From: [redacted]
[redacted]
To: LCLF Consultation
Subject: Low Carbon Liquid Fuels Consultation
Attachments: [redacted]

[redacted] [redacted]

Good afternoon

The Government has a number of separate consultation processes occurring at present, with some overlaps.

Our recommendations to achieve a goal of a 12% reduction in Australia's GHG emissions and create a $50 billion local manufacturing industry are outlined in the attached.

In respect of this specific process and defining low carbon liquid fuels, we would recommend including methanol as a qualifying low carbon liquid fuel and effective carbon capture technology when hydrogen manufactured using technologies including HPAG.

Methanol is an effective energy carrier, with reformation technology being progressed in the EU to enable replacement of diesel generators and provide a pathway for hydrogen and fast charge power to be delivered across Australia, particularly regional Australia.

We attach three documents which cover a lot of the questions asked in this consultation process, and covered by previous submissions we have made.

We would be happy to answer any questions, should you have them.

Cheers

Craig

Regenerating resources to live locally

craig allen
director

mobile [redacted]
email [redacted]
web www.xseed.solutions

12 December 2023

Secretary Jim Betts
Department of Infrastructure, Transport, Regional Development, Communications and the Arts

haveyoursay@aff.gov.au

Dear Secretary Betts

Agriculture and Land Strategy Consultation Submission

We are writing in response to the invitation for consultation by the Australian Government's Department of Infrastructure, Transport, Regional Development, Communications, and the Arts ("Department") sectoral programs for the Agriculture and Land sectors as part of Australia's pathway to Net Zero.

This paper is provided in addition to:

1. The separate consultation response to be provided to the Department in relation to the Transport sector including a copy of Xseed's confidential Hydrogen for the Long Haul© strategy; and
2. The previous consultation responses to the Australian Government Department of Climate Change, Energy, and the Environment and Water, also including a copy of the Hydrogen for the Long Haul© strategy. We understand that this paper was distributed to the various State Governments for further consideration.

Appendix A provides additional detailed recommendation commentary. Appendix B provides an overview of Hydrogen capable Plasma Assisted Gasification and its versatile applications.

Our Recommendations

We are providing some specific recommendations in relation to the fuel and energy and circular economy and waste aspects of the Agricultural and Land sector consultation process to reduce CO_2e emissions by at least 0.8 million tpa CO_2e annually.

Our specific recommendations are to:

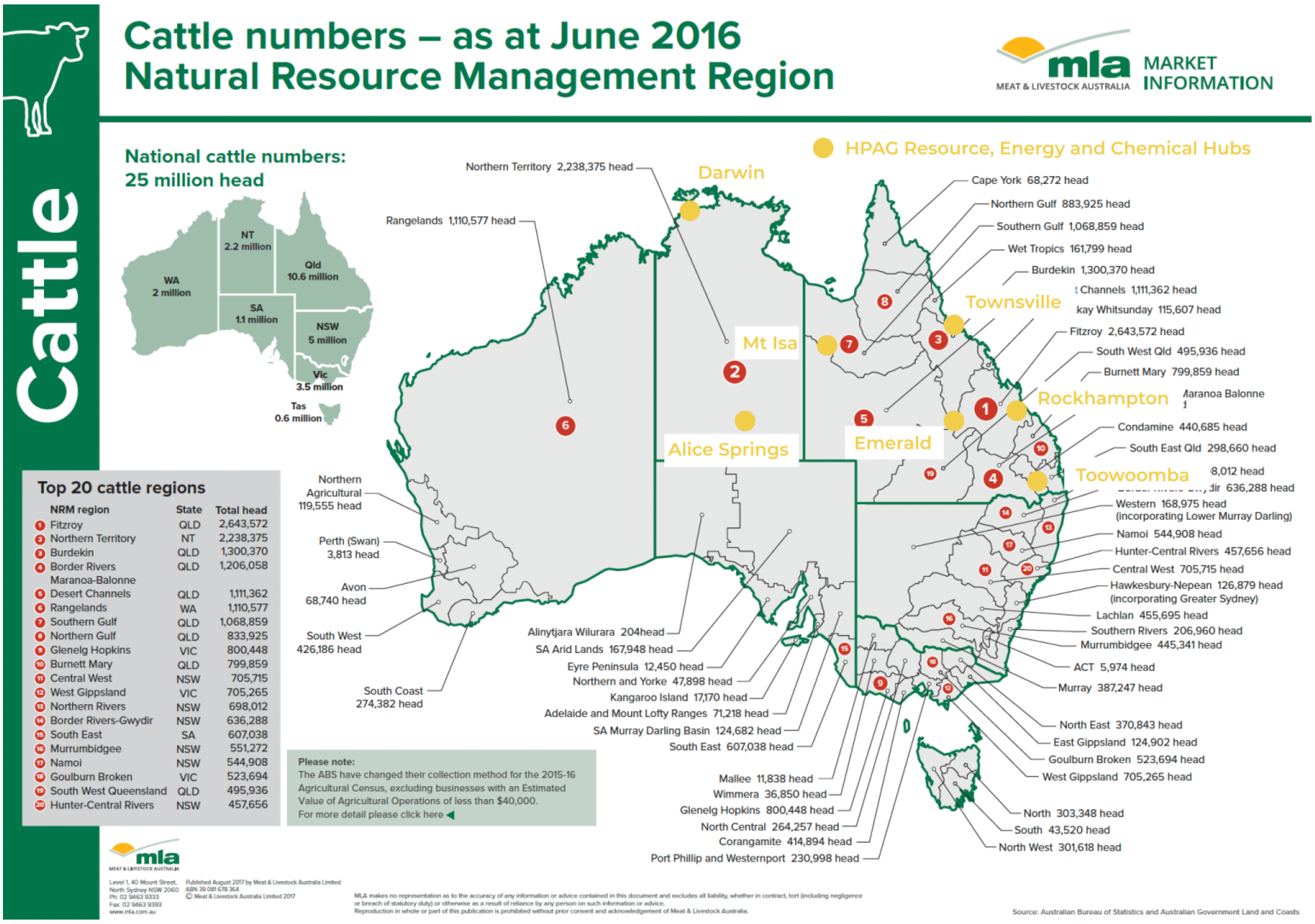
1. Enable a broader domestic based hydrogen strategy with the objective to accelerate the benefits of the strategy beyond encouraging export orientated electrolytic hydrogen being produced. Water is precious and a more efficient land use for solar/wind is encouraged.
2. Prioritise and streamline approvals processes for circular economy initiatives, like Waste to Hydrogen to X, across the three levels of government and the multiple government departments involved (ie climate, hydrogen, waste, transport, energy, circular economy, regional planning, etc).
3. Open up the ARENA funding opportunities to private and public hydrogen refueling infrastructure at scale, together with the downstream purchasing of zero emission vehicles.
4. Provide a $/kg subsidy to purchasers of hydrogen and fast charge power where the energy origin has a "well to gate" carbon intensity less than 2.0 kg CO_2e / kg hydrogen equivalent. This initiative should accompany a phasing out of the diesel fuel rebate.
5. Provide a 50% investment allowance to 2030 to purchasers of zero emission trucks and buses, phasing down by 10% every 2 years thereafter.
6. Expand the primary production immediate tax deduction regime to 2030 to include low carbon intensive stationary energy renewable power solutions for solar, wind, geo-thermal, hydrogen, methanol, etc.

Australia's Meat and Livestock Industry

Australia's 25 million head cattle industry operates across large areas of regional Australia. We understand that other industry submissions on land use, feed supplement and other initiatives have been made to encourage the reduction of CO_2e emissions across the agricultural industry. We are generally supportive of these initiatives and would specifically encourage an initiative program is adopted to manufacture Bovaer® or similar world scale proven supplement technologies in Australia. A facility with economies of scale for the Asia Pacific region and a subsidy to lower the cost of Bovaer® and other proven supplements to encourage greater use by the sector to reduce enteric fermentation methane emissions. Bovaer® in particular, is a supplement that is showing very encouraging signs to reduce methane from cattle and cows.

Focusing on Agricultural and Land sector's fuel, energy, and the circular economy opportunities. Based on recent industry reporting it is reported that 5% to 9% of cattle / pastoral owner's CO_2e emissions arise from fuel uses, largely:

- diesel or gas for stationary power production at homesteads, feedlots, and farms;
- diesel use for the long haul transport of cattle between stations and to market; and
- diesel or petrol for other heavy vehicle, light vehicles, and ancillary equipment usage.



A Circular Economy Solution

Based on extrapolating publicly available data it is estimated that annual diesel use equates to 25 lt per head of cattle, or 625 million litres of diesel annually across the entire Australian sector, contributing to 1.7 million tpa of CO_2e emissions.

For Queensland and the Northern Territory's 11.7 million of cattle (see MLA estimates above), this equates to an estimated 290 million litres of diesel and fuel usage annually. At the same time, seven of the closest regional towns (ie. Alice Springs, Darwin, Emerald, Mt Isa, Rockhampton, Townsville, Toowoomba) to many of these stations, feedlots and farms dispose of 309,000 tpa of household waste to landfill. An estimated total of 1.2 million tpa CO_2e emissions when combining these regional towns landfill waste and the cattle / pastoral sector's diesel fuel use in these two states.

As a base case scenario, we are proposing a circular economy eco-system that reduces annual CO_2e emissions by 0.8 million tpa, or 75% annually from current levels - Great Barrier Reef Hydrogen. For participating pastoral and cattle companies utilising carbon negative resources this could equate to around a 14% annual CO_2e abatement reduction. An average 14% reduction in the carbon intensity of some of Australia's premium red meat enhances both the sector and its' product's sustainability appeal to end consumers.

As a Great Barrier Reef Hydrogen base case, this household landfill waste availability from seven towns is capable to be processed utilising Hydrogen capable Plasma Assisted Gasification ("HPAG") technology to produce an estimated 30,900 tpa of hydrogen:

- an equivalent of 155 million litres of diesel (eg. over one-half of the estimated sector usage); or
- 623,000 MWh of peak or back-up power, more than twice that power capable to be sourced as weather dependant renewable solar/wind.

Across regional Australia, given available land areas and solar availability, renewable energy can be more closely located adjacent to HPAG generation facilities - reducing power transmission losses over other hydrogen production technologies.

Carbon Negative Hydrogen with Growth Options

HPAG hydrogen is estimated to have a "well to gate" carbon intensity of negative 12.7 kg CO_2e / kg hydrogen (ie the hydrogen produced and used is carbon negative). This is to be contrasted with electrolytic hydrogen using solar or wind carbon intensity ranging from 1 to 4 kg CO_2e / kg hydrogen. HPAG technology uses less than 1% of water (scarce in regional Australia) and 17% of the renewable power required to produce electrolytic hydrogen.

This base initiative could be combined in many ways and be expanded over time with:

- Additional suitable biomass and Commercial & Industrial waste streams to increase this hydrogen generation potential;
- Combined with on station and feedlot site solar or wind together with battery and/or methanol/hydrogen as a peak and back-up storage medium;
- When using the biogenic CO_2e captured it can be used to promote agricultural sector opportunities in terms of value add production, employment, and domestic self-sufficiency. Some examples we envisage include utilising the biogenic green CO_2:
    - with the residual heat for urban vertical farming;
    - to stimulate high value algae production;
    - broadening agricultural greenhouses reducing agricultural land usage;
    - enabling local protein production; and
    - enhanced food security;
- Additional waste inputs from Queensland regional towns like Cairns, Mackay, and Gladstone; and
- Expansion into regional Victoria, South Australia, Western Australia, and Tasmania. New South Wales opportunities are more limited based on current policy settings.

Flexible Device Solutions

When the driving distance between many towns and cities in regional Australia to stations is at least four hours, repurposing existing station diesel infrastructure for utilising methanol provides an efficient, lower case transition pathway for many owners and refuellers.

Overseas technology exists today to convert methanol to hydrogen or power on a small scale required in homesteads or vehicles. Methanol stored and used at a homestead to produce peak stationary power, provide power backup, and hydrogen or fast charge refuelling and recharging for vehicles provides a versatile safer option for regional Australia and the agricultural industry.

