SUBMISSION

Submission to the Department of Industry, Science and Resources

Submission to Australia's Science and Research Priorities: Conversation Starter

6 April 2023

The Australian Academy of Technological Sciences and Engineering (ATSE) is a Learned Academy of independent, non-political experts helping Australians understand and use technology to solve complex problems. Bringing together Australia's leading thinkers in applied science, technology and engineering, ATSE provides impartial, practical and evidence-based advice on how to achieve sustainable solutions and advance prosperity.

ATSE welcomes the opportunity to respond to the principles guiding the Science and Research Priorities and National Science Statement, as outlined in the National Conversation Starter. This submission outlines critical areas for inclusion in the Science and Research Priorities. This submission is also accompanied by an appendix, a joint submission made by ATSE's Digital Futures Forum with the Australian Academy of Science's National Committee for Information and Communication Sciences.

Australia's missions

ATSE supports an approach to the Science and Research Priorities of defining the challenges to be solved and assigning priorities accordingly, following a mission-oriented approach. Key challenges identified by ATSE's experts include: reducing carbon emissions to net zero by 2050 including from infrastructure, transport, and energy; building resilient communities and systems in adaptation to ongoing climate change; ensuring secure supplies of water and food; healthcare and wellbeing for an ageing population; preventing threats to population health; closing the gap with regard to life expectancy and quality of life, digital leadership, equity and inclusion; restoring sovereign capability and supply chain resilience; and developing the STEM (science, technology, engineering and mathematics) workforce and teaching capacity.

Science, research, innovation and uplifts to productivity will be required to respond to these issues and improve quality of life for Australians. ATSE highlights the important role of technology and engineering in realizing the vision of the Science and Research Priorities. To support solutions, there must be an uplift in STEM skills, engendering social license for and investment in science and technology, and the ability for Australia to be a nation of innovators, not adopters of technologies developed elsewhere.

Opportunities and strengths

Australia's unique advantages can be aligned with the challenges we've identified in developing the Science and Research Priorities. ATSE considers that an integrated approach is needed. For example, digital technologies and literacy will be an enabler for innovation in healthcare. A One Health approach that considers Traditional Knowledge is critical in agriculture, with implications across healthcare and water. Sustainable fuels and digital technologies will underpin productivity increases and adaptation in agriculture. Education will be the enabler for applying science and research across all areas. While the below topics are listed separately, applying a mission-oriented approach will require coordination across different areas of science and research including in their interdisciplinary spaces.

Advanced manufacturing

The global supply chain challenges wrought by the COVID-19 pandemic have created a renewed interest from the Australian Government in developing sovereign capability. There is capacity to leverage Australian expertise for advanced manufacturing – including medical manufacturing, industry in support of clean energy and electric transportation, and additive manufacturing as part of a circular economy - both to serve domestic needs and for export. Effort should be concentrated on high-tech exports where Australia can be globally competitive. A circular economy approach must be embedded at the outset to ensure environmental sustainability as well as to unlock waste processing export opportunities. This approach will be critical in replacing plastics and in providing the materials needed to power the green energy transition.

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Minerals
Minerals are an enabler for the green energy revolution taking place globally. Australia is endowed with critical minerals – combined with technical expertise, there is an opportunity to expand in clean, safe, environmentally low impact recovery and value-added refining of critical minerals as well as continuing work in mine rehabilitation. More broadly, Australia has an opportunity to move away from selling of bulk material (coal/iron ore/concentrates etc) towards providing value added highly refined intermediate or finished minerals required by global industries supporting the pivot towards our carbon neutral future. A shift to green energy will also be required to power this industry sustainably. Green energy can also be used to power steel and aluminium industries, with Australia having a comparative advantage.

Agriculture
Food and water security are becoming increasingly important as the impacts of climate change are felt in the region. In the coming decades, Australia will need to not only ensure its own population is supported but also collaborate with our Pacific neighbours to develop knowledge and translate research. There is an opportunity to leverage Australia's expertise in these areas and continue to work on island and atoll agriculture.

The challenge for agriculture is continuing to lift productivity while managing increased climate-related risks and reducing greenhouse gas emissions. This will require an integrated approach and innovation from the level of basic farming systems to the use of high-end technology and biotechnology. Crops will need to shift to reflect the changing climate and reduce greenhouse gas intensity. Fire risk research should also be continued and strengthened, including with integration of Traditional Knowledge. Managing risks cannot be confined to agriculturists but will need to involve partnerships with many other related sciences such as climatology, robotics and biotechnology. Approaches such as 'agrivoltaic farming' – using the same land for growing crops and generating solar energy – should be considered. Agriculture can also embrace the circular economy including by reducing food waste and packaging, and recycling wastewater.

