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Attn: Gayle Sloan

Re: EfW risks to the community

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by WMMR to provide advice to WMMR in relation to risks to community health from emissions derived from EfW, in particular the potential presence of PFAS.

It is understood that the information will be used to assist in communicating such risks within the industry, the community and regulators.

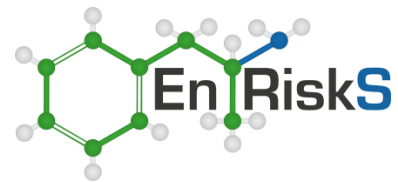
The following provides draft plain English summaries or fact sheets that address the following:

- general issue of EfW and impacts on community health
- PFAS and EfW.

If you require any additional information or if you wish to discuss any aspect of these fact sheets, please do not hesitate to contact Jackie on (02) 9614 0297 or 0425 206 295.

Yours sincerely,

Dr Jackie Wright (Fellow ACTRA)
Principal/Director
Environmental Risk Sciences Pty Ltd



Energy from Waste (EfW) and community health

A bit of history

Most power stations use turbines to generate electricity. These turbines can be run by combusting a fuel such as coal or gas (or using the force of flowing water – hydropower for example). The combustion process produces steam, that then turns a turbine to generate electricity. This process has been around for a long period of time. Instead of combusting coal or gas, EfW facilities combust waste to produce steam, which turns the turbine to generate electricity. Both steam and electricity can be used from these facilities. Only waste that cannot be recycled or reused is sent to an EfW facility, otherwise these materials would end up in landfill.

Waste incineration has been around for a long time with large scale incineration being conducted since the late 1800's and continuing into the 1900's. These facilities typically combusted waste for the purpose of waste disposal/destruction rather than to generate power. Some of the facilities in the 1900's were also used to generate steam and electricity. These older facilities had little to no control on emissions, and that resulted in adverse health impacts in the community. When clean air legislation was enacted, most of these facilities were closed.

Old incineration technology is very different to new technology used in EfW and these cannot be directly compared.

Modern EfW facilities are required to comply with EU Best Available Technologies (BAT BREF) [1-5] that stipulate how the facilities operate, the level of pollution control required, sets emission limits for what can come out of the stack and outlines requirements for monitoring and management (including upset conditions). The BREF has been developed since 2000, with the most recent revision or refinement, that incorporates continual improvements, issued in 2019.

Chemicals in air and what we breathe

It is important to remember that just like the earth (soil, rocks and water), the air is made up of chemicals. The air we breathe every day comprises nitrogen, oxygen and carbon dioxide as well as lower levels of many other chemicals. This includes chemicals from dust which includes the metals that are present in soil; pollen/spores and decomposition gases from plants and organic material; chemicals from combustion – like from running a car or truck, or using a wood fired heater or gas cooker; or dust and gases from bushfires. As a result, the air we normally breathe has low levels of a wide range of chemicals in the form of gases and particulates.

A BRIEF GUIDE TO ATMOSPHERIC POLLUTANTS

A number of different chemical entities, from a range of sources, can contribute towards atmospheric pollution, the consequences of which can include global warming and smog. This graphic looks at a selection of major groups of atmospheric pollutants, their major sources, and their effects.



CARBON MONOXIDE

A gas generated by the incomplete combustion of fuels – primarily from road transport. Affects human health, as it reduces oxygen-carrying capacity of the blood. It also reacts with other atmospheric gases to produce ozone.



CARBON DIOXIDE

A gas generated by the burning of fossil fuels in the production of electricity. Also emitted by natural processes. Human emissions are linked with rising atmospheric CO₂ levels and anthropogenic global warming.



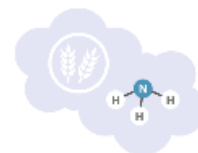
NITROGEN OXIDES

Primarily created by combustion in road transport. Nitrous oxide is an important global warming contributor, whilst nitrogen dioxide is involved in ground-level ozone-forming reactions, and is also a component of smog.



SULFUR DIOXIDE

The primary source of sulfur dioxide is the burning of fossil fuels to generate electricity. It can contribute to smog, reacts with water to produce acid rain, and can also cause wheezing and breathing problems for asthmatics.



