Enabling the decarbonisation of Australia's energy networks

## FF CRC’s RP1.1-02 - Electrification of heating: A two-page summary

Nowadays, the utilisation of the gas transmission network in Victoria is largely dominated by gas-powered generators (GPGs) and the heating sector. Moreover, the push towards multi-energy systems to reduce costs and greenhouse gas emissions will also increase the interactions between different energy sectors and vectors. Despite their physical coupling, electricity and gas systems are currently operated, managed, and planned separately. This therefore calls for developing integrated modelling frameworks that jointly coordinate multiple energy networks to better capture the multi-energy nature, constraints, spatial and temporal inter-dependencies, and synergistic opportunities of future systems.

One of the pathways towards low-carbon multi-energy systems is the electrification of residential heating, which consists of shifting (some) heating demand from the gas system to the electricity system to reduce carbon emissions, as the electricity system gets increasingly decarbonised.

This project demonstrated the potential capabilities of the integrated electricity and gas system (IEGS) modelling tool under development by the team at The University of Melbourne in conducting studies on the electrification of heating for the electricity and gas transmission networks of the state of Victoria. In particular, the studies consist of assessing the impact of electrification of residential heating on the electricity and gas networks of Victoria, under the “Step Change” scenario in AEMO’s 2020 integrated system plan (ISP) for the years 2025 and 2035. The electrification studies are conducted for five different representative gas demand days. These are:

Winter:

- 1-in-20 peak demand day on 9 August 2019 (1192 TJ/d)
- High winter demand day on 3 July 2020 (1116 TJ/d)
- Average winter demand day 17 July 2019 (935 TJ/d)

Autumn:

- High Autumn demand day 21 May 2020 (907 TJ/d)
- Average autumn demand day 15 May 2019 (640 TJ/d)

Each one of the five representative gas demand days is analysed under the two outlook years, 2025 and 2035. These representative days are then analysed under two wind availability scenarios, namely, normal wind and low wind, in an effort to capture the impact of low-wind conditions on the joint electricity and gas systems in the context of the electrification of residential heating. Two demand patterns, “adjusted” and “unadjusted”, are considered for the modelling of the electrification of space heating (SH) and domestic hot water (DHW), with “adjusted” correcting for time of use. Finally, three electrification levels of 0%, 50% and 100% of SH and DHW are considered. This overall results in 100 different scenarios for each outlook year. In this work, the electrification of SH is assumed to be enabled by air-to-air electric heat pumps (EHPs), whereas the electrification of DHW is assumed to be enabled by air-to-water EHPs.

The key results from the model identify whether any constraints have been breached on the electricity transmission lines, whether there is sufficient electricity and gas supply and the overall level of emissions including those from electricity (both coal, gas, renewables and imports) and the direct use of gas (in residential, commercial and industrial sectors). Based on the demand pattern that corrects for time of use on winter days, the results from the modelling show that:

- In 2025 under normal wind scenario, the full electrification of residential gas demand increases overall emissions by approximately 6% and 12% in 1-in-20-year and high winter gas demand day scenarios, respectively. However, in the case of an average winter gas demand day, these emissions stay at the same level whether the gas load is electrified or not. This reflects that the additional electricity demand from switching away from gas use in the home is being met with increased generation from brown coal or gas peakers.

- The overall emissions in 2035 are an average of 39% lower than the 2025 emissions due to the increased level of renewables in Victoria's electricity generation, in line with the 2020 ISP Step Change scenario.

- For 2035 normal wind scenario, the full electrification of residential gas demand reduces overall emissions by approximately 20% in 1-in-20-year peak gas demand day. For high winter and average winter gas demand days, this reduction is approximately 16%. This reflects that the electrification in mainly supported by gas peaking plants and electricity imports to the state. The slight reduction is due to the lower emission intensity of imported electricity (esp. from SA and Tas) compared to Victoria's domestic electricity supply.

- The emission reductions in the "low-wind" scenario are higher as a percentage although start from a higher base. This is due to more coal and gas peakers being used on those days. The reduction in emissions reflects a lower emission intensity from imported electricity. However, the emission intensity of the imports is an average yearly figure and may not reflect similar "low-wind" conditions in the connected states which may mean that the actual emissions at that point in time are actually much higher due to gas peakers being used.

- Electricity imports are required to supplement domestic energy supply in Victoria in nearly all of the 100% electrification scenarios in 2025 or 2035.

- Constraints on electricity lines from 100% electrification in 2025 and 2035 only occur when there is low-wind and this requires much higher levels of electricity imports.

- No constraints on gas supply have been observed in any of the scenarios except in 2035 1-in-20-year peak gas demand day under low-wind 0% electrification scenario.

The results show that using electrification as a policy measure to reduce emissions is highly dependent on the emission intensity of the electricity grid. Electrifying when the grid is mostly coal fired increases emissions even with highly efficient electrical appliances. Although the average emissions for electricity decline by 2035, the time of use of gas appliances and subsequent switching to electricity places higher demand on gas peaking plants and imports, and do not provide the same level of emissions reductions as averaged across the electricity sector over a year.

This report is an extension of the previous electrification study titled "RP1.1-02 - Integrated Electricity and Gas Systems Studies: Electrification of Heating". However, the current study differs from the previous study in key aspects including (i) changing AEMO's 2020 Integrated System Plan (ISP) scenario from "Central" to "Step Change", (ii) updating the assumptions on the EHP coefficient of performance (CoP) of both SH and DHW, (iii) improving the assumptions on gas demand sector breakdown to better estimate residential SH and DHW seasonal and intra-day energy usage, and (iv) updating gas supply forecast according to the 2021 Victorian gas planning report.

**Acknowledgements**

Future Fuels CRC is supported through the Australian Government's Cooperative Research Centres Program. We gratefully acknowledge the cash and in-kind support from all our research, government and industry participants.

Australian Government
Department of Industry, Science and Resources

AusIndustry
Cooperative Research Centres Program