27 September 2024

Submission to the Productivity Commission's Inquiry into "Opportunities in the circular economy"

circular.economy@pc.gov.au

Dear Sir/Madam

Introduction

The Sustainable Materials Research and Technology (SMaRT) Centre at the University of New South Wales Sydney (UNSW) is pleased to provide this submission in relation to the consultation for the Productivity Commission's Inquiry into "Opportunities in the circular economy".

This submission is on behalf of Professor Veena Sahajwalla and the UNSW SMaRT Centre. She and her respective SMaRT Centre teams have particular expertise in materials science and engineering, especially in relation to research and development of technologies that use waste as "new age resources and feedstock" for advanced manufacturing.

This expertise includes research and development capability across a wide range of wastes and recycling processes to help align recycling and manufacturing and overcome the current limitations in domestic capability in this area by using these wastes as new manufacturing resources, while also reducing the many negative environmental impacts of these waste types and from virgin mining of natural resources.

We have a track record in collaborating with industry sectors and businesses to research and develop innovative, 'circular' solutions that reuse and reform waste into value-added materials and products that align manufacturing and recycling, creating localised supply chains and enhancing sovereign capability.

The Commonwealth Government and its agencies are to be applauded for their work to address energy, waste, recycling and manufacturing challenges, and in particular for producing this consultation on "Opportunities in the circular economy".

Primary response

Our main point is that any circular economy system needs to place a high value on the use of waste streams as a resource or feedstock for new manufacturing (or we should say "re-manufacturing") and products. Any measurement of a circular economy must be weighted strongly in favour of the use of waste as a resource for remanufacturing. Where waste is discarded or incinerated, or in any case where the value is lost, any performance system should not recognise any value for that lost resource.

UNSW SYDNEY NSW 2052 AUSTRALIA

T +61 (2) 9385 1000 | F +61 (2) 9385 0000 | ABN 57 195 873 179 | CRICOS Provider Code 00098G

We believe it is essential in the nation's decarbonisation efforts and those to enhance and secure national capability and capacity for essential materials and future green metals production, that waste be recognised as a high-value input for the various high-tech manufacturing streams the Commonwealth Government is seeking to achieve. An example is the recent federal green metals consultation paper only primarily considered the elements of renewable energy as a production power source and the use of scrap metals in the manufacturing process.

The vital element not included – and which is crucial when considering true sustainability and in creating a circular economy – is the ability to use a variety of waste resources as feedstock within the production and manufacturing processes of various metals. Indeed, the alignment of recycling and manufacturing with respect to metals (and any manufacturing process) is a concept that can most readily shift the sustainability dial for "unlocking Australia's iron, steel, alumina and aluminium opportunity".

The ability to harness the vital materials needed for sovereign capability and renewable energy infrastructure and components is now even more important since the announcement by BHP to close its Australian nickel operations, in addition to foreshadowed copper mine closures.

It is essential we strive to develop a circular economy – or many localised circular economies – in which we keep materials in use for as long as possible via decentralised new green remanufacturing technologies and use these recovered materials to establish new business supply chains. Using "waste as a resource" to build the components and infrastructure needed to electrify our communities is really the only effective safe and sustainable solution for green metals opportunities for Australia. Such an approach would help to create new jobs, along with other economic, social and environmental benefits.

Some emerging technologies and capabilities are available to reform much of the valuable materials contained in many of the "hard to recycle" waste types not subject to traditional waste and recycling processes, such as electronic waste (e-waste), and battery and PV wastes, as well as recovering metals and polymers from millions of tyres, mattresses, appliances and auto waste, into new products and manufacturing feedstock needed to create a truly viable, long terms and sustainable clean energy industry.

But what is missing is the practical, implementation stage for R&D for industrial application, so that existing university-developed technologies can be industrialised and scaled. By successfully piloting and implementing such technologies means local SMEs using these emerging capabilities can become part of new supply chains and help develop 'green manufacturing' capability by adopting solutions like those developed by the UNSW SMaRT Centre, such as our decentralised MICROfactorie™ Technology solutions for creating value from waste, especially at sites where wastes are located.

This approach would drive local and regional solutions for hi-tech waste recycling and manufacturing, especially in capturing metals and other essential materials from waste, reforming them into high value materials to help obviate the need for mining, transportation

and processing of natural resources which collectively create negative environmental, economic and social impacts.

