12 December 2023

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

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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:

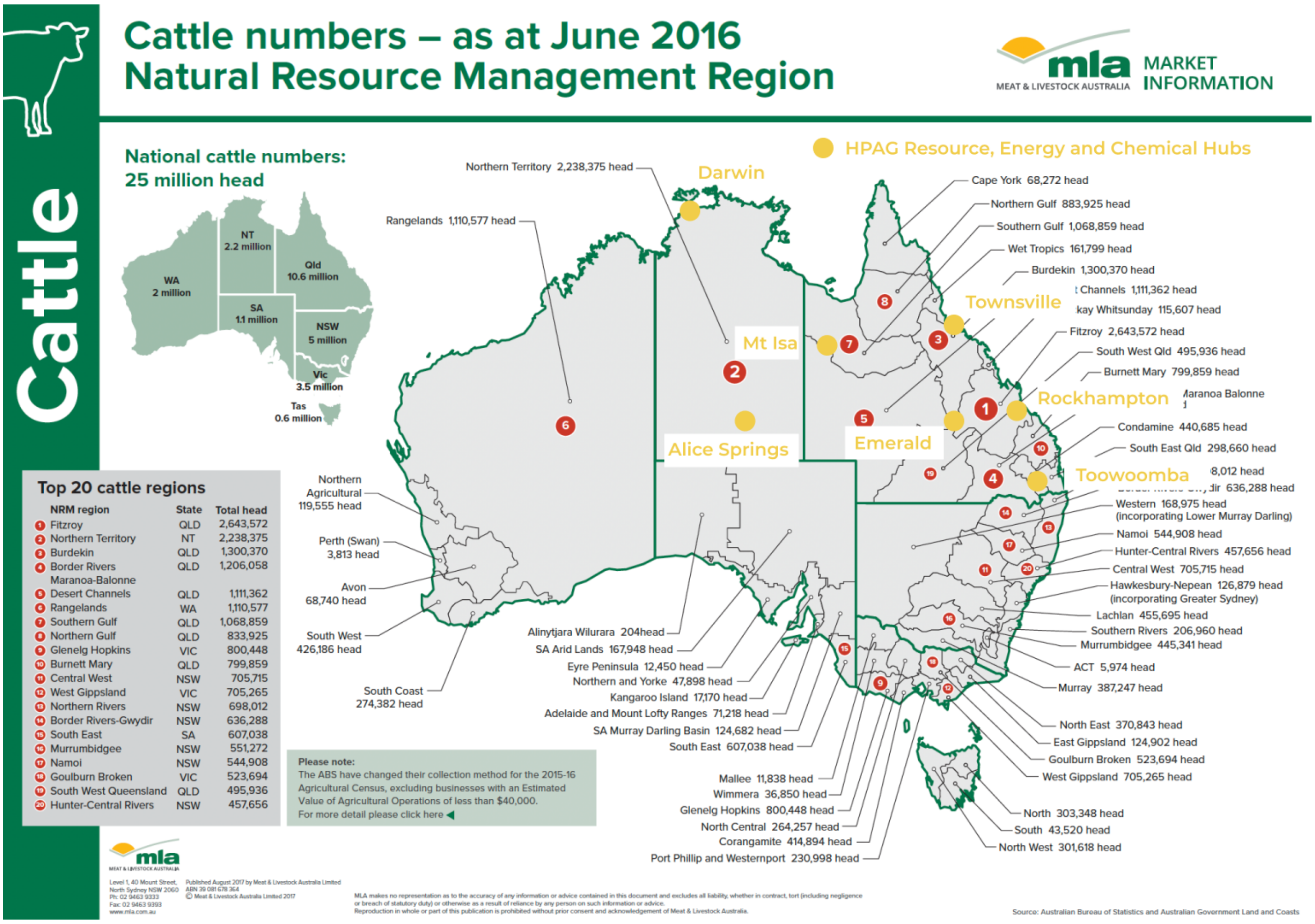
1. Enable a broader domestic based hydrogen strategy with the objective to accelerate the benefits of the strategy beyond encouraging export orientated electrolytic hydrogen being produced. Water is precious and a more efficient land use for solar/wind is encouraged.
2. Prioritise and streamline approvals 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.

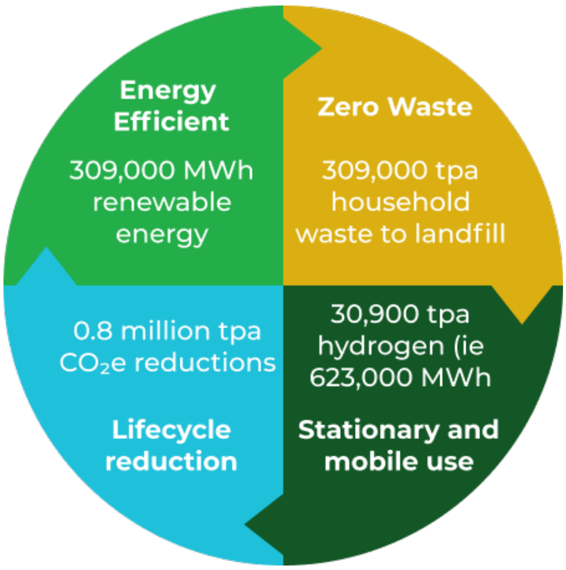
Distribution networks should ideally maximise choice and flexibility for technology transition. The use of methanol as fuel distribution supply source enables:

- 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.

If you have any questions or require any additional details please do not hesitate to contact Craig Allen on [redacted]

Kind regards

[redacted]

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.