Submission No 420

INQUIRY INTO PROPOSED ENERGY FROM WASTE FACILITIES

Organisation: Xseed Solutions

Date Received: 19 November 2025

Minister Penny Sharpe

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20 May 2025

Dear Minister Sharpe

Innovation enabling a $9.2+ billion NSW circular economy

Congratulations on initiating the *NSW Waste and Circular Infrastructure Plan* that recognises that we have six years to affect positive environmental and economic action. Your announcement and 'call to action' is timely with the recent release of the *Australian Circular Economy Framework* report with stated ambitions to add $26 billion to GDP, reduce Australia's emissions by 14%, and divert 26 million tonnes waste from landfill each year.

In summary, we recommend as part of the Plan the NSW Government establish the **NSW E-Mobility Clean Energy Sustainability Fund** (the Fund) to stimulate its circular economy. The Fund being capable to energise the delivery of over $2.2 billion in annual revenue annuity-style outcomes for NSW State and local governments from upcycling MSW resources. We have summarised the key attributes of the Fund in Appendix B, focused to deliver zero waste outcomes by upcycling waste as a resource, and enabling:

- **A Greener NSW -** lowering NSW Greenhouse Gas (GHG) emissions over 10% pa across hard to abate sectors,
- **Cost of living relief** to all NSW residents, savings estimated at ~$600 per NSW household annually,
- **Affordable, energy efficient sustainable fuels** – Higher yielding sustainable fuels per MWh of renewable power to decarbonise road, rail, ship and air transport, plus provide energy storage and energy security pathways for NSW. In this way, it mitigates the exposure to inflationary impact and fluctuating impact fossil fuel costs,
- **Creation of new jobs** across the state - future-facing regional and urban manufacturing jobs, and
- **New investment opportunities** - leveraging existing NSW businesses and growing new ones.

I co-lead an Australia and New Zealand business that is progressing advanced recycling or upcycling technology, that delivers a clean and final-solution alternative to directing waste to landfill or to incineration. The scalable technologies we provide include plasma gasification and the manufacture and use of methanol as a hydrogen carrier (that can be cost-effectively delivered and reformed to hydrogen at point of demand). Such technologies are scalable and regionally deployable and deliver circular economy and manufacturing opportunities across NSW and Australia.

The NSW Chief Scientist stating in its' 2020 report that *"From the various thermal waste processing technologies reviewed, plasma gasification appears to be the cleanest EFW technology in terms of air pollutants production. In plasma gasification, the high-temperature treatment degrades dioxins and tar, while the partial oxidation reaction inhibits the production of NOx. The extreme nature of plasma also ensures a high conversion of waste."*

In this way, our fifth-generation plasma gasification technology solution, currently being commercially scaled in Europe (and Australia), has low decile emissions relative to best available technologies and NSW's strict emission guidelines. Most importantly HPAG captures over 90% of CO_2 in the process for additional product reuse and recycling, providing a distinct advantage over traditional incineration technologies. Fully consistent with the NSW Chief Scientist's reported findings.

Upcycling has more positive environmental and economic impact than recycling as demonstrated through the innovative opportunity to:

- develop and enable a $49 billion Australia-wide green manufacturing industry,
- reduce Australia's GHG by 12% annually,
- create 14,000 new jobs across regional Australia, and
- divert and upcycle/recycle 22 million tonnes of household and business waste from landfill.

Attached in Appendix A is a recent brief article outlining our innovative approach for Australia and NSW.

Our objective is relatively simple. **Affordably recycle to dramatically reduce greenhouse gas emissions.**

Success is demonstrated through enabling an Australia-wide circular economy to recycle household and business red and green bin-style waste into hydrogen, carbon dioxide, and vitrified slag (and alternatively, methanol according to regional context). The former two to reduce diesel or natural gas emissions – are location and project dependent. The vitrified slag suitable for recycling into the construction industry to reduce emissions.

Zero waste, real zero emissions outcomes

We envisage with up to 3.6 million tpa of suitable NSW waste disposed of to landfill each year, NSW can reduce its GHG emissions by over 10% per year, create more than 2,900 new NSW jobs, and action the pathway to the development of $9.2+ billion in circular economy benefits across NSW - expanding local investment into an array of Industry 4.0 manufacturing sectors across the state.

To enable innovation, local manufacturing and lower GHG emissions, we have provided some summary observations below and some specific recommendations in the attached Appendices.

A Greener NSW

The circular economy is about promoting value-adding practices to reduce, reuse and recycle resources. For example, e-waste recycling involves separating electronic waste to reuse embedded critical minerals to reduce virgin material consumption - saving per tonne of e-waste, around 0.41 tonnes CO_2e. HPAG technology thermochemically upcycles suitable waste to simple hydrogen and carbon compounds for further refinement into a diverse range of commercial products. As an eco-system, the saving per tonne of waste can be up to 3.4 tonnes CO_2e, (which in this example is around 7.5 times more than recycling e-waste).

Extending the above e-waste comparison, we note that the *NSW Emissions impacts of food waste recovery technologies* fact-sheet highlights composting and anaerobic digestion technologies as reducing CO_2e emissions by 1.3- and 1.5-ton CO_2e per ton of FOGO waste respectively. As noted above, HPAG with a projected eco-system reduction of 3.4 tons CO_2e, when used as a low carbon fuel substitute, more than doubles the environmental benefits of these later two scenarios.

Importantly, these examples are to be contrasted with alternative residual waste solutions like incinerators that simply burn waste, emitting GHG. At best, in theory if all NSW waste was incinerated, it could reduce NSW GHG emissions by around 2.0% per year. With incineration, waste would need to be transported long distances to be burnt, inefficiently producing a low quantity of electricity potential outcomes to reasonably justify the cost or environmental impact. That older pathway is quite a contrast to the 10% annual GHG eco-system savings for NSW that we are outlining is achievable from upcycling waste with plasma gasification.

Scalable technology, delivered at a lower cost and risk profile when you consider that all carbon dioxide from the upcycling is captured for value uplift manufacturing opportunities (including NSW methanol and Sustainable Aviation Fuels (SAF) production) to extend the decarbonisation benefits beyond road transport into rail, ship and air transport modes. E-mobility sustainable fuel solutions such as these, leave a lasting positive legacy to lower GHG emissions, create further sustainable investments, and a deflationary step down in community waste management costs.

Cost of Living Relief

Victoria publishes detailed household waste management data reporting that waste management costs are up 62% over the last five years and are likely to accelerate and increase further with mandated FOGO waste separation activities currently in transition. This is more than double NSW's cost increases over the same time, and we consider that this is higher cost growth is a realistic indicator of the cost increases NSW households can expect with recently announced mandated FOGO standards.

We are very supportive of approaches that reduce and recycle food and organic waste, moreso if the environmental and economic benefits of the chosen technology are optimised. Nevertheless, we continue to see waste management costs rising above inflation in many Australian markets, given the additional recycling initiatives implemented and the burdens of separate FOGO collection and processing, often to compost.

NSW itself has reported:

- Over $1.7 billion in annual waste management costs for MSW waste streams,
- A 24% increase in waste management costs over the same period, before the additional costs of mandated FOGO and strategies considered in the draft Plan are implemented,
- NSW waste emissions have risen 24% and overall average recycling rates are static at 65%,
- NSW road transport diesel consumption and GHG emissions are up 16% over the same period, and
- Diesel prices are up 30%, impacting freight and transport costs for the delivery of goods and services.

All these additional inflationary pressures impact households and are outcomes that are undermining the benefits of the extensive stationary renewable energy network investments and developments across the state.

Organisations are looking for those opportunities, like HPAG, to turn waste into a value resource and avoid potential contamination and follow-on environmental concerns emerging with FOGO. The Logan City Council recently published a report that the anaerobic digestion pathway for FOGO was not a financially viable investment. Further, Victoria reports the cost to collect and manage FOGO at $220 per ton of FOGO waste, into a market where the compost product produced is sold at between $25 and $61 per ton and still emits 400 to 800 kg CO_2e per ton FOGO. FOGO to hydrogen, using HPAG, is anticipated to yield a materially higher greenhouse gas savings outcome and retail price – the essential requirements of a successful circular economy. An approach incorporating HPAG for mixed MSW, including FOGO, is consistent with fully diverting organics from landfill. The HPAG pathway mitigates higher costs for households for separation collection activities and contamination inspections, etc, whilst yielding increased volumes of higher value low carbon products.