In summary, we must broaden current thinking so that future strategies related to creating circular economies, for sustainability, criterial materials and enhancing sovereign capability, and for those strategies and plans to be truly safe and sustainable, must fully account for:

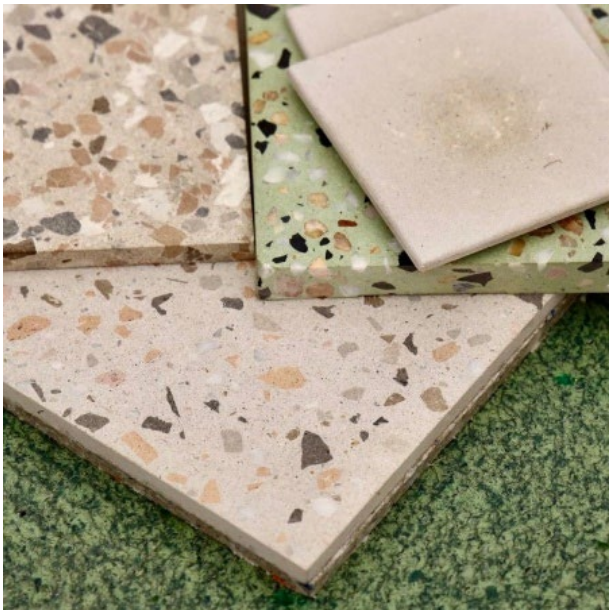
- New age resources derived from high tech recycling
- Valuing what are currently seen as low or no value wastes
- New opportunities from the alignment of recycling and manufacturing
- Support and expansion of emerging remanufacturing technologies.

Case study - Shoalhaven Green Ceramics MICROfactorie™

The Shoalhaven Green Ceramics MICROfactorie™ has been operating under a partnership model between the UNSW SMaRT Centre, Shoalhaven City Council, and Kandui Technologies, using SMaRT's patented Green Ceramics technology since 2022.

SMaRT has three current MICROfactorie™ Technologies operating commercially. Modules for each of these are located at UNSW SMaRT Centre and various others are being independently operated under licence. Of the three modules independently and commercially operated, one module type is for Green Ceramics which reforms waste textiles and problematic glass and other waste materials into a wide range of ceramics for the build environment, such as floor and wall tiles and table and benchtops.

The Shoalhaven Green Ceramics MICROfactorie™ is able to find new uses for many tonnes of waste glass (often composite and layered glass) and textiles that either can't be recycled or reused in some manner that would have gone into landfill or potentially shipped overseas for an uncertain future. Kandui and the council have created new jobs using the technology and are now extracting a high value from the waste they are reforming into highly sought after ceramics that do not have any of the silicosis concerns and issues of many other natural stone products.



Using waste in this way also reduces the many negative impacts of quarrying and transportation.

The Green Ceramics MICROfactorie™ facility is able to generate economic, social and environmental benefits and outcomes using these many tonnes of waste materials where there were none previously.

This MICROfactorie™ can process around 450 tonnes of glass, mattresses and other textiles per year, but it is part of a much bigger concept – the movement towards a 'circular economy', which aims to reduce the 'throw-away', consumer economy that relies on continuous extraction and use of raw materials and production of huge amounts of waste.

Instead, production and consumption are aimed at minimising resource extraction, cutting down waste and lowering carbon emissions. Sustainability in every step in the cycle is the goal.

Other issues to consider

Technologies

Manufacturing of renewal energy technologies – and the significant amount of infrastructure and related components required to bring them online, operationalise and maintain them – are currently dependent almost entirely on finite natural resources that need to me mined, transported and processed. This environmental impact can be both mitigated and reduced by using waste materials as the manufacturing feedstock needed to build these technologies and related infrastructure and components.

Some emerging technologies and capabilities are currently available to reform much of the valuable materials contained in electronic waste (e-waste), PV waste, old batteries, as well as recovering metals and polymers from millions of tyres, mattresses, appliances and auto waste, into new products and manufacturing feedstock needed to create a truly viable, long terms and sustainable clean energy industry. But support to scale these "new age resources" is lacking. With the right support, such materials reformation technology could sit

side by side with the manufacturing processes required to make all of the renewable technologies and systems required to electrify society. This means local SMEs using these emerging recycling capabilities can become part of new supply chains and help develop 'green manufacturing' capability by adopting solutions like those developed by the UNSW SMaRT Centre, such as our various decentralised MICROfactorie™ Technologies solutions for creating value from waste.

