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STANDING COMMITTEE ON ENVIRONMENT, CLIMATE CHANGE AND BIODIVERSITY
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Submission Cover Sheet

Inquiry into Climate Change and Greenhouse Gas Reduction (Natural Gas Transition) Amendment Bill 2022

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Submission to Inquiry into Climate Change and Greenhouse Gas Reduction (Natural Gas Transition) Amendment Bill 2022

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22 August 2022 By email: LAcommitteeECCB@parliament.act.gov.au

I am happy for my submission be published in full on the website including my name.

Background: I have worked in the energy efficiency area across all sectors for over 40 years and on climate issues for 35 years, with a focus on abatement action and policy. I have been involved in education, policy and program development and practical projects related to efficient appliance and building design.

Contents

Introduction and context

This submission provides an overview of some major issues and context, then explores them in more detail.

I strongly support urgent action to cut carbon emissions as quickly as possible. The ACT government's proposed approach makes a useful contribution to this by creating a 'new normal' in new home construction and urban development. This captures economies of scale, accelerates 'learning by doing' and mobilises the forces of competition to drive innovative solutions, build supply chain capability and streamline building development and construction.

Victorian government analysis for its gas strategy clearly shows that occupants of new homes can make substantial savings on ongoing energy costs through efficient electrification and on-site PV. Avoiding the cost of behind the meter and precinct level gas infrastructure and other economies can minimise up-front costs.

Renewable hydrogen?

Renewable hydrogen for use in buildings will take too long to introduce and will be expensive relative to high efficiency electric options: fossil gas is already more expensive. Part of the projected cost reduction of renewable hydrogen is linked to reduction in cost of renewable energy: cheaper renewable energy will also reduce the operating cost of competing electric options. Reticulated hydrogen would limit the potential for consumers to capture the benefits of on-site renewable electricity generation and utilisation and storage.

Many studies now rate distribution of renewable hydrogen to buildings as a low priority application: use for 'difficult to electrify' activities is far more significant (see for example

https://www.iee.fraunhofer.de/content/dam/iee/energiesystemtechnik/en/documents/Studies-Reports/FINAL_FraunhoferIEE_ShortStudy_H2_Blending_EU_ECF_Jan22.pdf). The short-term option of blending H2 with fossil gas offers very limited reduction in overall emissions: 10% of gas replacement by volume means about 3% reduction in combustion emissions, but leaves supply chain emissions at high levels. It is interesting to note that Japan's METI is now looking at using renewable hydrogen to produce 'artificial methane' as an alternative to distribution of hydrogen to small consumers (see *Low-carbon gases in Japan's Strategy reaching Net Zero by 2050* March 2022, Taichi Noda, Ministry of Economy, Trade and Industry). While this is even more expensive to produce and will take some years to commercialise and implement, it avoids many problems and costs such as appliance conversion, leakage, safety and deterioration of some types of infrastructure. In Australia, it is unlikely to compete with efficient, renewable electricity for households.

Climate issues

It is important to recognise that global temperature and energising of extreme climate events will continue to increase until the concentration of greenhouse gases falls from the present level (around 500ppm if all greenhouse gases are considered) to much lower levels when net energy flow into the earth is neutral: the pre-industrial concentration was around 270ppm. The cumulative quantity of emissions is driving global heating, so policy should focus on this indicator and our remaining carbon budget, not just annual emission targets. The sooner abatement occurs the greater the benefit.

The timeframe of climate impact of greenhouse gases is important. It is important to focus more on gases with high short-term impacts such as methane. The recent IPCC Working Group III report showed that methane contributed over half as much to global heating as carbon dioxide over the decade from 2010 to 2019 (see Figure 1), due to its high short term heating effect. This real-world impact is not reflected in standard carbon accounting methodologies that rely on 100-year Global Warming Potentials. It is therefore important that policy focuses on gas supply chains and usage that may involve methane leakage, such as urban gas distribution and use, not just combustion of fossil fuels.

Figure 1. Short term climate impacts of greenhouse gases (IPCC AR6 WGIII Summary for Policy Makers)

Methane has high short-term impacts – from gas and coal (40%), as well as cattle, sheep, landfills etc

In the past decade, methane contributed almost half of net human global heating impact (IPCC, 2021)

Over 20 years, methane has about 85 times the impact of CO_2 (Methane and climate change – Methane Tracker 2021 – Analysis – IEA)

