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### **ANU Energy Change Institute submission on the Technology Investment Roadmap**

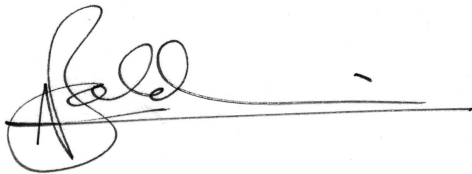
Please find below a submission by the Australian National University Energy Change Institute (ECI) on the Technology Investment Roadmap discussion paper.

We would also like to acknowledge submissions by our colleagues in the ANU Climate Change Institute, the Battery Storage and Grid Integration Program and the Centre for Climate Economics and Policy.

As well as providing expert advice in this submission from our researchers, the ECI would like to offer its expertise to contribute to the ongoing Roadmap process in whatever capacity is appropriate.

We thank you for the opportunity to provide this submission.

Yours sincerely,



Professor Ken Baldwin,  
ECI Director

On behalf of: Emma Aisbett, Fiona Beck, Wenting Cheng, Penelope Howarth, Llewelyn Hughes, Frank Jotzo, Thomas Longden, John Pye, Elizabeth Ratnam, Igor Skryabin, Matt Stocks and Lee White.

# ANU ENERGY CHANGE INSTITUTE

## Technology Investment Roadmap discussion paper response

*a) The challenges, global trends and competitive advantages that should be considered in setting Australia's technology priorities.*

Australia has the significant **competitive advantage** of world-leading solar and wind resources co-located with world-class mineral resources – combined with good governance, a highly skilled workforce and experience with global scale energy trade and investment. This will enable Australia to retain its status as **an energy export powerhouse** by future-proofing its export economy based on renewable energy – a development whose scale could surpass the energy transition of the domestic economy many times over.

There are **challenges** in ensuring that the Roadmap process does not lock in sub-optimal technologies over the long term, or lock out technologies which can optimally contribute in the future. We encourage the proper application of the **principle of technology neutrality** to the development of the roadmap. Technology neutrality in the context of industrial policy like the Roadmap requires “**conditional technology neutrality**”<sup>1</sup> in which competing technologies are treated in a neutral way, conditional on them passing the “filter” of supporting the Roadmap goals. In particular, **technology neutrality means that one technology capable of meeting an objective should not be explicitly or implicitly subsidised over another**. In the context of a low emissions roadmap, it means that technologies cannot be allowed to produce net carbon emissions without paying the full social cost of those emissions.

Technologies need to have clear carbon intensity benchmarking in order to ensure that investment decisions do not result in lock-in of infrastructure that is inconsistent with long-term domestic Australian abatement goals at scale, and to manage the risk of stranded assets arising from reducing global fossil fuel demand, especially where this involves public investments or subsidies.

We also need to ensure that the Roadmap is continually benchmarked across a range of parameters against **global trends**. The government needs to create a vehicle that enables the identification of potential areas of investment, assesses performance, and tracks international market developments, over time and on an ongoing basis. Institutional innovation is one approach to delivering this. In the United States, for example, Advanced Research Projects Agency-Energy (ARPA-E) utilises program directors seconded from the research sector to identify areas of high potential impact on a technology basis. External bodies, including universities, can play an important role in assessing performance over time.

We propose a model incorporating an international benchmarking process comprising:

- **Tasking a government agency with compiling the best available Australian and overseas data** to identify areas of high potential impact and track progress across all technologies (including carbon accounting and other externalities), drawing upon expert input;<sup>2</sup>
- **External benchmarking through an international advisory group** to provide global trends and context-setting for the Australian data;<sup>3</sup>
- **The Ministerial Reference Panel** chaired by the Chief Scientist to assess the agency data against international peer-reviewed benchmarking.

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<sup>1</sup> An ECI Grand Challenge Working Paper on this will available soon. The paper will also be presented by Emma Aisbett in the RegNet online [seminar](#) series 12.30pm Tuesday 30th June.

