Unlocking the value of food waste

A case study of co-digestion in the Western Parkland City

Prepared for NSW Circular and Sydney Water

Institute for Sustainable Futures

May 2022

NSW Circular

Sydney WATER

isf.uts.edu.au

Acknowledgment of Country

Sydney Water, NSW Circular & the Institute of Sustainable Future UTS acknowledge the Traditional Custodians of the lands and waters that include the Western Parkland City. Their lore, traditions and customs nurtured and continue to nurture the waters within Sydney Water's operating area, ensuring wellbeing for all. We pay our respects to Elders, past and present, and acknowledge their continuing connection to land, water and community.

Citation

Jazbec, M., Liu, A., Rutovitz, J., Nghiem, L.D. and Turner, A.. 2022 Unlocking the value of food waste: a case study of co-digestion in the Western Parkland City. Report prepared by the Institute for Sustainable Futures, University of Technology Sydney, for NSW Circular & Sydney Water.

The Institute for Sustainable Futures (ISF) is an interdisciplinary research and consulting organisation at the University of Technology Sydney. ISF has been setting global benchmarks since 1997 in helping governments, organisations, businesses and communities achieve change towards sustainable futures. We utilise a unique combination of skills and perspectives to offer long term sustainable solutions that protect and enhance the environment, human wellbeing and social equity.

NSW Circular is a unique cross-sector innovation network set up to accelerate the pace of change towards a circular economy. Funded by the NSW Office of the Chief Scientist & Engineers and hosted by the University of New South Wales, we empower government, industry and people to transition to a circular economy through impactful research and collaborations.

Sydney Water is Australia's largest water utility, providing water, wastewater, recycled water and some stormwater services to Greater Sydney. For 130 years Sydney Water has proudly delivered the water resources and infrastructure to look after our customers, city and environment. We're continuing this legacy by planning for a new city in the greenfield area of the Western Parkland City and embracing circular economy practices to create value for our customers and communities.

Institute for Sustainable Futures
University of Technology Sydney
PO Box 123 Broadway, NSW, 2007
www.isf.uts.edu.au

Executive Summary

The Western Parkland City is the largest growth area in NSW and is expected to become an economic powerhouse with direct access to the 24-hour Western Sydney International Airport. More than $20 billion of investments are currently planned with globally competitive industries creating 200,000 new jobs over the next 20 years. It has been estimated that 1.5 million more people will be living west of Parramatta by 2036 with more than 184,500 new dwellings.

This growth will generate waste, including organic waste such as food waste and fats, oil, and greases, needing infrastructure for collection and management. This presents a unique opportunity to manage organic waste to capture energy and nutrients in line with circular economy principles.

Background

Most organic waste in Australia (more than 80%) is disposed to landfill. Once there it decomposes to form methane, a potent greenhouse gas[1]. Strategies at all government levels are aimed at diverting organic waste from landfills and creating a pathway to zero greenhouse gas emissions.

Anaerobic digestion is an alternative treatment for organic waste streams and is one of the technologies identified to achieve emission reduction and waste management aims. The NSW Waste and Sustainable Material Strategy 2041 identified that by 2030 anaerobic digestors are needed to process 260,000 tonnes of organic waste per year in the Greater Sydney area.

Anaerobic digestion produces biogas (a mixture of methane and carbon dioxide), which is purified and used to generate electricity, as a transport fuel or as a replacement for natural gas. Anaerobic digestion also produces biosolids which contain valuable nutrients (nitrogen, phosphorous, and potassium) and other materials of value (copper and zinc).

The Upper Creek Advanced Water Recycling Centre

Sydney Water is planning to build an advanced water recycling centre (AWRC) at Kemps Creek for the predicted population and economic growth in Western Sydney Parkland City. The AWRC will treat wastewater from homes and businesses, producing recycled water with a range of beneficial uses. The treatment will include anaerobic digestion of the sewage sludge to create biogas for energy and biosolids rich with nutrients for agricultural application. Anaerobic digestors can be used to process other organic wastes, such as food waste or fats, oils, and greases. The process may be stand-alone, or these wastes may be co-digested with sewage. Co-digestion has been successfully adopted internationally to create circular economy precinct solutions and biorefinery hubs.

This study

This study looked at economic, environmental, and other benefits that the AWRC could unlock by co-digestion of sewage with organic waste from the Western Parkland City. Impacts cover the construction and operational phases of the AWRC, including food waste collection and transportation.

To assess the immediate opportunity five co-digestion scenarios plus a baseline (digestion of sewage only) were modelled for 2026-2036. The scenarios looked at adding to sewage food waste from residential multiple unit dwellings, commercial food waste, fats oils and greases (FOG) and combined food waste with FOG. The study also estimated the potential if co-digestion is extended to include the other three wastewater treatment plants in the Western Parkland City area as that AWRC can only accept up to 27% of food waste generated[2].

The economic impact analysis considered the direct, indirect, and induced impacts of constructing and operating the AWRC to include co-digestion. Due

[1] Less than one in five landfills capture and use the methane

[2] Includes food waste from multiple unit dwellings, commercial premises and the airport.

to the so-called ‘economic multiplier effect’, direct impacts of the AWRC lead to knock-on effects throughout the wider economy, where additional benefits are generated indirectly by the increase in production by other industries.[3]

The organic waste resource

From 2026 to 2036, approximately 1.5 million tonnes of residential food waste will be generated in the Western Parkland City. An additional 0.7 million tonnes of food waste will be generated in the commercial sector, with significant quantities at the new Western Sydney International Airport. While some of the residential food waste can be collected with garden waste for composting, the greater opportunity for food waste is in capturing energy and nutrients through anaerobic digestion.

To take advantage of co-digestion of food waste, a new source separated food waste collection service would be needed. Due to the small amount of food waste created per household each week (about 4.8 kilograms), a combined food organics plus garden organics service is generally suggested for single unit dwellings. However, combined food and garden waste is not well suited to anaerobic digestion. Multiple unit dwellings, by contrast, are grouped together making collection more economical. Introduction of the new separate food waste collection service for multiple unit dwellings in Western Parkland City would cost $1.4 million and create 45 new jobs.

Benefits from co-digestion at the AWRC

The study found that the AWRC could process up to 30,000 tonnes of organic waste per year by 2030, with the biogas used to generate electricity, with benefits for jobs, emissions, and the wider economy. Benefits included:

- **Direct jobs**: up to 100 additional direct jobs would be created for two years during the construction phase; collection of food waste creates the most ongoing jobs (up to 75 direct jobs)
- **Electricity:** the co-digestion process could generate enough electricity to power an extra 10,000 – 20,000 homes.
- **The savings**: electricity generation would save between $6-$13 million by 2036 (including use at the AWRC, exports to the grid, and certificate sales), and biosolids could bring in up to $2.8 million annually by 2036.
- **Emissions:** diverting food waste to the AWRC would avoid approximately 15% of greenhouse gas emissions compared to sending the wastes to landfill (19,000 tonnes per year).
- **The wider economy - the construction phase:** would last for two years and in both years lead to a direct investment of $22.8 M, with $38.8 M of value added to the economy. 138 direct construction jobs would stimulate a further 254 jobs in the overall economy for both construction years.
- **The wider economy - the operational phase:** would give total value added of $10 M per year ($3.8 M in direct plant operations, $4.7 M indirectly along the supply chain, and a further $1.6 M through consumer goods and service industries). For every 3 direct workers employed to operate the plant, there are an additional 6 jobs created in the wider economy across a variety of industry sectors.

Benefits of extending co-digestion to the Western Sydney Parkland City

Extending co-digestion to the rest of Western Sydney Parkland City[4] could divert up to 165,000 tonnes of organic waste from landfill per year by 2036. This would create up to 300 ongoing direct jobs, and by 2036 would save $40 million from electricity generation each year, with a further $14.4 million in revenue from biosolids production. The co-digestion process could generate enough electricity to power an extra 120,000 homes by 2036 and reduce emissions annually by 70,000 tonnes per year, with cumulative emissions savings of 651,000 tonnes by 2036. In the wider economy, there would be $155 million of value added for each construction year, and $40 million of value added in each year of operation.

[3] ‘Direct’ effects refer to the immediate impacts that would result from the initial investments. For example, in the construction phase, these result from extra construction to make the AWRC able to handle the additional food waste streams. ‘Indirect effects’ refers to the flow-on effects to suppliers. ‘Induced effects’ refers to the impact that would result from the additional wages from the direct and indirect jobs being spent in the wider economy.

[4] By also co-digesting organic waste at the Riverstone, St Mary’s, and Liverpool WWTPs

Organic Waste – a circular economy opportunity for the West

As the largest growth area in New South Wales, the Western Parkland City provides a significant opportunity to manage the organic waste created by additional residents and businesses differently through a new circular economy hub at Sydney Water's Advanced Water Recycling Centre. Taking in the organic waste from homes and businesses and processing it at the Centre can reduce waste going to landfill and contribute to achieving net zero emissions, as well as create new jobs and provide a major boost to the City's economy by keeping resources in use for longer.

Organic Resource

Source separated food waste from residential and commercial sector or fats, oils and greases are excellent feedstocks for anaerobic co-digestion with sewage.

RESIDENTIAL FOOD WASTE (2026-2036)

70 per cent single unit dwellings **1,016,155 tonnes**

4.8 kilograms per week per household

30 per cent multi unit dwellings **476,312 tonnes**

1.7 kilograms per week per person

COMMERCIAL FOOD WASTE (2026-2036)

Western Sydney Airport
5 - 18 million passengers
6,065 t

42 per cent of food waste produced in manufacturing sector
681,280 t

FATS, OILS AND GREASES (2026-2036)

FOG

Fats, oil and greases increase biogas production by **30 - 80 per cent** when co-digested with sewage

249,640 kilolitres of fats, oil and greases at Western Parkland City

Economic Benefits

Construction and operation of the AWRC to manage additional organic waste streams will allow Sydney Water to further expand on its invaluable contribution to the economy

CONSTRUCTION (2024-2025)

Construction jobs
138 full time equivalent per year

Indirect jobs
254 full time equivalent per year

Investment value
$22.8 million per year

Value added
$38.8 million per year

Household income
$27.3 million per year

Other Benefits

Co-digestion at AWRC will generate electricity, soil nutrients, and reduce greenhouse gas emissions from organic waste.

BIOGAS

Co-digestion generates enough electricity for an extra **10,000 - 20,000 homes**

And saves an extra **$6 - 13 million** by 2036

BIOSOLIDS

Biosolids with value of up to **$2.8 million** can be produced annually at Upper South Creek by 2036

$/dry tonne biosolids

N	P	Cu	Zn
$159.55	$117.81	$10.90	$2.76

GREENHOUSE GAS EMISSIONS

Co-digestion of food waste at AWRC could reduce cumulative emissions from Western Parkland City by **140,000 tonnes** by 2036

Co-digestion of residential food waste could reduce annual emissions **19,000 tonnes** by 2036, equivalent to the total emissions of **1,200 Australians**

OPERATION (2026)

The **3 direct workers** employed to operate the plant, serve as a stimulus to **additional 6 jobs** in the wider economy

For every **$1 million** of value added generated by ongoing operation of AWRC **$2.67 million** of value added is generated across the economy

$16.7 million output

$10 million value added

$0.7 million household income

9 full-time equivalent

Contents

Contents 4

Western Parkland City opportunity 5

Organic resource appraisal 7

Upper South Creek Advanced Water Recycling Centre 10

Introducing a separate food waste collection service 11

Assessing the opportunity: the scenarios 12

Economic and environmental impacts 13

Potential impact of co-digestion in across Western Parkland City 21

Conclusions 23

APPENDIX A - Policy context 24

APPENDIX B – Methodology and Assumptions 27

Western Parkland City opportunity

The projected investment and population growth in the Western Parkland City creates a major opportunity to create jobs and value by managing organic waste differently, implementing circular economy principles at the design stage while catering for growth in population, housing and employment.

This report identifies the circular economy benefits that could be unlocked by co-digestion of organic waste with sewage in the Western Parkland City.

The Western Parkland City is the largest growth area in NSW and is expected to become an economic powerhouse with direct access to the 24-hour Western Sydney International Airport. The 100,000-hectares surrounding the airport covers eight local government areas[5] (Figure 1).

More than $20 billion investments are currently planned to bring the Western Parkland City to life: $5.3 billion for the Western Sydney International Airport, $4.4. billion for infrastructure and roads and $11 billion for construction of the metro from Sydney to the airport[6]. This investment presents a generational opportunity to establish a circular economy that delivers a liveable, productive and sustainable city that is connected to Country.

Western Parkland City is expected to attract globally competitive industries, such as defence, aviation, aerospace, advanced manufacturing, freight and logistics, health, tourism, and agribusiness. It is estimated that it will create 200,000 new jobs in the next 20 years[6].

The NSW Government announced over $1billion in funding to start building Bradfield City Centre[6] – at the heart of the Western Parkland City – a smart digital city with opportunities for advanced careers and businesses, innovative education, and sustainable utilities. Bradfield City Centre will become Australia's first hydrogen and EV-ready, zero carbon city centre, utilising a microgrid and leading in renewable energy as part of a multi-utility corridor pilot in the surrounding precinct[7]. The first building in Bradfield City Centre, a visitor centre, is designed with connection to Country, is sustainable and based on circular economy principles.