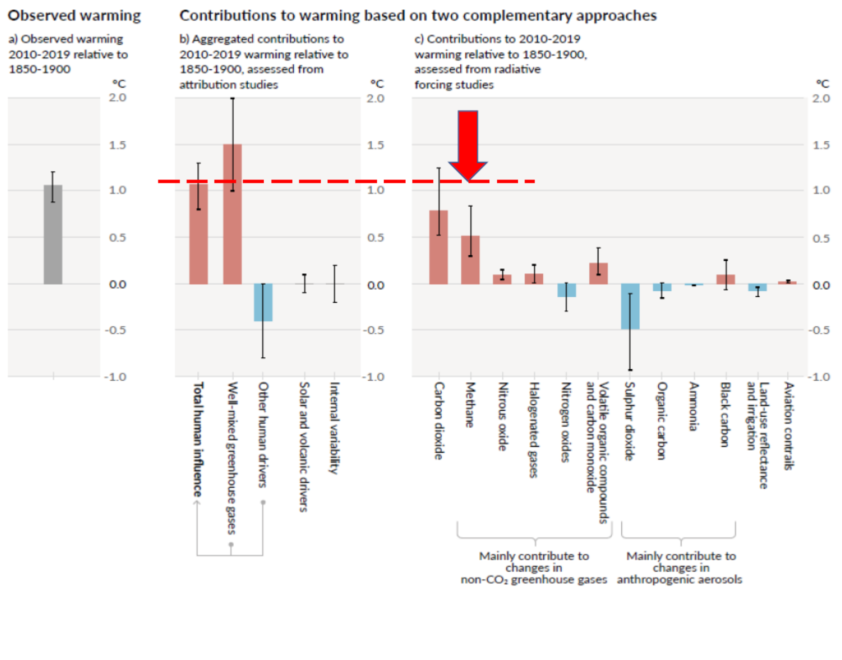


Figure SPM.2: Assessed contributions to observed warming in 2010–2019 relative to 1850–1900.

The Scope 3 emission factors for fossil gas published by the Australian government do not include leaks from low pressure distribution networks or from 'behind the meter' leakage (see Figure 2). There are increasing concerns that leakage upstream has been under-reported. The International Energy Agency has recently introduced a satellite-based monitoring system for methane tracking to address this problem. It has also flagged a need for greater focus on reducing methane leakage from the fossil gas supply chain, as gas is increasingly being sourced from large numbers of small producing wells, such as Coal Seam Gas, and some new gas fields also have high concentrations of CO_2 that must be removed before distribution.

Figure 2. Summary of factors included in values for scope 3 emissions from fossil gas. Note that 'behind the meter' emissions are not even mentioned (source: p.73 National Greenhouse Accounts Factors, Australian Government Department of Industry, Science, Energy and Resources, 2021).

Emission source	Fuel combustion	Fugitive emissions
Natural gas exploration	Included	Included
Natural gas production or processing	Included	Included
Natural gas transmission	Included	Included
Natural gas distribution	Included	Not included

Comprehensive policies, communication and education

It is also important to recognise that measures to reduce consumption of fossil gas require comprehensive programs, including extensive consumer and supply chain education (for trades, builders, services/design engineers and appliance retailers). For example, at the recent Energy Efficiency Council conference, ACT Minister Rattenbury commented that many people believed that woks could not be used on induction cooktops: my flat-bottomed wok works fine!

Success also relies on careful guidance regarding design, selection, installation and operation of high efficiency electric replacements such as heat pumps. My work with the Australian Alliance for Energy Productivity on application of heat pumps to aquatic centres, water heating and commercial/industrial heat has demonstrated pervasive ignorance, myths and negative attitudes among system designers, installers, clients and consumers. Some products are sub-standard. This can lead to consumer dissatisfaction and unnecessarily high capital and operating costs.

A comprehensive policy approach is also important as we switch from gas. ACT gas demand peaks in winter, driven mainly by building heating. Electricity demand also has winter and summer peaks, at which times significant fossil gas-fired generation is fed into the NEM. While ACT has zero emission electricity averaged over the year, addressing gas-fired generation associated with peaks and low variable renewable energy output helps to achieve 'real time' zero emissions from electricity. It also reduces the need for firming capacity (which can reduce renewable electricity contract prices). A multi-pronged approach is needed:

- Ensure building thermal performance is as high as possible: a high efficiency building typically has much lower demand for heat on extreme cloudy or foggy days with low solar generation, when wind generation can also be low.
- Ensure high performance electric equipment and appliances are installed and installation is done in ways that optimise comfort and ongoing equipment efficiency
- In parallel:
    - Drive rapid replacement of existing resistive electric space heating, hot water systems and high consumption appliances, to free up electricity supply capacity to cope with winter and summer early morning and evening peaks. While batteries will help to cope with short spikes in demand, we need to free up Megawatt-hours over periods of several days in winter, so that the batteries can recharge.
    - Target high electricity consumers for assistance to upgrade efficiency. Limited data for Victoria suggests the highest 5% of electricity consumers use around 15% of residential electricity. This relatively old data also suggests around 30% of very high consumers are vulnerable households. Commercial sector data also suggests the most inefficient buildings use far more electricity per square metre than average.

Provision of finance is crucial. Overall, households should benefit financially over time from a transition from gas. The fundamental challenges are the allocation of funds and management of equity. Landlords must be motivated and vulnerable households helped. Even 'wealthy' households often have tight cashflow, and may need transitional support that can be repaid from savings.

We also face emerging risks of winter gas shortages and likely high prices at that time, so rapid transition from gas as well as aggressive gas efficiency programs for remaining gas equipment (and buildings) are important.

Managing transition from gas

The main features of an effective transition strategy are outlined above. Attachments to this submission were prepared by the author as input to the Victorian gas substitution strategy, and they focus on rapid transition from gas, which involves a broader range of actions than for new homes.

