21 June 2020

Ministerial Reference Panel and task group
to the Technology Investment Roadmap

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Submission to Technology Investment Roadmap process

Please find attached responses to selected issues raised in the Technology Investment Roadmap of May 2020.

This input is based on research and analysis conducted at the Centre for Climate Economics and Policy at ANU Crawford School of Public Policy which I lead, and also refers to work done at the ANU Energy Change Institute, ANU Climate Change Institute and the Energy Transition Hub jointly led by the University of Melbourne and ANU. Most of the points made are substantiated in published work, or work underway, by these entities. References and other materials can be provided on request.

I appreciate the opportunity to provide input and will be happy to further engage in the process of determining technology investment priorities. I also welcome the institutional structure established through this process, including the stakeholder consultation process and annual reviews to inform the Low Emissions Technology Statements. This process should rely on rigorous analysis, and the involvement of a broad range of organisations that can provide relevant knowledge and analysis.

I urge emphasis on the long term interests that are at stake for the Australia, and a focus on economic analysis alongside technological analysis.

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Challenges, global trends and competitive advantages

The world economy is very likely to decarbonize to a significant extent over coming decades, as a result of both the imperative to reduce greenhouse gas emissions and the rapidly increasing availability and falling cost of zero- and low-emissions energy technologies.

Australia's energy and energy based exports are large and heavily based on coal and gas resources, reflecting comparative advantage in a world that in the past did not make efforts to rein in carbon emissions and where fossil fuel based technologies were generally cheaper than the alternatives.

The economic advantage from this particular aspect of Australia's resource endowment is waning. To safeguard this aspect of our economic prosperity, as a nation we need to make a concerted push into alternative energy sources. Australia is superbly placed as a large scale energy producer and exporter in a low-carbon world, based on the continent's abundant renewable energy potential coupled with the opportunities for large-scale energy and resource industry development.

Governments have a key role in such a transition: by funding research and technology development; by facilitating deployment of new technologies and processes; by supporting the establishment of new industries and helping in the often difficult process of winding down old industries; and by setting investment signals through policies, goals, and political statements.

Australia is no stranger to these challenges, and has risen to them with economic success in previous transitions, notably in manufacturing and some of our agricultural industries.

Priority technologies

The discussion paper lists a wide range of candidates for inclusion in a priority list. If the goal is to identify just a handful of priorities, these priorities should

- be defined relatively broadly, in order to allow for support to be provided to a basket of technologies within a category;
- be constrained to technologies that are compatible with a long-term net-zero emissions outcome;
- be prioritized with regard to likely long term cost effectiveness;
- with regard to deployment, be chosen not only for existing policy and market settings but for possible future changes in policies and market demand, and with recognition of how private incentives to invest relate to public outcomes;
- with regard to supporting technology development, be selective for technologies where Australia can make a difference in global technology development.

Application of these principles suggests the following for the formulation of technology priorities:

- Include technologies that will support the efficient deployment of very large amounts of renewable energy generation – including various technologies for large scale energy storage, both on-grid and off-grid.

- Include technologies that will support the efficient integration of decentralized energy resources, including harnessing the storage capacity of electric vehicles through relevant infrastructure, regulation and pricing structures.
- Include energy efficiency. This is almost exclusively a question of deployment, as large parts of Australia's building, transport and industrial installations are low in energy efficiency compared to best available technology and in many bases relative to technology that is mainstream in other advanced countries.
- Exclude natural gas. Natural gas is viable under present technology and market settings to assist with the integration of renewables, but is unlikely to be competitive economically in future with a renewables-plus-storage combination and large scale gas use is incompatible with long-term zero-carbon objectives.
- Include measures to improve the predictability of when Australia's remaining coal fired generators will cease operation, in order to improve the timing of investment in replacement capacity and to improve the chance for better economic and social outcomes in the regions where coal power plants are in operation.
- Include a basket of technologies for 'hard to abate sectors', such as CCS/CCUS[1] in specific industrial sectors, and recognizing that deployment will require a price signal or regulation; hydrogen production and distribution for heavy transport eg rail, shipping and potentially trucking; and other assorted applications.
- Include new technologies for carbon dioxide removal including biological and geological negative emissions technologies (beginning with research on technological and economic feasibility), yet exclude land management based carbon sequestration as this is not an issue of future technology but solely deployment.
- Include large-scale production and export of renewables-based fuels (hydrogen, or possibly more prospectively ammonia) and renewables-based energy intensive commodities, especially green steel but also aluminium and other minerals and metals processed using renewable energy.

