Australian Academy of
Technology & Engineering

To the Senate Standing Committee on Economics and Employment,

Thank you again for inviting the Australian Academy of Technology and Engineering to provide evidence to the Inquiry into Australia's Manufacturing Sector.

As requested, we provide here answers to the questions on notice taken during the hearing as well as to those provided to the Academy of Technology and Engineering after the hearing.

ATSE is very happy to provide any further information the committee may require. We also look forward to engaging with the committee on future inquiries.

Yours sincerely

Professor Hugh Bradlow
President

Kylie Walker
Chief Executive Officer

Questions taken after the hearing

1. *Your submission specifically called on Australia to leverage decarbonisation strategies and renewables to develop new areas of competitive advantage. Could you expand upon where you see these new areas of competitive advantage emerging, and what decarbonisation policies you think would be necessary to enable growth in those sectors?*

Australia is in a unique position to develop a competitive advantage, particularly regarding product stewardship for renewable technologies like solar photovoltaic (PV) panels. Product stewardship considers the entire lifecycle of a product including the end of its useful life and how products or parts of a product can be recycled as part of a circular economy. As solar panels continue to be installed on Australian homes in record numbers, and large-scale solar farms becoming more prevalent, solar waste is expected to rapid increase. ATSE's Towards a Waste Free Future[1] highlights this issue as a key area of opportunity for Australian advanced manufacturing. Solar PV recycling across Australia offers an opportunity for the Federal government to design a national process, as outlined by leading work of Sustainability Victoria.[2] One of Australia's first solar PV recycling facilities is up and running in Melbourne's north. Solar panel recycling will help: conserve the supplies of the finite resources used to manufacture the panels and provide materials to be reused for producing new solar panels[3].[OBJ]A national approach to redesigning the end-to-end process of recycling so that it aligns with manufacturing would create significant opportunity for sector growth and jobs creation [4][OBJ]

Australia's mineral resources also provide a competitive advantage in the production of electric vehicles and their batteries. Existing domestic car manufacturing facilities could also be refitted for the purpose of manufacturing EVs. There is also an opportunity to scale up technologies for recycling electric batteries and, more importantly, permanent magnets for the recovery of scarce rare earth metals (e.g., dysprosium) that are currently limiting the number of permanent magnets that can be produced which in turn limits the number of wind power generators that can be produced (which accounts for around 90 percent of the world production of dysprosium)[5].

Decarbonisation offers opportunities in manufacturing beyond simply reducing carbon emissions. Innovative ideas that improve current processes and, for example, reduce food waste and improve steel production, are now coming to the fore. Research into coal-free steel manufacturing has led to innovations including the use of spent coffee grounds as high-grade coking material.[6]

While these ideas are already being developed by Australia's world-class researchers, opportunities for commercialisation still require improvements. Policy and incentive frameworks can provide powerful frameworks for supporting greater application and commercialisation of Australian research. There are policies currently being developed to improve this commercialization: for details, ATSE draws

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[1] Australian Academy of Technology and Engineering, 2020, Towards a Waste Free Future, https://www.atse.org.au/research-and-policy/publications/publication/towards-a-waste-free-future/

[2] Sustainability Victoria, 2021, National Approach to Manage Solar Panel, Inverter, and Battery lifecycles, https://www.sustainability.vic.gov.au/research-data-and-insights/research/recycling-and-reducing-waste/national-approach-to-manage-solar-panel-inverter-and-battery-lifecycles

[3] Reclaim PV Recycling - solar panels recycling Australia

[4] Sustainability Victoria, 2021, National Approach to Manage Solar Panel, Inverter, and Battery lifecycles, https://www.sustainability.vic.gov.au/research-data-and-insights/research/recycling-and-reducing-waste/national-approach-to-manage-solar-panel-inverter-and-battery-lifecycles

[5] Pei, M., Petäjäniemi, M., Regnell, A., & Wijk, O. (2020). Toward a fossil free future with hybrit: Development of iron and steelmaking technology in Sweden and Finland. Metals, 10(7), 972; doi:10.3390/met10070972

