What role for gas in future HVAC?

by Richard Keech

Abstract

HVAC professionals should be well informed about the broader consequences of using fossil fuels. Gas has long had a reputation as a cheap, clean and safe fuel in buildings. This paper re-examines the role of gas in the carbon-constrained buildings of the future. Examined will be questions of the emissions from gas, the safety of CSG, and the impact of gas exports on domestic prices. Finally, the alternatives to gas are considered.

Introduction

Gas Consumption. In 2011-12 Australia consumed about 1067PJ of methane gas[1] of which about 28% (~300PJ) is used in the so-called 'mass market', *ie* commercial and domestic applications. Gas contributes about 17% of the mains energy used in commercial buildings[2] and about 34% of residential energy inputs[3].

Gas vs coal. In recent years, following the raised awareness of high emissions from coal-fired power, it has become common to view the use of the relatively low direct emissions of gas combustion as a worthwhile way of achieving global emissions reductions[4],[5]. This is exemplified by the statement *"Gas is an essential part of the transition to a low carbon economy"*[6] from the Victorian Government. This paper aims to critically examine that prevailing view, and the implications in future HVAC systems.

Emissions targets and gas use

Framework for emissions reduction. The Australian government has adopted national emissions-reduction targets and time frames in response to the global threat of climate change. The targets are for 15 % - 25% reduction (conditional upon the extent of international action) by 2020, and 80% reduction by 2050 based on 2000 levels[7]. Consistently, the advice from the scientists has been that strong emission reductions need to occur early in that time frame[8] if temperature rises are to be contained within the so-called two-degree 'guard rail'. The basis for these targets is the goal of containing CO_2 concentration below 450ppm. There is an emerging view in the climate science community that it will be necessary to return CO_2 concentrations back below 350ppm[9]. As a result, it is now apparent to many[10] that most of the remaining fossil fuels, including gas, are 'un-burnable', *ie* they need to remain in the ground to avoid catastrophic climate damage.

Gas. Those using gas as a fuel in buildings need to be mindful of this emissions reduction framework. In particular they should assess whether the use of gas remains consistent with the broad goal of environmental sustainability. The traditional view that *'low-emissions of gas make it a green fuel'* needs to be re-assessed in light of the latest understanding of the science.

Gas emissions

Direct emissions. Claims of the green merits of gas are generally based on the relative emissive intensity of gas versus coal, at the point of combustion. Current standard emission factors (kg-CO_2e/GJ) for combustion are 51.3 for gas, 88.4 for black coal, and 93.1 for brown coal[11]. These rates of emission from gas, although relatively lower, are not low in any absolute sense. It is hard to see how, by themselves, these rates of emissions are in-keeping with the goal of 80% emission reduction by 2050, since the life time of gas-related infrastructure represents a significant proportion of the time remaining till 2050.

Leakage. Combustion emissions are not the only emissions associated with gas. The net emissions are also influenced by the amount of leakage, or 'fugitive' emissions. Two main factors influence the calculation of emissions (per unit delivered) from the leakage of gas: a) the global warming potential (GWP) of methane, and b) the rate of leakage of methane in gas production and distribution.

GWP. Estimates for the global warming potential for methane have improved over time and are stated relative to the effect of CO_2. However, because different warming gasses last different times in the atmosphere, it is customary for both 20-year and 100-year GWPs to be cited. Methane has stronger warming effect, but lasts only about 12 years in the atmosphere, compared to CO_2 which lasts much longer[12]. As the understanding of the physics of emissions has improved, so to has the measurement of GWP, as shown in the table below.

Assessment	20-year GWP	100-year GWP	Residence time (years)
IPCC, 1992	63	21	10
IPCC, 2001	62	23	12
IPCC, 2007	72	25	12
Shindell, 2009[13]	105	33	12

Table 1. Global warming potential of methane

The The current Australian Government guidelines[11] still use the older value of 21, although they have committed to updating this in 2017. Given the increasingly compressed time frame for effective action in reducing emissions[8], the use of the 100-year GWP no longer seems appropriate. The author is of the view that it is more reasonable to use a GWP time frames consistent with the residence time of the gas and the time remaining for mitigation efforts to be effective.

Production Leakage rates. The current Australian standard method for calculation of methane production leakage rates uses an assumed leakage rate of 0.12%[14]. This methodology is applied to all gas production (both conventional and CSG) even though it is based on the methods of the conventional petroleum industry. Numerous recent studies suggest that fugitive emissions are much greater than 0.12%. The US EPA and put leakage in 2009 at 2.4% and other studies show higher leakage around 4% - 9%[15]. In Australia a study of the literature on fugitive emissions was conducted by Pitt & Sherry in 2012[14]. This compares numerous studies, all of which are consistent with a leakage rate of much higher than 0.12%. A study by Hardisty *et al*[16] suggests that "if methane leakage approaches the elevated levels recently reported in some US gas fields (circa 4% of gas production) and assuming a 20-year methane GWP, the GHG intensity of CSG-LNG generation is on a par with sub-critical coal-fired generation". In other words, it may be that the emissions situation for gas is actually no better than jfor coal in some situations.