The large distances associated with serving renewable fuels to agricultural customers require consideration of a range of carriers, require attention to the customer's requirements. When production and distribution systems are considered together with Customer Application Devices (CAD's), it is essential there is;

- A comprehensive production and distribution infrastructure;
- An attractive suite of commercial fuel / energy options that suit the CAD's;
- The commercial pricing structure is neutral / sustainable.

When incorporating methanol as an efficient hydrogen carrier, multiple technologies are available to address consumer needs across a range of Zero Emission Vehicles (ZEV) including:

  - Battery Electric Vehicles;
  - Hydrogen Fuel Cell Vehicles (HFC);
  - HFC with Methanol fuel hydrogen generator;
  - Direct Methanol Fuel Cell Vehicles;
  - Hydrogen / Diesel Dual-Fuel Vehicles; and
  - MCCI* Modified Diesel Engine Vehicles.

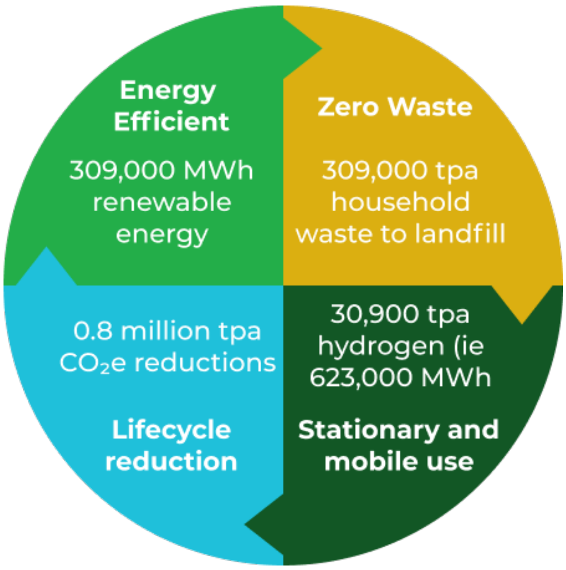
Distribution networks should ideally maximise choice and flexibility for technology transition. The use of methanol as fuel distribution supply source enables:

- All requirements above from the one fuel;
- Minimised and simple infrastructure to deliver the product; and
- An immediate start to advance net zero transition implementation.

Great Barrier Reef Hydrogen

Providing regional distributed hydrogen production across Queensland and the Northern Territory through the Great Barrier Reef Hydrogen initiative provides many benefits and enables:

- The utilisation of weather dependant renewable energy, abundant in regional Australia, with waste as a resource to produce twice the energy equivalent of energy availability on demand and for hard to abate sectors;
- Regional employment and a distributed network of carbon negative hydrogen and fast charge refueling stations across regional Australia;
- Greater agricultural sector revenue opportunities;
- Zero waste to landfill, an enabler for each local council involved to transition to be climate positive;
- Using 50% of the HPAG hydrogen produced for peak stationary power and micro-grid renewable energy to homesteads, First Nation communities and local towns;



- The remaining 50% is sufficient to fuel or fast charge over 1,750+ regional trucks or buses; and
- 0.8 million t CO_2e savings, or 1% of the Agriculturual sector's greenhouse gas emissions.

We would encourage each local council to be actively invested in the initiative as this enables those councils to become climate positive and achieve its 80% by 2030 waste diversion from landfill targets.

It is estimated that:

- Around 30% of the production is capable to be used by each of the seven regional towns and cities and its value chains to transition to become climate positive, with optionality to enable micro-grids in First Nations communities;
- Australia's fifteen largest pastoral companies are estimated to have capacity to consume 40% of this potential circular economy energy opportunity; and
- The balance is anticipated to be made available to provide public carbon negative refuelling and recharging infrastructure to enable the hydrogen highway across regional Queensland and the Northern Territory.

With the appropriate stimulatory Government circular economy policy settings at all levels with respect to:

- renewable energy use;
- hydrogen refueling production and infrastructure; and
- zero emission vehicle purchases

these pastoral organisations and its value chain providers should be more likely to invest and support the establishment and growth of a common user infrastructure eco-system like Great Barrier Reef Hydrogen.

Waste to Hydrogen to X

We encourage the diversification of Australia's Hydrogen Strategy for hydrogen production technologies to enable and stimulate non electrolytic hydrogen production technologies like HPAG. For the reasons outlined below, we consider HPAG is the next generation of technology to produce Grade A green hydrogen, respectful of biodiversity and environmental objectives, enabling enormous circular economy benefits and CO_2e savings as a result.

Xseed Solutions is joint venturing with Boson Energy to implement EU proven HPAG technology to Australia to accelerate Australia's climate transition, circular economy, and Waste to Hydrogen to X (W2X) solutions.

We have developed our Hydrogen for the Long Haul© strategy that provides a comprehensive input mechanism and technology solution to reduce Australia's carbon emissions by 6.5%.

In the EU, W2X technology adoption is rising rapidly, with waste to hydrogen projects now representing 4% of the targeted EU hydrogen production, coming from just 1% of the proposed hydrogen projects. Today, most Australian green hydrogen projects being considered are utilising some form of water electrolysis technology. Reflecting on this trend, electrolysis hydrogen requires an ideal suite of project parameters with respect to:

- large tracts of land to be available for the wind or solar to create renewable energy,
- an abundance of scarce water resources, requiring over 20 litres of water to produce 1 kg of hydrogen - HPAG requires less than 1% of water in its process to produce equivalent levels of ultra-low carbon hydrogen, and
- being limited to be located nearby to pipelines, shipping, or transport to transport the compressed or liquified hydrogen to minimise distribution costs and energy losses.

We encourage the development of all green hydrogen technologies, including hydrogen from electrolysis, that are assessed to be environmentally and economically sound. However, the above factors contribute to a driver that electrolysis projects need to be extremely large to be economic with large upfront capital expenditures and considerable, long dated offtake contracts to ensure financial viability. Very similar to the project characteristics of the combustion incineration industry. All these factors contribute to a high Levelized Cost Of Hydrogen (LCOH) for electrolysis hydrogen, currently estimated at over $6.50 per kg of green hydrogen.

We estimate a lower LCOH of HPAG produced hydrogen, with today's project challenge to encourage a more distributed network of offtake parties to transition to hydrogen or battery electric vehicles or energy uses in the agricultural sector. We encourage a multifaceted, streamlined strategy that extends its reach to domestic offtake parties to offset the associated transition costs so as achieve many of the government's stated hydrogen and net zero objectives and also solve government strategies with respect to waste management, circular economy, biodiversity protection, and decarbonising hard to abate sectors like long haul transport and construction.

The nature of constrained water resources and the contested nature of many high-water impact energy developments is a critical consideration for future energy projects. HPAG technology can play a critical role in the development of a domestic hydrogen industry in regional locations where water resources are scarce or already heavily utilised. This avoids the need of introducing another water stressor into regional communities, many who have been heavily impacted by drought in recent years.

We consider HPAG provides an ideal balance to stimulate regional economies, enable advanced manufacturing and lower emissions in Australia’s hard to abate sectors of waste and transport, in a water sensitive manner.

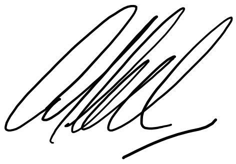
We believe a fuller consideration of the incentives required to promote downstream transition of our bus, truck, and large vehicle fleets from diesel to hydrogen could provide greater economic and environmental benefits than purely subsiding or developing a potential export market, or small, narrowly focussed trials. We estimate that a comprehensive roll-out in Australia of HPAG technology could provide at least $9 billion in direct annual economic benefits, with an investment cost less than 50% of that envisaged to develop a similar sized export electrolytic hydrogen market. The bonuses being:

- action now on plans to environmentally address landfill waste management;
- turning waste into a resource, lowering of the cost of waste management and ratepayers waste costs;
- at least maintaining similar employment levels in waste management per se, with more jobs in resource recovery than landfill management, but the technology facilitating extra regional jobs in and around the hydrogen sector and the circular economies that HPAG can engender; and
- actioning now tangible progress towards a further 6.5% reduction in Australia's annual carbon emissions. The equivalent Australian carbon emissions savings from an export oriented green hydrogen market, doing nothing to address waste to landfill, is estimated at around 1%.

We look forward to the opportunity to discuss the positive economic and environmental benefits arising from the use of HPAG and other hydrogen production technology further.

[redacted]

Kind regards



Craig Allen
Director – Xseed Solutions

Appendix A Xseed Submission – Agricultural Strategy

Specific incentives needed to rapidly switch to hydrogen in regional Australia

At present, we experience the lack of clarity of the rules and regulations and a cohesive legislative framework across governments and between governments is limiting major investment and uptake. Often there are multiple siloed polices in place, sometimes conflicting, and often limited in detailed actions unsupported by legislation.

Overcoming the legislative hurdles, the market will doubtless require stimulus, particularly in regional Australia.

Current technology enables both the battery electric and hydrogen transport infrastructure and equipment supply aspects in these sectors to grow and develop at a rapid pace over the next 5 years. Both sectors are significant carbon emitters, but require government alignment and clarity around:

- Harmonisation with international trucking specifications and standards to avoid the need to develop a specific Australian trucking solution; and
- Greater recognition of the need for funding and stimulus of public electric and hydrogen public and private charging infrastructure.

This is compounded with investor uncertainty with respect to:

- legislation related to all aspects of hydrogen production, carbon credit generation, carbon reporting, health and safety and tax;
- the transition process to hydrogen and technology transition;
- local innovations, adopting overseas innovation, and impacts on technology selection; and
- offtake / distribution and offtake pricing structures.

All this combined provides limitation and uncertainty with respect to proceeding with projects and technology innovation and imposes considerable focus on risk sharing and mitigation in offtake agreements.

Simulation modelling on circular economic benefits assessed regionally and sector-wise may benefit an understanding of locally available solutions for hydrogen uptake.

Actions required to overcome those barriers and realise the opportunities

Application and technology, not just the economic viability of electrolytic hydrogen opportunities will influence which are the most suitable projects worth consideration. Any transition to hydrogen use is influenced by where hydrogen is produced, what volumes are generated and what form of product delivery is appropriate. Smaller production facilities, with lower transport costs and higher retained hydrogen, together with a variety of offtake products introduces new investment parameters that may pass hurdle criteria in regional applications. The concept of generating and consuming hydrogen and derivatives locally and regionally that is good for regional communities and partially obviates the requirement to load-haul-decant bulk hydrogen over long distances.

Supply chain risks need to be addressed and overcome

Coordinated, regionalised, nodal approach and a cohesive modelling process. Minimising siloed legislation, policies, and initiatives that ignore the several hundred, localised regional investment opportunities that can make a genuine contribution to the transport and heavy industry sectors.

A maximum emissions intensity limit on a project lifecycle basis should be applied. This should be "well to gate" as well as "gate to point" and be aligned with the International Energy Agency's recent policy framework outlined in *"Towards hydrogen definitions based on their carbon intensity".*

The central target to adopt is a $ per CO_2e emission intensity target, both well to gate and well to point. The benefits of many technologies and hydrogen production and distribution systems are limited by energy and hydrogen losses associated with transporting the hydrogen from production to use.

Some regulatory mandates that should be considered by the government include:

- **Sovereign risk factors** – China produces over 80% of the world's solar and wind energy technology;
- **Speed to market** – the best available technology today with and providing the lowest carbon impact, lowest specific energy/water/land resource impact per kg hydrogen;
- **Transport domain** – a methanol-based transportation and distribution infrastructure is vastly more cost effective and lower cost than a hydrogen-based transport infrastructure for the Australian context;
- **Transport technologies** – we should invest effort to understand non-gaseous/non-liquid forms of hydrogen transport – a combination of regional/nodal designs that produce and consume energy locally, coupled with technologies that allow rapid transfer and transformation of hydrogen (metal hydrides, pipelines where practical etc).

The purposes of programs should be to support domestic decarbonisation and produce renewable hydrogen at scale in Australia to accelerate the development of Australia's hydrogen industry, it is appropriate not to limit eligibility purely to hydrogen production projects.