Figure 1: Western Parkland City local government areas. Image Source: Draft Blueprint for the Western Parkland City[6]

[5] The Blue Mountains, Camden, Campbelltown, Fairfield, Hawksbury, Liverpool, Penrith, and Wollondilly

[6] *Draft Blueprint for the Western Parkland City*, Western Parkland City Authority, 2021.
[7] https://wpca.sydney/about/the-bradfield-city-centre/

It has been estimated that 1.5 million more people will be living west of Parramatta by 2036[8] with more than 184,500 new dwellings[9] to support the growing population. Details of the new dwellings and population growth are summarised for each of the local government areas in the Appendix B, Table 8.

An additional 156,685 new jobs are projected in the Western Parkland City by 2036, an increase of almost 40% for the area. Details of current and future employment by local government areas is given in the Appendix B, Table 9.

Increased population and business activity in Western Parkland City will generate a range of organic waste streams across all sectors requiring new infrastructure for collection and management. This provides an opportunity to manage organic waste to capture the energy and nutrients in line with circular economy principles.

Following the waste hierarchy means starting with the reduction in generation of organic waste, followed by source separation of organic waste to enable higher levels of reuse, in this case capturing energy and nutrients.

Strategic documents at all levels of government (national, state and local) have set targets towards achieving the better management of organic waste as one of element of reaching zero emissions. Targets include the supporting infrastructure and formation of bio hubs enabling the circular economy. The strategic documents are summarised in Table 4 in Appendix A.

Upper South Creek Advanced Water Recycling Centre (AWRC) at Kemps Creek is identified in several Western Parkland City plans as a potential bio hub producing recycled water, bioenergy, fertiliser products and purified carbon dioxide. It offers a unique possibility to become an example of a world class circular economy precinct.

This report identifies the economic, environmental and other benefits that the Advanced Water Recycling Centre could unlock by co-digestion of organic wastes, and estimates the potential if co-digestion was extended to all the wastewater treatment plants in the area.

The bioenergy potential is determined for selected feedstocks within the Western Parkland City: residential food waste generated by multiple unit dwellings, commercial food waste and fats, oils and greases (FOG) from businesses, including the new Western Sydney International Airport. Economic benefits, such as value added, direct and indirect jobs, investment and wages are estimated for the construction and operational phases of the project.

The methodology for the study and the main assumptions used are included in Appendix B.

[8] https://wpca.sydney/about/the-western-sydney-aerotropolis/

[9] *Western City District Plan*, Greater Sydney Commission, 2018.

Organic resource appraisal

Food waste from the residential, and commercial sectors and fats oils and greases (FOG) from grease traps have been identified as potential feedstocks to be co-digested with sewage in the advanced water recycling centre (AWRC).

This section illustrates the estimated food waste and FOG that are available in the Western Parkland City for the 10-year period from 2026 to 2036.

Residential food waste

Of the eight councils that currently service the Western Parkland City area, only Penrith offers a separate food waste collection service. The remaining councils dispose of the food waste in the residual bin destined to landfill. In 2021, these councils disposed of 106,808 tonnes of food waste, which on average constituted 39% of the residual residential waste. The detrimental impacts of organic waste decomposition that forms methane in landfills (at least those that do not capture landfill gas) are well known. Methane is about 28 time more potent than carbon dioxide as a greenhouse gas. However, even if methane is captured, it is often flared with an estimated 15% of methane escaping. Furthermore, valuable nutrients in the "biosolids" are lost to landfill. Some landfills and alternative waste treatment facilities have been recently given for a limited time a provisional permission to process the organic component from the residual waste via composting or anaerobic digestion. The temporary permission has been given due to problematic organics management arising from a sudden halt to the application of mixed waste organic outputs to land[10]. The ban was introduced in October 2018 based on the findings about adverse impacts of application of mixed waste organic outputs to land. Therefore, the remaining organic material can only be used for lower nutrient value applications such as mining rehabilitation.

A much higher value is achieved when food waste is separated from the residential residual waste at source and processed in an anaerobic digestor. This process enables a more efficient and fugitive free biogas capture. Biosolids derived from this process can be used as a fertiliser replacement in agricultural soils.

Figure 2 illustrates the available food waste in multiple unit dwellings for each of the councils for the ten-year study period. On average, each household in the Western Parkland City generates 4.8 kilograms of food waste per week (1.7 kilograms per person per week). Between 2026 and 2036, it has been estimated that 1.5 million tonnes of food waste will be generated. 30% will come from multiple unit dwellings (0.5 million tonnes of food waste).

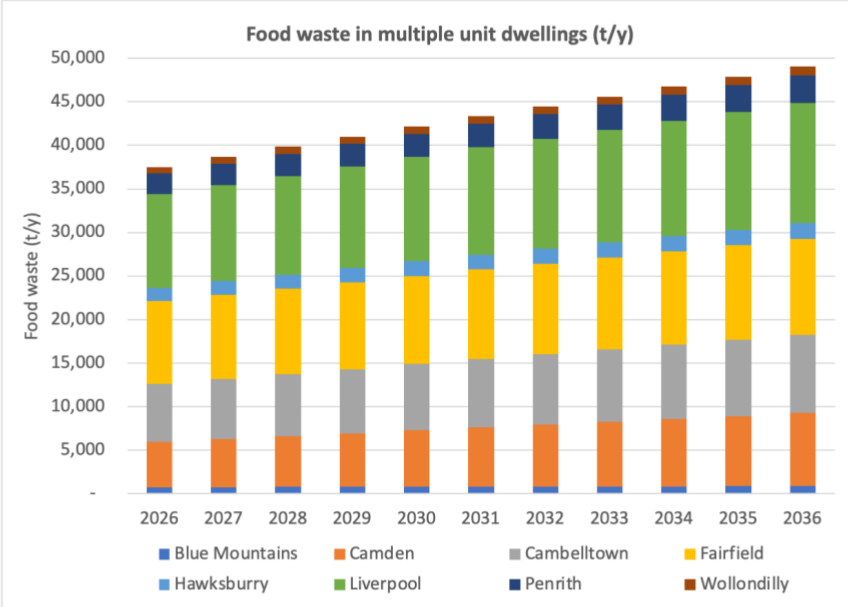


Figure 2: Food waste collected in residual bin from residential multiple unit dwelling in tonnes per year (t/y) for each council in the Western Parkland City.

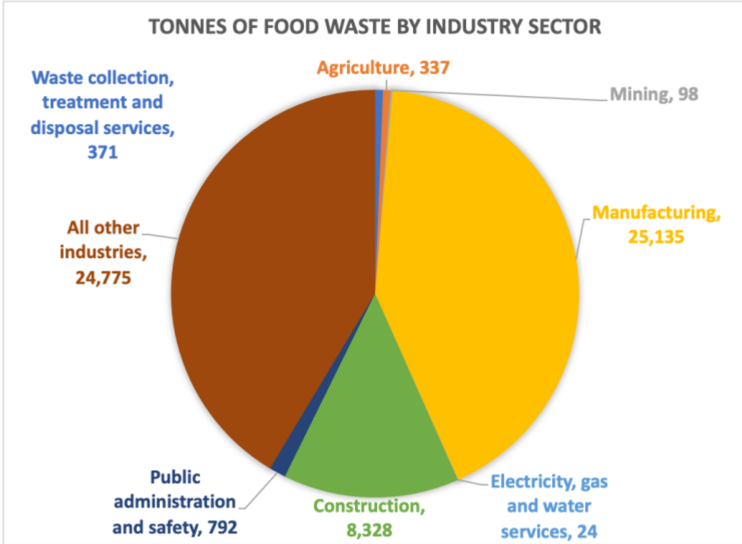
---

[10] https://www.epa.nsw.gov.au/your-environment/recycling-and-reuse/resource-recovery-framework/mixed-waste-organic-material

The NSW Waste and Sustainable Materials Strategy guide for future infrastructure needs identified a shortfall in anaerobic digestion infrastructure for Greater Sydney. By 2030 additional anaerobic digestors processing 260,000 tonnes per year of organic waste will be required[11].

> **1.5 million tonnes of food waste will be generated in the residential sector in Western Parkland City from 2026 to 2036.**

> **There will be a shortfall in anaerobic digestion infrastructure to process 260,000 tonnes of organics waste per year in Greater Sydney by 2030.**



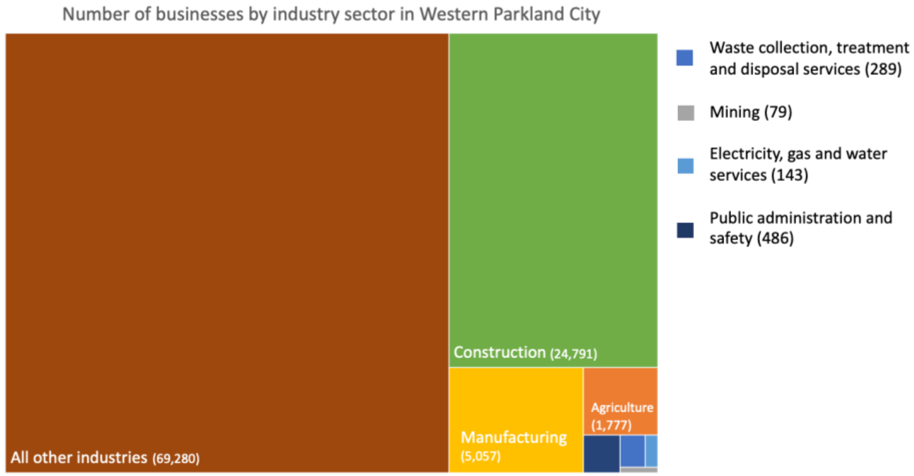


Figure 3: Commercial food waste generation in Western Parkland City in 2021 in tonnes per year by industry sector (pie chart on the top) and number of businesses in Western Parkland City in 2021 by industry sector (hierarchy chart at the bottom).

Commercial food waste

Forty percent of the commercial food waste in Western Parkland City in 2021 (25,135 tonnes per year) was generated in the manufacturing sector, although manufacturing only makes up 5% of the numbers of businesses (Figure 3). Another sector with significant food waste generation is construction (14%), but only due to the large number of businesses in that sector (24%).

Total estimated commercial food waste that will be generated in the Western Parkland City over the 10-year analysis period (2026-2036) is 681,280 tonnes. Figure 4 shows the breakdown of yearly commercial food waste by local government area.

[11] *NSW Waste and Sustainable Materials Strategy: A guide to future infrastructure needs*, NSW Department of Planning, Industry and Environment, 2021.

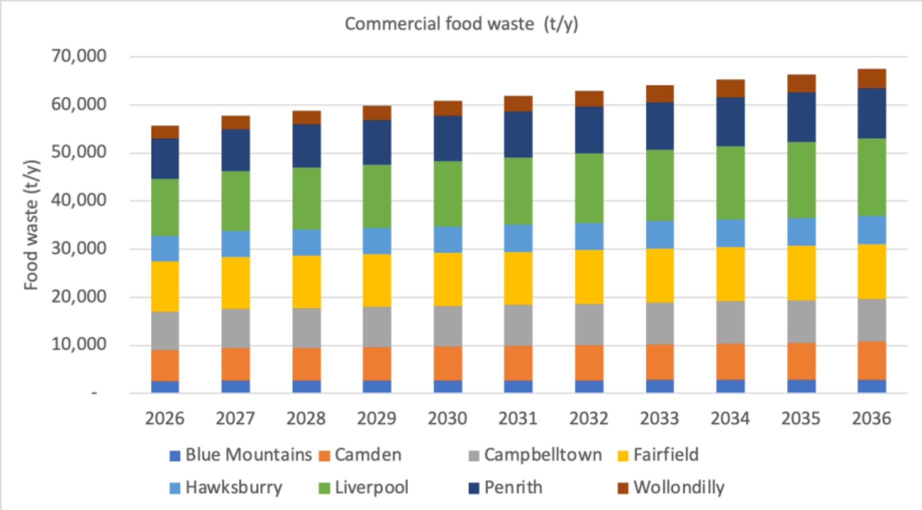


Figure 4: Estimated commercial food waste in tonnes per year (t/y) in Western Parkland City by local government area.

> **An additional 0.7 million tonnes of food waste will be generated in the commercial sector.**

Fats, oils and greases

Fats, oils and greases (FOG) captured in the grease traps are separately collected as they pose a number of problems in the sewage pipe system. They cause a blockage risk via the formation of fatbergs, and odour and corrosion issues due to formation of hydrogen sulphide. Grease traps are located to capture FOG from commercial properties. A common method of FOG disposal in Australia is soil injection. However, FOG has a high biogas potential making it an attractive feedstock for co-digestion with sewage, which has been successfully applied in wastewater treatment plants (WWTPs) internationally, although less so in Australia.

Figure 5 shows the estimated generation of FOG in kilolitres per year for the analysis period by local government area. A total of 249,640 kilolitres of FOG is projected to be generated in the Western Parkland City between 2026 and 2036.