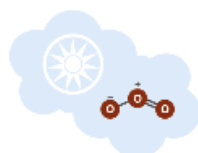
AMMONIA

Ammonia's primary atmospheric source is from its use in agriculture, such as manure & fertilisers. It can react with other pollutants to produce particulate matter. It also has the ability to over-enrich ecosystems with nitrogen.



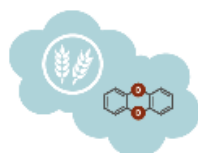
VOCs

VOCs (volatile organic compounds) are emitted naturally by vegetation. Amongst significant human sources is road transport, as well as solvents. They can contribute to formation of ground-level ozone and smog.



OZONE

The ozone layer shields us from UV radiation, but ground-level ozone is a major pollutant. It's formed from other pollutants in the presence of sunlight. Ozone is a major component of smog, and can also cause health effects.



POPs

POPs (persistent organic pollutants) are volatile chemicals released into the atmosphere, often from agricultural or industrial uses. They persist in the environment, and can have health effects on both wildlife & humans.



PARTICULATE MATTER

Particulate matter is composed of a huge number of different components. Some are directly emitted, while others are generated by reactions in the atmosphere. They cause haze and can also cause lung problems if inhaled.



HEAVY METALS

Heavy metals are released into the atmosphere from a range of sources, including burning of fossil fuels and road transport emissions. Some, such as mercury and lead, have toxic health effects in humans.



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Chemicals are present in the atmosphere from numerous sources that include a range of combustion gases, metals and persistent organic chemicals like polycyclic aromatic hydrocarbons and dioxin-like compounds. These are the same chemicals in emissions to air from EfW. It is important to understand what changes in air quality may occur from the operation of an EfW facility.

To understand how the operation of an EfW facility could impact on community health, this requires some understanding of how an EfW facility operates and what could be released into the air, for the community to be exposed to.

How does EfW work and control air emissions?

The technology used in EfW has been refined to maximise energy production and minimise losses including emissions to air, specifically [2, 6]:

- Waste is mixed in a bunker prior to entering the combustion chamber or furnace, so that the fuel used provides a consistent energy input
- The furnace is required to operate at a minimum temperature and waste is combusted for a minimum amount of time, under specific oxygen conditions to maximum combustion (destruction of chemicals in the waste) and minimise the generation of pollutants including the formation of dioxins
- Heat from combustion is used to make steam – this drives a turbine to produce electricity. Both the heat and electricity can be used by other industry or electricity sent to the grid

- Ash is produced in the chamber (like it does in a wood stove) and this can be cleaned up (metal removed) and reused for things like aggregate in roads
- Emissions from the furnace are treated by pollution control equipment before being discharged to air via a tall stack
- What remains in air emissions are primarily atmospheric gases like nitrogen with trace (or very low) levels of pollutants
- EfW facilities have continuous monitoring of a number of important parameters to make sure they are operating well – just like coal or gas fired power stations
- EfW facilities are also required to monitor a range of pollutants in the stack to make sure these meet licence emission limits – just like coal or gas fired power stations and other industrial facilities
- If something goes wrong and it cannot be fixed straight away by the operator, the facility shuts down. The first step is to stop waste entering the furnace, which prevents emissions to air occurring. It is also noted that there is no way the pollution control equipment can be bypassed at any time.

What then happens with the air emissions?

Emissions from an EfW process, after all the pollution control steps to remove pollutants from the air, are discharged to the atmosphere via a tall stack.

The stack is engineered to make sure emissions are well dispersed (i.e. mixed) in the atmosphere, before reaching anywhere that the community may be exposed [7].

