Electrification & Energy Systems Network

DECARB HUB New South Wales Decarbonisation Innovation Hub

# Submission to Public Consultation on the Electricity and Energy Sector Plan

## Enabling Electrification for a Smooth transition

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DECARB HUB New South Wales Decarbonisation Innovation Hub A nsw.gov.au Initiative

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# 1 Introduction

The aim of the NSW Decarbonisation Hub is to bring together research, industry, government and communities to develop cost-effective solutions to reduce carbon emissions to net zero by 2050, whilst creating jobs and economic growth in NSW and beyond. The Hub and its Networks support, accelerate, and attract investment to decarbonisation technology and services in NSW.

The Hub was established in June 2022 with funding from the NSW Government through the Office of the Chief Scientist & Engineer and The NSW Environmental Trust. Three underpinning Networks (Electrification & Energy Systems, Land and Primary Industries, Powerfuels including Hydrogen) accelerate and attract investment into decarbonisation tech and services projects in key sectors in NSW as we work towards net zero. This submission has been compiled by the Electrification & Energy Systems on behalf of all the networks in the Hub

- The Electrification and Energy Systems Network helps to resolve technical, economic, social and environmental challenges to innovate and commercialise the technologies needed to transform energy systems to reliably replace fossil fuels with renewables such as wind and solar.
- The Network's aim is to address issues and barriers to innovation, the need to develop a trained workforce, infrastructure planning to support innovation-to-impact, and energy equity.

# 2 Background

The most significant change which has occurred in the electricity supply industry since its formation is the uptake of distributed energy resources (DER), most particularly in the form of household solar installation. Recent figures indicate that the largest electricity generation source in the National Electricity Market (NEM) is solar on homes and businesses, with a total of 20 GW [1] of capacity at the beginning of 2023. Around one third of homes currently has solar generation installed and feeding power into the grid during the day.

The electricity transmission and distribution grids, and their associated rules and regulations were all designed when the electricity grid involved unidirectional power flows. That is, almost all electricity was generated by a relatively small number of generators fuelled by coal, gas and some hydro. Power flowed 'one way' from these generators, through transmission assets, then distribution assets, and was delivered to end users. The advent of substantial volumes of DER, present at distribution and transmission levels of the grid, means the electricity grid of today is multi-directional in nature.

It is remarkable that an electricity grid which was designed to operate unidirectionally has been able to accommodate such a large change in operating conditions while still delivering safe and, for the most part, reliable electricity to consumers. This is a testament to the robustness of the electricity grid, its fundamental engineering and the ingenuity of past and current grid operation organisations.

The rules and regulations which govern the control and operation of the grid have, however, not kept pace with the technological changes. From a regulatory perspective, we have a complete set of market structures, legal separation requirements, rules and regulations which are perfectly designed for an electricity system which no longer exists.

The connections between the economics of energy markets and the physics of electricity grid operation were, even at the commencement of the NEM, loosely aligned. However, economics and power electrical engineering obey different rules, the former being determined by market design, market regulation, participant and consumer behaviour and the latter by the fundamental laws of physics – voltage, current and power flow.

The advent of tidal power flows into and out of the grid resulting from DER have led to misalignment between the economics of market operation and the physical operation of electricity grids, to the point where the connection between market regulation and the 'real world' of power flows can, at times, be tenuous.

# 3 Enabling electrification for a smooth transition

## 3.1 DER Opportunities

Some entities within the electricity supply industry see DER management as a grid-impacting problem to be solved. This results in narrow minded approaches which are and will continue to operate to the detriment of consumers, for example, large scale solar curtailment regimes [2].

*Widespread DER is not a grid problem to be solved, it is an opportunity to be harnessed by consumers and service providers.*

The coordinated and dynamic management of large numbers of small controllable loads such as electric storage hot water, pool pumps, home batteries, EV charging, community batteries and grid support batteries will provide the ability to match DER output at high production times during daylight hours with controllable demand, while also working to reduce the evening peak demand and in the case of batteries, extend the solar window into the evening demand period. The result will be reduced bills for consumers as evening peak prices are reduced as the so-called 'duck curve' of demand is flattened out. The significant potential energy cost savings and environmental benefits of coordinated DER management have been quantified by Deloitte, in a comprehensive three-year research project part funded by ARENA, led by AEMO and culminating in an 11-month VPP trial conducted in regional Victoria by Ausnet Services and titled Project Edge [3]. The coordination and dynamic management of controllable loads would require the stimulation and support of what is currently a nascent market in Australia.

The implementation of this new approach requires embracing the role of the Distribution System Operator (DSO) as manifest in other countries' markets [12]. The DSO function could be delivered by current Distribution Network Service Provider (DNSP) businesses within their existing supply areas, although consideration should be given as to whether the function would be best 'ring fenced' outside of regulated business operations and placed into a more market-oriented business structure.

Taking a more decentralised approach to network control and operation has the dual benefits of aligning network control and operation with the technology pathway already being followed due to widespread connection of small-scale generation and storage, while providing the ability for innovative, locally beneficial approaches to grid operation to emerge.

## 3.2 Home electrification considerations

Home electrification as a decarbonisation measure can be considered from two perspectives. The first is new build situations and the second is retrofit situations.

In new build areas, the costs and challenges of full home electrification are minimised. More specifically, the costs of building full electrification into a new home construction are generally on par with the costs of connecting a new home to two energy networks – electricity and gas. Similarly, if it is known that an area will be 'all electric', then the network costs to supply the necessary infrastructure are also minimised, as they can be designed into the area from the start.

