CLEAN ENERGY COUNCIL

13 February 2022

Department of Industry, Science, Energy and Resources
Australian Government's Technology Investment Roadmap
technologyroadmap@industry.gov.au

Dear Sir/Madam,

Submission: Technology Investment Roadmap Discussion Paper

We welcome the opportunity to provide feedback on the technology priorities and progress towards a clean energy economy, outlined within the first Low Emissions Technology Statement.

The Clean Energy Council (**CEC**) is the peak body for the clean energy industry in Australia. We represent and work with over 950 of the leading businesses operating in renewable energy and energy storage. We are committed to accelerating Australia's clean energy transformation.

With its abundant solar, wind, hydro and rich mineral resources, Australia has all the natural advantages that it needs to seize the huge economic opportunities of a decarbonising world. The key test we face is our ability to leverage these resources in a timely way to cut our greenhouse gas emissions in line with our net zero emissions commitment, while maintaining and expanding our role as an energy producer and exporter, enabling energy-intensive industry to flourish in Australia over the long-term.

New modelling contained within the Australian Energy Market Operator's (AEMO) Draft 2022 Integrated System Plan (ISP) indicates that the renewable share of the National Electricity Market's (NEM) total annual electricity generation will rise from approximately 28% in 2020-21 to 79% by 2030, and to 96% by 2040 under the 'most likely' Step Change Scenario. Under a more ambitious Hydrogen Superpower scenario resulting from strong global action on climate change over the coming decade, change would occur more rapidly still, with all coal-fired generation retired by 2031, and an almost entirely renewable NEM by the end of this decade.

Whichever of these scenarios emerge, they both represent the complete transformation of Australia's electricity generation system, much of which is expected to occur in less than eight years.

With the transformation of the electricity sector playing such a fundamental role in the decarbonisation of the economy as a whole (including industry, transport, business and residential sectors) a critical function of the Technology Investment Roadmap must therefore be to prioritise those technology solutions which can support and smooth this transition.

The Technology Investment Roadmap can assist to both focus Australia's efforts and to accelerate the deployment of technologies and infrastructure, and we consider the Low Emissions Technology Statements (LETS) to be a useful annual review process for identifying barriers and prioritising solutions which will enable us to achieve our full clean economy potential.

The focus on technology advancements is particularly important for accelerating the development of emerging technologies and addressing emissions in 'hard-to-abate' sectors where solutions are at an early stage of development and remain risky and/or costly to deploy.

It must be recognised however that – as has been shown by a number of studies[1] – the majority of emissions reductions required across the economy can be delivered through mature technologies and solutions – such as direct electrification – which are already widely available. This indicates that in many cases, the barriers to deployment of clean energy solutions are policy settings and incentives rather than technological maturity, and that the Technology Investment Roadmap should constitute just one facet of a broader Australian decarbonisation strategy.

The remainder of this submission sets out in brief the CEC's feedback on the technology priorities for the clean energy transition.

1) A renewables-ready electricity grid

A 21st century economy requires a modern electricity network that can support reliability, security and low-emissions technologies and delivers low-cost energy to consumers.

As is well-documented, grid congestion and connection is the single biggest challenge facing new investment in large-scale renewable energy, and it has resulted in some clean energy investors exiting the Australian market. Accelerating construction and expansion of the transmission network will unlock new private sector investment in large-scale renewable energy, and broadly speaking, the CEC is advocating for:

- Major investment in the NEM transmission network in line with the Step Change scenario of the ISP, but with a close eye on the potential for Australia to need to invest more rapidly to capture the tremendous economic opportunities available under a Hydrogen Superpower scenario
- The efficient co-ordination of this transmission investment with energy storage assets, recognising that storage can help to optimise the network investment required.
- A more efficient, transparent and workable grid connections process.

Supporting stable voltage and frequency levels

As the share of renewables across the grid increases over the coming decade, managing system strength (to maintain stable voltage levels) and inertia (to maintain stable system frequency levels) will be a core technical challenge for the grid operator. Technologies are emerging which can provide simulated inertia (e.g., grid-scale batteries) and support system strength (grid-forming inverters). Accelerating the rollout of these assets is a priority for a smooth transition to a high share of renewables on the grid, and makes them strong candidates for support under the Technology Roadmap.

