnosed, due to insufficient information around the operation of Waste to Energy Incineration facilities.

However, this has not yet been proven, beyond any reasonable doubt, nor has the evidence been proven beyond any reasonable doubt that Waste to Energy Incineration is safe; only that it is acceptable, but for how long before harm is caused?

There are viable alternatives that don't have to risk the air, water and potentially food source pollution that comes with Waste to Energy Incineration. These could be world first initiatives that Victoria could lead the way in demonstrating how to truly manage a circular economy.

The evidence presented is emerging and suggests that Waste to Energy Incineration is not as safe as it has been advertised. However, this in itself is not yet conclusive. The evidence presented by Waste to Energy advocates largely stems from similar or the same studies and is also not yet conclusive. With that in mind, how can Waste to Energy businesses insist that it is safe when the evidence either way is not yet conclusive?

In the face of this uncertainty, the substantial risks to the environment and human health shouldn't we be cautious?

New South Wales (NSW) and the Australian Capital Territory (ACT) have already banned this technology due to a similar dilemma, among other concerns; can Victoria really do any less?

The simple reality is that filtration, even under the most optimum of conditions cannot catch everything.

We know that many of these emissions take time to break down or don't break down at all, increasing the risk of chronic exposure over time.

A deductively reasoned assessment of these circumstances strongly suggests that the previous literature on Waste to Energy being safe may not have been as conclusive as it seemed.

The reality is that there isn't enough empirical evidence to definitively prove that Waste to Energy Incineration is not safe and just as much there isn't enough empirical evidence to definitively prove that Waste to Energy Incineration is safe, due to the length of time it takes and the dispersion area, as well as other factors here, for readings of these emissions to build towards unsafe levels.

The evidence is now starting to emerge because the oldest, modern, Waste to Energy Incinerators are approaching or have already approached 20 years of operation.

Noting all of this, a cautious approach, already adopted by the ACT and NSW, would seem to be the most prudent.

Should we really abandon the precautionary principle in Victoria when the evidence is incomplete either way, are we really willing to roll those dice?

Additional References – Emerging Evidence (in cooperation with all previous references)

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