In retrofit situations, the costs and challenges of full home electrification are more significant. Firstly, the total carbon footprint associated with potential early retirement of existing appliances must be considered. Approaches which replace gas fuelled home appliances with electric appliances-only when the gas appliances reach end of life would be the ideal affordability approach, however other practicalities such as the cost advantage of replacing multiple appliances at once (such as all cooking appliances in a kitchen renovation) may come into consideration. The upstream network challenges for areas where large scale electrification occurs are more challenging and will require considered action, as outlined later in this submission.

The technologies required to achieve home electrification are readily available and are mostly cost competitive. More nascent technologies such as home batteries (also referred to as behind the meter batteries) and heat pump hot water systems are still at more premium price points, requiring some form of subsidy to be made attractive to consumers, especially when applied to retrofit situations.

One of the main home electrification cost challenges is the capacity of the internal home electrical system. It is common for consumers seeking to electrify their homes to be faced with the need to upgrade their home switchboards, home internal wiring and even their 'consumers mains', which are the wires connecting the home to the electricity network in the street. The costs associated with internal home wiring upgrades can often cause consumers to adopt 'like for like' appliance replacement options, thereby impeding the home electrification journey. Subsidies which significantly reduce the cost of electrical appliances are highly beneficial to address this issue.  Furthermore, any enhanced affordability of domestic appliances releases capital for investment in the home wiring upgrades required to connect the appliances.

A vital consideration is the skilling and awareness of installers and decision-makers respectively.  Electricians and plumbers need to be upskilled to incorporate electrified appliances in replacements – when renovating or replacing end of life products. Architects and other eco-system players also need to understand the benefits to their clients so they can advocate for long-term electrified residences.

## 3.3 Network Considerations

The widespread connection of DER resources in the form of solar on homes and businesses has, thus far, been accommodated by the existing local electricity networks with minimal upgrades and cost increases. As stated earlier, it is remarkable and significant that an electricity grid which was designed to operate in a command and control architecture has been able to accommodate such a large change in operating conditions while still delivering safe and reliable electricity to consumers.

However, increased levels of home electrification will automatically lead to increased levels of electricity demand. New electrical appliances in homes such as heat pump hot water units, induction cook tops and EV charging are some examples. Conversely, increased home electrification can equally be expected to be correlated with increased volumes of distributed energy systems, in particular solar generation and battery energy storage. Coordination of home energy systems to, for example, match solar output with EV charging during periods when the EV is parked at home, provide substantial potential for the present network demand implications of residential electrification to be minimised while also reducing energy bills for consumers.

There is a fairly polarised debate about network development: some say local electricity networks are at or approaching 'saturation point', past which large volumes of capital investment in network assets will be required to facilitate further home electrification; others state little to no new network investment will be needed. We can expect reality to be a combination of identified latent capacity and further investment required in specific network locations. What is clear, is that low voltage distribution networks have a key role to play in any scenario which involves increased electrification of homes. Traditionally, low voltage networks have received much lower levels of attention when compared to sub-transmission and transmission assets. This can no longer be the case.

Considerations which are and will continue to need to be addressed by DNSP's as home electrification increases are:

### 3.3.1 Power Quality

The ongoing installation of energy efficient electronic appliances into homes in conjunction with the increase in prevalence of inverter-based technology may result in concerns over power quality disturbance levels. In many cases new technologies are simultaneously sources of power quality emissions and are also more susceptible to power quality disturbances. Of note are:

- Harmonics – In particular, high frequency harmonics are increasing in electricity supply networks as more power switching devices are connected. The impacts of this increase are not certain, so further research into the effects of increased high frequency harmonic levels is recommended.
- Voltage increase – The issue of voltage levels is explored in detail in the following section of this submission. The impacts of ongoing voltage increases are increased energy consumption by consumers, reduced export capability from solar systems, increased energy bills and higher greenhouse gas emissions.
- Voltage imbalance – A significant proportion of homes are connected to one phase of the three active phases of the low voltage electricity supply network. Increased levels of home electrification when operating in conjunction with ever increasing volumes of home solar installation, creates a situation whereby the voltage and current can be highly variable between each of the three active phases of the low voltage power grid. Phase imbalance leads to less efficient operation of upstream grid assets such as major power transformers.

Effective maintenance of power quality disturbances within electricity supply networks requires proper alignment and cooperation between networks service providers, appliance suppliers and consumers with reference to appropriate regulations and standards in each case. With respect to network service providers, the National Electricity Rules along with other regulation require these organisations to maintain acceptable power quality disturbance magnitudes within their electricity supply networks. However, to date, regulation of power quality in low voltage networks has generally been 'light' and the ability for network operators to invest in management of power quality has been limited. Given the critical role that the low voltage network is now playing in hosting large volumes of DER, new frameworks for managing PQ will be required. This may include additional investment in power quality monitoring infrastructure and/or better ability for network operators to source data from retailers and other metering providers. For appliance suppliers it is critical that appliances are designed to conform with the electromagnetic compatibility environment as defined in relevant standards. Appliance suppliers should also strongly consider the power quality disturbance emissions from the appliances that they are designing and manufacturing. For consumer appliances connected at LV, responsibility is generally abrogated to appliance product standards. Consideration may need to be given to mandating Australian Standards which limit power quality disturbance emissions from consumer appliances. An example of such an Australian Standard is AS 61000.3.2 which limits harmonic current emissions from low power consumer appliances.

### 3.3.2 Voltage control

Australian Standard AS 60038 [4] specifies the acceptable voltage range for electricity supply to end use customers. Prior to 2000, the acceptable voltage range for supply to end use consumers was 240 V, ±6%. From 2000 onwards, the standard changed to align with international voltage standards, with a nominal voltage of 230 V. To make the transition easier for network operators, an asymmetric voltage tolerance was included, being 230 V +10%/-6%. Although the Australian Standard officially changed in 2000, the asymmetric voltage tolerance allowed by AS 60038 has resulted in minimal change from the previous 240 V (±6%) system. Traditionally, network engineers have configured the electricity grid for one-way electricity flows and generally regarded higher voltage levels on the low voltage network as a 'good thing'.