Potential for HVDC to lower the cost of major interconnectors

AEMO's 2022 Draft Integrated System Plan envisages more than 10,000 km of new transmission as part of the transformation by 2040. Such a large-scale build out of Australia's national electricity grid offers a rare opportunity to consider how technology advances may assist to most efficiently *'connect geographically and technologically diverse, low-cost generation and firming with the consumers who rely on it'.*

[1] See both Climateworks Australia's Decarbonisation Futures report, March 2020, https://www.climateworksaustralia.org/resource/decarbonisation-futures-solutions-actions-and-benchmarks-for-a-net-zero-emissions-australia/ and also Silvia Madeddu et al 2020 Environ. Res. Lett. 15 124004, https://iopscience.iop.org/article/10.1088/1748-9326/abbd02/pdf

Advances in HVDC cable technology in recent years make it possible to efficiently deliver electricity across long distances (undersea or overland) at a significantly lower cost than alternating current (AC) transmission. Being an island nation, HVDC is particularly important as subsea high-voltage AC systems are typically not viable at distances greater than 60-100 km. HVDC technology is increasingly being used for offshore wind connections and electrification of offshore oil and gas facilities.

In China and northern Europe, HVDC technology has been selected to transmit impressive volumes of energy from renewable energy provinces to load centres. Lower-cost options for electricity transmission open up new opportunities for Australia to service neighbouring markets with our low-cost solar and wind resources. This is the basis of the Australia-Asia Power Link project currently being pursued by Sun Cable, connecting the Northern Territory to Singapore. Low-cost HVDC would also make greater interconnection within the domestic market more attractive, enhancing system flexibility, reliability and security.

Finally, it is worth noting that as a supplier of many of the materials required to manufacture HVDC cables (principally copper and aluminium, as well as steel and lead), coupled with access to low-cost electricity, Australia would have a comparative advantage to become a centre of manufacturing for cutting edge HVDC cable technology.

2) Accelerated deployment of energy storage capacity

Large-scale energy storage will play an important role in creating a flexible and reliable energy system and supporting the rapid deployment of variable renewable energy sources. The CEC welcomes the prioritisation of energy storage within the Roadmap as an important enabler of high penetration renewables.

The Roadmap should prioritise both short and long duration energy storage. These have different characteristics and capability but are a significant complement to wind and solar generation which will inevitably dominate the future of the energy system.

Battery technology has proven to be incredibly effective at providing rapid system support, voltage and frequency control in the energy system. The technology is increasingly well-developed and proven, and private investors are gaining confidence to commit utility-scale battery projects. Batteries are now being used to improve the performance of existing fossil assets, for example by reducing starts/stops of gas peakers as well as being effectively integrated with solar and wind projects to optimize scarce network connection capacity.

We note that the economic stretch target of $100/MWh for firmed electricity from lithium-ion batteries indicated within the Roadmap appears challenging but achievable, and based on the estimates provided in the CEC's 'New Clean Peaker' paper in 2021[2], this cost objective would signify a ~50 per cent cost reduction for a two-hour battery and a 35 per cent reduction for a four-hour battery (see Figure 1 below).

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[2] *Battery Storage: the New, Clean Peaker*, April 2021, Clean Energy Council, https://www.cleanenergycouncil.org.au/resources/resources-hub/battery-storage-the-new-clean-peaker

Figure 1: Levelised cost of energy for lithium-ion batteries, compared with an open-cycle gas turbine peaker[3]

LEVELISED COST OF ENERGY (AUD$/MWH)	TWO-HOUR BATTERY	FOUR-HOUR BATTERY	OPEN CYCLE GAS TURBINE PEAKER
Capital cost	143	117	156
Fixed operations and maintenance	26	13	13
Variable operations and maintenance	26	26	65
TOTAL	**195**	**156**	**234**

There are many different types of cost-effective thermal energy storage solutions commercially available today that can be used at grid scale and behind the meter to shift peak load. Mechanical and gravitational storage is also undergoing significant innovation, particularly at the grid scale.

Traditional gravitational storage using pumped hydro also has a role to play in supporting the renewable energy system of the future. Hydropower can provide flexible ‘peaking services’ to meet rapid changes in energy demand as well as during peak periods. It can also help supply energy during less frequent, prolonged periods of energy supply shortfall due to reductions in wind and solar output. This capability is integral to managing the transition to a generation fleet that is dominated by variable wind and solar generation. With fast-start and fast-ramping characteristics, hydropower can also respond rapidly to dynamic changes in our energy system and maintain this service provision for as long as is necessary to keep the lights on.