Support should also address other equally important hydrogen constraints limiting transformation. With the power industry, the Government only needs to address power production as the distribution system and the end user equipment/demand doesn't change significantly. To replace oil derived liquid fuels, one needs to address each of production, distribution, and end user take-up. For example, hydrogen is the logical replacement for fossil fuel derived fuels in long distance and heavy haul transportation and a large part of stationary power. This won't occur unless the Government addresses hydrogen distribution across all major long distance transport routes.

Based on today's technology a comprehensive hydrogen distribution system could be achieved today with around 80 hydrogen refuelling sites across Australia at a total refuelling cost of less than $250 million. This would enable a decarbonisation of around 4% of Australia's carbon emissions from 735,000 long haul vehicles. Carrier hydrogen is available for this stated purpose, with the need for the envisaged project not to be restricted by reference to a single physical location site. Only once a comprehensive distribution system is in place does Australia have the foundation to change the heavy haul and long-distance transport and stationary power dependency upon fossil fuel derived fuels.

Further, as hydrogen powered truck and bus manufacture is an emerging industry and in the early years results in significantly higher prices for hydrogen powered vehicles, investment allowance eligibility should be extended downstream to transport and other companies, large and small, in its vehicle procurement and/or vehicle modification to adopt hydrogen fuels.

Appendix B – Hydrogen capable Plasma Assisted Gasification

Hydrogen is the most abundant chemical substance in the universe, 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 <u>burning</u> 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 <u>thermal</u> degradation of organic materials in the absence of oxygen at between 250 to 700°C;
- **gasification,** those <u>thermal-chemical</u> processes at between 500 and 1,600°C used to recover the chemical value of the resource; and
- **plasma,** a <u>physics</u> processes 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" 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 green industrial 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 (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 green 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 hubs:

- **Energy hub**, the green 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 4% 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 green biogenic CO_2 produced it is an enabler for the downstream production of:
    - green methanol for road and shipping transport, another high carbon emissions sector,
    - sustainable aviation fuel for airlines, being utilised to reduce jet fuel carbon emissions,
    - green ammonia,
    - green urea,
    - industrial grade green CO_2 as a replacement for other CO_2 production;
- **Greenhouse hub**, when utilising the biogenic green CO_2 and the residual heat for urban vertical farming, agricultural greenhouses reducing agricultural land usage, local protein production and food security; or

- **Cell glass 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.

3 April 2024

Committee Secretary
Senate Standing Committees on Environment and Communications
PO Box 6100
Parliament House
Canberra ACT 2600

Ec.sen@aph.gov.au

Dear Committee Secretary

Waste Reduction and Recycling Policies Consultation Submission

We are writing in response to the Australian Senate's enquiry and consultation process inviting feedback in relation to the effectiveness of the Federal Government's waste reduction and recycling policies and legislation in delivering a circular economy.

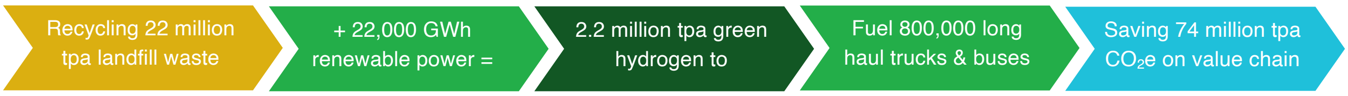
This response is provided in addition to separate responses we have provided on multiple occasions to federal, state, and local governments built upon Xseed Solutions' *Hydrogen for the Long Haul©* strategy developed to:

1. **Reduce** Australia's carbon emissions by up to 12% through the 100% use of landfill waste as a valuable resource to accelerate the transition away from diesel fossil fuels. In so doing, being additive to and doubling the value to Australian communities from other recycling activities;
2. **Manufacture** Grade A hydrogen locally, a key Industry 4.0 product, with a circular economy focus to keep landfill waste at its highest value use for the longest possible time - optimising CO_2e eco-system reductions. Largely biogenic CO_2 and IMBYROCK are manufactured using HPAG facilitating additional localised high value agricultural and industrial business across Australia; and
3. **Enable** value chain Hydrogen to X manufacturing business and employment opportunities across Australia to provide affordable Grade A hydrogen across Australia's potential hydrogen highway.

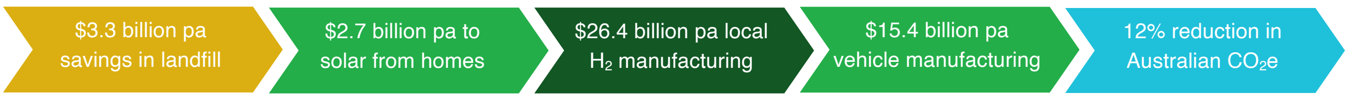
Xseed Solutions' *Hydrogen for the Long Haul©* strategy is framed in an objective, scientific way to enable all consumer, business, and government stakeholders to action today all the 2019 Federal Government Waste Action Plan targets.

As represented below, the Xseed Solutions' strategy is 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 up to 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.

Circular Economy



Waste to Hydrogen to X



In addition to eleven specific recommendations summarised below and detailed further in Appendix A, we have provided four informational appendices in response to the Senate enquiry:

1. **Appendix B** – A case study of a Waste to Hydrogen to X circular economy solution for Australia's Agricultural Industry - a hard to abate sector that benefits from a waste to methanol pathway;
2. **Appendix C** – A report of *Sub.Zero® hydrogen lowers the decarbonised Total Cost of Ownership of truck and bus pathways in Australia,* highlighting the benefits to road transport transition;
3. **Appendix D** – A case study of using waste to hydrogen to provide a below zero emissions road transport link between Toowoomba and the Port of Brisbane vicinity; and
4. **Appendix E** – provides an overview of Hydrogen capable Plasma Assisted Gasification (HPAG) technology and its versatile applications.

National Waste Policy Action Plan

After 5 years, progress on the 2019 Federal Government Waste Action Plan (Waste Plan) has been slow, mixed, and disappointing. With less than 6 years to 2030, there has been little progress to date or signs that 5 of the more substantial 7 key waste reduction targets will be met. The concern is now that without definitive investment and focused actions in relation to landfill waste diversions many aspects of the policy and accompanying legislation are now at risk of becoming very outdated and piecemeal. More importantly is that Australia's governments leave escalating greenhouse gas emissions from waste and landfill significantly unaddressed in the journey to net zero.

These comments are based on the Federal Government reporting in December 2023 that the following Waste Plan targets had not been achieved and/or were not reported as being on track:

- ✗ *Target 2 – Reduce total waste generated in Australia by 10% per person by 2030.*
- ✗ *Target 3 – 80% average resource recovery rate from all waste streams, following the waste hierarchy, by 2030.*
- ✗ *Target 4 – Significantly increase the use of recycled content by governments and industry.*
- ✗ *Target 6 – Halve the amount of organic waste sent to landfill for disposal by 2030.*
- ✗ *Target 7 – Make comprehensive, economy-wide, and timely data publicly available to support better consumer, investment, and policy decision.*

Xseed Solutions is a market participant with an articulated strategy and ambition to assist local councils, residents and businesses achieve 100% landfill waste diversion, that materially decarbonises Australian emissions and enables an Australian carbon negative hydrogen highway consistent with circular economy.

We are delivering our strategy through a **Waste to Hydrogen to X (W2X)** eco-system with our recommendations based on the interactions and work with multiple stakeholders across numerous sectors.

Waste to Hydrogen to X

At its core the Waste Plan lacks multi-stakeholder alignment and does not accommodate for science-based climate reduction decisions, emerging technologies and funding pathways that can work effectively to reduce and recycle waste to accelerate the transition away from fossil fuels in multiple hard to abate sectors. Significant advancements could be made to achieve targets with required, aligned government leadership at all levels in establishing objective measures embracing emerging circular economy technology solutions.

For example, the International Energy Agency (IEA) recently addressed the emotional and often confusing use of rainbow colours references to hydrogen attributes, i.e. green, blue, pink, white, yellow, etc to achieve enhanced carbon reduction outcomes. The IEA has proposed a more objective approach whereby hydrogen is graded by reference to its carbon intensity. The best, Grade A hydrogen, is graded as hydrogen that has a negative carbon intensity. Hydrogen manufactured using renewable power and biomass gasification is an example of Grade A. HPAG with renewable power that uses landfill waste feedstock is another Grade A enabling technology. Hydrogen from electrolysis with renewable power is a Grade B. The later, often referred to a “green” hydrogen given its prerequisite need to utilise wind or solar resources. It remains the pathway that the Federal Government solely endorses for its export potential, but as an export product it does very little to reduce Australia’s waste to landfill trajectory nor Australia’s own greenhouse gas inventory. Green is promoted as the best, when in fact it ranks second behind gasification technologies, including HPAG, that manufacture hydrogen from waste products.

Similarly, internationally respected research Project Drawdown (www.drawdown.org) ranks the impact of 101 initiatives that make a climate difference. Composting and landfill methane capture ranked in the bottom 10% of initiatives, with cumulative reductions less than 0.01% of total emissions. Despite this very low outcome Australia has a pre-occupation with FOGO to composting pathways. Reduced food waste, distributed solar photovoltaics, recycling and efficient trucks ranked numbers 4, 8, 36 and 38, respectively - with a cumulative CO_2e abatement savings of 12%. Despite these scientifically based examples, translating them to the subjective waste hierarchy in its multiple forms becomes confusing for those seeking to approve or advance projects that are best placed to reduce and recycle waste and lower CO_2e emissions.

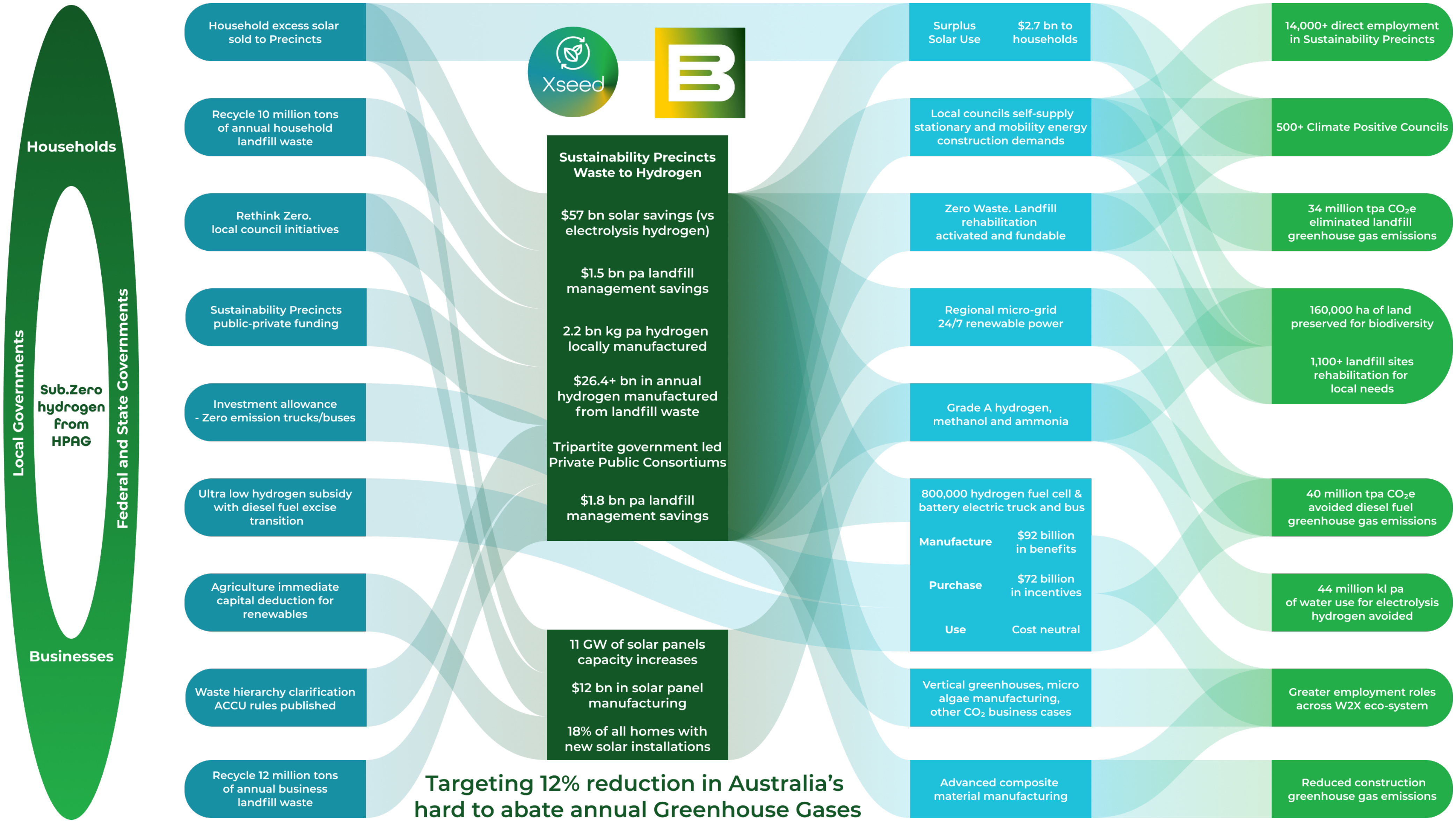
The circular economy principle is to maintain products at their highest value for the longest possible time with the need to remember that the objective is ultimately to reduce overall CO_2e emissions quickly.