The result is that despite all appliances sold in Australia since 2000 being required to operate with highest efficiency at 230 V, the actual voltage received by most electricity users for most of the time is between 240 V and 250 V [5] and is continuing to increase with the rapid growth in rooftop solar. The issue of oversupply of voltage has also been identified as far back as 2010 by the University of Wollongong National Power Quality Audit, who stated “Since the inception of the survey it has consistently been found that some 25 % - 30 % of LV sites record 95th percentile steady state voltage levels which are above the upper low voltage limit (230 V + 10%).” [6]. It is well accepted that higher voltage magnitudes will result in additional energy consumption. Given the propensity of Australian low voltage networks to be operating at voltage magnitudes at the upper end of the allowable range, energy is wasted unnecessarily on a system-wide scale. The consequences of this problem are:

- Higher bills as consumers are force fed more electricity than their appliances require, in order to operate satisfactorily;
- Increased greenhouse gas emissions when more energy (from fossil fuel generators) than necessary is generated and supplied to consumers;
- Reduced appliance lifetimes because appliances designed to operate satisfactorily at 230 V are electrically supplied at 240 V or above for most of their service lives; and
- Less ability of rooftop solar to generate power, as the solar inverters which connect panels to the grid are unable to push their clean power out into a grid which is operating at too high a voltage. This results in tripping of the solar inverters, reducing the energy they deliver back to the grid and reducing feed-in tariff payments to end-users.

The solution to this problem is, in principle, simple: reduce the voltage in power provision to reflect the specified voltage, while managing the extremes of voltage observed now. In practice this means reducing the average supply voltage from the range 240 V - 250 V to the nominal Australian Standard of 230 V.

Network companies currently control voltage levels and other power quality parameters using traditional technology such as on-load tap changers, voltage control relays and where available information from interval meters (sometimes referred to as smart meters). These control systems mostly lack the ability to control voltage dynamically and monitor the low voltage network in real time, resulting in inefficient solutions which rely on off-line monitoring and inexact estimation of the network status. Moreover, the voltage control systems were not designed to operate an electricity network with multi-directional power flows, such as networks with significant solar generation. Blunt instrument solutions to voltage control and system stability such as shut down of large volumes of solar generation during peak solar output times are increasingly being employed. The advent of further recent technology such as electric vehicle charging and distributed battery storage will further highlight the inadequacies of existing monitoring and control systems on the low voltage network, and if left unaddressed will result in more frequent shut down of distributed solar generation.

The challenge with reducing the voltage level across all low voltage networks is that the weakest low voltage networks will not be able to supply voltage above the minimum level specified in the Australian Standard (230 V – 10% = 207 V). It is estimated that most low voltage networks will operate satisfactorily at a lower voltage level than they presently operate and that only 5% of low voltage network will require some form of intervention to maintain voltage levels within the Australian Standard lower limit.

Globally voltage reduction is a well-established approach to energy efficiency [7]. The concept is commonly referred to as Conservation Voltage Reduction or CVR. The implementation of CVR results in an increased ability to host distributed generation from solar panels, as well as reductions in energy bills for commercial and residential consumers. In general, the amount of energy it can save depends on the load characteristics and the characteristics of the network.

Widespread adoption of CVR and dynamic voltage control is a cost-effective means by which DNSPs can manage the impacts of increasing volumes of residential electrifications. However, at present, the regulatory frameworks to allow DNSPs to make significant investments to reducing voltage magnitudes are lacking and it is difficult for DNSPs to build business cases for funding for voltage reduction activities. Notwithstanding this, the costs associated with this implementation could be recovered through existing incentive based regulatory frameworks [8]. There is also merit in considering an approach similar to OFGEM in the UK [9], who have granted permission for DNSP monopoly businesses, within appropriate guidelines, to operate dynamic voltage control services within energy markets, thereby reducing the overall cost burden on traditional monopoly network service charges to end use consumers by establishing market-based revenue streams.

### 3.3.3 Dynamic Network Operation

The DSO function has the potential to facilitate the coordinated and dynamic management of large numbers of small controllable loads such as electric storage hot water, pool pumps, home batteries, community batteries and grid support batteries. These controllable loads will provide the ability to match DER output at high production times during daylight hours with controllable demand, while also working to reduce the evening peak demand and in the case of batteries, extend the solar window into the evening demand period. DSO functions may also consider concepts related to management of energy locally or on a small-scale through the co-ordination of the full suite of generation, storage (household and community) and controllable loads. This may include the concept of community microgrids. Proper management of these resources may manifest in a range of benefits for both network operators and consumers including:

- Reduced electricity costs
- Improved equity (see further detail on equity below)
- Improved power system reliability
- Reduced capital spend on high voltage network assets

However, at present, there are a range of technical and regulatory barriers to management of energy at a community level, not the least of which are in the electricity retail space.

Establishing and maintaining the systems and personnel to deliver the DSO functions within DNSP's will incur costs. The DSO function could be delivered by current DNSP businesses within their existing supply areas. It is suggested that consideration should be given as to whether the DSO function would be best 'ring fenced' outside of regulated business operations of DNSP's and placed into a more market-oriented business structure, thereby allowing the costs of operation to be directly linked to the benefits. For example, the increasing volatility of daily wholesale electricity prices could be harnessed to allow DSOs to gain revenue by purchasing wholesale energy when it is cheap during the day and then selling that energy back into the wholesale market when prices are at premium levels of an evening. The substantial revenue generated from this wholesale energy market trading could be used to fund the establishment of DSO systems, thereby reducing the costs passed through to consumers from traditional regulated network monopoly charges.

