SUBMISSION ON NSW GOING CIRCULAR IN CLEAN ENERGY ISSUES PAPER

9 March 2023

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Introduction

The Clean Energy Council (**CEC**) welcomes the opportunity to make a submission in response to the New South Wales Government's *Going circular in clean energy* issues paper (**the Issues Paper**).

The CEC is the peak body for the clean energy industry in Australia. We represent and work with over 1,000 of the leading businesses operating in solar, on-shore and offshore wind and storage, as well as renewable hydrogen. We are committed to accelerating Australia's clean energy transformation.

We commend the NSW Government on consulting on such an important issue and considering what it takes to create a circular economy for clean energy technologies, particularly as governments have a large role to play in addressing barriers to achieving a circular economy.

Our submission outlines the key issues for circular economies in the clean energy sector, but this space is constantly evolving and improving, for instance with breakthroughs in technology, and we recommend that the NSW Government continue to engage with the Clean Energy Council as this important work is progressed.

What are the key barriers to adopting a circular economy for clean energy in NSW? Are there any specific barriers in your industry?

1. **Increasing requirements are slowing necessary renewable energy project development**

While we generally support measures that could support a more "circular economy" approach to clean energy, any measures or requirements need to be seen in a broader context of the industry and its regulatory environment. The cost and complexity of project development is already growing significantly due to a range of state and federal requirements. There are also growing social and environmental standards/expectations for renewable energy technologies. While we support and are advocates for responsible development of renewable energy projects, we are aware that this can lead to increased costs and timeframes to reach decisions and approvals.

An additional piece of context is that the annual pace of large-scale renewable energy roll-out needs to increase if we are to meet government targets and existing policy commitments.

All of this is occurring in this time when AEMO is warning of looming reliability gaps and the Federal Energy Minister Chris Bowen stating, "this transition to renewable energy needs to be faster than it has been over the last decade, much faster and much more orderly and reliable." Our industry is to trying to accelerate but there are already a range of challenges to achieving this.

We strongly recommend, if any targets are set for supply chain or design, that these be achievable. Unachievable, impractical or overly onerous targets would only serve to slow the roll out of renewable energy at precisely the time when it needs to accelerate.

2. Location of large-scale projects

One of the largest costs associated with end-of-life management for renewable energy projects is the transport of materials and components from the project sites to recycling facilities. Most large-scale renewable energy projects are located in regional areas, whereas most recycling facilities are based in the major cities.

Some potential solutions to cutting transport costs could be:

- Coordination between projects that are being decommissioned at similar times to share costs.
- The use of Special Activation Precincts, as mentioned in the Issues Paper, to assist with transport costs, or potentially to build recycling facilities where there is a concentration of renewable energy projects, eg where the SAP is close to Renewable Energy Zones (**REZs**).

However, it should be noted that the establishing new facilities close to REZs will create additional workforce pressures in regional areas. Research from the Institute for Sustainable Futures anticipates significant competition for labour with the existing workforce and anticipate workforce shortages across several REZs over the coming years.[1] Increased workforce activity in regional areas also creates additional social pressures, including:

- Availability of social infrastructure, such as roads, schools, hospitals and housing supply at affordable prices.
- Lack of training facilities and the instructors needed to meet the skill requirements of the workforce.

3. Barriers for wind turbines

A wind farm typically has a nominal design life of 20-30 years. However, site conditions being less severe than the design conditions and enhancements in technology and maintenance practices mean that many turbines can exceed this design life. Some wind farms are now designed for an operating life of a minimum of 30 years.

While 85 – 94 per cent of a wind turbine can be recycled,[2] the wind industry is currently seeking to go further and avoid any disposal of waste. The CEC has a Wind Recycling Working Group which has been identifying the barriers to a circular economy, as well as the opportunities and innovations overseas. We will be releasing a report in the next few months summarising our research.

Design

As noted in the Issues Paper, wind turbine manufacturers developing new blades that can be recycled as part of their commitment to zero-waste turbines by 2040.