This approach would drive local and regional solutions for hi-tech waste recycling and manufacturing, especially in capturing metals and other essential materials from waste, reforming them into high value materials to help minimise the need for mining, transportation and processing of natural resources which collectively create negative environmental, economic and social impacts.

Barriers

The main barrier for industry in adopting circular actions currently is that there is little commercial incentive for industry to adopt circular economy capabilities. As mentioned above, using waste as a resource must be a central aspect of any framework to develop a circular economy for clean energy. Companies also generally base their supply chains on the fundamental economic principles of lowest cost and maximum convenience (or efficiency).

Australian Bureau of Statistics' latest waste estimate figures show the Australian economy domestically generated 539,000 tonnes of e-waste in 2019, with more than 50% going to landfill and only 17.4% being claimed as recycled but much of this goes offshore where outcomes are unknown, yet it is classified as 'recycled'. The Australian Government Implementation of the National Waste Policy Action Plan, announced on 12 September 2022, presents seven national targets to guide investment and national efforts to avoid waste and improve resource recovery to 2030 and targeted 80% average resource recovery rate from all waste streams, but these targets will never be achieved without government action including new requirements around using waste as a resource.

The NSW Waste and Sustainable Materials Strategy contains many objectives and targets, including:

- Reduce total waste generated by 10% per person by 2030
- Have an 80% average recovery rate from all waste streams by 2030
- Significantly increase the use of recycled content by governments and industry.

Opportunities

In the battery market, for instance, Australia has huge prospect in the field of rechargeable batteries (like Li-ion battery, Ni-MH battery, etc.). Australia can use the advantages of having huge mineral resource of expensive and high-tech and critical or essential metals like Li, Mn,

Co, and Ni. These metals are very crucial for manufacturing the rechargeable batteries. Currently in Australia, the battery market is dominated by lead acid battery (82%), while other batteries like alkaline battery, Li-ion battery, Ni-MH battery, etc. control the rest of the battery market. But this scenario is changing rapidly.

It is predicted that within 2030 financial year stocks of lithium-ion batteries are projected to be 1.3 million tonnes, compared with lead acid battery stocks of 0.4 million tonnes. By 2050 lithium-ion battery stocks are projected to be well over 7 million tonnes, and lead acid battery stocks are forecast to have fallen to 0.3 million tonnes. So, it is easy to understand that within next few years Li-ion battery will dominate the battery market in Australia.

Economic, social and governance (ESG) benefits

The greatest opportunity for Australia is at the end portion of supply chains where we could create a high-tech recycling industry to provide processed-ready (and environmentally sustainable) feedstock to manufacture the components and infrastructure needed to have a viable clean energy industry.

In comparison with other developed countries, Australia is lagging in recycling and aligning recycling with manufacturing. For instance, Australia's battery recycling rate of around 6 to 7% compares to a rate in Europe of around 50%. China and South Korea combined make up 20% of the world's waste battery recycling effort. This means Australia has an opportunity to add value of many thousands of dollars' worth per tonnes of batteries.

In much of the dialogue around sovereign capability and manufacturing, using waste as a resource is either a missing aspect or it does not play a central role. For our clean energy industry, high-tech e-waste and battery recycling enabling these complex waste stream items to be taken back to their individual input materials so they can be used over again and again, should be central to the vision of creating a clean energy industry.

In relation to battery and minerals security and capability, recovering valuable materials from waste must play a central role in helping to manufacture the components needed to electrifying the world as we move towards renewable energies relying on storage and reducing our carbon footprint. Many of the commodities and essential materials needed for this electrification are being subject to record prices and supply constraint issues, but ironically society throws away many of these materials in the forms of e-waste, batteries and solar PV waste, for example.

Building such capability when left to the market alone will not achieve the vision. A collaborative model needs to be adopted so industry has government regulatory and funding support to work with researchers to do the R&D work needed to build the capability. Mapping and planning of essential infrastructure is also central to managing the immediate challenges facing the sector. Government and industry have a role to play in planning and implementing adaptive and sustainable infrastructure and related components (like for storage), with

recycled content also to be used as feedstock, which can facilitate the transition towards circular economy goals highlighted by this and various other NSW strategies, actions plans and objectives.