Funding models and leveraging private investment

What is before us is the replacement and likely large scale expansion of the majority of Australia's energy supply system and a significant portion of Australia's industrial production capacity.

This means that large amounts of funding will be needed for technology development and early deployment, and even large amounts of investment for large-scale deployment.

For *research and development*, government will need to provide ample resourcing, at levels substantially higher than currently. Government should establish large research programs and/or dedicated funding bodies that involve universities, the CSIRO and other organisations, businesses and international partners. Continuation of ARENA and expansion of its mandate will usefully be part of this, with appropriate funding.

But it will not suffice. The breadth of the challenge means that Australia needs an additional vehicle for providing consistent, targeted and large-scale funding for research on the future of our

[1] On CCUS, refer to the submission by the ANU Climate Change Institute.

energy and industrial system.[2] Grants for specific, applied purposes within ARENA's remit fulfil a vital function, but a different funding vehicle will be necessary to provide sustained funding on analysis eg on systemic issues and economic implications, as well as more fundamental technological research.

Whichever institutional vehicle is chosen, it will be important to create lasting structures that allow the building up of a strong and sustainable capacity for research and development. Dominant practice for research funding in Australia is a stop-start model of individual, typically uncoordinated, and relatively short term grants made eg by the ARC or government agencies. Universities have also been funding their research through cross-subsidies from international student fees, which may not be possible to the same extent in future.

For *early deployment*, funding and financing partnerships such as through the CEFC have been successful. It will be useful to expand the CEFC's investment mandate, but such expansion needs to go hand in hand with increasing the CEFC's investment pool. The CEFC has made returns for government while promoting technological rejuvenation, investment and business growth. Increasing the scale of the endeavour is advisable.

For *deployment at scale*, the right combination of market prospects and government policy is required. In some cases, technologies are already commercially viable, such as solar PV and wind power, and the issue for government and its institutions to take care of is to provide a market and regulatory framework that allows private business to make investment with confidence. In electricity supply, this importantly includes the timely provision of transmission capacity, electricity market design that provides confidence about medium to long term revenue prospects, and greater predictability of exit of existing coal fired power stations.

In other cases, government will need to set policy levers – whether by mandating standards, by providing a price signal, or by providing infrastructure – to facilitate investments that are intrinsically more costly than the alternatives that are most profitable from a purely private point of view. A "no government intervention" view is not a realistic option for the transition to a low-carbon, future-proof energy and industrial system.

Australia's advantages

Australia is extremely well placed as a future large scale producer and potential exporter of renewable energy and renewable energy based products – as mentioned elsewhere in this submission, and as has been well established in recent research and assessment exercises including by the Chief Scientist.[3]

The physical foundation of this advantage is the available land resource in combination with favourable wind conditions in many parts of the country (as well as offshore) and high levels of insolation. The economic and institutional foundations include Australia's expertise in establishing energy and resource industries, the open and generally stable investment framework, a reputation

[2] On funding models including international examples, also refer to the submission by the ANU Energy Change Institute.
[3] On Australia's opportunities for renewables-based exports, refer to the submission by the Energy Transition Hub and also the submission by the ANU Energy Change Institute.

for institutional and political stability, and established trade relationships with and relative geographic proximity to fast growing economies in Asia.

