The Australian Power Institute

# API Summer School 2022
# Syndicate 7

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# EXECUTIVE SUMMARY

Electricity supply currently accounts for roughly 20% of all energy consumed in Australia. To support the decarbonisation of other sectors, it is increasingly likely that electricity networks will need to supply 3 – 5 times more energy than it does today as these sectors turn to cheap and abundant renewable electricity as their energy source.

This paper attempts to highlight the challenges and opportunities electrification will pose for the electricity supply industry as well as to provide high-level recommendations on how the industry may want to navigate them.

The Australian electricity network traditionally comprised of large-scale thermal generation located in close proximity to the fuel source with transmission and distribution assets required to transport the electricity to the loads located where the population resides.

For the electricity supply industry to successfully facilitate a highly electrified society, where generation sources and loads may be positioned in non-traditional locations as well as having varied usage profiles, there are a number of barriers to overcome and uncertainties to investigate. This paper has identified four key challenge areas and posed some targeted questions that will require further investigation.

1. Technical
   *What are the technological advancements available or needed to meet the needs of reliable electrification? And how will resource this transition?*
2. Financial
   *How can the industry move to a regulatory regime that leads, not lags, technology advancement?*
3. Regulatory
   *How can the industry move to a regulatory regime that leads, not lags, technology advancement?*
4. Social
   *What is the best way to educate customers about the challenges and opportunities of Electrification? And how does the industry ensure they are heard their needs considered in the transition toward Electrification?*

However, Electrification doesn't have to be all barriers and roadblocks – it also represents a significant opportunity for the electricity supply industry. This paper explores three priority opportunities:

1. *Electrification to address Minimum Demand system issues*
2. *Network revenue growth AND better value for customers*
3. *Australia can lead the way*

In summary, a number of Start, Stop and Continue recommendations have been proposed for the electricity supply industry to consider.

## EXECUTIVE INSIGHTS CHALLENGE QUESTION

What are some of the major challenges and opportunities that electrification will pose for the electricity supply industry? And as an industry, how can we successfully navigate them?

## BACKGROUND

Greenhouse gas concentrations are at their highest levels in 2 million years and emissions continue to rise. These emissions blanket the Earth, trapping the sun's heat and raising temperatures. As a result, the Earth is now about 1.1°C warmer than it was in the late 1800s. The last decade was the warmest on record. Australia has an average of eight to ten years before we cross the threshold of catastrophic climate change which is a small rise of just 1.5°C.

However, warmer temperatures are only the beginning of the story. Other consequences of climate change include intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms and declining biodiversity. Australia has experienced many of these impacts in the past few years.

Carbon dioxide and methane are the key gas contributors to this, with the energy, transport, building and agriculture industries being the top emitters. To put transport emissions in to perspective, (including, cars trucks, public transport, domestic flights and shipping), Australia produced 18% of its annual greenhouse gas pollution in 2018 through transport use, emitting 102 million tonnes of Carbon Dioxide. With no action, this would be expected to reach 111 million tonnes of Carbon Dioxide by 2030. The usage of natural gas in residential and commercial settings are a major contributor in a costly, dangerous and irreversible direction towards climate change, with 10% to 30% of emissions being from natural gas use in business accounts.