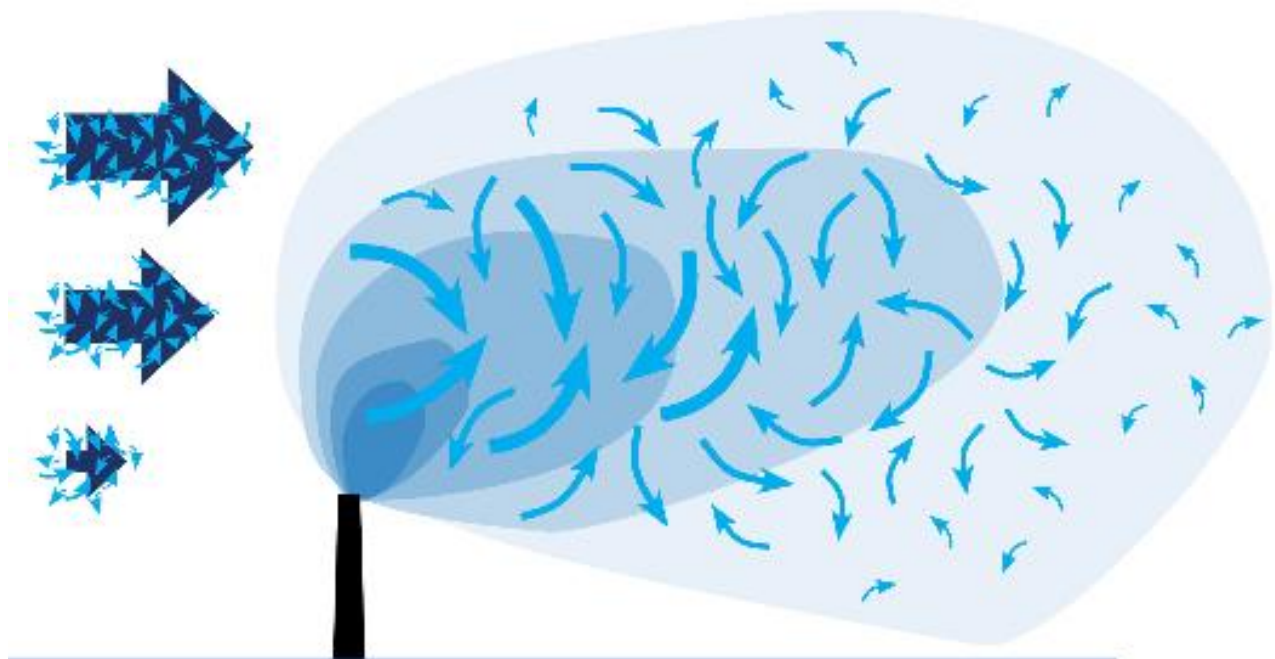
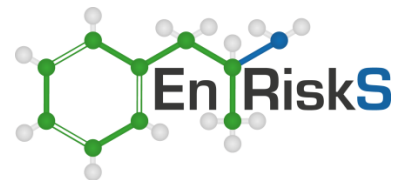


Figure showing air dispersion from a stack [7]

This means pollutant concentrations in air where the community may be present are much lower than in the stack. Concentrations in the air the community is exposed to are estimated using air



dispersion models, that are reviewed and approved for use by government experts in Australia [8, 9]. These models use site-specific information such as the stack details such as the location, height, how fast the air moves out of the top of the stack, weather data and terrain, and where people live, work and play.

Assessing health impacts

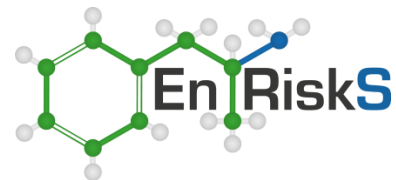
Assessing whether emissions from an EfW facility have the potential to impact on health can involve conducting a detailed assessment of risks to human health and reviewing published studies.

A detailed assessment of risks to human health is required, by Australian regulations, to be conducted following Australian guidance from enHealth (2012 [10]). Such an assessment:

- Calculates how the community is exposed to pollutants from the EfW facility. It links with the air dispersion modelling to identify concentrations in air that may be in areas the community is exposed – where we may breathe the air (i.e. at ground level in the neighbouring areas). All concentrations in the environment must comply with Australian and state air quality guidelines [8, 9, 11, 12].
- The assessment also looks at the deposition of particles containing metals and persistent organic chemicals. Like all dust in the air, the dust particles can deposit to the ground where they may accumulate in soil, dust inside a home and in water. Once in soil and water the chemicals deposited with the dust can be taken up into produce that may be grown in the soil. The chemicals that may accumulate in soil from EfW are already present in soil from other sources like metals from the earth's crust, fertilisers, controlled burning and bushfires. Exposure to these may occur as a result of ingestion (incidental intakes of soil and dust, drinking water and eating produce) and absorption through the skin (for soil and dust that gets on the skin and water when bathing or swimming for example).
- No EfW facility can be approved if exposure to pollutants in all these ways added together could result in adverse health effects for any members of the community.