[6] Biswal. S, Pahlevani. F, & Sahajwalla. V, 2021, Synthesis of Value-Added Ferrous Material from Electric Arc Furnace (EAF) Slag and Spent Coffee Grounds, https://link.springer.com/article/10.1007%2Fs11837-021-04678-y

the committee's attention to our previous work on this topic as it relates to University Research Commercialisation. [7]

2. *Following on from that, your submission called for more support for renewables and electrification. At the state level, we've seen a significant level of coordination to enable renewables through Renewable Energy Zones and the like, but at the federal level, I think it's fair to say that support for renewables and electrification has been a bit less enthusiastic. With that in mind, what more do you think the federal government could be doing to support this transition?*

Readily available and existing technology has the capacity to reduce most of Australia's emissions; future technologies will likely be required for complete transition to a net zero economy. If these technologies are to be developed and implemented in time to reduce the most severe impacts of climate change, ATSE believes more ambitious carbon reduction targets for 2030 must be introduced to encourage private, government and philanthropic investment. Short-term gains can be achieved with significant financial investment and strong federal policy settings that encourage and co-ordinate with industry.

Specific examples of where the federal government could contribute to facilitate a coordinated renewable and electrified technology deployment are:

- **Electric Vehicles:** federal policy should encourage Australians to choose EVs over petrol or diesel cars.[8] International examples show subsidies and incentives can shift the general population towards choosing low-emission cars. As specifically identified in ATSE's Transport Industry Technology Readiness[9] report, there is an opportunity for Australia to become a leading manufacturer of next generation battery technologies, including those specifically relevant to our climate. The report also reiterates that skills in manufacturing are a challenge that limits the readiness of Australia to take advantage of electric vehicle technologies. Government initiatives to support upskilling or reskilling the heavy industry workforce to take advantage of the opportunity could support the transition.
- **Solar and wind energy:** while the Australian Government's Low Emissions Technology Investment Roadmap and subsequent statements focus attention on emerging low-emissions technologies, they explicitly keep investment in mature technologies out of scope, instead calling on industry to make investments to support their widespread rollout. Along with emerging technologies ATSE also encourages investment in the deployment of mature energy technologies.[10] Greater federal support in deploying mature technologies will provide manufacturing opportunities now as well as deeper cuts to emissions sooner.
- Without Federal funding for mature technology deployment, or a national framework to guide industry-funded deployment of technology, it will be much more difficult for

[7] Australian Academy of Technology and Engineering, 2021, University Research Commercialisation Scheme consultation paper, https://www.atse.org.au/research-and-policy/publications/publication/urcs-consultation-paper

[8] Thomas. D, & Mareels. I, Can we break the petrol habit? https://www.atse.org.au/news-and-events/article/can-we-break-the-petrol-habit/

[9] Australian Academy of Technology and Engineering, 2019, Transport Industry Technology Readiness, https://www.atse.org.au/research-and-policy/publications/publication/transport-industry-technology-readiness/

[10] Australian Academy of Technology and Engineering, 2021, Australia's technology-led transition to net zero emissions, https://www.atse.org.au/research-and-policy/publications/publication/australias-technology-led-transition-to-net-zero-emissions/

Australia's manufacturing sector to support and realise the full potential of both mature and emerging technologies to achieve emissions reduction.

3. *Your submission called on Australia to leverage R&D spending and government procurement to prioritise Australian-made products. Procurement has been a feature of many submissions to this inquiry, so I was hoping that you might expand on what sort of procurement changes you would see as beneficial to supporting the growth of the Australian manufacturing sector?*

As outlined by ATSE's submission to the Senate Standing Committee on Economics The Australian Manufacturing Industry[11], Government procurement processes should be updated to require supporting Australian-made products. This would support developing sustainable local industries and could stimulate innovation across the manufacturing industry which would in turn result in demand creation.