## 3.4 Actions required to ensure Australia's energy systems can enable increased electrification, while maintaining equity, reliability and security

We concur that the electrification of the Australian economy requires the most significant investment in capital assets since the Second World War. This investment is across residential (DER), commercial, industrial and the supporting transmission and distribution networks. There is one consideration that has often been neglected in the planning of this transformational investment and that is **testing.**

Under the status quo, developers, designers, installers, owners and operators rely on testing performed offshore, either by the equipment manufacturer or from a regional testing centre. This approach ignores risks associated with:

- Australian Standards
- Australian environmental conditions (heat, humidity, dust etc.)
- The regulatory constraints and idiosyncrasies of the Australian electricity market networks

- Combination of equipment types that are brought together to operate within a set systems operating envelope

There is a need to create a **national testing facility** that has the capability to test equipment used in different operating environments (network, industrial process, commercial, residential, governmental). Further justification for a national testing facility include:

1. Australia's electrical network is unique: huge centres of demand separated by 1000s of kms. This presents systems and equipment connected to the grid with unique grid behavioural challenges that may not have been encountered elsewhere. Specific tests need to be administered to de-risk deployment on Australian grids. These tests need to be designed to represent uniquely Australian conditions.
2. The most proximate regional testing hub is 8 hours flight from the East coast of Australia and does not necessarily serve Australian requirements. This has implications for investors and installers who either must rely on OEM and importer certification/assertions or will be burdened with additional supply chain risks to conduct offshore testing.
3. Rural communities should be able to access competitively priced energy – not least through standalone power systems that are safe and resilient. Lower cost solutions need to be developed and tested to determine if they are fit for purpose in improving energy reliability of services at realistic price points.
4. Our electrical power systems must remain safe. The general level of understanding amongst trades associated with the installation of millions of small-scale systems means there will be risk of unsafe systems in operation in the solar PV market. These put at risk many workers every day. Testing of solar and other consumer-facing equipment needs to integrate into safety programs for trades and other workforces involved in renewable energy installation and maintenance.
5. The emerging cyber-security threat to our controlled and coordinated future grid drives the need for comprehensive cyber-security risk assessments and penetration testing. The current exposure leaves the future grid open to relatively simple threats that can cause much economic damage and network safety issues that place the public at risk. Thus, testing vulnerabilities to cyber threats concurrently is a consideration.
6. Energy storage will underpin both the integration of renewable energy and the electrification process. So, we need facilities where innovators can test storage technologies to destruction. This includes hydrogen production and conversion. Scaling facilities require the testing of failure-safe mechanisms to ensure the control of runaway events at the limits of the operating envelope.

7. Our existing grid was built to a high standard with a relatively simple, slow and well-behaved operating procedure. Our future grid will be considerably more dynamic, possibly the most dynamic power system on the planet. For this to happen we must test and verify a new generation of rules for operating grids. While we enjoy the fruits of innovative technology and services, there will be an imperative to continue to evolve these grid standards, requiring consistent investment in exploratory and confirmatory testing.
8. Electrification technologies are areas where Australia has a huge opportunity to develop new technologies in power conversion, smart sensing, synthetic fuel production across a huge range of applications.
9. Australia needs to be able to test these new electrification technologies as a technology failure can easily lead to years of setback for new technologies. This view is underpinned by AEMO's 2024 General Power System Risk Review (2024 GPSRR)
10. Taking a global view, we find that any nation wishing to deliver electrification equipment into this time-critical and large-scale opportunity has its own test and demonstration centre, quite often these are across multiple sites that offer facilities for parts of the market (e.g. the UK's Driving the Electric Revolution consortium for electrical transportation).
11. In summary, a national testing facility addresses speed to deploy, lowering commissioning and operating risks, reliability of performance and security - including the increasing need to manage the threats to data management across electrification.

The Electrification & Energy Systems Network under the auspices of the NSW Decarbonisation Innovation Hub, is putting together a plan to develop such a national facility: the **National Electrification Innovation Testing Centre** (NEITC). The services planned to be offered by the facility include:

A. Power conversion technology adoption – this is at the heart of energy transformation. This is critical to the electricity grid and the electrification processes required by the economy.
B. Grid Assurance Services – these services are to ensure continued grid stability and resilience, while variable renewable generation, storage and usage proliferate across the grid, resulting in decentralised control.
C. Local Equipment Development Support – providing support to established enterprise, startups and innovation research teams to develop their products in the context of local, regional and global markets.

We strongly recommend the establishment of the NEITC to address key barriers to electrification and assist with the required pace and scale of electrification ahead of Australia.

We believe it will be imperative for federal and state governments to support this initiative such that it provides Australia with the needed capabilities to de-risk and accelerate electrification.

## 4 Growing alternative low carbon fuels

Seeking your views: Growing alternative low carbon fuels, and managing fuel security

1. What policy settings and certainty are required to support a fair, equitable and orderly transition for the decarbonisation of both natural gas and liquid fuels?

*Network response:*

Australia's experience with carbon credit mechanisms offers valuable lessons for designing effective policies to decarbonize the fuel sector. The former Carbon Pricing Mechanism (Yr. 2012-2014) played a role in reducing emissions, but its shortcomings need to be addressed in the new framework. The previous scheme's fixed-price then floating-price model created uncertainty for businesses. Companies hesitated to invest in clean technologies for the fuel sector because they couldn't predict the future cost of carbon emissions. Additionally, the scheme's limited scope, excluding key emitters like transport and agriculture, weakened its overall impact.