Attachment 1 includes a number of actions that could be implemented in the short term to accelerate change. The commentary in Attachment 2 relates to a gas industry report on costs of switching for existing homes. My critique of an early gas industry study of the costs of transition from gas to electricity, based on a report by Frontier Economics is outlined at https://reneweconomy.com.au/hydrogen-vs-electrification-why-enas-gas-vision-is-a-house-of-cards-96820/ . My analysis identifies many flaws in the study.

Careful selection, installation and informed operation of high efficiency electric equipment

Where a reverse cycle air conditioner that replaces gas space conditioning will be used more for heating than cooling, a number of practical issues should be addressed.

First, ducted heating systems, regardless of the source of heat, can be very inefficient. One Victorian field study for Sustainability Victoria found ducting losses varied from 15 to 50%. Many ducted systems also significantly increase the proportion of air leakage into the house. The return air register draws air in from the 'easiest' sources. These sources are often gaps under external doors, open windows, fixed vents in toilets and laundries, and even reverse flows through clothes dryer ducts designed to move hot humid exhaust air to outdoors. If internal doors are closed, air from outlets in rooms beyond those doors cannot reach the return air register unless they have a suitable gap at the bottom. One US study found that when internal doors were closed, air leakage increased to up to 8 times the base level.

It can also be difficult to zone central systems, and some rooms may tend to overheat/cool or underheat/cool under some circumstances. Split and multi-split units are much more flexible.

Reverse cycle units mounted high on walls may not provide high levels of comfort. If there are low level drafts, the less dense warm air will tend to sit on top of the cold air. Some units may deliver relatively low temperature air. If this mixes with colder air in the room, it can create 'wind chill' effects. Cold air being drawn towards the unit can also cause discomfort for people sitting under the unit. Floor-mounted units are available, and can be more effective in winter while still working well in summer, especially in high thermal performance homes. Until recently, Daikin sold the high performance European-designed Nexura floor-mounted model that also incorporated radiant heating: unfortunately it is no longer available in Australia.

Sizing of reverse cycle units is very important, as the incremental cost of larger units is significant. Many smaller units have a 'boost' mode that increases output greatly for a period of time. AIRAH's *Fair Air* calculators can be used to estimate required capacity. In principle, the NatHERS software could be adapted to advise on peak thermal loads to guide sizing.

It is also important to recognise that the temperature difference across a reverse cycle air conditioner can dramatically affect efficiency. One degree change in this factor can affect efficiency by up to 5%, so the micro-climate of the location of the outdoor unit can be critically important. Increasingly, heat recovery or stored heat is being used to raise the inlet temperature, while cascaded heat pumps (two compressors in series, so the heat output of the first one becomes the heat source for the second one, reducing the temperature difference across each compressor) are used in cold climates. A lot more attention must be paid to the detail of heat pump installation for both heating and hot water supply.

Heat pump technologies can be managed to provide electricity demand management/response services through varying output or changing time of operation. But this requires user-friendly control systems and/or automation, which are rare at present.

Sizing and management of high efficiency electric technologies, including induction cooktops, is a key factor, as it can drive the cost of wiring on the consumer side of the meter as well as network infrastructure and generation costs and distribution losses.

A significant issue regarding hot water is choice between a heat pump or solar thermal HWS. A heat pump uses more electricity in summer, when appropriate timing of operation can help manage excess renewable generation and we have plentiful solar electricity. It uses much less electricity in winter, when the solar thermal system suffers from much higher heat loss from pipes, collectors etc. Further, a solar thermal HWS competes for roof space with PV and can only provide one service. PV can provide many services and solar cells work more efficiently in cold weather, though PV output still declines due to reduced solar radiation.

Feedback for users on operational efficiency of heat pumps and, indeed, most appliances, is vital, yet it is generally very poor. A University of Wollongong survey found that clogged filters were among the most frequent maintenance call-outs and greatest associated expense, dissatisfaction and inconvenience. Loss of refrigerant over time is another issue: it reduces energy efficiency and output capacity. Because it happens gradually, it is often not noticed until extreme weather or failure. In my view, all equipment with refrigerants should have high visibility, user friendly alert systems to warn of these issues. ACT government could argue for inclusion of such a requirement in appliance efficiency standards, while researchers may be able to develop add-on sensors to advise users.

Effective consumer education and advice

When I ran Melbourne's Energy Information Centre in the early 1980s, we had a comprehensive display centre staffed by trained and enthusiastic people. Our caravan unit travelled Victoria helping people design better homes and educating children about efficiency and renewable energy. We had energy-efficient passive solar display homes around Victoria. The Gas & Fuel Corporation employed teams of cooking experts and interior designers to help people learn how to best use gas. It sold insulation that could be paid for on your gas bill. When we introduced appliance energy labelling, the State Electricity Commission of Victoria spent millions of dollars promoting the scheme: this was crucial in building public commitment.

Today, policy makers seem to think that dumping information online and designing policies is enough. They don't seem to grasp that driving change involves competing for brain space with others who are spending tens of millions of dollars promoting their agendas. People (and businesses) need a lot of 'hand-holding' to change.