In addition to fulfilling potentially all of Australia's domestic energy needs from renewables, Australia will be able to supply renewable energy to other countries that are less favourably endowed with clean energy opportunities, whether by cable, in the form of synthetic fuels or energy intensive products. The amount of energy exported in this way could potentially be many times larger than the entire domestic energy demand.

New energy and industrial technologies are likely to imply a greater extent of trade, and a deepening of international supply chain relationships at least in some respects. This implies that Australia's traditional interest in an open international trade and investment framework remains and is indeed enhanced under a transition to new energy systems.

Enabling conditions for priority technologies

The main preconditions for the large-scale adoption of priority technologies are a supportive regulatory and policy environment, and the building up of expertise and skills.

As a growing economy with a capital-intensive resources sector, Australia is a net importer of capital. Investors need not only assurance of likely advantages in cost and competitiveness terms, but also the expectation of a *stable and supportive regulatory and policy* environment. The provision of long-term goals that governments will stand behind, and that survive changes in government, are crucial for investor confidence, as Australia experienced over the last decade.

The onus is on the political system to find common ground on key goals and principles for the transition of Australia's energy and industrial system.

Australia has an excellent base in research and in industrial capabilities in the energy and resources sector and associated business activities. However, expertise and skills in the new energy/industry remains thin relative to the very large opportunities and possible future investments.

Australia needs to urgently grow the pool of people who have deep knowledge and experience on the issues canvassed in the Technology Roadmap discussion paper, across the business, government and research sector.

Universities will be able and usually eager to do their part in this, by creating new cohorts of highly skilled, knowledgeable and dedicated people – the new generation of scientists, engineers, economists, social scientists and business experts who can drive this change. Enabling this will require adequate funding. Examples of specialized degrees at ANU include the Master of Energy Change and Master of Climate Change. The Energy Transition Hub, funded until mid-2020 by the Australian government, had started to create a new cohort of applied researchers on these issues at post-doctoral level in Australia. Such models can readily be replicated and scaled up.

Australia will also benefit by linking in with innovation systems in other countries, to expose Australian practitioners to world's best practice and new developments. Bilateral partnerships should play an important role in particular in R&D. Again, the universities can play an important role in facilitating this. For example, the Energy Transition Hub established close linkages with

researchers who work at the cutting edge of energy transition in Germany, and helped facilitate substantive government-to-government discussions through the bilateral Energy and Resources Working Group.

ANU, including through the Centre for Climate and Energy Policy, stands ready to support bilateral initiatives, with capacity and networks including on/in Germany, UK, Japan, China, USA.

Stretch goals

The Roadmap discussion paper sets out a price-based (or cost-based) 'stretch goal' for hydrogen. I would urge the consideration also of quantitative goals, and indeed possibly an emphasis on quantitative goals.

Price-based goals necessarily involve assumptions about future costs or market prices of alternative technologies and policy-driven price variables – for example in the case of hydrogen, the future price of natural gas and any possible carbon price signal in gas consuming countries. Such assumptions are necessarily highly uncertain.

Quantity-based goals can provide clearer guardrails for industry expectations and government support in many circumstances.

For example, the rollout of charging infrastructure for EVs or refilling infrastructure for hydrogen powered heavy transport is not to any significant extent a question of equipment cost. Similarly, the total costs of an electricity supply system with very high shares of intermittent renewable energy generation supported by large amounts of energy storage may be lower than the total costs of a system that runs on a mix of fossil fuel plants and intermittent renewables. Achieving the necessary investments in storage is less a function of the cost of energy storage than of market design and of policy and regulatory settings.

For energy efficiency, quantitative targets are also more applicable than price-based goals, as many high-efficiency options are already more cost effective over their lifetime but are not taken up because of misaligned incentives, unduly high discount rates or uncertainty.

Quantitative goals are also likely to be more useful than price-based goals in driving development and early deployment of new technologies, such as green steel or emissions-free concrete or products that can substitute for concrete.