Procurement has the potential to offer the scale and sophistication of demand required for Australia to become a leading market for selected innovative technologies embodied in new products in sectors where the public sector is the primary customer or beneficiary. It has been discovered that public procurement has the largest impact on the environment for:

- firms that are aware of the opportunity and can participate in a way that suits their resources.
- smaller firms.
- firms in regional areas.
- firms active in distributive and technological services.
- firms with limited resources. As orders from public entities are typically relatively large and lower risk, firms have the necessary certainty to engage in innovation activities which may otherwise be too expensive or risky. Public procurement also provides such firms with immediate sales opportunities, as opposed to support for research, which requires additional investments for exploitation in the future.

Clearly there are limits on how public procurement tenders can be tailored to specific firm characteristics and this may conflict with competition policies, but the results indicate they have large immediate impacts on innovation outputs in many small firms. The potential for economic benefit through the stimulation of innovation by government procurement has been acknowledged in a 2009 document by the OECD:

Governments not only play the role of 'rule setters' but are increasingly a central innovation actor playing within those rules. Demographic pressures, burgeoning demands, higher public expectations, and ever-tighter fiscal constraints mean that the public sector is seeking innovative solutions to enhance productivity, contain costs and boost public satisfaction. The innovation imperative is therefore equally strong for the public sector itself. Governments can also contribute to creating demand for innovation through public procurement. (p. 11)[12].

Public procurement is one of the most direct forms of stimulating innovation by means of demand. To stimulate private sector innovation by creating demand, a public agency can perform direct procurement (buying something to fulfil intrinsic needs), act as a proxy customer (e.g., by creating standards) or as a linkage creator between suppliers and users. Public procurement can create new markets (e.g., for emerging solutions such as digital hearing aids, etc.) and to drive sustainable products

[11] Australian Academy of Technology and Engineering, 2021, Inquiry into the Australian Manufacturing Industry, https://www.atse.org.au/research-and-policy/publications/publication/inquiry-into-the-australian-manufacturing-industry/

[12] https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=C/MIN(2009)8&docLanguage=En

and solutions. Researchers conclude that procurement policy is a more efficient instrument to use in stimulating innovation than any of a wide range of frequently used R&D subsidies.

Public procurement plays a fundamentally distinct role in relation to market development:

- Market creation occurs when there does not yet exist any established market for the offering that is being procured.
- Market escalation occurs in cases where a market has been established for a new or alternative technology but requires further development for the technology to succeed commercially. Many initiatives in cooperative public procurement fall into this category.
- Market consolidation occurs when technical standards or performance criteria are standardised to coordinate and concentrate demand within the public sector. Establishing 'critical' mass for the acceptance of new or alternative technologies eventually leads to similar developments with respect to the patterning of private demand.

The key barriers to using procurement to drive innovation are:

- lack of expertise, professionalism, and knowledge of procurers
- limited interaction between procurers and suppliers
- absence of a strategy to link policy objectives, procurement, and market/ technology developments
- perceived conflict between value for money and innovation
- tendency to favour lowest cost bids
- fragmented markets
- limited networking and collaboration between procurers.

In ATSE's submission to the Department of Industry, Science, Energy and Resources on Modern Manufacturing Roadmaps [13] , the Academy advised that procurement should be made in areas where Australia already has a competitive advantage. This includes the medical products, recycling and clean energy, resources and minerals, and food and beverages sectors. Using the buying power of government procurement mechanisms specifically in these areas would bolster domestic demand for these products enabling industry to invest in these areas of advantage.