While there are several traditional hydro and pumped hydro projects under investigation across the country, these are complex projects with long project development lead times and current investor uncertainty. There is a need for policy and market settings that price carbon costs and recognise the additional value and benefits of hydropower’s system services and characteristics. Current market arrangements do not recognise the full system value and benefits of storage (including fast frequency response and inertial response, flexible capacity, operating reserve and/or ramping capability) and so while there has been some increase in the number of financial commitments to battery storage projects in particular, the level of investment remains relatively low and will continue to be until market reforms are implemented and/or the cost of new storage capacity falls. In the meantime, government support for storage projects will remain critical, and the Roadmap should continue to support the accelerated deployment of these solutions.

It is also worth noting there are significant opportunities for Australia to develop a strong local supply chain across the various forms of energy storage, with the potential to become a significant export industry into the future. This could involve not only the local manufacturing of battery technology as well as R&D expertise, grid integration and software control systems and engineering and design expertise that are likely to become a competitive advantage for Australia should there be a strong storage industry developed over the coming years.

[3] *Battery Storage: the New, Clean Peaker*, April 2021, Clean Energy Council, https://www.cleanenergycouncil.org.au/resources/resources-hub/battery-storage-the-new-clean-peaker

3) Ultra low-cost solar

We welcome the Roadmap's recognition of the crucial role that solar will play in Australia's and the world's clean energy transition, and commend the ambition for Australia to make a direct contribution to achieving 'ultra low-cost solar'. This ambition provides an opportunity for Australia to build on the pioneering work of Australia's solar research community and the significant expertise that remains within a number of our leading research institutions.

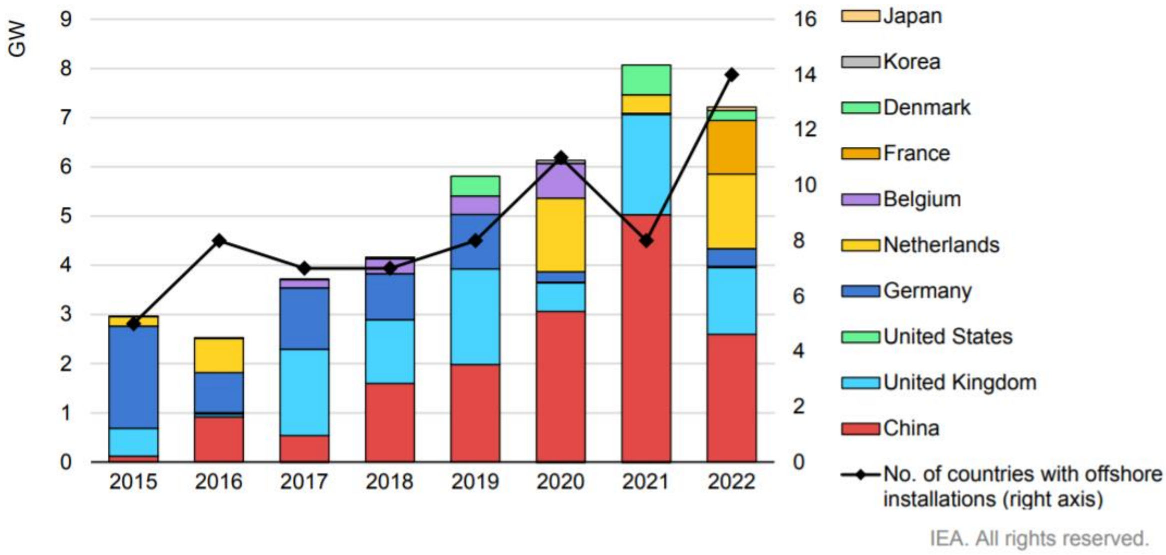
We note that the recently announced ARENA funding round will not only focus on the efficiency of solar cells but also on the total system build and operation. The CEC expects that advances can be made in both fields, and these learnings may provide the foundation for deepening Australia's participation in solar supply chains.

4) Offshore wind

In the same way that the Technology Investment Roadmap has established a stretch goal for the next stage of solar's evolution – a technology which was first developed more than half a century ago – the time may have also arrived to consider the next chapter of the wind industry's development in Australia.

Offshore wind has taken off globally over the past 7 years, with 35GW now installed worldwide – 10 GW of which was estimated to have been deployed in 2021 alone, with a further 10 GW expected to be built in 2022[4].

