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Sustainable Materials Research & Technology

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Submission to the NSW Critical Minerals and High-tech Metals Strategy Consultation

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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 to the NSW Critical Minerals and High-tech Metals Strategy Consultation.

Professor Veena Sahajwalla is Director of the UNSW SMaRT Centre, Director of the ARC Industrial Transformation Research Hub into Microrecycling of Battery and Consumer Wastes, and is Leader of the new national Sustainable Communities and Waste Hub. She and her respective teams have particular expertise in materials science and engineering, and helping to reduce waste through recycling science and innovative manufacturing technologies. This includes research and development expertise in novel battery recycling processes to overcome the current limitations in domestic capability in this area.

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 NSW Government and its agencies are to be applauded for their ongoing work to address energy, waste, recycling and manufacturing challenges, and in particular for producing this consultation around securing essential materials and high-tech metals. It is essential we strive to develop a circular economy – or many localised circular economies – in which we keep essential materials in use for as long as possible and use these recovered materials to establish new business supply chains, in order to better ensure we use "waste as a resource" to build the components and infrastructure needed to electrify our communities. So, 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 electronic waste (e-waste), PV waste and old batteries into new products and manufacturing feedstock needed to create a truly viable, long terms and sustainable clean energy industry. This 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™ 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.

Key responses to consultation points

Barriers

The main barrier currently is that there is little commercial incentive for industry to adopt circular economy capabilities. As mentioned in our introduction, 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).

Energy Renaissance has been building a factory in regional NSW that will start off with a manufacturing model similar to PowerPlus Energy. It hopes to supply the more commercial end of the energy storage market, such as schools and shopping centres. They said that unless mineral processing really starts in Australia, they are unable to buy what they need domestically to make their products. The company says in public comments: “The processing of minerals to battery grade, the volume we need just isn't here yet. What the country has missed is a reliable buyer of battery-grade minerals”. So, it is clear that there is shortage of battery grade materials. Both processing and high-tech recycling can overcome this gap. Yet the hi-tech recycling of e-waste and other complex waste streams can deliver process-ready feedstock of these sorts of essential materials.

A Future Battery Industries Cooperative Research Centre (FBICRC) report found barriers to a booming battery market include a lack of capital to build facilities, higher Australian wages, and a lack of specialists. However, it noted that wage costs were not always that much higher than other markets also making batteries, such as Japan, South Korea, and Germany. A main obstacle is the shortage of battery grade materials and lack of mineral processing. Or, a lack of high-tech battery recycling to produce the battery grade materials needed for onshore manufacturing capability. We believe such a recycling capability will, in the long run, be far more beneficial in terms of economic, environmental and social gains. The metals and materials in spent battery are already in refined form. Recycling can reduce the pressure on mineral processing and also create an export opportunity by supplying battery grade materials to overseas markets.

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, innovative recycling and remanufacturing should play a leading role in any circular economy strategy. Australia’s waste and resource recovery industry is being increasingly challenged by complex e-waste and other problematics wastes such as PV solar panels, textiles and all other waste streams that are not subject to traditional recycling processes.

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.

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.

NSW EPA performance data show that NSW is not on track to achieve these targets. Furthermore, current Australian traditional recycling facilities are limited to pre-processing or partial mechanical processing which can separate, dismantle or shred only. There are only limited decentralised technologies for the effective isolation of the valuable metal alloys, REEs (rare earth elements) and essential metals contained in e-waste.

Opportunities

In the battery market, for instance, NSW 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. And NSW (and Australia) has huge prospect in this Li-ion battery manufacturing sector due her mineral resources. Government can play a big role in this perspective by patronising the battery manufacturing industry and all those associated with clean energy, including hi-tech recycling as mentioned.

If Government was to make a policy such as requiring that 50% of Li-ion battery demand to be fulfilled by internal battery manufacturers by 2030 and 80% of Li-ion battery demand to be fulfilled by 2050, that is likely to boost the economy while reducing our dependency on international battery suppliers. Spent batteries like Li-ion batteries, Ni-MH batteries, etc. are essentially an “above ground metals mine” capable of delivering the many of the materials needed to build batteries. The environmental benefits, let alone positive economic and social impacts, would be enormous. At the end of 2019–20 it is estimated that 176,000 tonnes of batteries reached their end-of-life. But only around 6-7% of these batteries were recycled.

Economic, social and governance (ESG) benefits

The greatest opportunity for NSW (and 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 is being left behind, and this lost value could be between AUD $4,400 and $17,200/ton 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. Given the CSIRO's April 2019 forecast that the amount of discarded LIBs in Australia will grow from the 3,300 tonnes recorded in 2016 to between 100,000 and 188,000 tonnes by 2036, 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 at Cootamundra in regional NSW and several are under development in the South Coast region of NSW. Of the regional sites, one module type is for Green Ceramics which reforms waste textiles and problematic glass, plastics and other materials into a wide range of ceramics for the build environment. Another is for Plastics Ecofilament which reforms toner cartridges, and a range of e-waste plastics not being recycled, into filament for 3D printing and manufacturing. 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. MICROfactorie™ modules are small but scalable and can operate in rural, regional and even remote locations and benefits also include creating new decentralised supply chains. Such technologies have strong potential to create jobs throughout the material value chain, from research and development, through to services and manufacturing.

SMaRT's Green Metals (essential materials) modules have the capability to extract metals and alloys, rare earth metals (such as aluminium, copper, cobalt, gold and many others) from electronic waste (such as computers, phones, batteries etc). In term of materials and critical materials, thermally isolated materials by an e-waste MICROfactorie™ process, such

as Neodymium, Lanthanum, Cerium, Lithium, Nickel, Zinc, Cobalt, Graphite, Copper and Tin, are critical in supplying materials required for the renewable energy, and future manufacturing sectors including batteries. 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.

In conclusion

Many of the materials needed for clean energy equipment, national battery capability and future electrification components are subject to supply and price constraints and we are landfilling waste containing many of the valuable materials needed to manufacture these items. According to the 2021 E-Product Stewardship in Australia Evidence Report, "valuable materials like copper, silver and silicon can be extracted for high-value use in industries such as electric vehicle batteries" but unfortunately there is almost no recycling or recovery of these materials taking place because of a lack of capability. This is mainly due to obstacles such as cost, time and a lack of a collaboration ecosystem between industry partners and researchers. Addressing this gap would be an important step.

We strongly support the aims of NSW to develop supports to establish circular economies and to secure the future of essential materials. One of the challenges is a lack of facilities and cost barriers for industry, NGOs and councils, as well as technology implementation to enable problematic wastes to be recycled and reformed into valuable materials for use again. 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 circular and clean energy framework. 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.

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 with broad ESG benefits. 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. Given the severe impacts on global supply chains from COVID-19 impacts, the future of global manufacturing lies in small-scale, decentralised technology that will enable communities to produce many of the products, materials and resources they need locally by using resources largely derived from local materials that are unwanted or thought of as waste.

Technologies such as MICROfactories™ can enable the lateral integration of different industrial sectors to achieve various stated goals in various NSW strategies, 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 battery manufacturing or to different industrial supply chains for manufacturing products to electrify our nation. 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.

Yours sincerely

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