To ensure a successful transition, Australia's new carbon pricing mechanism must address these shortcomings. A clear and predictable price trajectory is essential. For significant scale emitters, the Federal Government should commit to a gradually increasing carbon price for the fuel sector. This provides businesses with the certainty they need to invest in low-carbon technologies and infrastructure. Furthermore, the scheme's coverage should be broader, encompassing all major emitters, including the fuel sector alongside transport and agriculture. This ensures a more comprehensive approach to emissions reduction in Australia.

Beyond carbon pricing, policymakers could explore a guarantee of origin scheme for natural gas, mirroring the existing program for hydrogen and renewable electricity. This would empower consumers and businesses to choose lower-emission natural gas, even at a premium. This financial incentive could drive investment in proposed technologies like carbon capture utilisation and storage. An emissions intensity scheme specifically targeting the electricity sector also warrants investigation. It sets a cap on average carbon dioxide emissions per unit of electricity generated. This approach would make high-emission generation costlier, incentivizing producers to transition towards cleaner sources like renewables.

A just transition framework is essential to complement these policy instruments. Earmarking a portion of carbon pricing revenue to offset impacts on regional communities and/or smaller businesses and landholders can ease the burden for communities and workers most impacted by the shift. This could include funding for retraining programs, regional development initiatives, and targeted assistance for low-income households. Additionally, implementing border carbon adjustments would level the playing field for Australian businesses competing in a global market. By ensuring imported goods reflect their carbon footprint, this approach discourages carbon leakage and incentivizes global climate action.

By learning from past experiences and establishing a comprehensive policy mix that includes a well-designed carbon pricing mechanism, guarantee of origin schemes, and an emissions intensity scheme, alongside a robust just transition framework, Australia can create a stable, equitable, and effective pathway towards a decarbonized fuel sector.

2. What actions are required to establish low carbon fuel industries in Australia, including enabling supply and demand, and what are the most prospective production pathways?

*Network response:*

Australia's fuel sector decarbonisation hinges on establishing robust low-carbon fuel industries that leverage existing infrastructure where possible and strategically invest in new infrastructure for emerging solutions. Achieving this requires a collaborative approach between government, industry, and research institutions. Innovation hubs dedicated to low-carbon fuel research and development can accelerate technological advancements. Streamlining approvals for new, efficient low-carbon fuel production facilities removes bureaucratic hurdles and incentivizes investment. Market mechanisms can also play a crucial role. Mandates for blending low-carbon fuels with traditional fuels, gradually increasing the low-carbon component, create demand for clean alternatives. Developing clear standards for low-carbon fuels also ensures quality and sustainability across the supply chain.

Investing strategically in infrastructure is critical. Australia's existing natural gas pipelines could be repurposed for transporting hydrogen gas, leveraging existing assets and minimizing stranded costs. Hydrogen refuelling stations for hydrogen-powered vehicles are a near-term priority, alongside infrastructure for production and storage of renewable hydrogen produced via electrolysis. A diversified portfolio of production pathways offers long-term security and sustainability. Sustainable biofuel production from agricultural waste or dedicated energy crops grown on marginal land unsuitable for cropping can utilize existing production and distribution infrastructure in some regions. Short-rotation woody crops based on regionally appropriate native species (particularly Acacia and Eucalyptus) and with coppicing to reduce regeneration costs offer an attractive option as they can be integrated within existing mixed farm systems, utilising less productive land parcels not suitable for food production. Coppicing systems can also be combined with stock grazing in some situations, further reducing the food versus fuel quandary. Investing in research and development of advanced biofuels with lower lifecycle emissions, like cellulosic ethanol, can further expand options while avoiding competition with food production.

The focus shouldn't solely be on light-duty vehicles. For hard-to-decarbonize sectors like mining and commercial shipping, alternative solutions are needed. Investigating the potential of ammonia as a fuel source is a promising avenue. Ammonia can be produced from renewable hydrogen, offering a near-zero emissions pathway for these sectors. Research into ammonia production, storage, and infrastructure development is crucial to assess its viability and pave the way for its integration into the fuel mix, potentially utilizing repurposed existing infrastructure where feasible. By fostering collaboration to establish low-carbon fuel industries, strategically leveraging existing infrastructure, and investing in new infrastructure for emerging solutions, Australia can ensure a secure and sustainable transition away from fossil fuels.

2. Are the proposed policy focus areas for managing the liquid fuels transition (outlined in Section 4 of the discussion paper) the correct areas to focus on, and what is missing?

The discussion paper's proposed areas lay a strong groundwork for Australia's fuel sector decarbonisation. However, for a well-rounded and successful transition, the paper could delve into several aspects.

- Ensuring a Just Transition for Workers and Communities:

  The human cost of decarbonisation requires careful consideration. The paper should explore specific strategies to support workers potentially displaced from the fossil fuel sector. Retraining programs equipped with in-demand clean energy skills, career counselling services, and financial assistance during job searches can ease the transition for these individuals. Furthermore, the paper should address the economic and social impacts on communities heavily reliant on fossil fuels. Strategies for economic diversification and investment in new industries can create fresh opportunities and mitigate these impacts. Additionally, the paper could explore measures to ensure a just transition for low-income households. Policy options like targeted energy efficiency upgrades and rebates for low-carbon technologies like electric vehicles or heating solutions can help these households navigate the transition without undue financial burdens.

- Engaging consumers and encouraging behaviour Change:

  Public awareness is crucial. The paper should emphasize educating the public about the benefits of low-carbon fuel choices and the urgency of decarbonisation. Effective public awareness campaigns can foster consumer support for the transition and encourage behaviour changes that benefit the environment. To bridge the knowledge-action gap, the paper could showcase successful public engagement initiatives, like the NSW Department of Primary Industries' (NSW DPI) innovative H2Cuts trailer. This mobile barber shop, powered by hydrogen fuel cells and solar panels, offers free haircuts at agricultural events. It sparks conversations with the agricultural sector about renewable energy adoption in a fun and interactive way. Additionally, initiatives like the NSW DPI P2X Express hybrid diesel electric truck, showcased alongside the H2Cuts trailer at events like AgQuip, can demonstrate the viability of alternative fuels. By combining informative displays with practical examples, these initiatives create a tangible connection between clean energy technologies and consumer choices.