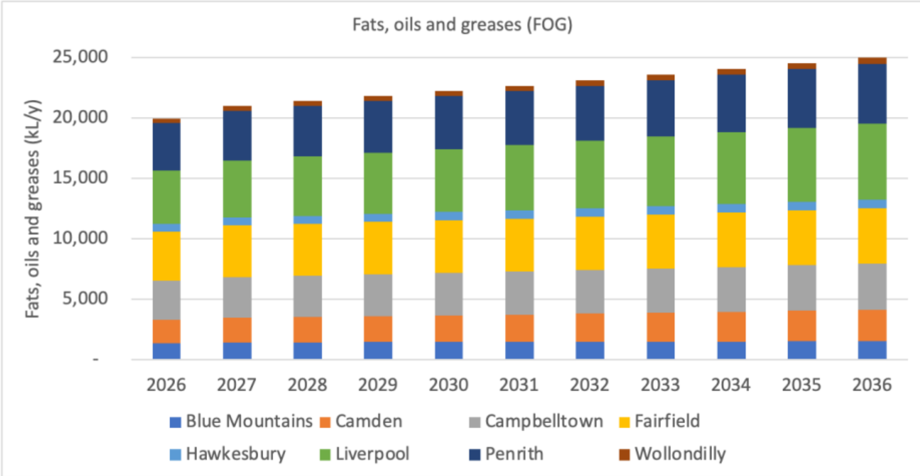


Figure 5: Estimated fats, oils and greases (FOG) in Western Parkland City in kilolitres per year (kL/y) per local government area.

New Western Sydney International Airport

The new Western Sydney International Airport is due to start operation in 2026. The airport will be located at Badgerys Creek, in close proximity to the advanced water recycling centre (AWRC). Initially it will welcome 5 million passengers per year, doubling capacity by 2030 and anticipating more than 80 million passengers per year by 2063[12] (the current Heathrow Airport capacity). Assuming similar waste generation per passenger to Sydney Airport, it is estimated that Western Sydney International Airport will generate a total of 6,065 tonnes of food waste in the first ten year of operation.

---

[12] https://www.westernsydneyairport.gov.au

Upper South Creek Advanced Water Recycling Centre

To accommodate the predicted population and projected economic growth in Western Sydney, Sydney Water is planning to build an Advanced Water Recycling Centre (AWRC) at Kemps Creek. The AWRC will collect wastewater from homes and business across Western Parkland City and treat it to produce high quality water suitable for a range of uses in homes and for industrial and business use, agriculture and for greening open spaces. The treated water will also be released into local waterways (Nepean and Warragamba rivers) sustaining the river ecosystems. The facility will generate renewable energy through co-digestion of sewage and organic waste and energy collection via solar panels.

The AWRC construction is planned to commence in mid 2022, with the Centre to be operational by 2026. The facility could be capable of accepting 30,000 tonnes of organic waste for co-digestion with sewage.

In the Western Parkland City area there are two additional wastewater treatment plants, with a third plant at Riverstone accepting some flows generated within the Western Parkland City (Figure 6). These facilities have the potential capacity to accept organic waste for co-digestion:

Estimated capacity for co-digestion feedstock based on sewage throughput (t/y)	
Riverstone WWTP	45,000
St Mary's WWTP	60,000
Liverpool WWTP	30,000

> **“ 165 kilo tonnes of organic waste per year could be processed at Western Parkland City wastewater treatment plants.**

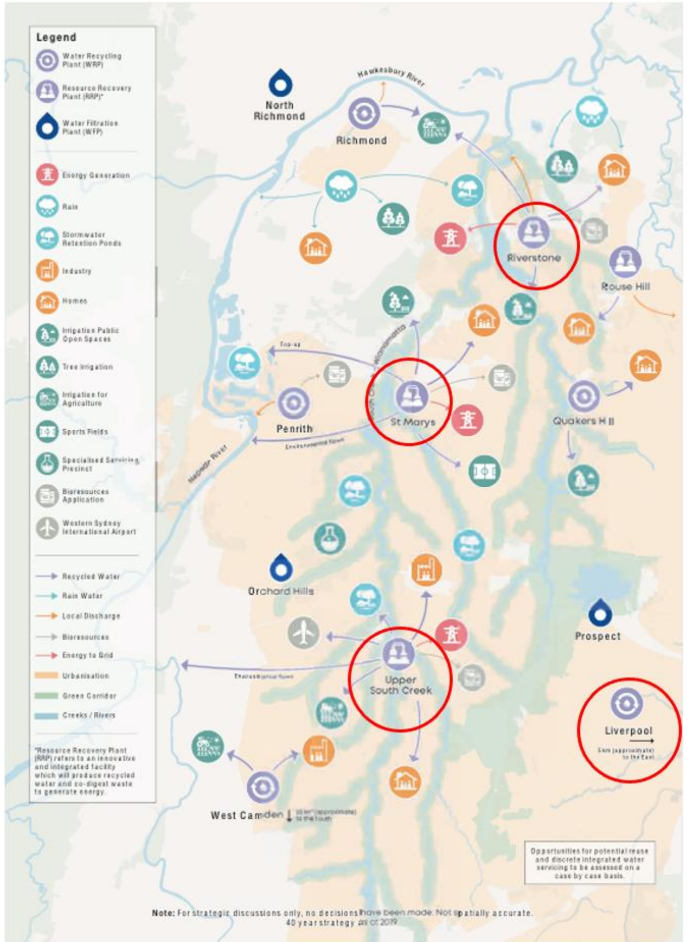


Figure 6: Location of Sydney Water wastewater treatment plants. Adopted from Re-imagining waster in Western Sydney.[13]

[13] *Re-imagining water in Western Sydney: Western Sydney Regional Master Plan*, Sydney Water, 2020

Introducing a separate food waste collection service

To take advantage of the AWRC potential to process food waste, a new source separated food waste collection service would need to be introduced.

Only Penrith City Council in Western Parkland City currently offers a separate food waste collection service, although this is via a FOGO bin (combined food waste and garden organic waste). Based on behavioural analysis the recommended practice is to reduce the residual waste (red bin) collection to fortnightly and introduce weekly food collection[14].

Food and garden waste combined or a separate collection?

If food waste is collected with garden organics, the garden organics green bin that is normally collected fortnightly is repurposed to collect both food and garden organics (FOGO) and is then collected weekly. This change does not create new jobs and the net number of the trucks in the fleet remains the same. This approach has been generally recommended and supported by the state and national governments. However, while the FOGO stream is well-suited to industrial composting, although with slightly higher contamination rates than the garden organics only stream, it is less suited for anaerobic digestion. Garden organics consisting of hard wooden components are not recommended for co-digestion with sewage and tend to have a lower bioenergy potential compared to food waste[15]. FOGO collection appears to be more economical for single unit dwellings as they are geographically dispersed and have only small amount of food waste available for collection. Typically, on average only 1.5-2.5 kg of food waste per household are separated from the residual waste[16] leaving a substantial amount of food waste in the residual bin. Estimated weekly food waste generation per household for Western Parkland City is 4.8 kilogram per household per week.

On the other hand, multiple unit dwellings are grouped together making separate collection of small amounts of food waste per household more economic. Multiple unit dwellings also have smaller garden areas producing only small amounts of garden organics.

We estimated that introducing a new food waste only service would create 137 additional collection jobs if applied to all households in Western Parkland City (excluding Penrith) and 45 additional collection jobs if separate food waste collection is introduced to only multiple unit dwellings.

Introducing a separate food waste collection service would not impact the total number of vehicles within the truck fleet, however some of the trucks might need to be replaced with the food waste specific collection trucks.

In addition to the impact on the trucks and collection jobs, each of the councils would need to introduce a specialised project officer, staff to run an education campaign, waste audits (normally contracted to a specialised consultancy) and produce signage and other material informing residents of the new service. Each of the households would normally be provided with a kitchen caddy and liners (deemed necessary to increase participation, especially at the introduction of the new service[14]). The cost of the instalment of the new service can be funded or subsidised by grants available from NSW EPA[17].

> **“ A new separate residential food waste collection service for multiple unit dwellings will create 45 new jobs and the introduction of the new service will cost $1.4 million.**

[14] *Food and garden organics: Best practice collection manual*, Hyder, Department of Sustainability, Environment, Water, Population and Communities, 2012.
[15] *Sustainable biogas production in municipal wastewater treatment plants*, IEA Bioenergy, 2015
[16] *Analysis of NSW Food and Garden Bin Audit Data*, Rawtec, 2018.
[17] https://www.epa.nsw.gov.au/working-together/grants/organics-infrastructure-fund/organics-collections

Assessing the opportunity: the scenarios

Five scenarios for co-digestion at the Upper South Creek Advance Water Recycling Centre (AWRC) plus a baseline have been modelled for 2026-2036 time period.

Table 1 describes the scenarios, the available organic waste at Western Parkland City, and the percentage of the available waste used as feedstock for co-digestion in each case. When co-digestion is extended to all four WWTPs in the Western Parkland City (Scenario 5), the available organic waste becomes a limiting factor by 2036.

Three scenarios for the AWRC (1, 2 and 3) using different waste streams (residential food waste from multiple unit dwellings, commercial food waste, and FOG) were defined in a workshop with Sydney Water. An additional scenario was added subsequently, using a combination of commercial food waste and FOG (Scenario 4). The baseline was defined as AWRC without co-digestion of waste but including the anaerobic digestion of sewage sludge and the associated electricity generation. Most physical and economic indicators for the baseline and the scenarios were taken from Sydney Water's feasibility study for the AWRC.

Scenario 5 extends organic waste co-digestion to the other three WWTPs in the Western Parkland City area. The project team estimated the impact by assuming that capital expenditure, operational expenditure, and digestion outcomes could be scaled from the impacts of co-digestion at AWRC.

Table 1: Scenarios modelled and availability of the feedstock for each in each scenario at the beginning of the study period (2026) and at the end (2036).

Scenarios modelled	2026		2036	
	Organic waste available [tonnes/year]	**Organic waste used at WWTP** [% of available]	**Organic waste available** [tonnes/year]	**Organic waste used at WWTP** [% of available]
Scenario 0 – Baseline (100% sewage) *AWRC is built to digest sewage and generate electricity, without co-digestion of organic wastes*	-	-	-	-
Scenario 1 – 20 % residential food waste and 80% sewage *AWRC is augmented to allow co-digestion of organic wastes: residential food waste from multiple unit dwellings is collected for co-digestion.*	37,528	29%	49,034	65%
Scenario 2 – 20% commercial food waste and 80% sewage *AWRC is augmented to allow co-digestion of organic wastes: commercial food waste is collected for co-digestion.*	55,768	19%	67,477	47%
Scenario 3 – 3% FOG and 97% sewage *AWRC is augmented to allow co-digestion of organic wastes: fats, oils and greases (FOG) is collected for co-digestion.*	19,961	8%	25,029	19%
Scenario 4 – 17% commercial food waste, 3% FOG and 80% sewage *AWRC is augmented to allow co-digestion of organic wastes: commercial food waste and FOG are collected for co-digestion.*	75,729	14%	92,506	34%
Scenario 5 – Co-digestion at 4 WWTPs, 20% food waste and 80% sewage *Co-digestion occurs at AWRC, St Mary's (twice capacity of AWRC), Riverstone (one and half capacity of AWRC), and Liverpool (same capacity as AWRC) WWTPs. Residential food waste from multiple unit dwellings, commercial food waste and Western Sydney airport food waste is collected for co-digestion)*	93,525	63%	117,409	100%

Economic and environmental impacts

This section details the economic and environmental impacts of the additional investment in construction and operation of the Upper South Creek advanced water recycling centre (AWRC) for co-digestion of organic feedstocks with sewage to generate energy.

The results are shown as 'direct impacts' (arising from the initial investment), 'indirect impacts' (subsequent flow-on effects on suppliers) and 'induced impacts' (resulting from the spending of additional wages across the economy). As is standard practice, the economic impacts are reported for one year of construction, and one year of operations. Only the additional impacts compared to the baseline (the AWRC digests sewage alone) are shown.

> **The construction and operation of the AWRC plant to handle additional organic waste streams would allow Sydney Water to further expand its invaluable contribution to the economy.**

Construction phase benefits (Sydney Water investment)

Construction industries serve as a strong impetus to the economy and are well known to have some of the highest economic multipliers across all of the 114 ANZSIC industries. Our analysis shows significant spill over effects from the construction phase of the project. Key outcomes relating to the additional work during the construction phase include:

- An additional direct investment of $22.8 M in 2023/24 and the same again in 2024/25 in construction of the new facilities to enable co-digestion, rather than the baseline construction of the AWRC.
- $38.8 M of value added to the economy in 2023/24, and the same value again in 2024/25. (Note this excludes the value of imported materials and equipment) (see Figure 7).
- The additional full-time employment of 138 construction workers in both construction years 2023/24 and 2024/25, which would stimulate a further 254 jobs in the overall economy.
- The impetus to the construction industries would be expected to bring economic benefits especially to other construction services industries, the professional, scientific and technical services sector, and a range of manufacturing industries, with these industries being among the most directly linked to construction.