A complete list of existing products where Australia has an existing or potential revealed comparative advantage (RCA) can be found in: Roos, G., Shroff, Z., Gamble, H., Taylor, P., Mares, T., Esvelt-Allen, R., & Baird, A. (2018). *Smart Specialisation-Insights for a Future Industry Policy*. Economic Development Board of South Australia. Government of South Australia. Adelaide, South Australia

4. *Your submission also called on Australia to target its R&D at SMEs that do not have the capability to independently fund R&D. This inquiry has heard that Australia's R&D support for business remains well below the OECD average. What changes would you like to see in the R&D sector, and more broadly, do you think that at the macro-level, more money needs to be put on the table by the federal government to support innovation in those areas of potential competitive advantage that you noted earlier?*

Unlike many other innovative nations, most of the support for Australian business research & development comes from an indirect mechanism (the Research & Development Tax Incentive). As the economy changes its focus to digital innovation and decarbonisation, there are opportunities to directly support R&D in areas of strategic growth.

[13] Australian Academy of Technology and Engineering, 2020, Modern Manufacturing Strategy Roadmaps https://www.atse.org.au/research-and-policy/publications/publication/modern-manufacturing-strategy-roadmaps/

One such area in which government support would speed development and deliver high impact value, is digitally enabled bespoke manufacturing techniques. This would provide manufacturing agility and quality management systems and deliver high-value manufacturing. Support packages for readily applicable and genuine R&D should therefore encourage digital updates to plant and equipment. This needs to be complemented by two key policies:

1. A regulatory change in the depreciation rules related to capital equipment that embodies rapidly developing technology. In this domain capital equipment becomes operationally obsolete before it becomes technologically obsolete and becoming technologically obsolete before it becomes economically depreciated. There is a need for accelerated depreciation rules or even the right to expense these types of capital equipment.
2. A successful model that could be adopted is the UK and Norwegian Catapult Centers. The governance of these centers is heavily influenced by large multinationals where the SMEs could be part of the Global Value Chain. These centers also work as a hub for SME's to access information easily on R&D advancements where they might not have the capacity to do so on their own.

Another area which would greatly benefit from government support is defense and security. Australia currently relies heavily on international suppliers for much of its defense technologies. Developing and implementing concrete policies that enable Australian SMEs to participate in research and development of these technologies is one area where SMEs can be supported to fill an already present domestic demand. In today's knowledge era, local SMEs and start-ups can develop critical defense technologies without billions in investment, particularly in the digital and cyber areas involving Artificial Intelligence, Internet-of-Things, blockchain, cyber-security, and other relevant technologies, leading to the establishment of home-grown sovereign capabilities to safeguard Australia.

5. *Your submission called on Australia to undertake a strategic mapping of supply chains to identify key areas or risk. You argued that this was necessary to rebalance supply chains and ensure efficiency, resilience, and skills. Could you expand on what you view as some of the emerging supply chain risk areas that the government should be taking a closer look at?*

The COVID-19 pandemic has shone a light on the importance of stable supply chains, including resources, products, services, and skills. The three biggest risks to supply chains – and therefore opportunities - are:

1) a changing climate and decarbonised economy;

2) a digital economy; and

3) a changing geopolitical landscape.

Changing climate and decarbonised economy

Moving to a net zero economy will require new products such as photovoltaic cells and batteries. While Australia has access to critical minerals essential to modern battery technologies, these products are not manufactured onshore, leaving Australia vulnerable to global pressures and supply chains.

Australia's raw products are also at risk as the world moves to a net zero future. Aluminum exports were worth over $4.2 billion in 2018-19 but this industry is heavily reliant on high-emission energy production, and vulnerable to market forces demanding a low-emissions approach.

A digital economy

In Australia and across the globe there is a drive towards a more digital economy: this is strongly supported by ATSE. As the internet of things accelerates a steady supply of microchips is essential.

However, global shocks such as a pandemic (or fires and natural disasters can put great strain on essential products like chips and semiconductors.