Where are the educators showing people how to use a wok on an induction cooktop? Where are the *independent* people to advise on the complexities and subtleties of positioning and using a reverse cycle air conditioner to deliver comfort? Where are the built-in features and advice that warn you when your reverse cycle unit is losing refrigerant or has a clogged filter that is reducing its heating and cooling output and efficiency? Where are the ongoing advertising campaigns explaining building and appliance star rating schemes?

My experience over forty years is that few policy makers or politicians appreciate how important competent, comprehensive and well-resourced implementation is. And few people know how to deliver that.

ATTACHMENT 1: Draft thoughts on a fast response strategy for gas replacement

Alan Pears 31/3/22(with some updates)

The Gas Statement of Opportunities 2022 has just been released by AEMO. It again flags concerns regarding winter gas supply, mainly for heating of buildings. [Note that AEMO does not publish an annual efficiency/demand side Statement of Opportunities. It should.]

Given delays in LNG import capacity and other supply sources, governments and energy retailers should implement backup/contingency strategies.

A draft fast response strategy for Victoria

Measures should target key groups: those with gas heating (especially ducted) or resistive electric heating who have existing reverse cycle air conditioners, those with gas heating and high winter gas bills, and those who can be encouraged to buy a high efficiency split system (or multisplit) reverse cycle air conditioner. It is important to focus on both reducing winter gas demand and freeing up electricity supply capacity to support a shift to reverse cycle air conditioning.

Strategies such as the following can be applied quickly:

- Encourage and advise owners of existing reverse cycle aircons to use them instead of or to assist gas heating and resistive electric heating (see below for how RCAC can assist existing heating)
- Encourage people to replace resistive electric heating with reverse cycle aircons
- Encourage regular cleaning of filters in all heating equipment
- Encourage use of zoning and closing of appropriate heating outlets in unused rooms (with advice on setting fan speeds lower)
- Encourage closing doors of laundries, toilets, bathrooms near return air registers (and draughtproofing them!)
- Encourage draughtproofing of homes with ducted heating to minimise outdoor air entry into return air registers
- Encourage fitting deflectors to in-floor ducts (and in-ceiling ducts near windows?)
- Gas retailers should be required to alert high winter gas consumers to this fact, and offer them discounts/incentives to apply the above strategies.

Replacing options with existing or new (high efficiency) reverse cycle:

Stock data from the 2015 Residential Baseline Study (modelling, not actual): 2020 data is latest from 2021 RBS worksheet [ACT data is included in the RBS reports and worksheets].

Appliance	Vic stock 2020 est	2020 from 2021 RBS	
Aircon ducted	197,951	209,271	
Aircon non-ducted	2,072,842	2,412,767	
Resistive electric	993,202	1,230,264	
Mains gas ducted	1,142,392	1,166,317	
Mains gas non-ducted	316,207	436,665	

Important data is outdated or limited. We have very little field data on the system efficiencies of ducted gas (and RCAC) systems. Data from the latest Residential Baseline Study has been released (see energyrating.gov.au) but unfortunately there is no user-friendly report: only the worksheets are available. This includes appliance stocks and estimates of energy use by source and activity at a state and territory level. The Victorian government has conducted modelling which, presumably, has included collection of data that should be made publicly available.

Full space conditioning stock data from 2021 Residential Baseline Study worksheet from www.energyrating.gov.au

Space conditioning	8,482,081
Combined space heating and space cooling equipment	**2,622,038**
AC ducted	209,271
AC non-ducted (split and WW)	2,412,767
Heating Equipment	**3,040,195**
Electric resistive	1,230,264
LPG gas non-ducted	13,037
Mains gas ducted	1,166,317
Mains gas non-ducted	436,665
Wood Heaters	193,912
Space cooling equipment	**2,819,848**
Evaporative (mostly central)	379,005
Fans	2,440,843

My understanding is that the vast majority (potentially over 90%) of Victorian air conditioners are reverse cycle. However, there is a widely held view that most of these are not used for heating at present.

What is the potential of these?

We have limited data, but the following outlines the potential.

Replacing resistive electric heating with RCAC, 30 to 80% reduction in electricity and running cost – and impact on use of gas electricity generation at peak periods, while also potentially reserving water in dams for hydro generation at other times. This can be achieved by using an existing RCAC or installing a new RCAC. Public housing is now shifting to RCACs in many parts of Victoria to reflect the reality that summer cooling is often needed for occupant health and comfort, while it is cheaper to run as well, as reflected in modelling for the Victorian government Gas Substitution strategy.

Replacing gas heating with RCAC saves 40 to 80% of heating energy – maybe more if a smaller area is heated. It may also save some more electricity due to reduced fan energy use relative to gas ducted systems. Running cost would be reduced. Losses related to ducted systems are often high.

Cleaning filters (in both electric and gas equipment): a clogged filter reduces the air flow, reducing the efficiency, as this increases the temperature difference across the RCAC heat exchanger. It also reduces the maximum heating capacity of the appliance. If 20% of RCACs are clogged, and each one improves efficiency by 20%, that is 4% saving on total energy for the RCAC but also using the RCAC instead of gas heating dramatically reduces the amount of heating energy consumed by the gas system (see above).

