Bulletin

Emissions from landfill and thermal waste-to-energy

A closer look at the burning question

Thermal waste to energy (WtE) involves converting residual waste into electricity, typically through direct combustion or high temperature gasification. It promises to put rubbish to good use – reducing greenhouse gas emissions by diverting waste from landfill and offsetting electricity generation from the grid. However the reality is not that simple.

The analysis of thermal WtE emissions is often assumption driven, and fails to accurately account for extensive energy capture at modern landfills and major changes already underway in the waste and electricity sectors. Well intentioned policy, supported by inaccurate analysis, risks unneccesarily locking in high emissions in the waste sector for decades to come.

In this bulletin we explore the drivers of waste to energy emissions and consider how the trade offs between landfill energy and thermal WtE will likely change over the next ten years.

Managing waste is an important building block of the circular economy

The management and treatment of waste is an important environmental and economic issue. Appropriate management of waste helps maintain local environments, reduce pollution of air and water, and minimise greenhouse gas emissions. Waste management also represents an economic opportunity. Certain waste streams may be reused or recycled for a range of productive purposes. The National Waste Policy[1] emphasises the importance of waste management in supporting a circular economy model. Optimal waste management should protect the local environment, maximise the value embedded in waste, and minimise greenhouse gas emissions.

Australia produces approximately 12.6 million tonnes (Mt) of municipal solid waste (MSW) per year, roughly 500kg per capita.[2] Some MSW is recycled, with the residual waste processed in landfills. Over the past ten years, due to a combination of policy and behaviour changes, the proportion of MSW that is recycled has steadily increased. Strong policies are in place to avoid and recycle more wastes, including food and garden wastes.

Where remaining residual MSW (including mixes of food and garden wastes, textiles, soft plastics, and contaminated paper products) is not suitable for traditional recycling, it can still be valuable for a range of uses. It is important to carefully consider the most appropriate way to manage residual MSW to minimise emissions and make the most of the useful waste.

Thermal WtE promises a lot, but it doesn't always deliver

One productive use of residual waste is as a feedstock for large scale waste to energy (WtE). In Australia, the most common existing form of WtE is the capture and combustion of 'landfill gas', a mixture of methane, carbon dioxide and other gases produced through the natural anaerobic breakdown of organic waste in landfill.

An alternative to landfill WtE is thermal WtE. Broadly, this includes the direct combustion of waste to generate electricity, or high temperature gasification to produce syngas (a fuel made up largely of hydrogen and carbon monoxide) which may be subsequently combusted or refined. Thermal WtE has been touted as an ideal use for MSW. Proponents promise to kill two birds with one stone, reducing greenhouse gas emissions by diverting waste from landfill and offsetting electricity generation from the grid.

Unfortunately, it isn't that simple. Broadly, there are three main drivers that determine the relative emissions of processing residual MSW with thermal WtE relative to landfill:

1. **The direct emissions from burning fossil waste at the thermal WtE facility**: This depends largely on the proportion of organic waste in MSW. Under Australia's emissions accounting framework, CO2 produced by burning organic waste is treated as zero emissions. However, the emissions intensity of the remaining MSW is comparable to coal. If the organic share of residual MSW waste falls, emissions from burning waste will rise materially.
2. **The proportion of landfill methane captured and used for electricity generation**: Landfill emissions depend directly on the landfill gas 'capture rate'; the proportion of methane produced that is captured and flared or used to generate electricity. Historically, gas capture has been variable, particularly in rural areas. However, licensed landfills near metropolitan centres are modern landfills designed to capture a high proportion of methane and generate electricity.
3. **The avoided emissions from offsetting grid electricity**: The benefit from offsetting grid electricity depends largely on the emissions intensity of the offset electricity. Thermal WtE

[1] https://www.environment.gov.au/protection/waste/publications/national-waste-policy-2018

[2] Blue Environment, 2020, *National Waste Report 2020*

produces more electricity per tonne of waste than landfill gas WtE, largely because it extracts energy from plastics where landfill energy is entirely derived from the natural breakdown of organic waste. If thermal WtE offsets brown coal, the benefit can be material. If it offsets low emissions electricity there will be little benefit. Much of the benefit of thermal WtE depends on grid electricity being high emissions.

Major changes underway in electricity and waste are removing the benefits of thermal WtE

There are major changes underway in the waste and energy sectors which will impact the drivers of thermal WtE and landfill emissions. Overall, these changes are removing the benefits of thermal WtE.

