The Phase Out of Natural Gas in the ACT

Prepared
for the

Conservation Council ACT Region

By **Caitlyn Baljak**

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“As the ACT moves to 100 per cent renewable electricity by 2020, gas will become one of the major remaining contributors to greenhouse gas pollution, so we will need to find options to reduce gas use,”

~ Shane Rattenbury MLA (2018)
ACT Minister for Climate Change & Sustainability

Cover image source(s): PNG Tree, (n.d.), “blue natural gas material”, [image] accessed on: https://pngtree.com/element/down?id=MzAwNTgyMg==&type=1, see also; University of Melbourne, (2001), “Basic Outline Maps – ACT”, [image] accessed on: https://library.unimelb.edu.au/dev/collections/map_collection/map_collection_outline_maps

EXECUTIVE SUMMARY

The climate emergency we face today sets the imperative for governments, organisations and individuals to examine every aspect of our lives and act swiftly to tailor them to serve in the best interests of our planet without negatively impacting on our quality of life. The ACT Government has recognised this in their role in the capping of planetary warming to 1.5 °C above pre-industrial levels through their development of and commitment to the *Climate Change Strategy and Action Plan* (2017).

By 2020, natural gas will serve as the second largest contributor to greenhouse gas emissions in the ACT. There are two possible options to decarbonise this energy infrastructure:

1. **Electrification**

This approach requires all gas appliances to be changed to electric appliances, with further expansion of the renewable electricity infrastructure by a factor of at least 2.3 needed to absorb an increased energy demand

2. **Fuel Switch**

This approach requires the production and sourcing of hydrogen gas and biogas on an industrial scale to feed into the existing gas network. Small modifications to existing infrastructure and appliances are also required.

Key Recommendations

- An amendment to the *Territory Plan 2008* to allow developers to construct electric-only developments
- Change to the accounting framework for the gas network greenhouse gas accounts to allow for a better understanding of the emissions load
- Develop a new appliance energy rating labelling system to allow for comparison between electricity versus gas appliances
- No new suburbs in the ACT should be developed with a household gas grid
- Subsidise the purchase and installation of electric appliances
- Run an education campaign around the economic, environmental and social benefits of electrification the household
- Invest in more local renewable energy infrastructure
- Gradually phase out the gas network suburb-by-suburb until 2045

When analysed against a triple-bottom-line criterion and in the context of the climate emergency, this report recommends an:

ELECTRIFICATION APPROACH

To the decarbonisation of the ACT natural gas network.

ACKNOWLEDGEMENTS

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To the team at EvoEnergy, thank you for giving me hours of your time to understand the complexities of the ACT's gas network. The challenge you are faced with concerning the future of gas is exciting and your willingness to engage with my work demonstrated to me the eagerness with which Canberra's zero carbon future is being considered.

To Jessica Stewart from Riverview Developments' Ginninderry team, your enthusiasm for sustainability is infections. I appreciate you giving me your time and resources and am excited to see where your work goes in the future.

Thank you to anyone reading this report that cares for and are working towards climate change solutions large or small; the time for action is limited and the fact that you are spending your time reading my work means a great deal. Do not despair about the climate emergency, for as long as you care and are involved – there is hope.

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TERMS

Fugitive emissions: greenhouse gas emissions that escape from infrastructure due to leaks and maintenance processes rather than by the design of the technology

Greening: the process of making technologies more environmentally sustainable

Decarbonisation: the process by which carbon reliant technologies or technologies that release greenhouse gas emissions are transitioned to non-carbon alternatives

Electrification: where an energy dependent infrastructure or appliance is converted to run on electricity

Fuel-switch: to replace inefficient or unsustainable fuels with more sustainable alternatives with the least modification to the original infrastructure possible