Siemens Gamesa has developed the RecyclableBlade, the world's first recyclable offshore wind turbine blades ready for commercial use, and already has agreements to provide them to three major customers from 2022.[3] GE is also developing a recyclable blade through a project program called ZEBRA (Zero wastE Blade ReseArch).[4]

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[1] Briggs et al., (2022). Employment, Skills and Supply Chains: Renewable Energy in NSW – Final Report, https://www.energy.nsw.gov.au/sites/default/files/2022-09/employment-skills-and-supply-chains-renewable-energy-in-nsw-final-report.pdf.
[2] Vestas, *Zero-Waste*, vestas.com/en/sustainability/environment/zero-waste
[3] SiemensGamesa, *Siemens Gamesa pioneers wind circularity: launch of world's first recyclable wind turbine blade for commercial use offshore*, 7 September 2021, siemensgamesa.com/en-int/newsroom/2021/09/launch-world-first-recyclable-wind-turbine-blade
[4] GE, *ZEBRA project achieves key milestone with production of the first prototype of its recyclable wind turbine blade*, 17 March 2022, ge.com/news/press-releases/zebra-project-achieves-key-milestone-with-production-of-first-prototype-of-recyclable-wind-turbine-blade

These recyclable blades use new types of resin that can be separated from the other components of the blade (fibreglass, plastic, wood and metals) through a chemical process, allowing the materials to be reused for new applications.

Reuse

It is possible to reuse wind turbines in their entirety, for example one Australian company, Blair Fox's business model involves building, owning and operating wind farms in Western Australia using decommissioned wind turbines.

However, while it may be possible to reuse turbine parts at other wind farms in Australia, this opportunity is limited by the number of compatible turbine models in operation. Many of the turbines currently in use in Australia only have a small number of equivalent turbines from which replacement parts could be obtained or on which replacement parts could be used. This lack of domestic opportunity means the reuse of components is likely to involve international trade with other wind farms.

Some other potential barriers to second-hand businesses include the impacts of decommissioning larger turbines on cranes and transport, as well as new grid connection regulations prohibiting older turbine technology from connecting to the grid.

Recycling

85–94 per cent of a wind turbine (by mass) is recyclable[5] and can be recycled in Australia. This recovery rate is well above the national average for commercial and industrial streams in 2018–2019 (57 per cent)[6] and exceeds the National Waste Policy Action Plan target of 80 per cent average resource recovery rate from all waste streams by 2030.[7]

The biggest opportunity to further reduce waste in the industry is establishing an end-of-life pathway for turbine blades, which are mainly made of fibreglass and carbon fibre (composite materials).

It is also important to note that composite materials are used by a range of industries, including construction, marine and aviation. The diagram below shows estimated composite waste produced per sector in Europe.

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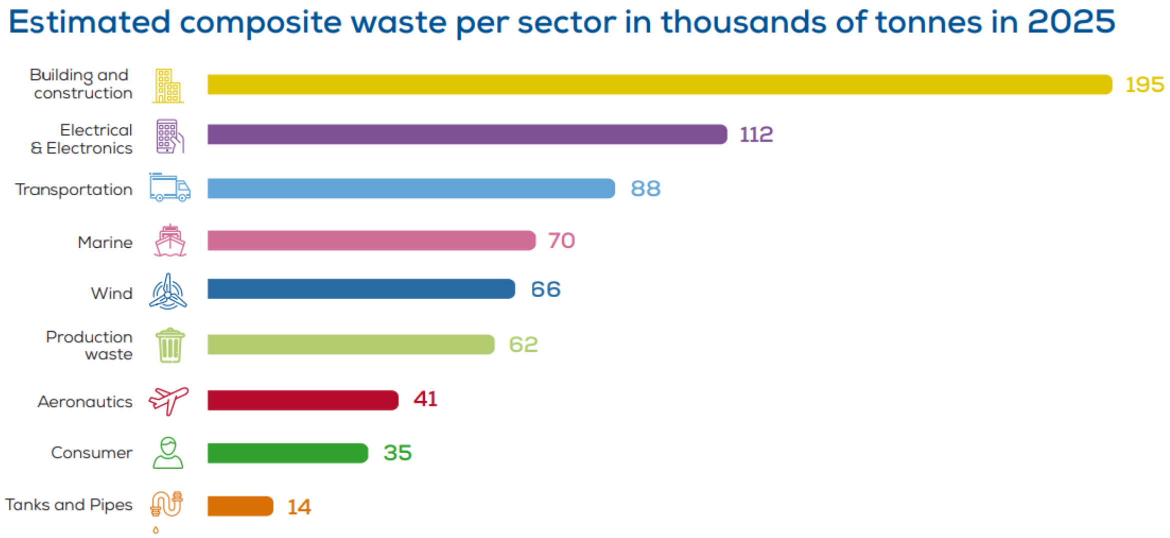
[5] Vestas, *Zero-Waste*, vestas.com/en/sustainability/environment/zero-waste
[6] Department of Agriculture, Water and the Environment, *National Waste Report 2020,* 4 November 2020, dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-report-2020.pdf
[7] Department of Climate Change, Environment, Energy and Water, *National Waste Policy Action Plan 2019,* dcceew.gov.au/sites/default/files/documents/national-waste-policy-action-plan-2019.pdf

Figure 1 | Estimated volume of composite waste in the European Union in 2025.[8]



There are currently very limited commercial or feasible end-of-life options for composite materials, mainly due to the resins that are used to bind the materials, but there are several innovative solutions emerging.