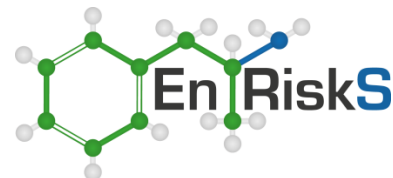
The potential for the community to be exposed to chemicals from the operation of an EfW facility, or experience health effects can also include a review of published studies from EfW facilities operating in other jurisdictions. This is the same for all other industrial facilities that currently or may want to operate in Australia.

For modern EfW facilities that operate in compliance with the EU BREF, such studies [13-24] show that there is no evidence that pollutants emitted to air from a modern EfW facility change existing concentrations in soil or produce, and there is no evidence of adverse health effects in the community surrounding these facilities.



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Energy from Waste (EfW) and PFAS

What are PFAS and why are they in our waste?

Per- and poly-fluoroalkyl substances (PFAS) are a family of man-made fluorine-containing chemicals that have unique stain and water-resistant properties. PFAS are a complex group of chemicals, which consists of compounds with carbon-fluorine solid bonds (C-F) which is the shortest and strongest known covalent bond in nature and is responsible for the thermal and chemical stability of PFAS.

These chemicals were developed between the 1930s and 1950s for a wide range of uses. Only since the 2000's have analytical methods been developed to be able to measure these chemicals in the environment. The unique properties of PFAS (which make them so useful in many products) also mean that once in the environment these chemicals are persistent and generally mobile, with some of PFAS chemicals also able to bioaccumulate.

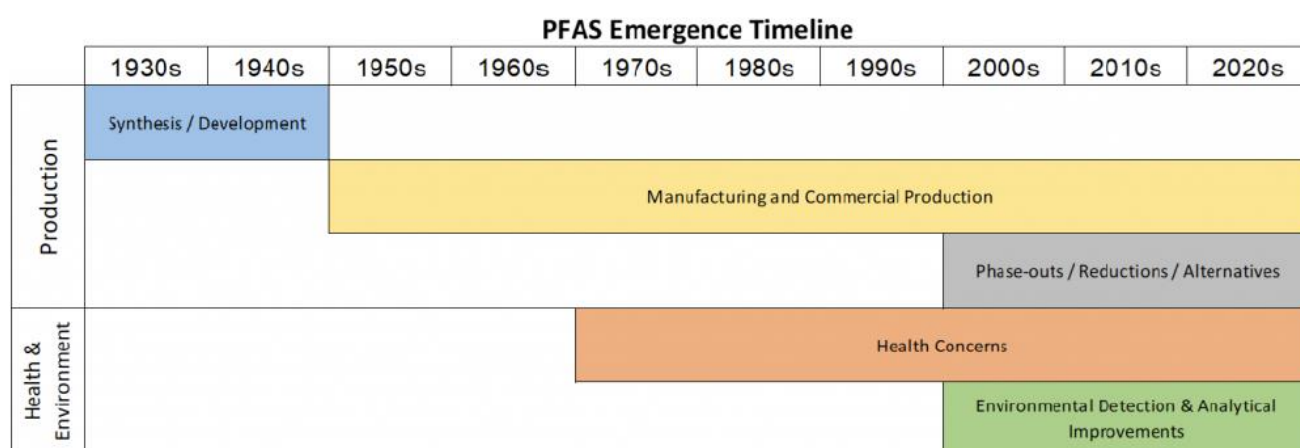


Figure 1: General timeline of PFAS emergence and awareness (from ITRC [1])

Due to the widespread use of PFAS in many products (**Figure 2**), PFAS is present at low concentrations in waste – municipal solid waste (MSW) and construction and demolition waste. MSW does not include PFAS from key source areas such as fire fighting foams, manufacturing wastes and other industrial processes.

While the manufacture, import and use of PFOS and PFOA were banned in 2025 in Australia, and levels of these compounds would be expected to be reducing in waste post 2025, consumer products contain many other PFAS compounds that would remain in waste.