<sup>2</sup> ECI can contribute expertise here in key technology areas and economics/institutions

<sup>3</sup> ECI can provide suggestions from our international networks in Germany, Japan, US and elsewhere

*b) The shortlist of technologies that Australia could prioritise for achieving scale in deployment through its technology investments (see Figure 7).*

The two initial investment timeframes to 2030 must deliver large reductions in electricity sector emissions. This provides the greatest emissions impact, and leverages other low emission technologies which through electrification deliver further emissions reductions. This requires:

- Integration of utility-scale renewables through time-critical investment in **efficient electricity transmission and** in a number of **energy storage options** that provide system-wide security and reliability for high VRE penetration;
- **Control and coordination technology** for effective integration of Distributed Energy Resources (DER) including rooftop solar, batteries, wind, electric vehicles and demand management. This includes advanced sensing technology in distribution networks to support DER control and coordination, and to observe and maximise resilience and grid security;
- Continued rapid deployment of **cheap, zero emissions generation capacity**.

The technology roadmap should be closely integrated with **AEMO's Integrated System Plan** which frequently reviews the National Electricity Market's transition needs.

With electrification, early gains would accrue from roll-out of **heat pumps** to displace gas for space and water heating. As Australia will largely be a technology taker of electric vehicles, the focus should be on **infrastructure to support EV rollout**, and technology-based frameworks to maximise the usefulness of vehicle demand flexibility.

Australia has demonstrated a significant comparative advantage in **solar energy research** which should be maintained. Indeed, solar should not be considered as one technology, but rather a range of potential technologies beyond the current dominant silicon PV rollout: some new technologies may yield major efficiency improvements that could significantly leverage cost competitiveness.

Australia has a potential resource advantage globally for **hydrogen production**. Hydrogen has a significant potential role as a non-carbon feedstock for emissions abatement of industrial processes (e.g. iron ore reduction). Round trip efficiency losses for hydrogen as an energy vector need to be continually assessed relative to local renewable energy generation to gauge the prospects for national and international markets. The Australian domestic emissions from all hydrogen export technologies needs to be assessed to minimise locked-in emissions from long-lived assets. **Ammonia** may also be an important energy vector and industrial product in its own right, not only as a hydrogen carrier. Direct generation of green ammonia using renewable electricity (not just from separately-generated renewable hydrogen), should be included in the technology roadmap.

In addition to its renewable energy advantage, Australia has a mineral resource advantage to leverage. Australia is the largest exporter of iron, aluminium, zinc, lead and mineral sand feedstocks and major exporter of other metals, such as copper and lithium. **Green steel** production has a potential scale that warrants significant priority in the roadmap from an economic perspective. Its emissions benefits would be realized by displacing current emissions-intensive production overseas (chiefly in the Asia-Pacific), at the benefit of potentially greatly increased value added in Australia. **Green aluminium and other green metal production** based on converting existing industries to using renewable electricity and heat can also yield a large local emissions benefit.

Australia has significant lithium and cobalt reserves (2<sup>nd</sup> largest) warranting exploration of support for an Australian **battery industry**.

We also support the prioritization of **Carbon Capture and Use (CCU)** negative emissions technologies as outlined in the submission by the ANU Climate Change Institute.

*c) Goals for leveraging private investment.*

**We propose a funding model similar to the US DOE ARPA-E model for targeted research**, applied against one or more of the stretch goals identified in the technology roadmap, that supports innovation without necessarily seeking a strong leverage of private cash investment for every deployment timeframe. This provides opportunities for risk-taking at the early stage of development for new businesses and start-up industries, bridging the gap between the early stages of innovation while accelerating technology readiness. Adopting a portfolio approach for key areas of technology would enable more risk-taking, while supporting overall program performance. At the same time, we acknowledge larger industries, with the financial capital to invest in more mature energy research, should be encouraged to further drive investment in commercial-academic research.

To support new innovation and technology, at multiple stages of technology readiness, **we propose a suite of goals for leveraging private investment for technologies expected to be deployed in the following timeframes:**

2020-2022

- High cash/in-kind leveraging of government funds by industry funds (e.g., 3,4,5 times)
- Supporting the deployment of new technology at scale
- Funding led by industry in a consortium including universities, research agencies, and other relevant industry partners (e.g. utilities).