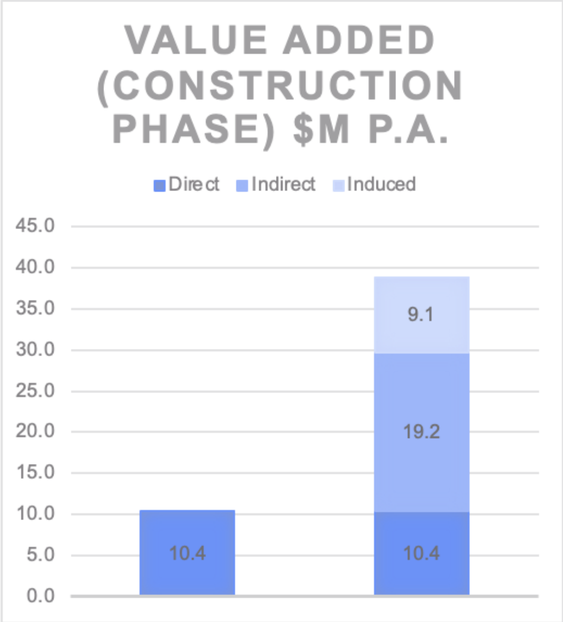


Figure 7: Value added in the construction phase in $ million per year ($M p.a.)

> **The construction phase of the project would generate an additional $53.9 million per year in output for the domestic economy, $38.8 million of value added, $27.4 million of household income, and full-time jobs for over 392 workers each year. The flow-on effects would reach a wide range of service and manufacturing industries that are linked to the construction industry.**

Operating phase benefits (Sydney Water investment)

- When considering the wider economic effects, it is estimated that for every $1 million of value added generated by ongoing operations at the AWRC, $2.67 million of value added would be generated across the economy. Total value added is estimated at $10 million per year of which $3.8 million would be generated by the direct operations of the plant, $4.7 million would be produced indirectly along the supply chain, and a further $1.6 million through production across all consumer goods and service industries. (See Figure 8).
- With every 3 direct workers employed to operate the plant, this serves as a stimulus to an additional 6 jobs in the wider economy across a variety of industry sectors including in the supply of transport, equipment and maintenance services, and thereafter their supplying industries.
- Additional wages and salaries linked to the plant's additional operations and its knock-on effects would total to over $0.7 million bringing benefits to a large number of households.

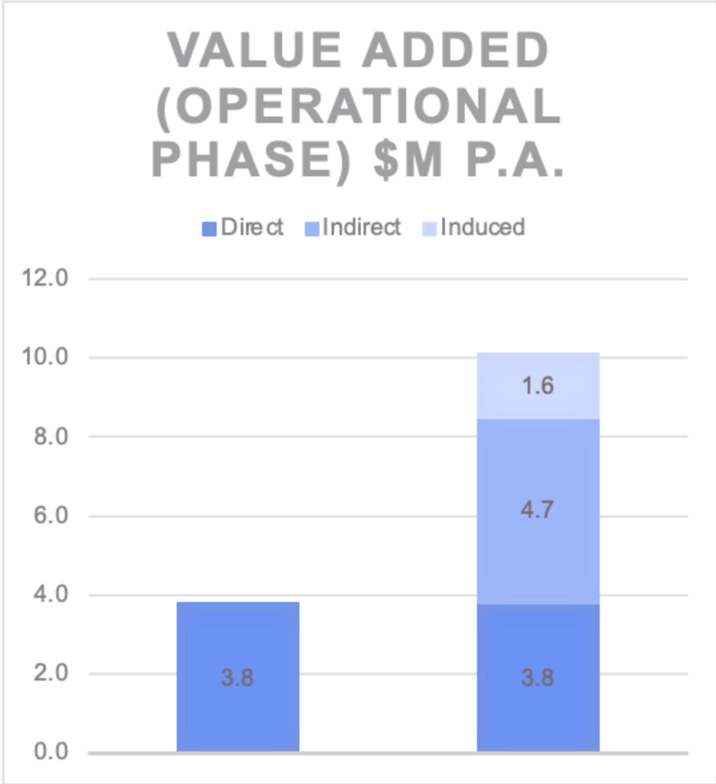


Figure 8: Value added in the operational phase in $ million per year ($M p.a.)

The high-level results of our economic impact analysis for scenarios 1, 2, 3 and 4 are summarised in Table 2. As is standard practice, results are reported for one year.

Table 2: Economic Impacts for scenarios 1, 2, 3 and 4 during the construction and operation periods.

	Value Added ($000)	Wages ($000)	Jobs (FTE)
During construction period (annual)			
Direct impacts	10,438	8,649	138
Indirect impacts	19,234	12,883	219
Induced impacts	9,145	5,857	35
Total impacts (Direct, Indirect, Induced)	38,818	27,389	392
During operating years (annual)			
Direct impacts	3,764	317	3
Indirect impacts	4,655	313	4
Induced impacts	1,614	97	2
Total impacts (Direct, Indirect, Induced)	10,033	728	9

> **The proposed enhancement would create over $16.7 million in output, an estimated $10 million in value added, and an additional $0.7 million in household income in 2025/26, its first year of operations, with the organic waste collection, treatment and processing and impacts on the wider economy providing ongoing employment for over 9 FTEs.**

Residential food waste for entire Western Parkland City - additional collection and transportation benefits

- To make the whole process operational from end to end, additional investment would need to be secured from the onset to set up both the collection and transportation. Councils would need to arrange for the provision of dedicated food waste bins and the administration required for collection and transportation to the AWRC plant. Education will also be needed for the households.
- This additional investment of $55.7 million in collection/transport across Western Parkland City would bring a further impetus to the economy, estimated at $200.7 million of output, $39.5 million of value added and a further 439 jobs, with wages amounting to $16 million.

Multiple unit dwellings only for residential food waste

- Considering multiple unit dwellings only, rather than all types of dwellings in the Western Parkland City region, an additional investment to the value of $17 million in a collection/transport function would generate an estimated total of $ 61.2 million of output, $21.3 million of value added and 353 jobs, with $13.2 million of wages.

Fats oils and greases - collection and transportation

- For FOG no further collection/transportation benefits are expected. This is based on the assumption that this organic waste would be redirected to the AWRC plant rather than current disposal, with the disposal fee the same as the current gate fee.

Commercial food waste for Western Parkland City - additional collection and transportation benefits

- To operationalise the whole process for commercial food waste, an additional upfront investment would be needed for the provision of an additional bin for food separation and to establish the associated collection/transportation service. Here, councils or specialised waste collectors would also need to be partnered with for the provision of dedicated bins and administration of collections. Education would also be needed for business engagement.
- This additional investment of $45.5 million in collection/transport for commercial food waste across Western Parkland City would bring a further impetus to the economy, estimated at $163.8 million of output, $33.7 million of value added and a further 389 jobs across the economy, with wages and salaries totalling to $14.4 million.

Commercial food waste (AWRC plant capacity only) - additional collection and transportation benefits

- To collect and transport the volume of commercial waste handled at the AWRC plant, an investment of $8.8 million would be required. This function would yield wider economic benefits estimated at $31.6 million of output, $6.5 million of value added and an additional 75 jobs across the economy, with wages of around $2.8 million.

> **Due to the economic multiplier effect, activity directly related to the construction and operation of the AWRC plant would lead to knock-on effects throughout the wider economy. Beyond the initial creation of additional output, value added and jobs, additional benefits are generated indirectly by the increase in production by other industries, as well as the income generated and spent in the economy.**

Construction and Operating phase benefits across AWRC, St Mary's, Riverstone and Liverpool WWTPs (Sydney Water investment)

- The economic benefits of an investment by Sydney Water at St Mary's, Riverstone, and Liverpool WWTPs similar to that at AWRC is shown in Table 3.

Table 3: Economic Impacts for scenario 5

	Value Added ($000)	Wages ($000)	Jobs (FTE)
During construction period (annual)			
Direct impacts	41,752	34,594	552
Indirect impacts	76,938	51,533	877
Induced impacts	36,581	23,427	140
Total impacts (Direct, Indirect, Induced)	155,271	109,554	1,569
During operating years (annual)			
Direct impacts	15,056	1,268	12
Indirect impacts	18,618	1,254	17
Induced impacts	6,456	389	7
Total impacts (Direct, Indirect, Induced)	40,130	2,910	36

Direct jobs created

Accepting additional organic feedstock for co-digestion at AWRC will create an extra hundred direct jobs during construction, and approximately 75 additional collection jobs.

We estimated direct jobs (Figure 9) related to construction, specifically for the reception and processing of the external organic feedstock, direct jobs for the new collection service that will deliver the organic waste streams to the AWRC for co-digestion and direct jobs for operation of the plant. It is assumed that the construction will take place in the first two years (2024-2025). In Figure 9 only the direct collection jobs related to the organic waste accepted by the plant are plotted. It should be noted that for the residential sector the collection would need to be established across the whole local government area rather than just the proportion of residential food waste accepted by the AWRC. The total direct jobs are discussed in the "Introducing a separate food waste collection service' section above.

> **An extra 100 direct jobs would be created during the construction period at AWRC.**

> **Collection of food waste creates most ongoing jobs, with up to 75 direct jobs created by 2036.**

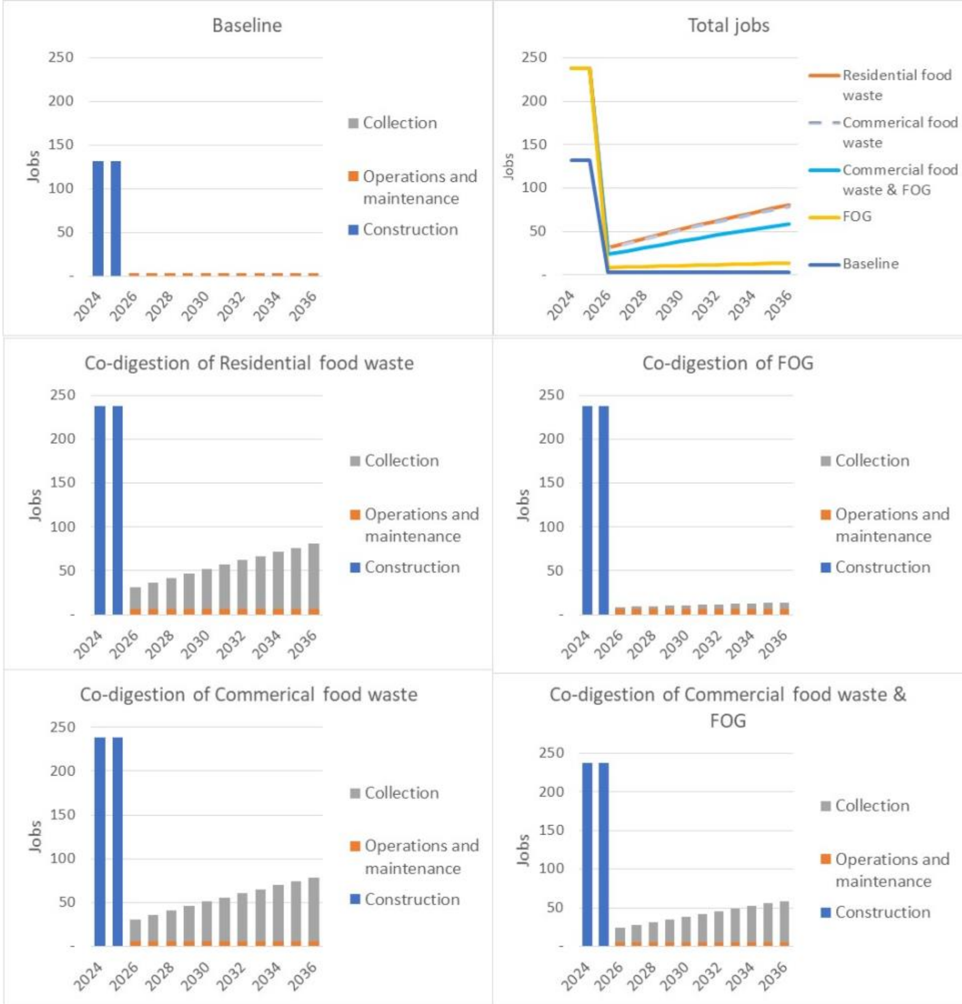


Figure 9: Direct jobs created in the construction, collection of food waste and operation of AWRC.

Methane produced from anaerobic digestion at Upper South Creek advanced water recycling centre (AWRC) and electricity generated

Figure 10 shows production of methane from the anaerobic digestion process at the AWRC. Methane forms the majority (normally more than 50%) of the biogas (a mixture of methane and carbon dioxide) produced in the anaerobic digestion process. Biogas may need purification depending on the application, which could be generation of electricity, as a transport fuel replacement or as a replacement for natural gas. In this study it is assumed that the biogas will be used to generate electricity to power the AWRC, with the excess sold to the electricity grid. Figure 11 shows the electricity generated in the four scenarios compared to the baseline, and total electricity and large-scale generation certificates (LGC) savings from the biogas generation. Also shown in Figure 11 are the equivalent of homes powered with the electricity generated from the process.