ABBREVIATIONS

IPCC Intergovernmental Panel on Climate Change

GHG Greenhouse gasses

ACT Australian Capital Territory

INTRODUCTION

In the context of the signing of the Paris Agreement in 2015, a global response to the climate emergency has precipitated. Authorities on climate change such as the IPCC urge that while the impacts of climate change are felt globally, the actions to mitigate and adapt must be local (IPCC, 2018). One of the major producers of greenhouse gas (GHG) emission are cities and it is well documented the impact that household consumption decisions have on climate change (Dubois *et al.,* 2019, see also; Bulkeley, 2013). Residing within the Australian Capital Territory (ACT) are several small towns and one major city (Canberra), which homes the majority of the Territory's residents. The governance framework afforded to the Territory along with the Territory's goal of achieving net zero emissions by 2045 makes the ACT a perfect candidate for pioneering local climate change solutions that can be scaled up to a national, if not global level (ACT Government, 2019).

After the ACT achieves its 100% renewable energy goal by 2020, natural gas will represent the second largest contributor of GHG emissions in the region after the transport sector (ACT Government, 2019). Considering the significant efforts taken by the ACT Government to decarbonise the transport sector, this paper instead turns to examining a less analysed but critically important contributor to GHG emissions; the natural gas network. While there is significant literature surrounding a transition away from natural gas for electricity generation (Edwards & Trancik, 2014, see also; Dresselhaus & Thomas, 2001, see also; Züttel *et al.,* 2010, see also; Turner, 2004), the decarbonisation of household natural gas is a relatively new discussion (Committee on Climate Change, 2019, see also; City of Amsterdam, 2016, see also; Stamford & Azapagic, 2014). The gaps in the literature surrounding household natural gas and its related climate change impacts highlights the global relevance of this issue, positioning the ACT at the forefront of this climate change mitigation strategy and aligning with the Territory's own interests to incorporate further actual abatement (rather than offsets) in its net zero emissions strategy (ACT Government, 2019, see also; ACT Government, 2017).

Global Context

There are some examples of greening the household natural gas sector in Europe (The Netherlands, Denmark, the UK) and North America on a more city-by-city basis however most of these decarbonisation strategies are in the planning and implementation phase, with no large-scale evaluations of the success of these projects yet available. There are several approaches that are being investigated to decarbonise the gas network.

BIOGAS (Denmark)

Biogas is a chemically equivalent fuel to natural gas, however instead of being derived from fossil fuel sources it is derived from bio-organic methane stocks. Biogas is a renewable resource because it can be reproduced from feedstocks such as household waste rather than relying on finite fossil fuel reserves (Deublein & Steinhauaser, 2011). Denmark is a world leader in biogas technology, particularly waste-to-gas technology that combines the ecological problem of waste and the methane emissions it releases by capturing these gases to produce usable biogas to feed into the network, one of the main benefits of this technology. Because biogas and natural gas are essentially chemical equivalents, existing gas infrastructure does not need to be altered significantly for use with this emerging technology. The drawback of biogas is that when it is burned the methane releases the GHG carbon dioxide, which continues to exacerbate climate change. Any fugitive emissions (leakage) from a biogas network would release the comparatively worse GHG methane into the atmosphere, contributing to climate change more than carbon dioxide. For these reasons, the case for an exclusively biogas network cannot be made in this report due to the restrictions and

targets within the ACT's (2017) *Climate Change Strategy and Action Plan.*

FUEL SWITCH – HYDROGEN (UK)

There is considerable research into hydrogen technologies with some speculating that it may be the solution to the sustainable energy crisis (Turner, 2004, see also Staffell *et al.,* 2019). It is hypothesised that hydrogen gas could replace a majority of natural gas in the UK's network, with the small remainder comprised of biogas (which allows for the introduction of odorants and colourants as safety features to the colourless and scentless hydrogen gas (Staffell *et al.*, 2019). When hydrogen is burned, it releases water vapour rather than carbon dioxide as a biproduct, thus is a climate safe energy source. Jones *et al.* (2017) speculates that the UK could replace as much as 30% of natural gas with hydrogen with little to no system modification. If the natural gas network is fully decarbonised, it could result in a GHG emissions reduction of as much has 18% of the UK's total emissions.