2023-2030

- Medium cash/in-kind leveraging of government funds by industry funds (e.g. 1:1)
- Supporting the development and deployment of new technology
- Funding led by a research entity in a consortium including an industry-based commercialization partner.

2030+

- In-kind/cash leveraging of government funds by industry funds (e.g. <1:1%)
- Supporting growth in new industries and early stage technology trials (e.g. real-time simulations, pilot studies, and experimental work)
- Funding will be led by universities in a consortium including a commercialization partner.

In setting the goals for leveraging private investment, we must be sure to incentivize bringing the best people and industries to Australia - providing an international technology advantage that will position the economy for recovery and growth.

Support for employment growth and business opportunities needs to be considered, particularly in regional and/or disadvantaged areas. Well-designed **regional adjustment packages** will not only support economic growth in these regions, but will encourage a fair energy transition and increase public acceptance of the fundamental, technology-driven changes that will occur in Australia's energy industries.

**We propose some guiding principles for leveraging private investment in a low emission roadmap:**

1. **Encourage international clean-high-tech leaders to set up their core R&D centres in Australia.** Such centres will provide an opportunity for Australian researchers and engineers to make a global impact – in which they should be funded to collaborate (and in industry more broadly). More importantly, core industrial R&D in multinationals will help us to further hone local high-tech skills, leading to more technology start-ups, innovation and Australian technology IP.
2. **Expand international technology development collaboration focusing on countries with high-tech industries.** This can be achieved by establishing specific bilateral collaboration funds where priority is given to collaboration between Australian researchers and foreign technology giants such as Siemens, NEL, Hyundai, etc. Real high-tech innovation comes from interactions between research talent and industry capabilities/expertise, which is where funded industry placement of university and research agency experts can play a role.

**Possible funding governance and suggestions:**

1. ARENA and CEFC continuation – perhaps using a new model with responsibility for different bodies to achieve stretch goals in the Roadmap sectors of
  - a. electricity;
  - b. built environment transport, industry, agriculture and land; and
  - c. new opportunities, including in large-scale, energy-intensive, emissions-free exports.
2. A separately funded energy-transition research centre for targeted research with long time horizons (2030+) – building on previous research priority consortia models such as NICTA and NCARF.
3. Increase the scale and scope of the Innovation Connection scheme to address energy-transition priorities – with industry leveraging consistent with the three technology deployment timeframes proposed above.

*d) What broader issues, including infrastructure, skills, regulation or, planning, need to be worked through to enable priority technologies to be adopted at scale in Australia.*

**Cross-sectoral planning and priority settings will be crucially important.**

The level of electrification of different economic sectors, and the degree of renewable penetration in the grid, are inextricably linked in determining suitable trajectories for technological updating, emissions reduction and economic change.

For example, halving the emissions intensity of the NEM would triple the emissions reduction resulting from a typical medium size car switching to electric<sup>4</sup>.

Similarly, investment in EV charging infrastructure will be cross-coupled with the implementation of technologies that enable demand response or distributed storage e.g. in virtual power plants.

Further, the expansion of **renewable energy technologies into the domestic electricity system will potentially be tied to the export market for green hydrogen** if renewable energy from the grid is used to power electrolyzers or other disruptive green hydrogen production technologies. Whether excess energy or offtake agreements are used for on-grid hydrogen production will determine the degree to which these markets are tied.

Alternatively, mega-scale stand-alone hydrogen generation hubs powered by independent renewable generation may set the export price, which in turn could dominate the business model of hydrogen generation tied to the grid.

**Skills development by Universities and Further Education could be coupled with industry investment** in Roadmap technologies as pioneered by the ACT Government Renewable Energy Investment Fund's requirement for local investment in research and education<sup>5</sup>. The previously-mentioned placement of government-funded agency researchers and university researchers in industry could also play a role in skills transfer and development.