Diverting heated air away from windows and uninsulated walls: Low cost plastic diverters can be clipped on duct outlets. In principle a similar approach could be applied to ceiling heating outlets. Hot air blowing past a window dramatically increases heat loss by increasing the temperature difference, and by breaking down the insulating still air film next to the window, which actually provides over 70% of the insulation value of a single glazed window. Hot air blowing past an uninsulated wall has a similar but smaller impact. Gas & Fuel Corporation research over 30 years ago showed that these deflectors could improve gas ducted heater efficiency by 20%

Sealing drafts and closing/sealing doors to ventilated unheated areas: this is potentially very significant, especially in very cold, windy weather. In theory, a ducted heating system recirculates air within a home, relying on existing air leakage for fresh air – note that combustion of the gas is isolated from indoor air in ducted systems. However, this rarely happens. A US study showed that running a ducted system doubled baseline air leakage and, under some circumstances, increased air leakage by up to 8 times. The basic issue is that the return air register draws in air from the sources with lowest resistance to flow. So cold outdoor air is sucked in through vents and open windows in laundries, bathrooms and toilets near the return air register in preference to warm air from distant rooms, especially if their doors are shut. I am not aware of any local studies that document the extent of this effect, but it is likely to be large. A further issue is that installation guidelines recommend having a significant gap under each internal door so that, if it is closed, air from the outlets in each room can still move to the return air register. In practice, few homes have such a gap and, even if there is a gap, there is still significant resistance to air flow. This will increase the likelihood that more cold outdoor air will be sucked in from sources with lower flow resistance.

Confused thermostats: Most central heating and cooling systems have a single thermostat, usually located in a hall near the return air register, or even inside the return air register. This drives the behaviour of the whole system, which is why some rooms may not feel comfortable at times – and people may turn up the thermostat to try to compensate. For example, if the thermostat is in a central hall, a room with large glass areas may never feel warm, as the thermostat feels warm. If a door between a living area and the return air is closed, the living area may get too hot or too cold, depending on the system's design. If the thermostat is exposed to cold drafts, much of the home can overheat.

'Interesting' user behaviour: When high energy use is identified, it can often be partly because of user behaviour interacting with equipment design. For example, some people prop a door open so their pets can go in and out of the building as they wish. Some people leave windows open permanently for 'fresh air' or because they smoke cigarettes. As noted above, closing internal doors can confuse thermostats and increase leakage of outdoor air into the building. Where central heating or cooling systems are not well balanced, a person in one room may open a window to adjust the temperature, since they cannot change the central thermostat setting.

Identify ducted systems with high losses: one Victorian study showed that ducting leakage can be a major energy waster, with losses ranging from 15 to 50%. Energy assessors frequently find damaged ducts and duct insulation, and even ducts that have fallen off heating outlets. Gas retailers know who the high winter gas consumers are: the government should require them to engage with these customers to help identify the causes of the high usage and remedy them. Victorian survey data suggests that the highest 5% of residential gas consumers use around 15% of residential gas.

I think it is also possible, to **use a reverse cycle airconditioner in partnership with a ducted heating system** to at least reduce gas consumption and heating costs: if the gas ducted thermostat is set to a lower temperature and the rev cycle unit thermostat a slightly higher, the RCAC will produce heat where it is located: this will tend to be drawn into the return air register and past the ducted unit thermostat, so some heat from the RCAC will replace some heat from the gas ducted system.

I haven't tried this in the field yet, and it is a bit complicated to explain, so maybe it is something to think about for the future…..

Closing unnecessary heating outlets: Many ducted systems have poor zoning, so unused spaces are heated unnecessarily. However, there are complications with addressing this. First, closing an outlet may still allow significant leakage. For ducted systems with fixed speed fans, pressure in ducts will increase, amplifying any leakage and increasing fan electricity consumption and noise. Many ducted systems do have multi-speed fans, which could be reset to a lower speed, but the control may be in the outdoor furnace unit.

Issues for AEMO:

To what extent does AEMO expect that existing gas generators will be able to cope with the proposed need for future firming? And what scale of gas resources (supply and storage) would be required?

Modelling of impacts on the electricity supply system of switching from gas.

As noted earlier, there is a lot of inefficient electric heating in use: addressing this will free up existing electricity supply capacity. Also, upgrading building thermal performance offers substantial reduction in both peak demand and consumption. Rough calculations suggest that a 6 star home requires about a third as much heat on a cold day as a 2 star home.

Using the estimated hourly gas use for heating as a basis for estimating peak electricity demand if gas is replaced by RCAC is deeply flawed. The marginal cost of extra capacity for a gas heater is much lower than for a RCAC. So many gas heaters operate at high demand (eg 80 MJ/hour or 22 kW) when they start. Using a split system instead would heat a smaller area, and would have a much lower peak electricity use, due to its Coefficient of Performance and smaller peak heating capacity due to the higher capital cost per kW. There is also scope to spread peak electricity load using timers and smart controls.

ATTACHMENT 2: Transition costs for existing homes

Comments on Frontier Economics paper regarding costs of transition from gas

Alan Pears AM Senior Industry Fellow RMIT University July 2022

The report referred to in this paper is available at Frontier-Economics-Report-GAMAA.pdf or

https://gamaa.asn.au/wp-content/uploads/2022/07/Frontier-Economics-Report-GAMAA.pdf

Introduction

Frontier Economics has released a paper, prepared for the gas industry, exploring the 'behind the meter' costs associated with transitioning existing homes that use gas to all-electric alternatives. This is certainly an important issue, though it should be seen in a context where Victorian government modelling has shown that, for new homes, an all-electric solution has lower ongoing operating costs.