The current 'green' method for producing hydrogen gas is known as electrolysis, a process by which water molecules are split into their separate hydrogen and oxygen components. This chemical process is thermodynamically unfavourable and requires a significant amount of energy to break the strong bonds that hydrogen molecules form with oxygen (Zeng & Zhang, 2010). This hydrogen would then primarily be used for heating at only 62% of the efficiency of the electrical energy used to create it (Le Page, 2018).

ELECTRIFICATION (Netherlands)

The approach being pursued by the Netherlands involves switching households from being dependent on natural gas to electric substitutes. The Netherlands is aiming to have one in four homes fully electrified by 2030, with no natural gas use by 2050 (DutchNews, 2018). This is particularly compelling as a country with one of the largest natural gas fields in the world (Groningen) (de Jager & Visser, 2017). While electrification has the potential to be the most effective climate change mitigation strategy when undertaken in conjunction with renewable electricity sources, The Netherlands currently has some of the lowest green energy uptake in Europe, though this will presumably change with the government's current goal of reducing the nation's GHG emission by 95% by 2050 (Government of the Netherlands, 2018).

Australian Context

Australia has recently seen a general decline in demand for household gas, with consumption in eastern Australia peaking in 2012 (Forcey, 2015a) The exportation of Australian gas to international markets, scarcer supplies forcing higher risk 'alternative' gas sources (such as shale gas and coal seam [fracking]), and general volatility of gas markets have caused an increase in prices that have likely contributed to this usage decline. This positions Australia well to transition away from natural gas nationwide (Alternative Technology Association, 2014, see also; Hernández Ibarzábal, 2011).

There is some discussion surrounding a transition away from household natural gas in Australia, with hydrogen gas trials in the cities of Sydney and Adelaide, as well as an examination of the future of natural gas in Victoria as the highest gas using state in the country, however a concrete implementation or transition policy framework is yet to be implemented anywhere in the country (CUAC, 2014, see also; Jemena, 2018)

The best example of gas phase out in Australia can be seen in the 100% electrified housing development of Ginninderry, the first of its kind in the country (Riverview Projects, 2016). The development of Ginninderry has sustainable community principles that follow a triple-bottom-line approach at the core of its design, with the Green Building Council of Australia bequeathing a 6 green star rating to the

development. This was partially achieved by the decision of the developers to not introduce gas appliances into the suburb, though gas connections are available to businesses and potentially households depending on future consumer demand. This development, residing partially within the ACT provides a valuable case study to examine the impacts of a gas phase out in a local context.