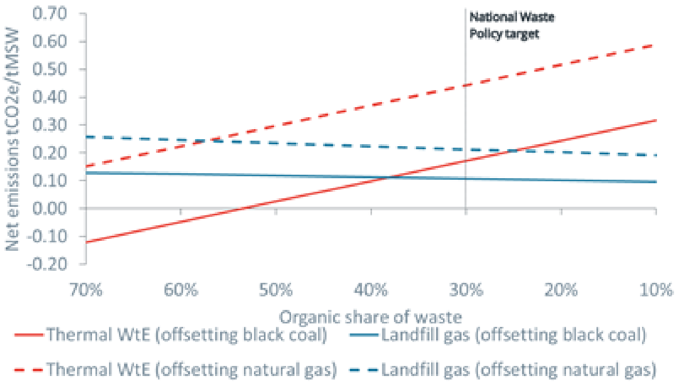
- **Improved waste separation:** State governments and councils are moving towards improved waste separation, particularly the diversion of food and garden organics (FOGO) from residual MSW waste. The National Waste Policy has set out a target for halving the amount of organic waste in landfill by 2030.[3] Removing organic waste from MSW would cause thermal WtE emissions to increase materially, and landfill WtE emissions to decrease.
- **Rapidly falling grid emissions**: The emissions intensity of grid electricity is falling and will continue to fall over time as coal retires and is replaced by renewable electricity – primarily driven by strong state renewable energy targets. As grid emissions fall, the emissions benefits of the high energy output from thermal WtE drop towards zero.

We've undertaken some modelling to assess how differences in the waste composition and grid emissions intensity impact the relative emissions of thermal WtE and landfill WtE. **Figure 1** below presents the key findings.

The Y-axis shows net emissions per tonne of MSW and the X-axis shows the share of organics in the waste stream. The red lines present net emissions from thermal WtE. The blue lines present net emissions from landfill gas WtE with 75% landfill gas capture.

The solid lines are calculated on the basis that WtE offsets electricity entirely generated from **black coal** (with emissions intensity of 0.9tCO2e/MWh), and the dotted lines on the basis that WtE offsets electricity with a lower emissions intensity of 0.45tCO2e/MWh (consistent with **natural gas** or a mix of coal and renewables).

Figure 1: Net emissions from thermal WTE and landfill WTE



Source: Frontier Economics analysis

There are a few key findings:

- **The emissions from thermal WtE increase significantly if the organic share of waste is lower.** Currently, about 55% of MSW processed through landfill is organic waste.[4] The National Waste Policy target will push towards an organic share closer to 30%, represented by the dotted vertical line. With that waste share, emissions from

[3] *National Waste Policy Action Plan*, 2019, https://www.environment.gov.au/system/files/resources/5b86c9f8-074e-4d66-ab11-08bbc69da240/files/national-waste-policy-action-plan-2019.pdf

[4] Frontier Economics analysis of National Waste Report 2020 database

landfill WtE are likely to be lower than thermal WtE, even with high grid emissions intensity.

- **There are 'tipping points' at which the emissions from thermal WtE exceed landfill gas WtE.** These are highly sensitive to the grid emissions intensity. For high emissions electricity, the tipping point is an organic share just below 40%. For lower emissions intensity, the tipping point is around 60% - which is close to the current state of play.
- The grid emissions intensity is falling (moving towards the dotted lines), and the organic share of MSW is falling (moving to the right side of the chart). Both of these trends move towards outcomes in which thermal WtE produces higher net emissions. If the state renewable energy targets for 2030 are met, and National Waste Policy Action Plan target for organic share of waste in 2030 is met, thermal WtE emissions will exceed landfill emissions.
- **Landfill WtE will have lower emissions than thermal WtE in some Australian regions already and it is likely that this will be the case across the country within ten years**, well within the life of thermal WtE facilities. Beyond this point, use of thermal WtE could lock in high emissions into the future.

More broadly, policymakers need to consider how thermal WtE aligns with the move towards improved waste avoidance and separation. Separating each component of MSW makes it possible to manage each stream in an efficient and targeted manner. This is central to maximising the value of waste generated. If thermal WtE was an optimal management option, there would be little to no point in pursuing waste separation.