Building **economies of scale in training hubs** and collaborative research training centres (as exemplified by the ARC Industrial Transformation Training Centres) will be important to create consortia of skills across technology and business working together.

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<sup>4</sup> Based on ECI analysis.

<sup>5</sup> This added significant value to the already broad portfolio of postgraduate training in the ECI's Master of Energy Change program.

*e) Where Australia is well-placed to take advantage of future demand for low emissions technologies, and support global emissions reductions by helping to deepen trade, markets and global supply chains.*

This is a question across three dimensions:

1. what is the stage of market development;
2. what is Australia's competitive advantage;
3. what is the structure of the value chain, and what is the opportunity for Australia to participate in this value chain through additional government support.

It is challenging for government to assess this in a top down way, or through informal expert elicitation.

Rather, assessment is best done through a competitive grant program, such as ARPA-E, informed by the broad technology categories where Australia may have some competitive advantage, and assessed by an appropriate government body with support from experts.

Including the requirement for a credible **international partner in any external funding requirement** would enable embedding in global supply chains.

Australia is in a strong position as a potential major future exporter of green hydrogen, green ammonia and green metals that will enable us to take an early role in the establishment of **carbon accounting certification schemes** for trade in these products<sup>6</sup>.

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<sup>6</sup> The ECI has a significant research program in this area and will soon have reports focusing on certification schemes.

*In particular, the Government would welcome suggestions for economic stretch goals that could help establish pathways for the cost-effective deployment of priority technologies.*

We propose several potential economic stretch goals:

1. Given that renewable energy investment will create significant abatement in the electricity sector, and electrification will underpin further emissions abatement across many other sectors, the typical cost of **supply of renewable energy** from new large-scale installations could be given a stretch goal of \$X/MWh (e.g.  $X \leq 30$ ).
2. A **green ammonia** f.o.b. export price of \$X/tonne (see below)
3. A **green metals** (steel, aluminium) f.o.b. export price of \$X/tonne.

We also support a stretch goal for **Carbon Capture and Use (CCU)** negative emissions technologies as outlined in the submission by the ANU Climate Change Institute.

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#### **Example: establishing a stretch goal for ammonia<sup>7</sup>**

To set a stretch goal for ammonia, we recommend the approach used in the Japanese Hydrogen Strategy: the hydrogen goal of \$2/kg for the period following 2030 was based on the future cost of liquefied natural gas (LNG) with a carbon price added to this cost.

For ammonia, a suitable reference price could be the current contract price for ammonia e.g. the Tampa ammonia contract price (\$250/tonne in April 2020). Using a future carbon price ranging from \$10-70/tonneCO<sub>2</sub>, and using the carbon content for a methane-fed driven Haber–Bosch process, an example price band for the ammonia stretch goal could be \$270 - \$370/tonneNH<sub>3</sub>. The centre point with a carbon price of \$35/tonneCO<sub>2</sub> is \$310/tonneNH<sub>3</sub>.

The Japanese Hydrogen Strategy sets an interim price target of \$2.98/kg by 2030 (\$2/kg for the period following 2030). So an interim ammonia stretch goal by 2030 could use a similar mark-up and be set as a range between \$400/tNH<sub>3</sub> and \$550/tNH<sub>3</sub> (with a centre point using a carbon price of \$35/tonneCO<sub>2</sub> at \$460/tonneNH<sub>3</sub>).

So using this approach, suitable stretch goals for ammonia could be \$460/tonneNH<sub>3</sub> for 2030, and \$310/tonneNH<sub>3</sub> after 2030.

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Many international strategies and roadmaps also set **interim goals** which are important to signpost breakthrough technology trajectories. We recommend including interim goals.

There is also the potential for **introducing broader stretch goals** (such as emission intensity stretch goals, storage/production capacity stretch goals, geo-social equity stretch goals) which complement economic imperatives (similar to some employed in the Japanese Hydrogen Roadmap).

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<sup>7</sup> An ECI report detailing potential future ammonia pricing will be forthcoming.