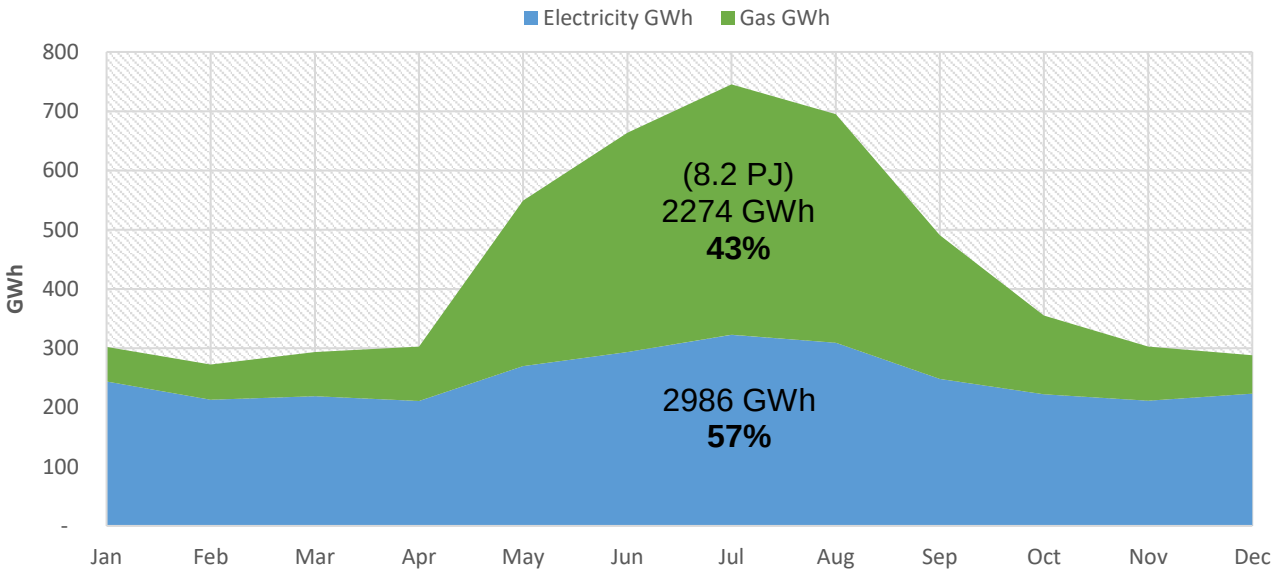
ACT Context

The ACT *Territory Plan 2008* currently mandates that all homes in the Territory must have the right to access a gas connection, with approximately 80% of households and business currently connected, serving 148,000 homes and businesses in ACT (Evoenergy, 2018, see also; ActewAGL, 2015, see also; *Territory Plan 2008*). Currently, natural gas makes up 43.2% of the ACT's overall annual energy profile with electricity accounting for the remaining 56.8%. Due to seasonal variation in energy demand however, gas makes up as much as 56.7% of the energy profile during Canberra's winter peak (July).

While by number, over 99% of the gas connections in the ACT are households, by consumption 67% of the consumption is household, with the remainder split between business and industrial users. Canberra does not face the challenge of supplying large amounts of energy to industrial users, who make up just 15% of the customer usage in the region. This gives the ACT a better platform to address household and business consumption as the major contributors to gas emissions, on which this report will focus (Evoenergy, 2018).

When considering the GHG accounts for natural gas network leakage is an important aspect to consider, as methane is a much more potent GHG than carbon dioxide. The federal government approved two methods of fugitive GHG accounting for natural gas supply in 2014, however the ACT government only allows for one of which while quicker to calculate is considered overall less accurate and less specific to the ACT (Department of Environment, 2014, see also; *Climate Change and Greenhouse Gas Reduction Determination 2017*). This accounting mechanism does not provide an accurate representation of the true emissions created by the ACT gas network.

Figure 1: ACT Combined Annual Energy Useage



Source: Evoenergy, (2018), "ACT Combined Annual Energy Useage" [data file]

METHODOLOGY

A comparative analysis has been conducted for an electrification versus fuel switch approach to the decarbonisation of the ACT gas network. This has been done through a triple-bottom-line approach for the full cost accounting of the economic, social and environmental benefits and drawbacks of each policy implementation (Elkington, 1998, see also; Slaper & Hall, 2011).

To draw this analysis, extensive desktop research has been conducted to construct a literature review through search engines such as Google Scholar and Scopus, focusing on key works in the literature and exploring their citations. Consultancy briefings from overseas governments as well as energy providers, housing developers and NGO's provided case studies on which to draw from for this literature review.

The domestic case study of Ginninderry, a gas-free development in Canberra's North where phone, in person and email conversations were conducted (though no formal interview data were used) to form the basis for the ACT specific analysis. This was supported by phone and email correspondence with the ACT's energy provider Evoenergy as well as investigation into ACT Government publications, media releases and legislation related to gas in the ACT. Attendance at a public forum hosted by the Conservation Council ACT Region (the host organisation), where speakers from research and industry discussed the future of gas in the ACT provided useful background for this investigation, though no information was directly referenced from this event.