Figure 2: Annual offshore wind capacity additions by country/region, 2015-2022 (Source: IEA)



While offshore wind remains considerably more expensive than onshore wind, there have been major cost reductions achieved, most notably within the UK market over recent years as a result of the UK Government's renewable energy support scheme which has set a target of deploying 40 GW of offshore wind by 2030. The UK Government now expects offshore wind to be cost competitive with onshore wind by 2030[5].

[4] See Bloomberg NEF's Top 10 predictions for 2022, https://about.bnef.com/blog/wind-10-predictions-for-2022/

[5] Offshore Wind Potential for Australia, Blue Economy Co-operative Research Centre, 2021, https://blueeconomycrc.com.au/projects/offshore-wind-potential-australia/

While the CEC acknowledges the superior scale and efficiency of the onshore wind energy market in Australia compared with the UK and some other land-constrained international markets, it is nonetheless clear that there is increasing interest in the role that offshore wind can play in Australia, particularly in a clean energy superpower scenario. In less than two years, Australia has gone from just one (well-progressed) offshore wind project proposal, the Star of the South off the south-west coast of Victoria, to almost 20 offshore wind proposals around the country, totalling approximately 2.3GW of proposed capacity.

The key drawcards for offshore wind in Australia are the (typically) higher capacity factors than onshore wind, the complementary nature of this resource to existing onshore wind and solar, the ability to locate closer to major load centres, the expectation of accelerated closures of coal fired power generation, and the passing of a new regulatory framework to support offshore clean energy infrastructure.

As a first step, the CEC encourages the Roadmap's Technology Investment Advisory Council's to include offshore wind on its list of emerging technologies which show promise for prioritisation.

6) Hydrogen

Hydrogen offers a transformative opportunity for Australia to transition from a major producer of emissions-intensive energy, to a globally significant producer of zero-emissions energy. As such, low-cost hydrogen is critical to Australia's terms of trade, as well as the sustainability and scale of our domestic heavy industries such as steel. It is therefore appropriate that this is classified as a top priority for the Technology Investment Roadmap.

While the industry is in a pre-commercial phase, dependent on government support for economic viability, there are indications that progress towards the threshold for cost-competitiveness with fossil fuels (approximately ~$2/kg) is accelerating. Firstly, BloombergNEF expects electrolyser sales to quadruple this year, from around 460 MW in 2021 to between 1.8-2.5GW in 2022[6], which is critical when considering the important learning curve relationship between technology deployment and technology costs.

Further, in November 2021 a coalition of major green hydrogen proponents – including a number of Australian producers – announced a commitment for 45 GW of electrolyzers to be developed with secured financing by 2026, with targeted commissioning in 2027. This represented an almost-doubling of the capacity that had been deemed deployable within those same timeframes just 12 months prior[7].

We note however the stiff competition that Australia will have from other countries across the Americas, the Middle East and Europe in order to be the supplier of choice (see Figure 3 below, showing BloombergNEF's forecast costs for green, blue and grey hydrogen across various markets). Highly co-ordinated planning and investment that can deliver cost reductions across the full value chain will be required in order to maintain Australia's position as a leading contender.