Affordable, Energy Efficient Sustainable Fuels

We have also completed separate programs of work to demonstrate that HPAG: firstly, lowers the Australian Total Cost of Ownership (TCO) of heavy vehicles into the zero emission transition phase (particularly from 2027); and secondly enables significant deflationary and cost of living relief for households. HPAG facilitates these outcomes, turning waste into a valuable resource. This arises from the fact that input costs for HPAG are relatively known, and the low, specific-energy consumption requirement for HPAG limits the exposure to rising renewable energy costs.

Consider two Zero Waste pathways to fully divert waste from landfill for NSW's 4.8 million tpa of household and business waste currently disposed of to landfill:

- **The first,** burn the waste in large incinerators for grid power. Grid power that competes with solar, wind and hydro renewable energy solutions. Incorporating carbon capture and use technologies the incineration pathway has the energy potential for around 1,450 GWh of grid power, equivalent to $218 million in annual revenues (i.e. at $150 per MWh).
- **The second,** upcycle the waste as a resource to manufacture an array of sustainable fuels capable to be substituted for 2.6 billion litres of diesel. By contrast with incineration, a waste to hydrogen upcycling and recycling pathway, that could yield up to 8,100 GWh of energy potential and $5.2 billion in annual revenues (i.e. substituting for 2.6 billion litres of diesel at $2 per litre). In manufacturing low carbon hydrogen, the funding potential from the existing Federal hydrogen incentive scheme exists to provide funds proponents of $2 per kg of hydrogen produced over 10 years from 2027 to 2040. For context, upcycling 4.8 million tpa of suitable waste would yield up to 480 million kg of hydrogen per annum.

Methanol lowers the logistics costs of hydrogen storage and transport as methanol as a liquid is akin to handling and storing diesel. Transporting one tanker of methanol as energy is equivalent to transporting 12 tankers of compressed hydrogen gas. Our technology solution incorporates utilising commercially available containerised methanol reformers, whereby methanol is stored and reformed at a refuelling station or depot to produce either fast charge renewable power or hydrogen. In this way, we are providing duality and flexibility of refuelling infrastructure to accommodate both battery electric and hydrogen fuel cell electric trucks and buses.

Create NSW Jobs and Investment

Over 2,900 new direct jobs across the state would be created, as reported by the Federal Government (ie. 6 more jobs per 10,000 ton of waste recycled (vs landfilled)). Additionally, more indirect jobs from new jobs and business investment across the Industry 4.0 sustainable fuels equipment supply and servicing spectrum would be created.

As a specific regional example, we are working with a client in Victoria to reinvigorate the Gippsland region as older fossil fuel industries wind down. The establishment of waste to hydrogen facilities locally is anticipated to provide new local jobs and enable a zero emissions airport with hydrogen supply and additional freight export opportunities and capabilities for the region. Infrastructure that is envisaged to attract additional jobs and investment.

Similarly, with some tangible action we envisage potential future facing changes for NSW could include:

- **Hunter Valley** – With three proposed Precincts, capable to transition Orica to lower emissions ammonia production and new low carbon methanol manufacturing capabilities at Port Kembla or across the region,

- **Western Sydney** – With four proposed Precincts, additional capability to be co-located with new paper recycling, sustainable fuels to new and existing logistics and transport hubs, new investment in new low carbon methanol manufacturing capabilities - all capable to leverage a new age international airport and logistics network fully capable of operating on a real net zero basis before 2030, and
- **Green transport corridors** – With distributed hydrogen and methanol manufacturing across the state, and nearby to key transport routes, the capability to enable green transport corridors (akin to the EU TEN-T plans) for the fast charge and hydrogen refuelling stations for trucks and buses, extendable to sustainable fuels for shipping, aircraft and rail transport.

Accordingly, one of our key objectives in engaging with local councils across NSW is to transform all household MSW waste into a potential $2.2 billion annual annuity-income stream for the benefit of residents. One where local councils can (if they choose) share/co-own/operate Sustainability Precincts to lower household rates, provide enhanced services, and truly set NSW on a path to net zero across those 'hard to abate' sectors.

In the EU, Boson Energy has three separate advanced project opportunities that are targeting commercial production starts from late 2026 to 2028. The projects vary in capacity from 40,000 to 220,000 tpa waste feedstock. The first of these projects being a FOAK 'HPAG to recharging station facility', funded by a large multi-national client and having the involvement of a global truck OEM and retailer. Siemens has a global collaboration arrangement in place with Boson Energy to advance HPAG, with a particular focus on German facilities to assist in Germany's desire to transition away from fossil fuels to hydrogen.

We anticipate that our first Australian project to advance this circular economy eco-system will be in Gippsland, Victoria with pre-approvals work now underway and study work to commence following allocation of waste processing licences by Recycling Victoria.

To date, we have engaged with various NSW government departments and many regional councils about ways to simplify their waste management cycles, reduce household rates costs, create regional jobs and transition to be Climate Positive Councils providing an enhanced service offering to the community.

Considering the global trend towards waste to hydrogen technologies that recycle/upcycle waste, the appropriate policy settings from the current Waste and Circular Infrastructure review provides an ideal platform to deliver many significant benefits to NSW residents and a lasting positive legacy for our children.

We would welcome the opportunity to meet to discuss how best to action and accelerate NSW to lead in the global circular economy transition.

Best regards

Craig Allen

Director

[redacted]

[redacted]

Appendix A – Innovation Solving Australia's Unique Net Zero Challenge

Please refer to the attached Xseed Solutions article published earlier this year.

Appendix B - NSW E-mobility Clean Energy Sustainability Fund (the Fund)

Recommendation 1: We recommend the NSW Government establish the Fund to stimulate the development of and co-ownership with local governments and businesses of up to 18 Sustainability Precincts across NSW. The Fund would be a complementary e-mobility focused funding extension of the NSW Government's Energy Security Corporation that is focused on NSW investments in stationary renewable energy.

To provide Zero Waste outcomes for NSW, the Fund would develop Precinct capacity across the State to initially upcycle the 2.0 million tpa of Municipal Solid Waste (MSW) with capacity to manufacture up to 200 million kg of Grade A+ hydrogen and/or low carbon methanol.

The Precincts could be extended, or new Precincts developed, fully funded by the private sector to upcycle the NSW EPA's reported 1.4 million tpa of Commercial & Industrial (C&I) waste present in garbage bags currently disposed of to landfill. As identified in the *NSW Waste and Sustainable Materials Strategy 2041*, we would encourage the NSW Government consider enhancing complementary recycling programs to encourage further recycling as detailed below. Sustainable fuels including hydrogen, methanol and Sustainable Aviation Fuels (SAF) would be manufactured to decarbonise the road, rail, ship and air transport sectors.

The establishment of Precinct capacity to achieve the NSW Department of Planning, Industry and Environment's targets to divert 80% of MSW and C&I from landfill by 2030 would require the upcycling of around 1,400,000 tpa of MSW and 1,500,000 tpa C&I by 2030. Considering that 25% of these feedstock streams are potentially recyclable, this provides a capacity target of 2,200,000 tpa of resource upcycling demand. Delivering that would provide a manufacturing output of around 220 million kg of hydrogen by 2030. [redacted]

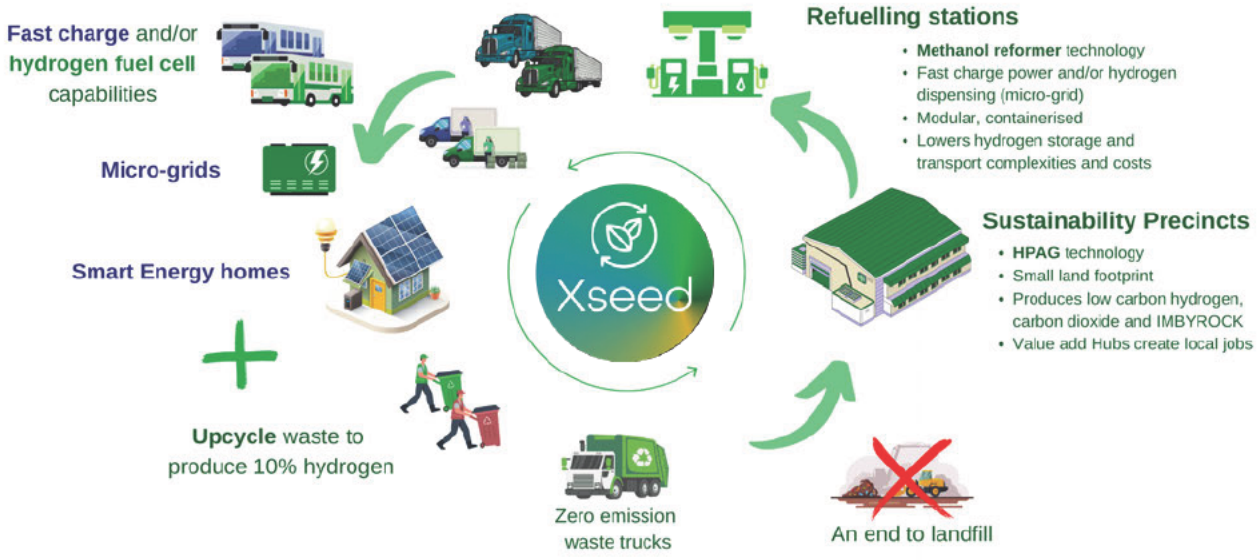


Figure 1 – Sustainability Precincts ecosystem – Zero waste, real zero emissions

General Framework

We estimate that $285 million of the $940 million in projected NSW waste levy collections is from MSW currently disposed of to landfill. In general terms we recommend the 18 Precincts are funded and owned by way of Public-Private Consortiums with the:

1. **NSW Government** coordinating and leading the Precincts' development with the Fund established with the objectives to:
    a. **Foundational funding** - In 2026, NSW Government to provide $500 million in foundational Precinct funding capacity to the Fund that in turn offers Precinct funding capable to then be matched 2:1 by participating local councils.
    b. **Waste levy (MSW)** - Thereafter, NSW waste levy receipts from MSW disposed of to landfill by local councils are received by the Fund,
    c. **Precinct funding** - The Fund anchors Precinct development funding through:
        i. 25% ownership of each Precinct's equity, plus

ii. 25% via 10-year in amortising Sustainability Loans.

d. **Annuity returns** - Equity distributions, loan interest received, and loan repayments enables the Fund to support other NSW recycling and sustainability programs over the longer term.

e. **Alignment** - Coordinate NSW Government departments and NSW GOCs to:
   i. Secure offtake demand for say 20% of total Precinct production by procuring hydrogen and methanol products by departments transitioning to zero emission vehicle fleets including: Transport for NSW, NSW Ambulance and others with vehicle fleet control,
   ii. direct its corporate waste to Precincts, to reduce NSW Government's Scope 3 emissions, and
   iii. update procurement policies to encourage and support the local buying of products and value chain supplier support and decarbonisation.

2. **Local councils** be encouraged to lower waste management costs for its residents leading to cost of living relief. To do so, local councils be stimulated, at its' option, to co-own and fund between 26% and 51% of the local or regional Precinct's equity funding. To ensure further alignment, local councils be encouraged to consider to:
   a. Operate the Precincts,
   b. Identify local buying opportunities to maximise local content for construction and operation,
   c. Direct council's corporate waste to the Precincts, and
   d. Adopt Climate Positive principles, local buying, procurement policy preferences, including secure offtakes of Precinct products.

   To the extent that the local council(s) elects to co-fund less than a 51% equity interest, businesses and infrastructure funds are offered the opportunity to increase its' equity ownership interest proportionately above the suggested target of 24% (see below).

3. **Businesses** and infrastructure funds to:
   a. Own a minimum 24% (and up to 49%) equity interest in the Precincts that have capacity to upcycle the local and regional MSW waste streams,
   b. Provide matched debt funding to the Precincts,
   c. Fully provide the incremental capital funding to expand or extend the Precinct network to accommodate upcycling of local and regional C&I waste streams, and
   d. Complementary policy changes to target NSW's already high emitting businesses to accelerate decarbonisation of waste and transport emissions (ie restaurants, food retailers, grocery stores, transport, agricultural businesses, etc).

Outcomes

From our discussions, councils are looking for funding assistance and policy leadership to transition to zero waste outcomes. For example, we see the NSW Hunter JO, Western Sydney and Albury regional councils the most progressive-thinking regional councils positioned to commence this program. Coffs Harbour and Northen NSW are also ideal locations to provide green highway corridors for NSW's main road transport routes.

Residents are encouraged to reduce, reuse and recycle their waste to ensure the minimum Precinct capacity size is developed. Precincts are distributed across NSW and developed locally to minimise waste transport costs. In this way, with community awareness and engagement programs, this minimises the frequent community concern that some towns are the recipient of other communities' inaction to reduce waste volumes.

We have modelled a phased development indicative using the following milestones:

- 2027 – an initial 40,000 tpa capacity Precinct,
- 2030 – increased to 1.4 million tpa capacity across 9 key Precincts, and
- 2032 – increased to 2.0 million tpa capacity across 18 Precincts.

1. **NSW Budget:** We have completed some illustrative modelling of the Fund and the capacity to deliver the General Framework outlined. We would suggest that this desktop modelling could need to be refined in collaboration with the NSW Government and other stakeholders. In summary, the Fund's projected financial impacts are:
   a. **Fund cashflows** - In 2026 receive foundational funding of $500 million. Thereafter, reallocate to the Fund the NSW waste levy receivable attributable to MSW. In this way, the impact of declining

waste levy collections is offset by the transition to equity and loan returns from the Precincts co-owned,

b. **Zero Emission Vehicle (ZEV) subsidies:** To facilitate offtake product demand we recommend the Precincts provide initial subsidies for business trucks and prime movers purchases from the expected HPTI entitlement (ie $2 / kg hydrogen) arising for ZEV owners for hydrogen purchased for at least for the first 5 years of vehicle ownership.

2. **Federal Hydrogen Funding:** Subject to final rules, hydrogen manufactured should be eligible for the $2 per kg hydrogen HPTI for Precincts built and committed before 2030. [redacted] We recommend the Fund provide this to accelerate value chain markets for mobility decarbonisation for:
   a. **Transport for NSW** – offset the higher comparable costs of new Battery Electric (BEV) or Hydrogen Fuel Cell bus vehicles (HFCV). This enables:
      i. A 100% green bus fleet by 2032 with BEV and HFCV flexibility, and
      ii. Growth for local manufacturing with hydrogen storage and hydrogen fuel cells stimulating NSW jobs and indirect businesses,
   b. **NSW Fleet and NSW Ambulances** – offset the higher switching costs to ZEV. Also, micro-grid and energy storage for NSW hospitals, First Nations and agriculture to transition away from diesel generators.
   c. **Businesses** – An operating rebate of [redacted] per kg of hydrogen purchased for the first five years to those organisations acquiring ZEV NSW trucks and buses as part of "Sub.Zero as a Service" NSW refuelling/recharging package. [redacted]
3. **Jobs and businesses** – We project over 2,900 new direct jobs across the NSW eco-system would be created. The Precinct production elevates the demand for ZEV manufactured from these bases. The eco-system stimulates ongoing and higher demand for Australia wide ZEV. This encourages the:
   a. attraction of new Hydrogen to X businesses to NSW (ie hydrogen storage, hydrogen fuel cells, etc as part of value supply chain), and
   b. new and greater regional Chemicals, Agriculture and Composite Materials Hubs to manufacture methanol, ammonia, SAF and other low carbon products.
4. **Zero Waste outcomes** – We would suggest targeting household zero waste outcomes by 2033 and businesses by 2040. Our desktop projections show sufficient hydrogen is capable to be manufactured in NSW from MSW and C&I garbage bags to transition around 40% of NSW's existing truck and bus fleets to ZEV, as either battery electric or hydrogen fuel cell electric. Additional manufacturing capacity increases could then extend capacity into methanol as a sustainable fuel for rail, shipping or SAF production.

Based on the above, an illustrative summary of the Fund cashflows and balance is shown below. If these milestones are achieved as planned, it is recommended that post 2033 Fund investments be made in new renewable energy infrastructure facilities and growing additional methanol manufacturing to extend the benefits to more vehicles and into other transport sectors.