LIMITATIONS

1. **Limited case study availability**

The recentness with which the phase out of natural gas has become a topic within climate change mitigation strategies globally has limited the number of resources and case studies available for this investigation. The furthest progressed examples were in the Netherlands and Denmark, whose government strategies and plans were not always available in English.

2. **Limited GHG and financial data availability**

Data were unavailable or incomplete to allow for a quantifiable comparison in of the two approaches in terms of tonnes of carbon dioxide emissions and an exact cost to both the consumer, utility provider and government.

3. **Uncertainty surrounding emergent technologies**

Many of the assumptions for the use of hydrogen gas in the network are contingent on 'successful' testing of the technology in the coming months and years. To date the Evoenergy hydrogen testing at Fyshwick has been 'successful' and the company hope to have a hydrogen home running by 2021, however there are several technical assumptions that must be sufficiently trialled and passed to ensure the introduction of a new substance into the existing network. There is significant scepticism surrounding the viability of hydrogen technology as hydrogen gas is a notoriously difficult molecule to work with at a large scale (Altfeld & Pinchbeck, 2013)

4. **Interpretation of secondary sources**

The research relied on the interpretation of secondary sources which can limit the extent to which conclusions can be drawn from the data for the purpose of this report, as it is unknown how the data have been manipulated prior to presentation.

5. **Bias in the available information**

There is significantly more information available on fuel switching strategies than electrification as gas companies have a pejorative (and the capital to support) for the continuation of household gas networks into the future.

ANALYSIS

This report will draw a comparative analysis between two different approaches to phasing natural gas out of the ACT. An **electrification** and a **fuel switch** approach will both be assessed against a triple-bottom-line criterion for the full cost accounting of the economic, social and environmental benefits and drawbacks of each policy implementation (Elkington, 1998, see also; Slaper & Hall, 2011).

For the electrification approach, this report assumes that any further electricity infrastructure added to the ACT network would be from renewable sources in line with the government's *Climate Change Strategy and Action Plan* (2017). This report assumes that a fuel switch is viable despite still being in the testing phase. This approach to greening the ACT's gas network would require a gradual increase in mixing hydrogen gas with natural gas until an 85/15 mix of hydrogen to biogas respectively is achieved by 2045. This mix allows for the addition of both an odorant and colourant to minimise the safety concerns around hydrogen flames and leaks (Staffell, 2019)

Social Impacts

The social impacts can be split into both the burden placed on the consumer in how they adapt the physical infrastructure in their homes to adapt to the new policy and how their way of living changes as a result. The two main social benefits received from gas currently are reliable heating and cooking. The comparison between gas and electric heating is straight forward as there are functional and price comparable equivalents for each. The trajectory of emerging electrical heating technologies may even make electricity a superior substitute for gas in the form of heat pumps, so neither decarbonisation strategy will severely alter this use (Luickx, 2008). Although cooking only makes up a few percent of general household gas usage it brings social benefits relative to other forms of household cooking (CUAC, 2014). This is due to the perception that gas cooking gives greater heat control, consistency and can engage in different methods of cooking than other electric alternatives. Induction cooking, however, which runs on electricity, provides greater heat control, consistency and efficiency than gas. Induction cook tops are easier to clean and safer, as the risk of injury or leakage from unburned gas is not a factor. Induction cooktops have also become price-competitive in recent years, making them comparable and in some cases superior (in terms of safety) to gas cooktops.

In 2016 Orima Research conducted a survey examining consumer preferences for gas and electric appliances in the ACT. The survey demonstrated that there was a strong preference for at least one gas appliance in the home amongst Canberra customers. The survey demonstrated that with the provision of more information and demonstrations as to the benefits and uses of electric technologies, consumer preference shifted in favour of their use.

If the gas network were retained, significant communication and education on behalf of Evoenergy would need to be conducted regarding the use of hydrogen gas, as the emergent technology is not widely known and households may resist a fuel switch due to a negative perception of the technology, resulting from historical mishaps such as the Hindenburg Disaster (Williams *et al.,* 2018 see also; Alternative Technology Association, 2014)

There is no clear superior decarbonisation approach in terms of social impacts, the benefits for either shifting with each individual household preferences.