Studies that have looked at MSW waste found that PFAS was present in a lot of different waste materials (**Figure 3**) with household waste being the largest contributor [2].

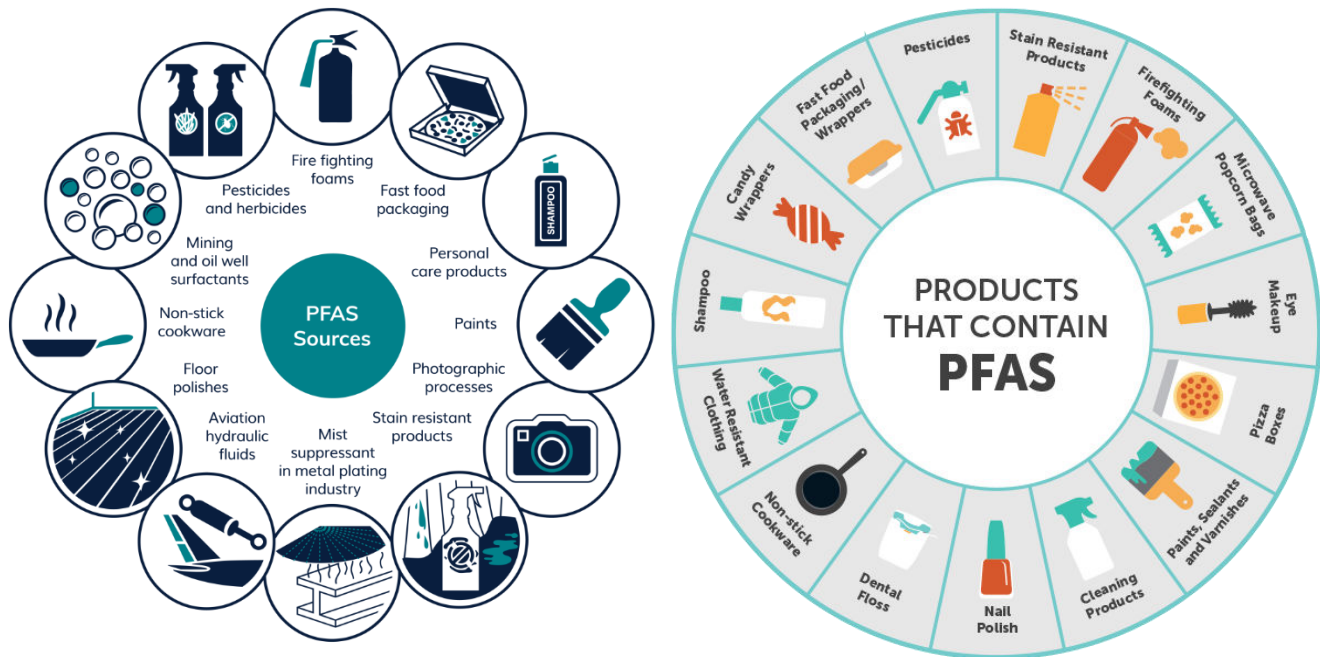


Figure 2: Key sources of PFAS (from Australian Government¹) and key products that contain PFAS ²