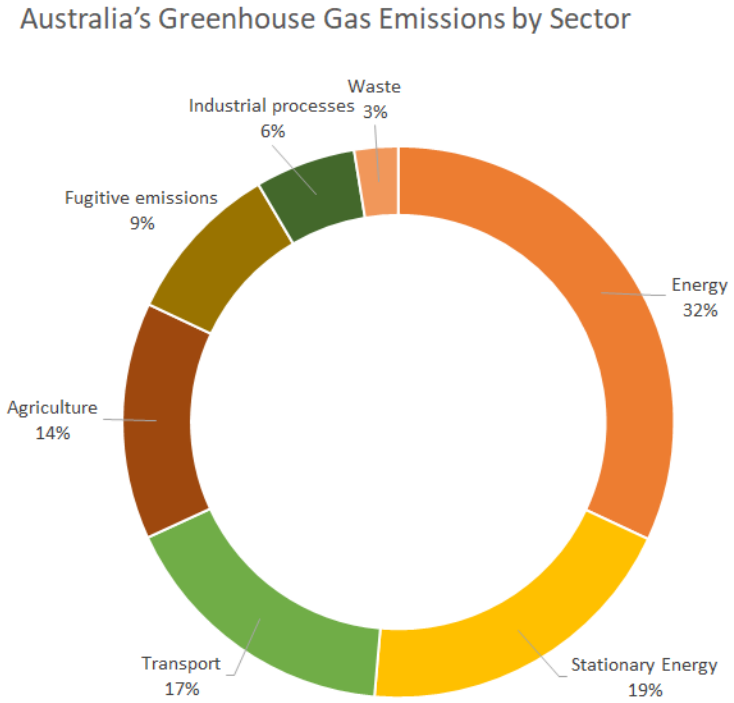



*Figure 1: Australia's greenhouse gas emissions by sector. Note: Stationary Energy includes manufacturing, mining, residential and commercial fuel use.*

Electrification is the movement from fossil fuel-based technology towards electric and with energy and transport industries making up over 50% of these emissions, it is evident that electrification plays a critical role in achieving carbon neutrality by 2050.

Electric vehicles, greener buildings, household energy use (gas cooking, hot water, gas and other fuel space heating), industry (mining, manufacturing), agriculture and hydrogen fuel present the largest opportunities in achieving this. Transport electrification not only enables fewer harmful emissions, but also presents many network benefits as well as lower costs to end consumers that benefit from cheaper electrical charging as opposed to the rising cost of petroleum. This brings with it both opportunities and challenges for the sector moving forward.

## ELECTRIFICATION OF ENERGY CONSUMPTION

The Australian economy has steadily grown by generally 2-4 per cent on average per year since 1970 to reach a GDP of $2.0 trillion in 2021. Population grew by 1-2 per cent on average per year over the same period to reach 25.4 million people. Australia's energy consumption has grown in line with the population and economy – exceeding 6000 petajoules in 2018-19.

The electricity supply sector accounted for 26 per cent of energy consumption in 2018-19, and transport, electricity supply and manufacturing accounted for three quarters of energy consumption in Australia.

While the total generation of electricity in Australia has increased steadily over recent years, the amount of energy contributing to electricity generation has been decreasing as growth in other sectors outpaces electricity generation growth and as electricity generation becomes more efficient.