> **“ Co-digestion could generate enough electricity for an extra 10,000-20,000 homes and saves an extra $6-$13 million by 2036.**

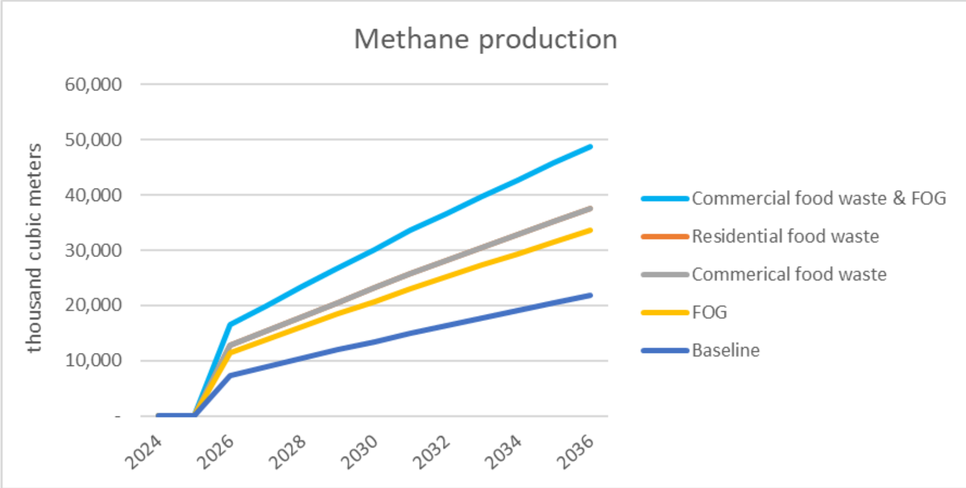


Figure 10: Methane produced in thousands of cubic meters from co-digestion of sewage with food waste and FOG compared to the baseline (digestion of sewage only).

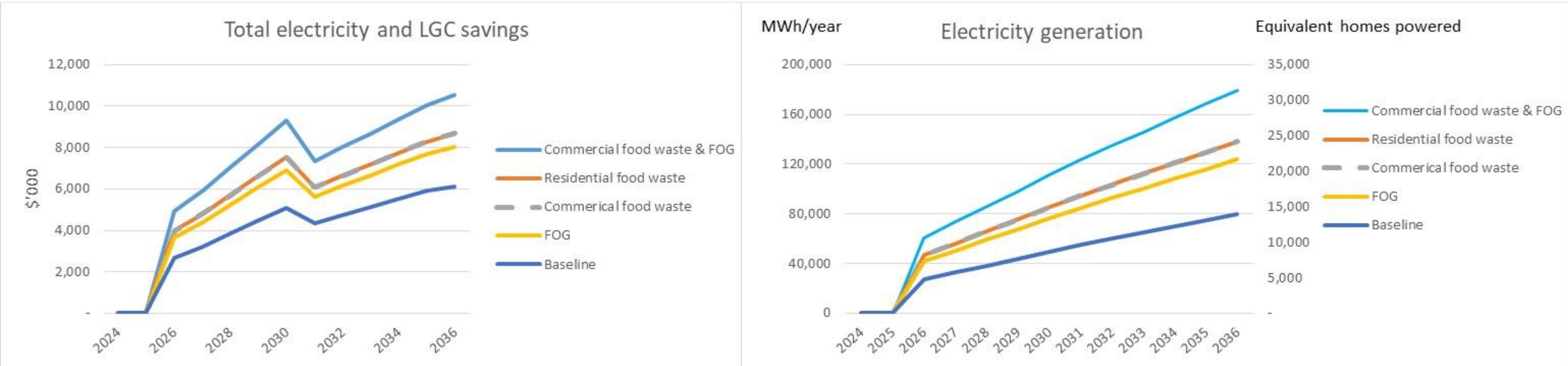


Figure 11: Electricity generated from biogas in MWh/year for the different scenarios, with the equivalent number of homes powered, and the value of the electricity.

Biosolids

In the process of anaerobic digestion, in addition to biogas, biosolids are produced which contain valuable nutrients and other materials of further processing value.

Biosolids may contain:

- Macronutrients, such as nitrogen, phosphorus, potassium and sulphur
- Micronutrients, such as copper, zinc, calcium, magnesium, iron, boron, molybdenum and manganese.

However, biosolids may also contain traces of synthetic organic compounds and metals, including arsenic, cadmium, chromium, lead, mercury, nickel and selenium, which may limit the potential uses. The use of biosolids is thoroughly regulated with appropriate government authorities[18]. In Australia, most of the biosolids are used for beneficial use (91%). In 2019, 70% of biosolids were used for agricultural application, 16% for land rehabilitation, 8% for landscaping. Of the remaining biosolids, 4% were disposed to landfill, 3% stockpiled and 1% discharged to the ocean. The majority of the biosolids were a by-product of anaerobic digestion (58%)[19]. Currently, Sydney Water bears the cost of management of biosolids that mostly have a beneficial application without receiving a revenue. Figure 12 shows the production of the biosolids in the four scenarios and baseline and their value based on nitrogen, phosphorus, copper and zinc for the residential waste co-digestion case (Scenario 1).

> **“ Biosolids with value of up to $2.8 million can be produced annually at AWRC by 2036.**

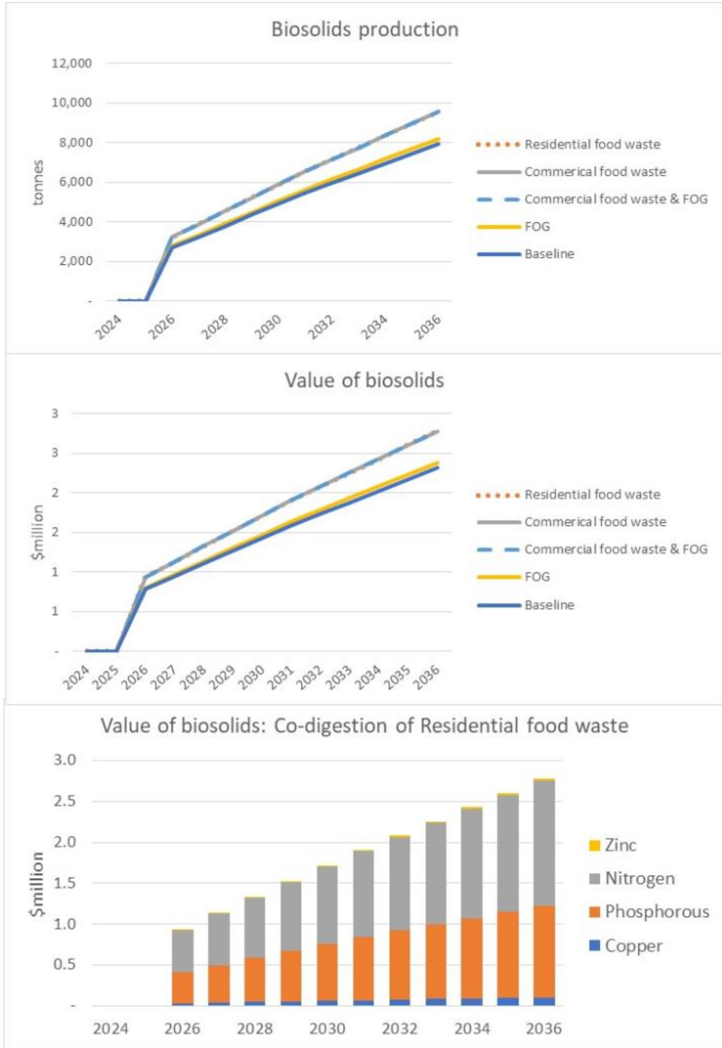


Figure 12: Biosolids production and total value by scenario and breakdown of value for Residential food waste (co-digestion at AWRC)

---

[18] *Biosolids Snapshot*, Department of Sustainability, Environment, Water, Population and Communities, 2012.

[19] https://www.biosolids.com.au

Greenhouse gas emissions avoided

In Figure 13 we estimated greenhouse gas emission savings from the co-digestion, compared to the alternative treatment of organic waste streams. These savings assume that anaerobic digestion at the AWRC would have a 15% improvement on greenhouse gas emissions from landfill, due to higher efficiency associated with capturing methane and using it for electricity generation compared to managed landfills or Alternative Waste Treatment (AWT) plants that separate organic material from the residual waste and further process it via industrial composting or anaerobic digestion. It should be noted that the current fate of the residual waste in the Western Parkland City local government areas is to be processed as described by the Alternative Waste Treatment. Should this food waste be sent to a landfill without landfill gas capture capacity, then the greenhouse gas generation would increase by 85%. In 2019, in Australia, 81% of food waste was disposed to landfill with no landfill gas capture option[20].

> **Co-digestion of food waste at AWRC could reduce cumulative emissions from Western Parkland City by 140,000 tonnes by 2036.**

> **Co-digestion of residential food waste could reduce annual emissions by 19,000 tonnes by 2036, equivalent to the total current emissions of 1,200 Australians.**

Figure 13 Annual greenhouse gas emission reduction by scenario and cumulative emission savings for residential food waste (co-digestion at AWRC)

[20] *Waste Account Australia, Experimental Estimates 2018-2019*, Australian Bureau of Statistics, Released 6 November 2020.

Potential impact of co-digestion in across Western Parkland City

Considering that there is more organic waste resource available for co-digestion than the AWRC can take (the AWRC only takes a maximum of 22% of the available resource) a fifth scenario was added to include the other three WWTPs in the Western Parkland City area: Riverstone, St Mary's and Liverpool. Figure 14 - Figure 16 depict the total jobs, emissions savings, biosolids production and biosolids value, and electricity generated and savings.

> **By 2036, co-digestion at all four WWTPs could create 300 ongoing direct jobs and reduce Western Parkland City emissions by 70,000 tonnes each year.**

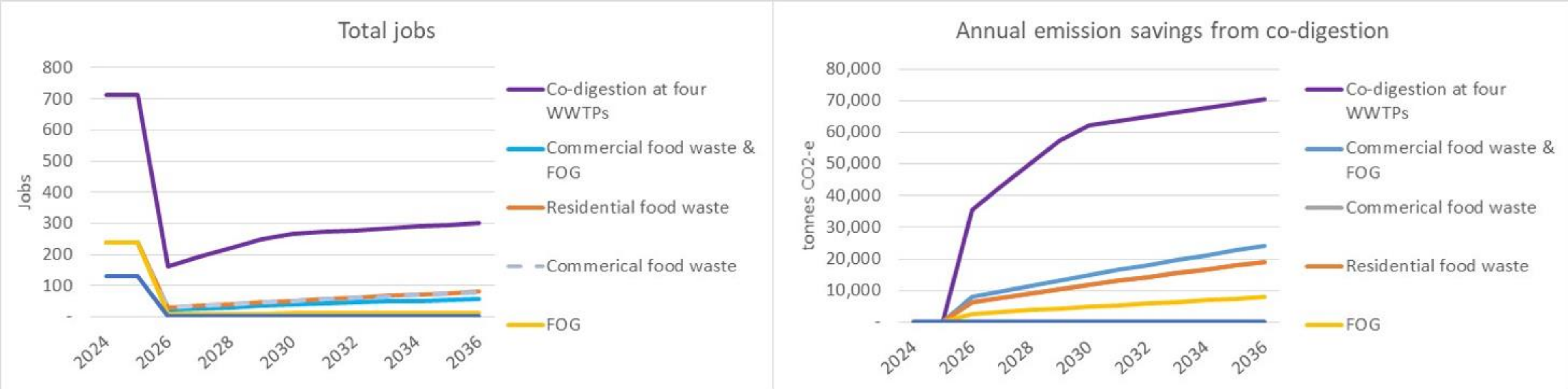


Figure 14 Total job creation and emissions savings by scenario, and for co-digestion extended to all WWTP in the Western Parkland City

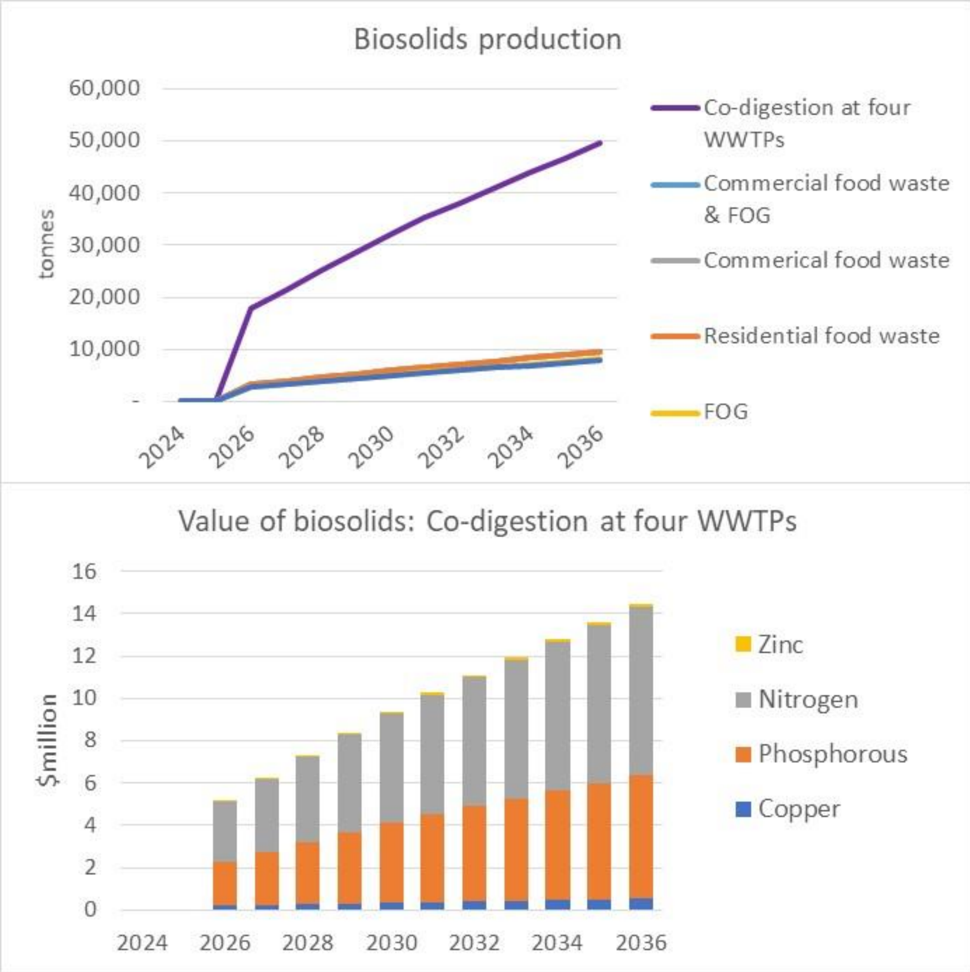


Figure 15: Total biosolids production by scenario and for co-digestion extended to all four WWTP in the Western Parkland City, and a breakdown of the biosolids value.