The most common way is mechanically breaking down the blades (cutting, grinding, sorting, sifting) to process the composite materials into short fibres and ground matrix (powder). One example of this process in action is company Continuum in Europe, who recently announced it would open six recycling plants. Continuum mechanically breaks down and separates the blades into their raw, basic materials to create new composites in the form of panels which can then be used by manufacturers.[9]

There are also chemical processes which are in various stages of development. Wind turbine manufacturer Vestas announced in early 2023 that it has developed a chemical process that can break down epoxy resins in existing blades into virgin-grade materials, which can potentially be used to build new blades. According to Vestas, the process relies on widely available chemicals and is therefore able to be scaled up quickly.

Several promising studies are also being undertaken by Australian universities to find a solution to composite recycling. For example, researchers at the School of Materials Science and Engineering at UNSW have been investigating recycling fibreglass plastic into biodegradable silicon for use in agriculture. At the University of Sydney, researchers have developed improved recycling processes for carbon fibres using pyrolysis and oxidisation, with the trial process retaining 90 per cent of the material's original strength.[10]

[8] European Technology & Innovation Platform on Wind Energy, *How wind is going circular: blade recycling*, https://etipwind.eu/files/reports/ETIPWind-How-wind-is-going-circular-blade-recycling.pdf
[9] Continuum – Circular composites for a better tomorrow
[10] The University of Sydney, *Researchers develop improved recycling process for carbon fibres,* 8 March 2021, sydney.edu.au/news-opinion/news/2021/03/08/researchers-develop-improved-recycling-process-for-carbon-fibres.html

Recover

Currently, the main technology for recycling wind turbine blades and other composite waste in Europe is cement co-processing. This process is categorised as energy recovery as the polymer matrix is burned as fuel. Using fibreglass blades as energy recovery reduces the carbon footprint of cement production by up to 16 per cent.[11] This process is currently being used by wind farms in Germany. While only available for fibreglass (not carbon fibre), this option is scalable, simple and cost-effective.

4. Barriers for solar panels

The average lifespan of a high-quality solar PV module is around 25 years, lower quality systems have shorter lifespans. The Clean Energy Regulator estimates that about 3.3 million rooftop solar PV systems had been installed across the nation by the end of October 2022, with a collective capacity of 18.4 GW. The earliest set of solar panels have now started to be decommissioned and, as we approach 2035, the projected amount of waste from retired solar panels in Australia is 100,000 tons. There is currently a very small return from the recycling of constitute materials, and therefore there is currently a relatively low incentive for recycling of solar PV panels to occur.

Solar PV components

The main contributor to the total weight of a typical crystalline silicon PV module is about 75 per cent glass, followed by 10 per cent polymer, 8 per cent aluminium, 5 per cent silicon, 1 per cent copper and small amounts of silver, tin, lead, and other metals and components.

The main barrier to recycling solar PV panels is the difficulty in dissolving the glue which holds the components together within the solar PV panels..

Solar PV recycling in Australia

Currently only the aluminium plates surrounding the solar panels and glass are recyclable within Australia, however there are several companies that are looking to provide material recovery and recycling services for solar panels in Australia using equipment used internationally, such as Solar Recovery Corporation, or already relied upon mechanisms for e-waste recycling, such as Scipher.

The CEC has a working group that focusses on the life cycle of solar PV systems, from manufacturers to recyclers of e-waste including solar PV panels. Currently the working group's main focus is responding to the Department of Climate Change, Energy, the Environment and Water's (**DCCEEW**) consultation papers for the development of an E-stewardship Regulated Scheme.

At present, stakeholders (including general recycling facilities, solar installers and companies waiting on the arrival of solar PV panel recycling machinery) are stockpiling solar panels in wait for a recycling facility to open that can recycle solar PV panels or, in many solar installer cases, awaiting a scheme that can facilitate the resell of second-hand panels.