Graphically, a more effective Waste Plan that would enable a clearer actioned pathway to zero waste with emerging waste to hydrogen technologies that are capable to enable landfill waste to be regenerated to a higher value outcome.

Transition from Waste Plan residual waste: To Zero Waste with Waste to Hydrogen:

Our Recommendations

An overview of our eleven recommendations of a pathway to target a 12% reduction in Australia’s greenhouse gas emissions are summarised in the following diagram highlighting our specific recommendations, translating to tangible actions into economic, environmental and employment outcomes.


Households
Local Governments
Sub.Zero hydrogen from HPAG
Federal and State Governments
Businesses
Household excess solar sold to Precincts
Recycle 10 million tons of annual household landfill waste
Rethink Zero. local council initiatives
Sustainability Precincts public-private funding
Investment allowance - Zero emission trucks/buses
Ultra low hydrogen subsidy with diesel fuel excise transition
Agriculture immediate capital deduction for renewables
Waste hierarchy clarification ACCU rules published
Recycle 12 million tons of annual business landfill waste
Xseed
Sustainability Precincts Waste to Hydrogen
$57 bn solar savings (vs electrolysis hydrogen)
$1.5 bn pa landfill management savings
2.2 bn kg pa hydrogen locally manufactured
$26.4+ bn in annual hydrogen manufactured from landfill waste
Tripartite government led Private Public Consortiums
$1.8 bn pa landfill management savings
11 GW of solar panels capacity increases
$12 bn in solar panel manufacturing
18% of all homes with new solar installations
Surplus Solar Use
$2.7 bn to households
Local councils self-supply stationary and mobility energy construction demands
Zero Waste. Landfill rehabilitation activated and fundable
Regional micro-grid 24/7 renewable power
Grade A hydrogen, methanol and ammonia
800,000 hydrogen fuel cell & battery electric truck and bus
Manufacture
$92 billion in benefits
Purchase
$72 billion in incentives
Use
Cost neutral
Vertical greenhouses, micro algae manufacturing, other CO_2 business cases
Advanced composite material manufacturing
14,000+ direct employment in Sustainability Precincts
500+ Climate Positive Councils
34 million tpa CO_2e eliminated landfill greenhouse gas emissions
160,000 ha of land preserved for biodiversity
1,100+ landfill sites rehabilitation for local needs
40 million tpa CO_2e avoided diesel fuel greenhouse gas emissions
44 million kl pa of water use for electrolysis hydrogen avoided
Greater employment roles across W2X eco-system
Reduced construction greenhouse gas emissions
Targeting 12% reduction in Australia's hard to abate annual Greenhouse Gases

Our specific waste reduction and recycling recommendations for Australian governments at all levels and the Federal Senate to consider include:

1. **Waste to Hydrogen doubles the value of recycled resources** – A domestic Waste to Hydrogen market could save $3.3 billion in landfill management costs (i.e. $150 per ton), creating a $26.4 billion domestic hydrogen market, enhancing domestic energy security, and diverting the importation of diesel retailing at $23.8 billion.
2. **Stimulate a broader domestic Waste to Hydrogen to X sector** - Enable a broader domestic based carbon negative hydrogen manufacturing strategy with the objective to accelerate the benefits beyond encouraging export orientated electrolytic hydrogen being produced. Water is precious and a more efficient land use for solar and wind is encouraged preserving Australia's biodiversity.
3. **Streamline policies and approvals** - Prioritise and streamline approvals processes for circular economy initiatives, including Waste to Hydrogen to X (W2X), across and within the three levels of government and the multiple government departments and the strategies involved (i.e. climate, hydrogen, waste, transport, energy, circular economy, regional planning, biodiversity, manufacturing).
4. **Climate Positive local council program** – Provide a funding framework for Sustainability Precincts that provide the opportunity for local councils to use current technology to fully divert its waste from landfill and self-supply all its stationary power and mobility fuel requirements, including promoting scope 3 value chain reductions. Surplus hydrogen is capable to be sold to third parties and surplus returns from the Sustainability Precincts are reinvested into local services and infrastructure.
5. **Incentivise subzero carbon hydrogen domestic offtake** - Provide a tiered $2 per kg of hydrogen maximum subsidy to domestic purchasers of hydrogen and fast charge power where the energy origin has a "well to gate" carbon intensity less than 2.0 kg CO_2e per kg hydrogen equivalent. This initiative should accompany a phasing out of the diesel fuel rebate.
6. **Business vehicle investment allowance** – To stimulate the W2X eco-system, provide a 50% investment allowance to 2030 to business purchasers of zero emission trucks and buses, phasing down by 10% every 2 years thereafter. These vehicles will range from heavy, medium, and light waste collection vehicles, public bus transport, general freight transport, government vehicle fleets and those vehicles used by suppliers to governments.
7. **Agriculture decarbonisation** – To 2030, expand the primary production immediate tax deduction regime to include low carbon intensive stationary energy renewable power solutions for solar, wind, geo-thermal, hydrogen, methanol, etc. A renewable energy eco-system sourced from waste enabling the partial decarbonisation of Australia's important agricultural products and stimulating new ones.
8. **CER to finalise waste and hydrogen ACCU rules** - The Clean Energy Regulator (CER) urgently finalise and publish the regulations and requirements with respect to ACCU entitlements from the proposed 2021 Emission Reduction Fund (ERF) methods, together with those applicable to all aspects of the waste management, waste to hydrogen and hydrogen to X sectors.
9. **Modernise and harmonise Waste Hierarchy(ies)** – Modernise and harmonise the multiple Australian waste hierarchy frameworks away from subjective measures, and by reference to objective CO_2e intensity abatement outcomes, highest value, and scientific based environmental considerations.
10. **Rethink Zero.** – Encourage local Climate Positive councils in establishing W2H facilities with residents to buy their excess household solar power, including providing: rebates or discounts for zero waste local food businesses; W2H powered public transport; and local businesses encouraged to purchase W2H power or hydrogen for their own use stationary micro-grids or vehicle uses.
11. **Methanol efficient energy carrier with flexible device solutions** – Extend the W2X eco-system to incorporate methanol as an efficient hydrogen carrier, whereby multiple technologies are available to address consumer needs across a range of Zero Emission Vehicles, across regional Australia, and the agricultural sector from homestead stationary power through to long haul vehicle transport.

Hydrogen capable Plasma Assisted Gasification (HPAG)

We encourage the development of all ultra-low and low CO_2e intensive hydrogen technologies, including hydrogen from electrolysis, that are assessed to be environmentally and economically sound. However, many factors contribute to a driver that electrolysis projects need to be extremely large to be economic with large upfront capital expenditures and considerable, long dated offtake contracts to ensure financial viability. Very similar to the project characteristics of the outdated waste combustion incineration industry. All these factors contribute to a high Levelized Cost Of Hydrogen (LCOH) for electrolysis hydrogen, currently estimated at over $6.50 per kg of green hydrogen, or energy inefficient waste incinerators that achieve carbon eco-system reduction outcomes below 2 t CO_2e of abatement per ton of waste combusted.

We estimate a lower LCOH of HPAG produced hydrogen, with today's project challenge to encourage a more distributed network of offtake parties to transition to hydrogen or battery electric vehicles or energy uses across multiple sectors. We encourage a multifaceted strategy that extends its reach to domestic offtake parties to offset the associated transition costs. Aligned and targeted so as achieve many of the many governments' stated waste, hydrogen, and net zero objectives and to solve governments' strategies with respect to waste management, circular economy, biodiversity protection, and decarbonising hard to abate sectors like long haul and regional transport, agriculture, shipping, and construction.

The nature of constrained water resources and the contested nature of many high-water impact energy developments is a critical consideration for future energy projects. HPAG technology recycling waste to manufacture hydrogen, plus the related hydrogen and methanol pathways can play a critical role in the development of a domestic hydrogen industry in regional locations where water resources are scarce or already heavily utilised. This avoids the need of introducing another water stressor into regional communities, many who have been heavily impacted by drought in recent years.

We consider HPAG and Sustainability Precincts provides an ideal balance to urban contexts and to stimulate regional economies, enable advanced manufacturing and lower emissions across Australia's hard to abate sectors of waste, transport, agriculture, and healthcare, in a water sensitive biodiversity friendly manner.

We believe a fuller consideration of the incentives required to promote the downstream transition of Australia's bus, truck, and large vehicle fleets from diesel to hydrogen could provide greater economic and environmental benefits than purely subsiding or developing a potential export market, or small, narrowly focussed trials.

We estimate at a high level that a comprehensive roll-out in Australia of HPAG technology eco-systems could provide at least $49 billion per annum in direct and indirect annual economic benefits. Investment costs are less than 50% of that envisaged to develop a similar sized export electrolytic hydrogen market.

A Waste to Hydrogen to X eco-system accelerates the path to both zero waste and net zero with higher carbon abatement outcomes for diverting waste from landfill. The bonuses being:

- **100% resource recycling** - action now on Waste Plan Targets 3, 4 and 6 with plans to environmentally address landfill waste management;
- **Value enhancing** - turning waste into a resource, lowering of the cost of waste management and ratepayers waste costs;
- **Creates jobs** – enabling a broader Waste to Hydrogen to X economy creates at least 14,000 new direct jobs in manufacturing and recycling (away from landfill management). More importantly value chain employment is created in the broader manufacturing, road transport, hydrogen, energy, and agricultural sectors both in urban centres and across regional Australia; and
- **Action real zero outcomes** - actioning now tangible progress of up to a 12% reduction in Australia's annual carbon emissions. The equivalent Australian carbon emissions savings from an export oriented green hydrogen market, does nothing to address landfill waste, is estimated at around 1%.

We look forward to the opportunity to discuss the positive economic and environmental benefits arising from the use of HPAG, Sustainability Precincts, and other Waste to Hydrogen to X production technology further.

[redacted]

Kind regards

Craig Allen
Director – Xseed Solutions

Appendix A – Detailed Recommendation Considerations

1. Waste to Hydrogen doubles the value of recycled resources.

South Australian local governments lead Australia in the reporting and analysis of its waste recycling market. For 2020-2021 it reported that the value created from all recycled waste was $477 million. At the same time, 360,700 ton of waste was being disposed to landfill annually. That 360,700 ton of landfill waste contains 36,700 ton of hydrogen, with an estimated minimum retail market value of $440 million, together with other product and service revenue streams.

Extrapolating those study findings, more progressive W2H recycling ambitions across all councils would transform a $3.3 billion waste landfill management cost to a W2X market realising a market potential of over $26.4 billion (at a hydrogen retail price of $12.00 per kg (see below)). Manufacturing 2.2 million tpa of hydrogen, from the 22 million tpa of landfill waste, creates a vibrant domestic hydrogen from waste market that enables other hydrogen to X businesses to flourish.

