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Australian Academy of Science Submission – Australia's Technology Investment Roadmap

The Australian Academy of Science (the Academy) welcomes the opportunity to provide comment on the Department of Industry, Innovation, Energy and Resources on the Australia's Technology Investment Roadmap discussion paper.

The Academy strongly supports the goal of placing Australian on a low- and zero-emissions energy trajectory. Multiple lines of evidence suggest that business as usual policy settings are leading to a global warming trajectory of 3 degrees or higher, with the resulting social, economic, and environmental damage. Put in this context, the development of a settled energy and climate policy, including the technology roadmap, by the Commonwealth is welcomed.

The Academy is very supportive of the roadmap development. The Academy appreciates that the discussion paper was based on previous scoping and planning work by the CSIRO, and that CSIRO retains an integral role in the roadmap development. In addition, the proposed plan of reconsidering the statement on low-emissions technologies on an annual basis is strongly supported by the Academy, and ongoing consultation would be encouraged for this process.

Fundamental research to drive success for Australia's future

It is of the utmost importance that fundamental (also known as "basic") research be adequately supported through public and private research funding to ensure the progress and breakthroughs required to ensure that the stretch goals of this roadmap and subsequent technology statements may be met. The presumption in the draft roadmap that fundamental or discovery research – currently supported by universities, the Australian Research Council (ARC) and the CSIRO – is a given does not reflect either experience or the current challenges.

Fundamental research (understood as basic research as defined by the Australian Bureau of Statistics), has been receiving a declining share of university and government support for decades. In 1998, 58 percent of university resources devoted to research and development were spent on basic research.[1] By 2018 this allocation had fallen to 41 percent.[2] The impacts of the pandemic on

research in Australian universities could see further declines in the proportion of resources for fundamental research in the coming years.

The Commonwealth is responsible for much of the funding of fundamental research in the Australian innovation system. Given this, the roadmap should have a greater appreciation of the need for such research to feed the innovation value chain that ultimately leads to the adoption of new energy technologies.

The primary purpose of fundamental research is to generate new knowledge, and to better understand nature and its laws. In this way, it generates 'scientific capital', or a repository from which practical applications can be drawn from. The National Science Foundation has stated "a nation which depends upon others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position in world trade, regardless of its mechanical skill."[3] It is such investments in Australian fundamental science, from chemistry, to materials science and beyond, that will build our nations scientific capital and enable industries of the future.

While the roadmap acknowledges the importance of Australian domestic R&D capability, there is a fundamental misapprehension about the nature of technology transfer. Not every technology discovered or 'invented' elsewhere can be bought 'off-the-shelf' and plugged in; researchers need the capacity to use their expertise to critique, amend, adjust, renew and manage the introduction of new ways of thinking, or new technologies, into Australia.

We cannot expect researchers in other countries to look after our interests because we are not prepared or strategic enough to look after ourselves. There are certain fields of knowledge and expertise where a sovereign science capability is of strategic national importance.

To this end, the roadmap could be improved by acknowledging the importance of fundamental science investments, and investments in fundamental science infrastructure.

More clarity is needed regarding the path for government investment and private co-investment from external capital for commercialisation of emerging technologies in this area. There may be useful existing mature technologies that may help lower emissions, but currently we lack the support to scale and implement the technology. As such, both coordination and support for this entire innovation spectrum will be required, from basic R&D to market development approaches. While support for translation of research to industry has made significant progress in recent years, further reform and coordination will be required to create a world leading low or zero emissions energy economy.

As requested, the Academy has considered global challenges and trends, while taking into consideration where Australia has a competitive advantage and recommends the following two sectors be considered as science priorities for the roadmap.

Agriculture as a priority

As noted in the Discussion paper, several technologies have potential to significantly reduce carbon emissions in diverse areas of the agriculture sector. Many of them will have relatively small but additive effects. One that could lead to major impacts, and which dovetails into the 'hydrogen economy' is the production of ammonia from renewable energy sources.

Australian soils are generally nitrogen poor, and cropping requires delivery of nitrogenous fertiliser. Technologies to replace the energy costly Haber–Bosch process in producing ammonia as fertiliser would have a major impact on fuel and energy consumption, as well as reducing carbon emissions. One approach being developed by CSIRO and funded by ARENA is aimed at producing ammonia from hydrogen directly sourced from an electrolyser powered by solar cells and nitrogen from an air separation unit.[4]

Fundamental research as a priority

Innovation in low-emission technologies depends on a deep understanding of how materials and devices function at the atomic scale. That understanding comes from applied analytical science, with one of the key analytical sciences in this domain being crystallography. Crystallography is the most important technique used by researchers to determine the identity and arrangements of atoms in materials.

Understanding the crystal structure of a material gives rise to all the physical properties relevant to energy production, storage, and conversion devices. From the way electrons are distributed to harness light in solar cells and water-splitting catalysts, to the ability of materials to absorb and release energy by moving atoms in supercapacitors, to the presence of open channels for the movement of lithium in solid-state batteries or oxygen/hydrogen in fuel-cells, the capture of pollutants like CO_2, or the storage of green fuels like hydrogen.

A mechanism for leveraging know-how and facilities, such as the Australian Synchrotron and the Australian Centre for Neutron Scattering, can rapidly increase the technological development agenda. These facilities and expertise exist and are widely used by researchers, with significant effort put in by the facilities to engage industry. However, the challenge lies in industry-based expertise and associated costs. If a funding mechanism (instrument time and people costs) to access these instruments and expertise were available this would increase engagement and undoubtably assist in solving key challenges for industry. Specifically, for crystallography, researchers in Australia are leading the design, implementation and development of *in operando* experimentation on low emission technologies under real working conditions, and therefore leveraging this unique skillset for applied targeted development could significantly accelerate Australian innovation and produce tangible outcomes.

Uncovering the key to affordable hydrogen

The discussion paper highlights Australia's diverse mineral resources as one of our greatest competitive advantages. There is a need for the UNCOVER approach to be utilised to unlock Australia's hidden mineral resource potential.[5] The discussion paper mentions lithium, however Australia will need to find more platinum group elements as these are critical for the catalytic process to produce hydrogen from water. As it stands, this is a weak link in the hydrogen energy chain and an opportunity to boost our mining industry while avoiding the costly process of importing platinum group elements.

Conclusions and recommendations

- Consider the role of investment in existing facilities, informed by the National Research Investment Plan, such as the Synchrotron to accelerate discovery in fundamental research
- Consider inclusion of the case-study of using hydrogen to produce ammonia for agriculture purposes as a potential high-impact solution
- Existing mature low emissions technologies should be considered for possible scaling and investment
- Fundamental research should be considered an integral part of the roadmap and prioritised accordingly

If you would like to discuss any aspect of this submission, please contact Mr Christopher Anderson, Director of Policy, Australian Academy of Science (chris.anderson@science.org.au).

Yours sincerely,

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References

1. Australian Bureau of Statistics (ABS). *Type of R&D activity TOA Socio-economic objective SEO*. (1998).
2. Australian Bureau of Statistics. *8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2016*. *2017* https://www.abs.gov.au/ausstats/abs@.nsf/0/AE02B963FB1D51B2CA2571B60075B1C0?Opendocument.
3. National Science Foundation. *Science the Endless Frontier*. https://www.nsf.gov/od/lpa/nsf50/vbush1945.htm (1945).
4. Australian Renewable Energy Agency (ARENA). Hydrogen to Ammonia. https://arena.gov.au/projects/hydrogen-to-ammonia/ (2019).
5. Australian Academy of Science. Uncover Australia. https://www.uncoveraustralia.org.au/ (2017).