The supply chain of skills is also at risk. Digital skills in Australia are already in short supply and this pressure will continue to build - not just for the Information Technology sector, but for the economy as a whole. The Covid-19 pandemic demonstrated that when international immigration is affected then Australia's digital skills availability is at risk. To counter this risk digital skills must be taught in schools, to everyone, through high-achieving and proven approaches such as ATSE's CS in Schools program.[14]

A changing geopolitical landscape

It's been strongly demonstrated in recent years that Australian supply chains are vulnerable to the shifting geopolitical landscape. Given Australia's reliance on imports, this is a significant risk to the nation. The recent release of the critical technologies list is an important starting point in identifying areas of importance. It is important, however, to focus on the supply chain as a whole, and how that might affect Australia's capacity to develop and implement these critical technologies.

6. *Your submission has called on the government to ensure a sufficient pool of talent is available to fill roles across the manufacturing supply chain by investing in STEM training and development. Could you expand upon what success would look like in that area, and more broadly, whether you think that there needs to be additional funding for more targeted initiatives?*

Successful Australian STEM training will produce a diverse talent pool and a sector in which people have the skills and opportunity to move between industry, academia, and government bringing with them the skills needed to create and implement solutions. It will also produce a digitally literate general population – so that the skill level and capability of the whole workforce (and the competitiveness of the whole economy) can be lifted as the economy continues to digitise.

Worthy of note is the declining Australian domestic student interest in engineering careers as evidenced by declining enrolments in professional engineering education programs. In 2017, engineering took only 5.2% of national commencing bachelor's degree students, the lowest proportion on record[15]. The Government's own labor market predictions outline, that by 2025 there will be a need for over 40,000 additional engineering professionals, not including software engineers[16]. These estimated workforce shortages should encourage the government to focus on creating programs that would see a further uptake of engineering by domestic graduates.

Another key concern is the declining participation of students in higher and intermediate mathematics in year 12 across the country. Since 1997 the proportion of students taking higher/intermediate mathematics in year has fallen from 40 per cent down to 30 per cent. One of the driving factors in this decline is the persistent issue of out-of-field teaching, especially in mathematics. Out-of-field teaching

[14] Australian Academy of Technology and Engineering CS in Schools – Building capabilities for a digital future, https://csinschools.com/

[15] Engineering Futures 2035: (aced.edu.au); http://www.aced.edu.au/downloads/Engineering%20Futures%202035_Stage%201%20report%20for%20ACED_May_16_2019.pdf

[16] Welcome to the Labour Market Information Portal. (lmip.gov.au); https://lmip.gov.au/default.aspx?LMIP/EmploymentProjections

has been shown to affect the confidence of teachers and the enthusiasm of the students, which flows on to declining enrolment numbers in higher/intermediate mathematics[17].

To achieve this success there are some areas which require greater support:

- Excellent teachers need to be incentivised, especially in science, technology, and mathematics to encourage greater uptake in this field and address out-of-field teaching
- SME employers must be able to access new approaches through peer-to-peer learning methods, industry networking bodies and internship programs
- Greater flexibility to encourage continuous education and industry-based learning programs, for example to train engineers on new product introduction to manufacturing systems and pharmaceutical manufacturing through VET. A consistent, strong, national VET sector will be critical in supplying the skills needed to Australian manufacturing, including digital technologies as immigration slows due to the COVID-19 pandemic.
- Business, digitalisation, data analytics, and customer orientation will also be essential for a modern renewable energy-powered economy, especially in combination and with cross-disciplinary collaboration. A highly skilled, digital technology enabled workforce will allow Australia's energy sector to grow R&D capabilities, and produce technologies with high export potential, thus contributing valuably to Australia's economy and the nation's transition to low emissions.
- Embedded school STEM education programs with a proven record of improving STEM and Digital skills for students. National, proven and schools-embedded hands-on curriculum delivery programs like CS in Schools and STELR are strong bases for investment and deployment nationally, to easily up-skill and engage the nation's secondary students in coding and STEM.'[18]

Questions taken during the hearing

"CHAIR: In that context, it's harnessing the knowledge of our First Nations people with respect to the natural environment and how that knowledge could lead to identification of potential products and leveraging off the natural environment. I guess you also see this in the medical sphere. A lot of products that are identified in the natural environment then enter into the medical sphere. Is that another potential example?