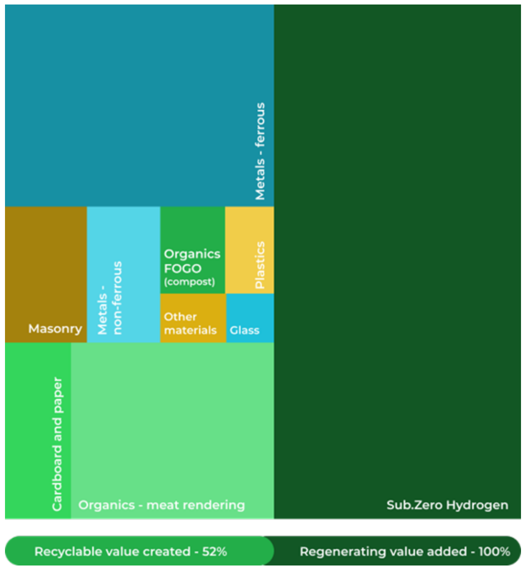


Figure 2: SA estimated market value of resource recovered material in SA during 2020-21

Using the Waste Plan metrics of 6.4 more jobs created from every 10,000 tpa of resource recovery, this creates new direct employment for more the 14,000 people. Importantly, these roles are across regional and urban Australia. In addition to enhancing Australia's energy security transitioning from 12 billion litres of imported diesel, it is estimated that significant more indirect energy, hydrogen, and manufacturing jobs would be created to enhance the supply chain that this stimulates.

An illustrative $12.00 per kg retail hydrogen price (GST inclusive) is based at the lower end of the range of $10.80 to $26.00 per kg based on two perspectives:

1. Electrolysis green hydrogen currently retails in Europe, California, and South Korea at between €10 to €15.75 per kg (that is, A$16.50 to $26.00 per kg of hydrogen - refer www.h2.live). These are prices after the application of EU hydrogen subsidies which we understand equate to around A$5.00 per kg; and
2. On average in road transport vehicles, 5.4 liters of diesel are substitutable with 1 kg of hydrogen. With average diesel prices at around $2.00 per litre, this equates to $10.80 per litre on a diesel parity basis.

2. Stimulate a broader domestic Waste to Hydrogen to X market

The purposes of government programs should be to support domestic decarbonisation and produce renewable hydrogen at scale in Australia to accelerate the development of Australia's hydrogen industry, it is not appropriate to limit eligibility of programs purely to hydrogen electrolysis production projects.

The central target to consider adopting for all waste hierarchy and circular economy solutions is a $ per CO_2e emission intensity target, both "well to gate" and "well to point". For hydrogen, it needs to be aligned with the International Energy Agency's recent policy framework outlined in *"Towards hydrogen definitions based on their carbon intensity".* The benefits of many technologies and hydrogen production and distribution systems are limited by energy and hydrogen losses associated with transporting the hydrogen from production to use. For waste, the issues of transporting waste long distances create similar leakages.

Some regulatory mandates that should be considered by the government include:

- **Sovereign risk factors** – China produces over 80% of the world's solar and wind energy technology, and Australia imports over 83% of its crude oil. Domestic hydrogen manufacturing with a stimulated stationary and mobility energy market reduces that dependence materially;

- **Speed to market** – the best available technology today providing the lowest carbon impact, highest diversion from landfill outcomes and lowest specific energy/water/land resource impact per kg hydrogen or CO_2e abatement per ton of waste;
- **Transport domain** – a methanol-based transportation and distribution infrastructure is vastly more cost effective and at a lower cost than a hydrogen-based transport infrastructure for the Australian context; and
- **Transport technologies** – we should invest effort to understand non-gaseous/non-liquid forms of hydrogen transport – a combination of regional/nodal designs that produce and consume energy locally, coupled with technologies that allow rapid transfer and transformation of hydrogen (metal hydrides, pipelines where practical etc).

Support should also address other equally important waste to hydrogen constraints limiting transformation. With the power industry, governments only need to address power production as the distribution system and the end user equipment/demand doesn't change significantly. To replace oil derived liquid fuels, one needs to address each of production, distribution, and end user take-up. For example, hydrogen is the logical replacement for fossil fuel derived fuels in long distance and heavy haul transportation and a large part of stationary power. This won't occur unless the Government addresses hydrogen and methanol distribution across all major long distance transport routes.

Based on today's technology a comprehensive hydrogen distribution system could be achieved today with around 80 hydrogen refuelling sites across Australia at a total refuelling cost of less than $300 million. This would enable a decarbonisation of over 5% of Australia's carbon emissions from 800,000 long haul vehicles. This outcome is significantly improved if the hydrogen manufactured into this distribution network is from waste that would otherwise go to landfill.

Carrier hydrogen is available for this stated purpose, with the need for projects not to be restricted by reference to a single physical location site. Only once a comprehensive distribution system is in place Australia has the foundations to change the heavy haul and long-distance transport and stationary power dependency upon fossil fuel derived fuels.

3. Streamline policies and approvals

At present, we experience the lack of clarity of the rules and regulations and lack of a cohesive legislative framework across, within, and between governments that affect the waste to hydrogen sector. This arises as the W2X technology crosses hydrogen, waste, energy, transport, circular economy, carbon emissions and biodiversity strategies. This is limiting major investment and uptake opportunities. Often there are multiple siloed polices in place, sometimes conflicting, and often limited in detailed actions unsupported by legislation, the science itself, and confused with a variety of outdated waste hierarchy interpretations.

Overcoming the legislative hurdles, the W2X market will undoubtedly require stimulus, particularly in regional Australia. The flow on benefits though are considered worth the investment.

Current technology enables both the battery electric and hydrogen transport infrastructure and equipment supply aspects in these sectors to grow and develop at a rapid pace over the next 5 years. Both sectors are significant carbon emitters, but require government alignment and clarity around:

- Landfill management diversion technologies and the distinction between outdated and inefficient incineration technologies to more recent gasification, pyrolysis and/or vitrification technologies;
- Harmonisation with international trucking specifications and standards to avoid the need to develop a specific Australian trucking solution; and
- Greater recognition of the need for funding and stimulus of public electric and hydrogen public and private charging infrastructure.

This is compounded with investor uncertainty with respect to:

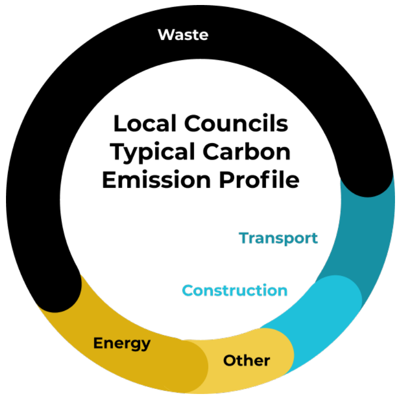
- legislation related to all aspects of "when is waste not waste", hydrogen production, carbon credit generation, carbon reporting, health and safety, and tax;
- the transition process to hydrogen and technology transition;
- local innovations, adopting overseas innovation, and impacts on technology selection; and
- offtake / distribution and offtake pricing structures.

All this combined provides limitation and uncertainty with respect to proceeding with projects and technology innovation and imposes considerable focus on risk sharing and mitigation in offtake agreements.

Simulation modelling on circular economic benefits assessed regionally and sector-wise may benefit an understanding of locally available solutions for waste diversion and hydrogen uptake opportunities.

4. Climate Positive local council program

In Australia, a majority of typical local council emissions are attributable to the landfill waste within its own region. Local councils are also often large consumers of energy, transport fuels, and construction materials. W2X facilities, or Sustainability Precincts, provide the opportunity for local councils to use current technology to fully divert its waste from landfill and self-supply all its stationary power and mobility fuel requirements, including promoting scope 3 value chain reductions. Surplus hydrogen is capable to be sold to third parties and surplus returns from the Sustainability Precincts are reinvested into local services and infrastructure.



Strict probity rules and local council reluctance to invest in new infrastructure beyond traditional landfill management inhibits all councils, particularly regional councils from progressing this style of Zero Waste, Net Zero initiative.

Australian local councils are also currently confronted with significant climate related transition risks and potential funding shortfalls associated with significant future landfill rehabilitation costs that will impact the cost of living for all Australians. As an example, one South East Queensland local regional council has a $92 million landfill rehabilitation cost to fund before 2039, representing a future household cost of $83 per year for 15 years, a tripling of current waste levies for those residents. All local councils should be taking steps now to transition away from landfill, securing pathways to fund and co-own infrastructure like waste to hydrogen that provides councils with a circular economy revenue stream to assist councils, households, and businesses alike in funding these future significant obligations.

Frameworks exist with the National Reconstruction Fund, ARENA, and other grant funding opportunities. Leverage these frameworks together with CEFC to initiate a specific Sustainability Precinct circular economy funding program for household Municipal Solid Waste (MSW) streams achieving (1) zero waste to landfill outcomes and (2) eco-system carbon intensity outcomes above a threshold, e.g. say 2 t CO_2e per ton of landfill waste "well to wheel" whereby:

1. Local councils operate the Sustainability Precincts to encourage local employment and higher than 80% MSW landfill diversions by 2030;
2. Local councils agree to purchase sufficient Sustainability Precinct product offtakes to enable them to achieve net zero from a baseline that is inclusive of a council's C&I and regional MSW streams;
3. CEFC provides or leads a Sustainability Precinct a 10 year loan to fund 60% of the capital cost;
4. For the remaining 40% equity requirement:
    a. The Federal government (i.e. through NRF or ARENA) subscribes for a minimum 10% equity investment in the Precinct;

b. Local council equity investments up to 20% equity are matched equally by Federal and State equity funds (i.e. funding 60% of the project equity); and

c. Local councils are given first preference to top up its equity investment with the remaining 30%, otherwise it is offered to private investors.

In this way, local councils can choose to take a 50% equity interest in a Precinct that funds up to 20% of the total Precinct costs, achieves Climate Positive outcomes, promotes local employment, provides funds for required landfill rehabilitation, and stimulates regional value chain businesses and decarbonisation. Federal and State governments achieve multiple goal outcomes, including reduced CO_2e emissions, zero waste, a localised, distributed network of carbon negative hydrogen and fast charge power for transport, localised employment, micro-grids for First Nation and regional communities, and blended equity and debt returns. NRF and/or ARENA anchor a 10% equity Precinct investment, and following government participation decisions, private market equity investors can participate anywhere from 0% to 87%.

5. Incentivise subzero hydrogen domestic offtake

The *Australia Institute* reports that Federal and State Governments provide $11.1 billion in fossil fuel subsidies.

HPAG waste to hydrogen is estimated to have a well to gate carbon intensity of negative 12.7 kg CO_2e per kg hydrogen. To incentivise domestic demand for low carbon intensive hydrogen, particularly hydrogen that is manufactured from waste, we recommend the Waste Plan provides a tiered $2.00 per kg hydrogen subsidy to domestic purchasers of hydrogen and fast charge power where the energy origin has a “well to gate” carbon intensity less than 2.0 kg CO_2e per kg hydrogen equivalent. This initiative should accompany a phasing out of the diesel fuel rebate.

Hydrogen with a carbon intensity that is better than negative 10 kg CO_2e per kg hydrogen would be entitled to the full $2.00 per kg subsidy, the $ per kg subsidy reducing by $0.167 for each one kg CO_2e per kg hydrogen increase in carbon intensity, reducing to $nil per kg when the carbon intensity is above 2 kg CO_2e per kg hydrogen equivalent.

This is accompanied with a phasing out of the diesel fuel rebate to target a cost neutral outcome. 100% of Australia’s household and business waste being used to manufacture 2.2 billion kg of Grade A hydrogen, this would have an expenditure impact of up to $4.4 billion annually, well below the current diesel fuel rebate.