Water
Further research and research translation is needed to support improved water management in cities and regional communities, and for environmental sustainability. Urban and regional water systems require improved resilience to a variety of climate-related threats, including droughts, floods and bushfires. Aquatic ecosystems require improved understanding and management for health and sustainability. An important factor in climate adaptation is improved drought resilience provided by non-conventional water sources, such as seawater desalination and purified recycled water. These technologies will enable communities and industry, including agriculture, to maintain productivity during severe droughts. Other areas of technological improvement include sensors and monitoring, water and wastewater treatment efficiency, and water accounting.

Australia has potential to become a significant global supplier of advanced water processing technology if the mass of small companies innovating in water processing can be supported rather than sold offshore for asset [especially IP]-stripping. Similarly, Australia has potential to become a major manufacturer of water processing consumables and equipment such as membranes, ion exchange resins, and carbon filters.

Health
Health is already a significant national expenditure. Serving the healthcare needs of an ageing population will be a pressing challenge over the coming decades, as well as preparing for future challenges including pandemics and antimicrobial resistance. Healthcare is also an area to target for decarbonisation, contributing 7% of Australia's carbon emissions (Malik, Lenzen, McAlister & McGain, 2018). There are opportunities to leverage Australian research strength in health and biotechnology, move towards more preventative healthcare, and improve patient education. Coordination and innovation will be required to enable the healthcare sector to meet the needs of Australians into the future.

Infrastructure

Innovation in infrastructure is a requirement for Australia both to reduce carbon emissions and to withstand the effects of climate change. Australia is already experiencing more frequent and severe storms, floods and bushfires. While limiting climate change is essential, we also need to ensure appropriate planning to mitigate the worst effects on Australian infrastructure, services and communities. Planning and design for resilience is a key component in mitigating the damage of major hazards and must be built into the planning of Australian infrastructure, including transport, energy, water, social, waste and digital infrastructure. Probabilistic risk assessment modelling using relevant technologies and evidence-based tools enables enhanced economic, environmental, social and cultural resiliency, while also reducing their interdependent vulnerabilities.

Infrastructure accounts for approximately 70% of total emissions in Australia (Infrastructure Sustainability Council, ClimateWorks Australia & Australian Sustainable Built Environment Council, 2020). There is an urgent need to decarbonise the construction industry, as well as the operation and end of use of our infrastructure if Australia is to reach net-zero by 2050. This will involve the development of innovative low carbon materials, construction processes, low-impact recycling, and adaptive re-use of materials that covers its entire lifecycle.

Future cities also need to be designed to be less carbon intensive. Growing populations and cities will present new challenges including for infrastructure, agriculture, water, energy and education. Strategies for the built environment are a critical pathway to uplift quality of life as well as meet Australia's zero carbon ambitions.

Green energy and sustainable fuels

The main challenges for science and research in energy in Australia are to develop lower-carbon, lower-emissions, safe and reliable electricity and fuels. Fuels include hydrogen and sustainable aviation fuels. Key areas of focus for research should include continued efforts in improving efficiency and cost of photovoltaics and catalysts for green hydrogen, as well as in liquefaction of hydrogen, and battery chemistries.

Also focus should be on electricity storage methods and science and research funding could be used to support innovative and early stage ideas in distributed energy storage, such as those using stored heat, gravity and so on, as well as challenges in the main storage methods of pumped hydro, batteries and a distributed and more complex electricity grid.

Sustainable fuels, using biowastes and other industrial and plastic wastes, is not an especially active area of research in Australia at the moment. It will be needed for aviation and other areas where other fuels or batteries are not suitable.

The carbon emissions associated with energy usage are of interest, since early-stage research is starting to show that captured carbon can be used to produce useful products such as animal feeds, building materials, and liquid fuels. Direct Air Capture of carbon will also be required at large scale to capture the carbon from broad energy usage, and this will require substantial innovation and research.

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Emerging digital technologies

Prioritisation of digital technologies is critical to enable solutions to Australia's most pressing challenges and it therefore must be considered a top-level priority. This is explored further in a joint submission with the Australian Academy of Science's National Committee for Information and Communication Sciences, appended here. Emerging digital technologies including artificial intelligence (AI), the Internet of Things (IoT), augmented and virtual reality, blockchain, quantum computing and 5G, are transforming traditional industries such as manufacturing, agriculture, waste management, transport, finance, education and health.

The digitisation of the economy, including with recent fast-paced innovations in Artificial Intelligence, is needed to keep up with developments globally. There is also a need to uplift digital literacy and the digitally skilled workforce to realise these benefits.