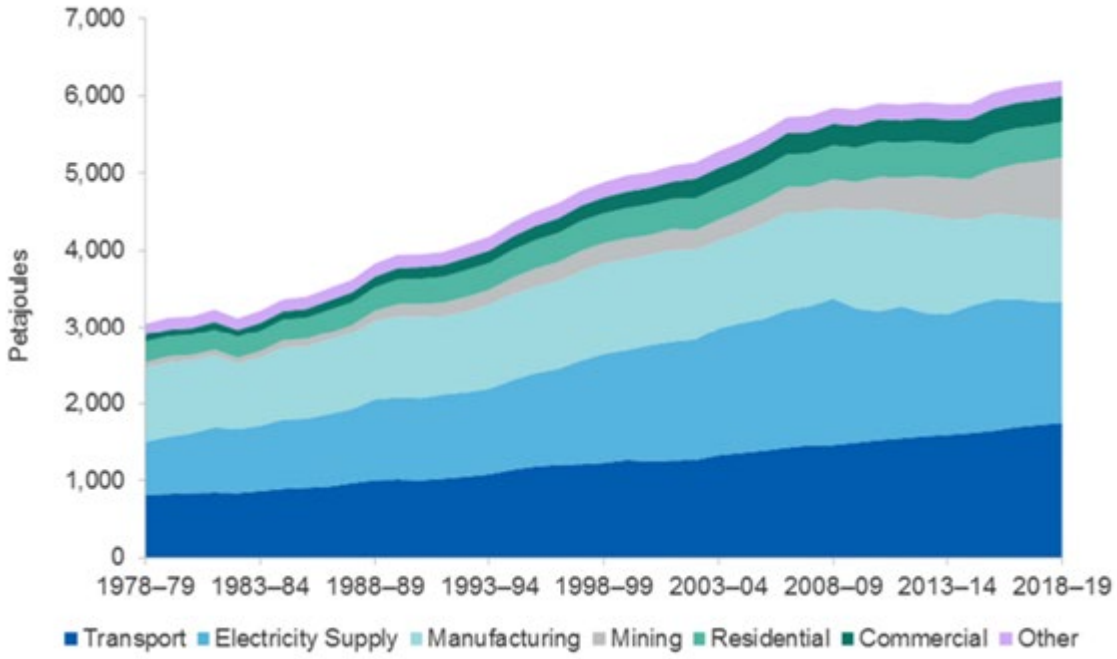



*Figure 2: End use energy over time (Source: Energy.gov.au Australian Energy Update 2020)*

Currently, 79% of electricity generation supplying Australia stems from non-renewable coal and gas generation. The other 21% of generation is from grid-scale and small systems owned by businesses and families. There are currently over 3 million solar power PV systems and 4.4 million small-scale renewable

installations, including 1.395 million solar and heat pump water heaters, 424 wind systems and 20 hydro systems[1].

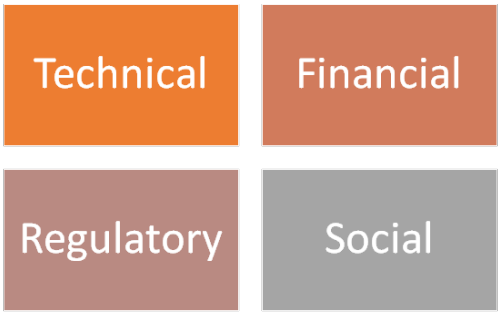
The renewable energy industry across Australia currently employs a total of around 28,000 employees and around 10,000 employees in the Coal thermal industry with some communities having a total of 5% of the population working in the coal mining industry[2].

The Australian electricity industry is in a transition from large-scale centralised thermal generation to renewable generation including Distributed Energy Resources (DER). This has resulted in technical challenges for the electricity industry. Traditionally the essential services of the synchronous network have been a free by-product of the large thermal generators – voltage control, system strength, frequency control, and inertia.

The increasing penetration of inverter-based generation including DERs has resulted in decreased inertia response and frequency regulation as well as reduced availability to control frequency via load shedding due to low and negative minimum demand particularly in South Australia in recent years.
There is an increasing impact of weather on the daily operation of the electricity network due to increased solar and wind generation – requiring rapidly dispatchable generation and Battery Energy Storage Systems. The intermittent nature of wind and solar generation will require increased over-building of generation as well as long term storage solutions to replace the reliability of base-load power generation.

## CHALLENGES OF ELECTRIFICATION

Four key challenge areas have been identified, under which there exist a number of barriers which need to be overcome for the network supply industry to successfully facilitate a highly electrified society. It is recognised that for each of these focus areas additional research and thinking is needed – as such, for each a Challenge Question has been proposed. These questions are intended to potentially set direction for future investigations, with an expectation that should they be able to be answered effectively, then the industry will be well positioned to successfully navigate the transition to a fully electrified society.




### 1. *Technical*

Network Congestion

- Congestion challenges are the new normal in the Australian electricity networks – whilst much of this is driven by new renewable generation connections today joining the NEM in potential sub-optimal locations. As the need for increased generation capacity grows with electrification, the risk of exacerbating these congestion issues increases.

Aging asset base

- Average asset age is old, difficult to provide new energy services with an ageing asset base

Ensuring reliability isn't compromised by Electrification

[1] Energy supply | energy.gov.au
[2] Roadmap to net-zero: Australia can be powered by renewable energy by 2030 | Clean Energy Council

- As industries transition to an electrified future, customers are unlikely to accept a reducing in the reliability of their energy source
- Intermittency of renewable generators (solar/wind) poses a risk that traditional energy sources don't face
- Operability of the network within limits

Resourcing the transition

- Does the industry have the skills needed to deliver Electrification
- How can the workforce prepare for the transition

**Challenge Question:**
*What are the technological advancements available or needed to meet the needs of reliable electrification? And how will resource this transition?*