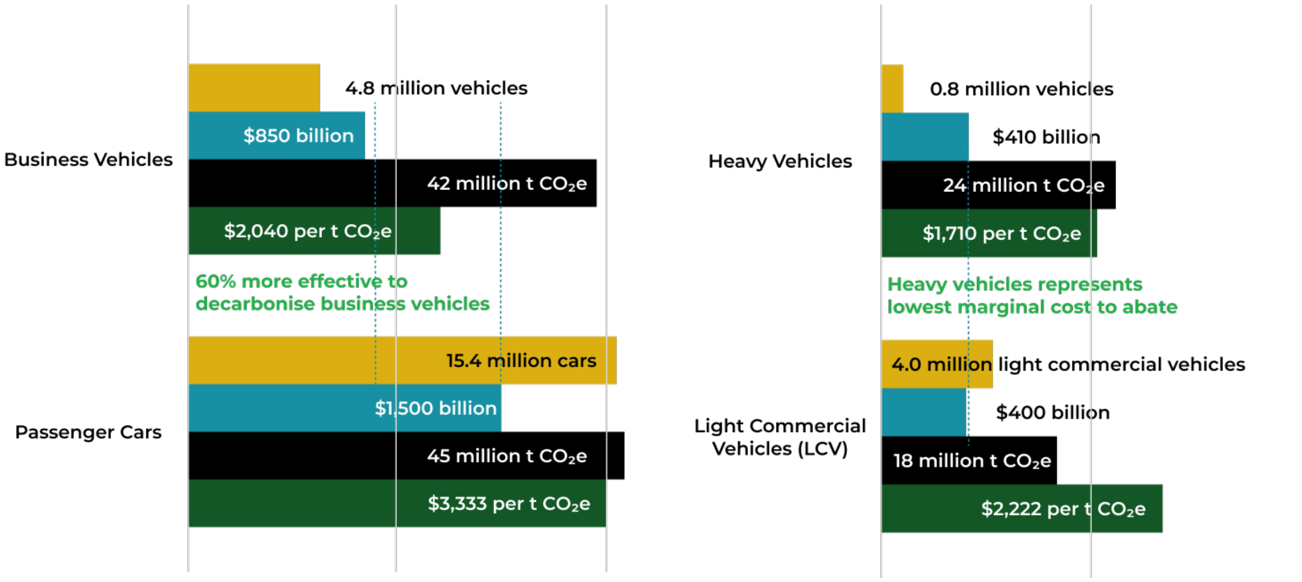
6. Business vehicle investment allowance

Australia has 800,000 heavy vehicles that contribute 24 million tpa CO_2e, around 5.2% of Australia’s total CO_2e emissions. Around 50,000 new trucks and buses are sold in Australia each year with the majority of truck and bus vehicles manufactured locally utilising up to 60% Australian owned resources in the supply chain. An Australian market currently estimated to be worth $12 billion annually.

Higher volumes and technology advances are anticipated to reduce the average zero emission vehicle cost over the next 3 to 6 years, with the average zero emission heavy vehicle cost still anticipated to be twice the cost of the diesel powertrain vehicle it is being transitioned from.

The introduction of higher fuel efficiency standards for heavy vehicles will stimulate new supply of heavy vehicles. On the basis, of a phase down to 2030, and 60% of the new vehicles production manufacturing remaining in Australia this represents a potential economic uplift of $15.4 billion per annum in terms of higher zero emission vehicle production sales and greater Australian value content. This equates up to $92.2 billion in economic contributions to 2030.

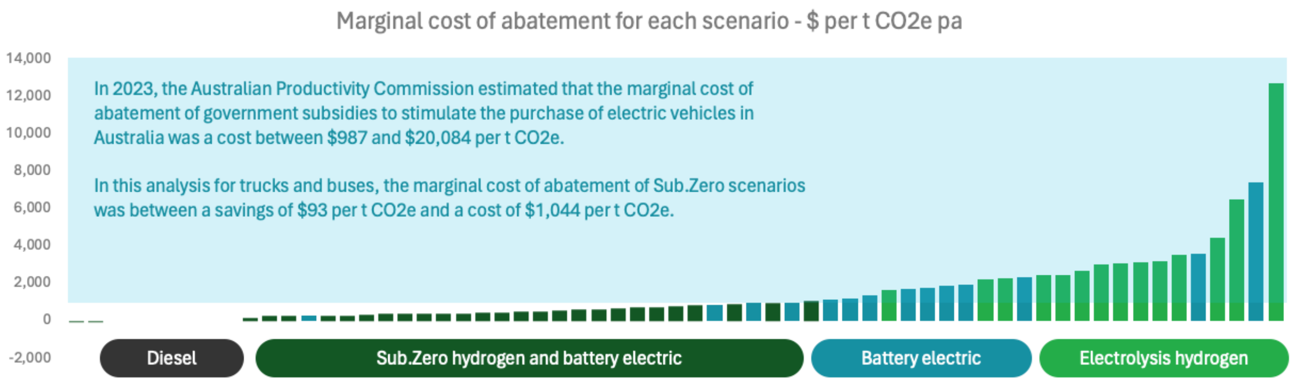
Hydrogen to X infrastructure is confronted with the challenges of establishing extensive hydrogen supply and refuelling infrastructure to encourage the transition to zero emission vehicles. HPAG and a distributed network of hydrogen production and refuelling capacity is ideally structured to provide that supply, to create the demand drivers for new vehicle production.



To assist vehicle owners in the cost of vehicle transition, that has the enhanced benefit of stimulating waste from landfill into hydrogen production it is recommended that a 50% investment allowance be provided to 2030 to business purchasers of zero emission trucks and buses, phasing down by 10% every 2 years thereafter. To 2030, it is estimated that this will reduce life cycle cumulative carbon emissions by 448 million t CO_2e and cost $72 billion, representing a marginal cost of abatement of $160 per t CO_2e – well below current subsidies and incentives provided to the passenger electric vehicle market.

As background, the Productivity Commission reported that it estimated that the marginal cost of abatement of government subsidies to stimulate the purchase of electric passenger vehicles in Australia was a cost between $987 and $20,084 per t CO_2e. This does not stimulate the manufacture of electric cars in Australia, as no passenger cars, electric or petrol, are manufactured in Australia.

In Xseed Solution's analysis for trucks and buses (refer Appendix C), the marginal cost of abatement of W2X scenarios ranged between a savings of $94 per t CO_2e and a cost of $1,044 per t CO_2e. The below figure illustrates the Total Cost of Ownership (TCO) $ per t CO_2e emissions for each of the scenarios modelled, with a majority of Sub.Zero W2H TCO $ per t CO_2e scenarios less than the current government abatement subsides for passenger electric cars.



7. Agriculture decarbonisation

Agriculture is estimated to consume 2.6 billion litres of diesel annually, emitting 9.3 million tpa CO_2e. Aspects of the agriculture industry are hard to abate, and difficult to electrify, including remote stations, road transport and farming equipment. We have presented a Case Study at Appendix B that details the benefits that a circular economy solution, diverting landfill waste across regional Australia towns to manufacture local hydrogen and methanol would provide agricultural, farming, and pastoral organisations with significant decarbonisation and cost benefits.

As part of the circular economy approach, the industry would benefit from the recommended investment allowance (Recommendation 6) and hydrogen subsidy (Recommendation 5). To enhance the full decarbonisation of the fossil fuel component for the sector we recommend that the Waste Plan expand the primary production immediate tax deduction regime to 2030 to include low carbon intensive stationary energy renewable power solutions for solar, wind, geo-thermal, hydrogen, and methanol. Utilising hydrogen and methanol from waste enables up to a 10% reduction in the carbon intensity of Australian beef, lamb, farmed prawns and other higher carbon intensity products so as provide a distinct low carbon export advantage as compared to other markets.

8. CER to finalise waste and hydrogen ACCU rules

In 2021 the Federal Government announced a range of Emission Reduction Fund (ERF) methods for development, including for road transport, hydrogen refuelling infrastructure, hydrogen uses, carbon capture use, and different agricultural wastes as feedstocks to support enhanced biomethane. After 3 years, these all remain outstanding and this is now coupled with uncertainty as the outcomes from the existing landfill and methane abatement methods in place, and how they would apply to various waste to hydrogen technology outcomes.

At a time that the Carbon Safeguard Mechanism (CSM) is in operation, and uncertainty continues as to Australian Carbon Credit Units (ACCU) entitlement from these ERFs for the Waste to Hydrogen to X eco-system, it is difficult for investors and affected CSM businesses to consider using ACCUs from 100% abated waste methane emissions.

We recommend that the Clean Energy Regulator (CER) urgently finalise and publish the regulations and requirements with respect to ACCU entitlements from the proposed 2021 ERF methods, together with those applicable to all aspects of the waste management and waste to hydrogen sectors.

9. Harmonise and modernise the Waste Hierarchy(ies)

The Waste Hierarchy had its origins in 1975 from the early versions of the EU Waste Framework Directive. A complementary circular economy model was later developed, that often creates confusion as to objectives and outcomes from each approach.

The Waste Plan has a reference to the waste hierarchy, but it does not clarify which of the multiple models and legislative outcomes in Australia it is referring to. Each state and local government in Australia has adopted its own unique interpretation of that original waste hierarchy that makes delivering lower cost regional solutions difficult, particularly when it comes to the permitting and planning assessments for multi-jurisdictional projects that often require inputs from three tiers of government. Enabling a hydrogen highway project between states utilising hydrogen from waste provides extensive complications from dealing with different waste hierarchy frameworks and interpretations.

All this is particularly confusing when it comes to the scientific and objective outcomes targeted from the regeneration of organic materials, recycling of products, the (re)manufacturing of others, like hydrogen and the recovery of energy (as electrons) from waste.

We recommend a harmonisation and modernisation of all the waste hierarchy(ies) in Australia requiring specific references to:

- Greenhouse gas (carbon) intensity outcomes of different solutions;
- An “end of waste” criteria, similar to the EU Waste Framework Directive, to specify when certain waste ceases to be waste and becomes a product, or a secondary raw material when it has undergone a recovery operation (including recycling) and complies with specific criteria, in particular when:
    - the substance or object is commonly used for specific purposes;

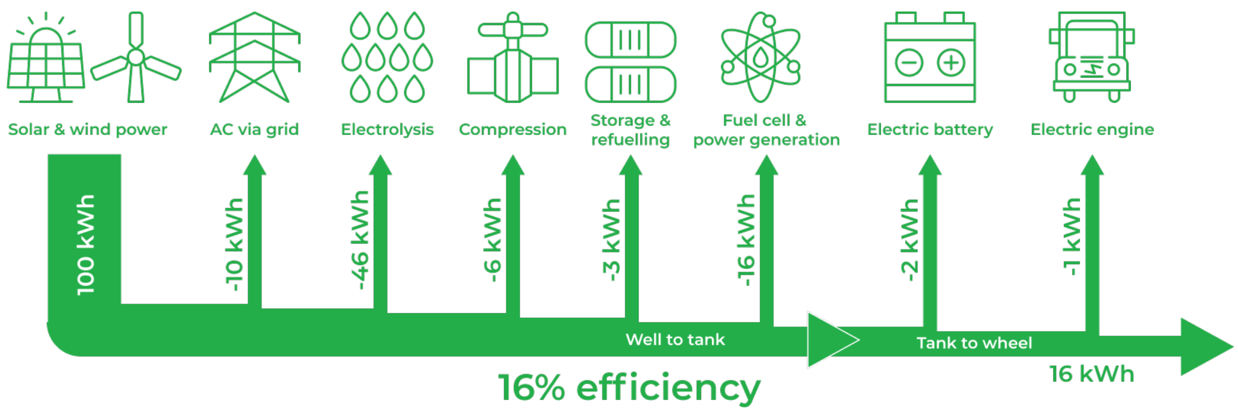
    - a market or demand exists for such a substance or object;
    - the use is lawful; and
    - the use will not lead to overall adverse environmental or human health impacts.
- Distinguishing waste recycling and recovery related manufacturing technologies based on multiplicity of end uses, process energy efficiencies, carbon intensity outcomes, and biodiversity impacts. This is particularly the case in distinguishing between two very different outcomes from:
    - Waste recovery activities typically attached to electron production into single use energy generation, particularly when it has up 20% residual outcome to landfill;
    - Waste recycling activities manufacturing hydrogen gas, with hydrogen gas having a multiplicity of end uses for example a non-exhaustive list including from ammonia, fertilizers, chemicals, biogenic methanol, energy carrier, metallurgical processes, glass and other manufacturing outputs, and metal fabrication, with zero waste to landfill; and
- Harmonisation of waste hierarchy concepts by reference scientific outcomes. All technologies have a role to play and need to be assessed on within the regional context it is to be adopted. For example, composting is often promoted as the only solution to deal with food and organic waste, whereas it has a small value-add; has limited carbon abatement; invokes extra collection and separation costs and requirements; has large land use; invokes significant transport emissions; and with high contamination risks of composting often overlooked when looking at composting in highly urbanised locations.