Currently, there are two streams of solar panels that need to be addressed – solar panels that have reached their end of life, and panels that are being removed early that can still be used.

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[11] Wind Europe, Accelerating Wind Turbine Blade Circularity, May 2020, windeurope.org/wp-content/uploads/files/about-wind/reports/WindEurope-Accelerating-wind-turbine-blade-circularity.pdf

End of life panels

For solar PV panels that have truly reached their end-of-life through age or damage, a regulated scheme is needed to properly decommission, collect, transport and recycle solar PV systems (inclusive of panels, wiring, racking, inverters, batteries etc.). As is being explored through the work with DCCEEW, although still in its infancy, a nationally consistent scheme with appropriate, safe and efficient collection, transportation and recycling mechanisms in place is essential to ensure for an e-stewardship scheme's success. The CEC has also outlined the required input of industry stakeholders in such a scheme – including manufacturers, installers, recycling facilities. This DCCEEW consultation has further highlighted the need for the scheme to be properly regulated to ensure materials (especially hazardous materials such as solar panels and batteries) are diverted from landfill and best practices are followed in all stages of the scheme – from collection mechanisms to acceptance of particular products/materials to how they are recycled.

A potential stewardship program must take on the learnings from the issues that have arisen from the National Television and Computer Recycling Scheme (NTCRS). For example, a known weakness of the NTCRS has been the varying quality of collection services provided from different scheme administrators which has led to pricing disparity and a lack of focus on recycling outcomes. Therefore, if there is a single scheme administrator then it should act as a clearing house which will achieve best outcomes for recyclers. If administrators compete, then pricing pressure is introduced and recyclers, who bear most risk of a product stewardship scheme, are reduced to price takers and recycling outcomes are reduced.

Used panels

The second stream is the increasing number of solar PV panels that are not yet at end-of-life (i.e. are still able to produce a sufficient level of power) but have been removed from houses/buildings to make room for an upgraded system. Given the great technological strides in the development of solar PV panels and its counterparts, solar installers are seeing an increase in homes and businesses upgrading their systems. This may be due to not having sufficient space on roofs to add more panels, so owners are replacing the entire system with newer more efficient solar PV panels, or, given the everchanging technical standards, the original system is no longer compatible with new systems so they need to be replaced in their entirety.

Currently, the CEC runs an Installer and Designer Accreditation Program that is nationally recognises people who have undertaken the necessary training to design and install solar, batteries and other renewable energy systems. However, there is currently no scheme in place regulating the resale or installation of solar panels. As a result, solar installers or the homeowner find themselves in possession of perfectly good solar panels which are only able to be sold through unregulated platforms such as Facebook Marketplace.

Many challenges would need to be overcome to facilitate a market for used solar panels, in particular, ensuring for adequate consumer protections and testing for panel sufficiency.

5. <u>Barriers for batteries</u>

While battery recycling is possible, albeit with varying levels of complexity and safety depending on the type of battery (for example, Lithium Iron Phosphate batteries do not utilise cadmium or nickel), one of the biggest barriers to recycling is safely handling the battery at its end of life. This is of concern for all areas from collection, transport, storage, second-life remanufacturing and materials recovery.

The CEC was recently involved a workshop run by the University of Sydney and Australian Battery Recycling Initiative (ABRI) on creating a lithium battery recycling regulatory framework in New South Wales. The key findings from the workshop included:

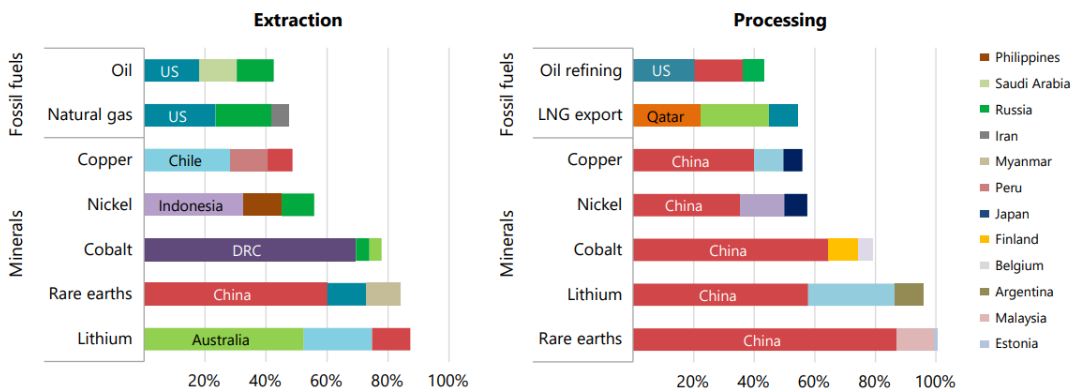
- The most serious risk at end of life is fire. The primary cause of fires is damaged batteries.
    - To reduce the fire risk, it is important to reduce consumer batteries entering waste and landfill streams.
    - There is a significant education task ahead which needs voices appropriate to specific target audience.
    - 'Hidden' embedded batteries present a massive problem and are difficult to manage.
- Issues are amplified in regional/remote areas due to limited technical skills, transport costs, etc
- Large batteries have narrower and more sophisticated reverse logistics chains than consumer batteries.
- Best practice in consolidation/recycling sites is still an evolving space especially storage arrangements.
- Regulation and compliance processes are inconsistent and complex.

We suggest collaboration with ABRI and B-Cycle to further evaluate the existing and potential challenges of batteries (small and large scale) in adopting a circular economy.

What role can a circular economy play in building resilient and circular supply chains for clean energy technologies? What industries or areas should be a focus?

Implementing a circular economy for clean energy technologies could enhance the resilience of the critical minerals supply chain. As noted in the Issues Paper, critical minerals are crucial to the development of clean energy generation and storage technologies, including solar panels, wind turbines, batteries and electric vehicles. While Australia has rich sources of many critical minerals, and is a leading exporter of lithium, the processing of critical minerals is highly concentrated in a few countries, mainly China (see Figure 2). This concentration is increasingly raising concerns about supply chain security, and potential impacts on the clean energy transition.

Figure 2 | Share of top three producing countries in production of selected minerals and fossil fuels, 2019.



Lithium-ion batteries present a key opportunity for recovery and recycling of critical minerals, due to the projected increase in demand for electric vehicles and the high potential for recovery and recycling. Current battery recycling techniques involve pre-processing lithium-ion batteries to create black mass, which typically recycles 85-95 per cent of the battery. Refining black mass to recover critical minerals can recovery up to 80 per cent of lithium, and 95 per cent of nickel and cobalt. At present, pre-processing is not well established in Australia and all black mass is exported overseas for further refining. Domestic refining would add 2-3x the current margin. With a growing supply of lithium-ion batteries, this presents a substantial economic opportunity. However, low feedstock volume presents a challenge to commercial viability in the short term.

Additionally, as raised above, the business of recycling solar panels is neither well-established nor lucrative, despite recycling facilities being able to recover high value nano silicon[12] from solar PV panels. While technically viable, in the absence of economic incentives or policy intervention, the re-use of recycled materials in new products may struggle to compete with the use of virgin materials due to the externalisation of true waste costs from the product lifecycle.

How can the NSW Government facilitate a circular economy for clean energy? What policy options could the NSW Government explore?

1. **Waste bans**

The CEC supports the introduction of waste bans for end-of-life clean energy technologies to divert products from landfill or inappropriate disposal, as well as an important first step in establishing an economy of scale for recycling clean energy products. However, the cost of disposal for existing installed consumer energy resources such as rooftop solar should be subsidised by government. Furthermore, the implementation of a waste ban needs to be carefully coordinated to ensure that there are sufficient holding or pre-processing facilities to safely stockpile and store any waste products to produce a feedstock for future recycling. For example, when Victoria implemented an e-waste ban, the Victorian Government invested $16.5 million to upgrade e-waste collection and storage facilities. As previously noted, it is also imperative a waste ban be tied to the implementation of economic incentives to establish a secondary market for recovered materials, without compromising the deployment of new clean energy assets.

2. **Harmonised regulations**

Given the hazardous nature of end-of-life batteries, storage of these materials must comply with the relevant laws and regulations. One of the challenges identified for the recycling industry is the variance between state regulations, which includes the extent of pre-processing required to declassify end-of-life battery waste as a dangerous good for storage and transport. For example, the CSIRO identified that having a set of comprehensive and consolidated transport regulations across all states and territories, as well as guidelines for import and export could assist the battery recycling industry and the battery manufacturing, importing and retail sectors more broadly.[13] This would apply to other technologies and waste transportation. NSW could play a coordinating role in working with other jurisdictions to align regulations that enable the transport of waste materials.