By way of example, the Senate Environment and Communications References Committee Inquiry into Waste and Recycling Report 2018 found the importance of investment in infrastructure for the collection and processing of recycled material and diverting waste from landfill. It said, "this infrastructure is needed both to enable regions to participate in recycling programs and to reduce contamination rates, and the report noted evidence that "to reduce the contamination rate of recyclable materials, investment in material recovery facilities (MRFs) is required". That report also highlighted the benefit of the MICROfactorie™ concept. Furthermore, the Waste Ban Response Strategy released March 2020 added weight (p16) to the argument of centralised support for new and innovative processes and infrastructure, saying "significant challenge raised in industry consultation is the ability for businesses to secure investment for facilities and equipment upgrades, and to develop and test new technologies for creating value-added products from waste".

It went on: "Governments have a role to play in ensuring that viable proposals from start-ups and small and medium enterprises receive the support they need to scale up, achieve commercialisation, and compete in the open market. Support offered could involve access to test facilities, expert knowledge, and seed funding for cross-sectoral approaches to solving waste challenges. *All governments opportunity: Investigate opportunities for regional micro-factories, to enable regional and remote areas to process locally generated waste resources into useful value-added products for community benefit.*"

Commercialisation of such technology / infrastructure will be slower than needed if left to market forces alone. Incentives from governments (regulatory and financial) will accelerate greater take up and rollout of existing capability across the value-chain. A circular economy – or many localised circular economies – need a strong guiding hand including a range of standards, targets, incentives and funding support. The forecast says within next few years Li-ion batteries will dominate the battery market and within 2025, 75% of rechargeable battery market will be LIBs. What is urgently needed is a framework to encourage government, industry and researchers to develop high-tech recycling capability, which would also reduce the pressure on mining and contribute to essential materials supply. The natural reserve of Co, Li, Ni, and graphite is limited. And these materials are indispensable in battery and other clean energy component manufacturing. To establish a viable and growth-oriented clean energy industry, it is essential to ensure a sustainable materials supply.

There are around 100 Material Recovery Facilities (MRFs) operating in Australia which separate out the different materials for recycling. Among them only a few are able to recycle some spent batteries. Therefore, a more efficient and decentralised way of recycling of battery waste is imperative. Moreover, the world is expected to produce 11 million tons of spent LIB by 2030, so Australia has a huge opportunity of leading with high-tech recycling of spent batteries by taking it from other countries and converting to a much higher value.

Scalable MICROfactories™ do not need very large amounts of capital compared to conventional facilities, rather can be incorporated to existing recycling, manufacturing and innovation precinct facilities. So, what are other MICROfactorie™ Technologies? SMaRT's e-waste and battery waste recycling technology modules can recover metals contained in those waste streams as feedstock for the clean energy sector to help create a true and sustainable circular economy. Various other modules are also currently operating at various sites in metro and regional NSW. Modules for each of these are located at UNSW SMaRT Centre and various others are being independently operated under licence, including in regional NSW and several are under development in the South Coast region of NSW.

In addition to the above mentioned Green Ceramics module which reforms waste textiles and problematic glass, plastics and other materials into a wide range of ceramics for the build environment, we are commercialising with industry partners a plastics module and green aluminium module. The Plastic Filament MICROfactorie™ operated by Renew IT in Lane Cove, Sydney transforms plastic parts from office equipment into long spools of filament that can be fed into 3D printers. Another module in development produces Green Aluminium from aluminium packaging such as coffee pods and problematic, layered (multi-materials) food packing, as a feedstock ready for manufacturing that requires no further processing. This module is being developed by manufacturer Jamestrong Packaging with support from the Commonwealth's Trailblazer program.

SMaRT's Green Metals (essential materials) scientific work is now looking at processes to extract metals and alloys from electronic waste (such as computers, phones) in an effort to help supply the materials required for the renewable energy and future manufacturing needs. This approach will provide the foundation for recovery of high-value materials to boost supply networks for local manufacturing and remanufacturing, and open export market opportunities for new technology and its recovered materials.

With the growth in electric vehicles, wind turbines, domestic solar systems, and so many batteries needed including for the huge range of electronic devices such as phones and computers, it is often overlooked that almost all of the materials needed to electrify our world are finite in supply. Most are subject to increasing costs (environmental and economic) and supply chain constraints. And this is where waste recycling technology as outlined must play a major leading role in helping Australia meet its national challenges and priorities.