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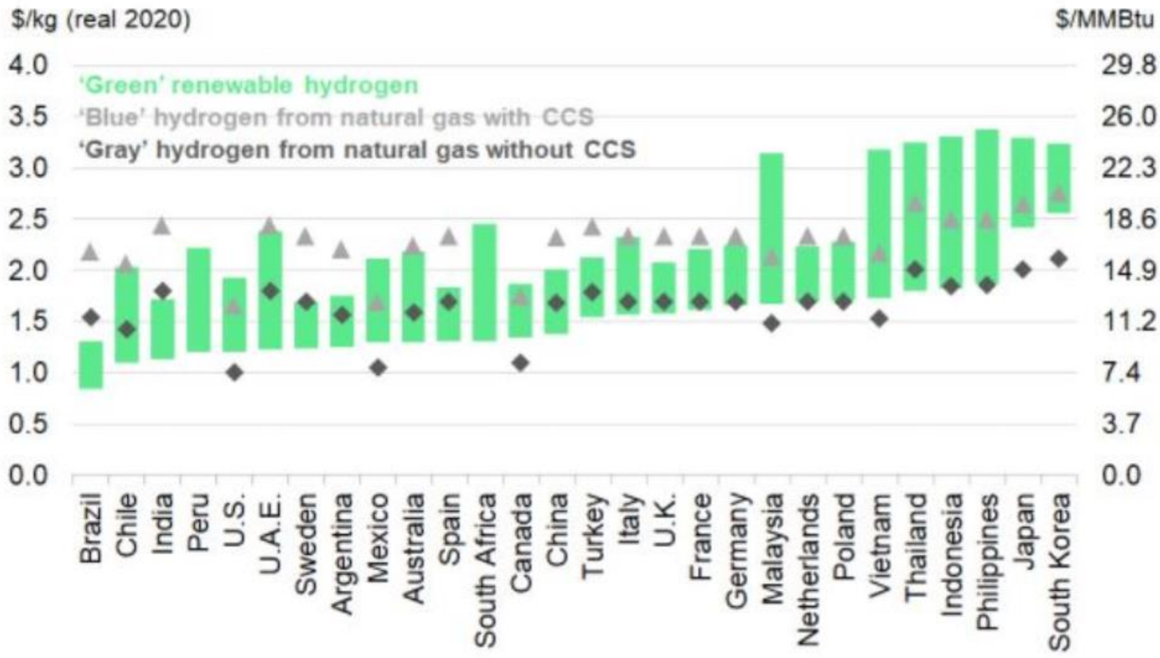
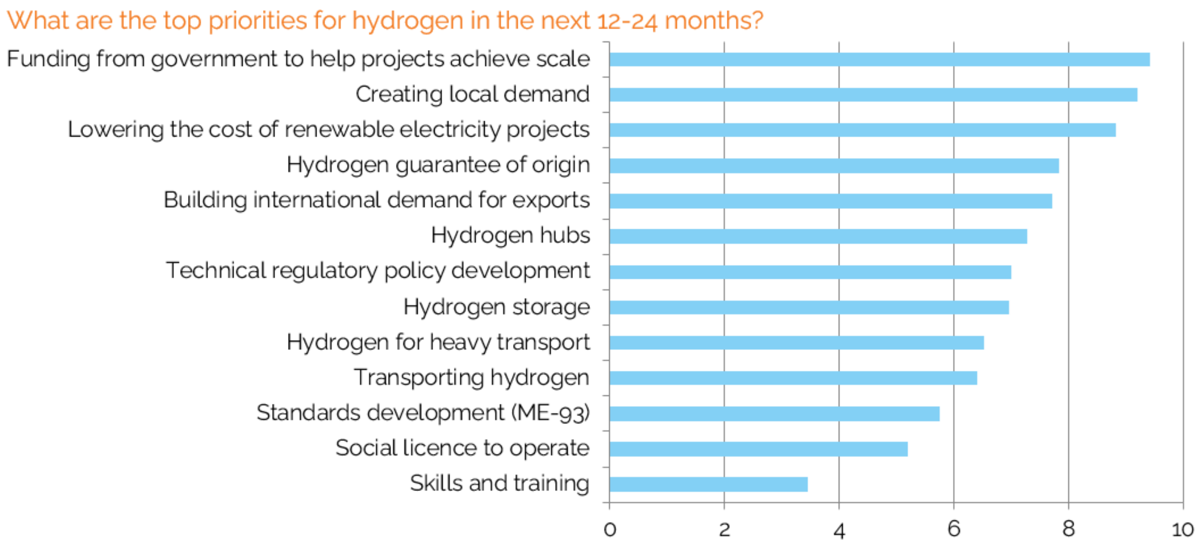
[6] https://about.bnef.com/blog/hydrogen-10-predictions-for-2022/
[7] Green Hydrogen Catapult Initiative, https://rmi.org/press-release/the-green-hydrogen-catapult-announces-expansion-of-world-leading-green-hydrogen-deployment/

Figure 3: Bloomberg's analysis of green versus blue hydrogen costs, 2030



In response to a renewable hydrogen sector survey carried out by the CEC in January 2022, our members reported that their top priorities to support the development of the sector over the next 1-2 years was 'funding from government to help projects achieve scale'. This speaks to the challenge that project proponents are having to bridge the funding gap to deliver economically viable projects.

Figure 4: Priorities of the CEC's Renewable Hydrogen membership, January 2022



Strong progress has been achieved over the past 18 months in kickstarting early projects via the ARENA Renewable Hydrogen Deployment Fund; through the more recent Hydrogen Hubs grant programs which will support proposals for new demand and production hubs to progress, via the international technology partnerships program, and via the HySupply feasibility study which is exploring the economics of hydrogen export supply chains to Germany/Europe. This support must both continue and be scaled up to reflect the magnitude of the opportunity available to us.