Environmental Impacts

Electrification is the significantly more effective option for combating climate change in the context of the ACT. This is because the ACT must maintain its 100%

renewable energy guarantee after achieving 100% by 2020. Even if the hydrogen grid can be achieved to its fullest capacity by 2045, there will still be GHG release from burning the mixture of biogas and leakage from the network. Not only does this make it harder for the ACT to achieve net emissions neutrality by 2045, but in the context of a climate emergency ever measure must be taken in the most time efficient way to mitigate the effects of climate change.

Economic Impacts

The economic impacts are the most uncertain and difficult to compare between options. For an electrification approach, the current electricity infrastructure would have to be increased by a factor of at least 2.3 to compensate for peak seasonal (winter) and peak daily (morning) load, which can be three to four times the daily average (Evoenergy, 2018). This would be a multi-billion-dollar initiative for the ACT Government that must adhere to the constraints of renewable energy investment so as not to fall behind on their 100% renewable achievement by 2020. Under an electrification approach, gas appliances would no longer be serviced by the network. This would require replacing gas appliances with electrical appliances, a large burden placed on individual households that on average have at least one gas appliance and in many instances up to three (CUAC, 2014). Further, the existing gas network would have to be 'decommissioned' (ie. filled with an inert substance) to ensure the safety of the retired network, which the ACT Government would have to compensate Evoenergy for. Evoenergy is the provider of both energy and gas in the ACT so any current revenues would be made up to the company in the instance of an all-electric network.

Despite this initial upfront cost, new electric appliances are more efficient than new gas (and significantly more efficient than old gas) appliances so both the amount of energy required to maintain peak load and the cost to the consumer is likely to fall. Heat pumps, for example, can produce a heat output over double the energy input; far more efficient than any hydrogen appliance (Melbourne Energy Institute, 2016, see also; Forcey, 2015, see also; Skarbek, 2014). A further saving will be afforded to the consumer in not having to pay connection fees for the maintenance for two networks (CUAC, 2014).

The cost of repurposing the network for a fuel switch is currently unknown (see section: *LIMITATIONS*), however, there are some considerations to ensure a safe use of hydrogen within the network. Because hydrogen is a much smaller molecule than methane, any current leaks in the system due to gaps in infrastructure would be even more severe, thus the network would have to be vigorously inspected and updated to minimise fugitive leakage. Further, there is some speculation that and plasticisers present in the network may need to be replaced to potential hydrogen permeation

Producing a reliable supply of hydrogen gas and biomethane is a challenging task, with current natural gas consumption at 8.2 petajoules p/a (the equivalent of running approximately 7.1 million refrigerators for a year (Department of Environment and Energy, 2016, see also Evoenergy, 2018). Producing or sourcing a reliable supply of this amount of hydrogen-biogas mix will require significant infrastructure, technology and skills investment. Hydrogen is significantly more expensive to produce than natural gas (at present) and if this cost were passed onto consumers it would not longer be a viable energy source for many, especially low-income households.

Hydrogen has a higher flammability range and flame speed than methane gas. This means that existing appliances may need modification, for example the jets that release gas into a gas burner will need to be changed to allow for a different flow rate of the fuel. This can be done at relatively low cost to the consumer with minimal technical training required for installation Further, currently used meters would not be appropriate for new flow rates due to

different pressure requirements posed by hydrogen gas and would need replacing.

In the short term, a fuel switch would prove more economically viable to both the government and the consumer, however in the medium-to-long term an electrification approach becomes more economically viable to the consumer

RECOMMENDATIONS

Overall, this report supports the pursuit of an ***electrification approach*** as satisfying the triple-bottom-line criteria most effectively with the least uncertainty and most straight forward means of implementation. The reason that a dual approach (eg. initially supplementing hydrogen into the network) is difficult as resources would have to be taken away from renewable energy investment for electricity production to the industrial-scale production of hydrogen gas, the technology for which is still in its development phase and will become obsolete if an electrification approach is pursued. Considering this, this report presents eight (8) recommendations for the ACT government.