The SMaRT Centre has developed various technologies and innovative solutions to enable a new era of 'remanufacturing' for metals that brings together waste resources and builds a circular economy. For example, waste rubber resources can and are being used as feedstock to generate in-situ hydrogen for metal production [1], as an alternative to coke and coal. By effectively producing hydrogen from waste materials, using non-metallic waste, a novel approach to a greener steelmaking process has been created with a reduced carbon footprint [2]. SMaRT's Green Steel™ Polymer Injection Technology (PIT) [3, 4], for electric arc furnace (EAF) steelmaking, not only lessens the need for coke or coal but simultaneously improves the steel manufacturing process efficiency, and increases the yield [5, 6]. Our next generation of research into Green Steel Polymer Injection Technology™ is

able to use waste coffee grounds as another alternative source to coke and coal as reducing and slag foaming agents in making of iron and steel. Our ambition is to be able to one day use 100 per cent waste as a replacement for coal and coke in EAF steel making.

Incentives

Decisions made around sustainability initiatives cannot be based purely on financial costs to the business. Instead, steelmakers/metal manufacturers must act with all stakeholders in mind and be prepared to make a balanced trade-off between industry, end consumers and the environment. Targetted incentives are likely the only way commercially driven industries will adopt new technologies. Aligning stakeholders will be critical to quicken the pace of change needed and to enable the collaboration required to co-develop feasible solutions to complex challenges.

Metals, such as, steel, aluminium, etc. are some of the world's most sustainable materials — permanent, forever reusable and the most recycled substance on the planet. Building a more sustainable production process is a long-term investment that will yield enormous environmental benefits over the full life cycle of green metals. Incentives, targets and regulation together will enable a greater uptake of innovation by industry and the waste and recycling sectors and for the transition to more rapidly take place to truly achieve a circular economy through remanufacturing. Innovative supply chains based on such new technologies that align sectors with waste as a feedstock for manufacturing is needed to create a true circular economy and realistically enhance sovereign capability while creating new job and export opportunities.

Businesses and organisations generally rely on traditional supply chains where reformed materials are usually not part of the system. We need to ensure alternative solutions to current common supply chain practices adopt new and local supply chains that incorporate the use of resources made from our waste resources. Technologies such as MICROfactories™ can enable the lateral integration of different industrial sectors to achieve various stated goals in issues paper, by recovering and reforming so-called waste materials to create new and localised supply chains, materials and products, offering economic and environmental benefits including new, skilled jobs.

The science and technology we already have available can provide a pathway to make it possible for a complicated waste stream to produce value-added materials which can then feed back into remanufacturing or to different industrial supply chains for manufacturing products. This proposed emerging model will profoundly disrupt today's centralised, vertically integrated model of production, where, for instance, a single material or part available only from an overseas supplier can disrupt the manufacturing process.

The UNSW SMaRT Centre strongly supports aims to develop supports to establish circular economies and to secure the future of essential materials for future needs. In terms of achieving the outcomes sought, what is needed is a coordinated, systematic process around ensuring waste as a recourse is part of any enabling remanufacturing and a circular economy. The hi-tech recycling of the many problematic wastes not normally subject to

traditional recycling services, and using the recovered materials as feedstock for future clean energy manufacturing needs, should be an urgent priority.

In conclusion

Incentives, targets and stronger regulation together will enable a greater uptake of innovation by industry and the waste and recycling sectors and for the transition to more rapidly take place to truly achieve a circular economy. Businesses and organisations generally rely on traditional supply chains where recycled content and materials are usually not part of the system. We need to ensure alternative solutions to current common supply chain practices adopt new and local supply chains that incorporate the use of resources made from our waste resources.

Technologies such as MICROfactories™ can enable the lateral integration of different industrial sectors to achieve various stated goals in issues paper, by recovering and reforming so-called waste materials to create new and localised supply chains, materials and products, offering economic and environmental benefits including new, skilled jobs.

The science and technology we already have available can now make it possible for a complicated waste stream to produce value-added materials which can then feed back into local manufacturing or to different industrial supply chains for remanufacturing products. This proposed emerging model will profoundly disrupt today's centralised, vertically integrated model of production, where, for instance, a single material or part available only from an overseas supplier can disrupt the traditional manufacturing process.

Yours sincerely

Stuart Snell
Head of Strategy, Stakeholders and Communication
UNSW SMaRT Centre

For and on behalf of:-
Scientia Professor Veena Sahajwalla
Director, UNSW SMaRT Centre

Ref:

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