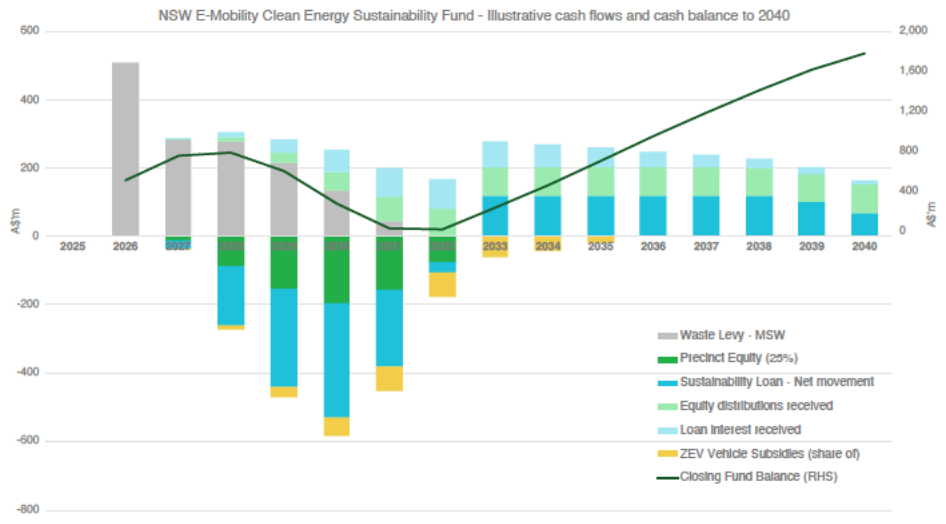


Figure 2 – Illustrative NSW Fund cashflows and balance to 2040 – pathway to Zero Waste

Additional complementary recycling programs

From our review of the publicly available NSW material, we would recommend several complementary recycling activities and initiatives are implemented including:

1. **Paper and cardboard** – The EPA reports that around 400,000 tpa of C&I paper and cardboard waste is not currently recycled. Consider as part of the NSW infrastructure Plan:
    a. Co-siting paper recycling as part the residual waste upcycling facilities. The work we have done to date on a potential Queensland site demonstrates significant synergies in energy, heat, waste, and water savings and reuse, mitigating virgin material use,
2. **Glass and Plastics** – Extend the current 'Return and Earn' program to capture more MSW and C&I glass and plastics and the reported 54,000 tpa of glass in C&I waste:
    a. Increase the bottle return rate to say $0.15 per bottle,
    b. Increase the extent of glass and plastics containers accepted (ie akin to the recent changes in Queensland's 'Containers for Change' program), and
    c. Encourage participation from communities, schools and families as a way of recycling,
3. **E-waste** – Establish formal e-waste collection programs with businesses to recycle the 34,000 tpa of e-waste currently not recycled by businesses.

Longer term biodiversity, environmental and economic benefits

- 5.5 times more hydrogen volumes from waste are manufactured per renewable energy MWh inputs than from electrolysis hydrogen using water.
    - As part of actioning NSW's renewable fuels strategy, lower input energy demand **saves at least $6 billion in extra solar/wind infrastructure costs** and mitigates the quarantining of additional land for renewables as compared to an alternative 100% electrolysis hydrogen pathway.
- Lower energy inputs assist to contribute lowering hydrogen's LCOH. [redacted] This is significantly lower than CSIRO estimated for electrolysis hydrogen at $6.78 to $15.60 per kg hydrogen.
- Utilising methanol and expanding its use reduces and flattens the CSIRO transport costs of hydrogen from $1.50 and $3.00 per kg hydrogen, to between $1.00 and $1.20 per kg hydrogen. More affordable hydrogen retail pricing outcomes are thus possible for regional NSW.
- Localised production Precincts encourage local distributed and rooftop energy networks and micro-grids. **Provides extra financial support to households that install solar at home.**
- Low water usage **mitigates additional water stressors for the agricultural sector.**
- Largely biogenic CO_2 manufactured provides a resource to **stimulate the NSW renewable fuels sectors** for methanol (shipping) and Sustainable Aviation Fuels (SAF) (aircrafts).
- **Enabler for agricultural and regional NSW** to utilise existing infrastructure for methanol storage and use to produce hydrogen and DC power at homesteads and with First Nations micro-grids.

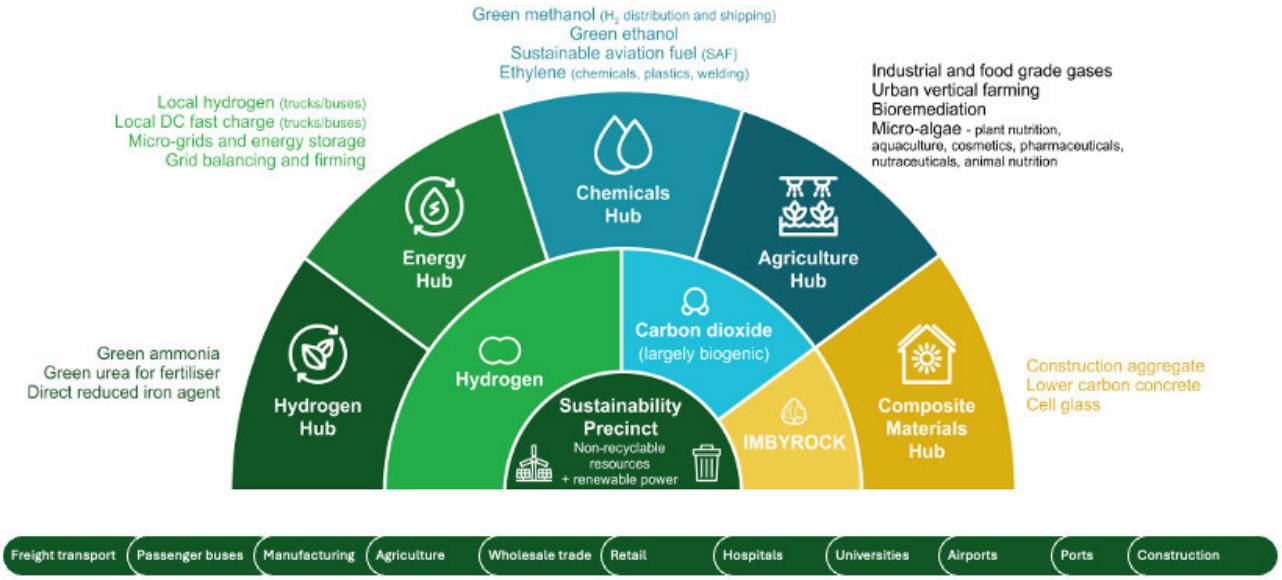


Figure 3 – Sustainability Precincts – Zero Waste, three primary Sub.Zero products with diverse revenue pathways

Appendix C – NSW Waste Infrastructure Roadmap

Energy is produced remotely and needed locally... Waste is produced locally and treated remotely...

Our solution addresses this paradigm; by actioning several policies and strategies currently being considered by the NSW Government including:

- **Circular economy** solutions are needed to be actioned today for organic and biogenic regeneration,
- **Landfill waste** creates harmful GHG methane and CO_2, consumes valuable land, underutilises resources,
- **Local infrastructure** for Zero Emission Vehicle (ZEV) refuelling at low cost, is required to facilitate higher acceptance of ZEV transport,
- **Grade A+ hydrogen** from electrolysis consumes scarce land and water resources and requires complex transportation, and
- **Transport** by long haul road, ship and air needs readily available low carbon fuel enables to transition from fossil fuel use.

Based on the publicly available information we have modelled an illustrative integrated network of Sustainability Precincts considering:

- Scalable and phased development program enabling funds to be directed to Precinct development rather than landfill expansions,
- Multi-phased developments lowering execution and transition risks,
- Encouraging reduce, reuse and recycle initiatives to reduce overall waste feedstock volumes to be upcycled,
- Yielding higher economic and environmental outcomes from upcycling FOGO, as opposed to composting and mitigating contamination risks associated with feedstock and land disbursement,
- Adjacency of Precincts to:
    - Lower transport costs and GHG emissions from longer distance transport of waste feedstock,
    - Match community feedstock volumes with Precinct capacity,
    - Heavy vehicle transport routes, depots and logistics centres for nearby refuelling,
- Repurposing of existing landfill, resource recovery and related waste management sites as Precincts,
- Ready access to Sydney's M1, M2, M5, and M7 ring roads for accessible inwards deliveries and refuelling access by heavy vehicles, and
- Establishment of NSW Green Corridors to heavy vehicle transport across the state.

Land footprints for the upcycling Precincts are envisaged at up to 6,000 m^2 each (i.e. typically less than the size of a Bunnings store), with fully enclosed building and necessary areas required for FC-HRS stations. In locations where additional adjacent land may be more readily available, complementary methanol or paper recycling facilities are suggested.

On this basis, we have modelled the outcome for:

- 7 Precincts in the Sydney region, such that Precincts are within 5 to 15 km of where waste is generated (Figure 5), and
- 11 additional Precincts across NSW (Figure 6).