- Fostering Innovation for the Future:

  While the paper focuses on promising pathways like hydrogen, it's vital to acknowledge the need for continued research and development (R&D) in emerging low-carbon fuel technologies. Funding for research institutions and public-private partnerships can ensure Australia remains a leader in clean energy innovation. Here, initiatives like the NSW Decarbonisation Innovation Hub's Powerfuels Including Hydrogen Network (PFHN) serve as an ideal model. PFHN fosters collaboration between researchers, industry players of all scales, and policymakers. By providing resources for project design, advanced research, and engineering services, PFHN de-risks powerfuels projects and accelerates their development. This collaborative approach showcases the importance of going beyond traditional research funding models and fostering a connected ecosystem for innovation.

Furthermore, the paper should emphasize the importance of a technology-neutral approach, fostering innovation across a broad spectrum of low-carbon fuel solutions to avoid limitations from a rigid focus on specific pathways. One promising area for exploration is sustainable aviation fuel (SAF). Unlike alternative fuels for ground transportation, which have more options like hydrogen and biodiesel, aviation currently lacks a widely available, low-carbon alternative. Australia, a major player in the global aviation industry, is well-positioned to contribute to and benefit from advancements in SAF. By investing in R&D and production of SAF, Australia can establish itself as a leader in this critical field, reducing emissions in a sector where electrification is not yet a viable solution.

- Collaboration on a Global Scale:

  Decarbonisation is a global challenge. The paper should acknowledge the importance of international collaboration. Australia can learn valuable lessons from successful policies and technological advancements in other countries, while also sharing its own expertise. Examples of solution approaches already being successfully applied internationally and with potential for application in Australia include Agrisolar deployments that combine solar electricity generation with synergistic microclimate effects that allow for cropping, grazing or other benefits such as favourable habitats for rare or threatened biodiversity on the same land hosting solar energy infrastructure. Coppice-based biomass for bioenergy, discussed above, is a further example of a practice well established overseas and contributing to emissions reduction in countries such as Sweden, Germany and Denmark. The discussion paper could explore the role of international agreements and frameworks in driving global decarbonisation efforts. Australia can play a proactive role in advocating for ambitious emissions reduction targets and fostering international cooperation on R&D for clean energy solutions.

By incorporating these additional areas, the discussion paper can provide a more comprehensive and future-oriented vision for Australia's fuel sector decarbonisation strategy. This holistic approach ensures a just transition that addresses social and economic considerations while fostering innovation, consumer participation, and international collaboration for a sustainable low-carbon future.

# 5 Building Australia's clean energy workforce

Electricity sector workforce projections undertaken for the Race for 2030 CRC based on the 2022 Integrated System Plan (ISP) developed by the Australian Energy Market Operator (AEMO) highlighted a rapid scale up of the energy workforce is needed to implement the optimal development path in the ISP. Under the Step Change scenario, the combined workforce for renewable generation, storage, and transmission construction needs to increase by 12,000 in just two years to 2025. Overall electricity sector employment grows by 37,000 from 2023 to peak at 81,000 in 2049. If Australia becomes a major exporter of renewable energy (the 'Hydrogen Superpower' scenario in the ISP), the workforce needed would be up to twice as high in the 2030s and up to three times higher in the 2040s, with a peak of 237,000.

Employment modelling undertaken for the RACE for 2030 CRC and by Job Skills Australia highlights some of the key shortages and priorities for skills development. Jobs Skill Australia has identified the following occupations as key occupations where shortages are likely:

- Electricians
- Electrical Engineering Draftspersons and Technicians
- Airconditioning and Refrigeration Mechanics
- Electronics Trades workers
- Telecommunications Trade workers
- Civil Engineering Draftspersons & Technicians and Architectural, Building & Surveying Technicians.
- Metal Fitters and Machinists
- Structural Steel and Welding Trades

Jobs Skills Australia concludes engineering supply is likely to be adequate, but the volume is close to projected demand so there remains a risk of skill shortages. From research by ISF, there are specialisations in power systems engineering and sub-stations that are considered acute risks of shortage within the sector.

It's important to note that projections for energy management and demand (e.g. energy auditors) are very limited. There will need to be a rapid scaling up in specialist skills to realise opportunities, such as technical specialists that can work on flexible demand systems and products and trades and technicians for the electrification of homes (primarily plumbers and HVAC technicians in addition to electricians) and electric vehicle charging infrastructure. However, the Australian Energy Employment Report is required to proceed to develop a better understanding of the employment requirements for the demand-side of the energy system.

Building the workforce for the energy transition requires a combination of programs on the demand-side, supply-side and enabling measures to build collaboration and capacity.