Pipleline leakage. Inevitable leakage occurs in the domestic gas distribution network. Harrison et al[17], in the US, measured about 3/4 of total fugitive gas emissions downstream of the initial production. A 2013 study[18] from New York City concludes leakage exceeds 5%. Data from Adelaide suggests rates of lost gas as high as 7.8%[19]. Current official estimates ([11] Section

2.4.2.8) from the Australian government put gas leakage factors, depending on state, at around 1.5%. A study from Sydney in the 1990s inferred leakage rates greater than 10%[20]. A realistic estimate is likely to be somewhere in between these estimates.

Net effect. A reasonable and conservative working estimate of production leakage would seem to be at least 2.4%, which is the current figure used by the US EPA. This is twenty times the current Australian default value of 0.12%. We can use the latest 20-year GWP of 105, which is five times the current generally used value. Combined, these give a net one-hundred times increase in the emissive effect from production leakage. Clearly this takes production leakage effects from being trivial to being considerable. For example, the net emissions (using assumed leakage of 2.4% and GWP of 105) from using 1kg of methane is 5.2kg CO2(e). Measured the old way (0.12%, 21) the net emissions are reckoned to be only 2.8kg CO2(e).

Other gas considerations

Gas costs – tariffs. The Australian domestic gas market has been isolated from world parity pricing because historically East-coast petroleum gas has not been traded on global market. This ceases in anticipation of the Gladstone LNG export terminal opening in 2014, exposing Australian consumers to significantly tighter and less-stable market conditions. For the consumer this means higher prices and price volatility[21]. To put this in context, a study by BNEF[22] reports that life-cycle costs of new wind and PV generation are already cheaper than new gas for large-scale generation.

Gas costs – projects. Fitting new developments with gas has a non-trivial cost. Where gas use can be avoided entirely, the project costs of fitting a new development with gas are also avoided.

CSG. Gas demand in Australia is increasingly being met from new Coal Seam Gas (CSG), especially in Queensland. The environmental impact of this production method is highly contested and beyond the scope of this paper to examine in depth. In summary, the claimed negative side effects of CSG production are broadly related to water, salts, erosion, clearing, fire risk, air pollution, and contamination[23][24]. These side effects have significant implications to public health, biodiversity and agricultural production[25].

Gas safety. Although gas is well regulated in Australia, it is intrinsically hazardous, and inevitable accidents occur. WA figures[26] indicate an average rate of 8.5 gas-related accidents per year, per million people. Assuming a similar rate Australia-wide, this is about 3 – 4 reportable accidents per average week. Arguably, substituting gas entirely with electricity would lead to a net reduction in hazard within our community, since the reduction in hazard arising from eliminating gas would be greater than any incremental increase in electrical hazard arising from using electricity for more energy services.

Alternatives to gas

Heat pumps. In HVAC systems, conventional electric boilers and heat pumps can provide a source of heat in place of gas-fired boilers. Heat pumps, in particular, have a large role to play as alternatives to gas-based heating because of their very high, and improving efficiencies[27] and cold-climate performance. As an example, COPs of better than 7[28] are seen, and better than 3 at -10C have been reported([27] pp 12). Electric heating using air-source heat pumps is even gaining traction in Alaska[29] of all places. Another factor in favour of heat pumps for heating is that they are generally slightly more efficient in heating mode than cooling mode because the mechanical work done contributes heat to the process.

Green power. The relative merits of gas vs electricity are obviously contingent on the emissions associated with the mains electricity used. Electricity can be either the best or the worst performing, depending on the source. The author's view is that all-electric HVAC driven from renewable power is preferred. Most Australian consumers of electricity today can choose the level of emissions associated with their power – at a small premium. This gives consumers enormous market power to drive the increase in renewable generation on the grid.

Denmark. Reports[30][31] from Denmark describe an integrated approach to energy, combining intermittent, wind and solar energy and delivering reliable heat in district heating systems which utilise heat pumps and heat accumulators to good effect. Heat pump use increases the the avoided fuel consumption considerably as penetrations of renewable power sources increases([31] pp12).

Characteristics of an example system. Suitable high-performance heat-pump-based systems, such as those described by Craven [32], and Mathiesen[31] might combine a) exhaust-air heat recovery with bypass, b) air-to-water heat pumps c) hot water and heating combined, and d) thermal energy storage. The use of thermal storage increases capital costs, but allows much greater use of off-peak power, and is thus more suitable on a grid with high penetration of renewables. By combining these elements, the current mains-per-GJ price advantage of gas will be lessened.

Case studies. Two cases of commercial-scale HVAC implementations that have chosen a non-gas approach are East Melbourne Library, and Kingston High School in Hobart. The library uses a ground-source heat pump system to drive in-slab heating and cooling. Ground-source heat pumps give quieter, more-efficient operation with higher up-front costs. The Tasmanian school uses two 300kW air-to-water heat pump systems providing heat to an in-slab hydronic system.

Conclusion

The present-day widespread use of gas as a fuel in buildings owes much to the belief that it is environmentally benign. However, current standard industry practice in calculating emissions from gas actually underestimates the size and effect of fugitive emissions. As a result, net emissions from gas use are probably too high for gas to make a useful contribution to climate change mitigation. Other low- or zero-emissions means of heating in buildings are available in place of gas but are not yet widely used.

Today there are very few building owners in Australia who are shunning gas. Hopefully, as the reality of un-burnable carbon, and the global consequences of fossil-fuel consumption become clearer, then the social acceptability of gas consumption will rapidly decline, along with its role in future HVAC systems.

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