Illustrative Case Study – Western Sydney

The opening of the Western Sydney airport and numerous other logistics and distribution centres in the area is setting a foundation for one of Australia's highest carbon intensive regions for Australians to live. The region has 18% of NSW's registered heavy vehicles and waste, emitting 18% of the state's GHG emissions. Affordable, localised, low carbon solutions in the region leverage the existing infrastructure and benefit the region economically and environmentally.

In planning for that, Global Drive to Zero (GDTZ) reports that Australia currently has 17 models from 5 OEMs across the heavy vehicle market. This is to be contrasted with over 200 models in all other regions in the world. Our recommendations incorporate the learnings and advancements in other regions. GBTZ outlines a six stage strategy to enable 100% zero emission medium and heavy vehicles (ZE-MHDV) in new markets by 2040 (and 30% by 2030):

- **Establish beachheads** - launch various ZE-MHDV models,
- **Secure policy alignment** - aligned and ambitious policies,
- **Launch long haul** - Establish priority zero emission long haul corridors by 2025,
- **Saturate cities** - Reach 100% sales in cities by 2030,
- **Build backbone** - Build priority green freight corridors by 2030, and
- **Complete network** - National networks in place by 2035, complete 2040.

Figure 4 – Illustrative pathway for the adaption of zero emission vehicles and infrastructure

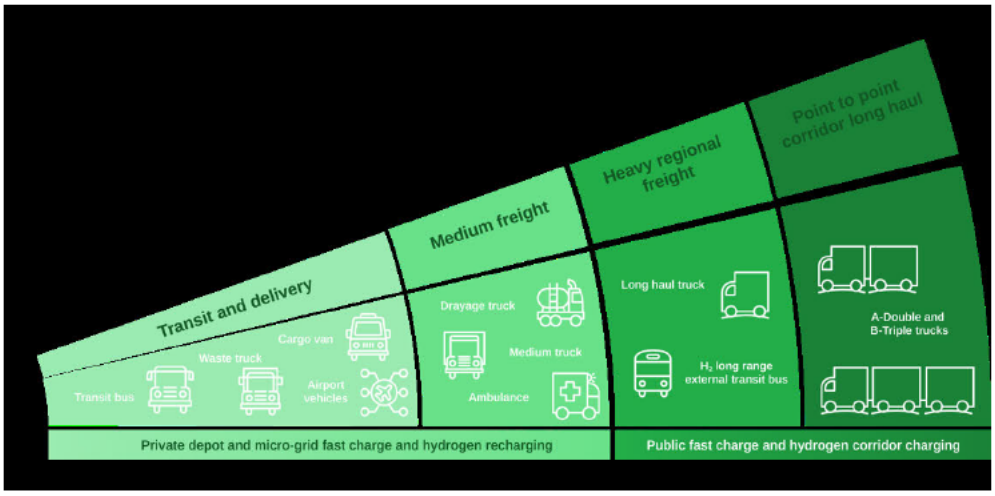


Figure 5 – Illustrative Sydney Sustainability Precinct integrated network – capacity target 1.5 million tpa waste

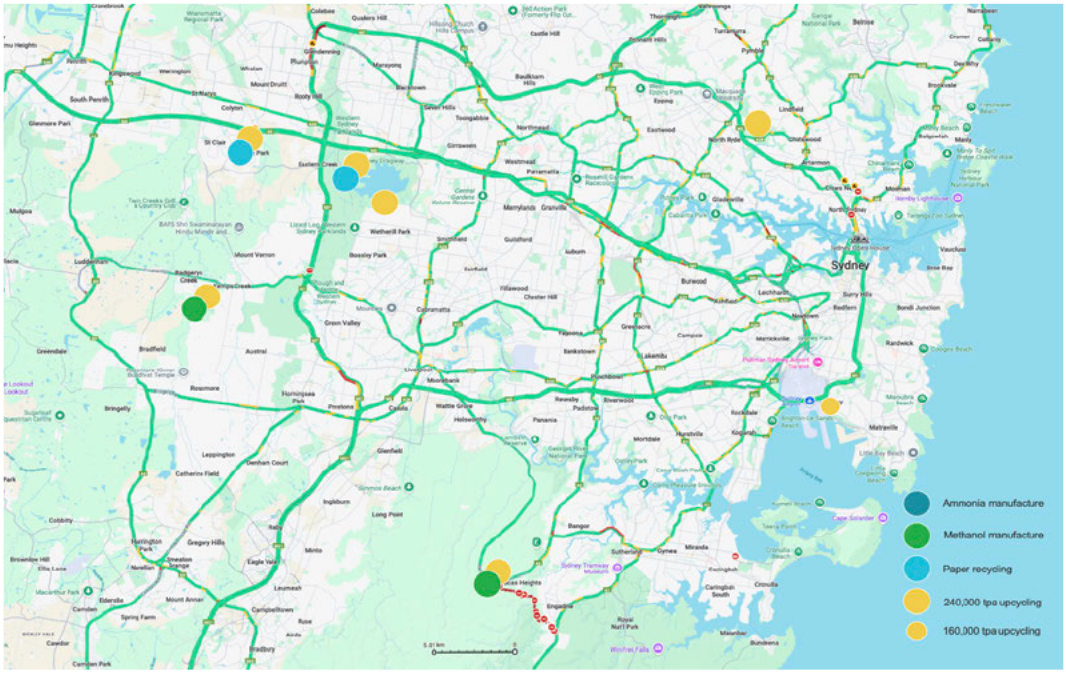
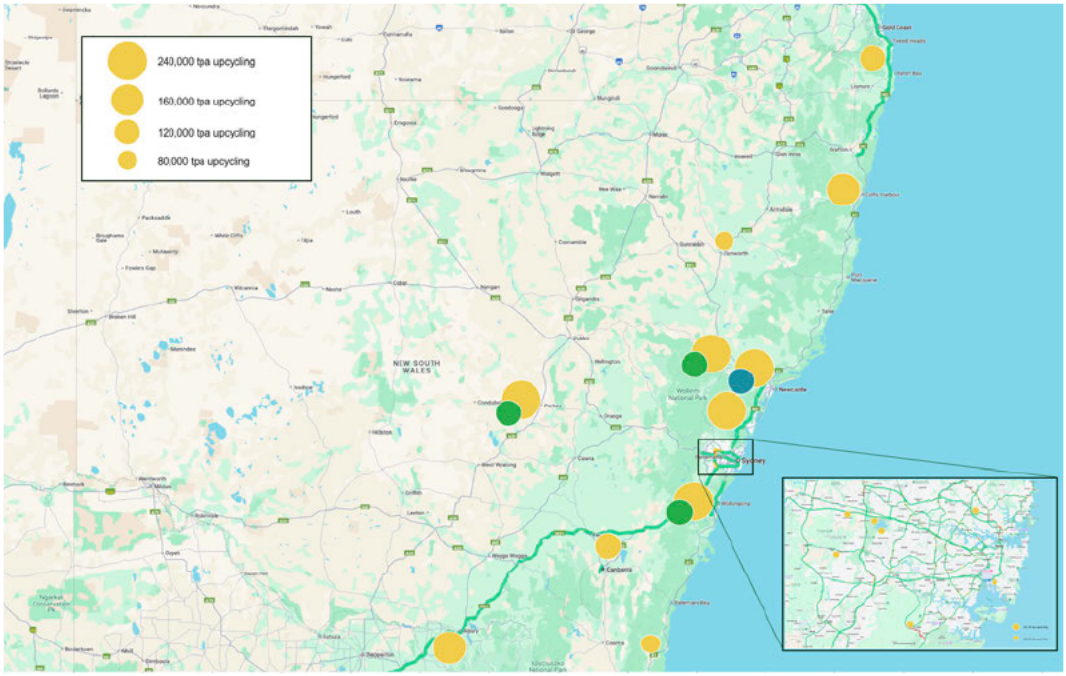


Figure 6 – Illustrative NSW Sustainability Precinct integrated network – capacity target 1.9 million tpa waste



Appendix D – NSW Waste Infrastructure Plan

We provided 11 key recommendations to the Federal Productivity Commission's (Federal PC) recent review of the circular economy. To validate the enhanced outcomes for NSW productivity, we suggest aspects of these recommendations, the draft Plan and strategy be referred to the NSW Productivity Commission for review.