## 2. *Regulatory*

Engage early and more frequently

- Discussions with AER need to occur more frequently than just during the revenue reset process as we are seeing changes more frequently than on a 5-year basis and the assumptions included in previous submissions demonstrate how little was understood/predicted for the changing market
- Regulatory regime is too slow, technology leading regulation
    - Engage with the regulator early in the technology development stage
    - Bring them on journey as the tech develops
    - Engage between regulatory cycles to minimise surprises

Timing uncertainty

- As there are many external factors, such as energy prices, social pressures and environmental concerns/impacts, contributing to various industries moving towards electrification of their assets the timing of the increased load to be placed on the network is a key unknown. Past network planning assumptions may not have appropriately considered the future load requirements in particular from a quantity and timing perspective. Along with this is the real possibility that any current assumptions around timing are underestimated and move at an accelerated pace. [aim for good, not perfect]

**Challenge Question:**
*How can the industry move to a regulatory regime that leads, not lags, technology advancement?*

## 3. *Financial*

Sharing the investment costs

- What are financial implications to develop expansion (CAPEX) as well as ongoing operation and maintenance (OPEX)
- Sharing the costs across the NEM in an equitable way for those benefitting from the new assets rather than directly by the state the infrastructure assets are required to be built in
- Cost of switching to electrification. Will this be born directly by

The risk of getting it wrong

- Timing of investment decisions will be critical in ensuring expenditure is prudent and effective
- Where this timing is wrong, the likelihood of over or under investment increases

**Challenge Question:**
*What will the cost of Electrification be? And how can networks share the cost additional investment in a fair and equitable manner?*

## 4. *Social*

- Social licence
  - The companies that make up the electricity network don't have a combined strategy to ensure social understanding of impacts of electrification / consumer behaviour are well understood by the general public
    - There can be social barriers towards moving to electrification that the industries transitioning to electrification should be working to overcome but it should be noted that due to lack of general public's understanding of the industry may lead to associated sentiments – people still think that gas is more efficient than electric[3].
    - Communities can pose threats to any projects that require the construction of new assets as such communication and community consultation is key. Large scale augmentation of the transmission network has not been undertaken in recent decades and unfortunately there has been clear demonstrations on some of the current large scale transmission projects where this has not been handled appropriately as such resulted in additional re-work to be undertaken on some projects with has subsequent cost and time implications.
- Accessibility – fair and equitable for all customers

**Challenge Question:**
*What is the best way to educate customers about the challenges and opportunities of Electrification? And how does the industry ensure they are heard their needs considered in the transition toward Electrification?*

# OPPORTUNITES FOR THE ELCTRICITY SUPPLY INDUSTRY

For all the challenges that Electrification may present the electricity network supply industry, there are equally significant opportunities for the sector. These opportunities extend to both the network businesses and the customers they serve. Whilst there are numerous financial, regulatory and societal opportunities this paper explores following priority opportunities in detail:

## 1. *Address minimum demand constraints by accelerating Electrification*

Utility networks across Australia are currently combating emerging technical challenges of Minimum Demand largely because of a rapidly increasing distributed renewable generation resource. However, the electricity supply industry has the opportunity to help accelerate the energisation of other sectors in an effort to increase overall demand with a considered and managed approach that improves network utilisation and helps address the impacts of the minimum demand during periods of peak distributed generation.

For this opportunity to be realised it is imperative that networks, regulators and governments take a coordinated and tailored approach. There is a risk that, if electrification isn't incentivised effectively, that the resultant demand growth will further exacerbate the existing issues of minimum demand and an under-utilised network.

There will be a need to create strong coordinated incentives for customers and leverage technology advancements to help facilitate this.

- Increase utilisation – smooth load profiles.
- Focus on incentivisation – not control (Hug + Nudge methodology)

[3] Electrifying the future | Green Building Council of Australia (gbca.org.au)

## 2. Network revenue growth and better value for customers aren't exclusive

Governments and regulators agree that significant investment in our power networks will be required to manage the unprecedented growth in demand that electrification is expected to bring. With the majority of these costs being passed onto consumers, on the surface this has the potential to appear to be detrimental for energy users. However, by allowing consumers to use electricity for more purposes and in offering a lower unitised cost of energy for those uses, the per unit cost of energy for consumers is expected to be significantly less than it is currently. Additionally, network providers are expected to grow revenue as they start to serve sectors of energy users which were previously the sole domain of oil and gas providers. In summary:

- Network revenue will go up with increased investment in the transmission and distribution networks – this will lead to higher network charges and increased costs for consumers
- Consumers will be using their electricity to power more and offsetting the unit cost of expensive and volatile energy sources like Fuel/Gas. As such, the 'unit cost' of energy to meet customer needs is expected to fall compared to this cost today.
- Opportunity to better utilise the electricity network asset base, increasing the return on capital (RAB x WACC) and offering a more efficient electricity service (Figure 3)
- Opportunity to deliver a net saving to Australian household customers - up to $302b by2035 (Figure 4)

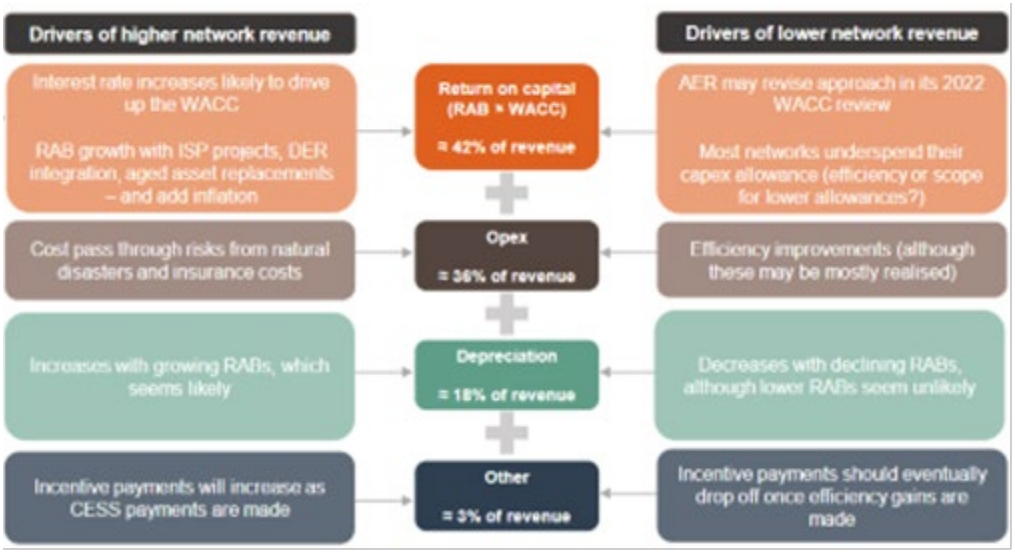



*Figure 3: Network Revenue Model (Source: Lisa Beckmann, API Summer School 2022)*