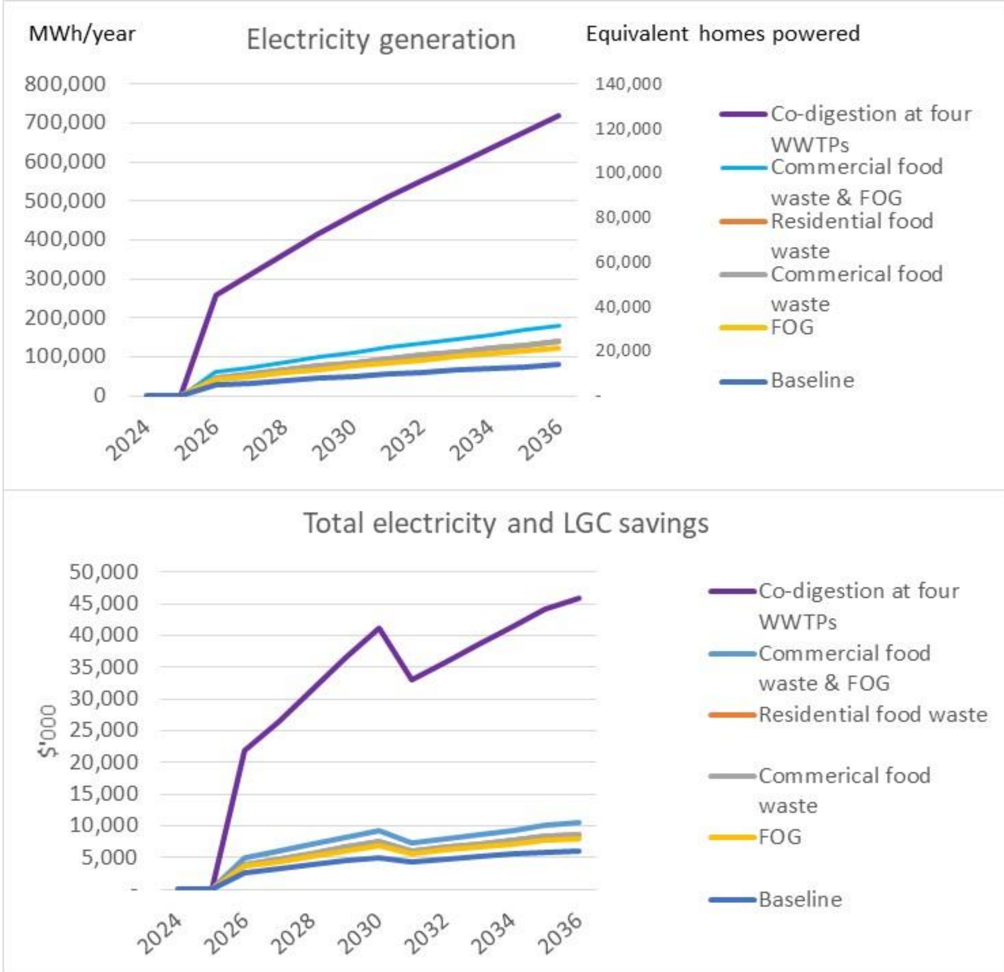


Figure 16: Total electricity generation and electricity value by scenario and for co-digestion extended to all WWTP in the Western Parkland City.

> **“ By 2036, co-digestion at all four WWTPs could produce each year biosolids with a value of $14.4 million, generate enough electricity for 120,000 homes and save $45 million in energy costs.**

Conclusions

The planned growth of nearly 17 thousand new dwellings, population increase of 0.5 million and employment increase of 37% within the Western Parkland City by 2036 along with investment in the Upper South Creek advanced water recycling centre (AWRC) will provide a significant opportunity to process organic waste in the Western Parkland City and provide a major boost to the overall economy. Opportunities up to 2036 include:

- 1.5 million tonnes of food waste in the residential sector and an additional 0.7 million tonnes in the commercial sector available for resource recovery;
- A new separate residential food waste collection service (implementation cost of $1.4 million) to collect food waste in multiple unit dwellings and create 45 new jobs;
- The AWRC and the Riverstone, St Mary’s and Liverpool WWTPs digesting up to 165 kilo tonnes of organic waste per year;
- The construction and operation of the AWRC plant to handle additional organic waste streams to allow Sydney Water to further expand on its invaluable economic contribution;
- During the construction phase of the project the ability to generate an additional $53.9 million per year in output for the domestic economy, $38.8 million of value added, $27.4 million of household income, and full-time jobs for over 392 workers each year with the flow-on effects reaching a wide range of service and manufacturing industries that are linked to construction;
- The creation of over $16.7 million in output, $ 10 million in value added, and an additional $0.7 million in household income in 2025/26, its first year of operations, with the organic waste collection, treatment and processing and impacts on the wider economy providing ongoing employment for over 9 FTEs;
- Due to the economic multiplier effect, activity directly related to the construction and operation of the AWRC plant knock-on effects throughout the wider economy beyond the initial creation of additional output, value added, jobs, and additional benefits are generated indirectly by the increase in production by other industries and the income generated and spent in the economy;
- An extra 100 direct jobs created during the construction period at AWRC but also the collection of food waste which will create most ongoing jobs, with up to 75 direct jobs created by 2036;
- Co-digestion at the AWRC generating enough electricity for an extra 10,000-20,000 homes and savings of an extra $6-$13 million by 2036 and biosolids with a value of up to $2.8 million per year;
- Co-digestion of food waste at the AWRC that could reduce cumulative emissions from the Western Parkland City by 140,000 tonnes by 2036 (a reduction in annual emissions of 19,000 tonnes by 2036 equivalent to the total emissions of 1,200 Australians); and
- Co-digestion at all four WWTPs creating 300 ongoing direct jobs, reduction in Western Parkland City emissions by 70,000 tonnes each year, production of biosolids with a value of $14.4 million each year and generation of enough electricity for 120,000 homes and savings of $45 million in energy costs.

APPENDIX A - Policy context

Policy Context

Table 4: Strategic documents from all levels of the governments relevant to the Upper South Creek Advanced Recycling Facility co-digestion of sewage with organic wastes

NATIONAL	
National Food Waste Strategy[21]	• **Target:** half Australian's annual food waste by 2030 (In line with the requirements of the United Nations SDG Target 12.3
Stop Food waste Australia[22]	• Implementation of the Food waste roadmap[23]
Australia Bioenergy Roadmap[24]	• Make the most of waste and residue resource: encourage source separation of organics, enable higher steps in the waste hierarchy • Identify and build bio hubs • Upgrade biomethane for replacement of natural gas
STATE	
NSW Circular Economy Policy Statement[25]	• Sustainably manage all resources • Valuing resource productivity • Design out waste and pollution • Maintain the value of products and materials • Innovate new solutions for resource recovery
NSW Waste and Sustainable Materials Strategy 2041 **Stage 1: 2021-2027**[26]	• **Targets:** – Half the amount of organic waste sent to landfill by 2030 – Net zero emissions from organics to landfill by 2030 • Needed new facilities to process FOGO and FO (in AD) in Greater Sydney
NSW Waste and Sustainable Materials Strategy 2041 **A guide to future infrastructure needs**[27]	• Long term vision to manage waste, plan for infrastructure, reduce carbon emission, create jobs in production, consumption of recycled products and materials • Ensure to have the right infrastructure to process the material expected to enter the waste stream over the next two decades

[21] *National Food Waste Strategy: Halving Australia's food waste by 2030*, Commonwealth of Australia, 2017.
[22] https://www.stopfoodwaste.com.au
[23] *A Roadmap for reducing Australia's food waste by half by 2030*, Food Innovation Australia Limited, 2019.
[24] *Australia's Bioenergy Roadmap*, Enea and Deloitte for ARENA, 2021.
[25] *NSW Circular Economy Policy Statement: Too Good to Waste*, NSW Environment Protection Authority, 2019.
[26] *NSW Waste and Sustainable Materials Strategy 2041, Stage 1: 2021-2027*, NSW Department of Planning, Industry and Environment, 2021.
[27] *NSW Waste and Sustainable Materials Strategy: A guide to future infrastructure needs*, NSW Department of Planning, Industry and Environment, 2021.

Net Zero Plan Stage 1: 2020-2030[28]	• **Priority 1**: Drive uptake of proven emission reduction technologies • Net zero emissions from organic waste by 2030
NSW Water Strategy[29]	• Promote and improve Integrated Water Cycle Management • Foster the circular economy in our cities and towns
NSW 2040 Economic Blueprint[30]	• Improve waste infrastructure network • Recover value from waste
GREATER SYDNEY	
Greater Sydney Region Plan: A Metropolis of Three Cities[31]	• Establish Western Parkland City: Western Economic Corridor and high population growth • An efficient city – Use resources wisely: – **Objective 33**: A low-carbon city contributing to net-zero emissions by 2050 and mitigating climate change – **Objective 34**: Energy and water flow are captured, used and reused – **Objective 35**: More waste is re-used and recycled to support the development of a circular economy
Draft Greater Sydney Water Strategy[32]	• **Priority 3.4**: Progress a circular economy approach for water services – management of complex interconnections between water, services, carbon emissions, ecological health and economic productivity • Initiatives such as food waste co-digestion and bioresource hubs (integration of food production, energy, water and organic waste management – establishing an organic waste processing hub in Western Sydney as part of the planned Upper South Creek Advanced Water Recycling Plant to produced recycled water, bioenergy, fertiliser products and purified carbon dioxide).
WESTERN SYDNEY	
Western City District Plan[33]	• W1: Plan for a city supported by infrastructure • W2: Work through collaboration • W3: Provide services and social infrastructure to meet people's changing needs • W19: Reduce carbon emissions and managing energy, water and waste efficiently
Western Parkland City Draft blueprint[34]	• **G2 Priority**: Upper South Creek Advanced Water Facility by 2025 • **G13 Priority**: Design circular economy pathways and systems that are resilient to climate change and promote energy efficiency

[28] *Net Zero Plan, Stage 1: 2020-2030*, NSW Department of Planning, Industry and Environment, 2020.
[29] *NSW Water Strategy*, NSW Department of Planning, Industry and Environment, 2021.
[30] *NSW 2040 Economic Blueprint: Investing in the state's future*, NSW Treasury, 2019.
[31] *Greater Sydney Region Plan: A Metropolis of Three Cities*, Greater Sydney Commission, 2018.
[32] *Draft Greater Sydney Water Strategy: Water for a resilient Sydney*, NSW Department of Planning, Industry and Environment, 2021.
[33] *Western City District Plan*, Greater Sydney Commission, 2018.
[34] *Draft Blueprint for the Western Parkland City*, Western Parkland City Authority, 2021.

Western Parkland City Draft Economic Development Roadmap Phase 1[35]	• Leverage the circular economy by targeting the Parkland City's existing waste, resource recovery and manufacturing industries, including integration of advanced, sustainable and resilient food production
Western Parkland Councils[36] **Western Sydney City Deal**[37]	• Councils of the Blue Mountains, Camden, Campbelltown, Fairfield, Hawksbury, Liverpool, Penrith and Wollondilly signed a 20-year Western Sydney City Deal with the Australian and NSW Governments to unlock opportunities in education, business and employment for Western Sydney and its people. Commitments have been reconfirmed through the formation of Western Parkland Councils. • Western City District Plan: – Infrastructure supporting new developments – Use resources wisely
Re-imagining water in Western Sydney[38]	• Western Sydney Regional Master Plan delivering affordable and essential water services, healthy waterways, and vibrant, cool and green places.

35 *Draft Western Parkland City Economic Development Roadmap – Phase 1*, Western Parkland City Authority, 2021.
36 *Western Parkland Councils: Local government partners in the Western Parkland City*, Western Parkland Councils, 2019.
37 https://www.wscd.sydney
38 *Re-imagining water in Western Sydney: Western Sydney Regional Master Plan*, Sydney Water, 2020.