- Programs to build the pipeline in schools: information programs, expanding schools VET and better definition of pathways into clean energy
- Investment in training capacity for clean energy such as mobile training units, training centres etc – especially in regional areas where the renewable energy infrastructure will be built as there are major gaps. One of the priorities is to develop a stronger understanding of the best value for public investment to scale up the energy workforce
- Extending the Australian Skills Guarantee procurement requirements for learning workers (apprentices, trainees and cadets) to renewable energy, storage and transmission through the Capacity Investment Scheme. As Jobs Skills Australia has concluded, employer investment in training in renewable energy needs to be increased alongside public investment. Applying the Australian Skills Guarantee to the Capacity Investment Scheme which aims to procure 23 GW of renewable energy and 9 GW of storage would generate a step-change in the volume of learning workers across the sector.
- Programs to increase commencements and completions in key trades such as electricians, plumbers, HVAC technicians, welders, mechanical technicians, line-workers
- Labour market programs for fossil fuel power station operators to manage impacts of closures. Some types of contractors (e.g. electrical) will be readily redeployed, but power station operator skills are more site-specific.
- Commission skill audits for emerging sectors including offshore wind, hydrogen, electric vehicles, electrification and energy efficiency/energy management where workforce requirements are less well defined
- *Collaborative efforts between Registered Training Organisations, TAFE, and Australian Universities will be required to encourage innovative approaches to employees requiring transition, training in new technologies and in community engagement efforts that will ultimately ensure the social licensing of electrification efforts*

## 5.1 First Nations

The Institute for Sustainable Futures is currently preparing a report for the First Nations Clean Energy Network in collaboration with SGS Economics, Indigenous Energy Australia and Alinga on a First Nations Clean Energy Jobs Strategy which should be a feature of the Australian Government's First Nations Clean Energy Strategy. The report is due for completion shortly.

First Nations Australians access to training has improved in recent years. However, as the Australian Government's employment White Paper noted: *'the employment* *rate of Aboriginal and Torres Strait Islander people continues to significantly lag that of non-indigenous people, and the gap has not closed notably over the past 30 years'* (Commonwealth of Australia 2023: Executive Summary) [13].

It is vital that this wave of economic development delivers real benefits for First Nations people for development that occurs on their lands that have generally not occurred with over waves of development. The First Nations populations in the Renewable Energy Zones is higher than the national average (6% relative to 3.8%) – and is highest in some of the REZs where the largest volume of renewable energy is projected to occur (e.g. around 12% in the New England REZ, 10% in the Central West Orana REZ in NSW. The First Nations populations in the REZs are very young – around half are less than 19 years – which illustrates the opportunity for a generational change if First Nations can be attracted and trained to work in renewable energy.

Past reviews have found most policy and programs have had limited success or primarily increased First Nations employment in low-skill, temporary jobs. Well-designed programs with collaboration across government, industry, employment and training specialists and First Nations Australians will be required to do better in clean energy.

One of the key learnings from past programs is that supply and demand measures need to be integrated wherever possible. Supply-side measures on their own can easily become 'training for training sake' – in our fieldwork we found a lot of cynicism amongst First Nations people about the commitment of industry to deliver jobs. Demand-side measures on their own, risk 'accounting' exercises as the industry finds way to comply with targets without the people with the right skills to create meaningful employment opportunities.

## 5.2 Workforce Recommendations

Some of the key recommendations from the forthcoming report include:

- Mandatory First Nations employment targets should be established for solar farms. There are some cases where high levels of First Nations employment have been created in entry-level jobs for First Nations people who are unemployed or not in the labour force – with very high social impacts. Using procurement to set targets for solar farms can have a major impact on employment rates for First Nations people within the REZs
- there are opportunities to integrate employment and training targets and complementary supply-side programs in First Nations clean energy

programs, especially Indigenous housing retrofits in trades that are central to the energy transition such as electricians, plumbers and HVAC technicians. A similar approach could be taken for micro-grids and diesel replacement with solar and battery in First Nations communities.

- The Federal Government should fund and lead co-design of a First Nations Clean Energy Cadetship Program with energy industry and professional associations, cadetship First Nations representatives and universities (a 'Careertrackers for clean energy' initiative).
- A clean energy careers program should be developed for First Nations students.

# 6 Maximising outcomes for people and businesses

## 6.1 Energy Equity

The most significant downside of the residential solar and emerging residential electrification success story in Australia is the widening of the divide between energy 'haves' and energy 'have nots'. Clearly, individuals who own a home and can afford to fund the installation of solar panels can reduce their energy costs over the long term. At present, individuals on lower incomes and renters are locked out of accessing self-generated clean solar energy and are forced by their circumstance to purchase all their electricity from the grid.

The costs of grid connection services (which are a monopoly) are recovered from electricity consumers through network charges, which are set by a revenue cap regulation scheme. The allocation of the network charges is achieved volumetrically based on actual electricity consumed. Thus, as more consumers who can afford to do so connect solar and reduce their energy consumption, the fixed revenue for network charges is recovered disproportionally from consumers who do not have solar generation. The social inequities of this situation are self-evident and are a further example of how far the fundamentals of electricity regulation are out of step with the technology now prevalent across the NEM.

The solutions to addressing energy equity lie in technology, regulatory reform and market-making.

From a technology perspective, the widespread adoption of grid side of the meter distributed storage in the form of community batteries offers the opportunity to democratise locally produced clean energy. Solar generated by one house could be stored in the street for use by others in nearby streets who do not have solar. The technology to deliver this is mature and available. The potential for such an approach to also reduce electricity bills exists and has been quantified in research sponsored by ARENA [10].

The regulatory barriers to addressing energy equity are substantial but not insurmountable. Considering again the example of community batteries (although there are other examples), the benefits derived from grid side of the meter distributed electricity storage are derived from two sources. Benefits to monopoly grid services such as voltage management and localised demand reduction, amongst others, sit with the monopoly DNSP. Benefits to market participants derived from energy arbitrage and network stability services (FCAS) sit with market entities, such as retailers and wholesalers. Thus, no single market entity that can monetise the total benefits of grid side of the meter electricity storage. The AER has (commendably) sought to address this issue by establishing a ring-fencing guideline [11]. The approach taken is still a 'least worse' approach however, as it seeks to force fit distributed storage into the existing market structure of DNSP and Retailer. A model which facilitates the establishment of entirely new entities such as community battery operator, which would be able to offer contract services resulting from community batteries to both DNSP's and retailers, would be a superior solution.