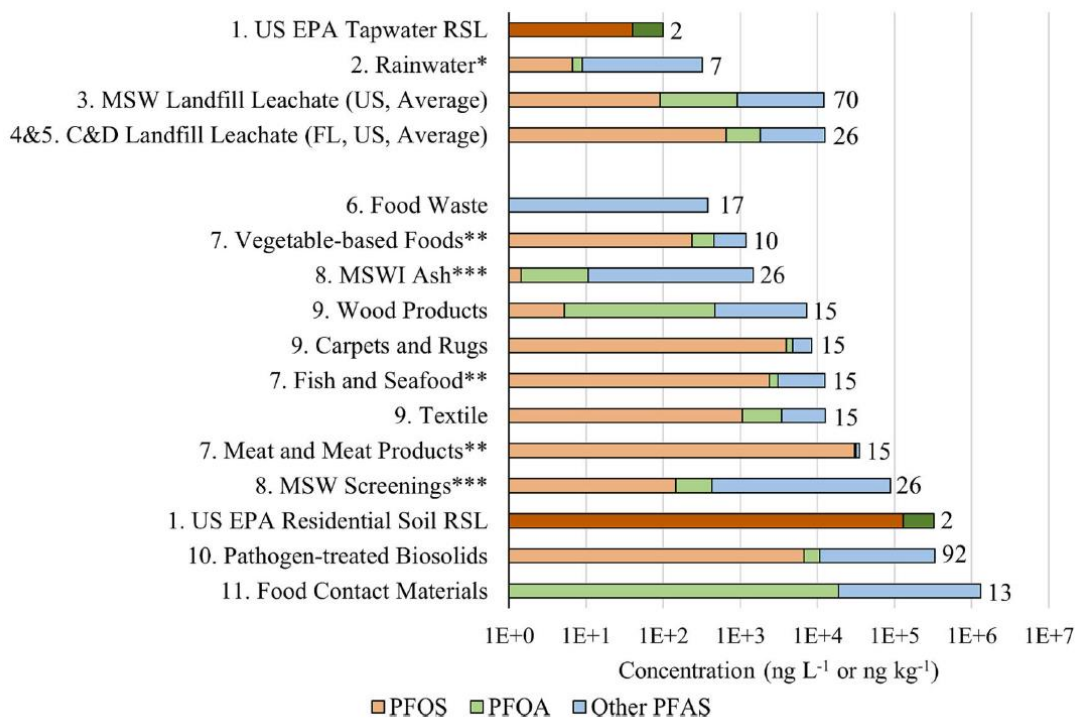


Figure 3: PFAS concentrations and compositions measured in various products, wastes and environment compared with PFAS in leachate at MSW landfills [2]

¹ <https://www.infrastructure.gov.au/infrastructure-transport-vehicles/aviation/pfas-your-questions-answered>

² <https://watermanaustralia.com/pfas-contaminated-water-treatment-techniques/>

Where waste is disposed to landfill PFAS migrates to leachate which requires management. PFAS (in particular the volatile PFAS chemicals which are short-chain chemicals) are also present in landfill gas. Hence PFAS are already in the environment as a result of the disposal of waste to landfill.

EfW only receives PFAS as a low-level contaminant from MSW (as above). EfW cannot accept high concentrations of PFAS waste from firefighting foams, industry or contaminated sites.

What happens to PFAS in EfW?

There is a requirement under the Stockholm Convention to manage PFAS in waste in a way that the chemicals are destroyed or irreversibly transformed or disposed in an environmentally sound manner. Australia is a signatory to the Stockholm Convention.

Incineration of solids and liquids has been identified as one of the few technologies that can “potentially destroy PFAS” [3-5], compared with many other technologies for treating PFAS contamination which rely on absorbing the chemicals to another media (just like a home water filter absorbs chemicals from water prior to coming out of a tap) or techniques to concentrate the PFAS for disposal.

Mineralisation is the more correct term to describe the process of complete breaking down PFAS molecules into base elements and compounds. This means the entire PFAS molecule (alkyl chain (tail) and functional groups (head)) are defluorinated and converted into fluoride salts, hydrogen fluoride and small hydrocarbons.

The carbon–fluorine bond in PFAS is much stronger than the carbon–chlorine bond in chemicals such as dioxin-like compounds. Breaking the carbon–fluorine bond requires 1.5 times more energy and therefore higher temperatures and reaction times. Hence the temperature and residence time for breaking the bonds in PFAS need to be considered. Concern has been raised in relation to the formation of products of incomplete combustion (PIC), where carbon-fluorine fragments recombine [5].

So, when PFAS is in waste that goes into an EfW facility the things that need to be looked for are PFAS that may not have been destroyed and PIC (**Figure 4**).