Digital technologies will be the pathway to increasing productivity in sectors with high demand, such as energy, manufacturing, and health. For example, the healthcare needs of the ageing population cannot be met by scaling up existing infrastructure and personnel. Innovations in population-scale data sets, machine learning for decision support, hospital-in-the-home and telehealth require further development as well as changes to privacy laws to increase capacity for healthcare delivery. Similarly, the development and application of digital technologies also has the potential to transform our ability to use and manage water sustainably. For example, new capabilities in analytics including machine learning and artificial intelligence for data driven real time decision making will improve both the speed and validity of complex decisions based on large and complex data. Shared digital platforms could be developed that monitor water quality and water quantity across all water uses, water users, industries, communities, and the environment on graded geographic scales and temporal regimes. It is important to consider data sovereignty: Australia relies on other nations to provide meteorological and space data, representing a risk into the future.

With the wave of the global digital revolution building, Australia has a critical opportunity to institute a strategic national approach, supporting fundamental science and research to drive innovation in emerging digital technologies. We have strengths in emerging digital technology research and development, but opportunities for sector growth and sovereign capability are nascent and require coordinated and strategic support.

Traditional Knowledge

The wealth of Traditional Knowledge held by Aboriginal and Torres Strait Islander people is both an opportunity and an enabler. Traditional Knowledge across STEM, including in land and water management, agriculture, the built environment, materials, and medical research, can be leveraged and translated to underpin innovation in these areas.

Education

Education is a key lever in addressing social issues and providing Australians with opportunities to improve their lives. Education and training opportunities will be critical to enable Australians to navigate society and provide the skilled workforce needed to diffuse innovation across the economy. Australia is also renowned as an international education destination, feeding into soft power; this strength should underpin and inform the Priorities.

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Building capability and capacity

While Australia has significant opportunities and strengths with which to align the Science and Research Priorities, a challenge is limited capacity within the context of an austere research funding environment and a talent shortage. Australia has not kept up with other OECD countries' average investment in research and development, as a percentage of GDP (OECD, 2022). ATSE considers there is an urgent need for an independent review of the research sector, with a view to uplifting government investment in research and development to an internationally competitive level of around 3% of GDP (ATSE, 2023). Both fundamental research and commercialisation need strong and stable funding to enable Australia to maximise the benefit from its existing research strengths.

Shortages of labour and talent, including in engineering, are also a risk to Australia's capacity to leverage its research priorities as well as to fulfil plans including the green energy transition and participate in AUKUS. This must include nuclear physicists, engineers and technicians for the planned nuclear submarines as well as for other applications such as nuclear medicine.

Estimates of projected engineer shortages vary but suggest a shortfall of at least 50,000 additional engineers by 2025 (ATSE, 2022). We already have a heavy reliance on importing engineering skills – which is a risk as global competition increases. An important opportunity is to build and maintain Australia's status as an attractive destination for immigration of skilled STEM professionals required by academia, government and the private sector.

Fundamentally, interventions are needed from the school level to lift STEM participation, creating a pipeline for the engineers and scientists needed for the future (ATSE, 2022).

Embedding collaboration into the principles

ATSE supports the seven principles communicated in the Conversation Starter as appropriate guidelines for the consultation process. The principle "be bounded" is particularly important: it is critical that the priorities be meaningful rather than generalist statements. ATSE also welcomes the inclusion of embedding Traditional Knowledge.

In addition to these seven principles, ATSE recommends the inclusion of an eighth principle: "Be collaborative and inclusive". A strength of Australian research is that it is collaborative, both domestically and internationally. While sovereign capability is critical, the challenges we face are global and with global solutions. There is also a need to integrate across research areas, for example, better integrate the humanities with the sciences so that sociologists, psychologists, economists, and lawyers are part of the design of science and health programs to ensure a better acceptance and take up by the community.

Australia has been, and remains a small research community, but it has a deep equity in global knowledge systems because of our long history of international collaborative research and development activities. This deep equity translates into effective soft diplomacy for Australia and provides security impacts as well as access to knowledge essential to our development.