Frontier rightly point out that an existing home faces some costs, such as removal of gas appliances, rectification of building fit-out and the possibility of electricity supply upgrading or rewiring. This may involve significant labour and materials costs. At the same time, an existing home does not benefit from the savings from avoiding costs of gas pipes and meters that a new home captures.

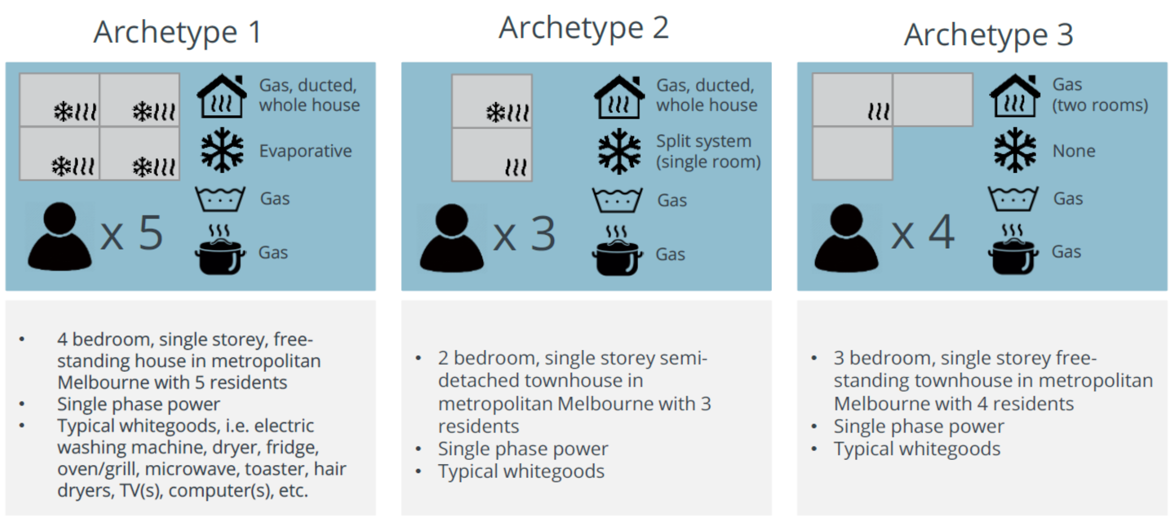
The study incorporates a number of unrealistic assumptions and simplifications and uses some outdated data. This results in estimates of total costs for Victorian households of $4 to 31 billion dollars over the transition period for the various scenarios assessed. This would lead to costs ranging from under $2,000 to almost $15,000 per home if 2 million homes switched fuels. However, these estimates seem likely to overstate the costs.

Clearly this area deserves more consideration and careful management with strong government action.

Frontier approach

The approach taken involved defining three 'archetype' homes (see Figure 1), then seeking price estimates from a range of installers for three sets of options.

Figure 1. The archetype homes and appliances analysed in the report



The installation package options included replacing gas hot water with heat pump hot water service and gas cooking with electric cooking using an induction cooktop and electric oven, as well as the following options for heating and cooling. Further, installers were asked to estimate costs for three situations, low, medium and high cost.

- **Option 1:** Heat pump split systems capable of heating and cooling the whole house (either multiple single splits or one multi-split unit)
- **Option 2:** A heat pump split system capable of heating and cooling a living area and master bedroom (either multiple single splits or one multi-split unit)
- **Option 3:** Ducted heat pump capable of heating and cooling the whole house.

The notional initial cost of hydrogen-compatible appliances for ongoing gas use was also estimated by adding 30% to the cost of existing gas appliances.

The study did not consider ongoing operating costs or costs associated with electricity or gas supply beyond the meter. The report's conclusion was:

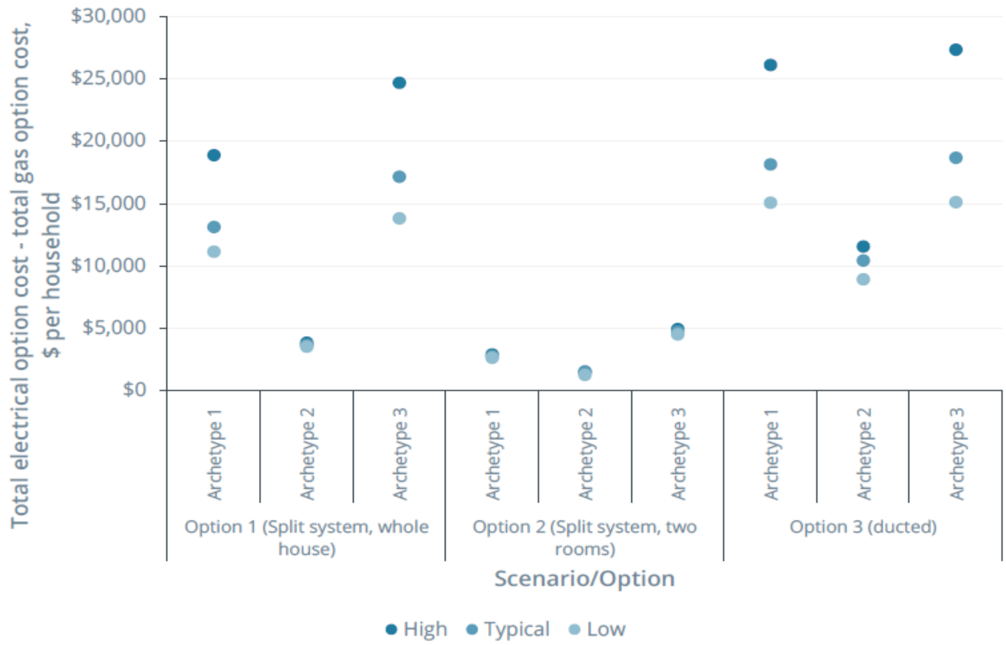
> We used the installers' responses to estimate indicative upfront costs for fuel-switching in Victoria based on the existing housing stock and appliance mix. The findings of this analysis suggest that the additional upfront cost to Victorian consumers of replacing their existing gas appliances with electric appliances, compared to replacing them with new gas appliances capable of burning hydrogen gas, varies significantly based on the level of amenity required. If all Victorian homes were to only attempt to heat and cool two major rooms of their home (Option 2), upfront costs of electrification of households could be as low as $4 billion. If, however, whole of home heating and cooling is required (Options 1 and 3), the cost is likely to increase to a figure in the region of $14 to $31 billion.

If we assume that Frontier expected around 2 million Victorian homes to fuel-switch, these estimates reflect a range in average cost per household of under $2,000 to over $15,000, depending on the mix of options used. The range of fuel switching costs in the scenarios actually studied is much wider when all archetypes, options and cost estimates are considered, as shown in Figure 2. These costs seem to exclude any cost involved in upgrading electricity supply within the home, if needed. The report suggests this additional cost may range from $2,150 to $12,250.

It is not clear from the report whether the mix of appliances considered was based on actual mix of appliances (eg proportions of gas-connected homes with electric ovens, hot water and/or electric heating) or whether it was assumed all gas-connected homes had the mix of appliances outlined in the 'archetype' homes. This has potential implications for cost estimates, as discussed later.

Figure 2. Difference between total electrical option costs and total gas option cost per household by Archetype (Figure 9 from the report). Note that additional costs of upgrading power supply where required are estimated to range from $2,150 to $12,250

Figure 9: Difference between the total electrical option costs and the total gas option cost by Archetype



Source: Frontier Economics analysis of installer responses

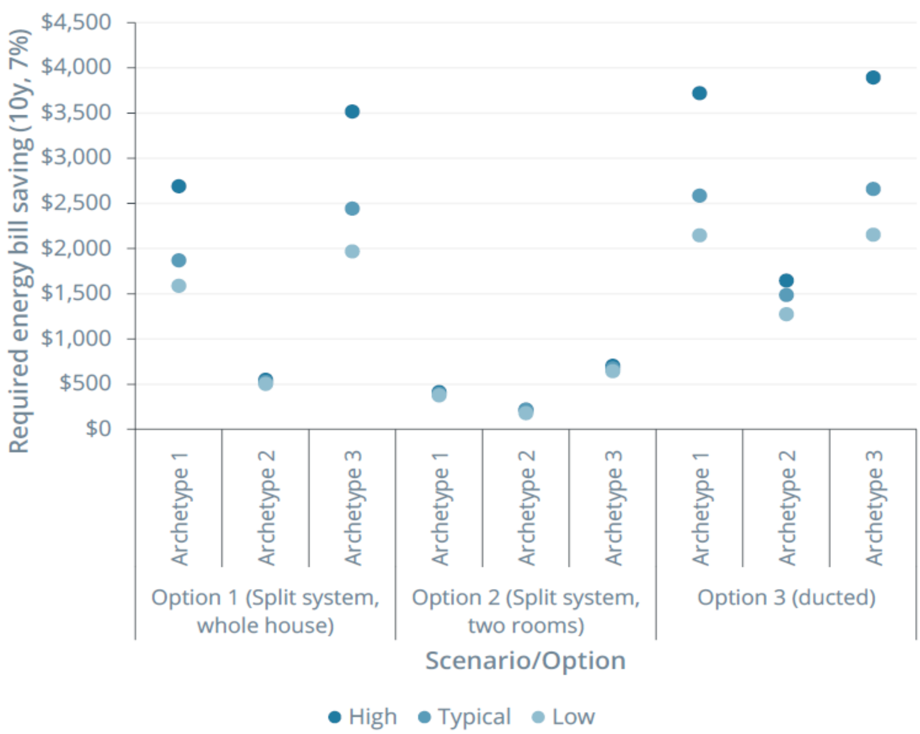
Note: Excludes power supply upgrade costs where there was not unanimous agreement that these were required.