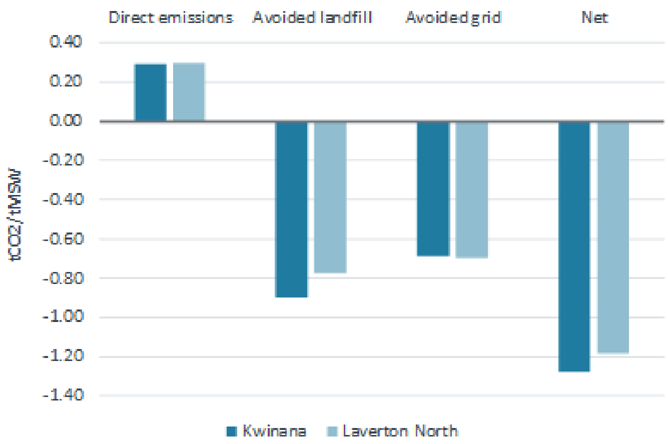
Current estimates of thermal WtE emissions overstate current benefits and miss these important changes

Several large-scale thermal WtE (waste combustion and waste gasification) projects have received regulatory approval in recent times. These include:

- The Kwinana waste combustion plant in Kwinana, south of Perth.
- The Recovered Energy Australia gasification project in Laverton North, West of Melbourne

Both projects were supported by life-cycle assessments (LCAs). The LCAs estimate lifetime greenhouse gas emissions (and other outcomes) compared to a base case in which the waste is diverted to landfill. Both LCAs found that thermal WtE produces greenhouse gas emissions but avoided more emissions than the landfill base case. The breakdown of net emissions for each project is presented in **Figure 2**.

Figure 2: Kwinana and Laverton North emissions in LCAs



Source: Frontier Economics analysis

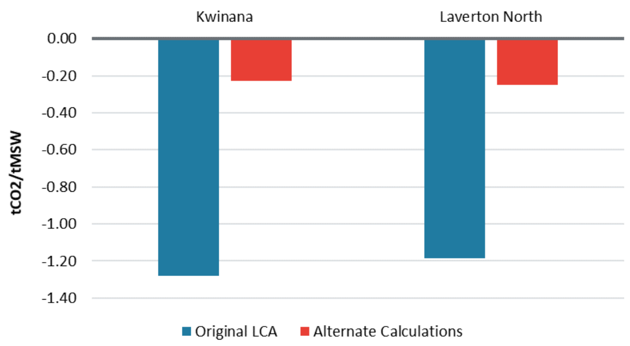
In each LCA, the net negative emissions were driven by the three factors outlined above:

- **Direct emissions** from the combustion of fossil waste (positive emissions)
- **Avoided landfill emissions** from the base case (net negative emissions)
- **Avoided grid emissions** from offsetting coal electricity generation in the base case (net negative emissions)

Frontier Economics was engaged by LMS Energy to assess the WtE emissions estimates in the LCAs. Overall, we found:

- The emissions estimates didn't use the most reasonable assumptions. In particular, the landfill gas capture rates did not accurately reflect modern landfills, the avoided grid emissions were based entirely on black or brown coal, and the direct emissions were below the values typically observed in local and international literature. We found that the emissions benefits on current conditions were likely overstated by about **80%.** This is presented in **Figure 3**.

Figure 3: Comparison of emissions in LCAs and Frontier Economics calculations



Source: Frontier Economics analysis

- The emissions benefits of thermal WtE depend largely on historic conditions, and the assessments did not take into account the major ongoing changes in electricity and waste. Incorporating these changes (reducing grid emissions intensity and improved waste separation) would likely remove any benefits of thermal WtE within the next ten years.

What does this all mean?

The analysis of thermal WtE and landfill WtE emissions is often assumption driven. It can fail to account for important characteristics of the waste and energy sectors such as landfill gas capture and energy recovery, the composition of MSW, and the marginal emissions intensity of grid electricity. It also fails to account for major policy driven changes already underway that are reducing the organic share of MSW and emissions from grid electricity. Together, these oversights give the impression that thermal WtE will materially reduce waste sector emissions, when it could be the opposite. There is a risk that well intentioned policy, supported by inaccurate analysis, could unnecessarily lock in high emissions from the waste sector for decades to come.

Contact Us

Frontier Economics has been providing independent advice to businesses, regulators and governments for over 20 years. From offices in Australia and Singapore, our team has a diverse range of skills and experiences to support the needs of our clients. To speak with one of our economists about this bulletin, please contact:

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