Prof. Bradlow: Exactly, yes. Unfortunately I don't have the specific knowledge of that, but yes, definitely.

CHAIR: Could you take it on notice to discuss with some of your colleagues and could provide one or two practical examples? I think that would be useful, because a point in the submission that stood out to me and something that interested me. I think it would be good if we could consider some practical examples of the opportunities in that space."

Indigenous communities have and continue to invent countless ways to yield food and bush medicine from Australia's landscape[19] and examples of some that have been respectfully and collaboratively translated into commercial purposes are:

1. Tea tree oil (Melaleuca alternifolia): Bundjalung Aboriginal people from the coast of New South Wales crushed tea-tree (or paper bark) leaves and applied the paste to wounds as well as

[17] The Australian Mathematical Sciences Institute, The State of the Mathematical Sciences 2020; https://amsi.org.au/wp-content/uploads/2020/05/amsi-discipline-profile-2020.pdf

[18] Australian Academy of Technology and Engineering CS in Schools – Building capabilities for a digital future, https://csinschools.com/

[19] Kamenev. M, 2011, Top 10 Aboriginal bush medicines, https://www.australiangeographic.com.au/topics/history-culture/2011/02/top-10-aboriginal-bush-medicines/

brewing it to a kind of tea for throat ailments. In the 1920s, scientific experiments proved that the tea-tree oil's antiseptic potency was far stronger than the commonly used antiseptic of the time. Since then, the oil has been used to treat everything from fungal infections of the toenails to acne.

2. Sandpaper Fig and Stinking Passionflower (Ficus opposita) / (Passiflora foetida): The combination of the two plants were used in northern coastal communities to relieve itching. The rough leaves of the sandpaper fig were crushed and soaked in water, the rubbed on the itch until it bled. The pulped fruit of the stinking passionflower was then smeared on to the affected area. Sandpaper fig leaves have also been used to treat fungal skin infections such as ringworm, sometimes in combination with milky sap.
3. Beyond medicine there are opportunities for manufacturing in the medical products sector itself. ATSE Fellow Professor Darren Martins has worked closely with remote Indigenous commercial partners to combine nanotechnology with traditional scientific knowledge and practices. This partnership between the University of Queensland and the Dugalunji Aboriginal Corporation in Northwest Queensland is working to commercialise the unique properties of spinifex grass in the production of stronger cement, recycled paper, ultra-thin surgical gloves and other new biomaterials.

"Senator PRATT: *I think you've answered that very well. Where do you see the best opportunities in procurement currently?*

Prof. Bradlow: *I'd have to take that one on notice if you don't mind. I haven't really given it enough thought. I will get back to you."*

COVID-19 has exposed weaknesses in health services and systems, from staffing and skills to supply chains. The healthcare sector has one of the best opportunities because of the ongoing digital transformation. In ATSE's recent submission to the Department of Health[20] to guide the priorities of the MRFF, we recommended improving resilience across the service spectrum, from how health care delivery personnel can be supported and protected to ensure resilient and sustainable service provision, to how health systems, tools and infrastructure can be designed to be agile in response to changing inputs and demands. It is also a crucial time to create domestic manufacturing capabilities to generate and test novel active drug ingredients. A strategic procurement policy would be a practical solution to solve this domestic manufacturing capability question in medical manufacturing.

ATSE's Towards a Waste Free Future report recommended the Australian Government to create standards and certification systems for reused and remanufactured goods to build consumer confidence and promote the design of products with reuse and refurbishment in mind. A co-operative research center for advanced materials development could accelerate this work and provide new industries in Australia with more durable materials, self-healing materials, biodegradable materials and other innovative technologies could be commercialised and create an export industry. Government procurement strategies that focus on these new industries can help generate domestic demand and create new industries with new opportunities for the manufacturing sector.

[20] https://www.atse.org.au/research-and-policy/publications/publication/mrff-australian-medical-research-and-innovation-strategy-and-priorities-consultation/