Frontier's analysis also included estimation of an annualised impact of initial behind-the-meter switching costs (see Figure 3) using a real discount rate of 7% over a ten year life, as a way of comparing installation costs with estimates of ongoing operating savings from fuel switching published by others. This approach seems likely to overestimate time to offset initial extra costs, because major appliances often have long lives, and a real discount rate of 7% is equivalent to borrowing money at a nominal interest rate of (7+inflation)%. This is significantly higher than the impact of missing out on typically lower bank interest by using funds from savings or many loan interest rates.

If the results from this analysis were accepted uncritically, a substantial proportion of existing households would not recover their fuel-switching costs from savings on energy bills. This brief paper explores a number of factors that could produce different results.

Figure 3. Required annual energy bill savings to offset initial extra electrification costs (using real discount rate of 7% pa over 10 years - Figure 11 from the report).

Figure 11: Required energy bill savings with a discount rate of 7 per cent over 10 years



Source: Frontier Economics analysis of Installer responses

Note: Excludes power supply upgrade costs where there was not unanimous agreement that these were required.

Some thoughts on the issues

It is clear that the transition cost of fuel switching from gas to efficient electric solutions involves costs – but it is also clear that these are not well understood and may vary widely, depending on circumstances. More sophisticated analysis with high quality data is needed to build an improved understanding of the costs, and of the options to reduce those costs and assist those who need help.

The Frontier Economics study provides some useful analysis, but relies on some significant assumptions and ignores the reality that many Victorian homes already have reverse cycle space heaters (there are over 2 million in Victorian homes according to the latest Residential Baseline Study at www.energyrating.gov.au) and electric ovens. Many households may transition over time, as appliances need replacement, or take advantage of a time when tradespeople are at the home for other reasons. A significant proportion of homes are all-electric apartments. Some homes may choose to use a combination of reverse cycle air conditioning and resistive heating in low usage rooms to reduce initial costs.

The dynamics of housing should also be considered. Tens of thousands of houses are demolished and replaced each year, while many homes have significant renovations. So there is potential for a significant underlying fuel switching transition to reduce the number of existing homes impacted.

Over time, upgrading to efficient electric equipment and improving thermal performance of buildings may be incentivised by government to reduce stress on electricity grids or reduce the need to invest in energy storage and supply capacity. For example, a 6 star home has a cold day peak thermal demand two-thirds lower than a 2 star home. Its lower heating requirements on a cold, cloudy winter day when solar output is limited can make a big difference to electricity infrastructure costs, which are not considered in the Frontier study.

The allocation of full wiring upgrade costs to the installed cost of electric heating, hot water and cooking to those activities may be inappropriate. For example, households may upgrade electricity supply for safety reasons, make changes as part of a major renovation, install a reverse cycle air conditioner primarily for cooling, or to support charging an Electric Vehicle. Some households that are installing rooftop solar and battery storage also incorporate wiring upgrades or convert to three phase power.

GHD have produced a report (*All-Electric New Homes – cost estimates* report for DELWP, April 2022) for the Victorian government that considers the potential need for upgrading wiring. This also notes that some types of homes may require wiring upgrades. However, both the GHD and Frontier studies make assumptions about likely peak loads that may overstate real world demand. For example, while an induction cooktop may be rated at 10 kilowatts, it is likely that it will rarely exceed 5 kilowatts. Peak cooking loads are also of short duration, as steady state cooking loads are much lower than heat-up demand. For example, while an oven may use 2 kilowatts or more when heating up, it uses more like 500 watts during cooking. There is a case to encourage manufacturers of induction cooktops to modify designs, for example, by incorporating smart management or even small amounts of built-in energy storage. In addition to improving building thermal performance, smart management of reverse cycle air conditioners, including programmed early starts, can limit peak demand. These measures may allow selection of smaller capacity heating/cooling equipment, or avoid the need for significant amounts of heating in some rooms.

It also seems likely that the purchase and installation costs of efficient electric technologies will decline over time with economies of scale, competition and ‘learning from experience’.

On the other hand, tenants, vulnerable households and some types of housing may need assistance to fund change. Provision of long term, low interest finance and policies that overcome split incentives may also be important.

It is also important to maintain ongoing review of factors that impact on future operating costs. Trends in carbon pricing/trading and gas and electricity prices/costs will impact on ongoing living costs, rather than being incorporated into once-off costs often linked into home finance. Factoring a carbon price of $50-100 per tonne of emissions into decision-making seems prudent. It is also important to factor into policy the reality that it is our cumulative carbon budget, not annual emissions, that drives global heating. Prompt action to cut emissions (or avoid land clearing) is of greater value than delayed action or offsets such as tree planting.

Emerging concerns about winter gas supply shortfalls and, indeed, concerns about either winter electricity shortfalls or high costs due to investment in winter electricity supply solutions are also relevant. These factors are likely to increase already high winter gas and electricity prices. Reducing peak demand of buildings is key to managing these problems, and would reduce the capital cost of reverse cycle air conditioners and the need to upgrade electrical wiring.

As noted at the start of this paper, initial costs for fuel switching are important. We need to understand them better. And look at them in an appropriate context. Given the many assumptions and simplifications of the Frontier Economics report, it seems likely that it has overstated overall costs of switching from gas, but it has highlighted that some households could face high costs if the transition is not well managed.