In our submission to that Federal PC review we demonstrated and provided an outline of Xseed Solution's actionable strategy for Australia from the circular economy. All targeted to enable a $49+ billion per annum domestic Waste to Hydrogen to X circular economy creating an extra 14,000 Grade A+ hydrogen manufacturing jobs, plus further value chain roles. Delivering a 12% reduction in Australia's CO_2e emissions across multiple initiatives in the hard-to-abate sectors of waste, road transport, agriculture, manufacturing, and healthcare.

Improving NSW's Waste Strategy 2041 outcomes

Since 2017, NSW's average Greenhouse Gas (GHG) emissions from waste and diesel emissions have increased by 24% and 16% respectively. This is counterintuitive to NSW's current Net Zero Plan.

In prioritising NSW's ambitions, section 3 of the NSW *Waste Avoidance Resource and Recovery Act 2001* (WARR Act) provides several objectives including *"to encourage the most efficient use of resources and to reduce environmental harm in accordance with the principles of ecologically sustainable development".*

South Australia actively reports GHG from different waste streams. In Figure 7, we consolidated that data and overlaid the opportunity that upcycling waste to hydrogen represents as part of updating its waste management strategy, clearly demonstrating that significantly improved economic and environmental outcomes are achieved:

1. Over the current multi-faceted 'traditional recycling' outcomes,
2. Upcycling FOGO to low carbon fuels rather than composting environmentally and economically,
3. Upcycling MSW to hydrogen and low carbon fuels can materially reduce waste and diesel GHG emissions.

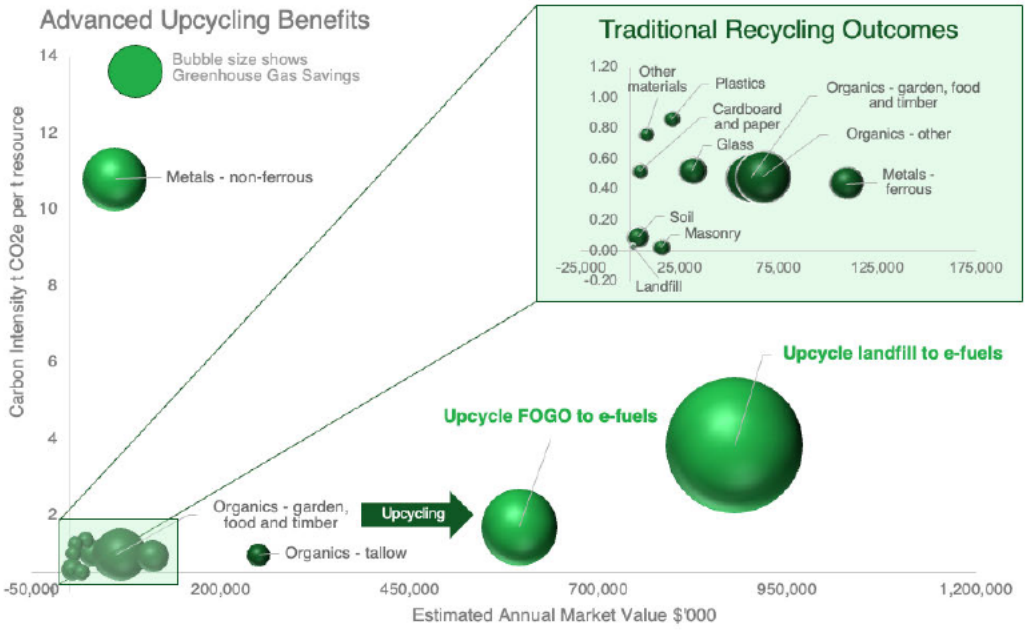


Figure 7 – South Australia's benefits from upcycling residual waste to low carbon fuels

Recommendation 2: We recommend that the NSW Waste and Circular Infrastructure Plan can achieve better circular economy measures and outcomes by implementing actions that:

1. **Stimulate end markets** through a E-Mobility Clean Energy Sustainability Fund (as outlined in Appendix B),
2. **Provide foundational funding support** to leverage NSW's existing manufacturing presence and resources. This would accelerate and range of benefits through the co-investing in Precincts to advance innovation across sustainable fuels in the upcycling of MSW, C&I and FOGO into low carbon fuels (i.e. hydrogen, methanol, ammonia, and SAF),
3. **Keep the goal simple, yet clear.** A clear Zero Waste goal by 2040, together with a NSW upcycling and green corridor infrastructure network, akin to Article 6 of the EU Alternative Fuels Infrastructure Regulation (AFIR) developed as part of the EU TEN-T program. This provides a tangible overseas

example which can be adopted in progressing a clear strategy for NSW's e-mobility pathways to realise economic value from waste that is currently buried in the ground,

4. **Modernise and enhance** NSW's *Energy from Waste Infrastructure Plan* as detailed below to:
    - Ensure that Life Cycle Assessment for facilities are reflective of the NSW Government's declining 2050 renewable energy ambitions,
    - Ensure that facilities are established to capture and use at least 90% of the CO_2 produced and energy efficiency thresholds are assessed on consistent bases, incorporating that carbon capture and use technology,
    - Expand the thermal treatment exclusions to be less prescriptive, provided that the new guidelines have a clear environmental benefit for excluded technologies, consistent with the principles of: Recycling, Carbon capture and use, and the Circular economy, and
    - Enable innovation, manufacturing and lower emissions, so that the thermal treatment exclusion allows thermochemical recycling processes including pyrolysis, gasification and plasma gasification to deliver hydrogen or hydrogen derivative product(s). Energy carriers such as methanol offer efficient transfer and storage solutions, or as low carbon fuels for road transport, rail, shipping and aircraft vehicles.
5. **Tangible action to provide a better environment for our children** with respect to:
    - The inclusion of GHG, ie CO_2e, absolute and intensity metrics and outcomes of different solutions in waste policies, strategies and communications,
    - Embracing today's technology and all emerging technology to advance recycling, including distinguishing waste recycling and recovery related manufacturing technologies based on multiplicity of end uses, process energy efficiencies, carbon intensity outcomes, and biodiversity impacts, and
    - The harmonisation of waste hierarchy concepts by reference scientific outcomes and vertical and horizontal policy harmonisation.
6. **Enable more 'green pathways' and less 'red tape'** with the alignment of NSW Government policies and regulations to optimise costs across waste, energy, climate change, sustainable fuels, transport, and procurement.
7. **Modernise of the NSW procurement policy** with respect to waste, transport and value chain emissions to be expressed to encourage and support private business and supplier climate transition.

Illustrative Case Study

NSW reports that currently 3,400,000 tpa MSW and C&I garbage bags are disposed of to landfill. We estimate that this 'waste' volume to landfill of is sufficient to manufacture 340,000 tpa Grade A+ green hydrogen using HPAG. Using HPAG, this hydrogen (from waste) volume is around five and half (5.5) times more than is capable to be manufactured using the equivalent renewable power sources to produce hydrogen from water.

On the basis that 1 kg of hydrogen is equivalent to 5.4 litres of diesel used in heavy road transport, this provides a NSW manufactured substitute avoiding the importation of 1.8 billion litres of diesel equating to a retail market value of $3.6 billion (i.e. at $2.00 per lt diesel).

That is, turning a reported $1.7 billion annual landfill waste management cost into a $3.6 billion resource value driver for NSW residents. A notional productivity gain of $5.3 billion annually for NSW.

In terms of end market use opportunities, as a minimum, this production volume provides sufficient product to refuel or recharge 40% of NSW's 148,000 registered diesel prime movers, trucks and buses as zero emission vehicles.

As an eco-system, the avoidance of landfill methane combined with avoided diesel emissions reduces NSW CO_2 emissions by 11.5 million tpa CO_2e, a 10% reduction against reported 2022 GHG emissions. This reduction target is likely higher today, given the continued growth in waste and diesel GHG emissions since 2022.

The low carbon content CO_2 product, captured through the HPAG process, is also capable to be used as an input when combined with electrolytic hydrogen production to manufacture an extra 2.7 million tpa of low carbon methanol. With the foundations in place, this provides a basis for a further annual market revenue potential of up to $5.6 billion annually, this extra low carbon product volume is capable to further progress to net zero to decarbonise:

- Additional heavy vehicles through the established NSW network,
- NSW's agricultural and mining off-road vehicles as zero emission vehicles,
- NSW's pastoral and agricultural homesteads with long term energy storage and supply,
- Rail, ships, and ferries used, as well those rail and ships importing and exporting NSW goods, or
- Aircraft with Sustainable Aviation Fuel (SAF) production to decarbonise airlines CO_2e emissions.