3. **Build up recycling capabilities**

We recommend that the NSW Government continue to partner with industry and support new and innovative recycling facilities and capabilities to address the growing stockpile of clean energy waste, ie

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[12] Nano silicon is a high value commodity for electronic industries and energy storage in batteries. Recycling silicon from PV panels for making advanced lithium ion batteries | Sustainability Victoria

[13] Australian landscape for lithium ion battery recycling and reuse in 2020 (fbicrc.com.au)

solar panels, batteries and fibreglass blades, as government support will be required to allow the industry, particularly the solar industry at the moment, to be able to manage this pipeline of waste.

The NSW government should also develop partnerships with clean energy industries to support and commission research on innovative recycling solutions, for example the recycling and reuse of fibreglass and carbon fibre. This should include university research into the scalability and commercialisation of recycling processes and pilot programs. It should continue and extend support provided under grant programs such as the Critical Minerals and High-Tech Metals Activation Fund which supported innovation on refining critical minerals from lithium battery waste.

In relation to wind turbine blades (and other products that use composite materials more generally), state environmental protection authorities, including the NSW EPA, should consider composite waste management, including setting goals and pathways for the next decade. These state agencies should engage with key industries, such as the wind industry, to understand the issue and develop solutions to avoid composite waste being disposed into landfill. The government could also support knowledge sharing between composite-using industries, including forums, working groups and online platforms.

Furthermore, there is a gap in the Australian market for mechanical grinding/crushing recycling services, which is critical to allow the establishment of a supply chain for new products that use recycled composite materials. The necessary equipment is available internationally but is currently not commercially viable in Australia and government support could assist with this.

In the case of lithium-ion batteries, commercial equipment to pre-process batteries into shreds costs between AUD$1-2 million, which is significantly cheaper than the cost of processing into black mass (AUD$6 million). Supporting a network of pre-processing facilities at point-of-collection would remove the fire danger associated with storing and transporting end-of-life batteries. If regulation regarding the level of processing required to declassify end-of-life battery waste was harmonised between states, battery waste could be stockpiled and more cost-effectively shipped to a centralised refinery to achieve scale and optimise critical mineral recovery for redeployment into the battery value chain.

What are some additional issues in creating a circular clean energy sector (if any) that haven't been discussed in the issues paper?

A major barrier to implementing a circular clean energy sector is the pace of change and innovation currently occurring. A circular economy is a largely closed system, with limited additional material and energy input. However, new technologies and materials are constantly emerging, making it challenging to develop efficient and cost-effective recycling technologies that can keep up with evolving demand from new inputs. Developing the needed supply chains at scale to enable affordable recovery and recycling will also be a costly, time-consuming undertaking and may struggle to keep up with the latest innovations. The rapid pace of change is evident in the SunDrive case study included in the Issues Paper; if their technology was deployed at a widespread scale, this would significantly affect market demand for recovered silver. These innovations play a critical role in delivering the efficiency improvements required to reduce the cost of transition and accelerate deployment of clean technologies. It is foreseeable that substantial investments in establishing a circular clean energy sector could inhibit innovation, increasing costs for consumers and delaying the energy transition.

Another barrier is uncertainty regarding the scale of future deployment of generation and storage assets. Scale is a major factor in achieving cost-effective recovery and recycling of clean energy assets. According to the 2022 Integrated System Plan (**ISP**), generation and storage capacity to meet domestic demands is most likely to increase 3.3x to 2050. However, a significant unknown affecting the scale of deployment of assets is the quantity of green hydrogen that Australia will produce, which requires substantial renewable assets. The ISP's Hydrogen Superpower scenario requires an increase in gross generation and storage capacity of 8.1x to 2050, with other researchers estimating that realising Australia's hydrogen ambitions would require capacity increases of as much as 44x[14] or 55x[15]. Growing demand is fundamentally at odds with the closed nature of a circular economy. While principles of reuse and recovery can and should be implemented, the clean energy sector cannot be truly circular until it is no longer required to grow.

Thank you for the opportunity to provide feedback on NSW's circular economy. We welcome the opportunity to discuss any of these issues further.

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[14] Net Zero Australia, (2022). Interim results. https://www.netzeroaustralia.net.au/wp-content/uploads/2022/08/Net-Zero-Australia-interim-results-draft-public-version-30-August-22.pdf
[15] Garnaut, R. (2022). The Superpower Transformation. La Trobe University Press.