1. **Amendment to the *Territory Plan 2008***

Element 6.2 in the *Territory Plan 2008* made under the *Planning and Development Act 2007* should be changed to omit the inclusion of the gas network as an essential service provided by the ACT. This is justified as there is a cost and functionally equivalent product (electricity) that is also provided as an essential service and would not force developers to be 'locked-in' to the gas network.

2. **Change to the accounting framework for the gas network GHG accounts**

Section 5.2 in the ACT's *Climate Change and Greenhouse Gas Reduction (Greenhouse Gas Emissions Measurement Method) Determination 2017* made under the *Climate Change and Greenhouse Gas Reduction Act 2010*, should be altered to include the use of 'Method 2' from the Federal *Technical guidelines for the estimation of greenhouse gas emissions by facilities in Australia* (2014). This will allow for a more accurate estimation of fugitive emissions from the natural gas network to aid future decisions making surrounding emissions reduction.

3. **Develop a new appliance energy rating labelling system to allow for comparison between electricity versus gas appliances**

This allows for better understanding of the life cycle cost of the appliance for the consumer when selecting appliances that best suits their individual household. While realistically this measure should be taken at a Federal Government level, there is the possibility for the ACT to implement a labelling system for all appliances sold with the jurisdiction.

4. **No new suburbs should be developed with a household gas grid**

Following from the Ginninderry model of continuing the pipeline to the suburb to allow commercial and public service providers to continue to use gas where necessary (eg. the cost dynamics for schools and hospitals may still favour gas), and new suburb that is constructed in Canberra should not extend the network to individual homes in the interests of avoiding future sunk costs of infrastructure as technology changes (Melbourne Energy Institute, 2016).

5. **Subsidise the purchase and installation of electric appliances**

The ACT government should incentivise an appliance switchover at the end of the lifecycle of currently installed gas appliances. The lifecycle of most gas hot water systems, for example, is approximately 10-15 years, thus would allow for an easy transition for most households prior to the 2045 deadline (Alternative Technology Association, 2014). Examples of appliances that could be subsidies include reverse cycle heating and cooling, heat pumps, induction cook tops and electric hot water.

6. **Run an education campaign around the economic, environmental and social benefits of electrification the household**

Many consumers lack information about the cheapest way to heat their homes and water, the sustainability concerns of natural gas or the benefits of induction cooking This could be improved by running a government run campaign supporting electrification and helping the public through the transition to an electrified grid.

7. **Invest in more local renewable energy infrastructure**

In order to ensure the security of the ACT energy network after a natural gas phase out, the energy network will have to increase by factor of at least 2.3 to ensure functionality during peak times. This could be achieved by a combination of local productions (such as the solar farm currently at Royalla) and energy buy-backs such as the current deal with Victoria. It is plausible that this would be achievable by 2045, considering the rate of technology change and previous zero carbon energy goals being moved forward by 15 years.

8. **Gradually phase out the gas network suburb-by-suburb until 2045**

Much like the phase out of towns gas in Sydney or the phase in of green waste bins in the ACT in 2019, a suburb-by-suburb phase out of the gas network would allow for a gentle transition to an all-electric network in the ACT

CONCLUSION

In the context of the climate emergency, there is no time to waste with partial or temporary solutions. We cannot wait for future technologies to save us, we must act now with the technologies we have already at our fingertips to avoid a worst-case warming scenario. When there are environmentally sustainable solutions that also provide social and economic benefits to individuals and communities, they should be pursued with vigour.

The ACT has never been in a better position to decarbonise its natural gas network and could act as a national and even international leader in this climate change mitigation strategy. If an electrification approach is pursued, this will achieve the most favourable long-term benefits for the social, environmental and economic outcomes for the decarbonisation of the natural gas network.

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