This cumulative minimum $9.2 billion per year recycling opportunity is additive to the current NSW's current recycling revenues. Importantly as the approach avoids CO_2e emissions from waste and hard to abate transport sectors the cumulative CO_2e reductions upwards of 10% of NSW's currently reported emissions.

Recommendation 3: Aligned with the WARR Act objectives, we recommend that clearer actions and objectives are expressed in the Waste and Circular Infrastructure, Renewable Fuels, Net Zero and other associated NSW Government actions and plans with respect to those objectives. For example, the NSW Government has barriers to optimising the strategy outcomes from:

- A higher order, enhanced circular economy use, for organics,
- The lack of clear, actionable initiatives towards net zero in non-stationary energy sectors like waste and transport, and
- Procurement policies that don't readily enable state and local governments to reduce costs, create investment, and encourage innovation to enable broader circular economy outcomes.

To date, our experience has been that the lack of clarity and ambiguity in these objectives across and within the NSW Government and NSW local councils significantly deters action. This includes the ability to action and achieve progress consistent with the WARR Act's objectives with respect to the circular economy, polluter pays, user pays, proximity and product stewardship principles.

NSW's current waste and recycling targets are ineffective given the absence of tangible action, misalignment between state and local governments on outcomes, siloed decision making, the lack of targeted investments to deliver the outcomes, and a lack of policy or strategy to encourage end markets and demand for recycled products. In this regard, we note that over the last few years NSW local councils have been provided funding from the *Waste Less, Recycle More* program and at the same time NSW CO_2e waste emissions continue to increase, with recycling levels and waste diversion targets relatively unchanged.

Recommendation 4: With NSW currently reporting 48.6% and 51.4% outcomes from the diversion of MSW and C&I waste streams respectively from landfill, we consider that the 2030 waste diversion targets of 80% are achievable if action is taken now. We recommend the 2030 targets remain, but with definitive action on how they will be achieved. In 'waste to hydrogen' terms to achieve this target it translates into targeted recycling and manufacturing 220,000 tpa of hydrogen from MSW or C&I waste by 2030. Illustratively, such production can recharge or refuel towards 40% of NSW trucks and buses largely on a micro-grid basis, mitigating the high costs associated with extensive grid upgrades to deliver renewable energy to recharging stations or depots. With that 2030 baseline maintained and achieved we consider that:

- a 95% recycling target for each should be set for 2035, and
- a zero waste economy target be set for 2040.

In that regard, priority recycled products and materials should be assessed having regard to circular economy value uplift and its climate GHG impact if not recycled or upcycled. Figure 7 provides an overview of those potential priority products and materials, with that further detailed below in Figure 8 as an example for South Australia's waste by GHG savings and carbon intensity impacts:

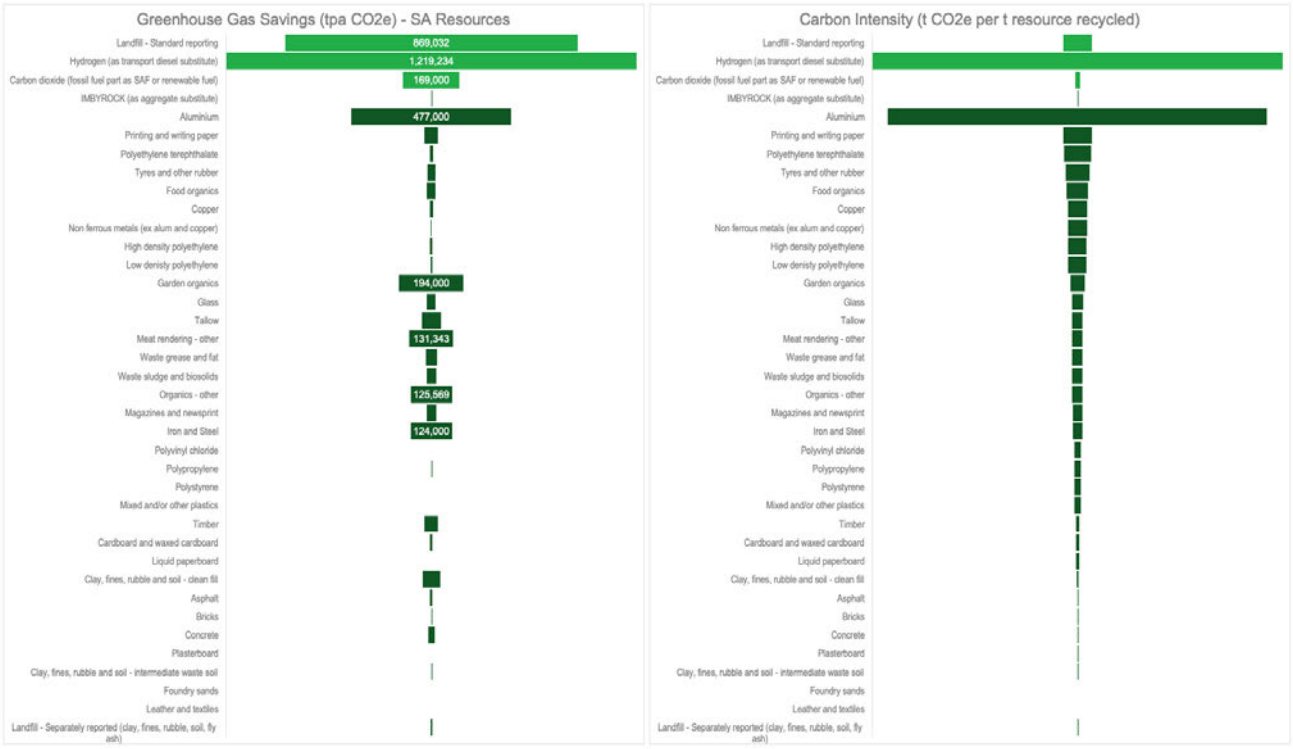


Figure 8 – South Australia's benefits from upcycling residual waste to low carbon fuels

As such, the highest priority waste outcomes would be tangible action plans for the localised recycling of the current MSW, C&I, FOGO, paper and metals waste streams. For the Fund and its' actions to be successful, we recommend that pre-planning and communication strategies occur to address the current barriers the recycling industry experiences to establishing technologies to recycle waste streams as:

- An unwillingness for local councils to engage on establishing alternative technologies,
- Short term focus by local councils on capital costs as opposed to the longer-term outcomes to delivery of cost of living relief to residents, environmental protection, emissions reductions and circular economy protection outcomes consistent with the WARR Act,
- A reluctance by governments and business to engage to establish end markets for recycled products,
- Uncertainty from businesses to invest in recycling or upcycling given the absence of government policy and strategies and without subsidies or government support, and
- Limited actions by governments to progress circular economy and/or net zero plans and strategies.

Recommendation 5: We recommend that the NSW Government, together with other States, work together for a harmonised, consistent framework and set of principles across each of the three impactful areas of productivity gains, circular economy and net zero.

Our current experience is that all States have different waste, transport, energy, environmental, hydrogen, and climate laws and regulations. These differing laws make delivering a consistent upcycling pathway in Australia difficult, complex and time consuming to try and accommodate each of the differing laws.

The Commonwealth Government and Productivity Commission have recently published a Circular Economy Strategy, Waste Management Strategy and Productivity Gain recommendations for Australia.

From a state perspective, we believe the current NSW regulations and principles with respect to mitigating GHG emissions for new projects together with the refined end of waste criteria applying to waste streams should be extended nationally.

Recommendation 6: Ensure that Life Cycle Assessment for facilities are reflective of the NSW Government's declining renewable energy into 2050 ambitions. That is, the greenhouse gas replacement benefit of incinerators that propose to provide grid energy is calculated as reflective of a projected lowering carbon intensity per MWh outcome as published by the NSW Government.

Current practices in the UK and the EU's Best Available Technologies (BAT) are that thermal processes are required to be energy efficient and capture and use at least 90% of the CO_2 produced from waste.

Recommendation 7: Ensure that facilities are capture and use at least 90% of the CO_2 produced and energy efficiency thresholds are assessed incorporating that carbon capture and use technology,

In this submission, we have provided numerous examples of higher value recycling outcomes, yet despite the NSW Chief Scientists recognition of positive benefits of plasma gasification, its use is curtailed in NSW. We request that the NSW Environmental Protection Agency, modernises the *Energy from Waste Infrastructure Plan* (EfW Plan) aligning it with the NSW Greenhouse Gas Emission regulations and in so doing, to draw the distinction between thermal processes for **electron** energy recovery activities and thermal processes for hydrogen or other **molecular** recycling activities. The latter being essential to provide decarbonisation solutions in hard to abate sectors like road, rail, ship and air transport.