Distinguish "waste to energy" incineration from waste to hydrogen

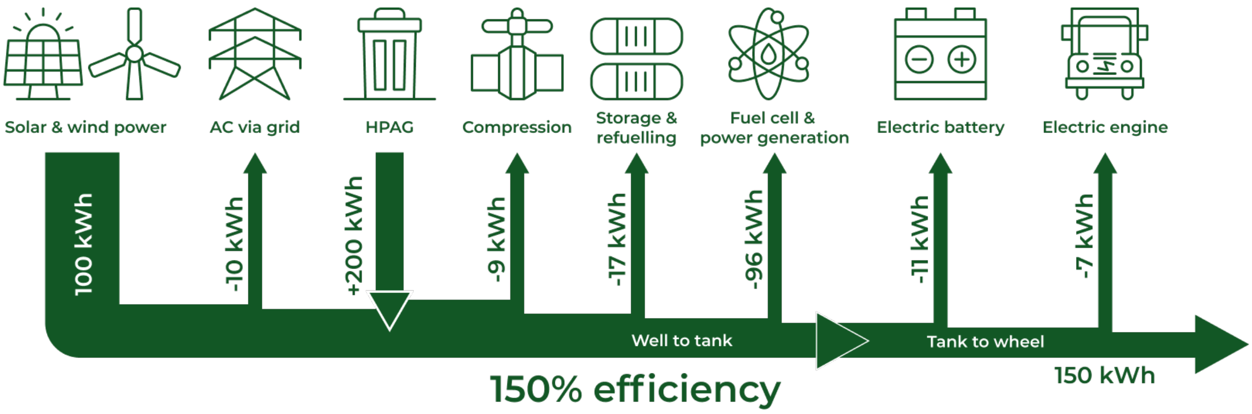
In broad terms, a clear distinction should exist as the waste hierarchy outcomes as it relates to the energy spectrum between:

- **Renewable power (electrons)** – That is the generation of continuous grid power that is often the only output from incineration or stand-alone gasification or pyrolysis technologies. Often these technologies have high emissions, sub-optimal carbon intensity outcomes, are energy inefficient and generate up to 20% fly ash residue still requiring disposal to landfill.
- **Hydrogen gas (molecules)** – That is the manufacture of hydrogen gas molecules from the waste, as the manufacture of hydrogen from water is already viewed as an acceptable technology pathway. This is particularly the case in HPAG's circumstances that provides significantly higher energy efficiency outcomes than both incineration and electrolysis production.

The Federal government has embarked on a program to streamline hydrogen regulatory frameworks. This work does not necessarily overcome the inherent inefficiencies in the waste hierarchy nor delivering electrolysis hydrogen to the road transport sectors. Illustratively, electrolysis hydrogen that consumes significant scarce water in its production has a 16% energy efficiency outcome "Well to Wheel", with a carbon intensity of 2 to 4 CO_2e per kg of hydrogen "Well to Gate".



This is to be contrasted with the manufacture of HPAG hydrogen from waste that has a 150% energy efficiency outcome "Well to Wheel" with a carbon intensity of negative 12.7 CO_2e per kg of hydrogen "Well to Gate". That is, an outcome that is over 6 times more beneficial than electrolysis hydrogen.



This high level of environmental effectiveness in terms of carbon intensity and energy efficiency outcomes are often overlooked when a subjectively ranked waste hierarchies are developed. The following table highlights some of the key aspects of each.

		Conventional waste incineration faces challenges that are mostly not fixable			Incineration (Wte)
		Waste Incineration	Is there a fix?	HPAG = H_2 + power fast charging	Wte vs HPAG
Energy	Energy efficiency	Poor	No. No fix.	**High.** Eco-system optimises outcomes	Est ~43% of energy output
	Energy storage	Poor	Expensive and inefficient storage	**Full (24h). High (72h). Medium (7d+)**	Poor
Hydrogen	Hydrogen capable	No. Burns H_2 and C molecules	No. No fix.	**Yes.** H_2-native process. **Biodiversity** benefits.	No.
	CO_2 emissions	**100% emitted**	**Very expensive.** Takes up to 60% of power produced	**Designed with native CO_2 capture.** Non-combustion CO_2	100% emitted
Climate positive	CO_2e abatement	Landfill waste diverted. Baseload power output.	Combine with renewables?	**3.7 times H_2 output vs combination**	Limited impact on own CO_2e targets
Emissions	NO_x & PM emissions	Poor	Very expensive	**Up to 95% below EU regulations**	TBC. Likely higher.
	Ash residues	Toxic	Very expensive	**Zero.** Vitrified slag construction material	Not "Zero Waste"
Investment profile	Investment risk	High. Singular revenues.	Concentrated capex investment. Low ROI.	**Small. Scalable. Diversified revenues.**	Capex and opex likely higher.
	Project Scale / Customer	Large. Centralised. / Low alignment.	No. No fix. / Unlikely.	**Distributed. Localised. / Aligned.**	High to/from transport and CO_2e costs

In the EU, W2X technology adoption is rising rapidly, with waste to hydrogen projects now representing 4% of the targeted EU hydrogen production, coming from just 1% of the proposed hydrogen projects.

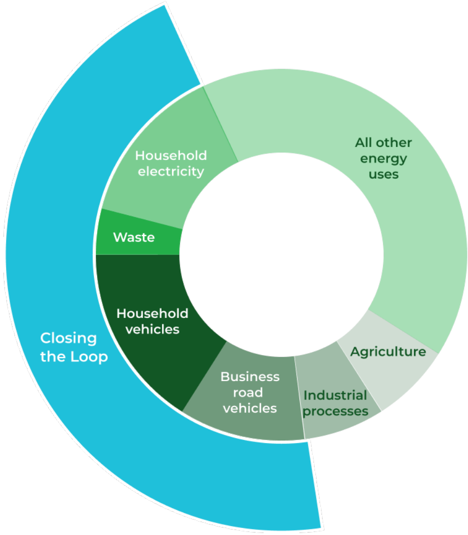
Today, most Australian green hydrogen projects being considered are utilising some form of water electrolysis technology. Reflecting on this trend, electrolysis hydrogen requires an ideal suite of project parameters with respect to:

- large tracts of land to be available for the wind or solar to create renewable energy;
- an abundance of scarce water resources, requiring over 20 litres of water to produce 1 kg of hydrogen - HPAG requires less than 1% of water in its process to produce equivalent levels of ultra-low carbon hydrogen; and
- being limited to be located nearby to pipelines, shipping, or transport to transport the compressed or liquified hydrogen to minimise distribution costs and energy losses.

HPAG flexibility means that many of these electrolysis hydrogen disadvantages are not applicable to HPAG.

10. Rethink Zero.

Beyond electrifying your home with affordable solar electricity, we are encouraging local councils with Sustainability Precincts to buy residents excess household solar power as a pathway to provide households with lower council rates, cheaper real zero public transport, reasonably priced zero emission freight trucks on our roads, and to simplify our collective journey to zero waste. Xseed Solutions' **Rethink Zero.** initiative is detailed online at [Rethink Zero.]

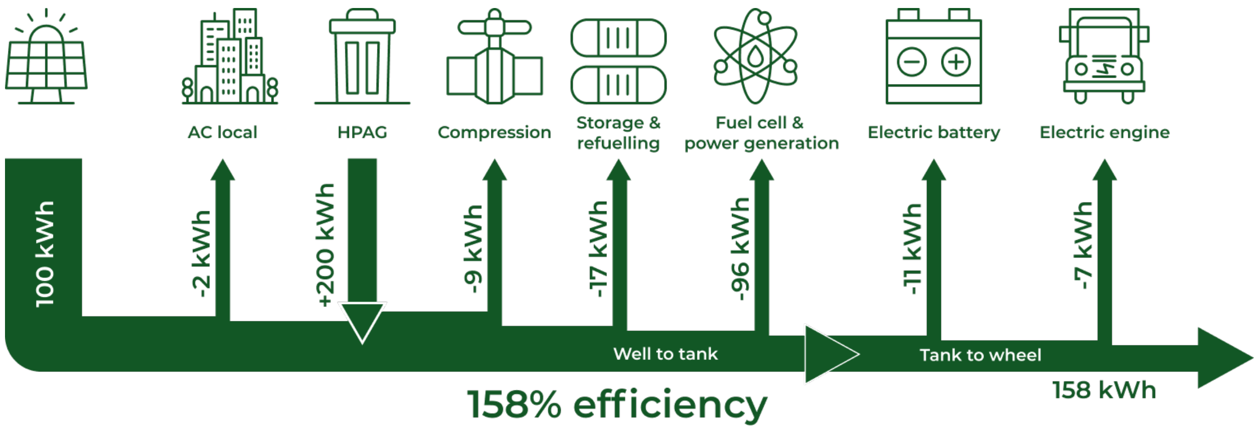


Less than 30% of Australian households have solar. Many have excess solar energy that is being sold into grid network at less than $0.05 per kWh, whilst paying $0.30 per kWh or more. Hydrogen from waste facilities require renewable power which is best sourced locally.

Based on producing 2.2 billion kg of hydrogen with renewable power and using the CER's estimated cost per MW of solar farms of $1.1 million per MW;

- Using electrolysis would require a solar farm investment of $69 billion delivering 63 GW of renewable power, noting that this solar farm would cover 160,000 ha, an area six times the size of Whitsunday Island;
- To be contrasted with HPAG hydrogen manufacturing, the solar investment is closer to $11 billion as it requires one-sixth of the renewable power, or 11 GW of renewable power. At full capacity, this could be accommodated on 13% to 18% of the over 200,000 ha of roof areas of Australian homes, aligning with the Electrify Everything initiative.

Local councils with zero waste to hydrogen facilities using excess household solar power provides cost of living relief to households and reduces the 10% in transmission losses from long distance solar farms. Reduced transmission losses are estimated to improve overall efficiency of zero waste to hydrogen by 8% to 158%.



Rethink Zero. encourages local councils in establishing Sustainability Precincts towards being Climate Positive to promote with retail energy providers Rethink Zero. plans for residents whereby the Precincts buy residents excess household solar power for use in the Precincts. Involving energy retailers may assisted in providing funding pathways for households, with participating households being paid a higher feed-in rate than currently received, but lower than the cost to establish new long-distance infrastructure. Assuming that purchase rate was $0.125 per kWh this provides an income stream to households of $100 per excess solar panel energy generation, or $2.7 billion to households as an input to the manufacturing of upwards of $26.4 billion in Grade A hydrogen.

In addition to supplying hydrogen to decarbonise Australia's road freight transport, councils could consider pathways to enhance benefits for its residents from co-owned facilities. These could include:

- rebates or discounts for local businesses, particularly restaurants, food retail and agriculture, with food and organic waste to participate in waste to hydrogen supply and off-takes;
- local residents encouraged to use Sub.Zero hydrogen and fast charge powered public transport;
- local businesses encouraged to purchase Sub.Zero power or hydrogen for their own use stationary or vehicle uses.

Boosting the *Rewiring Australia* model, this pathway provides those residents participating in the plan with higher returns to lower their overall household running costs. Using local infrastructure reduces the biodiversity impacts, energy losses, and costs of constructing renewable energy facilities at long distances.

11. Methanol Flexible Device Solutions

Australia's bioenergy sectors developing biofuels from biomass and related agricultural waste products is progressing, particularly in terms of Sustainable Aviation Fuels (SAF) and methanol directed at shipping decarbonisation. Methanol is an efficient hydrogen carrier, enabling the equivalent of 12 road tankers of hydrogen molecules to be transported in one tanker of methanol. We encourage the enhanced infrastructure use of largely biogenic sourced methanol, capable to be manufactured at Sustainability Precincts.