APPENDIX B – Methodology and Assumptions

Figure 17 gives an overview of the modelling approach. Three scenarios using different waste streams (residential food waste, commercial food waste, and FOG) were defined in a workshop with Sydney Water, with the study undertaken for the AWRC. An additional scenario was added subsequently, using a combination of commercial food waste and FOG.

The baseline was defined as AWRC without co-digestion of waste but including the anaerobic digestion of sewage sludge and the associated electricity generation. Most physical and economic indicators for the baseline and the scenarios were to be taken from Sydney Water's feasibility study for the AWRC.

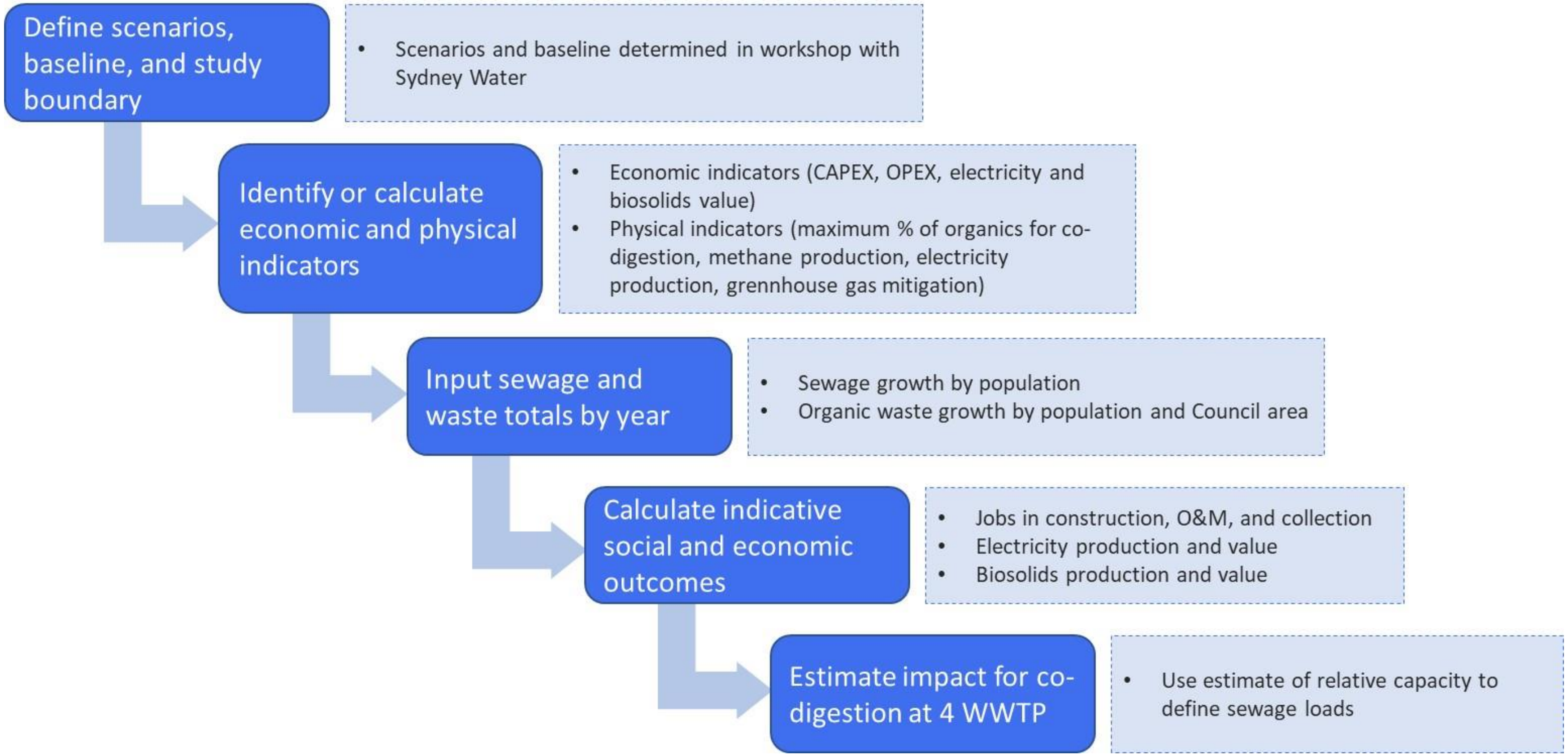


Figure 17 Modelling approach

Table 5, Table 6, Table 7, detail the indicators used in the analysis.

Table 5 General physical indicators used in the analysis

Indicator	Unit	Value	Notes
Greenhouse gas emissions - methane	tonnes of CO_2-e/tonne methane	28.00	Research team information
Methane density	kg/m^3	0.66	Research team information
Percentage of fugitive emissions from CH_4 capture in landfill	%	0.15	Sydney Water information
Conversion - Biomethane m^3 to GJ	GJ / m^3	0.0377	Sydney Water information
Conversion - Biomethane GJ to MWh	GJ / MWh	3.6	Sydney Water information
Conversion - Biomethane m^3 to MWh	MWh / m^3	0.01	Sydney Water information
Engine efficiency	%	40%	Sydney Water information
Methane flared	%	8%	Sydney Water information
Sewage sludge convert ML to tonne	%	1.182%	Sydney Water information
Dewatered biosolids production	tonnes/tonne	5%	Research team information

Table 6 Economic indicators used in the analysis

Indicator	Unit	Value	Notes
Construction jobs per million dollars	FTE (full time equivalent)	11.66	Derived from average construction worker salary of $66,000[39] plus on-costs of 30%.
Proportion of capital costs related to labour costs	%	40%	Research team estimate
Construction period for WWTP	years	2	Sydney Water information
Operational and maintenance employment (baseline)	FTE	2.80	Sydney Water information
Employment per tonne current residential residual waste collection	FTE/kg	1.7	Assumes weekly collection with no separation of food waste and is based on the average employment in the eight council areas in Western Parkland City. See section Organic waste appraisal for more details.
Employment per tonne residential waste collection with separate collection of food waste	FTE/kg	2.4	Assumes weekly collection of food waste and fortnightly collection of the residual waste and is based on the average employment in the eight council areas in Western Parkland City. See section Organic Waste appraisal for more details.

[39] (https://www.payscale.com/research/AU/Job=Construction_Worker/Hourly_Rate)

Indicator	Unit	Value	Notes
Copper (value of biosolids)	$/tonne	10.9	Based on current copper price[40] and assumed concentration of 550mg Copper/kg of biosolids[41]
Nitrogen (value of biosolids)	$/tonne	159.6	Based on diammonium phosphate and urea price[40] and assumed concentration of 4% nitrogen/t of biosolids[41]
Phosphorous (value of biosolids)	$/tonne	117.8	Based on diammonium phosphate and triple superphosphate price[40] and assumed concentration of 2.5% phosphorous/t of biosolids[41]
Zinc (value of biosolids)	$/tonne	2.8	Based on current zinc price[40]and assumed concentration of 800mg zinc/kg of biosolids[41]
Total value of biosolids	$/tonne	291	Sum of copper, nitrogen, phosphorous and zinc value.
Electricity value (self-consumption) at 2024	$/MWh	120.4	Sydney Water AWRC feasibility study
Electricity value (self-consumption) 2031 - 2036	$/MWh	134	Sydney Water AWRC feasibility study
Electricity value (export); ratio to self-consumption	$/MWh	0.3	Research team estimate. Export value is reduced compared to self-consumption, as only energy value is included (and not network, environmental, or retail charges).
Large scale generation certificates (LGC) value until 2030	$/MWh	25	Research team estimate: assumed value is zero after 2030 as Renewable Energy Target (RET) scheme is finished.

Table 7 Scenario specific indicators used in the analysis

Indicator	Unit	Scenario 0 Baseline	Scenario 1 Residential food waste (multiple unit dwellings)	Scenario 2 Commercial food waste	Scenario 3 FOG	Scenario 4 Commercial food waste & FOG	Scenario 5 Co-digestion at 4 WWTP
Maximum ratio to sludge for co-digestion	%	100%	20%	20%	3%	20%	20%
Methane production per tonne waste stream alone	m^3/ tonne	137	218	218	603	276	218
Methane production per tonne co-digested at appropriate % with sewage	m^3/ tonne	n/a	197	197	205	256	197

[40] https://www.indexmundi.com
[41] *Biosolids Snapshot*, Department of Sustainability, Environment, Water, Population and Communities, 2012.

Direct jobs

Direct jobs were calculated as construction jobs plus operation and maintenance jobs plus collection jobs, using the indicators in Table 5. Construction jobs were calculated as shown in Equation 1; operation and maintenance jobs were taken from Sydney Water Information (and assumed to remain the same across the different scenarios at AWRC).

[Equation 1]

$$\boldsymbol{Construction\ jobs\ per\ \$m\ capital\ expenditure} = \frac{\textbf{capital expenditure x proportion of capital expenditure spent on labour}}{\textbf{Average construction salary}}$$

Collection jobs per tonne of waste were calculated for the base case program, taking account of different council practices, and then averaged as an indicator "collection jobs per tonne". This was calculated assuming residual waste collection without food waste separation (the baseline), and a weekly collection for food waste and a fortnightly collection for the residual. Equations 2 and 3 summarise the calculations.

[Equation 2]

$$\textbf{FTE for waste collection program} = \frac{[\textbf{seconds per lift x households x persons per truck}] + [\boldsymbol{number\ of\ truck\ movements\ x\ time\ to\ unload}]}{\textbf{Average hours on collections per FTE}}$$

[Equation 3]

$$\boldsymbol{Collection\ jobs\ per}\ tonne\ of\ waste = \frac{\textbf{FTE for waste collection program}}{\textbf{Total tonnes collected}}$$

For the commercial food waste collection was used the same approach, replacing the number of households with number of businesses, assuming longer lift time and less employees on each collection truck. For FOG it was assumed that there would be no change to the collection service.

Bioenergy potential and biosolids

Bioenergy potential was calculated using the methane production per tonne as detailed in Table 7. The tonnage co-digested was determined by tonnage of sewage, plus the maximum percentage of organic waste for each scenario as a percentage of the sewage going to the digestor (subject to waste availability). Biosolids were calculated as a simple percentage of the total tonnage going to the digestor.

Greenhouse Emission reductions

The emission reduction resulting from co-digestion was calculated from the tonnage that would otherwise have been going to landfill, assuming that methane capture would occur at the landfill, and that 15% would escape as fugitive emissions. Methane production was calculated using the data for the relevant waste stream alone, shown in Table 7. The calculation is shown in equation 3, with methane production per tonne of being 28 tonnes of CO_2-e/tonne methane

[Equation 4]

$$\boldsymbol{Emission\ reduction\ per\ tonne\ diverted} = methane\ production\ per\ tonne\ of\ waste\ x\ 15\%$$

Organic Resource Appraisal

Residential Sector

Organic waste resource baseline in residential sector for all types of households was determined for each of the eight individual local government areas in Western Parkland City and is based on the WARR reports, population and household profile as described below. Waste projections were estimated based on the population and household construction growth, and waste behaviour trends for the Local Government Areas. Collection related jobs (in FTEs), truck fleet numbers and costs were also estimated as outlined below. All the parameters were also estimated separately for multiple unit dwellings. The study focused on the period from 2026- 2036.

Population and households

Current population and household profile was adopted from ABS data[42] for each Local Government Area separately. Detached houses were classified as single unit dwellings and medium and high-density dwellings were classified as multiple unit dwellings. Population and household projections were adopted from the NSW Department of Planning and Environment[43]. The ratio of single unit dwellings/multiple unit dwellings for each of the local government area was assumed to remain constant in the projections. This assumption was adopted based on the observed projections in the housing strategies by the local government areas in focus and based on publicly available projections.

Residential waste baseline

WARR reports for 2019/20[44] were used to establish waste baseline for residual waste and organic waste collection (garden organics and FOGO – food organics garden organics), frequency of collection services for residual and organic streams, waste generation per capita and waste generation per household for each of the eight analysed local government areas. The data was also compared to the national waste generation average[45]. Food waste quantities in the residual waste were calculated using councils' audit reports where available, and if not available, it was assumed that 40% of residual waste was food waste and 10% was garden organics (based on the NSW EPA state audits summary reports[46]).

Waste projections

For each of the analysed local government areas, calculated waste per capita trend over the past few years in conjunction with population and household projections[47] were used to estimate waste projections. It was assumed that the percentage of food waste in relation to the residual waste would remain the same over the projected years, trend that has been nationally observed over the past decade[45]. Waste generation in multiple unit dwellings was estimated by applying the multiple unit dwellings numbers proportion to the total waste generated.

Residential waste collection

None of the studied councils, except Penrith, currently have a separate food waste collection. To incentivise participation in food waste separation, there is a common practice to introduce a weekly collection of food waste (either as food only collection or combined food and garden organics collection (FOGO)) and at the same time to reduce the residual waste collection from weekly to fortnightly. While when transitioning to FOGO, normally there is no impact in collection employment numbers or number of trucks required as there is in essence only a switch in frequency between collection of residual and garden organics services. In the FOGO service, food waste is accepted in the garden organics bin and collected weekly instead of fortnightly. Considering that almost half of the residual waste is food waste, once it is shifted from the residual bin, there is supposed to be a significant reduction of residual waste and consequently reduction in the collection frequency is reasonable. Another reason for weekly collection of food waste is odour.