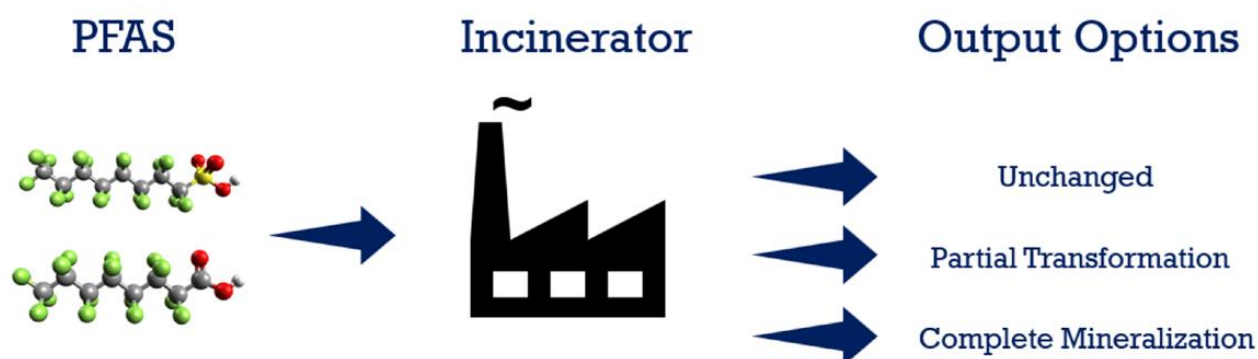
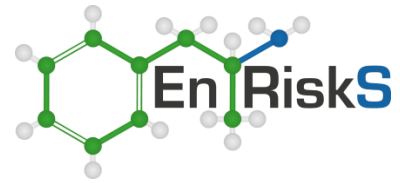


Figure 4: PFAS and incineration [6]



In an EfW facility PFAS is removed from the waste through destruction in the combustion chamber, and through the implementation of pollution control equipment to capture and remove residual gases and particulates.

Combustion conditions*

- Temperature and residence time are important to break the C-F bonds
- EfW conditions have been found to result in high levels of destruction of PFAS (more data is required)
- Products of incomplete combustion (PIC) potential – short chain PFCs

*Combustion conditions required to be used in EfW have been shown to be effective in destroying PFAS and minimising the formation of PIC [5, 7-12]

Acid gas treatment**

- Removes acid gases from emissions
- Also captures breakdown products and PIC from PFAS

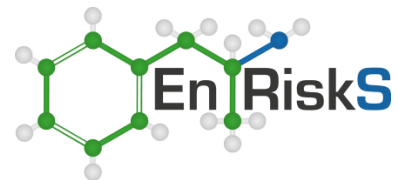
Activated carbon**

- Proven method to adsorb and remove key PFAS - commonly used to remove PFAS from water

Baghouse**

- Chemicals attached to particles are captured in baghouse
- Includes PFAS bound to particulates
- PFAS removed are present in air pollution control residues (APCr)

** Air pollution control steps that also remove PFAS from air following combustion [3, 5] before being discharged to air via the stack



Are there studies that have looked at PFAS emissions from EfW?

There are a number of studies that have been conducted to assess the effectiveness of EfW in destroying PFAS as noted above. It is noted that more studies are required to further support these outcomes.

The EU BREF does not currently include any requirements for the sampling or analysis of PFAS in emissions from any waste incineration process. There are studies that have been conducted where measurements have been done to look for PFAS in emissions from EfW facilities.

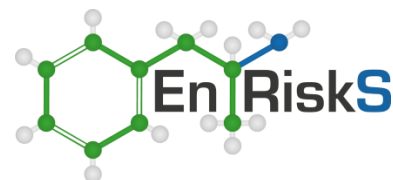
The few studies available on measured levels of PFAS in stack emissions from operating EfW facilities, have reported very low level detections of some short-chain PFAS (noting methodological issues with this study) or no detections of PFAS in emissions [10, 13, 14]³.

In bottom ash PFAS were either not detected or at low and variable levels [15, 16]. Some PFAS with less than nine carbon atoms have been detected at low concentrations in air pollution control residues [15, 16].

Can the presence of PFAS in emissions be of concern to community health?

PFAS are persistent organic pollutants (POPs) and these are assessed in the same way as other POPs that may be present in emissions to air from the operation of an EfW facility. This involves following Australian guidance [17] on assessing risks to human health. This is the approach that is recommended by the NSW Chief Scientist [18]. The same as other POPs a risk assessment is required to assess all the ways the community may be exposed to PFAS. This includes inhalation as well as the deposition to soil and water, and potential uptake into produce that may be consumed. No EfW facility can be approved unless there are no risks to human health from being exposed to all emissions, including PFAS and other POPs.

³ <https://norfors.dk/ikke-fundet-pfas-i-roggassen/>



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