References

Australian Academy of Technological Sciences and Engineering (ATSE), 2022. 'Our STEM skilled future — An education roadmap for an innovative workforce', <https://www.atse.org.au/research-and-policy/publications/publication/our-stem-skilled-future-an-education-roadmap-for-an-innovative-workforce/>

Australian Academy of Technological Science and Engineering (ATSE) 2023, 'Pre-budget submission 2023-24', < https://www.atse.org.au/research-and-policy/publications/publication/pre-budget-submission-2023-24/>

Infrastructure Sustainability Council (ISC), ClimateWorks Australia & Australian Sustainable Built Environment Council (ASBEC), 2020, 'Issues paper: Reshaping infrastructure for a net zero emissions future', < https://www.cefc.com.au/media/402347/reshaping-infrastructure-to-lower-emissions-march-2020.pdf>

Malik, A, Lenzen, M, McAlister, S, and McGain, F 2018, 'The carbon footprint of Australian health care', Lancet Planet Health, vol. 2, no. 1, < https://doi.org/10.1016/S2542-5196(17)30180-8>

OECD 2022, 'Main Science and Technology Indicators', vol. 2022, no. 1, <https://doi.org/10.1787/4db08ff0-e>

Appendix: Joint submission with the Australian Academy of Science's National Committee for Information and Communication Sciences

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NATIONAL COMMITTEE FOR INFORMATION AND COMMUNICATION SCIENCES

Australian Academy of Science

Submission on *Australia's science and research priorities: Conversation starter*

12 April 2023

The National Committee for Information and Communication Sciences of the Australian Academy of Science and the Digital Futures Forum of the Australian Academy of Technological Sciences and Engineering welcome the opportunity to comment on *Australia's science and research priorities: conversation starter*.

The Committee and the Forum would like to make a case for Elevating "Emerging Digital Technologies" as a National Science and Research Priority[1].

- Digital technologies will be the enabler to unlocking progress and productivity growth across sectors such as advanced manufacturing, agriculture, water management, healthcare, infrastructure and others. Emerging digital technologies will play an increasingly fundamental role in Australia's way of life, but we risk falling behind as a technologically driven nation unless we recognise emerging digital technology as a central and independent science and research priority.
- With the rapid advancement of emerging digital technologies, science priorities should not be limited to specific application areas or unduly focused on today's demands, as this limits the possibility for innovation that could otherwise create totally new industries and jobs.
- It is important also to not single out a particular area such as Artificial Intelligence (AI), blockchain, or quantum computing, as it will take innovation across all areas of emerging digital technologies to demonstrate Australia's digital leadership.

Emerging digital technologies include artificial intelligence (AI), cybersecurity and blockchain, augmented and virtual reality, quantum computing and quantum engineering systems, 5G, the Internet of Things (IoT), new computing infrastructures and processing units, machine learning, and data science. These digital technologies are considered 'emerging' as they are not yet at a stage where they can be considered commoditised; they are instead undergoing rapid innovation and active research and transforming traditional industries such as manufacturing, agriculture, resources, transport, finance, and health.

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The digital revolution is well underway, and many countries and sectors have signalled that digital futures should be a critical priority for investment, skill and capacity-building, and economic growth. Many of Australia's international peers, including the USA, UK, France and Canada, are prioritising digital technologies as a strategy to bolster competitiveness in the emerging 'digital economy'. Australia is lagging its global peers, with digital innovation accounting for only 7.4 per cent of Australia's GDP compared to the 11.2 per cent average across the OECD[2].

With the wave of the global digital revolution building, Australia has a critical opportunity to institute a strategic national approach, supporting fundamental research and engineering to drive innovation in emerging digital technologies. We have strengths in emerging digital technology research and development, but opportunities for sector growth and sovereign capability are nascent and require coordinated and strategic support. We need a vision for innovation and research in areas of national strength and strategic priority—one that is matched by a globally competitive level of commitment and investment.

Information and Communication Sciences has a long history of international collaborative research and development activities, resulting in a deep equity in global knowledge systems. Elevating emerging digital technologies to a national science priority ensures the protection and growth of local expertise and opportunity for homegrown talent and companies, to allow Australia to adequately tackle the asymmetry created by the dominance of big tech in US and China.

Australia must also strive to address the digital divide to ensure equity of access to the benefits delivered by digital technologies, and to meet the skill requirements for a future digital workforce. We recommend mission-oriented implementation frameworks for the National Science and Research Priorities that provide incentives and pathways for cross-disciplinary research between information and communication scientists and engineers with social scientists, application domain experts and education leaders.

References:

1. Australian Academy of Science & Australian Academy of Technological Sciences and Engineering. *Australia's Digital Future: a nation of users or leaders?* https://www.atse.org.au/wp-content/uploads/2021/09/Australias-Digital-Future-September-2021.pdf (2021).

2. McKinsey and Company. *Australia's automation opportunity: Reigniting productivity and inclusive income growth*. https://www.mckinsey.com/featured-insights/future-of-work/australias-automation-opportunity-reigniting-productivity-and-inclusive-income-growth (2019).