To collect food waste separately, an additional service would be required. To estimate if additional employees and trucks would be required due to the new service, we firstly established number of FTEs and truck fleet size for the current collections for each of the councils and then calculated the requirements for the modified service pattern.

We assumed that the average truck collection capacity is 5 tonnes[48]. We estimated that each truck takes 31 seconds per household to pick up waste (based on 8.28 seconds per bin lift, at the speed of 7 km/h and average

---

[42] https://profile.id.com.au
[43] *NSW 2019 Population Projections: Greater Sydney Commission Districts Projections*, NSW Government, 2019.
[44] *NSW Local Government Waste and Resource Recovery Data Report 2019-20*, NSW Environment Protection Authority, 2021
[45] *National Waste Report 2020*, Department of Agriculture, Water and the Environment, 2020
[46] *Analysis of NSW Kerbside Red Lid Bin, Audit Data Report*, Rawtec, 2020.
[47] https://profile.id.com.au
[48] J. Edwards, M. Othman, S. Burn and E. Crossin, Energy and time modelling of kerbside waste collection: Changes incurred when adding source separated food waste, Waste management 56 (2016), 454-465.

distance between households of 43.9 m[48]). In addition, we assumed that an additional hour would be required to empty each of the full trucks. We assumed 3 FTEs per truck, trucks operating 5 days per week at 2 shifts and the average FTE to be 1470 hours per year. Number of FTEs and trucks in the fleet were estimated for each type of collection service and each of the local government areas. Based on our calculations it was determined that on average there are 2.4 FTE per kg waste required.

We have also separately estimated collection parameters if separate food waste collection was only introduced in multiunit dwellings.

Commercial Sector

Food waste generation in the commercial sector was estimated based on the ABS waste accounts data[49], number of employees by ANZSIC (Australian and New Zealand Standard Classification) sectors[50] and local government area[51] as well as the number of businesses in each of the local government area distributed based on the business number of employees[52]. The future projects were based on the projected increase of employees[53].

Commercial waste collection

It was assumed that all business would require to introduce a new collection service for food waste. This included distribution of new 240L bins and new collection service. The number of new collection jobs was estimated using similar methodology used to determine number of residential waste collections jobs. It was assumed that collection would occur weekly and the waste truck capacity would be 5 t. Due to potentially bigger bin sizes and uneven distance distribution between businesses, the time required for each bin collection was estimated to be 1 minute (which aligns with literature estimates in international jurisdictions[54]). Additional time required to empty full trucks was assumed to take 1 hour. Number of bins required were based on the amount of food waste available for collection rather than on the number of businesses, assuming that some businesses are generating too small amounts of food waste to introduce a new food waste service.

Fats, oils and greases (FOG)

Data on quarterly collection of FOG for each of the local government areas was provided by Sydney Water. Future projections of FOG were linked to the employment projections as described above to determine the future projection of food waste.

Western Sydney Airport

Western Sydney Airport is projected to build up capacity to 82 million passengers per year by 2063 over the four stages[55]:

- Stage 1: 5 million passengers in 2026
- Stage 2: 10 million passengers by 2030
- Stage 3: 37 million passengers by 2050
- Stage 4: 82 million passengers by 2063

Waste generation per passenger was assumed to follow the Sydney Airport trend and the projection was applied in estimation of waste generation per year. It was assumed that 27% of waste is food waste[56].

[49] *Waste Account Australia, Experimental Estimates 2018-2019*, Australian Bureau of Statistics, Released 6 November 2020.
[50] *Employed persons by industry sub-division of main job (ANZSIC) and Sex time series*, Australian Bureau of Statistics, 2021.
[51] *Jobs in Australia: New South Wales spotlights by Local Government Areas 2018-19*, Australian Bureau of Statistics, Released 26 October 2021.
[52] *Counts of Australian Businesses, including Entries and Exits, June 2017 to June 2021*, Australian Bureau of Statistics, Released 16 December 2021.
[53] *TZP19 Employment Projections by ANZSIC code and LGAs (2016-2056)*, Transport for NSW, 2020.
[54] M. Carlos, A. Gallardo, N. Edo-Alcón and J.R. Abaso, *Influence of the Municipal Solid Waste Collection System on the Time Spent at a Collection Point: A Case Study*, Sustainability (2019), 11, 6481.
[55] https://www.westernsydneyairport.gov.au
[56] Private communication with Sydney Airport.

Western Parkland City population and dwellings projection

The data in Table 8 and Table 9 has been used in the estimation of the waste resource appraisal.

Table 8: Increase in the number of dwellings (Single unit dwellings and multiple unit dwellings) and population from 2022 to 2036 in each of the local government areas. Source: NSW 2019 Population Projections[57] and profile.id[58]

		Blue Mountains City Council	Camden Council	Campbelltown City Council	Fairfield City	Hawkesbury City Council	Liverpool City Council	Penrith City Council	Wollondilly Shire Council
Single unit dwellings	2022	30,341	26,368	44,273	45,630	25,807	51,257	60,518	16,534
	2036	32,057	45,689	62,235	53,459	25,346	75,044	86,450	22,674
Multiple unit dwellings	2022	5,354	16,537	20,865	23,033	4,779	31,260	29,394	4,278
	2036	5,678	28,655	29,329	26,984	5,761	45,768	41,990	5,866
TOTAL DWELLINGS	**2022**	**35,580**	**42,905**	**65,138**	**68,662**	**25,807**	**82,517**	**89,912**	**20,812**
	2036	**37,735**	**74,344**	**91,564**	**80,443**	**31,107**	**120,812**	**128,440**	**28,540**
Population	2022	79,692	124,970	182,477	212,898	68,137	254,201	236,385	57,529
	2036	82,844	214,411	256,041	238,195	77,048	358,871	350,906	87,865

[57] *NSW 2019 Population Projections: Greater Sydney Commission Districts Projections*, NSW Government, 2019.
[58] https://profile.id.com.au

Western Parkland City employment projections

Table 9: Distribution of businesses by size in each of the local government area. Employment in 2021 and projected employment for 2036 for each of the government areas. Source: ABS NSW jobs in Australia spotlights by local government areas[59] and ABS Counts of Australian Businesses[60]

		Blue Mountains City Council	Camden council	Campbelltown City Council	Fairfield City	Hawkesbury City Council	Liverpool City Council	Penrith City Council	Wollondilly Shire Council
Non employing		3,011	4,182	5,876	8,327	3,506	9,793	7,689	2,175
1-19 Employees		2,427	4,348	4,560	7,965	3,519	8,490	6,979	2,371
20-199 Employees		68	171	224	305	147	326	348	61
200+ Employees		3	3	6	11	6	15	4	3
TOTAL businesses		**5,509**	**8,711**	**10,671**	**16,612**	**7181**	**18,621**	**15,020**	**4,615**
Employees	2021	23,235	34,538	66,037	72,185	31,379	90,551	88,920	14,669
	2036	25,857	53,813	82,415	80,302	36,388	156,628	119,895	22,901

Economic Impacts

The overall economic benefits of co-generation at the AWRC plant depend essentially on the associated expenditure patterns, including the shares that flow to domestic industries, and the structure of the economy, with different expenditures supporting different levels of output, employment and income.

Our analysis of the impacts on the wider economy draws on input-output (IO) analysis. IO models provide a detailed picture of the economy in terms of the flows of goods and services in a given year. An IO table presents the relationship between producers and consumers and shows how purchases by one sector impact on other sectors through their supply linkages. The idea behind the IO model is that a change in production activity by one industry will impact other industries, with a stimulus to production of output by other

[59] *Jobs in Australia: New South Wales spotlights by Local Government Areas 2018-19*, Australian Bureau of Statistics, Released 26 October 2021.
[60] *Counts of Australian Businesses, including Entries and Exits, June 2017 to June 2021*, Australian Bureau of Statistics, Released 16 December 2021.

industries – the so called output multiplier effects. Multipliers can also be calculated for value added, wages, and jobs to view the benefits from different perspectives.

The economic impacts in our analysis were estimated using IO based economic multipliers to estimate the effects of the initial investment on the wider economy. The multipliers were calculated using the latest available ABS IO table[61]. The economic stimulus and the distribution of impacts to domestic industries were identified using information provided by Sydney Water about the new AWRC plant and its extension to co-generation of sewage using food waste or/and FOG.

The IO method is widely used to complement financial analysis and cost-benefit analysis which carry a different focus and purpose. An economic impact analysis goes beyond looking solely at the goods and services produced or jobs created as a result of investment within a company or sector, but rather extends much more widely to capture the additional economic production, both by suppliers and their own suppliers etc., as well as the additional spending of wages by the employees engaged throughout the supply chain.

The approach was applied to of the direct, indirect and induced economic impacts on the economy in terms of various economic indicators. These impacts are defined as follows:

- **Direct effect:**
  This is the initial stimulus which starts of additional economic activity and production. For example, a $1 million investment in a particular industry's infrastructure implies a direct impact of $1 million on the sector. For the current study, the direct effect comprised a core system relating to the construction and operation of the additional co-digestion facilities for food waste, FOG or other organic waste feedstock, together with the systems for transport/collection of organic waste to bring the waste to the new facilities.
- **Indirect effect:**
  This represents the response by supplying industries in terms of purchasing additional inputs and employing additional workers to produce the additional output. This effect is also known as the "production-induced effect" and captures both the first-round industry impacts and second to n^{th} round effects as each industry engages other industries e.g. raw materials, manufacturing and transport to produce output.
- **Induced effect:**
  The effects of additional household spending due to additional income received as wages/salaries in producing the additional output across all impacted industries. This is also known as the "consumption effect".

As with all methods, the IO approach has a number of assumptions and limitations[62] but remains the preferred approach when it comes to providing high level estimates of wider economic impacts.

Due to the requirements of this rapid high-level assessment, the results focus on the Australian economy at large. However, estimates of the imported shares of capital expenditures are deducted from the impacts. Future work might focus on the effects on the regional e.g. Western Parkland City economy, but goes beyond the scope of this assessment.

Data

The expenditures for investments in and operation of the new facilities were based on financial data provided by Sydney Water. The Sydney Water data

[61] *5209.0.55.001 Australian National Accounts: Input-Output Tables, 2018-19*, Australian Bureau of Statistics, 2021

[62] Key assumptions of IO analysis are: (1) Homogeneity (all companies within the same industry classification are assumed to have the same production process and inputs requirements); (2) Fixed proportions (i.e., a fixed input requirements proportion relative to output); (3) No supply constraints (i.e. unlimited supplies of intermediate inputs and labour for production available at a fixed price) See: R.E. Miller and P.D. Blair. (2009) Input-Output Analysis: Foundations and Extensions, Second Edition.

included itemised estimates for capital expenditure and operational expenditure which allowed for separate analysis of the construction and operational phases of the project. The data provided estimates for incremental expenditures associated with the construction and operation of dedicated capacity for organic waste (i.e. additional expenditures that would be incurred beyond the base case (or “core scope”)). Deductions to these incremental expenditures were then made to account for imported inputs[63], which as substitutes for domestic production lead to so-called ‘leakages’ from the economy. Expenditure flows to domestic industries by contrast were the focus of this analysis since these stimulate local production. Contingencies were apportioned to either direct or indirect capital expenditure items.

The analysis began with calculating the economic output (i.e. the overall contribution to the economy or total gross revenue). Data for operating revenues were used comprising of estimates of gate-fee revenues, the value of electricity sales to the grid and local government areas revenues.

Operating expenditures included labour, digestate disposal, co-generation and chemical costs. Transport and collection costs were estimated using assumptions from the literature[64], as were estimates for deductions for the import shares.[65] Capital expenditure on repairs were also incorporated. Capital and operating investment expenditures for intermediate inputs were allocated to appropriate industries based on ANZSIC classifications.[66] The calculations of value added, wages and FTEs were based on Sydney Water data, with direct value added approximated by Earnings Before Interests, Taxes, Depreciation, and Amortization (EBITDA) and wages.[67]

[63] It was assumed that the pre-treatment, anaerobic digestors, thickening, cogeneration units and centrifuge equipment carried a 90% import share; while electrical, instrumentation, mechanical, site excavation and civil works carried an 80% import share.

[64] J. Edwards, M. Othman, S. Burn and E. Crossin, Energy and time modelling of kerbside waste collection: Changes incurred when adding source separated food waste, Waste management 56 (2016), 454-465.

[65] Communication with Sydney Water

[66] Construction phase expenditures for intermediate inputs were apportioned to the construction services sector, heavy and civil engineering construction sector, and waste collection, treatment and disposal services sector according to expenditure categories. In a similar manner, operational phase expenditures were apportioned to the waste collection, treatment and disposal services sector, specialised and other machinery and equipment manufacturing sector, and other repairs and maintenance sector.

[67] Impacts in terms of value added were based on an apportioning using average value added per ANZSIC industry sector in the absence of detailed supplier data. Further work could investigate in greater detail the cost and revenue structure of production by suppliers.

UTS

Institute for
Sustainable
Futures