Recommendation 8: Expand the thermal treatment exclusions in the EfW Plan to be less prescriptive, provided that the new guidelines have a clear environmental benefit consistent with the principles of:

1. **Recycling** – Exclusions do not restrict thermal processes that 'recycle' waste (as an end of waste solution) to produce 'like for like' products or new inputs for those products,
2. **Carbon capture and use** – Ensure that facilities are maintaining alignment with emerging EU Best Available Technology outcomes of energy efficiency (inclusion of carbon capture equipment use) and the technology or project captures and use at least 90% of the CO_2 produced, and
3. **Circular economy** – Encourage highest value reuse and recycling both environmentally and economically. Instil a principle in the various NSW regulations of a framework that prioritises highest carbon intensity reductions per ton waste recycled.

Recommendation 9: We request to enable innovation, manufacturing and lower emissions, that the thermal treatment exclusion allows thermal recycling processes including pyrolysis, gasification and plasma gasification that manufactures hydrogen or hydrogen derivative product(s) that can be used as an energy carrier, for energy storage, or as low carbon fuels for road transport, shipping and aircraft vehicles.

Appendix E – Hydrogen capable Plasma Assisted Gasification (HPAG)

Hydrogen is the most abundant chemical substance, constituting roughly 75% of all normal matter. It is colourless, odourless, tasteless, non-toxic, and highly combustible.

Photosynthesis gives us cheap hydrogen. Photosynthesis uses sunlight and CO_2 to "crack" the strong hydrogen-oxygen bond in water and produce the oxygen we breath. The "leftovers" are stored as hydrocarbons in plants, that in the end make up most of our non-recyclable waste.

Energy systems are evolving globally driven to achieving CO_2e reduction targets, increasingly embracing hydrogen as part of the reduction solutions. Coupled with that are actions to maximise the circular economy principles that are seen as a key pillar to achieve many of these reduction targets.

The simple objective of the circular economy is to maintain resources at their highest possible value for the longest possible time. Pre-dating the "circular economy", was the concept of the "linear economy". The simple notion that we all "take, make, consume and waste". This linear notion of waste was further extended with the waste hierarchy concept that prioritised waste management into the famous 3 Rs "reduce, reuse, and recycle" before "recovery" was added as a last resort before the disposal of waste to landfill.

The emergence of overlapping principles has led to many government policies addressing the crowded "recycle and recovery" phases. Limited distinction is drawn in that arena between technologies and processes suitable for technical resource recovery, vs those suitable for biological resource recovery. In so doing policies and rules can often ignore the various innovative, and emerging biological, chemical, mechanical, and thermal recycling and recovery processes that will occur.

The confusion also extends to electrolysis, where significant energy is applied to extract the 11% hydrogen content of water, itself a scarce resource and required in large volumes to produce electrolysis hydrogen. This is to the detriment of technologies that extract the 10% content of hydrogen from otherwise non-recyclable waste. The confusion is also easiest to illustrate with the simple burning of waste, or "incineration", that was remarketed in Australia as "waste to energy". In so doing, we have lost sight of the four vastly different processes, technologies, and outcomes that these different processes encompass:

- **combustion**, the burning of resources with oxygen at between 800 and 1,450°C creating toxins and ash. In the EU, the combustion process is used in 99.5% of all incinerators;
- **pyrolysis**, the thermal degradation of organic materials in the absence of oxygen at between 250 to 700°C;
- **gasification,** those thermal-chemical processes at between 500 and 1,600°C used to recover the chemical value of the resource; and
- **plasma,** a physics process where ionized substances becomes highly electrically conductive. Utilising extremely high temperatures (over 5,000°C) to break-down hazardous contaminants such as PCBs, dioxins, furans, and pesticides, into their atomic constituents. Highly efficient, the gases created are cleaned, with a vitrified residual slag created.

Refer to the EU Best Available Techniques (BAT) Waste Incineration for detailed guidance as to the technology differences.

New technologies more prevalent in the EU and the US built on the pyrolysis, gasification and plasma spectrum are leading to opportunities for integrated low carbon electricity and fuel systems, referred to as "Power-to-Hydrogen". Hydrogen's simplicity provides it with a multiplicity of uses, coining the term "Hydrogen to X" or “Power to X” in many markets. Very few, if any, Australian policies in the waste sector recognise the potential of this resource to be recovered environmentally and economically efficiently to provide low-cost green hydrogen. Rather, policies are currently anchored in the outdated waste to energy or combustion incineration technology.

HPAG as disruptive technology will replace combustion incineration

Increasing regulatory pressure on environmental performance (bottom ash and fly ash containing Per- and polyfluoroalkyl substances (PFAS) and Persistent Organic Pollutants (POPs), flue gas emissions of NOx, particulate matter, and other pollutants), high water footprint, low carbon emission outcomes and large capital expenditure requirements are seeing combustion incineration being replaced by newer technology. We support these changes made in a fully informed, measured and considered way.

After 40 years of development, **Hydrogen capable Plasma Assisted Gasification (HPAG)** processes have now emerged to produce two important molecules for the functioning and decarbonisation of our society, climate positive green hydrogen (H_2) and low carbon content carbon dioxide (CO_2).

Disruptive technologies significantly alter the ways that businesses, consumers, and industries operate. We envisage HPAG technology disrupting the combustion incineration sector given its preferential environmental, biodiversity and economic benefits.

Scalable, modular. Importantly, overcoming the shortcoming of incineration, the HPAG processes have been developed to be scalable, modular, process efficient and cost effective enabling environmentally safer localised developments (with lower transport costs and energy leakages). HPAG's small plant footprint (from less than 3,000 m^2), low environmental impacts and limited inter-dependencies provides maximum optionality for smaller regions and for locations nearby to resource recycling centres, landfills, power transmission and distribution infrastructure, existing pipelines, and transport routes.

Aligned with recycling and FOGO. The modular design approach to scale up the input supply also mitigates the need for contractual guarantees of large waste volumes. This avoids the needs for all encompassing lock-in waste feedstock contracts (and associated gap penalties) that operate counterintuitively to our aspirations to increase recycling targets and embracing emerging FOGO composting ambitions. All aimed to divert landfill waste and reduce carbon emissions.

90% lower emissions. The integrated HPAG pyrolysis, gasification and vitrification processes utilise plasma torches and generate extremely high temperatures, radically lowering the levels of emissions - up to 90% less in absolute terms and far below EU BREF standards that many combustion incineration plants struggle to meet.

No ash, with captured CO_2 emissions. HPAG processes produces no ash, in contrast to the 15 to 25% Incineration Bottom Ash (IBA) and 2 to 5% hazardous 'fly ash' (Air Pollution Control residue - APCr) produced by combustion incineration (weight being a percentage of initial waste treated). Incineration also emits large amounts of post-combustion CO_2 with its flue gas, as opposed to early-stage CO_2 that HPAG processes splits out from the syngas and are captured for downstream uses, e.g. creating low carbon methanol.

HPAG as an enabler for the circular economy is capable to promote and encourage development and facilitate significant public benefits from one or more of the following circular economy Sustainability Precincts:

- **Energy hub**, the Grade A+ hydrogen recovered as a gas is available for supply locally to be used in a variety of forms in other downstream activities or processes, including:
    - Diesel replacement in long haul transport, contributing towards reducing upwards of 8% of Australia's carbon emissions from this sector,
    - Fast charge power generation,
    - 24/7 365 day available local grid connected power generation;
- **Chemicals hub**, when recombined with the low carbon CO_2 produced it is an enabler for the downstream production of:
    - low carbon methanol for road and shipping transport, another high carbon emissions sector,
    - sustainable aviation fuel for airlines, being utilised to reduce jet fuel carbon emissions,
    - low carbon ammonia,
    - low carbon urea,
    - industrial grade green CO_2 as a replacement for other CO_2 production;
- **Agricultural hub**, when utilising the low carbon CO_2 and the residual heat for urban vertical farming, agricultural greenhouses reducing agricultural land usage, local protein production and food security; and/or
- **Composition Materials hub**, utilising the vitrified slag known as IMBYROCK from the HPAG process, that is also able to be further treated downstream to produce cell glass. IMBYROCK is available as a construction material substitute and cell glass is available as a cement substitute.