Further, we consider that there is a need for the Government to also develop a more granular plan for getting to *'H2 under A$2/kg'*, breaking down Australia's strategy and role in driving down the cost. It is currently unclear which aspects of this goal will be achieved through global technology advancements, and which will be led by Australian governments, industry and the research community working together. Such a plan would assist to more clearly focus efforts and investment.

Further, with analysis illustrating that the costs of renewable ('green' hydrogen) will be lower than those of 'blue' hydrogen (via steam methane reforming of natural gas), within eight years, the CEC contends that such a plan should be squarely focused on supporting cost reductions in renewable hydrogen, which is the only strategy for a zero-emissions hydrogen industry. The current Government emphasis on supporting natural gas-based hydrogen risks wasting public money on an industry with a very short lifespan.

7) Direct electrification solutions for energy intensive users

A feature of some heavy industries, such as metals processing, cement making, chemical production, ceramic and glass manufacturing, is the high temperature process heat required. Table 1 below demonstrates these sectors. While it often considered that fuel combustion is essential to achieve these temperatures, there have been steady technological advancements in a range of direct electrification solutions (eg. industrial heat pumps) which makes them contenders for delivering a larger share of the needed industrial emissions reductions.

Many of these direct electrification technologies were recently canvassed in a 2020 research paper by Silvia Madeddu at the Potsdam Institute for Climate Impact Research[8], and are listed in the table overleaf. We suggest that the Technology Investment Advisory Council may wish to explore/monitor/pursue developments in some of these electrification technologies further, particularly in relation to those emerging technologies with the potential to achieve high-temperature process heat.

[8] Silvia Madeddu et al, 2020, Environmental Research Letters, 15 124004, *The CO_2 reduction potential for the European industry via direct electrification of heat supply (power-to-heat)*.

Table 1: Electrically powered technologies for industry electrification (Madeddu et al, 2020)

<100°C	100 – 400°C	400 – 1000°C	>1000°C	TECHNOLOGICAL MATURITY	APPLICATIONS	EFFICIENCY /COP	ELECTRIFICATION STAGES
Compression heat pumps and chillers				Established in industry (only <100 °C)	Space heating Hot water Low pressure steam Drying Cooling and refrigeration	COP 2 – 5	1
Mechanical vapour recompression (MVR)				Established in industry	Energy recovery (e.g. in distillation, evaporation) to provide steam and process heat	COP 3 – 10	1
Electric boilers				Established in industry	Space heating Hot water Thermal oil Steam	0.95 – 0.99	1
Infrared heaters				Established in industry	Drying Paint curing Plastic treatments Food processing	0.60 – 0.90	1
Microwave & radio frequency heaters				Established in industry except cement and ceramic firing/sintering	Drying Ceramics firing and sintering Cement treatment Food processing	0.50 – 0.85	1
Induction furnace				Established in industry	Metals melting, re-heating, annealing, welding	0.50 – 0.90	2, 3
Resistance furnace				Established in industry	Metals melting, smelting Heaters for the chemical industry Ceramic firing Glass melting Calcination	0.50 – 0.95	2, 3
Electric arc furnaces				Established in industry	Metals melting and partial refining	0.60 – 0.90	2, 3
Plasma technology				Established in industry only for metals and waste treatment	Waste treatment Metals treatments (e.g. welding) Sintering Cement production	0.50 – 0.90	2, 3

Notes: Efficiency is the ratio between UE output and FE input of an appliance. The COP measures the heat output (for heat pumps) or the heat absorbed (for chillers) per unit of work input. Stages 1 and 2 of electrification refer to those technologies which are already fully developed and established in industry. Stage 3 electrification involves technologies that have higher uncertainties and lower technological maturity.

Conclusion

The last year has been characterised by increasing global political and investor momentum in delivering on the world's climate and decarbonisation goals, and the pace of Australia's clean energy transition has quickened even since the Technology Investment Roadmap was first released.

With AEMO recently confirming that Australia is likely to have largely completed the clean energy transition of its National Electricity Market by the end of this decade, the Technology Investment Roadmap should focus its efforts on those solutions – a modern and efficient electricity network that can operate at very high levels of low cost solar and wind, energy storage, electrification and renewable hydrogen – which can support and smooth this transition. The successful completion of this renewable energy transition will create the foundations for Australia to build new markets and expand our existing industries, standing our economy in good stead to thrive in a decarbonised world. We look forward to continuing to work with you in delivering on these priorities over the coming year.

Yours sincerely,

Anna Freeman
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