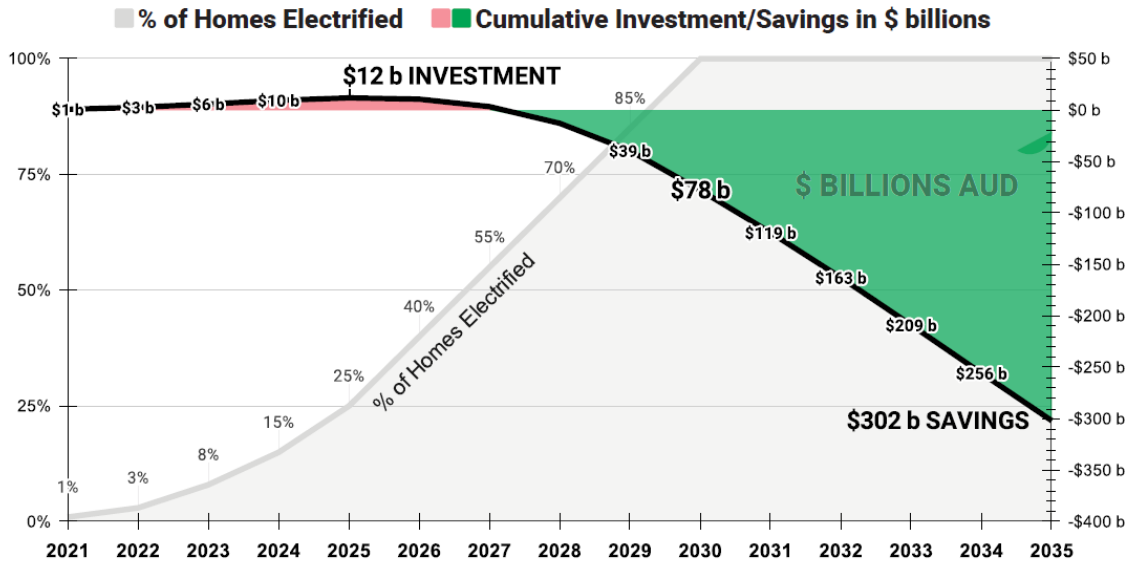



*Figure 4: Cumulative Investment and Savings with Accelerated Electrification (Source: Castles and Cars Discussion Paper, Rewiring Australia)*

## *3. Australia can lead the world towards full electrification*

Due in part to our continuing reliance on fossil fuels, rarely have other countries looked to Australia for direction on progressive climate policy. To date, Australia is significantly lagging our European and American counterparts in electrifying other sectors, particularly Electric Vehicles. However, given our abundant renewable resources, Australia has the potential to demonstrate to the world what a coordinated strategy to renewable electrification can look like. Some of these opportunities include:

- Opportunity to set the strategy on how to successfully deliver electrification
- Opportunity to 'sell' our knowledge/experience to the world
- Australia can have a significant impact on decarbonisation and addressing climate change
- Opportunity to sell 'green' energy to the international market
- The social opportunities of skills development and job growth can also help establish Australia as a world leader in delivering electrification on mass
- Australia will have the opportunity to set the blueprint and develop a standardised approach for the rest of the world
- Establishment of Australia as a Hydrogen Superpower

## SUMMARY OF RECOMMENDATIONS

The following Start, Stop and Continue recommendations have been proposed for the electricity supply industry to consider in determining how to successfully navigate the electrification transition.

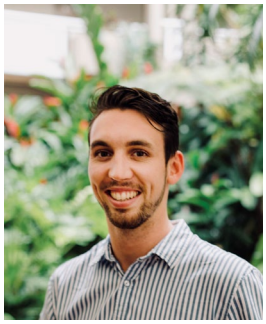
# APPENDIX A - CONTRIBUTORS

**Janhavi Kale** is an experienced Automation Engineer within the Secondary Systems Design team at Powerlink Queensland, involved in the circuitry, protection and control design functions. She started at Powerlink on the Graduate Development Program, rotating through various teams across the organization spanning Field Support, Secondary Systems Design, Energy Management Systems, Network Planning and Project Management. Janhavi is an engineer by qualification - holding a Bachelor of Engineering from The University of Auckland - and a Diversity, Equity and Inclusion advocate by choice.

**Murray Chapman** is an electrical engineer with fifteen years' experience in the electricity supply industry, specialising in testing and commissioning of HV equipment and technology. Murray's recent work includes new solar farm connections, electrical substation refurbishments, and communications upgrades. His professional interests include metering compliance, network testing, and development of automated testing tools. Murray holds a Bachelor of Engineering from the Queensland University of Technology and is a Registered Professional Engineer of Queensland.

**Kailee Standen** is managing a team of Telecommunication and Electrical Apprentices for Transgrid across NSW and the ACT. Kailee began her career as an electrical apprentice with Transgrid and has since developed 9 years' of experience in the industry. Kailee is passionate about recruiting the right people with diverse backgrounds and supporting those people to ensure they are challenged to the best of their abilities, leading to the retention of a talented, trained and skilled workforce in the industry. Kailee holds a Certificate 3 in Electrotechnology, Advanced Diploma of Leadership and Management, Advanced Diploma of Business and Advanced Diploma of Management (HR).

**Adrian Lloyd** is senior electrical engineer with a diverse range of knowledge, experience, and skills with subject matter expertise in the area of grid connected renewable, hybrid and battery systems. He is currently the Technical Program Lead of Emerging Opportunities at Yurika, part of the Energy Queensland group, providing technical, commercial and program management input into key hybrid and renewable projects for Yurika and its customers. Adrian passionate about contributing to future energy solutions that leverage new and innovative technologies to deliver better energy solutions for Australia.



**Louise Poole** is a Maintenance Projects Manager at Transgrid.