When the driving distance between many towns and cities in regional Australia is at least four hours, repurposing existing station diesel infrastructure for utilising methanol provides an efficient, lower case transition pathway for many residents, business owners, and refuellers. Repurposing existing infrastructure for a lower carbon impact outcome.

Overseas technology exists today to convert methanol to hydrogen or power on a small scale required in homesteads or vehicles. Methanol stored and used at a homestead to produce peak stationary power, provide power backup, and hydrogen or fast charge refuelling and recharging for vehicles provides a versatile safer option for regional Australia and the agricultural industry.

The large distances associated with serving renewable fuels to agricultural customers requires consideration of a range of carriers, and customer's requirements. When production and distribution systems are considered together with Customer Application Devices (CADs), it is essential there is;

- A comprehensive production and distribution infrastructure;
- An attractive suite of commercial fuel / energy options that suit the CADs;
- The commercial pricing structure is neutral / sustainable.

When incorporating methanol as an efficient hydrogen carrier, multiple technologies are available to address consumer needs across a range of Zero Emission Vehicles (ZEV) including:

- Battery Electric Vehicles;
- Hydrogen Fuel Cell Vehicles (HFC);
- HFC with Methanol fuel hydrogen generator;
- Direct Methanol Fuel Cell Vehicles;
- Hydrogen / Diesel Dual-Fuel Vehicles; and
- MCCI* Modified Diesel Engine Vehicles.

Distribution networks should ideally maximise choice and flexibility for technology transition. The use of methanol as fuel distribution supply source enables:

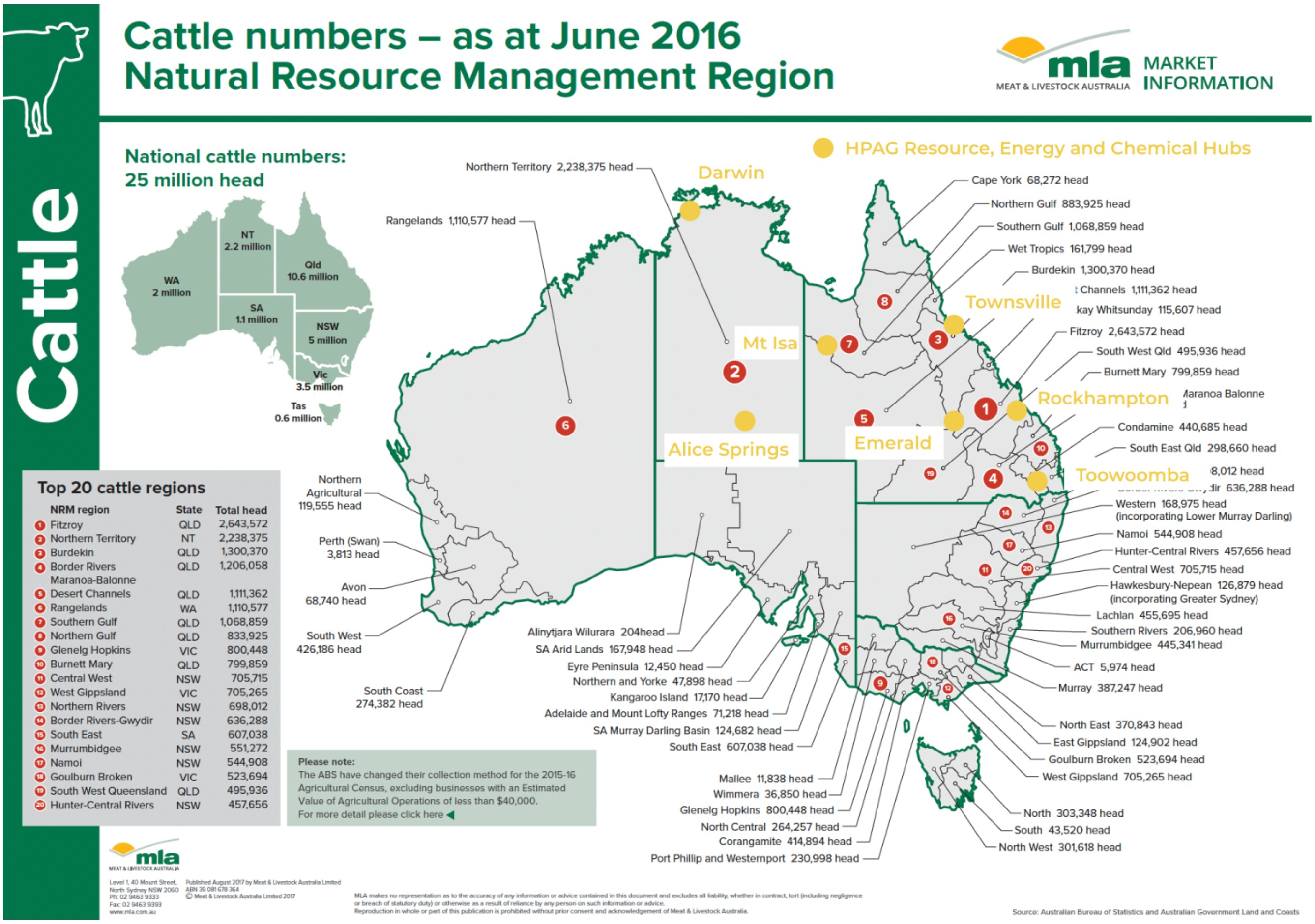
- All requirements above from the one fuel;
- Minimised and simple infrastructure to deliver the product; and
- An immediate start to advance net zero transition implementation.

Appendix B – Case Study - Australia's Agricultural Industry

Australia's 25 million head cattle industry operates across large areas of regional Australia.

Focusing on Agricultural and Land sector's fuel, energy, and the circular economy opportunities. Based on recent industry reporting it is reported that 5% to 9% of cattle / pastoral owner's CO_2e emissions arise from fuel uses, largely:

- diesel or gas for stationary power production at homesteads, feedlots, and farms;
- diesel use for the long haul transport of cattle between stations and to market; and
- diesel or petrol for other heavy vehicle, light vehicles, and ancillary equipment usage.



A Circular Economy Solution

Based on extrapolating publicly available data it is estimated that annual diesel use equates to 25 lt per head of cattle, or 625 million litres of diesel annually across the entire Australian sector, contributing to 1.7 million tpa of CO_2e emissions.

For Queensland and the Northern Territory's 11.7 million of cattle (see MLA estimates above), this equates to an estimated 290 million litres of diesel and fuel usage annually. At the same time, eight of the closest regional towns (ie. Roma, Emerald, Proserpine, Mackay, Rockhampton, Townsville, Toowoomba, and Darwin) to many of these stations, feedlots and farms dispose of 309,000 tpa of household waste to landfill. An estimated total of 1.2 million tpa CO_2e emissions when combining these regional towns landfill waste and the cattle / pastoral sector's diesel fuel use in these two states.

As a base case scenario, we envisage a circular economy eco-system that reduces annual CO_2e emissions by 0.8 million tpa, or 75% annually from current levels – Xseed's Great Barrier Reef Hydrogen strategy. For participating pastoral and cattle companies utilising carbon negative resources this could equate to around a 14% annual CO_2e abatement reduction. An average 14% reduction in the carbon intensity of some of Australia's premium red meat enhances both the sector and its' product's sustainability appeal to end consumers.

Great Barrier Reef Hydrogen's focus on household landfill waste availability in stages that is capable to be processed utilising HPAG technology to produce an estimated 30,900 tpa of hydrogen:

- an equivalent of 155 million liters of diesel (eg. over one-half of the estimated sector usage); or
- 623,000 MWh of peak or back-up power, more than twice that power capable to be sourced as weather dependant renewable solar/wind.

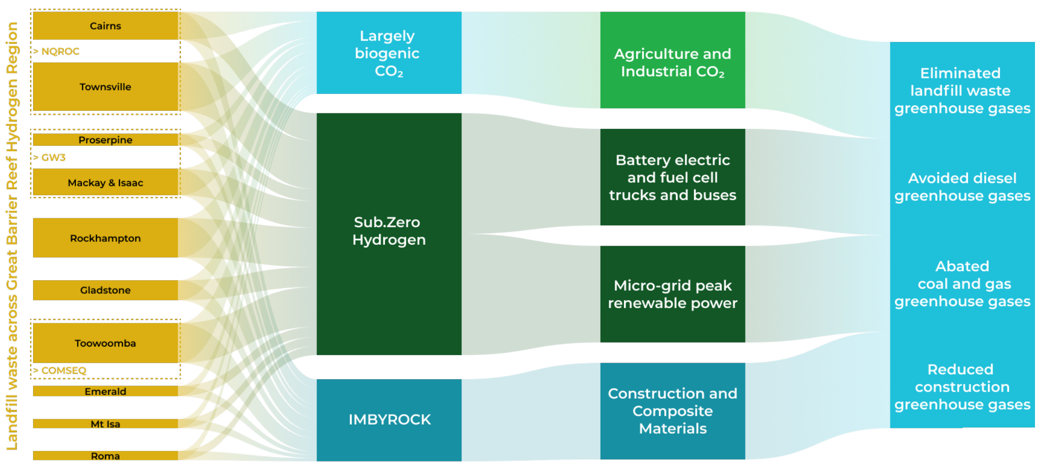
Across regional Australia, given available land areas and solar availability, renewable energy can be more closely located adjacent to HPAG generation facilities - reducing power transmission losses over other hydrogen production technologies.

Carbon Negative Hydrogen with Growth Options

HPAG hydrogen is estimated to have a "well to gate" carbon intensity of negative 12.7 kg CO_2e per kg hydrogen (ie the hydrogen produced and used is carbon negative). This is to be contrasted with electrolytic hydrogen using solar or wind carbon intensity ranging from 1 to 4 kg CO_2e / kg hydrogen. HPAG technology uses less than 1% of water (scarce in regional Australia) and 17% of the renewable power required to produce electrolytic hydrogen.

This base initiative could be combined in many ways and be expanded over time with:

- Additional suitable biomass and Commercial & Industrial waste streams to increase this hydrogen generation potential;
- Combined with on station and feedlot site solar or wind together with battery and/or methanol/hydrogen as a peak and back-up storage medium;
- When using the biogenic CO_2e captured it can be used to promote agricultural sector opportunities in terms of value add production, employment, and domestic self-sufficiency. Some examples we envisage include utilising the biogenic green CO_2:
    - with the residual heat for urban vertical farming;
    - to stimulate high value algae production;
    - broadening agricultural greenhouses reducing agricultural land usage;
    - enabling local protein production; and
    - enhanced food security;
- Additional waste inputs from Queensland regional towns like Cairns, Mackay, and Gladstone; and
- Expansion into regional Victoria, South Australia, Western Australia, and Tasmania. New South Wales opportunities are more limited based on current policy settings.



Appendix C

Refer to attached paper - *Sub.Zero® hydrogen lowers the decarbonised Total Cost of Ownership of truck and bus pathways in Australia.*

Appendix D – Case Study - Zero emissions freight transport Toowoomba to Brisbane

Refer to attached paper – *Enabling Real Zero Emissions Toowoomba to Port of Brisbane road transport*

Appendix E – Hydrogen capable Plasma Assisted Gasification

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" 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 green biogenic 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 (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 green 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 hubs:

- **Energy hub**, the green 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 5% 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 green biogenic CO_2 produced it is an enabler for the downstream production of:
    - green methanol for road and shipping transport, another high carbon emissions sector,
    - sustainable aviation fuel for airlines, being utilised to reduce jet fuel carbon emissions,
    - green ammonia,
    - green urea,
    - industrial grade green CO_2 as a replacement for other CO_2 production;
- **Greenhouse hub**, when utilising the biogenic green CO_2 and the residual heat for urban vertical farming, agricultural greenhouses reducing agricultural land usage, local protein production and food security; or
- **Cell glass 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.