Encouraging innovation in regulatory spaces for DER in terms of dual land use operations is also worthy of exploration to improve equitable access to energy. In international contexts, for example, dual land use options like Agrivoltaics are ensuring consistent ROI for landholders when traditional farming methods are impeded by the effects of climate change. Community energy groups in some rural contexts are having a degree of success on improving ROI through dual solar and sheep-grazing land uses, but the sector requires priming for wholesale adoption of Agrivoltaic systems for this to become a viable option in the Australian context.

## 6.2 Holistic Response

The least cost, highest benefit transition to electrification will be achieved through a holistic pathway which must consider the following aspects:

- Electricity supply networks
- Housing construction practice and regulation
- Appliance energy efficiency

Electricity supply networks are dealt with in detail above. With respect to housing construction and practice, consideration should be given to identifying the aspects that are relevant to electrification to ensure that they are fit for purpose. Energy efficient design will manifest as fundamentally reduced electricity demand for loads such as space heating. Perverse limitations on electrification should be removed. As an example, electric storage hot water tanks which have long been overlooked (or not viable to meet energy efficiency requirements) in favour of gas alternatives should be encouraged as a 'solar soak'.

Increasing the energy efficiency of appliances is another method of managing demand. Appliance efficiency minimum energy performance standards (MEPS) should continue to be rigorously applied and developed for products that they are not presently available for.

### 6.3 Energy Literacy

Any significant transition is much easier if consumers are engaged and supportive. While there are many resources available to assist consumers in understanding their energy use there remains strong evidence that overall levels of energy literacy remain low. AS an example, electricity is a significant household expense however statistics show that many customers are still not engaged with few engaging with or switching retailers to achieve lower electricity bills.

Many consumers also are unaware of which appliances within their households consume the highest amounts of electricity.

While customers can't be expected to be electrical engineers, steps should be taken to increase overall energy literacy. Electricity supply is critical, or is seen to be critical, to many consumers who are sensitive to outages. To date, for the most part, consumers have experienced an electricity supply network that is highly reliable. Transitions to new generation technologies and new means of electricity supply can create uncertainty for some consumers who seek the same reliability of supply as they receive at present. Action may be required to de-mystify new technologies to ease consumer concern.

## 7 Conclusion

The technologies required to achieve home electrification are readily available and are mostly cost competitive. More nascent technologies are still at more premium price points, requiring some form of subsidy to be made attractive to consumers, especially when applied to retrofit situations. Subsidies which significantly reduce the cost of electrical appliances are highly beneficial, with the enhanced affordability of the appliances releasing capital for investment in the home wiring upgrades required to connect the appliances.

Concerns that local electricity networks are at or approaching some sort of 'saturation point', past which large volumes of capital investment in network assets will be required to facilitate further home electrification are as inaccurate as claims that little to no new network investment will be needed. Opportunities exist to allow monopoly service providers to access new revenue streams which will offset capital and operating cost increases resulting from home electrification.

Urgent regulatory reform is needed to avoid the ongoing outcomes of the status quo – higher prices for consumers and brute force engineering ideas such as switching off DER resources. Examples of required reform include:

- Taking a more decentralised approach to network control by rapidly implementing the Distribution System Operator (DSO) model will provide the ability for innovative, locally beneficial approaches to grid operation to emerge.

- Adopting an approach similar to OFGEM in the UK [9], who have granted permission for DNSP monopoly businesses, within appropriate guidelines, to operate dynamic voltage control services within energy markets, thereby reducing the overall cost burden on traditional monopoly network service charges to end use consumers by establishing market-based revenue streams.

- The establishment of entirely new entities such as community battery operators, which would be able to offer contract services resulting from community batteries to both DNSP's and retailers, would assist in addressing energy inequities within the NEM.

A holistic strategy for electrification that considers factors such as dwelling design and construction as well as appliance performance must also be adopted.

Finally, a National Testing Facility is an imperative. It is required to support the vast electrification transformation ahead of Australia and remove dependence on off-shore testing services that don't necessarily meet the needs of Australia. This facility will de-risk installation, commissioning and operations of equipment and systems in the context of Australian electricity networks or industrial processes or residential DER services.

# 8 References

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# 9 Inquiry Terms of Reference

That the following matter be referred to the Economics References Committee or inquiry and report by the last sitting day in 2024:
Australia's residential electrification efforts, with particular reference to:
(a) the economic opportunities of household electrification, including but not limited to:

- (i) long-term reduction of energy price inflation,
- (ii) long-term employment opportunities, and
- (iii) the scaling up of domestic capacity;

(b) the macro-barriers to increasing the uptake of home electrification;
(c) the total upfront cost and longer-term benefits of household electrification and alternative models for funding and implementation;
(d) the marginal cost of abatement for household electrification compared to alternative sectors and options to decarbonise the economy;
(e) the optimal timeline for household electrification accounting for the likely timing of decarbonising electricity;
(f) the impacts and opportunities of household electrification for domestic energy security, household energy independence and for balance of international trade;
(g) the impacts of household electrification on reducing household energy spending and energy inflation as a component of the consumer price index;
(h) solutions to the economic barriers to electrification for low-income households;
(i) the effectiveness of existing Australian Federal, state and local government initiatives to promote and provide market incentives for household electrification;
(j) Australia's current standing against international standards, particularly with respect to the uptake of rooftop solar, batteries and electric household appliances; and
(k) any other matters.

**Committee Secretariat contact:**
Senate Standing Committees on Economics
PO Box 6100
Parliament House
Canberra ACT 2600

Phone: +61 2 6277 3540
economics.sen@aph.gov.au